Water Supply Intake Resilience Analysis

Montana DNRC

Bartlett & West, Inc.

3470 Gabel Rd. Ste. 1

Billings, MT 59102

October 2019

Prepared By:

Bartlett & West

NewFields

Table of Contents

List of Tables

List of Figures

Appendices

Abbreviations

°F --	Degrees Fahrenheit
API --	American Petroleum Institute
ASRWSS --	Assiniboine Sioux Rural Water Supply System
cfs --	Cubic Feet Per Second
CPM --	Computational Pipeline Monitoring
CFR ---	Code of Federal Regulations
COC	Contaminants of Concern
DNRC --	Department of Natural Resources and Conservation
DPRWS --	Dry Prairie Rural Water System
DRWA ---	Dry-Redwater Regional Water Authority
ERP ---	Emergency Response Plan
FEMA --	Federal Emergency Management Agency
FOSC ---	Federal On Scene Coordinator
FRP ---	Facility Response Plan
Ft-msl --	Feet Mean Sea Level
gpm --	Gallon per Minute
GWUDISW ---------------------------------------	Ground Water Under the Direct Influence of Surface Water
HDD --	Horizontal Direction Drilling
HEC-RAS ---	Hydrologic Engineering Center's River Analysis System
HP --	Horse Power
IMP ---	Integrity Management Plan
kg/m^3	Kilogram per Cubic Meter
MARCo ---	Montana Aviation Research Corporation
MCL --	Maximum Contaminant Level
MFSA --	Montana Major Facility Siting Act
mg/L ---	Milligrams per Liter
mgd --	Million Gallons Per Day
MT DEQ---	Montana Department of Environmental Quality
NAS ---	National Academies of Sciences
OPA	Oil-Particle Aggregates
OSHA --	Occupational Safety and Health Administration
OSLTF --	Oil Spill Liability Trust Fund
PHMSA ---	Pipeline and Hazardous Materials Safety Administration
PSRP--	Pipeline Spill Response Plan
ppb ---	Parts Per Billion
ROW --	Right-Of-Way
SCADA ---	Supervisory Control and Data Acquisition
SCAT ---	Shoreline cleanup Assessment Technique
SEIS --	Supplemental Environmental Impact Statement
SPCC ---	Spill Prevention, Control and Countermeasure

USACE ---	United States Army Corps of Engineers
USCG --	United States Coast Guard
USEPA ---	United States Environmental Protection Agency
USGS --	United States Geological Survey
VOC --	Volatile Organic Compound
WTP --	Water Treatment Plant

I. Introduction

The Montana Department of Natural Resources and Conservation (DNRC) was tasked with evaluating the resiliency of existing surface water diversions on the Missouri and Yellowstone Rivers in Eastern Montana to further analyze potential impacts of oil leaks from existing and proposed pipelines, including the Keystone XL pipeline project. The planned route for the Keystone XL pipeline crosses both rivers in Eastern Montana (**Figure 1**).

The following key evaluation tasks were identified as objectives of this evaluation:

1) Assess/document existing water intakes and diversions;
2) Identify key factors that control the resiliency of surface water intakes; and,
3) Formulate intake alternatives and potential water supply replacement options.

DNRC partnered with the Montana Department of Environmental Quality (MT DEQ) along with technical consultants Bartlett & West, Inc. (B & W) and NewFields Companies, LLC (NewFields) to examine these issues. Beginning in November of 2018, the group also identified key interested parties to engage and collect information on issues related to Eastern Montana source water. Interested parties include:

- Drinking Water Facilities
  - Assiniboine & Sioux Rural Water Supply System (ASRWSS)
  - Dry Prairie Rural Water
  - Dry-Redwater Rural Water
  - City of Glendive
  - City of Culbertson
- Irrigation Facilities
  - Lower Yellowstone Irrigation District
  - Irrigation Districts
  - Individual Irrigators on the Yellowstone, Missouri, and Milk River
  - County Commissioners

Past oil pipeline spills in Montana near Glendive and Laurel and others (such as Kalamazoo, Michigan) demonstrate the extensive potential impacts that releases of petroleum-related contaminants (hydrocarbons) have on water quality and the communities reliant on affected water resources. This report analyzes the water infrastructure of Eastern Montana, evaluates factors that determine the resiliency of surface water intakes to contaminant spills, and identifies possible preliminary alternative solutions to increasing resiliency. Flooding and drought conditions are also analyzed, as they have the potential related to contaminant spills to detrimentally impact drinking water and irrigation operations.

Eastern Montana water sources are geographically scarce, and due to low population density, systems often operate independently in the financially challenged and under-funded water infrastructure sector. Drinking water and irrigation system operators have difficulty securing funds for critical upgrade and replacement projects. Without adequate funding, the operators are unlikely to invest in improving the resiliency of surface water intakes.

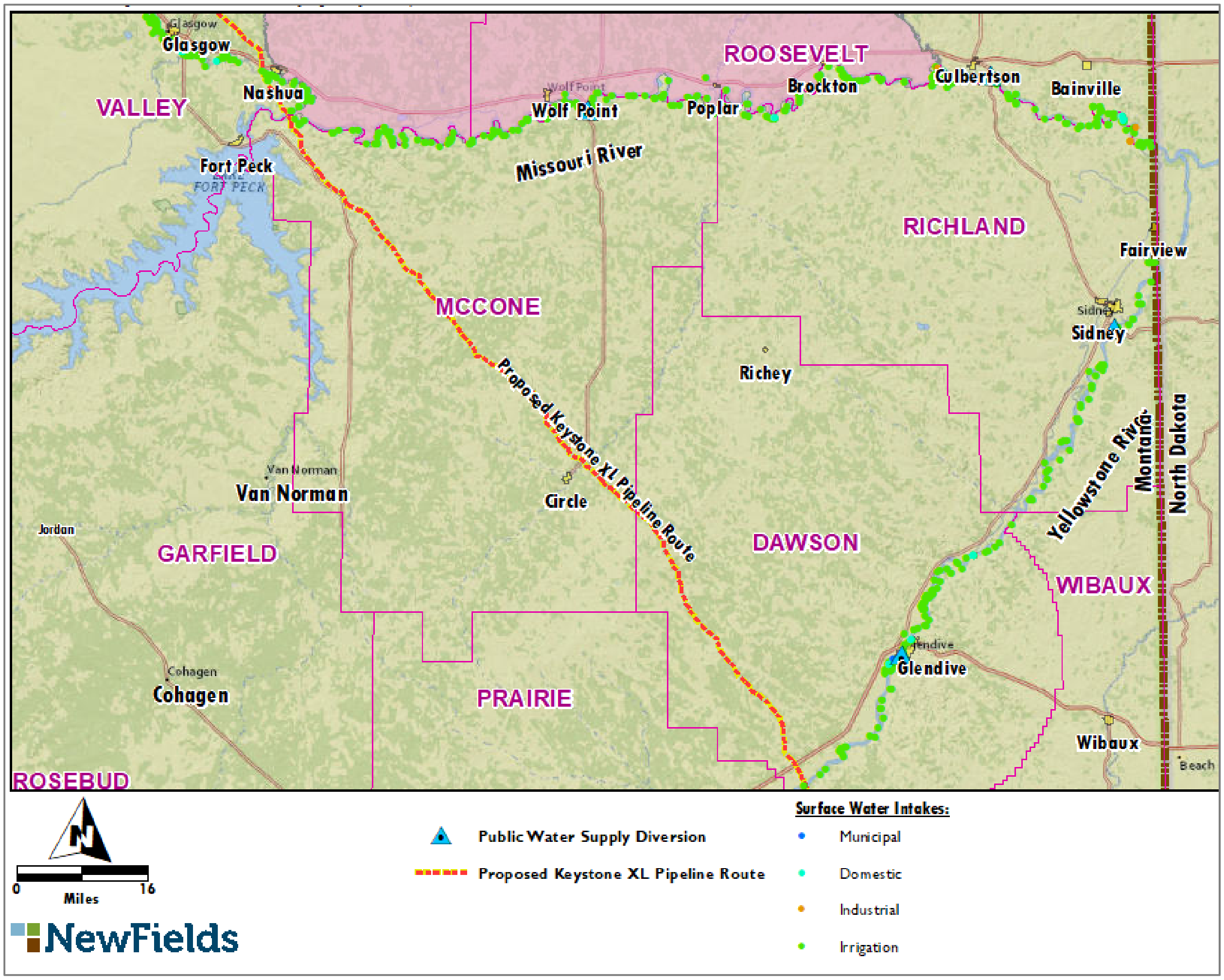


Figure 1: Surface Water Intakes in Study Area

The reporting group reviewed existing data from various sources related to the proposed pipeline including: Keystone XL permitting documents, Federal Emergency Management Agency (FEMA) floodplain maps, reports on leaks from existing pipelines, and communication with stakeholders. Based on the data, the group addressed the following topics related to the proposed pipeline and potential impacts to the Missouri and Yellowstone Rivers in Eastern Montana (**Figure 1**):

- Existing drinking water and irrigation facilities using the Missouri or Yellowstone Rivers as source water;
- Proposed pipeline river crossing construction techniques;
- Resiliency of existing drinking water and irrigation intake infrastructure to contaminant releases from pipelines;
- Evaluation of potential contaminant transport in the event of pipeline spills through modeling;
- Consideration of alternative sources for drinking water and irrigation intakes;

- Disaster mitigation strategies; and,
- Drought and flood resiliency.

II. Water Intake Infrastructure

Pumped and non-pumped surface water supply intakes exist along the Missouri and Yellowstone Rivers. Water diverted via these intakes is used for several different beneficial uses including but not limited to agricultural (including stock water), domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, instream flow to benefit fish, aquifer recharge, mitigation, and recreational (§ 85-2-102 (4) (a), Montana Code Annotated). The existing intakes are described in Sections II(A) through II(C). Surface water diversions on the Missouri and Yellowstone Rivers (downstream of the proposed pipeline crossings) that have valid water rights associated with them are listed in **Appendix G, Table G-1.** These data were queried from the Montana DNRC water right database (DNRC 2019).

A. Drinking Water Facilities

The Missouri and Yellowstone Rivers supply five separate drinking water systems. The service areas for these systems are shown on **Figure 2**, and the approximate intake locations are shown on **Figure 3**.

Figure 2: Drinking Water System Overview Map

Assiniboine and Sioux Rural Water Supply System

Public Law 106-382 was signed by the President in October of 2000 to authorize construction of the ASRWSS. The system was authorized to provide municipal, rural, and industrial water to the Reservation and surrounding areas. The service area of the system is the area in Montana north of the Missouri River; south of the Canadian Border; west of the North Dakota border and east of the western line of range 39 east. The ASRWSS provides treated water from the Missouri River for the Fort Peck Reservation and to the portion of the service area of the Dry Prairie Rural Water System (DPRWS) that lies outside of the boundaries of the Fort Peck Reservation. The water system serves reservation populations in or around the towns of Wolf Point, Poplar, Brockton, Fort Kipp, Oswego, and Frazer. Towns not on the Reservation include Glasgow, Scobey, Plentywood, and Culbertson and are served by the Dry Prairie Rural Water Association.

The ASRWSS intake is located about 6 miles southeast of Wolf Point, 4.3 miles southwest of the Water Treatment Plant (WTP), and about 66 river miles downstream of the Fort Peck Dam. This intake construction was completed in 2005. Locations of the intake and WTP for the ASRWSS are shown in **Figure 3**, along with the proposed pipeline route and the Fort Peck Dam. The intake is located about 175 feet from the river bank, and the top of the intake screen is reported to be at an elevation of 1,956 feet above mean sea level (ft-msl; **Figure 4**). A full set of drawings for the ASRWSS raw water intake, pump station, and proposed pipeline route is provided in **Appendix A**. Water diverted via this intake is conveyed via gravity through four 18-inch screened intake pipes (reduced into two 24-inch pipes). The diverted water is then conveyed into two wet wells that are inside a booster pump station located northwest of the intake structure (**Figure 4).**

The booster pump station is located about 300 feet from the river bank and receives water through the two 24-inch pipelines via gravity from the Missouri River. The two wet wells are approximately 27.5 feet in depth, installed with sluice gates to provide the capability of operating them individually or in tandem. The northeast wet well was originally installed with three vertical turbine pumps, while the southeast wet well was installed with two vertical turbine pumps (including room to accommodate a third pump in the future). Each pump is rated at 75 horsepower (HP) with a capacity of 2,725 gallons per minute (gpm). Water is transferred from the booster pump station to the WTP through a 30-inch pipeline. The booster station is shown in **Figure 4** (Watson Engineering, January 2002).

Assiniboine and Sioux Rural Water Supply System (ASRWSS) Critical intake information is summarized as follows:

Screen Elevation:	*1,955 feet*
Water Level Range:	*1,968.07 feet (2015) – 1,983.34 feet (2011)*
Current Water Level:	*1,971.5 feet*
Depth of Water Over Screens:	*13 – 28 feet*
River Bed Elevation:	*1,950 feet (at construction in 2005)*

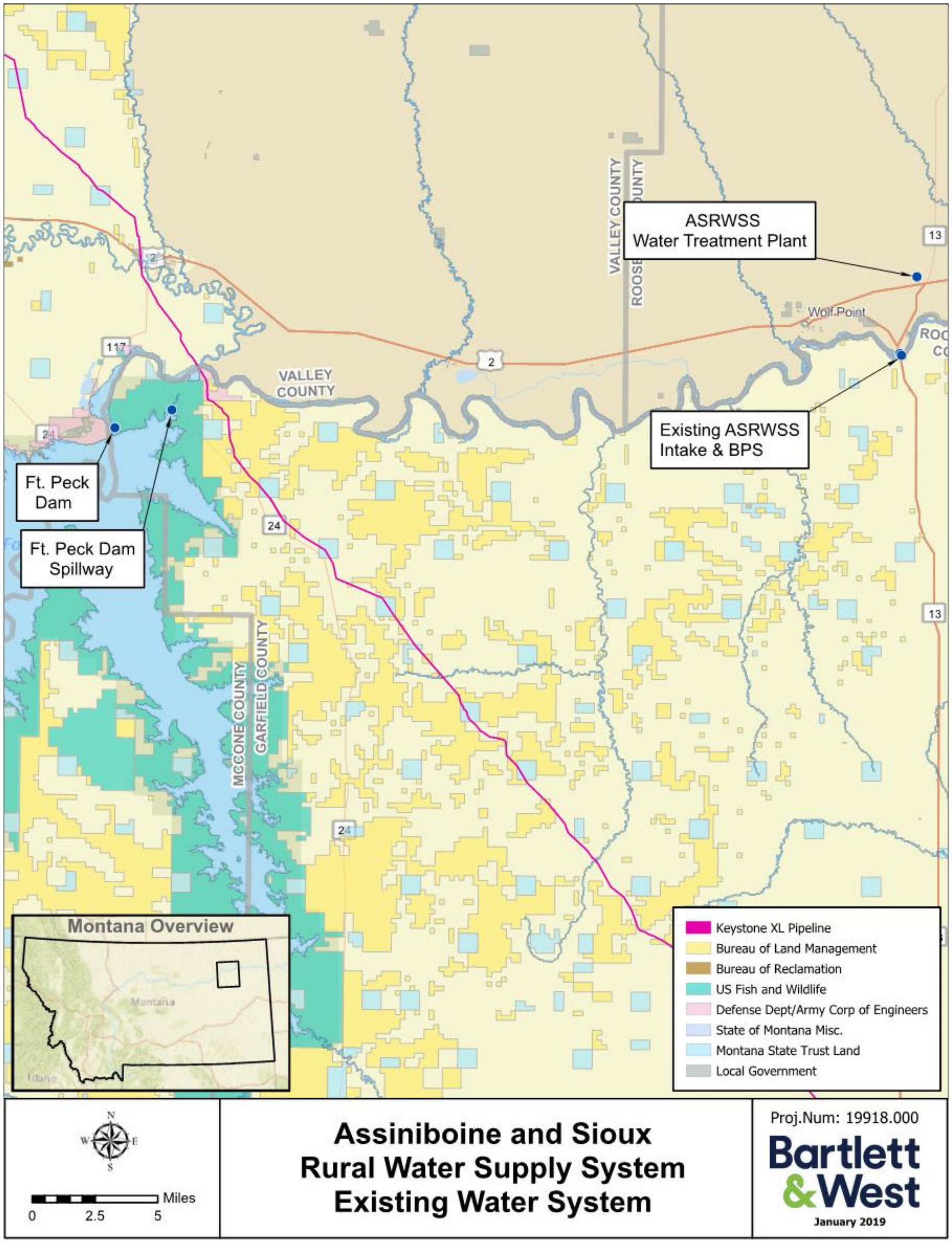
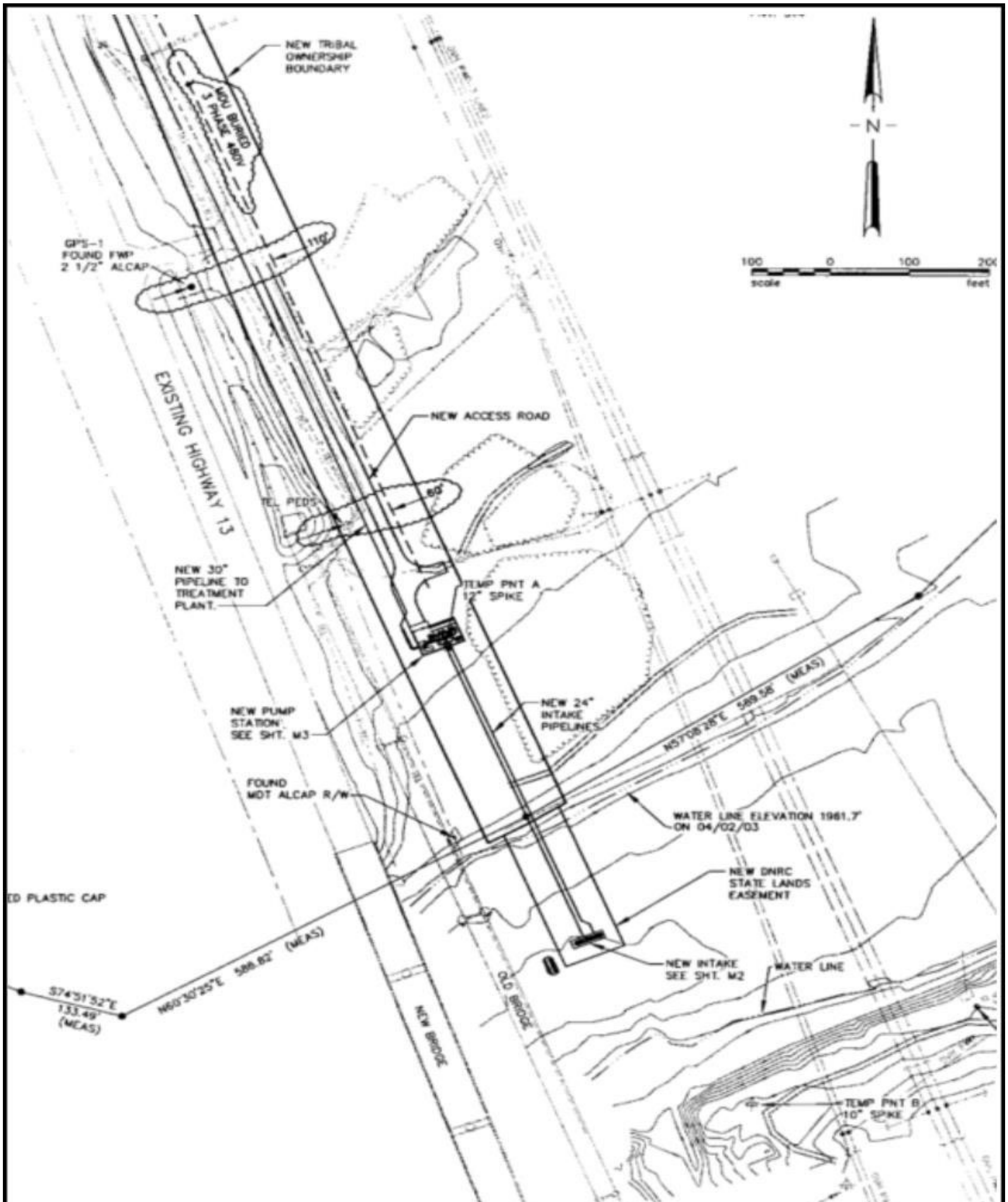


Figure 3: Assiniboine and Sioux Rural Water Supply System intake and water treatment facility in relationship to the Fort Peck Dam and the proposed Keystone Pipeline



Raw Water Intake, Pump Station, and Pipeline - General Layout

Exhibit Source: Record Drawings-Construction Plans for Ft. Peck Res. RWS, Sheet G5, HKM Engineering Inc.

Project Number: 19918.000

Bartlett & West

January 2019

Figure 4: Raw Water Intake, Pump Station and Pipeline General Layout, ASRWSS

The ASRWSS WTP is located about 6.6 miles northeast of Wolf Point (**Figure 3)**. The final WTP phase was completed in 2012 and was constructed to serve both the Fort Peck Reservation and the DPRWS. The plant receives raw water directly from the booster pump station and from the Missouri River intake. The WTP (which uses a pre-oxidation basin, ballasted flocculation/sedimentation basins, gravity filters, and the addition of chlorine and ammonia for disinfection) currently produces an average of 3 million gallons per day (mgd). This production rate is about 22 percent of the system's maximum design capacity of 13.6 mgd. "The ASRWSS and DPRWS projects were designed to serve a population size of 31,102 persons. Several decades of growth will be required to achieve this target population. By 2020, about 20,000 persons will be served." (Reservation, 2018)

Dry Prairie Rural Water System

The DPRWS was authorized as a portion of the Fort Peck Reservation Rural Water System Act of 2000, in part to address insufficient potable water sources. This system originated from the proposed expansion of the ASRWSS that was to include Dry Prairie. An informal committee formed to represent individuals outside of the Reservation and eventually evolved into what is now the DPRWS. DPRWS embodies the entirety of the project that lies outside of the Fort Peck Reservation boundaries, including Daniels, Roosevelt, Sheridan, and Valley counties. "In the DPRWS service area, the towns of Culbertson, Bainville, Froid, Medicine Lake, Antelope, Plentywood, Nashua and Saint Marie are served by the project" (Reservation, 2018). **Figure 5** shows the Fort Peck Indian Reservation Boundary served by ASRWSS and the surrounding area north of the Missouri River that is served by DPRWS.

The DPRWS uses the ASRWSS WTP, which processes water drawn from the Missouri River. The ASRWSS WTP is designed with the following estimated capacities (Reservation, 2018):

Assiniboine and Sioux Rural Water Supply System (ASRWSS) WTP Estimated Capacity information is as follows:

ASRWSS Reserved Capacity of the WTP:	*53%*
Population Served by 53%:	*10,567 residents*
Year 2020 Projection:	*98% Served (10,356 residents)*
DPRWS Reserved Capacity of the WTP:	*47%*
Population Served by 47%:	*10,144 residents*
Year 2020 Projection:	*91.3% Served (9,262 residents)*
ASRWSS WTP Design Population Capacity:	*31,102 residents*

Disruption to the ASRWSS intake has the potential to negatively influence the entire Northeast portion of Montana and leave thousands of people without water.

Based on the above information, the ASWRSS WTP should be operating at 63 percent of capacity by year 2020. According to data provided by WTP staff, the plant is currently operating at about 22 percent of the maximum capacity (3 mgd of a maximum 13.6 mgd).

According to their staff, DPRWS has not experienced any problems with receiving water from the ASRWSS (DPRWS personal communication 2018). Plans do not currently exist to construct a supplemental intake. During discussions with DPRWS, staff indicated that an Emergency Response Plan (ERP) that is not specific to any particular occurrence was prepared by the MT DEQ and jointly adopted by DPRWS and ASRWSS. DPRWS also identified the following potential backup water sources in the event that their intake/source water is compromised:

- Town of Culbertson intake and WTP (currently not being used);
- City of Glasgow;
- Montana Aviation Research Corporation (MARCo; old Air Force Base); and
- Various small towns that have previously used groundwater sources that are currently idle after being served by DPRWS.

Notes from the discussion with DPRWS can be found in **Appendix B** of this report. **Figure 5** shows the Fort Peck Indian Reservation Boundary served by ASRWSS (denoted in yellow) and the surrounding area north of the Missouri that is served by the DPRWS (denoted in grey). The combined ASRWSS and DPRWS is often referred to as the joint Fort Peck Reservation Rural Water System Project.

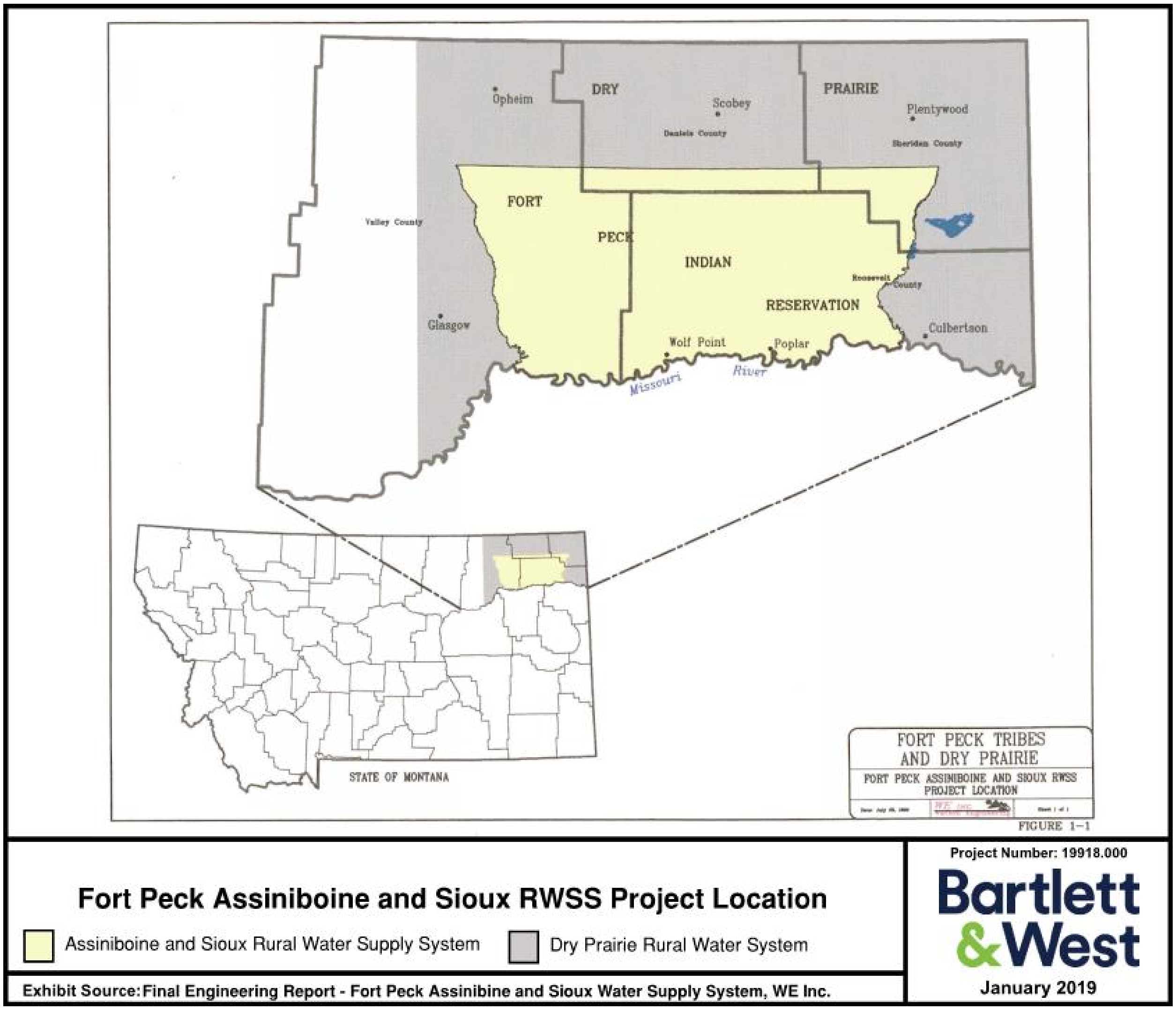


Figure 5: Fort Peck Assiniboine and Sioux Rural Water System and Dry Prairie Rural Water System Service Areas

Dry-Redwater Regional Water Authority

The Dry-Redwater Regional Water Authority (DRWA) was formed in May 2005. The DRWA includes the counties of Dawson, McCone, Richland, Garfield, northern portion of Prairie, and the portion of McKenzie County, ND west of the Yellowstone River (**Figure 6**). About 15,000 people live in the DRWA service area. Currently, water is supplied to residents by groundwater wells drawing from deep and shallow aquifers. A feasibility study was completed in 2006 for a DRWA system expansion. The system would include a surface water treatment plant and distribution pipelines with an estimated construction cost of $260 million. The location of the proposed intake, pump station, and WTP is at the North Fork of Rock Creek on Fort Peck Lake (DryRedwater

Regional Water Authority, n.d.) (Montana DNRC, n.d.). No risk from the Keystone XL Pipeline is expected.

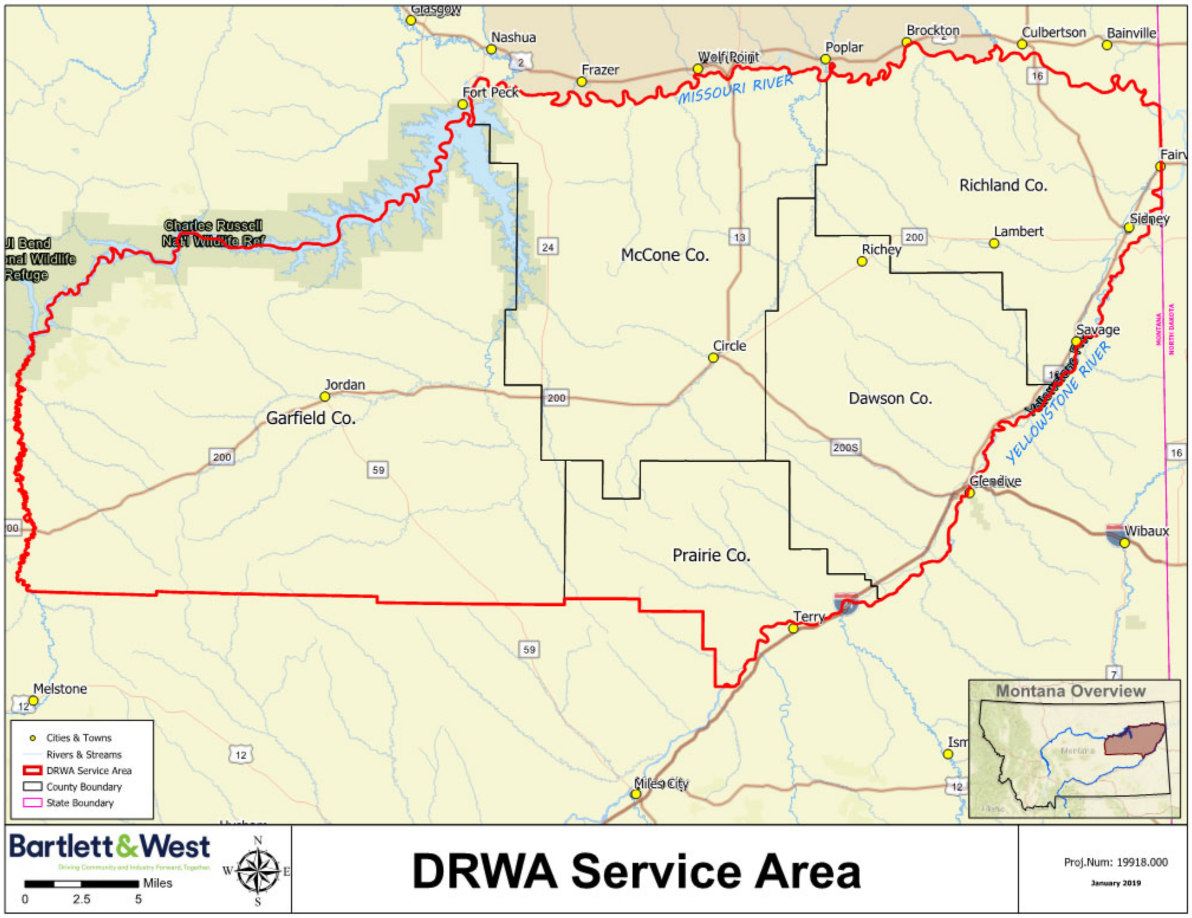


Figure 6: Dry-Redwater Regional Water Authority Service Area

City of Glendive

The City of Glendive water system has an intake in the Yellowstone River (**Figure 7**). Construction of the intake was completed in 1999. The intake has four submersible pumps and is located about 6.8 feet below the low water surface of 2,036.8 ft-msl. Each pump is rated for 1,750 gpm and there is room for an additional fifth pump. The maximum capacity of the current screens is 10.8 mgd. The minimum water stage elevation at the intake site is 2,036.8 ft-msl and the maximum stage is 2,067 ft-msl. The elevation of the intake screens is approximately 2,030 ft-msl. The intake screens are cleaned with an air burst system five times daily. A trailer-mounted air compressor is used periodically to clean debris around the screen. Due to the velocity of the Yellowstone River near the intake, inspecting the screens with divers is extremely difficult. The City owns a Godwin trailer mounted pump with an irrigation river screen as a backup to the intake. Additional intake and pump station drawings and photos are included in **Appendix C** of this report.

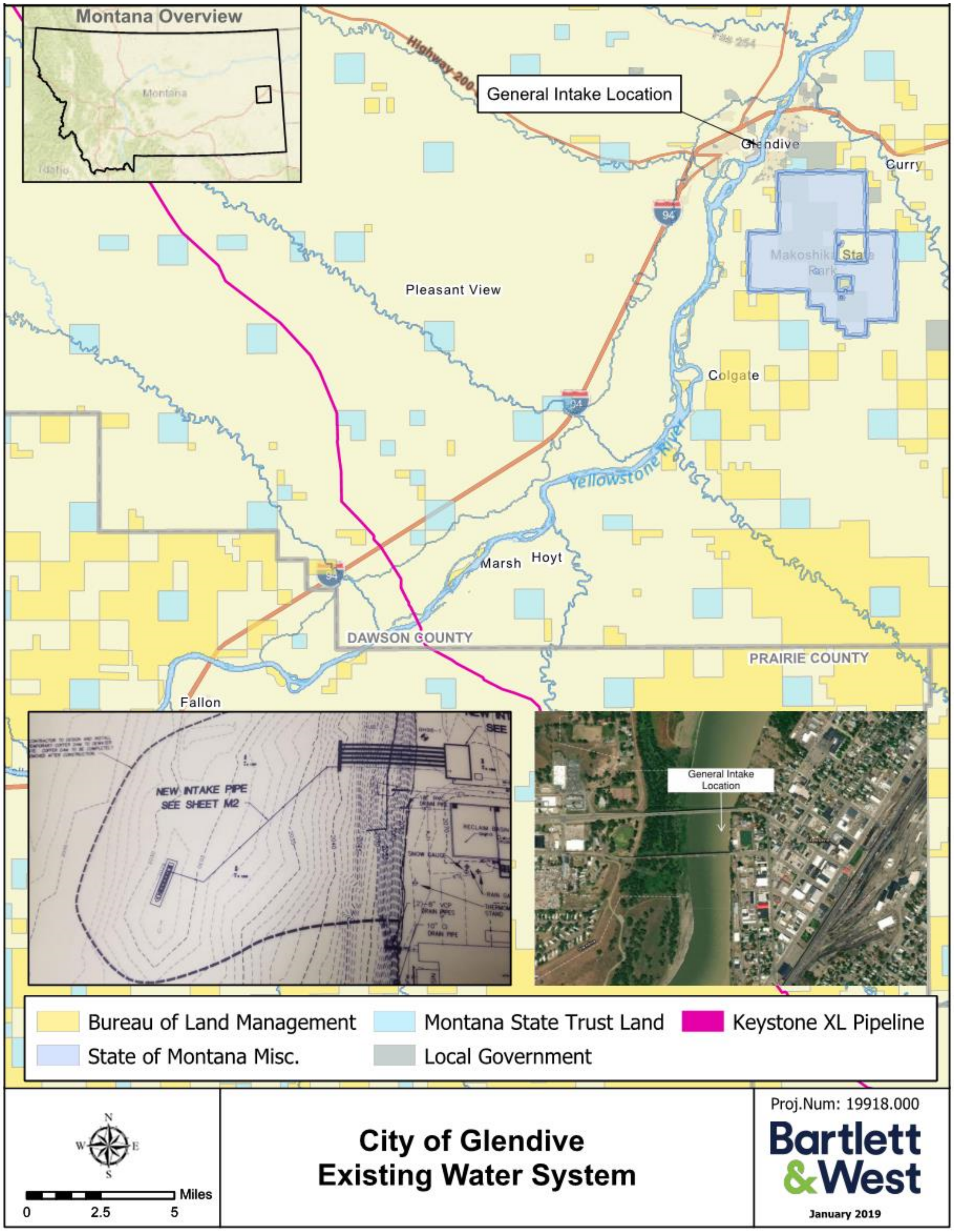


Figure 7: Glendive Existing Water System

The population of Glendive is about 5,100. The city uses about 300,000 gallons per day and reports a maximum peak instantaneous demand of 1,500 gpm. At full operation the facility could be rated at 1.2 mgd average flow. The distribution system has two storage tanks. The Hungry Joe Tank and the Hillcrest Tank have capacities of 1.0 million and 1.1 million gallons, respectively. There are about 2,100 service connections in the distribution system downstream of the WTP. The Glendive WTP consists of the following treatment processes: coagulation, sedimentation, lime softening and multi-media filtration (Glendive, MT, 2012). Gas chlorination is used for disinfection and activated carbon is used for odor control and taste improvements. Powdered activated carbon has also been used to reduce organics, specifically following an oil spill in January 2015. The WTP includes two clear wells and four high service pumps that feed the distribution system. The plant uses Supervisory Control and Data Acquisition (SCADA) to monitor and control the valves, pumps and storage tank levels.

The January 2015 Bridger Spill released petroleum products into the Yellowstone River, which contaminated Glendive's water supply. To detect contaminants in the water supply, Bridger purchased a volatile organic compound (VOC) monitor for the City of Glendive. A photo of the monitor (Modern Water Multisensor 1200™) is shown in **Figure 8**. The monitor has a precision of 200 parts per billion (ppb) of total VOCs. Samples are collected every 20 minutes, with sample analysis requiring two minutes per sample. The monitor was installed in the intake header in the pump house and sounds an alarm if concentrations of VOCs are detected. If the benzene level reaches 2 ppb, the monitor triggers an alarm in the main control room and the plant operators will then shut down the WTP. The United States Environmental Protection Agency (USEPA) Maximum Contaminant Level (MCL) for benzene permitted in drinking water is 5 ppb. The monitor needs to be calibrated every 180 days.

In addition, Bridger purchased a DR 6000 spectrophotometer to manually monitor water quality at various locations within the treatment and distribution systems. Glendive received $615,000 for WTP upgrades. Construction is anticipated to begin on the upgrades in 2019. Upgrades are slated for the system's sedimentation and filtration processes as well as improvements to the clarifiers.

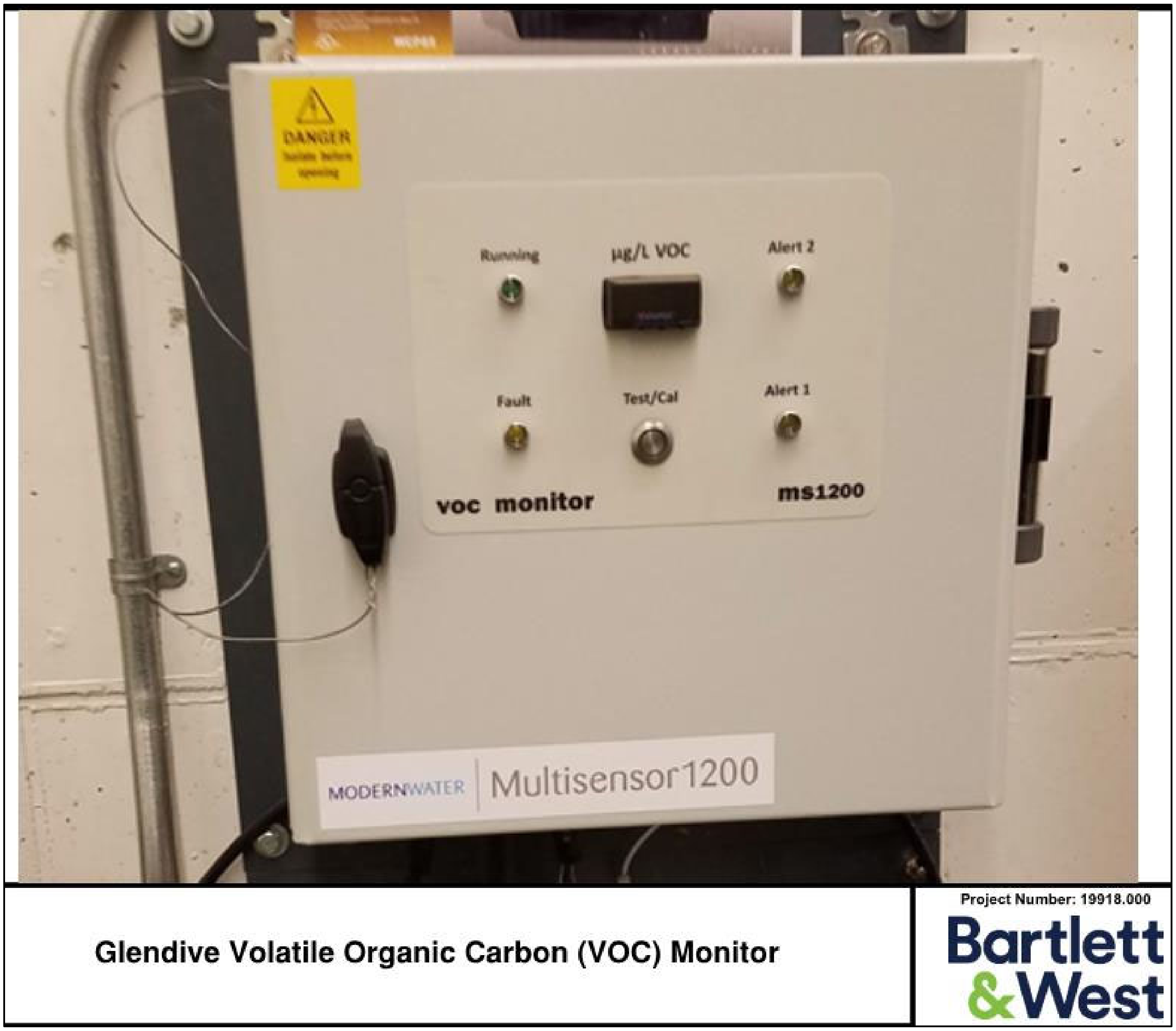


Figure 8: Glendive VOC Monitor

Town of Culbertson

The Town of Culbertson is located about 22 miles west of the border between Montana and North Dakota, along the north side of the east-west running Missouri River (**Figure 9)**. Water service to Culbertson is currently provided by the DPRWS, which is part of the Fort Peck Reservation Rural Water System. As discussed above (Section II(A), *Dry Prairie Rural Water System*), the DPRWS is required by federal authorizing legislation to provide water to off-reservation users north of the Missouri River, including all or part of Daniels, Roosevelt, Sheridan, and Valley counties.

Prior to Culbertson being connected the DPRWS in 2017, the town's water was supplied by an intake and WTP owned and operated by the Town. Culbertson's water supply system provided water to the Town itself, along with serving some surrounding residential areas. According to Town staff, Culbertson has not experienced any problems receiving water via the DPRWS since their connection to the system was established. Town staff also indicated that they discontinued

use of the WTP primarily due to the high operation and maintenance costs of the treatment plant. These high costs could not be justified for the relatively small community.

While Culbertson's water supply system is no longer being used to supply the Town's everyday demands, they have maintained the river intake and WTP. They operate the system periodically when the Town sells water for industrial uses, or when water is needed for emergency purposes.

When operating full-time, the Culbertson system had some problems caused by ice jams in the spring and the accumulation of sediment around their intake structure. The intake is located 100 to 200 feet from the river bank and gravity feeds a wet well located directly north of the intake. The river intake is designed to operate when the discharge from the Fort Peck Reservoir is at or above 9,500 cubic feet per second (cfs). When flows drop below 9,500 cfs (drought conditions), the system is set up to bring in a portable Crisafulli® pump to be used on a temporary basis to provide a source of raw surface water.

The Culbertson system is designed to divert water from the river via the intake and convey the water directly to a booster pump station that pumps the water about 0.75 miles northeast to the WTP (**Figure 9**). The WTP is located about 2 miles southeast of the Town and the river intake is about 1.25 miles further southeast. The WTP uses pressurized sand filters for primary treatment and chlorination for disinfection. The WTP also has two 10,000,000-gallon ponds and a clearwell that can be used for the following three purposes: pretreatment for the WTP, raw water storage for the WTP, and occasional raw water storage for industrial sales.

Culbertson does not currently have plans to install additional water supply intakes. When asked what their biggest concern is, Town staff indicated the ability to respond to a potential pipeline rupture upstream of the ASRWSS intake. Such a rupture would directly impact the Town's primary source of water. If Culbertson's water supply were to be compromised, the Town would: 1) rely on their 20,000,000 gallons of storage capacity, and 2) bring their WTP back into operation. The combination of these two strategies would allow Culbertson to provide citizens with potable water for a period of time, the length of which would be dictated by the extent of water quality impacts to the river and the rate of the Town's water demands at the time.

Town staff have indicated that they have an ERP in place but are unaware of how recently the plan has been updated.

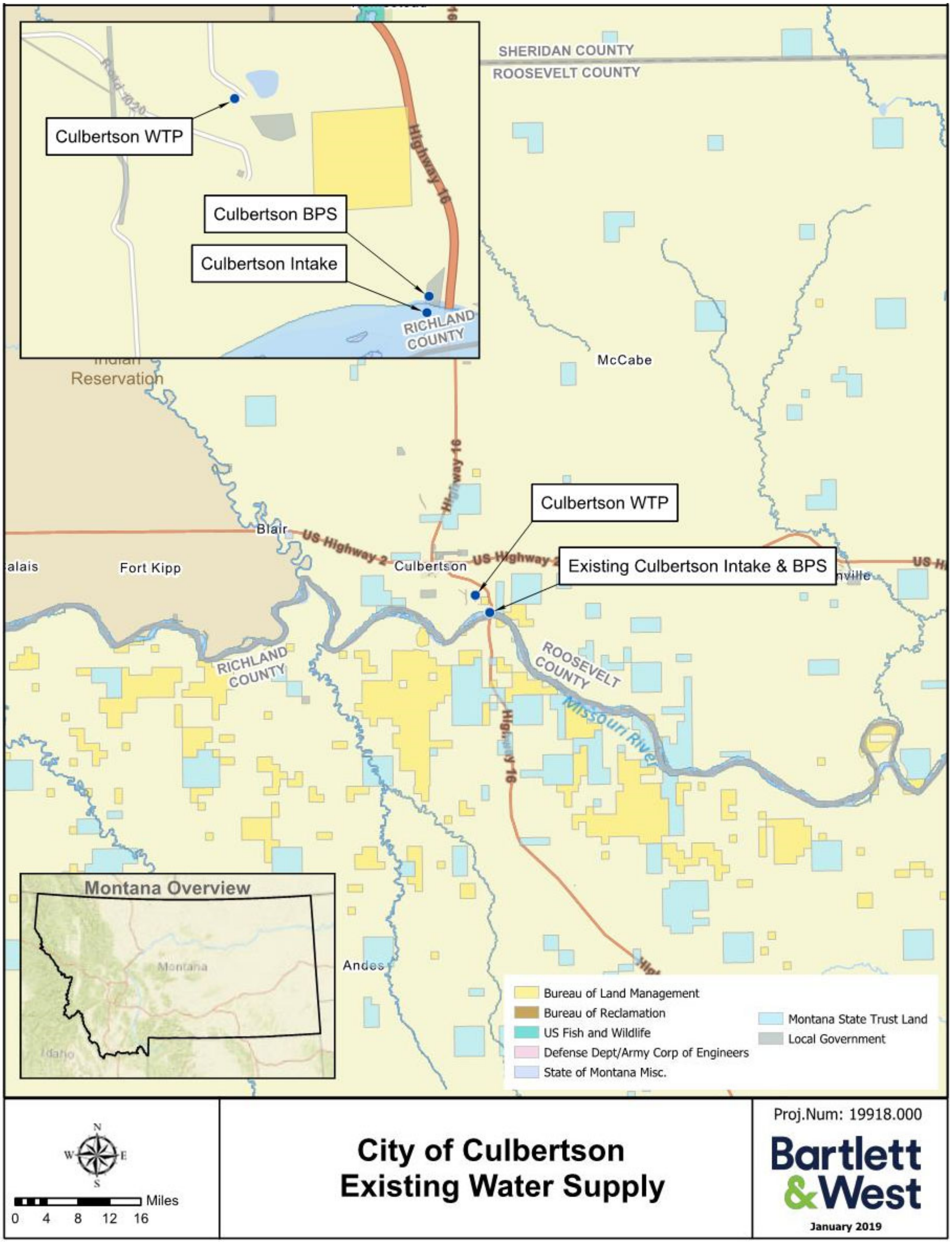


Figure 9: Culbertson, MT Water System Intake Location

City of Sidney

The City of Sidney is served by groundwater, which is not under the influence of surface water. No risk from the Keystone XL Pipeline is expected.

Just outside of Sidney, there is a small public water supply owned and operated by Montana Dakota Utilities Co. with a surface water intake on the Yellowstone River. This system is classified by MT DEQ as a non-transient, non-community system. While this *private* system is noted for location purposes, the resources available for this analysis did not allow for a deep dive into details of its specifications.

B. Irrigation Facilities

There are 11 irrigation districts in northeastern Montana along with many individual irrigators that draw water from the Missouri and Yellowstone Rivers. Irrigators in multiple counties along the two rivers could be impacted by a spill from an oil pipeline. Most irrigators on the Missouri and Yellowstone Rivers use either diversion dams or pumping plants. Operation of these facilities is discussed in the following subsections.

Irrigation Districts

Letters were sent to the 11 irrigation districts to gather feedback from the facility administrators. Examples of the letters, including a questionnaire requesting specific information related to the particular irrigation system, are provided in **Appendix D**.

A summary of the irrigation districts in northeastern Montana is provided in **Table 1**, below.

Table 1: Irrigation Districts in Northeastern Montana

Irrigation District	Primary Diversion Point	Diversion Type	Total System Capacity
Buffalo Rapids Irrigation District	Yellowstone River[1]	Five Pumping Plants[1]	Unknown
Frazer-Wolf Point (Unit of the Fort Peck Irrigation Project)	Missouri River[2]	Four Pumping Plants[2]	605 cfs[2]
Little Porcupine Unit (Unit of the Fort Peck Irrigation Project)	Little Porcupine Creek[2]	Diversion Dam[2]	200 cfs[2]
Wiota (Unit of the Fort Peck Irrigation Project)	Big Porcupine Creek[2]	Diversion Dam[2]	100 cfs[2]
Frenchman Irrigation Company	Frenchman Creek[3]	Diversion Dam[3]	Unknown
Glasgow Irrigation District	Milk River[3]	Diversion Dam[3]	Unknown
Intake Irrigation District	Lower Yellowstone Main Canal[3]	Pumping Plant[3]	18 cfs[3]
Lower Yellowstone Irrigation District	Yellowstone River[3]	Diversion Dam[3]	1,400 cfs[3]
Malta Irrigation District	Milk River[3]	Diversion Dam[3]	700 cfs[3]
Rock Creek Canal Company	Rock Creek	Diversion Dam	Unknown
Sidney Water Users Irrigation District	Yellowstone River	Unknown	Unknown

(Bureau of Reclamation, n.d.)[1]
(Voggesser, 2001)[2]
(PBS&J, 2009)[3]

The Lower Yellowstone District, headquartered in Sidney, is the largest irrigation district in terms of system capacity in northeastern Montana and withdraws water from both the Yellowstone and Missouri Rivers. The manager of this irrigation system is aware of the planned Keystone XL pipeline route and associated river crossing locations. However, the manager indicated that (to his knowledge) there have been no direct discussions between TransCanada and the District's irrigators. The District does not have an ERP for drought conditions or an oil spill, but is interested in developing a plan for such events. The District uses fixed intake locations and does not have any backup or redundant water supplies. Drought conditions and low river flows have negatively impacted the District's water supply in the recent past. Notes from B & W's discussion with the District can be found in **Appendix B**.

Individual Irrigators

There are numerous private irrigators in Eastern Montana that divert water from the Missouri and Yellowstone Rivers and tributaries. Many of these irrigators use pumps to divert water directly from the rivers using either permanent or mobile intake/pumping equipment. Letters and questionnaires were sent to 41 individual irrigators. A list of the irrigators that were contacted and an example of the letters sent to them are included in **Appendix D**. Of the irrigators contacted, three (3) completed and returned the questionnaire. None of the respondents indicated access to an alternative water source. Copies of responses received are included in **Appendix E**.

County Commissioners

Letters were sent to Dawson and Valley County commissioners requesting information about their use of water from the Yellowstone and Missouri Rivers, respectively. Example letters are provided in **Appendix D**.

The City of Glendive, Montana is located in Dawson County, about 20 miles downstream of the proposed pipeline crossing on the Yellowstone River. Based on information provided to the project team by the Dawson County commissioners, Glendive has a water intake on the Yellowstone River. Glendive does not have an alternative water source and according to information provided by the commissioners, they do not anticipate any negative impacts to their intake resulting from construction of the pipeline, flood, or drought. Questionnaire responses for Glendive are included in **Appendix E**.

The Milk and Missouri Rivers form the southern boundary of Valley County. The proposed pipeline route crosses the Missouri River immediately upstream of the confluence between the Milk and Missouri Rivers (**Figure 1**). However, according to the Valley County commissioners, (**Appendix E)**, Valley County does not operate an intake in either the Missouri or Milk Rivers. Any pipeline spills into the Milk or Missouri Rivers (or their tributaries) in Valley County would potentially impact intakes in downstream counties/states.

The City of Glasgow and the Town of Nashua are located along the Missouri River in Valley County. Water for Glasgow is supplied by wells operated by the City, and the Town of Nashua's water is supplied by a combination of wells and a consecutive connection to the DPRWS.

In addition to the written responses from the various county commissioners discussed above, B & W staff attended a November 20, 2018 Roosevelt County Commission meeting to observe discussions about existing infrastructure and potential impacts from the proposed pipeline construction. Notes from this meeting are included in **Appendix B**. Because the pipeline is not planned to pass through Roosevelt County, the commission indicated that substantial discussions

between county citizens and commissioners regarding potential impacts of the pipeline have not taken place yet. The County currently has a draft ERP in place, and updates to the ERP have been completed in conjunction with the Montana Liquid and Gas Pipeline Association. However, the current version of the county's ERP does not specifically address the potential effects of oil pipeline spills into navigable waters. Recent updates addressed potential pipeline breaks, and the County is awaiting public comment prior to adoption and finalization of the updated ERP. The County has identified potential backup water supplies as DPRWS, ASRWSS, the Town of Culbertson, City of Glasgow, and other water wells not currently being used due to the use of the DPRWS and ASRWSS.

C. Irrigation Intake Structures

Several different types of intake structures are used in the State to divert surface water for use in irrigation. The main types of diversions are summarized in the following subsections.

Diversion Dam Intake Structures

Diversion dams control the water elevation in a waterway through permanent structures such as gates, removable boards, or adjustable air bladders. The diversion dam is designed to ensure that sufficient water elevation (i.e., hydraulic head) is available to supply associated irrigation canals or conveyance pipes. **Figure 10** shows a typical diversion dam.

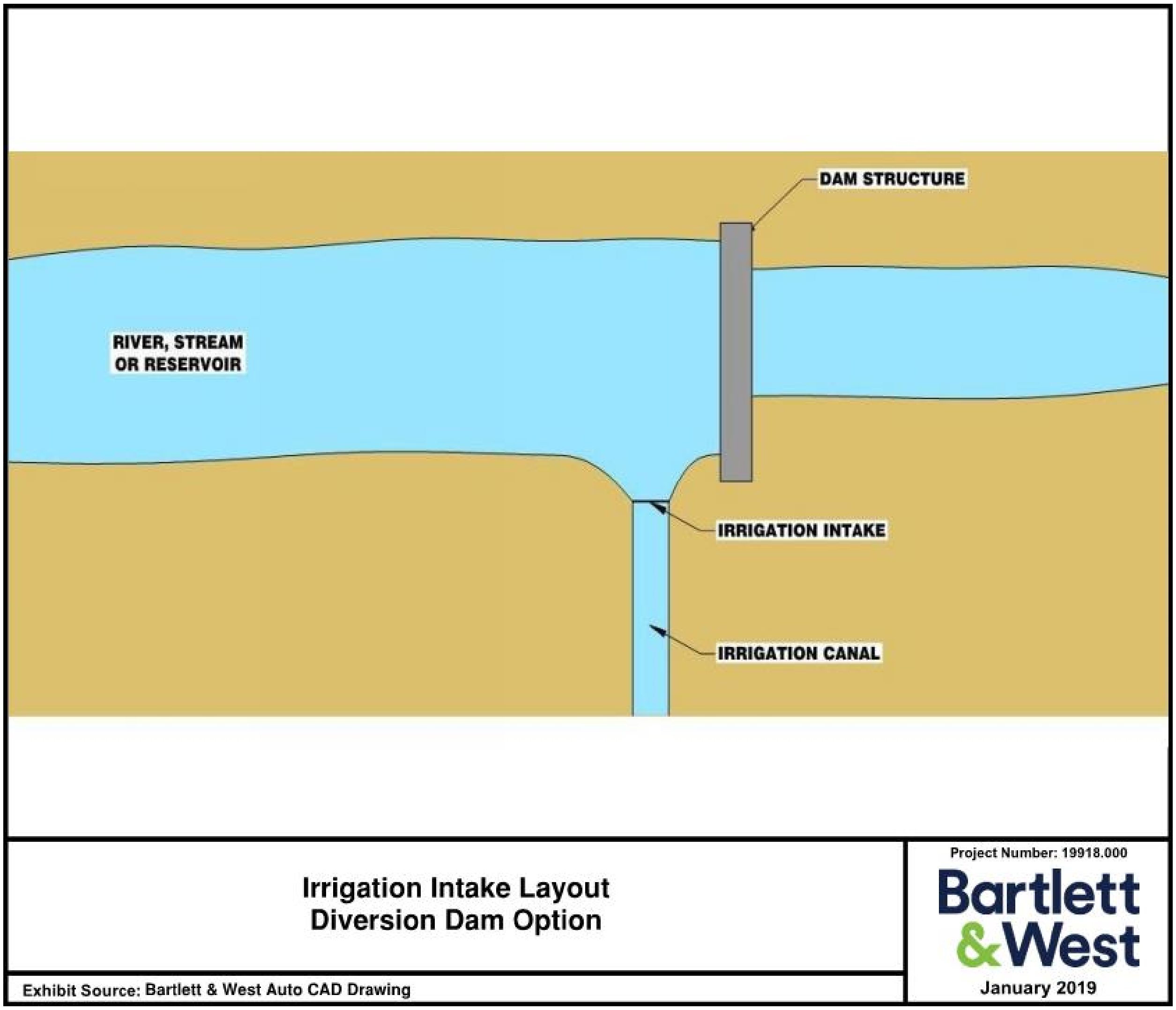


Figure 10: Irrigation Intake Diversion Dam Layout

Pumping Plants

Pumping plants extract surface water directly from the river. **Figure 11** shows an example of a pumping plant layout. Pumping plants have an intake screen placed in the water source, and water is pumped from the source of supply into the irrigation system conveyance and delivery system. Pumping plants can either have a floating intake or fixed intake. **Figure 12** and **Figure 13** show floating and fixed intakes, respectively.

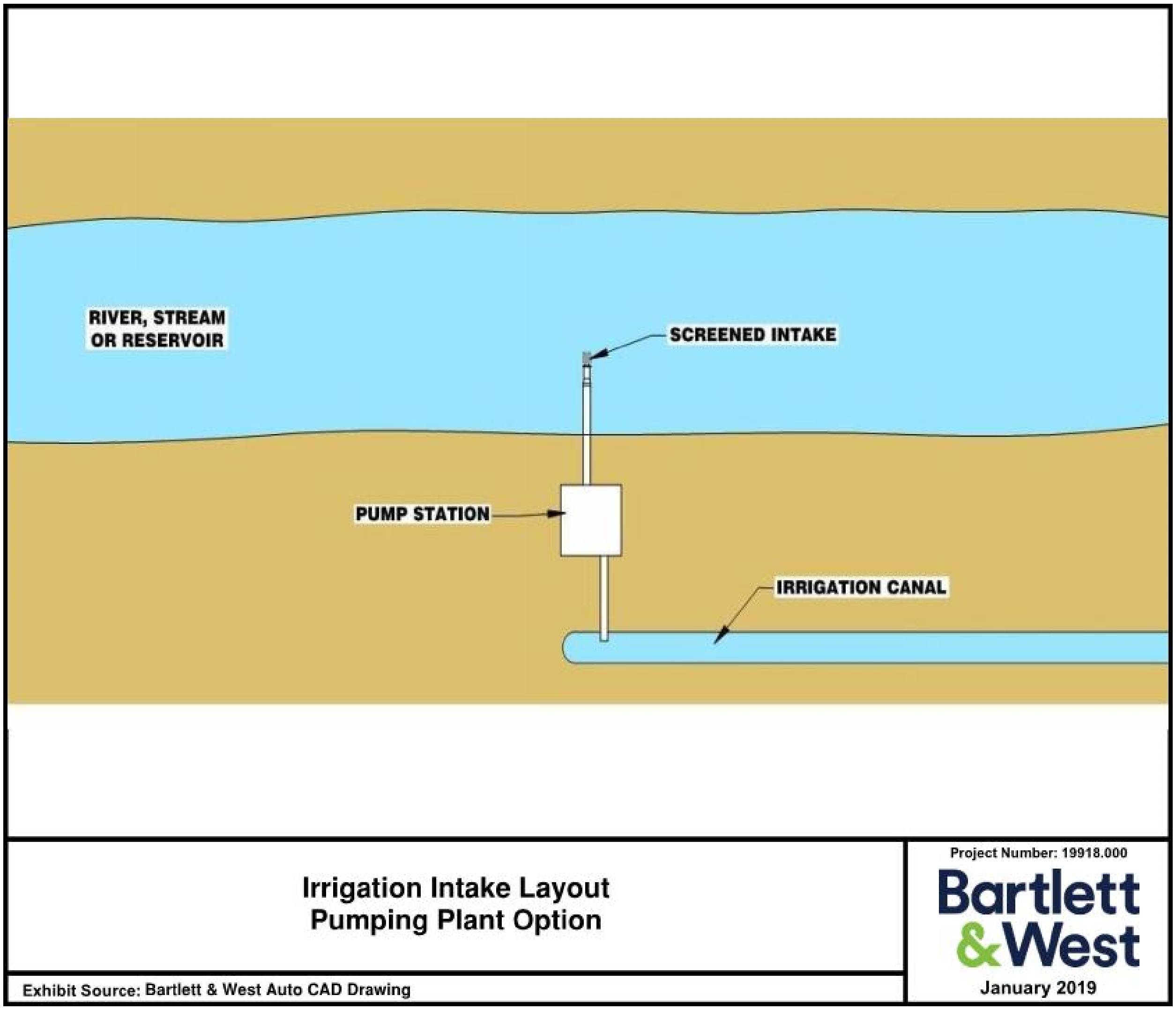


Figure 11: Irrigation Intake Pumping Plant Layout

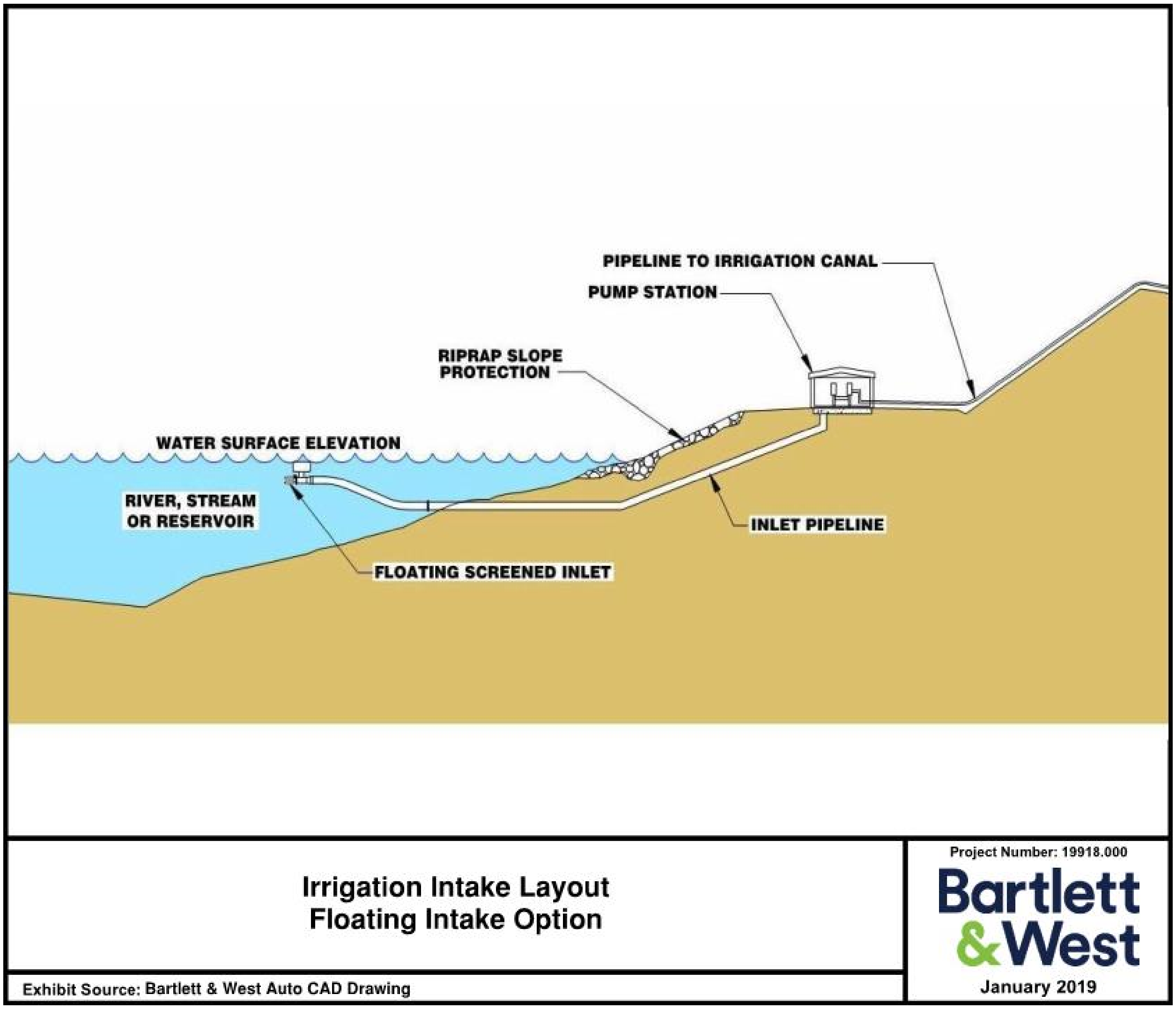


Figure 12: Irrigation Floating Intake Example

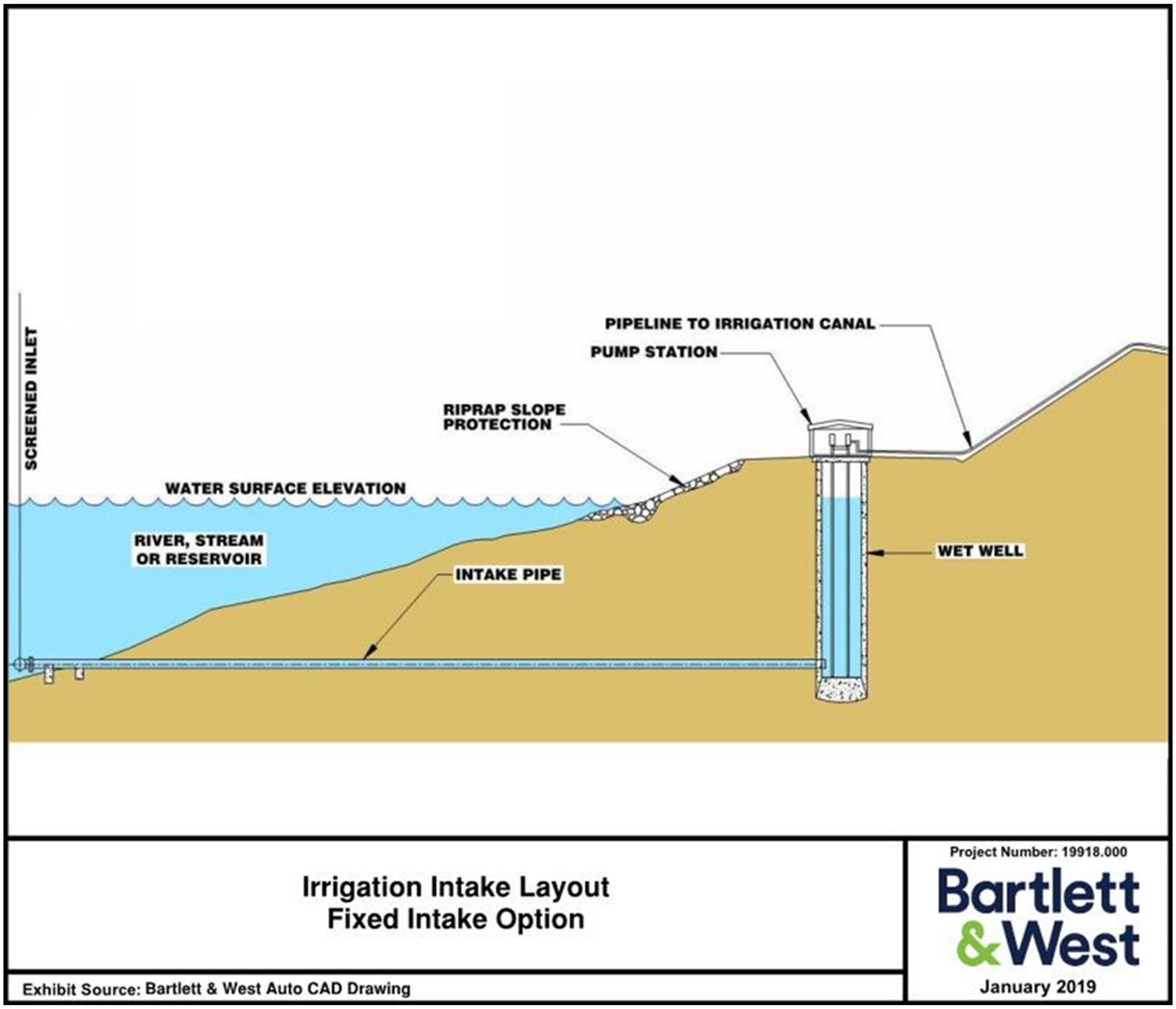


Figure 13: Irrigation Fixed Intake Example

D. Water Users Concerns

Water users on the Missouri and Yellowstone Rivers downstream of the proposed pipeline crossings have provided feedback related to the pipeline through direct conversations, responses to questionnaires, and information communicated through press articles. Drinking water and irrigation water users who draw water from the Missouri and Yellowstone Rivers have summarized what events or conditions they consider the most likely to negatively impact existing surface water intakes. B&W has reviewed the requested feedback and other communications and identified two main topics of concern: (1) potential oil spill impacts and (2) flooding and drought conditions.

Oil Spill Related Impacts

Members of the Assiniboine and Sioux Tribes of the Fort Peck Reservation have discussed with various news outlets their concerns associated with the proposed Keystone XL pipeline. In a November 2018 article published in the *Great Falls Tribune*, tribal members identified the difficulties related to treating oil-contaminated water at the Eagle Shield WTP without equipment

to remove petroleum hydrocarbon contaminants. Potential impact to irrigated crops on the reservation was also discussed (Puckett, 2018).

In an article published in *The Guardian*, individuals of the Fort Peck Assiniboine Council indicated concern that excessive snowmelt over a relatively short period could create conditions conducive to pipeline damage. In the article it was surmised that excessive snowmelt could fill the reservoir to capacity, which would create the need to release large volumes/high flows of water from the Fort Peck Dam. A large release of this nature could cause excessive riverbed scour. Depending on the extent of scouring and the depth of pipeline bury, the pipeline could be exposed, damaged, and/or ruptured. Chemicals released from a ruptured pipeline could reach water intakes and require shutdown of existing water supply systems on the Missouri River (Pauli, 2018). Analysis of this concern is contemplated further in Sections IIIC and IIIF.

The Yellowstone Irrigation District indicated concerns about potential impacts to their irrigation system if a spill from the proposed pipeline were to occur and the absence of an ERP for such an event. Currently, proper shutdown of the irrigation system requires 4 to 10 days to protect the structural integrity of the canal's earthen embankments. The District provided the following statement pertaining to immediate canal shut down, "This scenario would create a rapid drawdown condition on the banks of the earthen canals within this system as water drains out of the canal system. The drawdown condition results in a reduced slope stability, which occurs when submerged slopes experience a reduction of the external water level in a short timeframe." Such a situation would result in the need for costly repairs. The District also questioned whether the pipeline operator could be found liable and thus be required to reimburse the irrigators for crop yield reductions, loss of production, and direct labor for cleanup if a pipeline spill were to negatively impact irrigated acreage within the District.

Roosevelt County Commissioners noted that a pipeline rupture would require an organized response. This would require significant preparation and planning, purchasing and maintenance of emergency response equipment, specialized training and certification of personnel. The activities involved in the preparation would be a considerable expense to the County for which a funding source has not been identified.

The commissioners also questioned how modeling of downstream transport of contaminants is being done to account for the chemical and physical characteristics of diluted bitumen.

Multiple irrigators indicated concerns over financial responsibility associated with cleanup from an oil spill, should one occur. Irrigators are uncertain as to the financial role that the pipeline operator would be required to play in the aftermath of a pipeline spill (including potential lost income due to impacts on irrigated crop yields).

Flooding and Drought Conditions

Personal discussion with ASRWSS WTP staff revealed that recent years of flooding have led to an increased number of intake operation difficulties, including the transport of a large volume of sand downstream (Trent, 2018). The riverbed, although once 5 feet below the intake screen elevation, now is believed to be quite close to the screen elevation. This has increased the amount of sand/grit that is transported through the intake, and has caused significant degradation of the vertical turbine pumps.

The Fort Peck Dam reservoir levels and related operations have a substantial impact on intakes downstream. High water levels and inflows into the reservoir have led to the release of water

through the emergency spillway on multiple occasions. The release of water and resulting increase in river flow results in significant scouring effects that have been documented throughout the Missouri River Basin below the Fort Peck Dam.

Flood conditions and associated transport/deposition of sediments may cause intake degradation when large volumes of sediment accumulate around the intake structure. Accumulated sediments may also become corrosive to the pumping system over time. Drought conditions can lead to low outflow from the dam, which may leave intakes with minimal water for operation. The long-term effects of sedimentation and low water conditions can include intake failure. Descriptions of the impacts of low flow conditions on intakes provided by individual irrigators are provided in **Appendix E**.

III. Pipeline River Crossing Risks

In their responses to questions from the project team (**Appendix E**), many of the operators of drinking water and irrigation facilities focused on how they would respond to a pipeline leak or rupture resulting in impacts to the Missouri or Yellowstone rivers. In response to issues raised by these operators, B & W reviewed the currently proposed Keystone XL pipeline design and construction methods. Results of this review are detailed in the following subsections.

A. Welding

One of the most important aspects of steel pipeline construction is the quality of the welded joints between pipe sections. Qualified welders, using approved welding procedures, materials and equipment, are required for proper pipeline construction. All welders, welds and welding inspection processes fall under the jurisdiction of Title 49 Code of Federal Regulations (CFR) Part 195 (Regulations, 2017). This federal regulation requires that all welders, welds and welding inspection processes meet American Petroleum Institute (API) Standard 1104, the federal standard for welding pipelines and related facilities. Per API 1104, all welding equipment, both gas and arc, shall be of a size and type suitable for the work and shall be maintained in a condition that ensures acceptable welds. Arc welding equipment shall be operated within the amperage and voltage ranges given in a qualified welding procedure that meets the requirements detailed in API 1104. Gas welding equipment shall be operated with the flame characteristics and tip sizes given in the qualified welding procedure (Institute, 1999). Equipment that does not meet these requirements shall be repaired or replaced. A minimum of 10 percent of girth welds made by each welder and welding operator must be nondestructively tested over the entire circumference of the weld (Regulations, 2017). All welds shall be inspected using nondestructive radiographic, ultrasonic, or other methods that provide an equivalent or better level of safety than that required in 49 CFR 195. The pipeline installer will be required to use these comprehensive practices to ensure that all of the welds meet federal specifications.

B. Valves

Valves installed on oil pipelines fall under the rules and regulations of 49 CFR 195, API 6D. Additional requirements associated with the valves installed as part of the construction of the proposed Keystone XL Pipeline are found in the Final Supplemental Environmental Impact Statement (SEIS) and the Certificate of Compliance issued pursuant to the Montana Major Facility Siting Act (MFSA) for the project. Per 49 CFR 195, valves must be installed in locations that are easily accessed by authorized personnel and are required to be built with tamper protection. Additionally, valves must be installed on each side of water crossings greater than 100 feet in width, on each side of reservoirs holding water for human consumption, and at locations that will minimize damage to the terrain in the event of a spill. As part of the Final SEIS review, mainline valves installed on the project are required to be operated remotely. Per the special conditions of the project required by Pipeline and Hazardous Materials Safety Administration (PHMSA) as part of the Final SEIS, all remotely operated valves must have remote power backup on site for surrogate operation purposes. Valves installed on the pipeline shall meet API 6D requirements and the specification respective to each design criteria:

- Pressure ratings;
- Temperature ratings;
- Maximum pressure differential;
- Valve body and type configurations;

- Flange types;
- Composition limits;
- Toughness tests;
- Bolting materials;
- Weld impact tests;
- Hardness tests;
- Pressure tests;
- Coatings;
- Markings; and,
- Dimensions.

In accordance with the MFSA Certificate of Compliance, a motor operated block valve is required on the north side (upstream side of the pipeline) on both the Yellowstone and Missouri rivers. Additionally, a check valve and manually-operated block valve are required on the south side of both rivers. Specific valve locations were determined to position the valves outside of the anticipated high-water level of the rivers and to minimize potential impacts to riparian areas. Valves would be monitored by the SCADA system (State, January 2014). Anticipated valve locations, as indicated in the MFSA Certificate of Compliance, for both the Missouri and Yellowstone River crossings, are presented in **Appendix F**. Valves installed on the pipeline are expected to be weld-end valves, rather than flanged valves. Weld-end valves have historically shown a reduced occurrence of leaks compared to flanged valves (State, January 2014).

C. Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) is typically considered the best available technology to construct pipeline crossings beneath large rivers. This method significantly reduces incidences of excessive sedimentation/turbidity and bank destabilization that often occur with other installation methods. The spills recorded to date have occurred with pipelines installed with an open cut construction method resulting in a shallow burial depth of the pipeline. The HDD construction techniques typically allow for pipeline installation and excavation activities to occur below the streambed and beyond the influence of surface water flows/bed scour or other excavation activities. The depth of the HDD provides an added level of protection for the river; any crude oil released at a HDD crossing would preferentially move within the less consolidated material in the HDD bore path rather than migrating vertically through the compacted overburden to reach the stream bed.

Potential adverse effects that may occur with HDD include “frac-out”, which is the unintentional return of drilling fluids to the surface during drilling. When the down hole mud pressure exceeds pressures in the overburden (i.e., shallow or loose sections of the bore), the fluid may return to the surface or may find a favored seepage pathway. Seepage pathways can be faults, fractures, infrastructure trenches or loose fill materials). While frac-outs are relatively common on HDD projects, most are minor, with seepage of drilling fluids typically occurring within the construction right-of-way near the borehole. The drilling operator must closely monitor the drilling process to minimize occurrences of frac-outs, as well as the amount of disturbance if such an event occurs. Increased surface soil disturbance caused by equipment at entry and exit locations should be mitigated through reclamation and revegetation plans.

Geotechnical investigations should be conducted to evaluate soil properties at the HDD sites prior to drilling. Entry and exit locations should be planned in areas where stable soil conditions are

identified. Investigation results may also be used to design a drill path that avoids river meander zones and areas with significant groundwater. Careful design of drilling plans will minimize the potential for bank destabilization, erosion, and sedimentation during the installation and construction of pipeline river crossings.

TransCanada is required by the MFSA Certificate of Compliance to use HDD construction methods during the construction of the proposed Keystone XL pipeline, to cross the Missouri and Yellowstone Rivers. The drilled pipeline profile at the Yellowstone River crossing is anticipated to be close to 3,200 feet in length, with the proposed entry points being located outside of the riparian zone and beyond the high-water level on both sides of the river.

At the Missouri River crossing, the pipeline bore length will be about 2,482 feet, with the southern exit location surfacing outside of the high-water level of the river. Potential drill profiles are included in **Appendix F**. These figures were originally included as Appendix L in the MFSA Certificate.

D. Corrosion Protection

Pipelines under the jurisdiction of 49 CFR 195 are required to have an external coating for corrosion control and must have a cathodic protection system installed within one year of the pipeline being constructed. The cathodic protection system must have electrical test leads installed along the pipe in locations that allow the collection of electrical measurements appropriate to evaluate the adequacy of the cathodic protection system. The pipeline coating must be designed to:

- Mitigate corrosion,
- Have sufficient adhesion,
- Be sufficiently ductile to resist cracking,
- Have enough strength to resist damage due to handling and soil stress and
- Support the supplemental cathodic protection system.

Cathodic protection using anodes and a power source protects metal pipelines from soil corrosion, slowing the rate of corrosion.

According to the Final SEIS the pipeline will be coated with a fusion-bonded epoxy coating. A cathodic protection system using impressed current will be used for corrosion protection (State, January 2014). All pipelines constructed as part of the project will employ similar methods to inhibit pipeline corrosion.

E. Casing Pipe

When steel oil pipelines are installed via the HDD method, common industry practice avoids the use of casing pipe. Casing pipes (left in place) could potentially serve as a containment measure for leak events and could facilitate maintenance to HDD sections. However, cased crossings may adversely affect the integrity of the carrier pipe by shielding the cathodic protection current to the pipe, as discussed in NACE International Standard Practice for Steel Cased Pipeline Practices (International, 2014). Maintaining an effective cathodic protection system is critical to the integrity of the pipeline. Common industry practice for HDD crossings utilizes an abrasion resistant overcoat to protect the underlying external coating from damage that could be incurred during installation.

TransCanada is not planning to install casing pipe at the crossing of the Missouri River, but will use thicker-walled steel pipe coated with an abrasion-resistant material (Stantec, 2017). Based on the information available for this analysis, it is not known if the same procedures, materials, and equipment will be used for the Yellowstone River crossing.

F. Depth of Cover

Per the requirements of 49 CFR 195, the pipeline must be installed with a minimum of 48 inches of cover between the top of the pipe and the river bottom. Across the rural terrain adjacent to the river crossings, the pipeline shall be installed beneath the level of cultivation but no less than 30 inches deep. The pipeline shall be constructed with 36 inches of cover beneath drainage ditches at public roads. More stringent, additional depth of cover, at the Missouri and Yellowstone River crossings are scheduled. These standards are detailed in the MFSA Certificate of Compliance for the project. Per Appendix L of Attachment 1B to the Certificate, TransCanada is required to calculate a depth of scour based on a 100-year flood event and to determine the size of sediment found at the crossing. The pipeline depth of cover at the Missouri and Yellowstone Rivers shall be greater than the calculated scour depth, and the burial depth shall be extended laterally as approved by the MT DEQ. Should bedrock be encountered during construction, the pipeline shall be buried to a minimum of two feet below the top of the bedrock surface.

According to the HDD profiles presented in **Appendix F** of this report, it is anticipated that the pipe will be 55 feet below the riverbed depth where the pipeline will cross beneath the Yellowstone River. A scour analysis performed by TransCanada for the Yellowstone River crossing is presented in the MFSA Certificate of Compliance. The analysis indicates that a 100-year flood event will cause a 5-foot deep scour. In the event of a 500-year flood, the analysis suggests that the pipe will remain 17 feet below the predicted scour depth (State, January 2014). As noted previously, TransCanada has performed a scour analysis for the Missouri River and has determined the amount of scour associated with a maximum spillway release (350,000 cfs) will be 21.7 feet at the proposed pipeline crossing. Based on this degree of scour, the pipeline will remain 58 feet below the current riverbed (Stantec, 2017). TransCanada has stated (in the Missouri River Crossing Site Specific Plan) that there will be 4 feet of pipe cover in areas outside of the HDD bore sections. This exceeds the 2.5 feet (30 inches) required, as discussed above.

G. Leak Detection Monitoring

Often multiple leak detection systems are used on a single pipeline to increase the likelihood of detecting a spill. Most pipelines utilize at least two methods of leak detection.

Typically, oil pipelines use computational pipeline monitoring (CPM) systems for leak detection. These systems use algorithmic monitoring tools to recognize hydraulic anomalies that may indicate leaks. CPM systems include displays and alarms that call the operators attention to conditions that may be associated with active or pending leaks. Alarms prompt operators to evaluate changes in pipeline flow conditions. Between 2010 and 2016, PHMSA indicated 264 crude or refined oil pipeline spills occurred on pipelines operating with CPM systems; however, only 19 percent of the incidents were detected by the CPM systems (Kumar, 2016). Other techniques used for leak detection include line patrol by aerial or ground observation, inspections, hydrocarbon detection sensors, meter-out versus meter-in, and third-party reports. SCADA sensors with the CPM systems detect and alert operators to conditions (e.g., pressure and flow) that are outside of the normal operating specifications for the system. Leaks of about 1.5 to 2.0 percent of the total flow rate of the system can typically be detected through monitoring

of the SCADA system. Leaks smaller than 1.5 to 2.0 percent can typically be identified using computer-based gain and loss volume trending.

According to Keystone XL's operating procedures stated in the Final SEIS:

- After a SCADA system alarm is sounded, the control room would enter a 10-minute evaluation window.
- No investigation is required before an operator shuts down the system.
- Once a leak is determined, operators shut down pumps and close isolation valves (State, January 2014).

Data from PHMSA indicate "pipeline spills are usually detected within 1.2 days, and 97 percent of oil spills are detected within 7 days" of release (Stantec, 2017).

For the proposed Keystone XL pipeline, the Final SEIS indicates the following leak detection methods would be utilized (2014):

- Pump station valve pressures and flow rates will be monitored via the SCADA system. Remote monitoring typically detects leaks down to about 25 to 30 percent of pipeline flow.
- Software-based monitoring systems will be used to track receipt/delivery of transported product. Volumes will be monitored using technology typically able to detect leaks down to about 5 percent of pipeline flow.
- Model-based leak detection systems used to monitor shorter pipeline segments, on a mass balance basis, will evaluate any changes in flow/volume between valves/measurement points. These systems typically have the capacity to detect leaks down to about 1.5 to 2.0 percent of pipeline flow.
- Computer-based, non-real time accumulated gain or loss volume trending will be used to assist in identifying these low-rate or slow-seepage releases (loss rates below 1.5 to 2.0 percent by volume).
- Direct observation methods, which include aerial patrols, ground patrols and public and landowner awareness programs, are designed to encourage and facilitate public reporting of suspected leaks.

It is a common misconception that because a leak threshold of 1.5% is stated for computerized systems, any leak rate smaller than 1.5% would go undetected. Utilizing overlapping methodologies noted above, TransCanada will also deploy in-line leak detection devices that can detect leaks of below 1.5 to 2.0 percent, by volume (State, January 2014). The Site-Specific Risk Assessment for the proposed Keystone XL Project's Missouri River Crossing states "aerial surveillance will be conducted on a bi-weekly basis (average of 26 times per year), in accordance with federal requirements. If the sample collection schedule must be adjusted due to site-specific conditions, sampling intervals will not exceed three weeks during any interval.

H. Recent Spills and Concerns

The amount of time required to detect a pipeline leak has a significant impact on the volume of oil released during a spill event. Timely leak detection and response are potential challenges faced by all pipeline operators. Large diameter pipelines with multiple entry and exit locations are the most challenging for leak detection systems, due to the dynamic nature of these pipelines (Kumar, 2016). Recent examples include the spill for the Bridger Pipeline in Glendive, MT where about 42,000 gallons of crude oil were spilled into the Yellowstone River 6 miles upstream of the

Glendive drinking water intake, the closest intake for the proposed KXL route is 22 miles, also at Glendive. The Silvertip Pipeline spill in Laurel, MT released about 50,400 gallons of crude oil into the Yellowstone River. The Keystone Pipeline spill in Amherst, SD spilled about 407,000 gallons of crude oil.

In the case of the Bridger Pipeline in Glendive, MT, about 56 minutes passed from the time when abnormal pressures were first identified to when the pipeline was shut down. The operator of the Silvertip Pipeline in Laurel, MT shut down the pipeline about 7 minutes after low pressure alarms first sounded (Environmental Protection Agency , n.d.).

Although the amount of time that transpires prior to a pipeline leak being detected has a significant impact on the spill volume, there are several additional factors that can determine spill size. These factors include the size of hole/break in the pipeline, operating pressure, pipeline diameter, pipeline elevation change (in the sections surrounding the spill), distance between isolation valves and the effectiveness of isolation valves (State, January 2014).

The Keystone XL pipeline, as planned, would be the largest crude oil pipeline to cross the Missouri and Yellowstone Rivers in Montana.

The publicly available Final SEIS (2014) does not include estimates of the maximum pipeline spill volumes for the Missouri or Yellowstone River crossings. In the publicly available version, worst case spill volumes were calculated for response scenarios for pump stations in Canada and pipelines in North Dakota, South Dakota, Kansas, Missouri, Illinois and the Cushing Extension.

I. Reference Standard Matrix

The previous information was provided to show the various federal and State requirements for pipeline construction and leak detection that must be met by the proposed Keystone XL and any similar, planned oil pipelines. The following table shows the various standards that must be met for river crossings by pipelines carrying oil. Federal regulating code Title 49 CFR Part 195 incorporates an extensive list of standards that have the full force of law (Regulations, 2017) and regulate construction standards for proposed Keystone XL river crossings. Reference standards (including 49 CFR 195) are listed in **Table 2** below along with other standards that apply to pipeline river crossing construction. As designed, Keystone XL meets or exceeds applicable industry standards and regulations as detailed below, numerous older pipeline river crossings do not as the technology or standards did not exist at the time of their construction.

Table 2: 49 CFR 195 Incorporated Standards

#	Reference Standard	Reference Standard Description	Applicable to River Crossing Construction	Falls Short of Industry Standards	Meets Industry Standards
1	49 CFR 195	Transportation of Hazardous Liquids by Pipeline	✔		✔
2	API PUBL 2026	Safe Access/ Egress Involving Floating Roofs of Storage Tanks in Petroleum Service		N/A	N/A
3	API 5L1	Recommended Practice for Railroad Transportation of Line Pipe	✔		✔
4	API 5LT	Recommended Practice for Truck Transportation of Line Pipe	✔		✔

#	Reference Standard	Reference Standard Description	Applicable to River Crossing Construction	Falls Short of Industry Standards	Meets Industry Standards
5	API RP 5LW	Recommended Practice Transportation of Line Pipe on Barges and Marine Vessels		N/A	N/A
6	API RP 651	Cathodic Protection of Aboveground Petroleum Storage Tanks		N/A	N/A
7	API RP 652	Linings of Aboveground Petroleum Storage Tank Bottoms		N/A	N/A
8	API RP 1130	Computational Pipeline Monitoring for Liquids: Pipeline Segment	✔		✔
9	API RP 1162	Public Awareness Programs for Pipeline Operators	✔		✔
10	API RP 1165	Recommended Practice for Pipeline SCADA Displays	✔		✔
11	API RP 1168	Pipeline Control Room Management	✔		✔
12	API RP 2003	Protection against Ignitions Arising out of Static, Lightning and Stray Currents	✔		✔
13	API RP 2350	Overfill Protection for Storage Tanks in Petroleum Facilities		N/A	N/A
14	API 5L	Specification for Line Pipe	✔		✔
15	API 6D	Specification for Pipeline Valves	✔		✔
16	API 12F	Specification for Shop Welded Tanks for Storage of Production Liquids		N/A	N/A
17	API 510	Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair and Alteration		N/A	N/A
18	API 620	Design and Construction of Large, Welded, Low-Pressure Storage Tanks		N/A	N/A
19	API 650	Welded Steel Tanks for Oil Storage		N/A	N/A
20	API 653	Tank Inspection, Repair, Alteration and Reconstruction		N/A	N/A
21	API 1104	Welding of Pipelines and Related Facilities	✔		✔
22	API Std 2000	Venting Atmospheric and Low-pressure Storage Tanks		N/A	N/A
23	API Std 2510	Design and Construction of LPG Installations		N/A	N/A
24	ASME/ANSI B16.9	Factory-Made Wrought Buttwelding Fittings	✔		✔
25	ASME/ANSI B31G	Manual for Determining the Remaining Strength of Corroded Pipelines	✔		✔
26	ASME/ANSI B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids	✔		✔

#	Reference Standard	Reference Standard Description	Applicable to River Crossing Construction	Falls Short of Industry Standards	Meets Industry Standards
27	ASME/ANSI B31.8	Gas Transmission and Distribution Piping Systems		N/A	N/A
28	ASME BPVC, Section VIII, Division 1	Rules for Construction of Pressure Vessels		N/A	N/A
29	ASME BPVC, Section VIII, Division 2	Alternate Rules, Rules for Construction of Pressure Vessels		N/A	N/A
30	ASME BPVC, Section IX	Qualification Standard for Welding and Brazing Procedures, Welders, Brazers and Welding and Brazing Operators	✔		✔
31	ASTM A53/A53M-10	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	✔		✔
32	ASTM A106/A106M-10	Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service	✔		✔
33	ASTM A333/A333M-11	Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service	✔		✔
34	ASTM A381-96	Standard Specification for Metal Arc Welded Steel Pipe for Use with High-Pressure Transmission Systems	✔		✔
35	ASTM A671/A671M-10	Standard Specification for Electric-Fusion-Welded Steel Pipe for Atmospheric and Lower Temperatures	✔		✔
36	ASTM A672/A672M-09	Standard Specification for Electric-Fusion-Welded Steel Pipe for High-Pressure Service at Moderate Temperatures	✔		✔
37	ASTM A691/A691M-09	Standard Specification for Carbon and Alloy Steel Pipe, Electric-Fusion-Welded for High-Pressure Service at High Temperatures	✔		✔
38	MSS SP 75	Specification for High-Test, Wrought, Butt-Welding Fittings	✔		✔
39	NACE SP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems	✔		✔
40	NACE SP0502	Pipeline External Corrosion Direct Assessment Methodology	✔		✔
41	NFPA-30	Flammable and Combustible Liquids Code	✔		✔

#	Reference Standard	Reference Standard Description	Applicable to River Crossing Construction	Falls Short of Industry Standards	Meets Industry Standards
42	PR-3-805	Modified Criterion for Evaluating the Remaining Strength of Corroded Pipe	✔		✔

IV. Modeling of Contamination

Modern pipelines are designed and constructed to minimize the likelihood of leaks, and to decrease time for initial leak detection and response. However, the possibility of a spill occurring always exists. Modeling of contaminant transport in the rivers crossed by the pipeline, downstream of proposed crossings, can help characterize impacts from a potential leak. In general, models are used to simulate specific conditions, based on a set of simplifying assumptions, boundary conditions, physical parameters, and modeling objectives. As such, model results approximate potential impacts, rather than providing definitive predictions of impacts. The extent of water quality impacts resulting from an actual pipeline spill depends on the volume of contaminant that enters the environment, along with various environmental/physical factors attributed to the receiving waters.

NewFields performed contaminant transport modeling to evaluate potential impacts resulting from theoretical pipeline spill scenarios on the Missouri and Yellowstone Rivers. A detailed description of the modeling approach and results is provided in the sections below.

All tables, figures and charts referenced in this section (Section IV) of the report are included in **Appendix G**.

A. Introduction

The project area (**Figure G-1**) encompasses surface water supply intakes on the Missouri and Yellowstone Rivers. The project area is bounded to the west by the proposed route of the Keystone XL pipeline ("pipeline"), and the borders with Wyoming to the south, North Dakota to the east, and Canada to the north.

As described above, the pipeline will cross the Yellowstone River about 22 miles upstream of the town of Glendive, Montana. The planned pipeline route crosses the Missouri River about 5 miles downstream of the Fort Peck Dam. The pipeline also crosses multiple tributaries of the Milk River, all of which are upstream of the towns of Glasgow and Nashua, Montana (**Figure G-1**). This section of the pipeline (about 60 miles of the proposed route northwest of Nashua) crosses tributaries to the Milk River that drain south into the Milk. A spill along this section could provide a source of contamination that would drain south into the Milk River, which could then impact the Missouri River downstream of the confluence between the Milk and Missouri Rivers (**Figure G-1**). Aside from this approximate 60-mile section of the Milk, spills from the proposed pipeline would directly impact either the Missouri or Yellowstone Rivers.

B. Objectives

The primary objective of the modeling exercise was to evaluate the fate and transport of contaminants of concern (COCs) resulting from potential spills of crude oil (of the type that would typically be transported by the Keystone XL pipeline). Potential impacts to the Missouri and Yellowstone Rivers downstream of proposed pipeline crossings (Project Area) were simulated to evaluate the extent and duration of potential impacts to the two rivers.

Model results are intended to provide the Montana DNRC with a management tool to help the Department make informed decisions regarding the resilience of municipal surface water supply intakes in the Project Area (**Figure G-2**), and to evaluate the impact of theoretical spill scenarios that could occur at pipeline river crossings.

NewFields completed a desktop review of surface water intakes. The firm then simulated multiple pipeline spill scenarios using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) numerical model and evaluated potential water quality impacts at the Assiniboine and Sioux Rural Water Supply System surface water supply intakes on the Missouri River and the Glendive intake on the Yellowstone River. Simulation results suggest the minimum volume of crude oil that would be required to create a safe drinking water act violation at each intake, in the event of a pipeline spill.

C. Model Development

Fate and transport modeling of COCs was performed using the United States Army Corps of Engineers (USACE) HEC-RAS modeling system. HEC-RAS is a hydraulic modeling system that allows the simulation of flows within surface water bodies either as one-dimensional or two-dimensional transport. HEC-RAS can be used to perform both steady-state and transient flow modeling and can be used to simulate the fate and transport of contaminants downstream of releases of contaminants into surface water.

In this analysis, flows within both the Missouri and Yellowstone Rivers are modeled as one dimensional steady-state flows. The fate and transport of the spilled COCs are modeled as one-time mass injections of the contaminants over a fixed duration of time. Model results help characterize patterns of flow in the river reaches within the model domain under a variety of flow regimes.

A steady-state HEC-RAS contaminant model requires three main inputs: (1) defined river/stream geometry (width, depth, and roughness along stream cross section) along the entire reach of the stream or surface water body being analyzed, (2) stream flow data, and (3) the chemical and physical properties of the COC being modeled. Development of these inputs and specific modeling scenarios is discussed in the following subsections.

River Geometry

The HEC-RAS models used in this study were obtained from various government agencies: the model for the Missouri was supplied by the USACE Omaha District, and the Yellowstone River model was provided by the Montana DNRC. The specific model inputs used by NewFields were cross-sections that defined the geometry and roughness of each river. As described below, NewFields modified the cross-sections prior to use and adapted them for the purposes of this study.

The HEC-RAS model obtained for the Missouri River starts below the Fort Peck Lake dam in Montana (**Figure 3**) and ends in Lake Sakakawea in North Dakota (east of the Project Area). The model obtained from the USACE also contains a portion of the Milk River to the north and the Yellowstone River to the south. Modifications made by NewFields included removing the Milk River and Yellowstone Rivers, and terminating the model at the Montana-North Dakota state line. The Missouri River model was developed as a transient flow version and then was converted by NewFields to steady-state flow.

In the case of the Yellowstone River, two separate HEC-RAS models were obtained. One model domain covers the portion of the Yellowstone River that starts at the Dawson County/Prairie County boundary and flows to the northeast, through Dawson County. The other section starts at the Dawson County/Richland County boundary and runs through Richland County, to the North

Dakota border. Modifications included combining the geometries from the two versions to create a single model for the entire section of interest of the Yellowstone River.

The modified and adapted geometries for the Missouri and Yellowstone Rivers were used as the basis for modeling of impacts to the two rivers resulting from a potential oil spill from the proposed Keystone XL pipeline.

Flow Parameters

Flow parameters used in the two HEC-RAS models were derived from long-term stream flow records obtained from the United States Geological Survey (USGS). In the case of the Missouri River, flow data were obtained from USGS Station 06132000 (Missouri River below Fort Peck Dam MT). Flow data for the Yellowstone River were acquired from USGS Station 06329500 (Yellowstone River near Sidney MT and USGS Station 06327500 Yellowstone River at Glendive, MT). Data from the period 2002 to the present were used to develop flow parameters.

The total distance of transport of any contaminant and its respective rate of dilution during the transport process depends directly on the stream flow/discharge rate. The one-dimensional HEC-RAS model assumes 100 percent mixing of the contaminant from the spill location downstream. To provide a complete analysis of the fate and transport of COCs, three different flow regimes were simulated, and were developed by performing statistical analyses on historical stream flow data. The three flow regimes developed included low-flow (based on the 7Q10 statistic of the data), average-flow (based on the 50th percentile value), and high-flow (based on the 95th percentile value).

During winter months both the Missouri and Yellowstone Rivers experience long periods when they are covered by a layer of ice with an average thickness of 18 inches (Wuebben 1995). This ice cover not only affects their flow regimes but also impacts the rate of volatilization of contaminants from the rivers. Consequently, additional flow regimes (low, average and high) for the winter months were also determined and modeled. These model simulations assume that the spill/contaminants will remain under the ice. The flow parameters for the Missouri and Yellowstone Rivers are provided in **Table 3**.

Table 3: Flow Parameters for Steady-State Modeling of the Missouri and Yellowstone Rivers

Stream	Period	Discharge (cfs)		
		Low Flow	Average Flow	High Flow
Yellowstone River	All	1,411	7,520	27,320
Yellowstone River	Winter	3524	6,200	9,337
Missouri River	All	3,229	7,000	11,000
Missouri River	Winter	3,775	6,600	11,100

Crude Oil Contaminants of Concern and Spill Quantities

The proposed Keystone XL pipeline would transport a variety of types of crude oils. In their planning document (USDS, 2014), TransCanada provided two representative crude oil formulations that would be transported -- Bakken Light Conventional and Western Canadian Diluted Bitumen, commonly referred to as dilbit. Composition and properties of common volatile

petroleum hydrocarbons in representative crude oils to be transported by the Keystone XL pipeline are summarized below in **Table 4**.

Table 4: Chemical Composition (volatiles only) of Representative Crude Oils

Component	Bakken Light Conventional	Suncor Synthetic A	Western Canadian Blend Diluted Bitumen	Solubility (mg/l)
	Average % by Volume			
Benzene	0.28	0.04	0.16	1800
Toluene	0.92	0.19	0.29	515
Ethylbenzene	0.33	0.13	0.06	152
Xylenes	1.4	0.46	0.29	162-175

Table 4 uses the term “solubility” to express the mixing/dispersion of these non-polar compounds in water, which is highly polar.

An important decision for this study was selecting the compound(s) to model fate and transport. Benzene, being highly toxic lends itself well to human health concerns. On the other hand, Benzene is the *least* persistent in the environment due to its volatility. Therefore, models using Benzene as the COC understate transport distances in river systems *relative to the other compounds in crude oil and dilbit, particularly the Polycyclic Aromatic Hydrocarbons (PAHs), some of which are carcinogens (DEQ, 2019)*.

Most PAHs are regulated under the Clean Water Act (CWA) as priority pollutants rather than the Safe Drinking Water Act (SDWA) due to their low toxicological thresholds on aquatic organisms. However, one PAH, Benzo[a]pyrene, is regulated under the SDWA and has a National Recommended Water Quality Criteria of 0.00000012 mg/l (EPA, 2015). Benzo[a]pyrene has negligible volatility and a greater density than water 1.24 g/cm^3 @ 25°C. This means it would sink in the water column unless the turbulence present in the river was sufficient to suspend it. Unfortunately, modeling the density/turbulence dynamics and fate and transport for Benzo[a]pyrene and other PAhs with ultra-low-level carcinogenic effects was not achievable within the time and budget of this study.

Therefore, among the compounds in Table 4 Benzene is the most volatile (Benzene has a vapor pressure of 14 kPa @ 20^{o}C). This means it will evaporate when river turbulence exposes the dispersed molecules to the air. This becomes an important factor to consider in different seasons, with higher temperatures in the summer increasing volatility, and with winter conditions lowering volatility and limiting exposure to air during ice over.

Benzene is the most toxic of the chemicals in Table 4 to both aquatic organisms and humans. Benzene has a low drinking water standard (or) MCL of 0.005 milligrams per liter (mg/L) (USEPA, 2019). The basis behind the EPA SDWA standard is 70 years exposure by drinking 2.4 liters/day and consuming 22 g of fish from the same waterbody. Contrariwise, a drinking water standard is based on the toxicity of a single compound rather than the cumulative toxicity of ALL compounds comprising crude oil or dilbit.

For these reasons Benzene was selected as the chemical of concern (COC) for modeling spill scenarios where water intakes along the subject rivers may be impacted. While the modeling

performed in this analysis is limited to Benzene due to time and resource limitations, a thorough examination of the behavior of other compounds in Table 4, as well as others not listed *such as PAHs*, would improve understanding of fate and transport that occurs during crude oil or dilbit spills, as well as the resilience of surface water intakes to these events.

NewFields examined the potential for modeling the behavior of dilbit using HEC-RAS, the only model readily available for this analysis. However, the environmental processes and behavior of dilbit in river systems does not lend itself well to fate and transport modeling using HEC-RAS.

Bitumen is produced in the tar sand fields of Alberta and is transported via pipeline as dilbit. Dilbit is a bitumen diluted with one or more lighter petroleum products (diluents) such as naphtha or natural gas condensate. Diluting bitumen makes it possible to transport in pipelines. Per the Alberta Oil Sands Bitumen Valuation Methodology, "Dilbit Blends" means,

> *"Blends made from heavy crudes and/or bitumen and a diluent, usually natural-gas condensate, for the purpose of meeting pipeline viscosity and density specifications, where the density of the diluent included in the blend is less than 800 kilograms per cubic meter (kg/m^3) (CAPP, 2008)."*

If the diluent density is greater than or equal to 800 kg/m3, that diluent is typically synthetic crude and accordingly, the blend is referred to as *synbit* (NEP, 2004).

Bitumen is collected by separating it from the host rock or sand by heating, which reduces its viscosity so that it can flow to a collection point. Once collected, it is mixed with a diluent to reduce its viscosity enough to allow transport in a transmission pipeline. Dilbit is engineered to resemble other crude oils that are transported via pipeline and is processed in the same refineries. The composition of diluted bitumen is dependent on several factors, particularly the diluent or diluents chosen and the diluent-to-bitumen ratio. As a result, diluted bitumen has dimensions of variability significantly exceeding those of crude oil from a given source region.

Modeling Scenarios

The following global assumptions were used for all scenarios to provide a conservative estimate of the spatial extent of contaminant transport within the rivers:

1. The proposed Keystone XL pipeline has been designed to be built about 70 feet below the riverbed at all river crossings. Any spill from the pipeline would have to migrate vertically through the soil into the water column above or originate beyond the HDD section and migrate to a tributary to its confluence with the rivers. This migration would result in part of the oil from the spill being trapped within the soil layer and only a portion would reach the river. However, there was no means to model this "trapping" in the soil layer from a depth of 70 feet. *For this analysis, oil spill volume is that which reaches the river and is transported downstream*. It is understood that a much larger spill would have to occur to achieve the spill volumes modeled at the pipeline crossing.
2. The solubility of petroleum hydrocarbons in water is extremely limited, even that of Benzene. In general, these compounds preferentially stay within the oil with only a small portion dispersing into the rivers. However, *in this analysis it is assumed that all Benzene available in the Western Canadian Diluted* Bitumen *disperses uniformly into the rivers*.
3. *The rivers are assumed to flow under steady-state conditions for all flow regimes modeled.*
4. According to TransCanada, their personnel can react to and shut down any spill within a 12-minute time period from the start of the spill. *In this analysis, all spills were modeled as mass injections with uniform duration of 12 minutes.*
5. It is assumed that *the rate of volatilization of Benzene in the rivers during summer periods results in a half-life of approximately 4.8 hours*. During winter months ice cover is assumed to eliminate the process of volatilization. *During ice over, it is assumed that Benzene biodegrades (rather than volatizes), with a half-life of 16 days*.
6. The analysis assumes that the spill volume is allowed to be transported along the river with no intervention or containment of by responders.
7. The risk of a pipeline spill resulting in SDWA violation at the municipal water intakes was defined as the minimum spill volume that would be required to result in a Benzene concentration exceeding the MCL for benzene (0.005 mg/L).

Each river was modelled for six (6) flow regime scenarios, three (3) flow regimes (low, average, high) for data representing all months and an additional three (3) flow regimes (low, average, high) for the winter months. These scenarios represent approximations of the fate and transport of Benzene in the Missouri and Yellowstone Rivers if a spill occurred during operation of the proposed Keystone XL pipeline.

The HEC-RAS model is not capable of accounting for stranding losses, i.e. losses due to crude oil that becomes trapped on the sides of stream banks and within vegetation and does not transport downstream. To account for stranding loss, a sensitivity analysis was performed. Based on prior studies and NewFields experience, stranding losses account for between 5% to 20 % of the total spill volume. Thus, the sensitivity analysis was performed by reducing the assumed spill volume by 5% and 20% and determining the "stranding loss" concentration of Benzene at the intakes. These stranding loss concentrations were then compared against full spill volume concentrations.

D. Modeling Results

Modeling results are provided in **Appendix G** (**Tables G-1** through **G-6)**

List of Appendix G Tables:

List of Appendix G Figures:

Table G-2 summarizes the two active municipal water intakes in the Project Area (the ASRWSS intake and the City of Glendive intake).

Tables G-3 and **G-4** provide modeling results for the five different spill volumes simulated. **Table G-3** presents the modeling results for the Missouri River and **Table G-4** presents the modeling results for the Yellowstone River.

These tables present the minimum spill volumes above which the model predicts benzene concentration would exceed 0.005 mg/L at the ASRWSS intake on the Missouri and the City of Glendive intake on the Yellowstone. Three different river flow conditions (discussed previously) were simulated, considering both year-round conditions and winter conditions.

Predicted minimum spill volume results for the Missouri River for non-winter and winter conditions show the following observed trends in the model results:

- The minimum spill volume that would result in Benzene concentrations above the MCL at the ASRWSS intake decreases with an increase in stream flow for all months, however, this trend is reversed during winter months, which show an increase in spill volume with an increase in stream flow.
- The observed trend of decreasing spill volume as the river flow increases is due to the decreased travel time (i.e., the elapsed time between the pipeline spill and the arrival of the Benzene concentration at the respective intake). The shorter the travel time, the less opportunity there is for loss of Benzene mass due to volatilization.

In the case of the winter months, the predicted minimum spill volume increases with river flow, this trend is due to increased dispersion that occurs with increased flow velocities. During winter months, dispersion is the dominant mechanism as the thick ice cover limits or eliminates the potential for Benzene Volatilization.

TransCanada reviewed historic spill data obtained from the PHMSA in the United States and found that from January 2002 to July 2012 there have been 1,692 hazardous liquid pipeline incidents reported in the United States. Of these, 1,692 incidents less than 79 percent were classified as small (less than 50 barrels), 17 percent as medium (between 50 barrels to 1,000 barrels) and 4 percent as large (greater than 1,000 barrels). The spill volume required to create a SDWA violation at the ASRWSS intake would have to be characterized as large, using these thresholds.

Results for the Yellowstone River are like those for the Missouri River. However, the minimum spill volumes necessary to exceed the Benzene MCL at the Glendive intake are much smaller due to the shorter distance of the intake from the pipeline crossing on the Yellowstone. A medium or larger spill would create a SDWA violation at the Glendive intake.

The sensitivity analysis reviewed stranding losses up to 20% the spill volume. Sensitivity results (Tables G-5 and G-6) indicate that predicted concentrations at the two intakes are only slightly less than 0.005 mg/L, due to stranding loss.

E. Conclusions of Contamination Modeling

Results of modeling performed by NewFields demonstrate that the impacts to surface water intakes downstream of proposed pipeline crossings vary based on the combination of: 1) characteristics of the spilled product (i.e., spill volume and chemical components); and, 2) characteristics of the receiving river when the release occurs (i.e., flow rate, temperature, ice cover).

Observed trends in simulated Benzene transport results are controlled by the interplay among different model input parameters and the river flow/climatic conditions represented in each respective simulation. For example, river flow rates are higher during winter (ice-over conditions), which results in increased initial dispersion of contaminants. As a consequence, predicted spill volumes that would result in exceedances of the Benzene MCL are lower under winter/ice-over conditions (compared to no-ice conditions).

Many assumptions inherent in the modeling exercise are quite conservative, particularly that all oil released from the pipeline would immediately enter the river. Considering these assumptions and model results, the risk of benzene concentrations exceeding the MCL (0.005 mg/L) from a spill at the HDD river crossing for either of the two river intakes is extremely low. The rigor and preparedness for leaks and spills can further reduce this risk.

V. Disaster Mitigation, Cleanup and Site-Specific Planning Considerations

Impacts from oil spills are influenced by variables such as the weather, time of year, water level, soil, local wildlife, and human activity. The extent of impact will also depend on the response time and capabilities of the emergency response team. Of greatest concern would be spills in environmentally sensitive areas such as wetlands, flowing streams and rivers, shallow groundwater areas, locations near intakes for drinking water treatment plants or commercial/industrial facilities, and areas with populations of sensitive wildlife or plant species.

Industry response to pipeline spills can vary significantly. Response/cleanup efficacy is influenced by many interrelated factors, which include, but are not limited to: environmental conditions, equipment availability/suitability, competency/training of response personnel, spill tracking accuracy and the timing of deployment of countermeasures (Research, 2015).

Current regulations pertaining to oil spill response requirements are summarized below, after which there are discussions of various factors that affect the fate and transport of spilled oil/components. Current and past procedures employed in spill cleanup are included.

A. Current Spill Regulations

The PHMSA, USEPA, and USCG require transmission pipelines to submit spill response plans. The National Academies of Science (The National Academies of Science, 2016) reviewed response plans for a number of pipeline projects, as prepared by different agencies. NAS found that the USEPA and USCG review plans for completeness and adequacy, while PHMSA reviews plans only for their completeness as they pertain to regulatory requirements. NAS also determined that the type of oil transported by a pipeline in most response plans is identified only as "crude oil" -- the specific types and sources of the crude oil or crude additives/diluents transported in the pipeline are typically not identified. Lack of more specific information presents a greater challenge for spill response planning and procedures.

Current regulations do not require pipeline operators to provide information to the public as to the volumes and various types of crude transported via a specific pipeline. The NAS report noted existing regulations and agency practices, but did not consider the unique properties of dilbit, nor did it encourage effective spill planning for dilbit spills (The National Academies of Science, 2016).

Current federal regulations require initial responders to be on site and initiating containment within 6 hours (Stantec, 2017). The sections of the Missouri and Yellowstone Rivers that are downstream of the proposed pipeline crossings are within a 6-hr drive of Billings, Miles City, Havre, and Lewistown, Montana and Williston, North Dakota; as well as other communities located within the study area (Glendive, Sidney, Culbertson, Poplar, Wolf Point, Fort Peck, Circle, Jordan, Glasgow, Nashua). The effectiveness of oil cleanup is dependent on the speed and efficiency of emergency response teams, combined with the environmental setting.

In the Final SEIS, TransCanada outlines types of equipment which will be staged along the planned pipeline route to facilitate response to spills, as follows:

> *Keystone will be required to develop a PSRP for review and approval by PHMSA and an ERP for review by PHMSA for the proposed Project.*
>
> *The specific locations of Keystone's emergency responders and equipment would be determined upon conclusion of the pipeline detailed design and described in*

the PSRP and ERP. Company emergency responders would be placed consistent with industry practice and with applicable regulations, including 49 CFR Parts 194 and 195. The response time to transfer additional resources to a potential leak site would follow an escalating tier system, with initial emergency responders capable of reaching all locations within 6 hours in the event of a spill. Typically, emergency responders would be based in closer proximity to the following areas:

- *Commercially navigable waterways and other water crossings;*
- *Populated and urbanized areas; and*
- *Unusually sensitive areas, including drinking water locations, ecological, historical, and archaeological resources.*

Types of emergency response equipment situated along the pipeline route. Would include pick-up trucks, one-ton trucks and vans; vacuum trucks; work and safety boats; containment boom; skimmers; pumps, hoses, fittings and valves; generators and extension cords; air compressors; floodlights; communications equipment including cell phones, two-way radios and satellite phones; containment tanks and rubber bladders; expendable supplies including absorbent booms and pads; assorted hand and power tools including shovels, manure forks, sledge hammers, rakes, hand saws, wire cutters, cable cutters, bolt cutters, pliers and chain saws; ropes, chains, screw anchors, clevis pins and other boom connection devices; personnel protective equipment (PPE) including rubber gloves, chest and hip waders and airborne contaminant detection equipment; and wind socks, signage, air horns, flashlights, megaphones and fluorescent safety vests (sic).

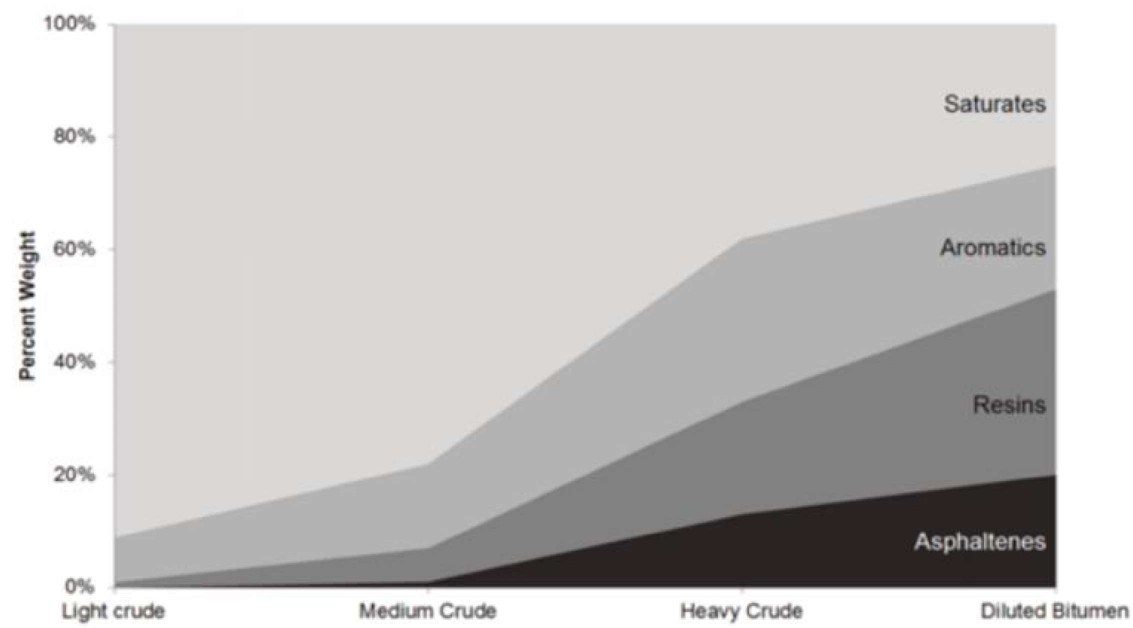
The Oil Pollution Act of 1990 addressed oil spill liability, cleanup and compensation issues. This created the Oil Spill Liability Trust Fund (OSLTF) which provides federal funding for response to and cleanup of oil spills. Funds in the OSLTF can be applied to a variety of oil spills, including dilbit, and can be used for removal costs and monitoring of removal, assessing damage to natural resources and developing and implementation of restoration plans. The OSLTF funds are generated by a per barrel tax on domestic and imported crude oil and petroleum products. In the beginning of 2017, the tax was increased to 9 cents per barrel. However, in 2011 the Internal Revenue Service concluded that crude derived from oil sands or tar sands are not subject to the tax (CRS Oils Spill Liability).

B. Factors Affecting Fate and Transport of Oil in River Systems

Upon release into the environment, spilled oil begins to break down. The physical and chemical changes that occur due to this breakdown (i.e., weathering) affect the transport, deposition, attenuation, and environmental persistence of contaminants. Weathering of spilled oil occurs due to many processes; the type of weathering that occurs has an impact on the fate and transport of the spilled product and its components, as well as affecting required cleanup procedures. Weathering processes are divided into three general categories, based on the nature of chemical and physical effects on the oil. A synopsis of different weathering modes is presented below.

Chemical Weathering Processes

Weathering effects are strongly dependent on the properties of the crude oil released. Due to properties of dilbit, environmental weathering processes affect dilbit differently than they would light or medium crude oils. Mitigation and cleanup for a dilbit spill would differ from that for a more typical crude oil released by a leaking or ruptured pipeline. **Figure 14** indicates components of typical crude oils.



Typical Crude Oil Composition

Project Number: 19918.000

Bartlett & West

January 2019

Exhibit Source: (The National Academies of Science, 2016)

Figure 14: Typical Crude Oil Composition Graph for Various Crude Types (The National Academies of Science, 2016)

According to NAS, dilbit typically is 50 to 70 percent bitumen by volume, with diluents (lighter-weight hydrocarbons) making up the remainder. Added volume of diluents will vary based on density and viscosity specifications specific to the pipeline and its operating conditions. These conditions change based on seasonal variations in pipeline temperature (The National Academies of Science, 2016).

Chemical weathering processes such as photooxidation and biodegradation will alter molecular structures through the cleavage and formation of covalent bonds between atoms within the crude oil components.

Photooxidation

Photooxidation occurs when oil is exposed to sunlight. The oxidation of crude oil occurs more readily within the lighter oil constituents (e.g., light crude and diluents) and with greater solar intensity. Shorter periods of daylight or cloudy days during wintertime would restrict the efficacy of such processes. Photooxidation could lead to the production of persistent molecules which may have higher degree of solubility in water, with the potential to be transported into either surface water or groundwater. The resulting photodegraded oil may be more toxic than the original crude.

Biodegradation

Biodegradation occurs when living organisms, primarily bacteria, degrade hydrocarbons. For these processes to occur, microbial populations must become established and the oil must not be in concentrations that are toxic to the organisms. Light or medium crude typically will not have undergone as much anaerobic degradation prior to extraction, in comparison to dilbit. The resins and asphaltenes in dilbit are minimally impacted by biodegradation.

Physical-Chemical Weathering Processes

Physical-chemical partitioning processes, which include evaporation and dispersion, do not change molecular structure but partition materials, such as between the liquid and gaseous phase. For example, dispersed hydrocarbons released into a river eventually move from the river into the atmosphere as they volatilize.

Evaporation

When volatile compounds are exposed to the atmosphere, evaporation will occur, and is the primary weathering mode affecting concentrations of contaminants in rivers. Light or medium crude spills evaporate readily due to a large portion of the crude being volatile components. Their physical properties (non-polar and lower specific gravity than water) cause them to spread over the top of the water, increasing the surface area of the spill which is susceptible to this process.

With dilbit spills, the diluent is composed of light natural gas condensates or naphtha that evaporate readily when exposed to the atmosphere. The remaining product has properties closer to bitumen, with low viscosity and higher specific gravity than the original dilbit. The increase in specific gravity may be enough to cause the remaining dilbit to sink in the water column. An endpoint for the specific gravity depends on the original bitumen composition, as well as environmental conditions to which the dilbit is exposed. Rates increase with warmer temperatures and persistent wind or wave action. Evaporation generally will reduce the toxicity of the spill but will increase its persistence as the semi-volatile, and finally, nonvolatile compounds remain.

Dissolution

Dissolution occurs when soluble crude oil components form a homogenous mixture with water. Petroleum hydrocarbons are non-polar compounds and water is highly polar, which means that there is little dissolution which occurs in a crude oil or dilbit spill to surface water. Dissolution is a slow process and is enhanced when photooxidation also occurs. Low molecular weight compounds, higher temperatures and increased concentrations of dissolved organic matter increase the rate of dissolution in water bodies. In dilbit, most of the soluble components are the more volatile compounds that make up the diluent. Depending on environmental conditions at the time of the spill, these compounds commonly evaporate rather than dissolve. Dissolution plays a larger role in spills where the crude is spilled in deep water and remains at depth, and in cases where the spill remains beneath an ice cover.

Physical Weathering Processes

The NAS (2016) and Stantec (2017) indicated the mobility of crude oil in waterways is impacted by the environmental conditions at the time of (and following) the spill. Important factors include: wind and air temperature as well as stream velocity, turbulence, and water temperature.

When crude oil contacts water, oil droplet size distribution impacts the environmental weathering. Larger droplets are more buoyant than smaller ones, causing the oil to rise to the surface even when released deep in the water column. The buoyancy behavior of certain crude oil spills also depends to great extent on the presence of medium-to-fine-grained sediments in the water (Canada, 2013).

Droplet size also impacts potential toxicity. Smaller droplets increase the surface area per unit mass of oil released, which increases the amount of oil ***dissolved*** in the receiving waters. Increased viscosity and volume of weathered oil makes cleanup operations more difficult compared to freshly spilled oil (The National Academies of Science, 2016) (Stantec, 2017).

Streams and rivers vary in several ways that are important for the fate and transport of oil released. Key factors include: gradients and velocities of flow; the type and concentration of suspended particulate matter; the types and abundance of underwater algae and plants; the extents and types of zones in which oil may be deposited, such as sedimentation in impoundments and side channels; and variations in flow and water levels. The transport of oil in rivers can also be affected by whether the river is gaining or losing water through exchange with groundwater. Submerged oil carried by streams and rivers can continue to move downstream until it reaches static water bodies or floodplains, where it can be deposited over relatively large areas.

Rivers may transport sediment (and associated crude oil) by wash load, suspended load, and bed load.

Wash load consists of very fine particles that are relatively evenly distributed through the water column, such as in suspended clays and organic matter; it may represent those particles that would interact with spilled diluted bitumen and influence its initial behavior. However, knowledge of bed material composition does not allow accurate prediction of wash load transport.

Suspended load is the portion that remains suspended in the water column but still interacts with the streambed. The interaction usually occurs at riffles, causing the shear stress to increase and sediments to be suspended from the lee side of the ripples.

Bed load has continuous contact with the streambed and is directly influenced by turbulence present along the river bottom. Although suspended and bed load both are commonly predicted using sediment transport models, wash load is not.

Dispersion

Dispersion occurs when oil droplets become entrained in the water; how completely this occurs depends on the tension between oil and water droplets, oil viscosity, and the energy input. Turbulent waters and wind are examples of energy factors which can aid the dispersion process. Also, while turbulence and wind may reduce the visibility of an oil slick, they do not remove non-volatile components of oil from the water. Chemically-induced dispersion may help in cleanup efforts of large volume crude oil spills.

Emulsification

Emulsification is a process that occurs when oil droplets and water droplets become dispersed into each other, forming a stable mixture. The stable mixture can have properties which vary significantly from those of the original oil or the receiving water. Emulsification of oil spills can increase the spill volume and density. The water content is generally 50 to 70 percent, which substantially increases the total volume of the spill/contaminants. Depending on the type of emulsion formed, density can be up to 1,000 times greater than that of the original oil. Stable oil emulsifications slow the rate of evaporation and are challenging to disperse or recover with skimmers. Dilbit has a greater proportion of compounds with heavy molecular weights, such as asphaltenes and resins, compared to light or sweetened crude. Consequently, dilbit emulsifications are more stable and persistent than lighter crude oil emulsions.

Adhesion

When oil clings to surfaces, adhesion occurs, and it can be in evidence at the water-shore interface on tree trunks, rocks, concrete and manmade structures within the waterway. As the light molecular constituents are removed from an oil spill due to environmental weathering, the likelihood for this action increases. Any spill of petroleum product with a large portion of resins and asphaltenes will result in higher rates of adhesion. However, dilbit reverts to initial properties of bitumen more rapidly than traditional heavy crude, resulting in a shorter window for cleanup.

Sedimentation

When oil sinks within a waterbody to the river bed, sedimentation can occur by several routes, including an increase in density of the oil through physical-chemical partitioning or chemical processes. The adhesion of dispersed oil droplets to bed sediments, and formation of oil-particle aggregates (OPAs) can cause the oil to remain submerged (rather than float). There are two major types of OPAs: 1) oil droplets coated by small particles, and 2) oil trapped within or adhering to large particles (Frelichowska, 2002). The first type is more common and has been studied in greater detail. Particulate matter on the surface of oil droplets prevents the drops from coalescing, which can result in spread of the oil throughout the water column.

Turbulence within a river may influence sedimentation rates, determining whether or not particulates will remain in suspension which could allow for downriver migration of spilled product. Sediment bound with oil tends to be persistent and can result in long-lasting shoreline effects in both rivers and static water bodies. Viscous oils, heavy crude or dilbits all tend to form larger oil droplets than less viscous oils (such as light crude), enabling greater sedimentation and requiring more complex subsurface cleanup efforts. An additional concern is that cold water decreases the viscosity of the oil, making it more likely to form solid oil globules containing sediment.

C. Spill Cleanup

Spill cleanup is site specific and depends on many factors including the grade of petroleum released and water temperature of the river. This section briefly describes the primary methods used to contain, capture and remove petroleum from the environment and the potential challenges associated with river cleanup.

Booms, or temporary floating barriers, are often deployed following a spill to contain the oil and limit the spread of contaminants. A hard boom consists of floats with a hard plastic, weighted skirt below the water surface. They are not effective in icy waters or situations where strong wave action is present (SDWF, 2018). Booms are useful in diverting spills away from environmentally sensitive areas and into areas conducive for collection, containment, recovery and treatment.

Sorbents are materials used in cleanup which absorb oil and are often used in conjunction with booms to capture surface oil. These substances are most effective for light oil spills. Removal of sorbents must be done in a manner such that the oil is not introduced back into the waterbody. Sorbent materials can be applied to the water surface as powders to soak up the spilled oil, and commonly include natural organic materials (peat moss or sawdust) or synthetic organic materials (polypropylene, polyester foam or polystyrene). Most often sorbents are applied by hand and recovered using nets and rakes. (SDWF, 2018)

Dispersants are chemicals that are sprayed on a surface oil slick to break down the oil into smaller droplets which can more readily mix with the water. They do not reduce the amount of oil entering the environment but push the effects of the spill underwater. Chemical dispersants contain surfactants which, when applied to the water surface, bind to the oil and allow it to mix more homogeneously within the entire water column. Dispersants can reduce potential contact with water fowl and other organisms found at or near the surface of the water (SDWF, 2018). Such substances are most effective when applied within 1 to 2 hours after the initial spill of oil.

Oil on the surface can be skimmed off with the use of a floating mechanical skimmer that gathers the spilled materials in holding tanks. This process involves the motorized or suction conveyance of the spilled oil into a collection receptacle on the floating equipment. Skimming does not change the physical or chemical properties of the oil. The effectiveness of skimming depends on the type of material spilled, the amount of debris in the water, and weather conditions. Calm, debris-free water conditions are the most favorable for skimming. (SDWF, 2018)

Burning of surface oil is done in limited instances to remove the oil from the water surface. However, incineration of the petroleum product releases nitrogen and sulfur into the atmosphere, which may increase the incidence of acid rain. Burning requires calm water and low or no winds, and is therefore seldom used in response to oil spill events involving rivers (SDWF, 2018).

Removal of oil after it sinks to the bottom of a waterbody is not possible with the methods described above. Other techniques used to collect oil after it sinks, such as vacuum equipment, are typically less efficient and require significant investment of time.

D. Past Spills and Cleanup Efforts

According to the Final SEIS, from January 2002 to July 2012 there were 1,692 hazardous liquid pipeline incidents reported to PHMSA in the United States. **Figure 15** shows the total number of incidents reported to PHMSA and where the failures occurred.

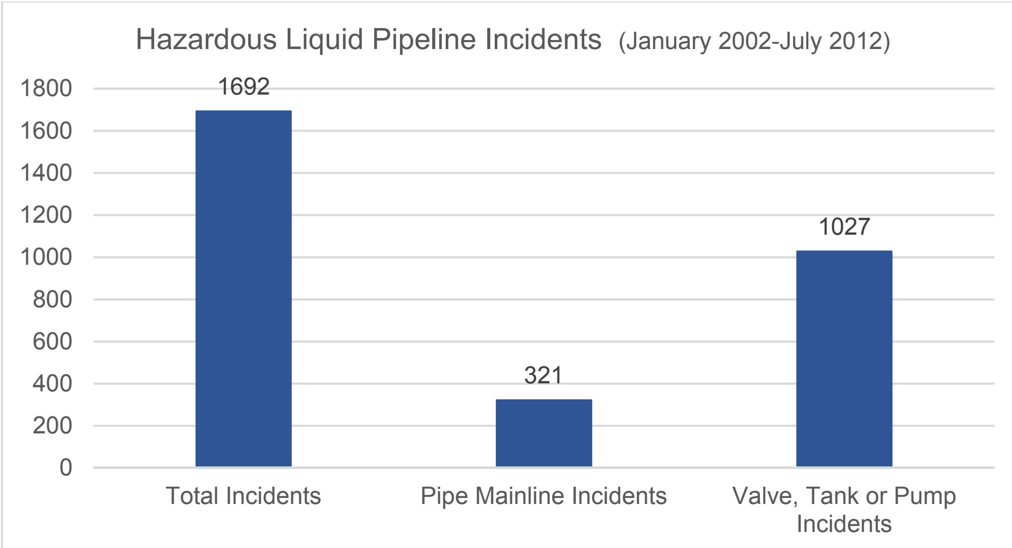


Figure 15: Hazardous Liquid Pipeline Incidents from January 2002 – July 2012; Data from PHMSA (State, January 2014)

Figure 16 illustrates the size classification of the 1,692 spills reported to PHMSA.

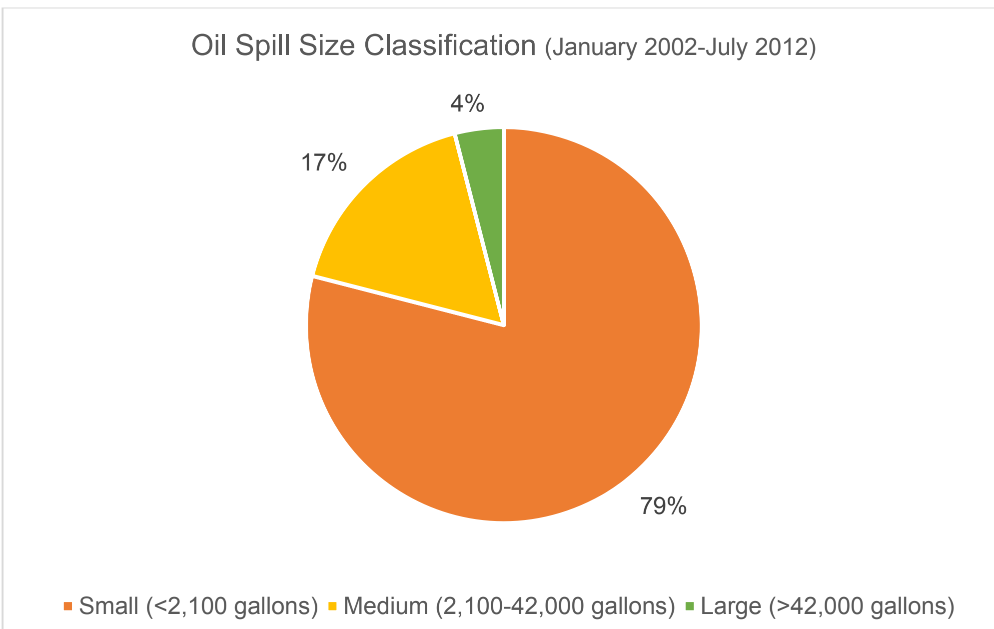


Figure 16: Oil Spill Size Classification of spills occurring between January 2002 – July 2012; Data from PHMSA (State, January 2014))

Common causes of oil pipeline spills include external or internal corrosion, stress corrosion cracking, manufacturing defects, incorrect construction procedures, equipment failure, damage

caused by third-party contractors, incorrect operation and maintenance, and weather-related forces. According to PHMSA, 34.4 percent of spills are due to breaches caused by corrosion.

Examples of past oil spills and resulting cleanup efforts are presented below. Summaries of these incidents are included for potential reference in response to future spills from petroleum product pipelines. Included are incidents that occurred in Montana and/or involved spilled dilbit or heavy crude oil. All oil spills are expensive to clean up, but responses to dilbit releases are expected to cost up to 10 times more than those for light crude, due to longer-term persistence of dilbit released into waterways (Nikiforuk, 2016).

A review of several pipeline spills and the resulting responses are presented below to provide a narrative context relevant to a potential spill from an existing or proposed pipeline.

Bridger Pipeline

The 2015 Bridger Pipeline spill was classified as a medium-sized spill. Documentation provided by the MTDEQ and USEPA pertaining to the Bridger Pipeline spill is provided below.

At about 10:00 AM on January 17, 2015 an operator noticed abnormal pressure readings in the pipeline from the control room in Casper, WY. At 10:30 AM pipeline alarms sounded and at 10:56 AM the pipeline was shut down, making the response time for this spill about 56 minutes. An emergency response team was assembled to initiate the cleanup process. After the pipeline was shut down and the appropriate parties were notified, the spill response contractor installed a boom across the Yellowstone River near Sidney, MT (**Figure 1**). The river was completely frozen over during the time of the spill, which complicated the oil recovery process. Shoreline inventory of the spill was taken using airboats. Slots in the ice were developed and booms inserted to capture the oil.

According to a January 21, 2015 progress update provided by Region 8 USEPA (2015), the following pipeline operation and spill containment/recovery tasks were accomplished:

Pipeline Operations:

- Approximately 240 barrels of crude oil was recovered from the segment of the pipeline between the block valves at the Yellowstone River crossing.
- The response team was able to push the remaining crude oil to one end of the pipeline, where it was removed with vacuum trucks.
- The location of the leak was identified by pressurizing the pipeline with nitrogen and observing the areas of surfacing bubbles. The leak was found roughly 50 feet from the south bank of the Yellowstone River.
- The pipeline was tapped and flanged on each end to minimize any additional leakage.

Oil Spill Containment and Recovery Operations:

- Ice slotting operations in the river were used to help identify and recover oil between the spill site and Glendive, Montana.
- Reconnaissance crews examined the same segment of the river to locate and access pockets of oil trapped beneath the ice.
- Crews maintained a final containment recovery site approximately 30 to 40 miles downstream of the spill near Crane, Montana. This site, which became the last line of

containment, consisted of a series of ice slots that crews maintained to prevent contaminants from moving any further downstream.

Flyovers were performed to identify sheen in open water areas, as well as to locate ways to access pockets of oil trapped beneath the ice. Recovery efforts were slowed by warmer weather that resulted in unsafe ice conditions on the river. By January 24, 2015, about 5,800 gallons had been recovered from the pipeline and stored in holding tanks. About 2,000 gallons were recovered from the river. An additional 30,000 gallons (estimated) which entered the river were not recovered.

Air quality monitoring for Benzene, VOCs and other compounds associated with crude oil was performed continuously from January 18th to January 24th. No, air quality impacts were observed. Based on a review of the cleanup effort for the Bridger Pipeline spill, the following strengths and areas of need for improvement were identified (Environmental Protection Agency , n.d.) (MT Department of Environmental Quality, 2015).

Strengths:

- Technical data sharing between agencies;
- Knowledge of public water supply treatment and distribution systems;
- Building public trust; and,
- The understanding of the incident command system.

Areas of need for improvement:

- Formalizing logistics and administrative support emergency procedures;
- Developing standard templates and checklists for program coordination;
- Assisting local government with clear communications and rapid messaging; and,
- Planning and sampling focused on worst-case environmental impacts.

After the spill, Dawson County received complaints regarding the taste and odor of the City of Glendive's drinking water. The water was tested and registered elevated levels of Benzene. The water treatment plant increased the dosing of activated carbon in order to reduce the Benzene levels. The distribution lines were flushed through fire hydrants and water samples taken to test for presence of Benzene were collected as part of ongoing monitoring. The City recommended use of bottled water for drinking and cooking. Bottled water was then used from January 18th until January 23rd. As of the latter date Montana DEQ determined that the quality of the water produced at the Glendive WTP rendered it safe for human consumption (MT Department of Environmental Quality, 2015).

Initially, sampling and laboratory testing of the river water took place 1 to 2 times per day. Contaminants quantified by the lab included metals and VOCs, and pH of the water was negatively affected. Samples were collected from the water surface and at deeper points in the water column using standard sampling procedures and equipment. Groundwater wells along the river were also sampled.

Lessons learned from the Bridger spill included: 1) adequate background samples of surface water and groundwater must be collected/analyzed in order to determine if results from samples collected during/after a spill indicate water quality impacts have occurred. For example, when samples were taken in the summer following the Bridger spill, there was no way to determine if

the elevated pH levels were a result of the pipeline spill or if they were caused by seasonal increases in watercraft usage in the area (DEQ, Bridger Pipeline Water Sampling, 2018).

Silvertip Pipeline

The Silvertip Pipeline spill was classified as a medium-sized spill. According to the USEPA, at about 11:30 PM on Friday July 1, 2011, a break occurred in a 12-inch pipeline in a location about 20 miles upstream of Billings, MT on the Yellowstone River. The spill released 750 to 1,000 barrels (31,500 to 42,000 gallons) of oil into the river. The damaged pipeline was in a 14-mile section between two pump stations. The spill was identified when a low-pressure alarm at a pump station sounded via the SCADA system. The pipeline was shut down about 7 minutes after the initial alarm sounded (Environmental Protection Agency, n.d.).

Following the spill, Arcadis completed a summary of assessment and cleanup activities. The downstream area was divided into eight sections for cleanup purposes. The shoreline cleanup assessment technique (SCAT) teams had to receive permission to access the river by contacting landowners and trustees. Segments were classified into zones based on oiling conditions observed by SCAT teams. The recommended cleanup technique for each specific segment was determined based on the oiling zone category. Small operations teams accompanied the SCAT teams during the assessment activities and the operations teams performed the cleanup procedures. Treatment methods employed to clean up the site/segments included:

- Cutting of vegetation/shrubs along shorelines;
- Removal of dead oily vegetation, small oily debris, large woody debris and soil sediment;
- Removal of oily debris using heavy equipment;
- Treatment with dust fixative; and,
- Use of light mechanical equipment in the riparian zone.
- Natural attenuation;

Oil-contaminated vegetation and debris were removed from the zones after placement in trash bags. Equipment that was used in oil removal activities included Bobcats, wood chippers, utility terrain vehicles, boats, hand tools, helicopters, weed whackers, brush cutters, chain saws and mini-excavators. Certain sections of the shoreline identified by the SCAT team review determined that oil removal activities would pose more harm to the environment, so no removal was taken in those sections (Arcadis, 2011).

Enbridge Pipeline

July 25, 2010 was the largest dilbit spill in a waterway in the United States. The spill, which was classified as a large incident, was the result of a break in the 30-inch diameter Enbridge Line 6B pipeline. This spill released an estimated 843,000 gallons (20,070 barrels) of dilbit into Talmadge Creek, a tributary to the Kalamazoo River in Michigan (The National Academies of Science, 2016).

Following the spill, the USEPA, as the Federal On-Scene Coordinator (FOSC), completed a report documenting the spill response. The discharge was reported about 17 hours after the start of the release, and cleanup efforts began on July 26th. Enbridge isolated the break in the pipeline by closing the nearest upstream and downstream block valves. Due to the break occurring outside of the river channel, it was possible to expose the leaking pipe area for repair. Dewatering was done by placing a trench box around the pipe area and dewatering from inside the trench box. It

was determined that the spill occurred due to a failed pipe joint. The joint was removed and shipped to the National Transportation Safety Board laboratory for additional analysis.

On July 29, 2010, the public health department issued a precautionary drinking water advisory to residents with wells within 200 feet of the river. The advisory was lifted November 8, 2010. With owner-granted access, wells within 200 feet of the 100-year floodplain were routinely sampled for oil-related and non-oil related chemicals, to evaluate the potential impacts of the spill. Via five monitoring wells at each location, groundwater near the wellfield for the City of Kalamazoo, MI and the wells that serve the Village of Augusta, MI were sampled. The State of Michigan Department of Agriculture (MDA) and the county health departments in the affected counties either advised against or banned the use of surface water for irrigation and livestock watering from the time of the spill until April 2012.

According to the USEPA, Enbridge identified the spilled oil as a mixture of heavy crude oil including bitumen blended with diluents, but only after the pipeline had been repaired and restarted. Cleanup efforts involved nearly 2,500 initial responders, with the spill cleanup divided into 5 planning and operational sections. When the first cleanup responders arrived at the spill site, surface water was not visible under the layer of oil, and flight observation of the spill indicated that oil was present bank-to-bank in Talmadge Creek and on the Kalamazoo River. Enbridge was not familiar with local response resources and was mobilizing contractors from Minnesota, because they did not have adequate on-site resources available (USEPA, 2016).

NAS included information on the Enbridge spill and associated cleanup as part of their report on dilbit from pipelines. The cost for the Kalamazoo spill remediation was about $1.2 billion and took over 4 years to complete. Spilled oil flowed down the tributary to the confluence of the Kalamazoo River impacting 40 miles of stream and river channel. The floodplain also was impacted by the spill due to the river being at flood stage when the spill occurred. Due to a low elevation gradient, river turbulence is limited, and the river’s sediment load is minimal.

The USEPA led the emergency response under the National Contingency Plan. They worked with Enbridge and federal, state and local government agencies. The USEPA remained involved in the cleanup through 2014. The Michigan Department of Environmental Quality was involved in the cleanup in 2015. Initial efforts focused on traditional oil spill cleanup methods (conventional and sorbent booms and skimmers) to capture floating oil and oil deposited on land. After about 2 weeks the oil began to sink to the bottom of the river, and recovery of submerged oil became the focus of cleanup efforts (The National Academies of Science, 2016).

The USEPA noted that submerged oil collected in oxbows and behind manmade dams, in areas where the river flow rate was minimal. Manmade dams restricted downriver flow of oil. The Ceresco Dam and the Battle Creek Dam on the Kalamazoo River acted as hydraulic barriers, slowing oil migration downstream and providing target locations for oil recovery activities. Booms and multiple vacuum tankers were used to collect surface oil and water where the heavy oil accumulated. Downriver oil spread was stopped at the Morrow Dam. Islands and sandbars within the river channel were also areas where submerged oil was *preferentially* deposited. A variety of structures were placed in the river in an attempt to contain submerged oil through deposition, as was observed with natural structures. Items placed in the river by the cleanup team included:

- Air curtains to push oil entrained in the water column to the surface;
- Underflow dams and hay bale structures;

- An in-situ stream sediment basin, upstream of Talmadge Creek and the Kalamazoo River confluence;
- Surface boom with sediment curtain at the confluence of Talmadge Creek and the Kalamazoo River;
- Gabion basket structures containing sorbent snare booms at two locations across portions of the river to contain suspended sediment containing oil and submerged oil;
- Surface containment with silt curtain installed at numerous control points along the Kalamazoo River; and,
- Surface boom with X-Tex® sediment curtain (oleophilic synthetic filtering material designed to sorb oil while allowing water to pass through) placed between the Morrow Lake Delta and Morrow Lake.

The use of gabion baskets filled with sorbent boom was found to be relatively effective according to the USEPA. The placement of the gabion structures influenced their effectiveness. In areas with velocities less than 1 foot per second the gabions were the most effective. Areas with greater velocities experienced significant bed scour with resultant capturing of less oil than in areas with lower velocities. It also was found that closed loop snare booms were the best type of boom to place in the gabions. The submerged oil cleanup effort led to a determination that sediment curtains made with X-Tex® material were more effective in absorbing submerged oil than traditional sediment curtains. Low river velocities were found early on to be an important factor in the capture of submerged oil by sediment curtains. In 2013 and 2014 (3 and 4 years following the spill) cleanup crews used half-curtain deployment techniques, which allowed for installation and capture of submerged oil in higher flow areas than previously experienced. The response to the Kalamazoo spill resulted in innovative efforts in cleanup techniques (USEPA, 2016).

Note: X-Tex® was the material, made of recycled polymer fibers, that was used by the USEPA for spill cleanup. This material is effective at removing oil, oil sheen and sediment from water due to its properties of being non-polar, lipophilic, and hydrophilic. The USEPA noted that similar materials may be as effective as X-Tex®, but none were tested during the Enbridge spill response.

Following cleanup, the USEPA noted challenges in determining the location and amount of sunken oil to be removed. Localities of sunken oil were determined by disturbing river sediment and observing the amount of oil sheen and floating globules to estimate the amount of sunken oil. In some areas chemical fingerprinting, which is an expensive set of measurements, was utilized to determine that the sheen was from oil released from the pipeline rather than from other sources. Dredging was the only proven technique for recovery of sunken oil at the time recovery efforts began. Multiple pilot tests were conducted in the field to explore additional methods for recovery. The following submerged oil liberation and recovery techniques were identified (USEPA, 2016):

- Hydraulic Flushing: Pressurized river water was used to agitate shallow sediment so that oil could be recovered at the water surface.
- Aeration: Pressurized air was injected into shallow sediment so that oil could be recovered at the water surface.
- Manual Agitation: River sediment was agitated using manual methods, such as raking, so that oil could be recovered at the water surface.
- Dredging: Sediment containing submerged oil was mechanically removed.

Many of the above methods involved having individuals stand in the waterway to improve efficacy of the procedures. River conditions at the time made this possible. In certain sensitive areas of

the river, sunken oil was left in place and monitored rather than disturbing the waterway. The USEPA estimated that up to 80,000 gallons of oil released into the river were not recovered. It is possible that a significant portion of this total volume of oil remains in the river, bound to sediments. Water and sediment removed from the river required storage and decontamination, or disposal at appropriate facilities. Toxicity studies performed shortly after the spill indicated evidence of toxic effects on lotic biota. (The National Academies of Science, 2016)

The cleanup and monitoring performed following the Enbridge oil spill led to a better understanding of the fate and transport of spilled dilbit in the environment. The cleanup effort also provided evidence of which remediation techniques were most effective for removing submerged and sunken oil. Spill containment and cleanup efforts led to the development of a multifaceted approach to cleanup. Six main techniques were used to determine the appropriate action for given locations (USEPA, 2016):

- Geomorphic mapping;
- Field assessments of submerged oil (poling);
- Systematic tracking and mapping of oil sheen;
- Hydrodynamic and sediment transport modeling;
- Forensic oil chemistry; and,
- Net Environmental Benefit Analysis.

Response to the Enbridge spill underscored the importance of several factors which governed the success or failure of aspects of the cleanup:

- Knowing what is being transported in the pipeline;
- Timely spill detection;
- Quick response to the spill and stopping of the pipeline oil leak; and,
- Having appropriately-trained response individuals available in the right place, at the right time.

Communication with the public regarding health concerns was important throughout spill response and cleanup process. This included implementation of a multifaceted safety program with collective buy-in from involved parties, crucial for the minimization of number and severity of incidents.

E. Site-Specific Planning

As presented in the Final SEIS, site-specific planning pertains to mitigating and addressing potential oil spills from the proposed Keystone XL pipeline. A brief synopsis is provided below.

According to the Final SEIS, the existing Keystone Mainline ERP will be used as a template for the current project. Federal, state and local authorities will be involved with the Keystone XL ERP. Under provisions of the Clean Water Act, the Oil Pollution Prevention Regulation requires that pipeline facilities develop a Spill Prevention, Control and Countermeasure (SPCC) Plan.

The Final SEIS indicates that TransCanada has agreed to implement 84 additional mitigation measures recommended by PHMSA, Battelle and Exponent® risk reports. Specific mitigation measures, intended to reduce the likelihood of a spill occurrence, are included in Appendix Z of the Final SEIS. A partial list of construction and operation topics related to mitigation measures follows:

- Steel pipe manufacturing, material properties, pipe fracture, quality control, transportation effects, pipe coating, fittings and pipeline welding;
- Construction monitoring by a third-party inspection company;
- Pipeline operating temperature and pressure limitations;
- Pipeline bury depth, construction and testing prior to being placed into service;
- Internal and external pipeline corrosion control;
- SCADA system usage and operation;
- Pipeline marking and ROW patrol;
- Immediate notification of incidents and annual pipeline reporting to PHMSA;
- Pipeline inspection frequency, methodology and leak detection methods;
- Revisions to the Facility Response Plan (FRP) and associated documents with new technologies or knowledge;
- Integrity Management Plan (IMP) to consider new leak prevention and detection methods;
- Decreased incident response time;
- Validation of *stated valve close times*;
- Increased scheduled maintenance;
- Incorporation of additional information in the PHMSA-required risk analysis;
- Additional planning and operations information specific to dilbit;
- Items to include in the ERP:
    - Long term sampling/monitoring following a spill
    - Plans to remediate cold weather processed, floating and submerged oil
    - Response equipment locations
    - *Emergency response* drills to address a spill
    - Work in conjunction with local emergency response groups during development
- Contingency plan if drinking water is contaminated:
    - Be responsible for providing alternative water source of comparable volume and quality or provide compensation for such
- Contingency plan if industrial or irrigation water is contaminated:
    - Be responsible for either providing an alternative water source or compensation

While the Final SEIS indicates TransCanada will implement the recommendations noted above, many of the items pertain to documents that are not available for the Keystone XL pipeline (ERP, FRP and IMP) and the enforcement of compliance with these measures is also not clear.

In the event of a spill occurring from the proposed Keystone XL pipeline, TransCanada will first contact local emergency responders and then contact state and federal agencies. According to the Keystone Mainline ERP, all response personnel must complete associated TransCanada and Occupational Safety and Health Administration (OSHA) training regarding spill response. Communication equipment used during a spill response includes radios, landlines and cell phones. The following is a list of guidelines included as stated in the Final SEIS:

- Any concern regarding health or safety issues should be immediately addressed;
- The first responder must consider the spill site as dangerous and the local atmosphere explosive until air monitoring procedures prove that the area is safe;
- The first responder must exit the area against or across the wind, if possible and must also evacuate others who are working in the area;

- All injuries, no matter how minor, must be reported to the Incident Commander in a timely manner; and,
- Prior to entering a spill area, a qualified person must perform an initial safety and health evaluation of the site.

In the event of a spill, *Material* Safety Data Sheets (*MSDS*) of the product being transported must be immediately provided to first responders. Responders must classify the spill as instructed in the pipeline ERP. Classifications include minor, serious, major, or critical. The classifications are based on potential impacts to environment and public safety. The following items stated in the Final SEIS are actions to be taken after a spill to minimize negative impact:

- Take appropriate personal protective measures;
- Secure the site;
- Call for medical assistance if an injury has occurred;
- Notify the Oil Control Center and area management of the incident;
- Eliminate possible sources of ignition in the near vicinity of the spill;
- Take necessary fire response actions by trained staff and responding fire departments;
- Advise personnel or public in the area of any potential threat and/or initiate evacuation procedure;
- Identify/isolate the source and minimize the loss of product;
- Restrict access to the spill site and adjacent area as the situation demands;
- Take additional steps necessary to minimize any threat to health and safety; and,
- Verify the type of product and quantity released if MSDS are available.

TransCanada has stated the ERP for the Keystone XL will incorporate lessons learned from the Enbridge Pipeline spill in Marshall, MI. One of the lessons learned from the Enbridge spill is that sufficient manpower for cleanup responses is critical to reducing cleanup time and negative impacts of the spill. Additionally, the response to the Enbridge spill made it clear that cleanup teams need to be trained in the containment and removal of suspended, submerged and floating oil in rivers, including swift-water environments.

The Keystone Mainline ERP includes information on equipment trailers that are stored at response stations along the pipeline. Similar trailers could be utilized along the course of the proposed Keystone XL pipeline. These trailers would store equipment to be used in the event of a spill. TransCanada has contracts with oil spill removal companies that maintain the equipment according to TransCanada specifications.

As indicated in **Figure 17**, each trailer is equipped with 500 feet of river boom. The perpendicular river width at the Missouri River crossing is greater than 1,000 feet; it is about 500 feet at the Yellowstone River crossing. Due to the Keystone XL project's specific ERP not being complete, it is not currently known whether response equipment trailers will be stored at or near the Yellowstone and Missouri River crossings.

COMPANY OWNED RESPONSE EQUIPMENT	
5 SPILL RESPONSE TRAILERS (ONE PER RESPONSE ZONE)	
Description	**Quantity**
Response boat 18.5 foot work boat with a 60 HP outboard	1
Jon boat 14 foot Safety boat with a 9.9 hp	1
34 ft Equipment trailer with 6 ft office includes equipment shelving, heat lights, power awning, rear ramp door and 1 side door. Roof rack for storage of the 14' boat and 500ft boom.	1
River Boom 6" x 6'	500 ft
Portable dam 50 ft	1
Diesel /hydraulic Skimming System with diesel power transfer pump and hoses	1
Sorbent pads	5 bales
Sorbent boom	5 bales
500 gallon portable tank	1
2,000 gallon portable tank	1
10,000 gallon portable bladder	1
Winter equipment(e.g. Chain saws, chains, pry bars, ropes,ice,augers)	varies
Bird Hazing Kit	1
20' boom Trailer	1

Spill Response Equipment

Project Number: 19918.000

Bartlett & West

January 2019

Exhibit Source: (State, January 2014)

Figure 17: Spill Response Equipment

Even when numerous precautions are taken to decrease the possible impacts of an oil spill on a waterway, significant potential for impacting downstream water users exists. For the benefit and protection of existing drinking water systems using the Yellowstone and Missouri Rivers as a water source, the types and scope of such impacts need to be addressed.

F. Community Economic and Local Infrastructure Impacts

Because of the critical nature of water use in communities including domestic, industrial and agricultural uses, events which involve such water resources can have broad-ranging impacts. The size and extent of these impacts will vary widely based on proximity, time of year, duration, type of event, and other factors. Potential impacts to surface water diversions on the Missouri and Yellowstone Rivers, and the communities that rely on them, from flooding, drought, and oil spills, are discussed below.

Flooding

Typically, floods are short-term events that may require actions such as the construction of temporary dikes and the use of pumps to prevent inundation of infrastructure. Flood events are somewhat predictable based on factors such as snow pack, weather forecasts, and year-to-date precipitation accumulations. Planning for flood events affords a forward orientation for response by organizing actions and resources in an effort to minimize adverse impacts.

Drought

By definition, drought occurs over extended periods of time and may last for months or years. Longer-term drought events can create the need for communities to find alternative water sources and build new infrastructure. Because of their extended duration, preplanning for droughts can be very effective in minimizing impacts, particularly if plans for potential alternate water supply sources have been identified ahead of time.

Communities' response to drought conditions often includes implementation of new or revised water conservation measures. Extent and length of the drought conditions may directly affect the duration and severity of these measures, potentially impacting a broad range of activities. Reduction or elimination of some residential, recreational and commercial activities may be employed as countermeasures. Significant impacts to rural communities from drought often coincide with reduced agricultural production. Reduced income resulting from decreased crop yields can impact both the tax base and local spending in affected communities.

Oil spills

Generally, oil spills are short-term events with varying degrees of impact based on location and spill volume. Spills may pass by a system with little to no impact to diversion intakes. In other instances, adverse effects may require significant, long-term rehabilitation and/or construction of new infrastructure. The effects on a community and its economy will depend on the degree to which a spill impacts the potable, commercial, and irrigation water supplies. Unlike flooding and drought, costs associated with cleanup and mitigation are largely borne by the oil pipeline owner/operator and not the local communities. Because quick reaction times are critical to these events when they occur, the development of an ERP and considerations of water supply alternatives are crucial to successful mitigation of the effects of spills.

Economic impacts of oil spills can range from thousands to millions to perhaps billions of dollars and often depend on the degree to which they impact commercial, industrial, and agricultural water use. A critical factor in impacts on a community is the risk to human health associated with using contaminated water and/or the temporary lack of access to potable water. Hospitals and certain other medical clinics would be of particular concern due to their being at-risk for low water supplies from drought or poor water quality caused by floods or oil spills. These entities need to be identified by the owners and operators of their respective water supply systems and would advisably be among the highest priority users for the development of specific portions of ERPs.

Most communities lack sufficient reserve funds to deal with emergency situations and will likely try to rely on outside funding to assist with prevention and/or recovery efforts. Development of emergency response and contingency plans well in advance of disruptive events will help minimize the impacts and costs, if and when such disasters do take place.

Irrigation Impacts Potential impacts to agricultural resources from contaminants entering irrigation systems can also have far-reaching effects on communities. Irrigators typically have limited

options for developing alternate water supply sources because they often require large volumes of water for their operations.

Because irrigation in Montana is not year-round activity, adverse impact events may occur either outside of, or during only a portion of, the irrigation season. Options available to irrigators during a drought event are limited but could include the use of storage reservoirs or groundwater sources. Development of these alternate sources would be subject to the State water right process.

The impacts from flooding are typically limited to farmland that is close enough to a river or stream to be affected by the river overtopping its banks and inundating the floodplain. For oil spills that occur during the irrigation season, irrigation activities must cease until the petroleum product no longer poses a threat and impacted infrastructure is cleaned. For events lasting more than a few days, response options would be similar for those employed during a drought and include supplemental storage or groundwater use. Overall impact may affect crop yields and farm-based income. Potential impacts from flooding, drought and oil spills may also be affected by the type of irrigation system used.

VI. Drinking Water Alternatives

For community water systems with surface water intakes that do not have an adequate alternative water source, the Final SEIS assumed a 5-mile buffer radius around these intakes. Various buffer zone sizes were assumed for groundwater sources, defined by the PHMSA as Unusually Sensitive Areas. The proposed Keystone XL pipeline route was selected to avoid these buffer zones. Contaminants released into surface water or groundwater could, however, be transported into defined buffer areas from sources located outside of them.

The Site-Specific Risk Assessment analyzed a range of downstream transport distances based on a variety of Missouri River flow rates (Stantec, 2017). This analysis allowed for transport of spilled oil to occur for 6 hours based on the maximum allowable federal pipeline safety regulation, 49 CFR 194, for response time. In the 6-hour transport time it was predicted that oil would travel between 6.5 miles and 33.3 miles downstream, depending on assumed river flow rates and velocities of between 1.6 and 8.1 feet per second. The maximum estimated river flow velocity was based on data collected during a 2011 flood event (Stantec, 2017).

A Site-Specific Risk Assessment was not available for the Yellowstone River at the time of completion of this report; it is unknown whether one has been completed by TransCanada.

To address the possibility of an oil spill impacting drinking water supplies, changes to existing intake locations, intake structures and other system infrastructure were considered and analyzed. Potential changes to drinking water facilities are discussed below.

A. Surface Water Facilities

Surface water is and will remain a valuable source of drinking water throughout the Missouri and Yellowstone River basins. Oil spills upstream of existing intakes would impact these systems. In the event any of these intakes is impacted by an oil spill, alternative water supplies or and/or systems would likely be required. An alternative available to all system operators would be the installation of a new raw water pipeline and a new surface water intake located upstream of the potential contamination source. Although there may be numerous tributary streams near the current intakes on the Missouri and Yellowstone Rivers, most tributary streams would not provide adequate year-round water flow/volume to serve current demands.

Assiniboine and Sioux Rural Water Supply System and Dry Prairie Rural Water System

Depending on the extent of downstream oil migration, use of Culbertson's intake could occur. Considerable challenges would be associated with reinitialization of the intake if scheduled maintenance has not been performed on the infrastructure during the period of inactivity. This option also would require construction of a new raw water pipeline from the Culbertson intake to the ASRWSS treatment facility. Installation of about 52.2 miles of 30-inch pipe would be required, at an estimated cost of $39 million. The current pumps may not be capable of producing the 12 mgd (future anticipated facility flow) needed for the ASRWSS.

Due to the challenges associated with using the Culbertson facilities as part of an alternative supply, this option was not explored further as a long-term option for the ASRWSS, if an oil spill were to impact the system's intake.

To minimize the likelihood of the ASRWSS raw water intake being impacted by a crude oil spill from the proposed Keystone XL pipeline, the potential for relocating the water source intake was

considered. A possible area for a replacement intake on the Missouri River for the ASRWSS was identified based on some basic criteria. It was assumed that a replacement intake would need to be located upstream of the proposed Keystone XL pipeline crossing alignment, upstream of the confluence between the Missouri and Milk Rivers and the Fort Peck Dam spillway. An alternative intake location could be developed below the Fort Peck Dam in the dredge cuts. This area is currently used by City of Glasgow, MT (**Figure 2**) as a raw water intake source. Water rights would need to be evaluated to determine if current water right claims, permits or reservations would apply to a point of diversion installed in the dredge cut area. Alternate intake locations are not proposed for installation in the Fort Peck Reservoir due to additional infrastructure and permitting requirements. If a new intake for the ASRWSS were to be constructed, it is recommended that further study be completed to identify the best overall location.

Relocation of the ASRWSS intake to a point upstream of the proposed Keystone XL pipeline crossing would require construction of approximately 45 miles of new 30-inch pipeline. **Figure 18** shows a preliminary pipeline route and potential intake sites. The small portion of the Missouri River downstream of the Fort Peck Dam and upstream of the emergency spillway would provide protection for the intake during times of spillway release. The preliminary routes shown on **Figure 18** were chosen to parallel Montana Highway 2, because the terrain appears suitable for pipeline construction and would provide easy access for construction and maintenance. The pipeline alignment would require obtaining right-of-way access from both public and private entities.

The ASRWSS WTP currently produces on average 3 mgd to serve all of ASRWSS and DPRWS users. At full build out, the facility will be capable of processing 12 mgd. Any proposed pipeline supplying the 12 mgd would need to be 30-inch diameter with a minimum pressure class of 160 pounds per square inch (psi). The intake style for the above proposed site could be drilled angle wells, sloped tubes, or a vertical caisson with a horizontal intake and vertical turbine pumps. The type of intake selected would depend largely on the topography and the soil characteristics at the proposed site, which are not evaluated in this report.

Estimated cost of the intake relocation is presented in **Table 5**. Depending on the location chosen, the construction costs could range between $67.5 to $74.0 million.

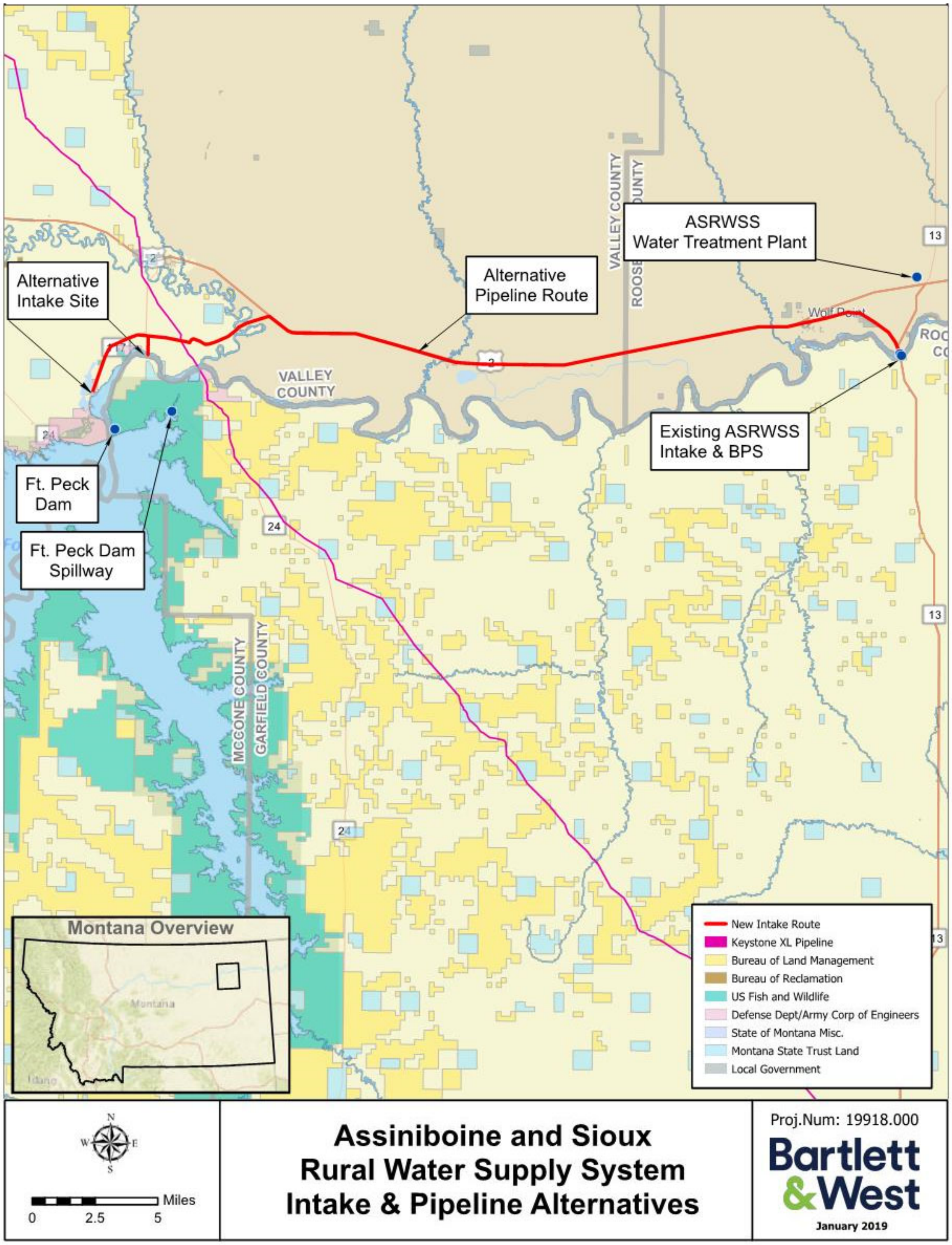


Figure 18: ASRWSS Intake Potential Relocation

Table 5: ASRWSS Intake Relocation Construction Cost Estimate

Intake Relocation Upriver on the Missouri River					
Item No.	Description	Quantity	Unit	Cost Estimate	
				Unit Price	Extension
1	Mobilization and Preparatory Work	1	LS	$400,000.00	$400,000.00
2	10 mgd Raw Water Intake Construction	1	LS	$5,000,000.00	$5,000,000.00
3	30" Raw Water Pipeline	224,400	LF	$140.00	$31,416,000.00
4	Pipeline Appurtenances (25% of Pipeline)	1	LS	$7,854,000.00	$7,854,000.00
	Subtotal				$42,538,000.00
	Construction Contingencies (25%)				$10,634,500.00
	Subtotal				$53,172,500.00
	Non-Contract Costs (20%)				$10,634,500.00
	TERO Tax (3.0%)				$1,595,175.00
	TOTAL				$67,534,175.00
Intake Relocation to Dredge Ponds					
Item No.	Description	Quantity	Unit	Cost Estimate	
				Unit Price	Extension
1	Mobilization and Preparatory Work	1	LS	$400,000.00	$400,000.00
2	10 mgd Raw Water Intake Construction	1	LS	$5,000,000.00	$5,000,000.00
3	30" Raw Water Pipeline	254,496	LF	$140.00	$35,629,440.00
4	Pipeline Appurtenances	1	LS	$7,854,000.00	$7,854,000.00
	Subtotal				$46,751,440.00
	Construction Contingencies (25%)				$11,687,860.00
	Subtotal				$58,439,300.00
	Non-Contract Costs (20%)				$11,687,860.00
	TERO Tax (3.0%)				$1,753,179.00
	TOTAL				$74,012,339.00

Operation and maintenance costs for the increased pipeline length are not included in the above cost estimate (**Table 5**).

Glendive Intake

An alternative to reduce the risk of oil leaks contaminating the City of Glendive water supply could involve moving Glendive's intake upstream of the proposed pipeline crossing. This would include about 24 miles of new 12-inch diameter pipeline as shown in **Figure 19**. The addition of pipeline

to the City's source water system would increase costs due to the extra pipeline length and associated operation and maintenance costs.

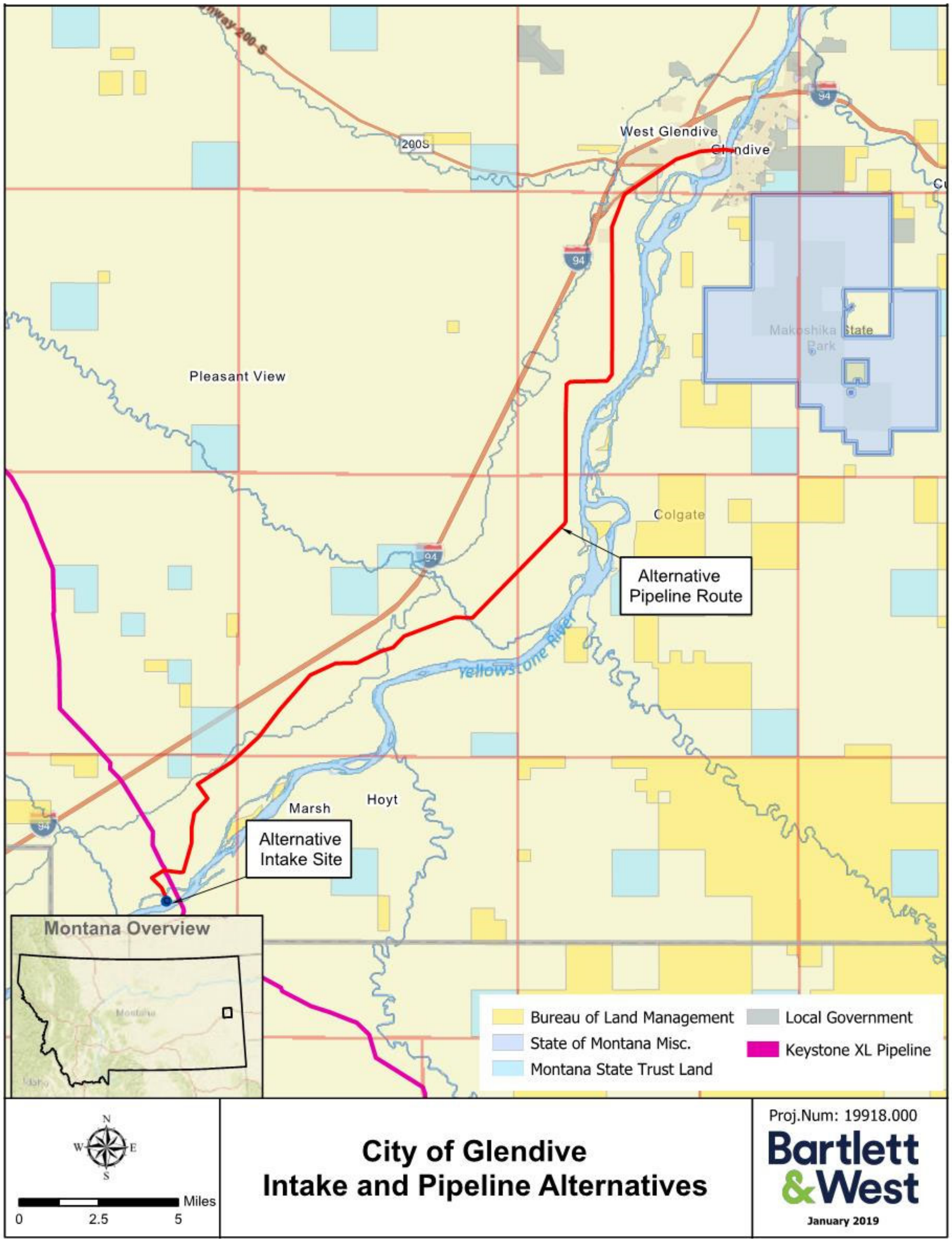


Figure 19: Glendive Intake Relocation

The selection of replacement intake for Glendive would depend on factors such as the topography, hydrogeologic features, soil conditions and depth to bedrock at the site. A likely option would be duplicating the sloped tube intake currently used by Glendive. Sloped tube intakes are made by directionally drilling or coffer dam construction methods. Inlet casing pipes are installed at an angle under a lake or riverbed until reaching the target intake elevation. The intake pipeline is then levelled off and installed horizontally under the riverbed, until emerging on the bottom of the riverbed (**Figure 20**). Each sloped tube intake includes a screened inlet assembly and is anchored underwater. The interior discharge, or drop pipe, is attached to a submersible pump and motor. The drop pipe, pump and motor assembly are lowered inside of the casing pipe, positioning the pump and motor at the target intake elevation. The drop pipe is attached to a pitless adapter or within a structure that allows the water to discharge from the pipe without bringing the water to the ground surface and being exposed to freezing conditions. A general example of a sloped tube intake is shown in **Figure 20**.

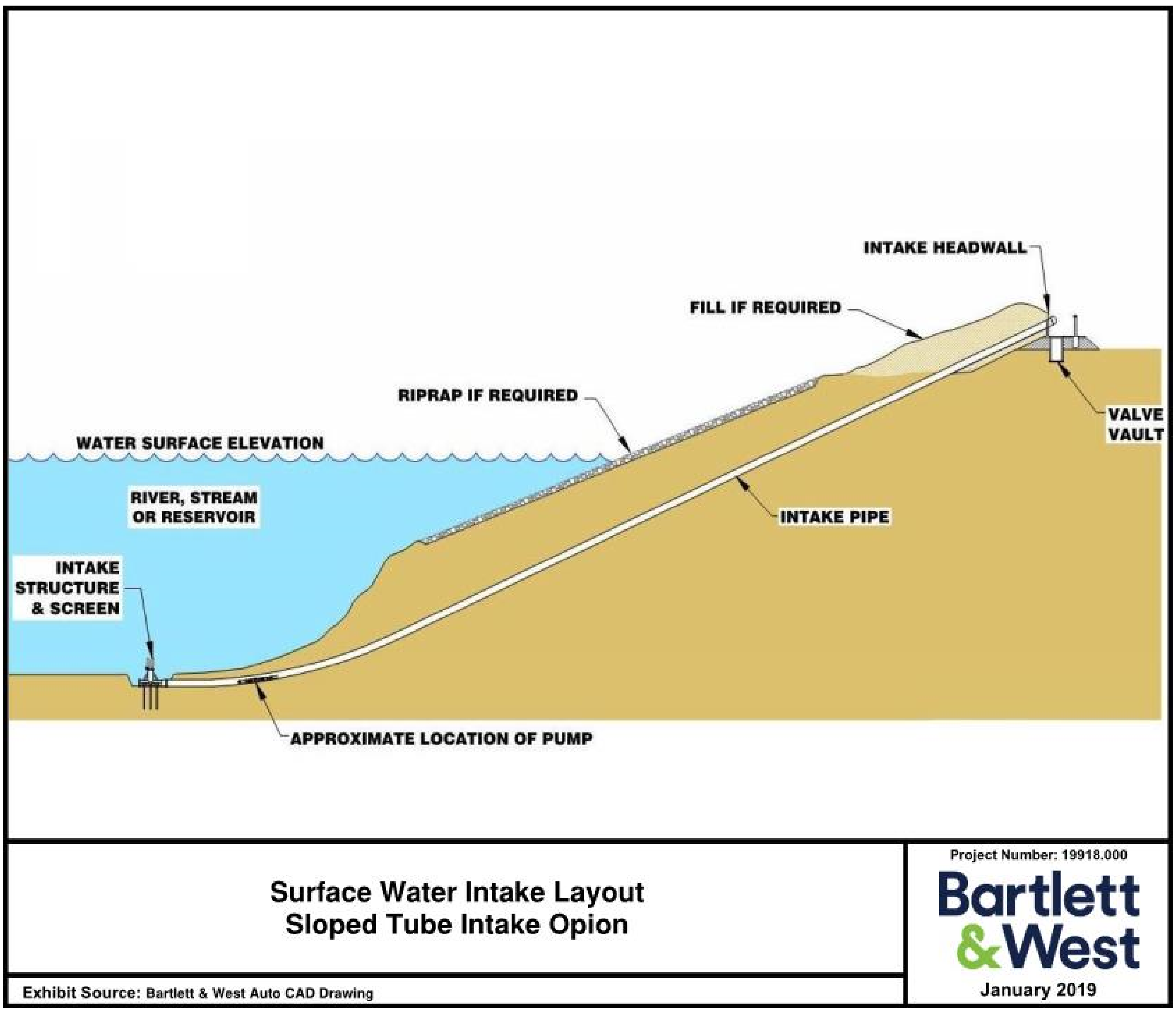


Figure 20: Sloped Tube Intake

A preliminary estimate of construction costs for the intake relocation shown in **Figure 19** is can be found below in **Table 6**.

Table 6: Glendive Intake Relocation Construction Cost Estimate

Item No.	Description	Quantity	Unit	Cost Estimate	
				Unit Price	Extension
1	Mobilization and Preparatory Work	1	LS	$250,000.00	$250,000.00
2	Intake Screen, Building, Pumps, MEP (Installation Included)	1	LS	$2,300,000.00	$2,300,000.00
3	12" Raw Water Pipe (Installation Included)	126,720	LF	$30.75	$3,900,000.00
4	Pipeline Appurtenances	1	LS	$780,000.00	$780,000.00
	Subtotal				$7,230,000.00
	Contingencies (25%)				$1,807,500.00
	Subtotal				$9,037,500.00
	Non Contract Costs (20%)				$1,807,500.00
	TOTAL COST ESTIMATE				**$10,845,000.00**

Dry-Redwater Intake

The intake facility for the Dry-Redwater system, as proposals currently stand, is planned for a site on and adjacent to the Big Dry Arm of Fort Peck Reservoir on which the Authority at this time retains an option to purchase. As part of a yet-to-be completed feasibility study, there will be additional evaluations of the suitability of utilizing this site for the main raw water intake for the proposed regional systems. not having a surface water intake, the potential for moving this intake was not examined in this evaluation. When the intake location is finalized, and design activities proceed, potential impacts from flooding, drought and possible petroleum product spills can be considered.

B. Groundwater Facilities

Developing alternate water supplies that use groundwater rather than surface water could be a possible strategy for either replacing surface water intakes impacted by an oil spill or constructing backup sources of supply to be used in the event of a pipeline spill. The ability to develop groundwater supplies to replace existing surface water systems would depend on groundwater characteristics (quantity and quality) in areas proximal to impacted intakes/communities.

Wells completed in shallow groundwater systems that are in direct hydraulic connection with surface water are considered by MDEQ to be Ground Water Under the Direct Influence of Surface Water (GWUDISW). These wells often have limited amounts of matrix material to filter out potential contaminants between the surface water source and the aquifer providing ground water for the well/intake. GWUDISW intakes would be beneficial in situations where the oil spilled is

less dense than water, as the contaminants are unlikely to sink and enter the well/intake. GWUDISW source water may also require additional treatment, which can include energy-intensive filtration/treatment methods, to meet Federal Safe Drinking Water Act standards. This applies especially for metals and total dissolved solids (TDS), both of which are generally in higher concentrations in ground water than surface water.

Several types of GWUDISW intakes exist. A vertical Concrete Caisson with horizontal intake piping is one, with general layout information shown in **Figure 21**. The intake structure consists of a vertical reinforced concrete caisson constructed down to a bottom-plug elevation, which is determined by the water depth at the intake site and final design of the caisson. The concrete or steel intake piping is constructed using micro-tunneling or directional drilling technology, with the method of installation depending on the caisson diameter. If the interior diameter of the caisson is too small, the intake piping is installed with directional boring equipment remotely from the caisson and intercepts the concrete shaft wall to continue to the lake or riverbed. Pipe manufactured from high-density polyethylene (HDPE), polyvinyl chloride (PVC), or steel is then pulled back from the lake or river into the caisson and the remaining angled entrance drill hole is abandoned. Alternately, if the caisson is large enough, a micro-tunneling machine may be able to be placed inside the concrete structure. A screened inlet is provided at the lake or river end of the inlet piping. Pumps for this type of intake are normally vertical turbines, located in a building constructed above the caisson, with the suction column piping extending to the base of the concrete structure.

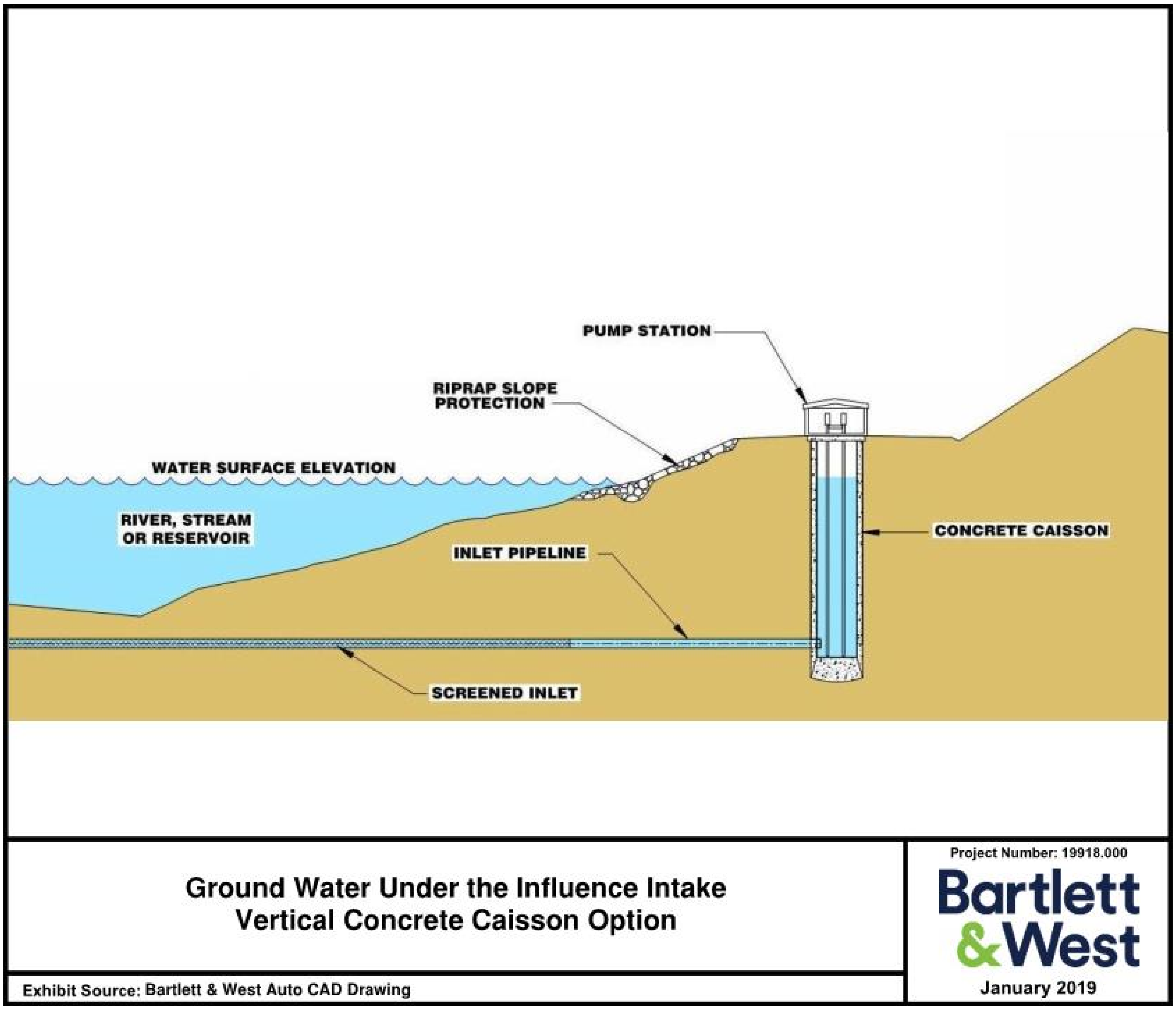


Figure 21: Ground Water Under the Influence Vertical Concrete Caisson Layout

Another option for GWUDISW are angled wells. A general layout is indicated in **Figure 22**. This example intake consists of wells drilled at an angle under the lake or riverbed. The pump for this intake is a submersible unit positioned at the lowest section of inlet piping within the screened interval. The interior pump discharge piping is connected to a pitless adapter near ground elevation with a buried concrete manhole or vault housing an isolation valve, check valve, metering and electrical equipment. This type of intake can be constructed with one, two or more inlet tubes, each with a separate pump and pitless adapter, to provide redundancy in the event of pump failure or screen fouling.

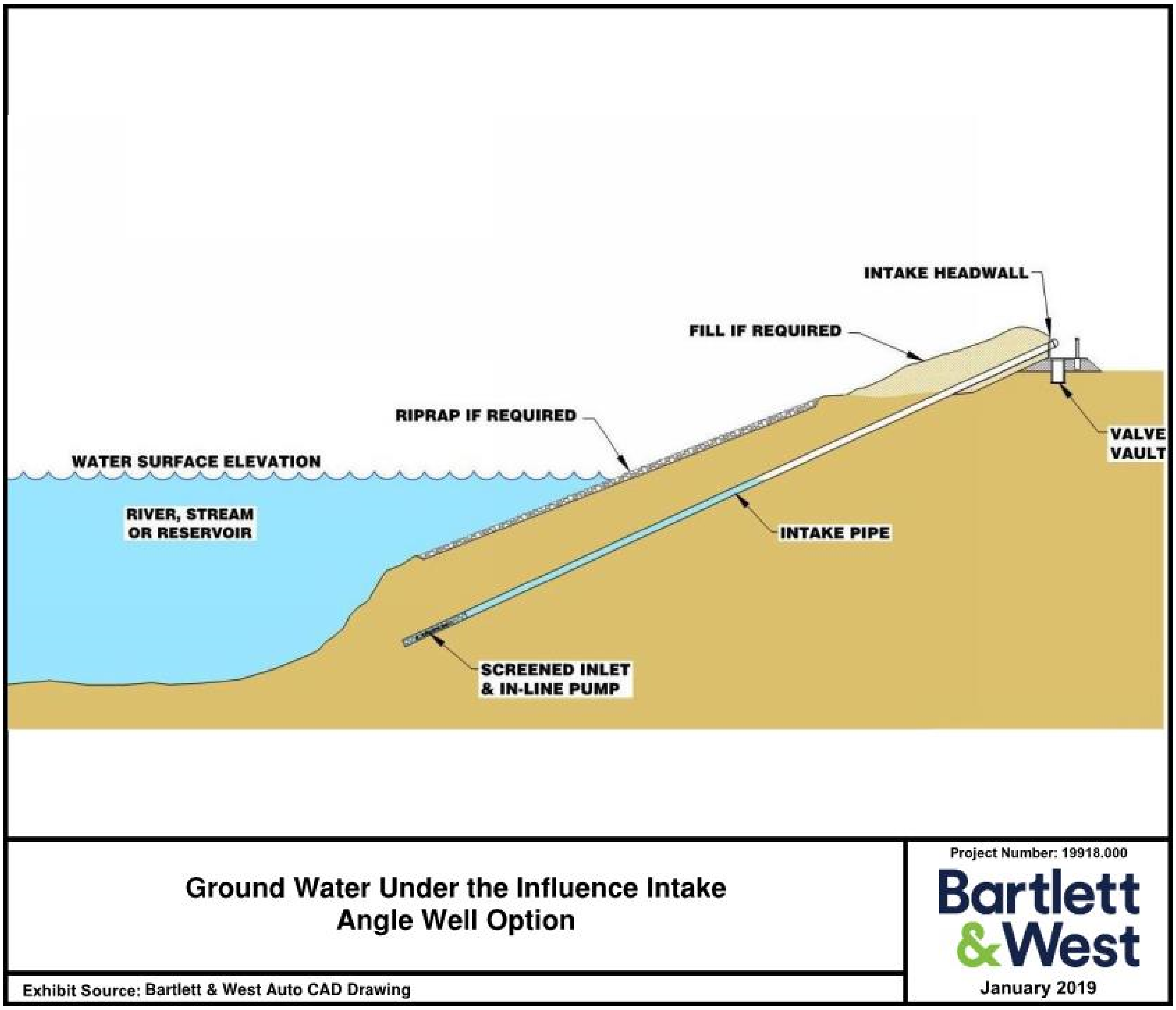


Figure 22: Ground Water Under the Influence Angle Well Layout

Glendive

A potential non-surface-water backup for the Glendive water system is the West Glendive Water system managed by Dawson County Public Works. The West Glendive Water system is served by wells and is less likely to be affected by a pipeline spill. Depending on how the DRWA system progresses, the West Glendive System may be supplied by water from the DRWA system rather than their existing wells.

Another option to improve resiliency of the system could be to change the configuration of the intake from a surface water intake to a GWUDISW system such as angle wells or a vertical caisson with horizontal intake well screens under the river. This option would require additional study to determine feasibility and applicability to a potential spill of dilbit.

C. System Resiliency Improvement

Water treatment facilities could make modifications to their existing facilities to increase resiliency in the case of an oil spill in the Yellowstone or Missouri rivers. Appropriate modifications would depend on the type of oil involved in a spill, the type of water supply intake, and existing treatment operations.

Due to drinking water intakes being located downstream of the proposed pipeline crossings, it would be of the utmost importance to notify the drinking water treatment facilities immediately if an oil spill were to occur. Fast, efficient spill detection and notification by owners and operators of drinking water facilities is aided by the use of SCADA systems (discussed in Section III, above). For example, TransCanada could set up the pipeline monitoring SCADA to send a signal to the drinking water system SCADA in the event of a pipeline depressurization event. This would provide the drinking water utility administrator time to investigate and respond to a potential spill. A mutually agreed upon system integrator would be required to implement this type of coupled SCADA system.

Regardless of the type of crude oil being transported by any pipeline, Benzene would be present in the event of an oil spill. Benzene is a VOC, and the USEPA considers it a carcinogen. According to the World Health Organization (2003), benzene in surface water will:

- Volatize to the air;
- Biodegrade in a few days to weeks; and,
- React with hydroxyl radicals in several weeks to months.

Benzene has a higher water solubility than most other petroleum hydrocarbons, but also has an affinity for oil over water (Stantec, 2017). In turbulent river situations the Benzene may be more soluble due to the oil particulates being broken apart via physical mixing and dispersion. For dispersion to occur, kinetic energy must be added to the liquid to break apart the surface tension between oil droplets. The kinetic energy will cause some particles to break apart and others to coalesce, creating larger droplets. A pressure drop will also break apart the bonds between particles, resulting in smaller oil droplets that are harder to remove. In the Bridger Pipeline spill the ice cover was suspected as a cause of increased dissolution of Benzene in the water (Environmental Protection Agency , n.d.). Kinetic energy and pressure drop occur naturally in river systems. It is recommended that drinking water treatment systems below major pipeline crossings of their source water have equipment for monitoring Benzene and VOC levels of their source water.

Distribution & Intake System Improvements

Enhanced monitoring of the water supply distribution system could augment protection as a back-up system to SCADA systems. Water systems are at risk from various contamination sources. These include non-point sources (e.g., train derailment, sewage treatment outfall, septic systems). Use of VOC monitors would detect volatile hydrocarbons from a variety of sources. Continuous water quality monitoring of both raw and finished water can be analyzed for concentrations of VOCs, including Benzene. An inline, continuous VOC analyzer similar to that installed at Glendive after the Bridger spill should be considered at the ASRWSS intake. Because benzene is highly toxic, the inline monitor should be sufficiently sensitive to detect concentrations lower than 0.005 mg/L.

If a spill were to occur, WTPs could utilize floating booms to minimize the amount of oil that would reach the intake. Intakes could have permanent tie-down points for the booms for easier and faster deployment. Multiple tie-down points would be needed to place the booms at different angles, depending on river conditions at the time of the activities.

If a spill were to occur in the Yellowstone (for Glendive) or in the Milk or Missouri Rivers (for ASRWSS), the river intake screens would have the potential to draw contaminated water into the systems. The best situation would be to seal the intake by removing the screen and replacing it with a blind flange. The blind flange would keep the intake from drawing contaminated water into the supply infrastructure. The replacement would need to be done in a timely manner to prevent the passive capture of contaminated water.

A diver would need to be mobilized to the intake site to replace the flange. Depending on the facility location and the nearest contractor capable of deploying divers, this could require hours or days to complete. River flow and other conditions at the time of the spill would also have a significant bearing on any ability to successfully complete such a procedure. It may be possible to have divers access the Fort Peck intake, but it is not known at this time if the effort would be successful. If a break were to occur below the Fort Peck Dam when there is a release through the spillway, it would be highly unlikely that a diver could access the intake screen and successfully install a blind flange. Glendive has attempted to have divers access their river intake screens in the past, without success. Winter and frozen river conditions also would make removal of intake screens more difficult. The Glendive intake is equipped with air-burst capabilities for removal of debris from the screen. It might be possible to continuously run the air system to keep from pulling any contaminated water into the intake structure. An appropriately sized continuous-duty air compressor would be required for the attempt.

Exploration of the possibility of establishing a temporary alternative intake location and/or source of supply is recommended. If a temporary intake can be established in a location where un-impacted (or significantly less-impacted) water can be accessed, this water can be sent first to a pre-treatment system. After pre-treatment, the existing WTP could potentially be used along with the temporary intake, until the permanent intake is usable again. Hard pipe could be installed in advance or Certa-Lok Yelomine type pipe could be installed in the event of a spill. The use of Certa-Lok Yelomine pipe, or similar, would allow for the pipe to be laid on the ground surface and avoid the added cost of installing buried pipe. Potential pipe types are defined in further detail below.

Temporary Pumping and Piping

An alternative which could be considered by rural water systems to address an oil spill is to place a temporary surface water intake upstream of the pipeline crossing and pump water above ground using flexible pipe to the existing treatment facility. For the ASRWSS treatment facility this would require about 43 miles of pipe and for Glendive this would require around 24 miles of pipe. Routing would be similar to that needed for installing a new permanent intake as described in Section VI.

Modifications for the DRWA intake are not included here due to the current plan to use water from the Fort Peck Reservoir as the raw water source. If the raw water source were to change to either the Yellowstone River or the Missouri River below a pipeline crossing, modifications similar to those described below for the Glendive or ASRWSS intakes would be applicable.

The use of flexible pipe may be a cost-effective alternative to trenching-in permanent large diameter pipeline when evaluating temporary solution options. This system is currently being used successfully in the Bakken Oil Play to transport large volumes of water over substantial surface distances to provide frac water. There are a number of companies that have the resources and materials necessary to supply the volumes of water needed by the ASRWSS and Glendive water systems. Flexible pipe can be installed quickly and efficiently in emergency situations. This type of pipe could be rapidly placed as far upstream as necessary to maintain a safe distance from the source of contamination.

One of the key factors to determine the viability of using flexible pipe would be the duration of the impact caused by an oil leak. If the impact would only be for a matter of days and not weeks, the time needed to install the flexible pipe would most likely eliminate this as a reasonable alternative, particularly if stored water might be sufficient to supply demand in the short term.

To estimate the approximate costs to use flexible pipe on a temporary basis, it is necessary to determine the approximate volumes of water which would need to be moved. Strict water conservation measures would likely need to be implemented to increase the viability of any potential solution. The estimated average day demand for a particular facility would be an adequate amount of water to meet needs during a raw water emergency situation. The applicability of using lay-flat hose to supply raw water to the ASRWSS treatment facility was completed for a flow of 6.6 mgd (4,580 gpm). To facilitate this flow rate, it is recommended that two 12-inch diameter, 250 class pipes be laid in parallel with 8 pumps per pipe. It would require 84.6 miles of lay-flat hose to accomplish this.

For the City of Glendive, the WTP is anticipated to produce an average day flow of 833 gpm at full build-out. To provide this flow with lay-flat pipe would require 10-inch class 250 flexible pipe and 2 inline pumps to transfer the 833 gpm east 24 miles from the proposed intake.

The estimates of total funds needed to transfer water via flexible pipe is based on a cost/pump/day, setup and takedown expenses, and a daily pipe rental fee. These figures fluctuate depending upon the distance the water is being pumped and the diameter of pipe used. The estimates for the use of flexible pipe are presented in **Table 7**. The pipe rental fees include the use of the pipe, necessary equipment, all personnel, and the transfer of the water itself based on the designed pumping rate.

Table 7: Temporary Flexible Pipe Cost Analysis

System	Item	Quantity	Unit Cost	Total Cost
ASRWSS	Pipeline Setup	1	$ 100,000	$ 100,000
	Use of Pumps (daily)	16	$ 2,000	$ 32,000
	Pumping/Operation (12", daily)	4,580 GPM	$ 10.42 / 1,000 Gal.	$ 68,000
	Pipeline Takedown	1	$ 75,000	$ 75,000
	Total Daily Operational Cost			**$ 100,000**
	Total 30 Day Operational Cost			**$ 3,175,000**
Glendive	Pipeline Setup	1	$ 30,000	$ 30,000
	Use of Pumps (daily)	2	$ 2,000	$ 16,000
	Pumping/Operation (10", daily)	833 GPM	$ 2.08 / 1,000 Gal.	$ 3,000
	Pipeline Takedown	1	$ 30,000	$ 30,000
	Total Daily Operational Cost			**$ 19,000**
	Total 30 Day Operational Cost			**$ 630,000**

Table 7 indicates the cost to pump water 42.5 miles versus 24 miles is almost double. The primary driving factor will be the number of pumps required to move the water through the pipe. An operation period of 30 days was assumed to provide general magnitude of the expenses that could be incurred for the use of flexible pipe.

Winter conditions will affect the ability to utilize flexible pipe as a temporary solution. The pipeline surface installation and exposure to environmental factors can have significant negative impacts on the setup and operation of flexible pipe. When temperatures are near 32 ^{o}F, water transferred through flexible pipe must be heated in order to keep the water from freezing. The cost to heat water for use in flexible pipe is estimated at $0.24 per 1,000 gallons per ^{o}F increase. This could add significantly to costs noted in **Table 7,** depending on the temperatures experienced during a spill event,

As an example, if it is assumed the temperature of the water needs to be increased by 20 ^{o}F to account for low winter temperatures, the costs would increase by $4.80 per 1,000 gallons pumped. This would add roughly $31,500 per day for the ASWRSS and $5,760/day for Glendive.

ASRWSS and Glendive might consider purchasing a portion of the flexible pipe for ready availability for emergency uses. At current rates, the approximate cost to purchase flexible pipe and appurtenances is $17 per foot for 12-inch pipe and $13 per foot for 10-inch pipe. For purposes of comparison, if both systems were to purchase the full amount of flexible pipe needed to support a temporary intake installed upstream of the pipeline crossing, the costs would be $3,814,800 for ASRWSS and $1,647,360 for Glendive. These figures do not include purchasing pumps. Annual maintenance and operational testing to ensure their functionality for an event makes this an

undesirable option. It is expected pumps could be available for rent from the energy sector in the region, to meet the needs identified.

Another option is the potential to establish a contract with a company for an emergency response plan to install and operate flexible pipe within a set time. It is expected these costs would be either in the form of an annual fee, an initial lump sum cost, or a combination of the two. Due to the uniqueness of this situation there is no current information available on estimated pricing for this option and would therefore need further analysis.

Additional communication with State and county right-of-way officials would be needed to determine the ability of using road ditches/rights-of-way for emergency placement of flexible pipe for transmission of water. Water systems and other officials would have to work to secure temporary easements in advance of possible deployment of this option when needed. If the option to purchase flexible pipe were to be considered, only 12-inch pipe is recommended for purchase as it could then be used to supply water for either the ASWRSS or Glendive systems.

It appears the safest alternative to mitigate impacts from the occurrence of an oil spill or other disaster compromising the intakes for either the ASRWSS or the City of Glendive would be the installation of new intakes above the planned crossing locations and construction of the associated permanent pipelines. The substantial expense of installing this additional infrastructure, as well as the increase in operational costs, are more prohibitive for local drinking water facilities to fund, in comparison to the estimates in **Table** 7 for flexible pipe.

Drinking Water Treatment Improvements

The USEPA states a combination of granular carbon and packed tower aeration can remove Benzene in drinking water to below the current MCL of 0.0005 mg/L (5 ppb). Aqua Pure Filters, a drinking water treatment company, indicates that 0.35 pounds of activated carbon can treat about 1,000 gallons of water containing 570 (ppb) of Benzene. For reference, Benzene levels detected in the Glendive system following the Bridger Pipeline spill were above 5 ppb. For removal to occur, the Benzene must be in contact with the carbon for at least 10 minutes and the carbon must be replaced when exhausted (Aqua Pure, 2018). Treatment facilities could install granular carbon treatment to the existing process in preparation for a response to a spill event involving Benzene.

Drinking water treatment plants located along the Missouri River and Yellowstone River could work with water treatment consultants and hydrocarbon removal contractors to develop emergency treatment options for hydrocarbons. The emergency plans would include the design of temporary or permanent pretreatment systems capable of removing hydrocarbons from water sources best suited for each site.

Temporary pretreatment systems can be designed and stored by hydrocarbon removal contractors. In the event of an oil spill, the pretreatment system would be delivered, installed, operated, maintained and removed by the contractor. The system proposed for separating crude oil from water would be a sand filter followed by granular activated carbon and finished with a 1-micron bag filter. Costs for this option mostly consist of expenses for mobilization and demobilization of the equipment as well as the amount required for the equipment and operators to be onsite running the system. Additionally, a daily fee would be assessed to reserve and store the equipment at the contractor's facility.

Existing Storage in System

In the event of a release of oil from a pipeline, all water treatment plants downstream could attempt to utilize existing system storage. Upon receipt of emergency notification, the system operators could use the time prior to oil reaching an intake to fill available existing storage facilities. A topping up of existing storage would increase the period in which water under controlled use could be distributed throughout the service area. For smaller volume leaks and other more limited incidents, the additional time provided by these measures could allow for more extensive cleanup and more thorough response plans to be implemented. Extraordinary measures for conservation of water resources through severe restrictions to use need to be considered for incorporation into the ERPs of all affected water systems.

The Town of Culbertson has an existing 20 million gallons of raw water storage, which could be used in the event of an oil spill, if proper planned employment of the facilities were part of the ERP for the area. Following notification of a spill and depending upon the operating conditions for the intake and related pumps, the Town could begin filling the storage ponds with fresh water. This option requires a determination of operational fitness of the Culbertson intake. Whether or not upgrades would be required to the equipment to provide the flow rates needed is a topic worthy of further investigation.

In one scenario the water from Culbertson's raw water storage ponds could be piped to the ASRWSS treatment facility rather than being treated in Culbertson. This would require the use of about 50.6 miles of temporary piping and pumps to convey water from the ponds to the treatment facility. Another option would be to bring the Culbertson treatment facility back online to treat the water, and then backfeed the ASRWSS and DPRWS systems from Culbertson. The Culbertson facility has limited treatment capacity (about 1.2 mgd the last time it was in daily operation); severe water restrictions would need to be in place for this to work. Estimates of time and money required to reinitialize operation of the Culbertson WTP are not available for the scenario under consideration.

If oil contamination were to reach the intake before the storage ponds could be filled with fresh water, any water stored in the ponds might be used. This would depend on the water quality, which might be degraded due its being stored for an extended period. To offset such effects, fresh water could be added to the ponds on a predetermined schedule. Winter conditions or low river flows might negatively affect the ability to fill the existing ponds. Water rights issues would also need to be further addressed, to determine if the current right would permit such use.

The Glendive drinking water system includes 2.1 million gallons of storage. Assuming water restrictions would be put in place at the time of an oil spill which could result in 50 percent water use reduction as described in the *Temporary Pumping and Piping* Section; the existing storage would be expected to last 1.9 days. This assumes depletion of all stored water.

Based on review of the ASRWSS WTP drawings and communication with the consulting engineer working with ASRWSS and DPRWS, total estimated storage volume was determined. At full system buildout there could be a total of 5.35 million gallons of storage within the ASRWSS and 4.60 million gallons more of storage in the DPRWS. This storage is within the rural portion of the systems and does not consider additional storage available in communities served by the system. Total additional storage in community systems was estimated as 6.5 million gallons. The regional treatment facility (WTP) includes a 0.6 million-gallon clearwell. Based on the daily flows identified in the *Temporary Piping and Pumping* Section the existing storage would allow for 2.6 days of

operation prior to depleting all of the storage. This assumes 100 percent of the stored water volume is usable.

Raw Water Storage Ponds

A further alternative for consideration for emergency water supply in both the ASRWSS and Glendive treatment facilities would be to construct a high-capacity earthen raw water storage pond near each of the water treatment plants. Raw water storage ponds have been a very cost-effective alternative in the Bakken Oil Play. Large volumes of water can be stored and utilized at moments of need when intake pumping capabilities are inadequate or become inoperable. This alternative potentially could provide sufficient storage for each of these systems in the instance of an oil spill impacting the raw water supply for an extended period.

Conservatively, an operational period of 30 days was assumed. The amount of storage needed for such an interval would most likely provide sufficient time for mitigation of impacts caused by an oil leak. With the water usage values from the *Temporary Pumping and Piping* Section, the ASRWSS pond would need to store as much as 197 million gallons and the Glendive system would need to store more than 32 million gallons of raw water. Calculations are based on the daily requirements defined in the *Temporary Pumping and Piping* Section, and are not adjusted for decreased water usage due to water restrictions which would be in place.

Construction estimates indicate ponds of this size cost approximately $44,000 for every million gallons of storage. Based on this, the cost to construct the pond needed for 30 days of storage would be about $8.7 Million for ASRWSS and $1.43 Million for Glendive. This does not include any piping to the water treatment plant. Those connections could either be through the installation of permanent underground piping or quick-connection points to accommodate the use of flexible or temporary piping. The preferred type of connection would need to be determined by each system.

It is important to point out the approximate footprint of a pond of this size is quite substantial; a ground storage pond currently being built with a capacity of 40 Million Gallons of storage has dimensions of 375-feet wide, 825-feet long, and 20-feet deep, covering just over 7 acres of land. Due to the sheer scale of these ponds, recommendations would likely include that the pond be utilized as more than a raw water storage pond. A structure of this size could potentially be used as a multi-use recreational facility providing the community with not only safe drinking water storage but also an area to fish, swim, and engage in other recreational activities. Another option would be to construct a pond that is geared primarily toward creating a wetland which would be used mostly by wildlife. Benefits to the community and area for uses beyond raw water storage could be part of the evaluation of whether benefits derived were worth the construction costs.

Bottled Water

Use of bottled water could provide water for drinking and cooking, until the water treatment plant resumes normal operations. Depending on the system size and duration of the event, costs may range from thousands to tens of thousands of dollars for purchasing and distributing bottled water. This option was used by the City of Glendive for the Bridger Pipeline spill event.

Water Hauling

Depending on the impacts to a water system’s intake, water treatment plant, and distribution system, water could be hauled from nearby systems to supplement existing reservoir storage. This option would require close proximity to a stable unaffected water source. Where the water

would be added into the system would depend on whether the water was potable or raw, and which portions of the existing system remained operational. This would require minimal system upgrades to accommodate and could be deployed almost immediately. Contingency plans could be developed in advance to identify sources of supply for water hauling, with agreements in place with cooperating entities. This option could provide significant amounts of water for an extended period; costs could range widely, depending upon a number of basic factors.

Flood Resiliency

The WTPs for Glendive and the ASRWSS are both built outside of the 100-year flood zones and therefore there is minimal risks to these facilities for flood-related impacts. Their respective intakes may be exposed to damage or clogging due to scouring or debris during floods. Pump stations on each of the systems could also be damaged in the event of a major flood. Steps that could be taken to increase flood resiliency for water systems include the following (EPA, 2014):

- Sign up for USGS alerts for stream and river gauges:
  - Water Alert – Select gauges of interest and USGS will send an email/Short Messaging Service (i.e., text) message when parameters exceed user defined thresholds.
  - Water Now – Receive current conditions for water data at a specific gauge directly to your mobile phone or email.
- Install monitoring equipment upstream of intakes to provide an early warning of raw water conditions (e.g., turbidity, flow).
- Develop capability to temporarily remove and safely store vulnerable components in advance of a flood.
- Elevate electrical controls and instrumentation above 100-year flood elevation.
- Replace standard electrical conduits with sealed, water proof conduits.
- Replace instrumentation and control enclosures with waterproof models.
- Store sand and sand bags for minor flooding.
- Fill water storage tanks prior to anticipated storm events.
- Maintain sufficient supplies of chemical and fuel in anticipation of supply disruption during a flood.
- Contact power utility concerning priority restoration of power to water facility in the event of flooding.
- Ensure backup power for pumps and treatment facilities.
- Ensure generators are kept above flood levels and have “quick connect” capability.
- Installation of two independent power feeds to facilities.
- Have the capability to operate pump stations remotely in case buildings are inaccessible.
- Establish interconnections to share resources with neighboring water utilities.
- Have a cache of spare parts.
- Train staff to shut down electrical equipment prior to flooding to limit damage.
- Fill fuel storage tanks in anticipation of flooding.
- Install additional or larger fuel storage tanks.
- Install solar panels or wind turbines to reduce dependence on the electrical grid and to supplement backup power.

VII. Irrigation Alternatives (Drought and Flood Resilience)

A. Floodplain Review

Irrigation headworks structures are at risk of damage from erosion and debris during floods. Response from irrigators indicated stream erosion and sediment deposition resulting from high flows would negatively impact intake infrastructure. For instance, the deposition resulting from the flood events of 2011 completely sealed one irrigator off from river access by a 500-foot sand bar. Irrigation facilities need to be inspected after flooding to determine if any repairs are required. Systems are advised to have an emergency response plan in place, in case emergency repairs are required due to washouts. River banks surrounding headworks structures should have sufficient concrete and riprap to prevent damage from floods.

B. Drought Conditions Review

Discussions with irrigators indicated many respondents already have issues during low-flow periods.

C. Irrigation Diversion Resiliency Improvement Alternatives

Many irrigation systems have earth-lined canals and when the flow of the water into an open canal suddenly stops, the slope stability of the earthen embankments of the canals is reduced. This may cause the sides of the canals to slough into the bottom. Repairing this over an entire canal system would result in significant costs and may take several years to complete. This stability issue makes it difficult for irrigators to quickly respond to oil leaks or spills. Larger systems may need 3 to 4 days to shut down their intake to avoid damage to the canals. If extensive portions of a canal system are piped or have concrete or plastic lined canals instead of earth-lined canals, the intake can be shut down with a greatly reduced risk of damage to the canal system.

Piping and lining canal systems improve water efficiency in canal systems, which would help in periods of drought. Canals that are piped also have reduced water losses to evaporation. Both piped canals and lined canals have reduced water loss due to seepage into the ground.

There are few options for irrigation intakes to prepare for a potential oil spill on the Missouri or Yellowstone Rivers. Immediate warning that a leak or spill has occurred is necessary to help irrigators protect their canal infrastructure from damage or contamination. Irrigators with diversion structures rather than pumps could install permanent anchor locations on both sides of the river for deployment of booms. Permanent anchor points would allow for faster installation of river booms in an attempt to channel spilled oil away from the irrigation intake structure. The location of the anchor point would need to be upriver of the intake and angle across the river. The most appropriate angle would depend on the river flow rate at the time of a spill. Irrigators could install multiple anchor points to allow for multiple angles or choose an angle and know that at different flow rates it would be less effective. Irrigators would also need to maintain enough river boom length to deploy in case of a spill. The boom would need to be stored at a location that would allow for quick response and would need to be inspected and maintained in accordance with the manufacturer's recommendations.

Intakes with pumping plants may be able to place a filter around the intake or in the pipeline to remove oil contaminants. There are multiple filter options available, such as filter bags, drain inserts and filter mats to filter oil out of discharged water. Additional research would need to be

conducted to determine their applicability to irrigation intakes, but sorbent gabions or water barriers may provide additional response possibilities.

Finally, it may be feasible for some of the canal irrigation systems to develop a secondary ground water source to supplement irrigation water. However, due to the vast quantity of water used for irrigation in Eastern Montana, ground water is not a feasible replacement in most cases.

VIII. Conclusions

There were a number of additional study areas identified during the review of publicly available documents associated with the proposed TransCanada Keystone XL pipeline that are noted as potential subjects for future investigations. Items identified include:

- No publicly available Site-Specific Risk Assessment associated with the Yellowstone River crossing.
- The Site-Specific Risk Assessment for Keystone XL Project's Missouri River crossing did not include:
    - Response and cleanup information specific for a spill of diluted bitumen
    - Analysis of Milk River and tributary pipeline crossings, given the Milk River -- Missouri River confluence's position upriver of the drinking water intake
- Lack of diluted bitumen spill response information included in the Site-Specific Risk Assessment for Keystone XL Project's Missouri River crossing.
- Review of the Keystone Mainline ERP and SPCC provided background information, but without completed Keystone XL pipeline-specific ERP and SPCC at the time of this report writing, the following points remain unclear:
    - Proposed cleanup techniques that would be specific to this project.
    - Information detailing proposed spill response equipment, location and training of individuals to utilize the equipment.
    - How and where cleanup equipment would be stored, whether in a warehouse or trailer, and what impact this decision has on the anticipated response times.
    - Planned control access points, planned control equipment and personnel who comprehend the planning in place and possess the required training to assess sufficiency of resources necessary for response to product release (spill).
    - The specific capabilities and limitations of TransCanada and associated contractors to respond to a spill from the XL pipeline.
    - Contractors TransCanada will employ to respond to an oil spill impacting the Rivers of Montana.
- Lack of clarity as to whether preparations are complete, and procedures are in place to respond to submerged or sunken oil.
- The Site-Specific Risk Assessment for Keystone XL Project's Missouri River Crossing states "bi-weekly aerial surveillance in accordance with federal requirements" but also states "aerial surveillance: 26 time per year, not to exceed 3-week intervals." From these two statements it is unclear on which intervals aerial surveillance will be conducted.
- Information on potential impact to culturally or archeologically sensitive or important areas*, due to related mitigation activities resulting from an oil spill*.
- The publicly available Final SEIS (2014) does not show pipeline maximum spill volumes for the Missouri or Yellowstone River crossings.
- Planning assumptions need verification, and information gaps in currently available spill response plans must be closed or filled.

The scope of this report was to investigate impacts to drinking water and irrigation. This report does not address the following interrelated impacts from oil spills, noted here for clarity:

- Impacts to wildlife and plant life resulting from an oil spill.

- Environmental impacts resulting from the use of the crude oil transported in the pipeline.
- Air pollution potential due to an oil spill.
- Limiting direct contact exposure to oil in the river following a spill.
- Deposition of oil outside of the river channel on the shore, floodplain etc.
- Water systems whose source is ground water.

IX. References

Aqua Pure. (2018, December 10). *Methods of Treatment for Water Contaminants*. Retrieved from Aquapure Water Conditioning: https://www.aquapurefilters.com/contaminants/110/benzene.html

Arcadis. (2011). *Summary of Assessment and Oil Removal Activities.*

Bureau of Reclamation. (n.d.). *Projects & Facilities*. Retrieved from Reclamation: https://www.usbr.gov/projects/facilities.php?type=Project

Canada, E. (2013). *Properties, Composition and Marine Spill Behaviour, Fate and Transport of Two Diluted Bitumen Products from the Canadian Oil Sands.*

DEQ, M. (June 2019) Water Quality Division, Water Quality Planning Bureau, Water Quality Standards and Modeling Section. 2019. DEQ-7 Montana Numeric Water Quality Standards. Helena, MTMontana Dept. of Environmental Quality.

DEQ, M. (2018). Bridger Pipeline Water Sampling. (B. &. West, Interviewer)

DEQ, M. (October 5, 2015). *Sanitary Survey Inspection of City of Glendive; PWSID: MT0000229.* Glendive, MT: Department of Environmental Quality, Public Water Supply Program, Lisa M. Kaufman.

DryRedwater Regional Water Authority. (n.d.). *History* . Retrieved from DryRedwater Regional Water Authority : https://www.midrivers.com/~drwa/History.htm

Environmental Protection Agency . (n.d.). *Bridger Pipeline Release*. Retrieved from United States Environmental Protection Agency : https://response.epa.gov/site/site_profile.aspx?site_id=9708

Environmental Protection Agency. (n.d.). *Enbridge Spill Response Timeline* . Retrieved from United States Environmental Protection Agency : https://www.epa.gov/enbridge-spill-michigan/enbridge-spill-response-timeline

Environmental Protection Agency. (n.d.). *Silvertip PIpeline Spill - Yellowstone River*. Retrieved from United States Environmental Protection Agency : https://response.epa.gov/site/site_profile.aspx?site_id=7055

Environmental Protection Agency. (June, 2015). *Update of Human Health Ambient Water Quality Criteria: Benzo(a)pyrene 50-32-8 Final*. USEPA Office of Water, Office of Science and Technology, EPA 820-R-15-012. https://www.regulations.gov/document?D=EPA-HQ-OW-2014-0135-0177

EPA. (2014, September). *Flood Resilience: A Basic Guide for Water and Wastewater Utilities.* Retrieved from United States Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/flood_resilience_guide.pdf

Glendive, MT. (2012). *Water Department*. Retrieved from City of Glendive Montana: http://www.cityofglendive.us/departments/public_works/water/index.php

Hardcastle, J. L. (2015). Modern Water Introduces Oil in Water Monitor Into US Market. *Environmental Leader*.

Institute, A. P. (1999). *Standard for Welding Pipelines and Related Facilities.*

International, N. (2014). *Standard Practice Steel-Cased Pipeline Practices.* Houston.

King, T. R. (2014). *Flume Tank Studes to Elucidate the Fate and Behavior of Diluted Bitumen Spilled at Sea.*

Kumar, J. R. (2016, September 29). *Technology designed to detect U.S. energy pipeline leaks often fails.* Retrieved from Reuters: https://www.reuters.com/article/us-usa-pipelines-colonial-analysis/technology-designed-to-detect-u-s-energy-pipeline-leaks-often-fails-idUSKCN1200FQ

Montana DNRC. (n.d.). *Dry-Redwater Regional Water System*. Retrieved from Montana DNRC: http://dnrc.mt.gov/divisions/cardd/regional-water-systems/dry-redwater-regional-water-system

MT Department of Environmental Quality. (2015). *Bridger Pipeline's Oil Spill on the Yellowstone River near Glendive*. Retrieved from Remediation Division: http://deq.mt.gov/DEQAdmin/dir/postresponse/yellowstonespill2015

Munch, J. (1995). *Method 524.2 Measurement of Purgeable Organic Compounds In Water By Capillary Column Gas Chromatography/Mass Spectrometry*. Retrieved from EPA: https://www.epa.gov/sites/production/files/2015-06/documents/epa-524.2.pdf

Nikiforuk, A. (2016, July 12). *Why We Pretend to Clean Up Oil Spills.* Retrieved from Smithsonian.com: https://www.smithsonianmag.com/science-nature/oil-spill-cleanup-illusion-180959783/

Pauli, H. (2018). The Fight to Save Clean Water on the Fort Peck Indian Reservation. *The Gaurdian* .

Pauli, H. (August 2018). The fight to save clean water on the Fort Peck Indian Reservation. *Montana Free Press*.

PBS&J. (2009). *Irrigation in Montana: A Preliminary Inventory of Infrastructure Condition.* Montana DNRC Conservation & Resource Development Division.

Puckett, K. (2018, November 28). Great Falls Tribune. *Keystone at a crossroads: Tribes question running oil pipeline under MIssouri, Milk rivers*.

Regulations, C. o. (2017). *Part 195 - Transportation of Hazardous Liquids by Pipeline.* Federal Register. Pipeline and Hazardous Materials Safety Administration.

Research, N. (2015, May 1). *Technical Analysis of Oil Spill Response Capabilities and LImitations for Trans Mountain Expansion Project.* Retrieved from City of Vancouver: https://vancouver.ca/images/web/pipeline/NUKA-oil-spill-response-capabilities-and-limitations.pdf

Reservation, F. P. (2018). *Position Paper For the Assinibooine & Sioux Tribes for the Fort Peck Reservation on the Keystone XL Pipeline.* Assiniboine & Sioux Tribes.

SDWF. (2018, December 9). Retrieved from Safe Drinking Water Foundation (SDWF): https://www.safewater.org/fact-sheets-1/2017/1/23/oil-spills

SLH. (2018, August 8). *Cleaning Up the Oil Spill*. Retrieved from Science Learning Hub: https://www.sciencelearn.org.nz/resources/1140-cleaning-up-the-oil-spill

Stantec. (2017). *Site-Specific Risk Assessment for Keystone XL Project's Missouri river Crossing.* Stantec Consulting Services.

State, U. S. (January 2014). *Final Supplemental Environmental Impact Statement Keystone XL Project .*

The National Academies of Science, E. &. (2016). *Spills of Diluted Bitumen from Pipelines - A Comparative Study of Environmental Fate, Effects, and Response.* Washinton DC: The National Academies Press.

USEPA. (2016). *FOSC Desk Report for the Enbridge Line 6b Oil Spill Marshall, Michigan.*

Voggesser, G. (2001). *Fort Peck Project.* Bureau of Reclamation.

Watson Engineering, I. (January 2002). *Final Engineering Report - Fort Peck Assiniboine and Sious Water Supply System / Dry Prairie Rural Water System.* Helena, MT.

WHO. (2003). *Benzene in Drinking-water.* Geneva: World Health Organization.

APPENDIX A
ASRWSS Record Drawings

These materials are available upon request.
Please contact Rick Duncan rduncan@mt.gov

APPENDIX B

Meeting Minutes & Correspondence

Intake Resiliency/Supplemental Risk Analysis/Report
Communication Notes

Date:	Conference Call 11-14 Onsite Meeting 11-15	**Time:**	3 PM MT 9:30 AM MT
Contact Name:	Glendive-Kevin Dorwart (operations manager) and Jack Rice (Public Works Direction	**Contact Organization:**	City of Glendive, MT
Contact Phone #:	406-377-3318	**Contact Email:**	dorwartk@midrivers.com ricej@midrivers.com

Attendance Information	
Name	**Organization**
Jarrett Hillius	BW
James Landenberger (Phone Only)	BW
Kevin Dorwart	City of Glendive
Jack Rice	City of Glendive

Glendive noted that the protocols associated with communication during the Bridger spill is something they learned from and understand better if they every have a break to deal with again.

Noted Bakken crude is volatile and mixes with Yellowstone river water-in their expereince

Glendive Intake is 19' below Yellowstone River water surface in scour hole.

Questions to address in report:

- Reference Grizzly spill/Bridger spill in report
- Construction of River crossing vs what Bridger did previously
  - Glendive requested EIS information on Construction HDD plan for Yellowstone Crossing for their reference so they don't have to review the entire document

Bridger bought city a VOC detector, only 2 in the US. $110k ModernWater MS 20, installed on intake header in pump house. VOC detector measures in PPB and will shut down pumps/alarm.

- Contact Shasta with DEQ for more information on sampling records/Benzene sampling/SEP with City/EPA information

Bridger also bought DR 6000 spectrophotometer to use to measure inorganics manually to check VOC detector.

There have been several meeting with Transcanada in Glendive; few years ago, well attended by public both for and against. Meeting with County also on Zoning and Planning of Man-Camps

City Reference Spill Response Plan (LEC) - DEQ and EP involved

City received $615k from Bridger from spill for use in designing WTP upgrade

No issues experienced by the city with drought since 1999 Intake upgrade

Did have issue with BNSF rip rap work since that time, clay accumulated on intake screens.

City uses air burst system 5 times per day to clean screen. Also periodically will bring in trailer mounted air compressor to run all the air burst lines at once to clean debris around screens. Impossible for divers to access with river velocity, not able to inspect.

City feels that Bridger treated the spill as very critical and worked to address. Operators of WTP were very appreciative of how everyone worked together to work through the situation.

City have Godwin Trailer mounted pump, irrigation river screen as backup to intake if needed.

City uses a minimum of 300k gallons per day; Distribution system has 2-1M concrete tanks; looking to add more capacity in the near future-elevated 250k in the area north of town/interstate

West Glendive system is separately managed by Dawson Co Public Works; system is served off of wells-may be an option to look at as a backup source; PW director for county is Doug Keiver

Intake Drawings Photos attached; elevations, pumps, capacity location
Intake cost to construct was $1.7M in 1999/2000
Godwin Trailer Pump approximately $50k in 2015

See photos located here:
"F:\Proj\19000\19918\19918.000\Documents\Correspondence\Glendive Photos-11-15-18\Photos"

November 14, 2018

ASRWSS:

- Email to Bob McNally and Rick Kirn (attached Questionnaire and Scope of Work)-Sabrina

Roosevelt County Commissioners:

- Called Lindsey (Administrator) 406-653-6246
- Email to commissioner@rooseveltcounty.org
- Emailed Questions to Lindsey, Gary, Duane, and Gordon and Lindsey will see if they want to line up a meeting or just fill it out.
- **Lindsey called back Commissioner's set up a Special meeting for November 20th at 1:00**

Fort Peck Irrigation District:

- Called Renee Fettig on her cell phone 406-650-6475
- Next Board meeting is **Monday November 19th at 6:00 at the Great Northern Building in Wolf Point** (right behind McDonalds)
- Emailed copy of questions to fpwua@nemont.net and Renee will forward on to board members to review before meeting
- Renee said to call mid-morning on Monday to make sure meeting is still on……sometimes they don't have quorum if members are busy with farming, but she doesn't see a problem this time of year.

Dry Prairie Rural Water:

- Called Joni Sherman the email I sent previously too is no longer in service
- Re-emailed questions to jonidprw@nemont.net
- **Joni does not think the whole board will want to weigh in she said she will review the questions and probably just have Patrick Deering on the phone. She will try to get back to me with a date and time today. She also mentioned that their answers will probably vary from the ASRWSS answers.**

November 13, 2018

ASRWSS:

- Ryan, Trent, and I attended the Board Meeting
- After Several attempts and questions from Mike Watson, Bill Whitehead (Chairman) decided they needed to discuss the questions with their Attorney's and Engineer and we have a tentative meeting scheduled with the ASRWSS board for November 20th at 9:30 in Poplar. Will Coordinate with Thomas (Project Manager) to see if everyone can meet. We got informational copies from Bill Whitehead on the KXL Court Order and a response that they sent in. I will scan and put in Project file.
- Meeting time changed to the 19th at 9:30 am.
- The water board suggested the following be contacted regarding this also:
  - Wiota & Frazer Irrigation System (Fort Peck irrigation)
  - Deanna Hauf – Glendive
  - Norther Plains Resource Council, Olivia Hanah 406-248-1154
  - Land Committee – They meet Wednseday Mornings, Grant Stafne – Chariman
  - Roosevelt County Commissioners
  - Frank Smith – State Representative that lives in Poplar

Town of Culbertson:

- Stopped at the Town Hall the City Clerk was out but the part time secretary gave me her email- Sabrina
- She said best place to catch Mayor is at school
- I talked to Larry Crowder (Mayor) after school; He would like to visit with us and have his city works employee Bob Jasper present; if we do full board they have to post the meeting and invite public. I told him himself and Bob would be the best.
- **Trent and Sabrina will meet with Larry and Bob in Culbertson at Town Hall at 1:00 Friday the 16th.**

Roosevelt County Commissioners:

- Sent Lindsey (Secretary), Duane, Gordon, and Gary (Commissioners) an email with the questions asking if there was a time this week or early next week we could visit with them. I will follow up with phone call.

Fort Peck Irrigators:

- I called Kirk Sibley a landowner that I worked with for easements who is an irrigator over by Wiota. The Wiota and Oswego/Frazer intake are both part of the Fort Peck Irrigators district. There are about 12 members on the board and he thinks they meet next Tuesday.
- Kirk said to call Renee Fettig at 406-650-6475 she is their Administrator and I could set up a time to meet with them through her. He said they all communicate through email through Renee so I told him I would email the questions in advance, so they had time to think about them.

November 12, 2018

ASRWSS:

- Communication with Thomas Bauer 406-650-6698 and board meeting is tomorrow at 9:30
- He will add us to the Agenda

Dry Prairie Rural Water:

- Sent questions and email to dprw@nemontel.net asking to set up a time to meet.

NOVEMBER 7, 2018

ASRWSS Inc.:

- Texted Rick Kirn (Director and TE Council) 406-768-7195

1. Rick thinks they will have a meeting next week Tuesday when everyone is back from San Diego

Culbertson Town Council: Tiffani Transgrud (Clerk) 406-787-5271

- Just had meeting on 11-5-18 won't meet again until 12-3-18
- Larry Crowder – Mayor
- Dave Solem – Council Member
- Bruce Houle – Council Member
- Jamie Green – council Member

Roosevelt County Conservation District: Tiffani Kempton (Administrator) 406-787-5232 X101

- Met Yesterday won't meet again until December
- Gina Snyder – Chairman 406-787-5878

- David Anderson – Supervisor
- Mark Nelson – Supervisor
- Ray Smith – Urban Supervisor
- Michael O'Toole - Supervisor

Dry Prairie Rural Water: Joni Sherman (Project Manager) 406-787-5382

- Just had meeting on November 1st – Joni is in California at Water Conference will be back the 13th

Richland County Conservation District: Julie Goss (Administrator) 406-433-2103

- Julie is out until next Wednesday, Not having a November meeting due to Convention in Billings

Fort Peck Irrigation District: Hubert Wright

Intake Resiliency/Supplemental Risk Analysis/Report
Communication Notes

Date:	Onsite Meeting 11/19/18	**Time:**	9:30 AM MT
Contact Name:	Thomas Bauer (project manager)	**Contact Organization:**	assiniboine & sioux rural water supply system
Contact Phone #:	406-768-5719	**Contact Email:**	tbauer@fortpecktribes.net

Attendance Information	
Name	**Organization**
Colin Nygaard	BW
Ryan Waters	BW
Sabrina Labatte	BW
Thomas Bauer	ASRWSS Project Manager
Bill whitehead	ASRWSS Board Chairman
A. T. Stafne	ASRWSS Commissioner
Rick Kirn	ASRWSS Commissioner
Peter Dupree	ASRWSS Commissioner
Robert McAnally	ASRWSS Commissioner
Mike Watson (by phone)	Tribe Consulting engineer
Majel Russell (by phone)	Elk River Law Firm (Tribe Attorney)

- Watson and Majel started by questioning the study being conducted through the DNRC, and if/how it will overlap with the recently court ordered supplemental EIS. BW responded there may be some overlap, but the DNRC study is gathering feedback from individuals and groups to determine if all water intakes have resiliency in the event of drought or pipeline break for example.
- The ASRWSS questioned what the states jurisdiction would be with Keystone XL as the Environmental review is being handled by the US State Department.
- After a short discussion the Board asked BW to step out so they could conduct an executive session.
- After the executive session, the Board stated they did not want to answer any questions or participate until they more fully understood the purpose of the study and met with the State.
- On behalf of the Water Commission Board - Bob McNally requested the State of Montana (DNRC and Governor's Office) to answer the "Who, what, when, where and why questions" the Tribe has about the study. They want to full understand the intent of the study and how those results are planned to be utilized prior to responding to the questionnaire.
- The ASRWSS is concerned of the politics behind this study, and how it will be used against them in the future.
- The ASRWSS stated their concerns had not been heard and/or addressed up to this point.
- The only action item is Colin would help arrange a meeting between the ASRWSS and the DNRC/State.

Supplemental Risk Analysis/Report
Communication Questions Guide/Notetaking Form

Date:	November 16, 2018	**Time:**	1:00 PM MST
Contact Name:	Bob Jasper, Public Works Director	**Contact Organization:**	Town of Culbertson
Contact Phone #:	(406) 790-1491 (406) 787-5271 office	**Contact Email:**	townclerk@culbertsonmt.com crowderl@nemont.net

Attendance Information	
Name	**Organization**
Larry Crowder	Town of Culbertson - Mayor
Bob Jasper	Town of Culbertson - PWD
Ryan M. Waters	Bartlett & West Inc.
Sabrina Labatte	Bartlett & West Inc.

1. Have you had any discussions with your stakeholders/customers regarding the Keystone XL pipeline river crossings?

   No.

2. Are you aware of the current pipeline route and river crossing types and locations?

   Yes. General pipeline route and that it crossed the Milk and Missouri Rivers in Valley County.

3. Did you have any consultation with Keystone XL? (i.e. Right-of-Ways, NEPA, etc?

   Yes. Discussion with a Keystone Representative about suppling potable water for work force camps during the construction of the pipeline.

4. Do you have any current emergency response plans for drought, spills, or other issues?

   Yes. The Town currently has an emergency response plan in place. They were unsure of the last update to that document.

5. Do you have any future intake/diversion plans?

   No plans to add future intakes or diversions. Dry Red Water has requested possible interim use of the City's water treatment plant and intake to provide water to that system.

6. Do you have any backup or redundant water supplies?

The City has two (2) 10-million-gallon sedimentation ponds upstream of the Water Treatment Plant. In an emergency situation the ponds can be filled to provide system storage of untreated water.

7. Have you experienced ANY water supply issues in the past?

   River intake issues with sedimentation at the intake sites; Ice jams in the spring of the year. The intakes are pulled out until the event passes. The City has two options to divert water from the Missouri River: 1) a fixed intake with screen; gravity operation; this system will only work when the discharge from Fort Peck Reservoir is at or above 9,500 cfs. 2) portable Crisafulli pump.

8. What is your biggest concern regarding the Keystone XL project crossing upstream of your current intake?

   Minorly concerned with a pipeline rupture and being prepared for the emergency response required.

Additional Questions and Miscellaneous Notes:

Favorable of the temporary economical boost it will provide the community during construction and the long-term jobs to operate/maintain the pipeline.

Supplemental Risk Analysis/Report
Communication Questions Guide/Notetaking Form

Date:	November 20, 2018	**Time:**	1:00 PM MST
Contact Name:	Gary MacDonald, Chairman	**Contact Organization:**	Roosevelt County Commissioners
Contact Phone #:	(406) 653-6247	**Contact Email:**	commissioner@rooseveltcounty.org

Attendance Information	
Name	**Organization**
Gary McDonald	Roosevelt Co Commissioner
Gordon Oelkers	Roosevelt Co Commissioner
Duane Nygaard	Roosevelt Co Commissioner
Lindsey McNabb	Roosevelt Co Commissioner – Admin Asst.
Brenda Weeks	MT - State Dept of Revenue
Donna Ruem	Roosevelt Co Attorney – Legal Asst.
Ralph J. Patch	Roosevelt Co Attorney
Corey Ruem	Roosevelt Co Chief Deputy
Bill Suve	County Resident
Clayton Vine	Roosevelt Co GIS Administrator
Ryan M. Waters	Bartlett & West Inc.
Sabrina Labatte	Bartlett & West Inc.

1. Have you had any discussions with your stakeholders/customers regarding the Keystone XL pipeline river crossings?

   No. Explanation was given that the pipeline does not cross Roosevelt County, therefor the need for a Public meeting was not warranted yet at this point. Discussion of possible future public meeting to discuss risks or impacts to Roosevelt County citizens.

2. Are you aware of the current pipeline route and river crossing types and locations?

   Yes. General pipeline route and that it crossed the Milk and Missouri Rivers in Valley County.

3. Did you have any consultation with Keystone XL? (i.e. Right-of-Ways, NEPA, etc?

   No. Individually attended the Public meeting held by Keystone in Valley County.

4. Do you have any current emergency response plans for drought, spills, or other issues?

   Yes. The County currently has an emergency response plan in place: Roosevelt County Emergency Operation Plan (EOP- 2004). The EOP does not address a pipeline spill in to a navigable water way. The County is working with the Montana Liquid and Gas Pipeline

Association to update the EOP to address emergency response to a oil/gas pipeline break. The updated EOP is completed, awaiting public comment before the County Commission adopt.

5. Do you have any future intake/diversion plans?

   No. N/A

6. Do you have any backup or redundant water supplies?

   Yes. The County recognizes the DPRW and ASRWSS as regional water supplier to the County. As DPRW, the County identified backup as follows: Town of Culbertson (1MGD); City of Glasgow; and various small Towns that have ground water wellfields/sources that are now idle after being served by DPRW or ASRWSS.

7. Have you experienced ANY water supply issues in the past?

   River intake issues with sedimentation at the intake sites

8. What is your biggest concern regarding the Keystone XL project crossing upstream of your current intake?

   Pipeline rupture and being prepared for the emergency response required.

   The Study: Blended tar sands oil with Light sweet crude for flowability in the pipeline; the resulting chemical/physical characteristics of this blended oil and how is this being accounted for in the downstream modeling.

   The cost to be proactively prepare for the emergency response
   - ***Cost to purchase and maintain emergency response equipment and supplies***
   - ***Cost to train and maintain certification for an emergency response team***
   - ***Who will be responsible to pay these costs?***

Additional Questions and Miscellaneous Notes:

Pipeline protest (if or when it happens); Who would provide additional law enforcement? Who will pay for the additional law enforcement?

ROOSEVELT COUNTY COMMISSIONERS

GARY MACDONALD, PRESIDING OFFICER
DUANE NYGAARD, MEMBER
GORDON OELKERS, MEMBER

PUBLIC NOTICE
SPECIAL PUBLIC MEETING

WHEN: Tuesday November 20, 2018 at 1:00 P.M.
WHERE: Commissioners Office
400 2nd Ave South
Wolf Point, MT 59201

AGENDA

- **DNRC Supplementary Risk Analysis Communication Questionnaire Report for Keystone Pipeline**

PROCEDURAL RULES FOR PUBLIC MEETINGS

To assure effective participation by all members of the board and to protect the right of participation by all individuals appearing before the board, all meetings and hearings shall be conducted in general conformance with "Roberts Rules of Order Revised," except as otherwise provided by Law.

The following are procedural rules for the Roosevelt County Commissioner's public meetings.

1. The agenda will be as follows: Approval of minutes, Public comment, Administrative Issues, Approval of claims, new hire, Pay raises, and additional administrative issues as needed, new business, old business and Adjourn.
2. The minutes will contain a record of what is required by M.C.A.2-3-212.
3. The board room will not be disturbed; all chairs will remain as positioned so the public will face the Commission.
4. The board recognizes the value of public comment on County issues and the importance of involving members of the public in its meetings. The board also recognizes the public's statutory and constitutional rights to participate in governmental operations. In order to permit fair and orderly expression of such comment, the board will permit public participation through oral or written comments prior to a final decision on a matter or significant interest to the public. The Presiding Officer may control such comment to ensure an orderly progression of the meeting.
5. Individuals wishing to be heard by the board shall first be recognized by the presiding officer. Individuals, after identifying themselves, will proceed to make comments as briefly as the subject permits. The presiding officer may interrupt or terminate an individual's statement when statements are out of order, too lengthy, personally directed, abusive, obscene, or irrelevant. The board as a whole shall have the final decision in determining the appropriateness of all such rulings. Members of the public shall be recognized and allowed input during the meeting, at the discretion of the board.

Supplemental Risk Analysis/Report
Communication Questions Guide/Notetaking Form

Date:	November 20, 2018	**Time:**	9:30 PM MST
Contact Name:	Joni Sherman, Manager	**Contact Organization:**	Dry Prairie Rural Water
Contact Phone #:	(406) 787-5382	**Contact Email:**	jonidprw@nemont.net

Attendance Information	
Name	**Organization**
Joni Sherman	Dry Prairie Rural Water - Manager
Ryan M. Waters	Bartlett & West Inc.
Sabrina Labatte	Bartlett & West Inc.

1. Have you had any discussions with your stakeholders/customers regarding the Keystone XL pipeline river crossings?

   No, except for contact with landowners in Valley County where the existing water lines were lowered to accommodate the installation of the Keystone Pipeline. (pipeline crossings)

2. Are you aware of the current pipeline route and river crossing types and locations?

   Yes. General pipeline route and that it crossed the Milk and Missouri Rivers in Valley County.

3. Did you have any consultation with Keystone XL? (i.e. Right-of-Ways, NEPA, etc?

   Yes. Consultation with Keystone to address proposed pipeline crossings. Formal crossing agreement to be executed after the completion of construction activities.

4. Do you have any current emergency response plans for drought, spills, or other issues?

   Yes. Dry Prairie Rural Water (DPRW) currently has an emergency response plan in place. The Emergency Response Plan was prepared by the MT DEQ and jointly adopted by DPRW and ASRWSS. No emergency response plan or section specific to the Keystone Pipeline.

5. Do you have any future intake/diversion plans?

   No. System water is purchased from ASRWSS.

6. Do you have any backup or redundant water supplies?

   DPRW identified backup as follows: Town of Culbertson (1MGD); City of Glasgow; Marco (old Air Force Base) and various small Towns that have ground water wellfields/sources that are now idle after being served by DPRW. These water sources potentially could be used if absolutely needed.

7. Have you experienced ANY water supply issues in the past?

   No.

8. What is your biggest concern regarding the Keystone XL project crossing upstream of your current intake?

   Pipeline rupture and being prepared for the emergency response required.

Additional Questions and Miscellaneous Notes:

None.

Supplemental Risk Analysis/Report
Communication Questions Guide/Notetaking Form

Date:	November 27, 2018	**Time:**	3:00 PM MST
Contact Name:	James Brower, Manager Bill Hamburg, Asst Mgr.	**Contact Organization:**	Lower Yellowstone Irrigation District
Contact Phone #:	(406) 478-4502 JB (406) 489-3318 BH	**Contact Email:**	Jbrower@midrivers.com

Attendance Information	
Name	**Organization**
James Brower	LYID
Ryan M. Waters	Bartlett & West Inc.

1. Have you had any discussions with your stakeholders/customers regarding the Keystone XL pipeline river crossings?

   No. LYID plans to notify the irrigators prior to Keystone construction activities to cross the Yellowstone River.

2. Are you aware of the current pipeline route and river crossing types and locations?

   Yes. General pipeline route and that it crossed the Milk and Missouri Rivers in Valley County; and the Yellowstone River in Dawson County.

3. Did you have any consultation with Keystone XL? (i.e. Right-of-Ways, NEPA, etc?

   No.

4. Do you have any current emergency response plans for drought, spills, or other issues?

   Not currently, but LYID is interested and recognizes the need to develop an emergency response plan for a spill or other emergency events that would impact delivery of water to its stakeholders. To date LYID has relied on long-time experienced staff to address emergency situations.

5. Do you have any future intake/diversion plans?

   Yes. Fish Bypass Project; Construction to begin the Spring of 2019.

6. Do you have any backup or redundant water supplies?

   No. The LYID does have fixed intake locations that provide supplemental water to the irrigation system. Portable pumps are used to lift the water to the existing canals; these fixed

intake locations are located on both the Missouri and Yellowstone Rivers. (SEE ATTACHED MAP)

7. Have you experienced ANY water supply issues in the past?

   Yes. Drought or low river flows.

8. What is your biggest concern regarding the Keystone XL project crossing upstream of your current intake?

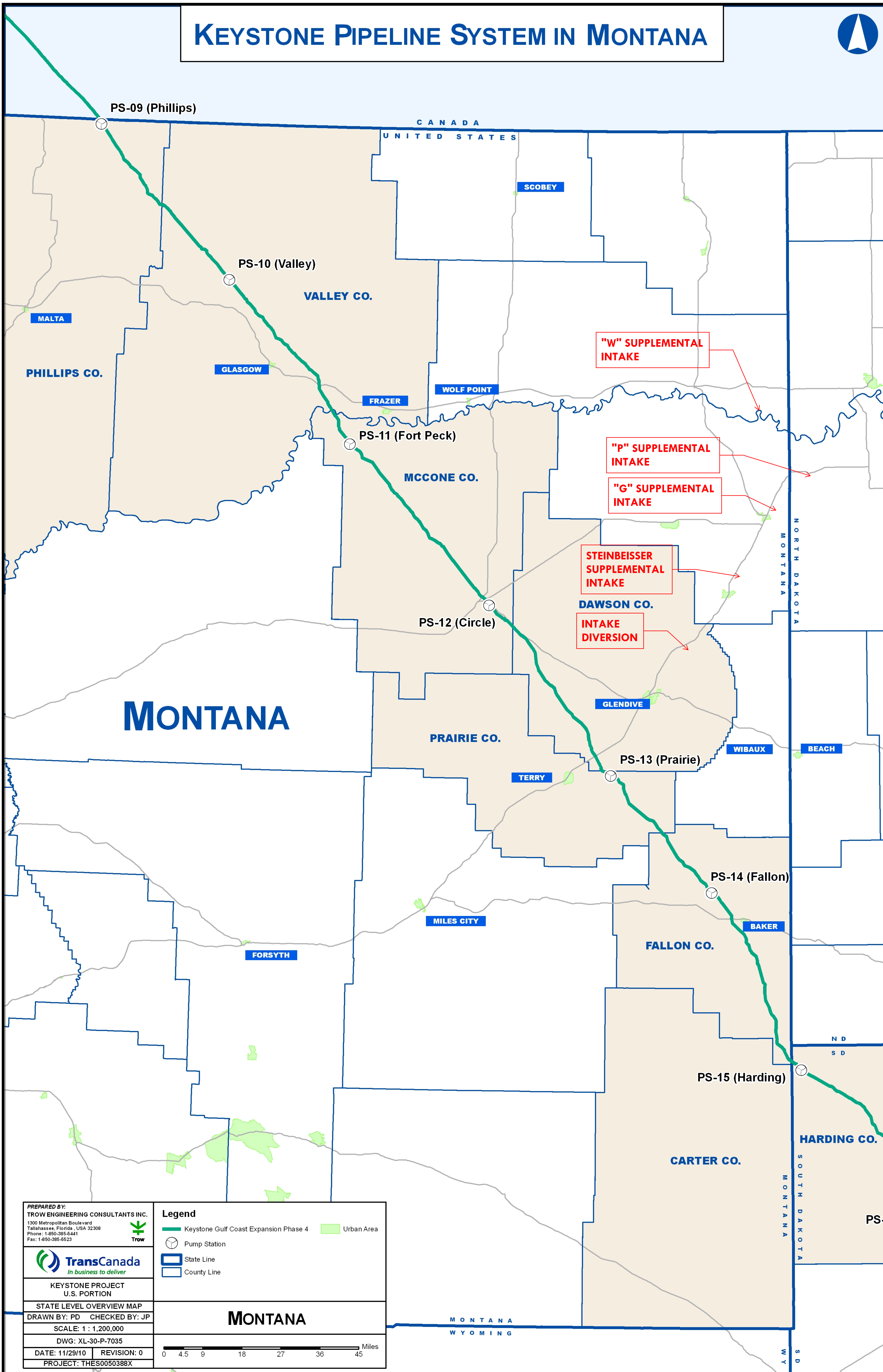
   Are there environmental impacts to the irrigation districts if there is a spill, if so what are they?

   Pipeline rupture and being prepared for the emergency response required.

   Sufficient lead time in notification of a leak to allow the District to shut down the intake facility. The intake shut down requires 4 days (preferable 10 days) to safely/slowly close the diversion gates to protect the structural integrity of the earthen embankments. Immediate shut down is not an option for the District. The following writeup was provided:
   "Immediate shut down: This scenario would create a rapid drawdown condition on the banks of the earthen canals within this system as water drains out of the canal system. The drawdown condition results in a reduced slope stability, which occurs when submerged slopes experience a reduction of the external water level in a short timeframe."

Additional Questions and Miscellaneous Notes:

If a spill did negatively impact LYIP acreage, would Keystone Pipeline reimburse crop yield reductions, loss of production costs and direct labor to respond to the spill?



KEYSTONE PIPELINE SYSTEM IN MONTANA
PS-09 (Phillips)
CANADA
UNITED STATES
SCOBEY
PS-10 (Valley)
VALLEY CO.
MALTA
PHILLIPS CO.
GLASGOW
"W" SUPPLEMENTAL INTAKE
FRAZER
WOLF POINT
PS-11 (Fort Peck)
"P" SUPPLEMENTAL INTAKE
MCCONE CO.
"G" SUPPLEMENTAL INTAKE
NORTH DAKOTA
MONTANA
STEINBEISSER SUPPLEMENTAL INTAKE
DAWSON CO.
PS-12 (Circle)
INTAKE DIVERSION
MONTANA
GLENDIVE
PRAIRIE CO.
WIBAUX
BEACH
PS-13 (Prairie)
TERRY
PS-14 (Fallon)
MILES CITY
BAKER
FORSYTH
FALLON CO.
ND
SD
PS-15 (Harding)
HARDING CO.
CARTER CO.
SOUTH DAKOTA
MONTANA
PS-1
PREPARED BY:
TROW ENGINEERING CONSULTANTS INC.
1300 Metropolitan Boulevard
Tallahassee, Florida , USA 32308
Phone: 1-850-385-5441
Fax: 1-850-385-5523
Trow
TransCanada
In business to deliver
KEYSTONE PROJECT
U.S. PORTION
STATE LEVEL OVERVIEW MAP
DRAWN BY: PD CHECKED BY: JP
SCALE: 1 : 1,200,000
DWG: XL-30-P-7035
DATE: 11/29/10 REVISION: 0
PROJECT: THES0050388X
Legend
Keystone Gulf Coast Expansion Phase 4
Urban Area
Pump Station
State Line
County Line
MONTANA
0 4.5 9 18 27 36 45 Miles
MONTANA
WYOMING
WY
SD

12/19/2018
Call with Laura Alvy from MT DEQ

What contaminants they were testing?

Testing for a variety. Initially looking at all the things present in crude oil (metals, pHs, VOCs). Once established that metals weren't a concern, focus shifted to VOCs and SVOCs. Anaylze by a variety of methods depending on detection limit.

What equipment they were using for the testing?

Samples were collected down in the river lower down – weighted column that is dropped down to desired depth and at the right depth the mechanism snaps shut. Out on boats for a lot of the testing.

Surface water collected right into the laboratory supplied container.

Testing Frequency?

Initially after spill 1-2 a day, a number of stations along the river. When the release happened the river was completely frozen over- they had to drill holes through the ice and take samples through the holes. Samples collected through the glendive public water supply. Not sure the tools they were using.

Groundwater and sediment sampling was also done. Groundwater sampling at water wells along the river.

Sampling after ice melted off. The summer of 2015 they came back and did another sampling event up and down the river where they collected sediment and surface water.

How successful were the tests?

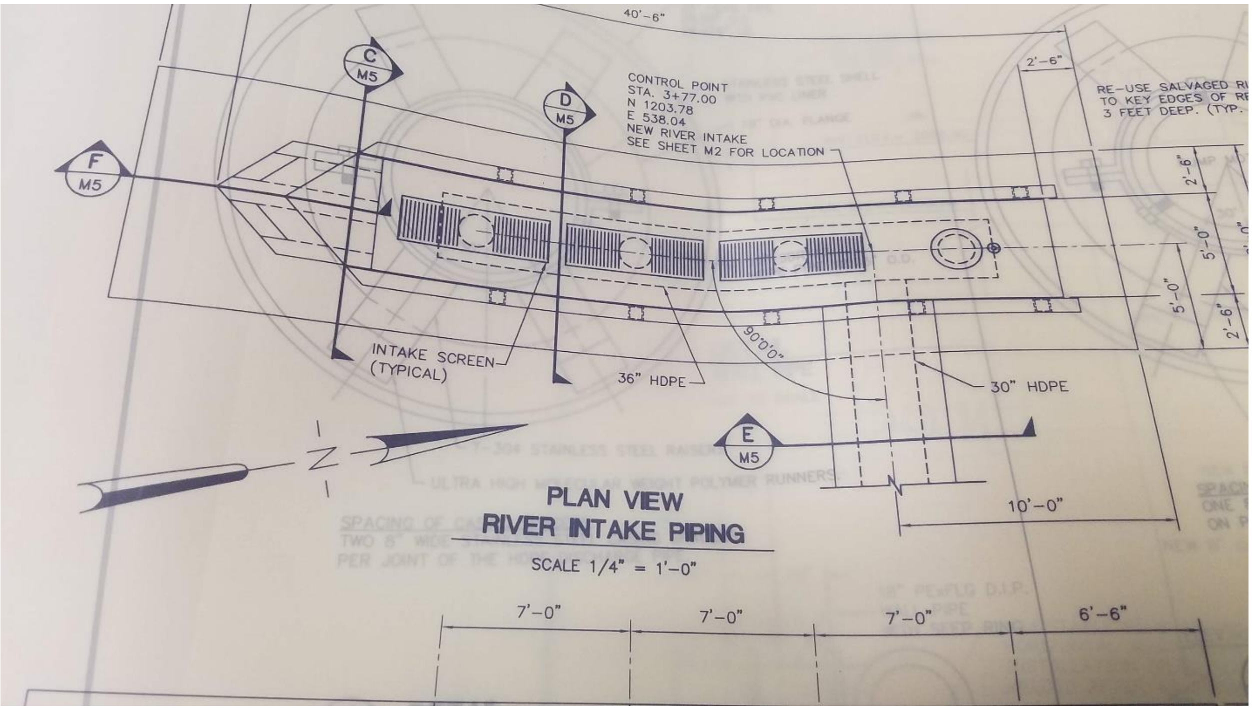
The sampling was successful- based on common sense weren't expecting there to be contaminents to be coming from the spill itself in July. During summer sampling found detections of pHs but doesn't think that was attributing to boat use- hard to say that the detections were attributable to spill or to boating or other factors. Recommend to someone doing that type of sampling to have a good program in place to quantify what is in background and what is coming from other sources- when detection limits are so low- need background samples to compare to.

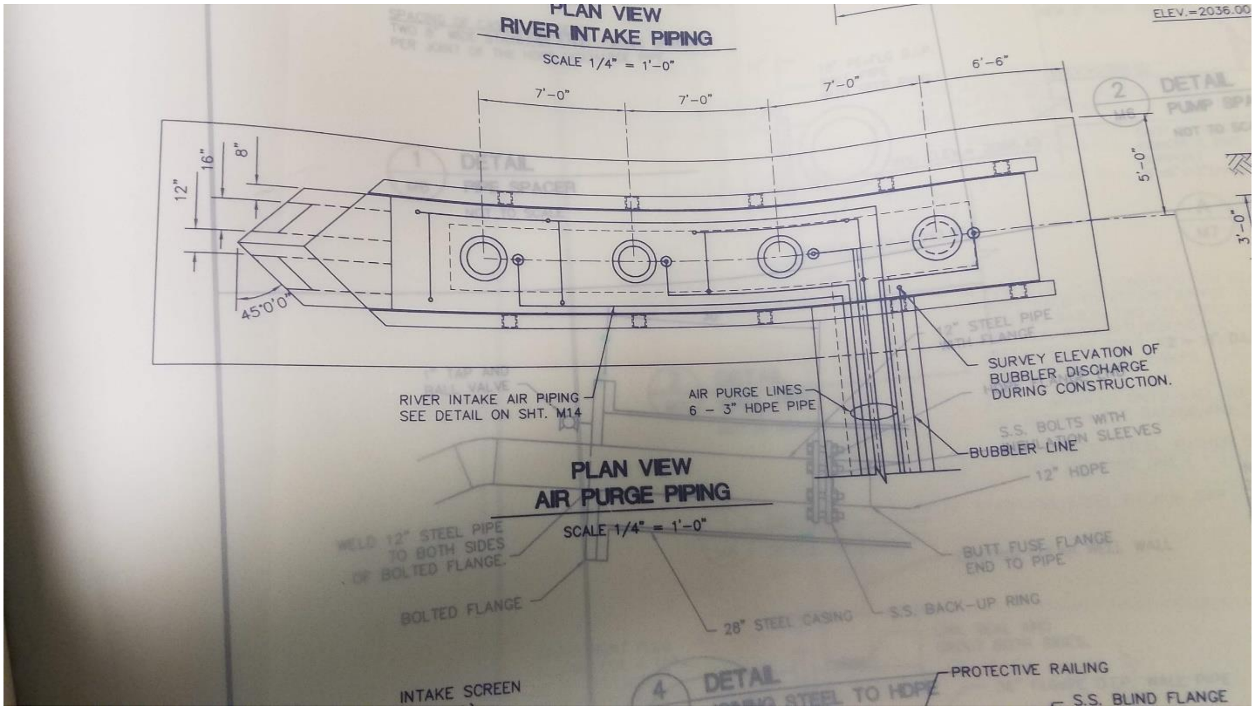
When they were doing blanks as QAQC – equipment rinsate blanks and there was detection of petroleum hydrocarbons showing up but because they were not using lab supplied distilled water- grocery store water- it wasn't clear where they were coming from. Do a good job planning QAQC especially when looking for things at such low concentrations that any little thing can throw you off .

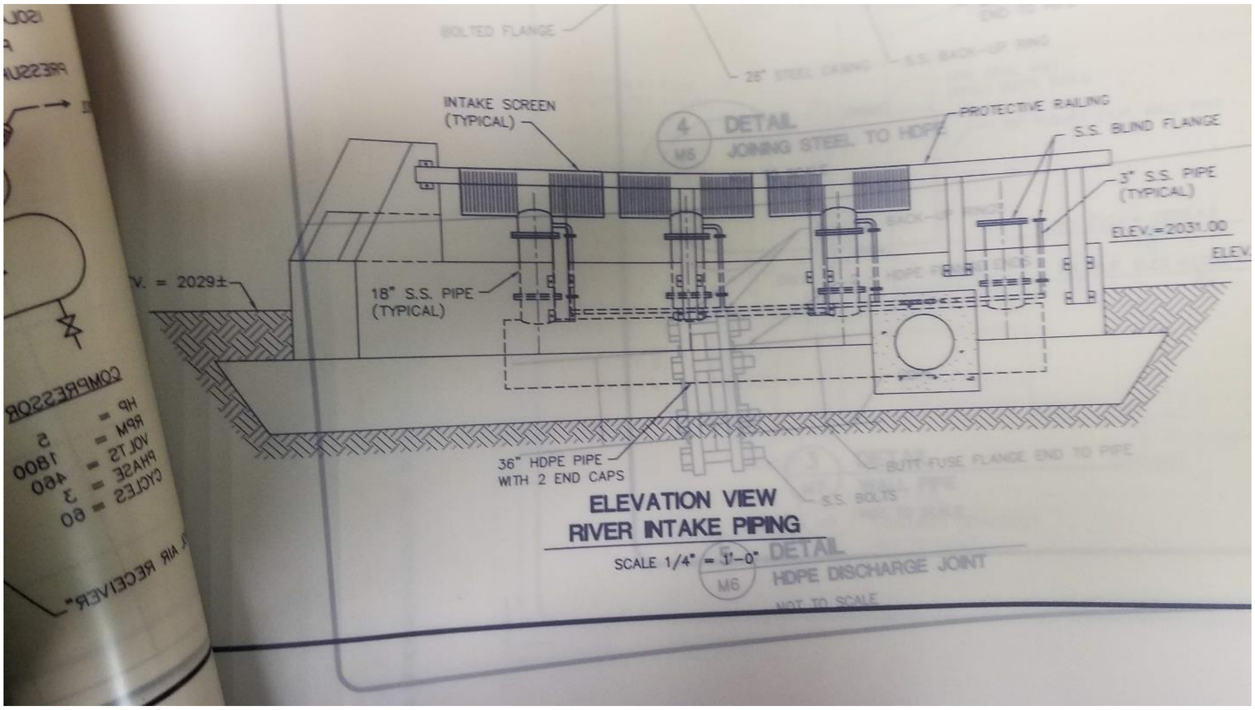
APPENDIX C

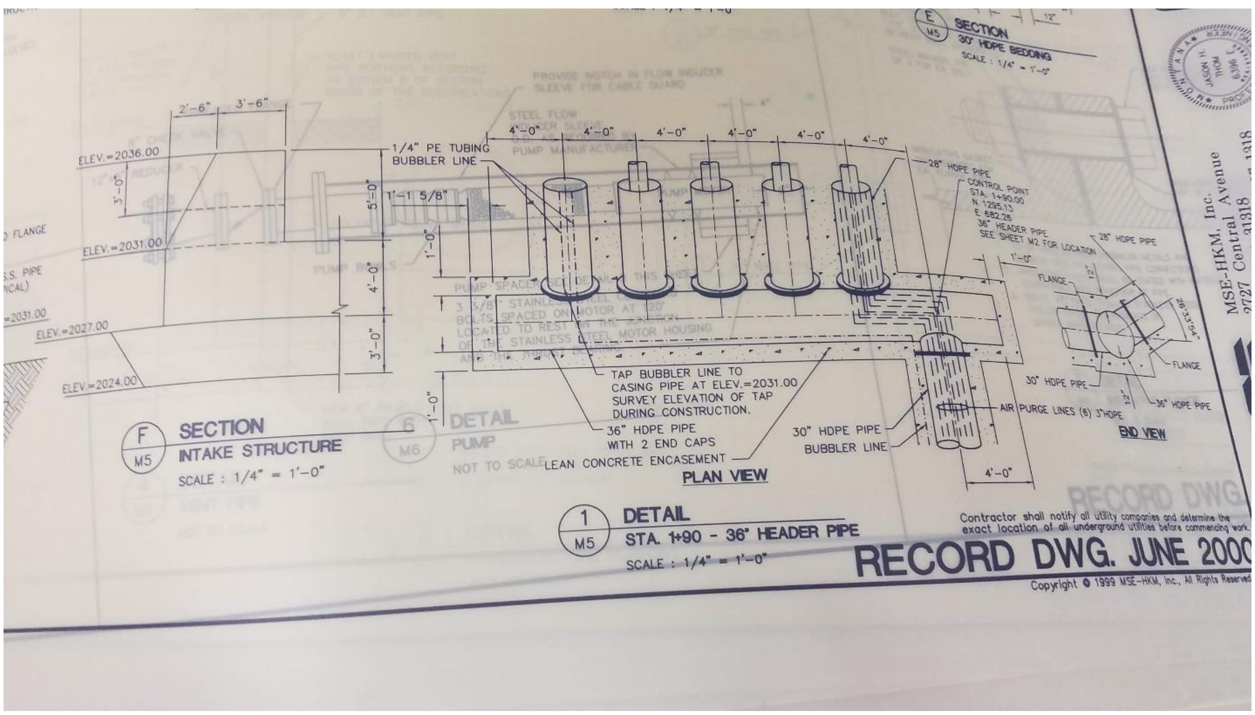
Glendive Site Photos & Record Drawings

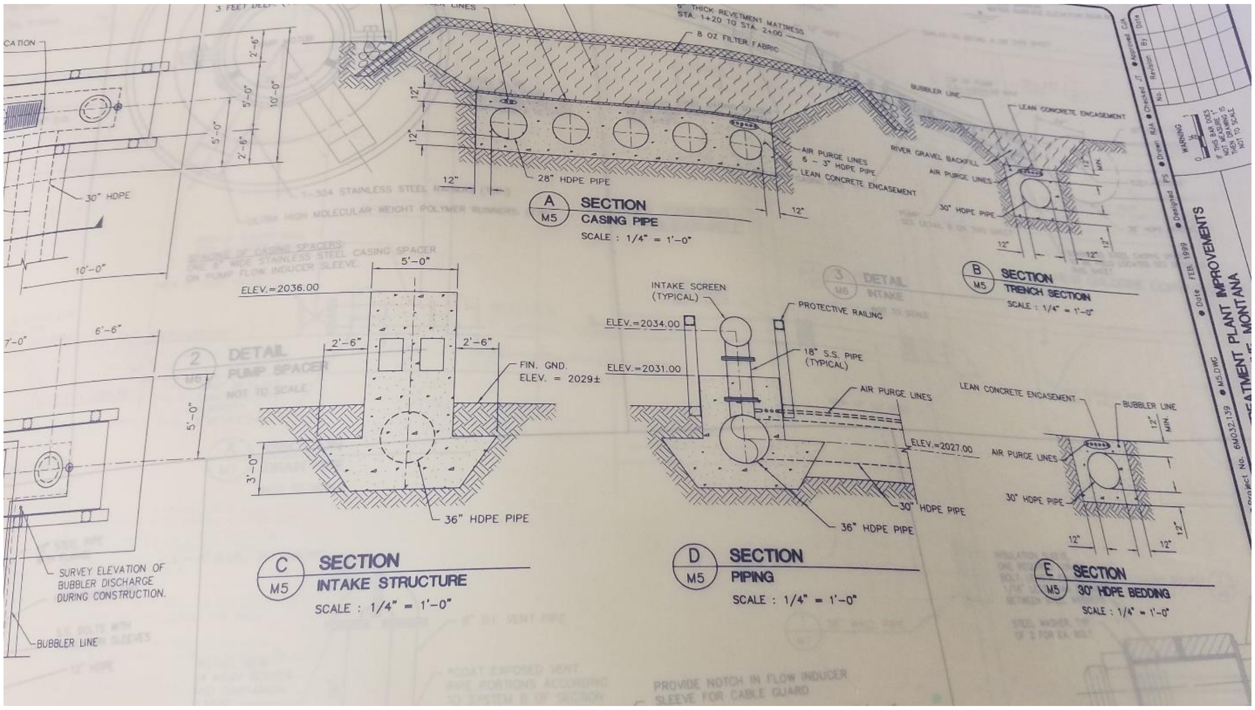
GLENDIVE INTAKE PHOTOS

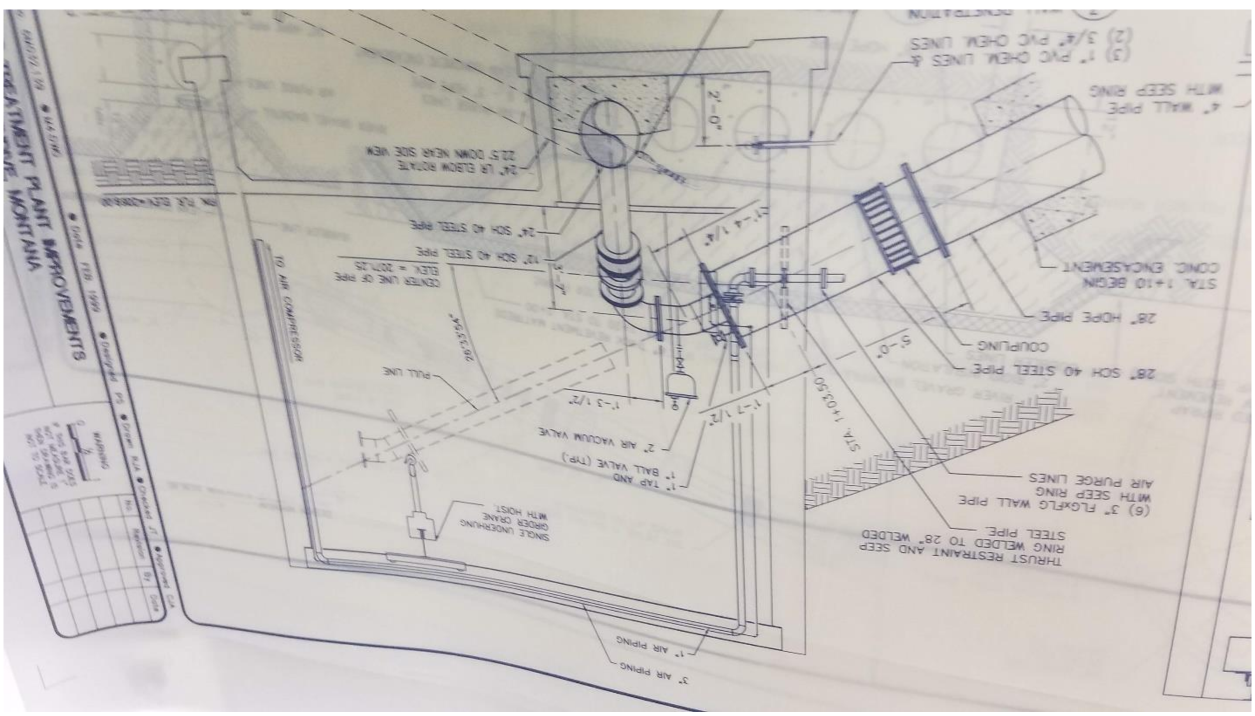


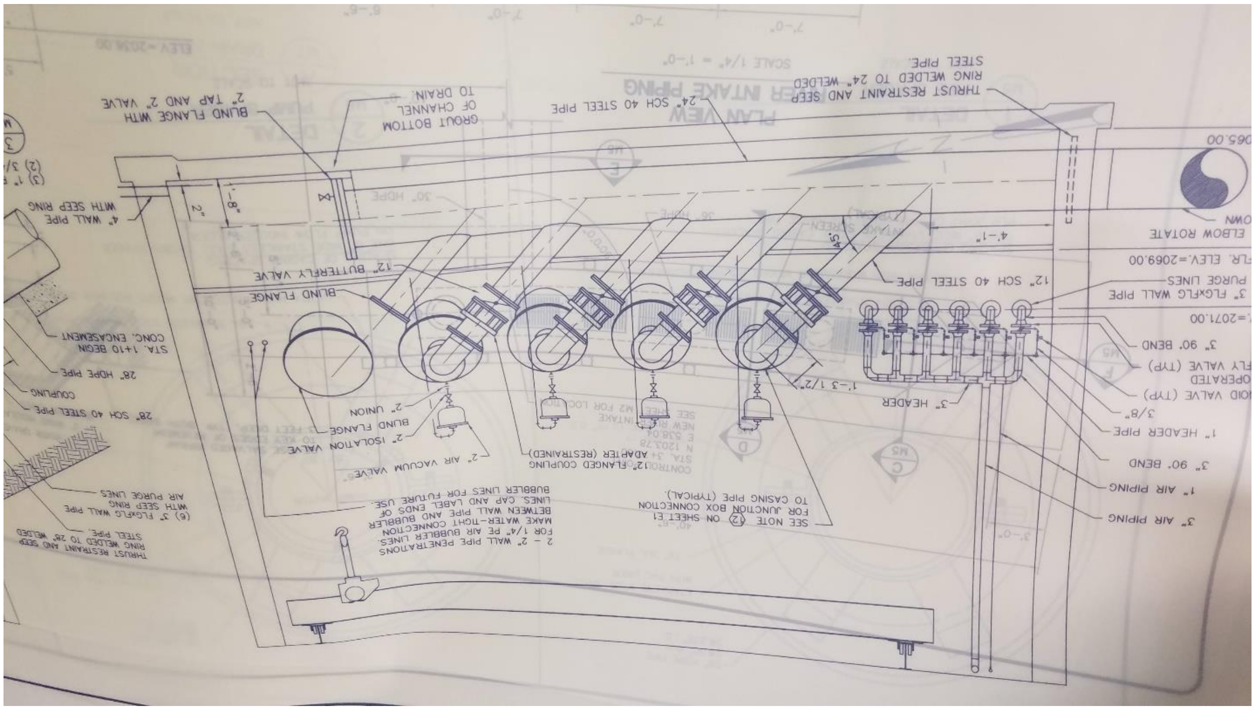



INTAKE SCREEN
(TYPICAL)
PROTECTIVE RAILING
S.S. BLIND FLANGE
3" S.S. PIPE
(TYPICAL)
ELEV.=2031.00
18" S.S. PIPE
(TYPICAL)
36" HDPE PIPE
WITH 2 END CAPS
ELEVATION VIEW
RIVER INTAKE PIPING
SCALE 1/4" = 1'-0"
HP = 5
RPM = 1800
VOLTS = 460
PHASE = 3
CYCLES = 60
COMPRESSOR

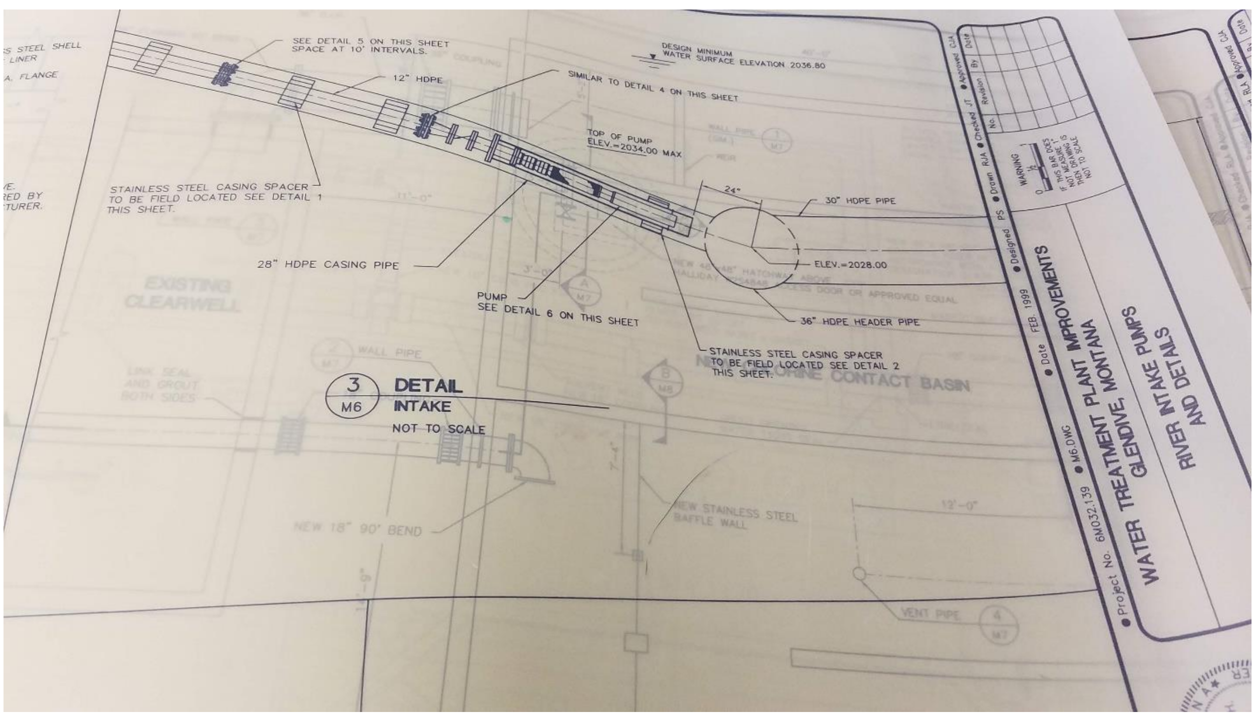

SECTION
30" HDPE BEDDING
ELEV.=2036.00
ELEV.=2031.00
ELEV.=2027.00
ELEV.=2024.00
1/4" PE TUBING
BUBBLER LINE
28" HDPE PIPE
CONTROL POINT
STA. 1+90.00
36" HEADER PIPE
SEE SHEET M2 FOR LOCATION
TAP BUBBLER LINE TO
CASING PIPE AT ELEV.=2031.00
SURVEY ELEVATION OF TAP
DURING CONSTRUCTION.
36" HDPE PIPE
WITH 2 END CAPS
LEAN CONCRETE ENCASEMENT
30" HDPE PIPE
BUBBLER LINE
AIR PURGE LINES (6) 3"HDPE
PLAN VIEW
END VIEW
SECTION
INTAKE STRUCTURE
SCALE : 1/4" = 1'-0"
DETAIL
PUMP
NOT TO SCALE
DETAIL
STA. 1+90 - 36" HEADER PIPE
SCALE : 1/4" = 1'-0"
Contractor shall notify all utility companies and determine the exact location of all underground utilities before commencing work.
RECORD DWG. JUNE 2000
Copyright © 1999 MSE-HKM, Inc., All Rights Reserved
MSE-HKM, Inc.


6" THICK REVETMENT MATTRESS STA. 1+20 TO STA. 2+00
8 OZ FILTER FABRIC
28" HDPE PIPE
AIR PURGE LINES 6 - 3" HDPE PIPE
LEAN CONCRETE ENCASEMENT
A M5 SECTION CASING PIPE
SCALE : 1/4" = 1'-0"
BUBBLER LINE
LEAN CONCRETE ENCASEMENT
RIVER GRAVEL BACKFILL
AIR PURGE LINES
30" HDPE PIPE
B M5 SECTION TRENCH SECTION
SCALE : 1/4" = 1'-0"
30" HDPE
ELEV.=2036.00
FIN. GND. ELEV. = 2029±
36" HDPE PIPE
C M5 SECTION INTAKE STRUCTURE
SCALE : 1/4" = 1'-0"
INTAKE SCREEN (TYPICAL)
PROTECTIVE RAILING
ELEV.=2034.00
ELEV.=2031.00
18" S.S. PIPE (TYPICAL)
AIR PURGE LINES
ELEV.=2027.00
30" HDPE PIPE
36" HDPE PIPE
D M5 SECTION PIPING
SCALE : 1/4" = 1'-0"
LEAN CONCRETE ENCASEMENT
BUBBLER LINE
AIR PURGE LINES
30" HDPE PIPE
E M5 SECTION 30" HDPE BEDDING
SCALE : 1/4" = 1'-0"
SURVEY ELEVATION OF BUBBLER DISCHARGE DURING CONSTRUCTION.
BUBBLER LINE
TREATMENT PLANT IMPROVEMENTS
MONTANA
FEB. 1999

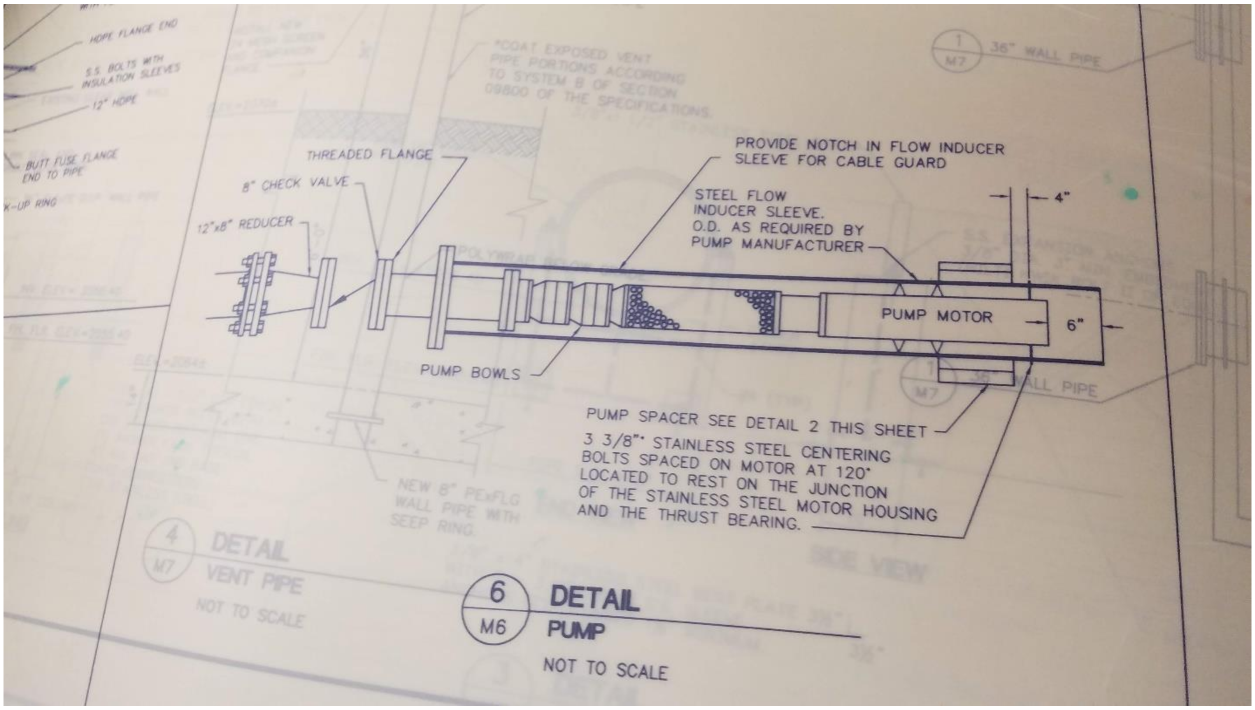

(3) 1" PVC CHEM LINES
(2) 3/4" PVC CHEM LINES
4" WALL PIPE WITH SEEP RING
24" LR ELBOW ROTATE 22.5° DOWN NEAR SIDE VIEW
24" SCH 40 STEEL PIPE
12" SCH 40 STEEL PIPE
STA. 1+10 BEGIN CONC. ENCASEMENT
28" HDPE PIPE
COUPLING
28" SCH 40 STEEL PIPE
2" AIR VACUUM VALVE
1" TAP AND 1" BALL VALVE (TYP.)
PULL LINE
TO AIR COMPRESSOR
(6) 3" FLGxFLG WALL PIPE WITH SEEP RING AIR PURGE LINES
THRUST RESTRAINT AND SEEP RING WELDED TO 28" WELDED STEEL PIPE.
SINGLE UNDERHUNG GIRDER CRANE WITH HOIST
1" AIR PIPING
3" AIR PIPING
TREATMENT PLANT IMPROVEMENTS
MONTANA
FEB. 1999

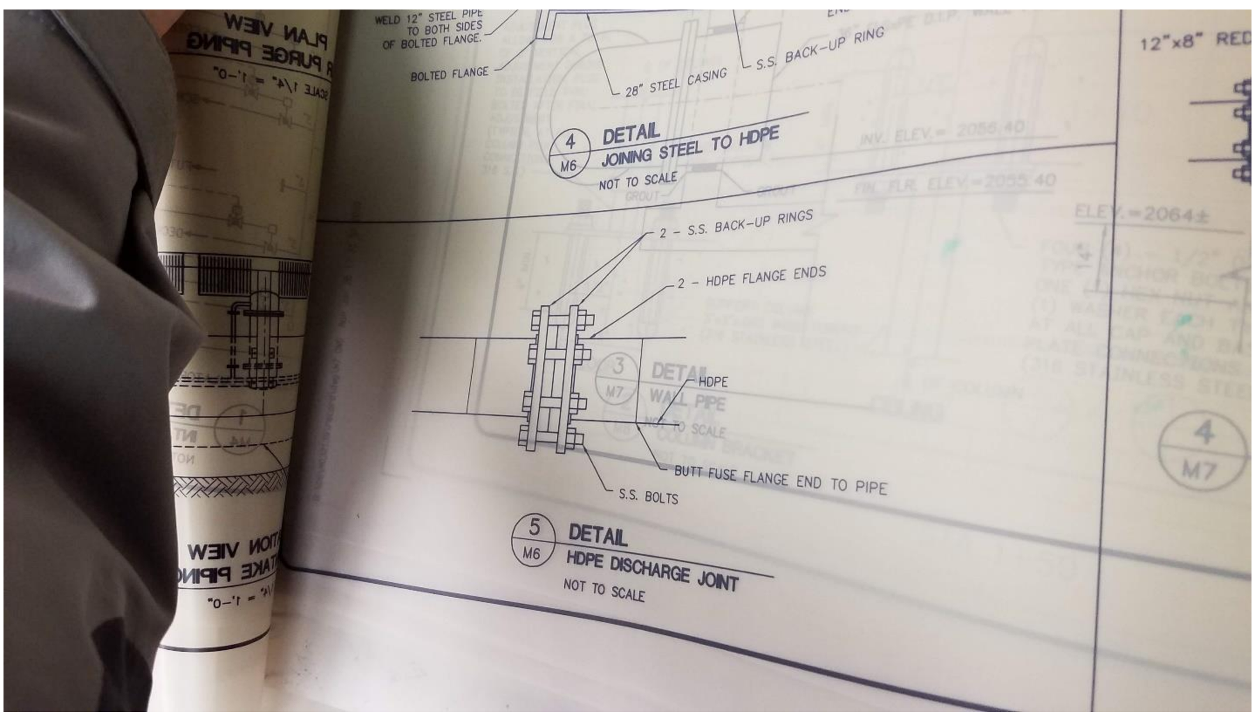


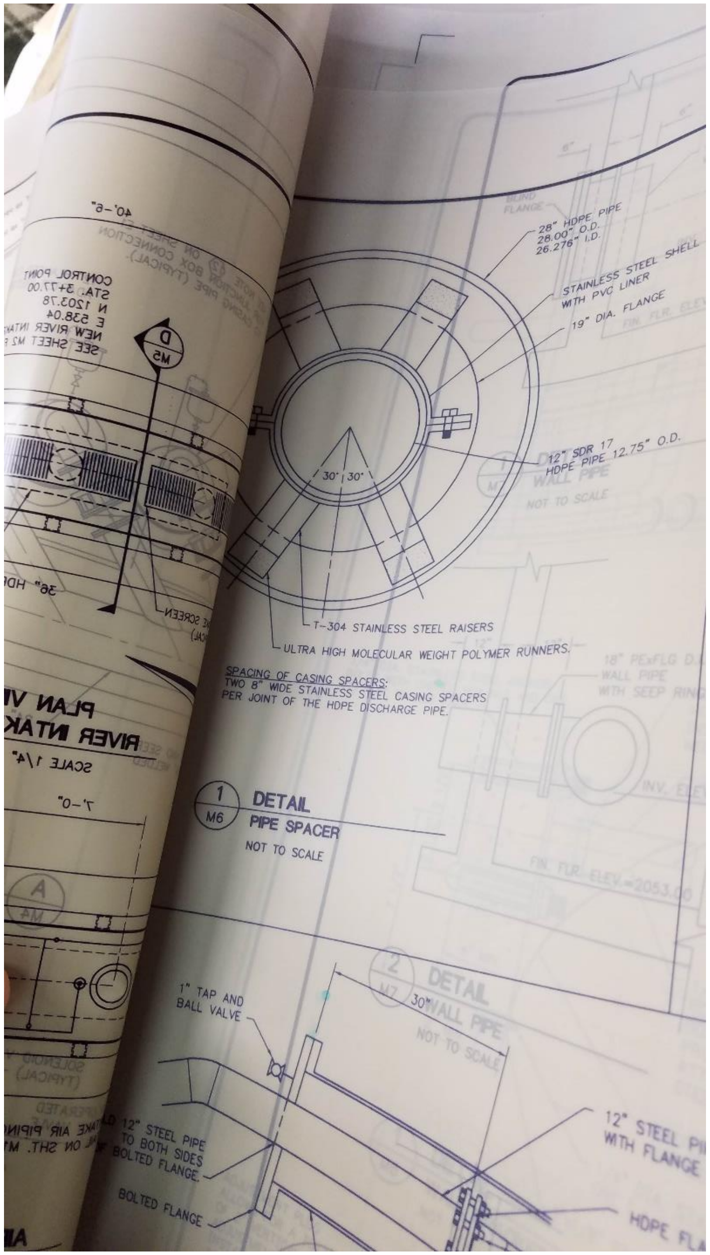
BLIND FLANGE WITH 2" TAP AND 2" VALVE
GROUT BOTTOM OF CHANNEL TO DRAIN
24" SCH 40 STEEL PIPE
THRUST RESTRAINT AND SEEP RING WELDED TO 24" WELDED STEEL PIPE
4" WALL PIPE WITH SEEP RING
12" BUTTERFLY VALVE
BLIND FLANGE
12" SCH 40 STEEL PIPE
3" FLGxFLG WALL PIPE PURGE LINES
3" 90° BEND
1" HEADER PIPE
3" HEADER
1" AIR PIPING
3" AIR PIPING
2" UNION
BLIND FLANGE
2" ISOLATION VALVE
2" AIR VACUUM VALVE
12" FLANGED COUPLING ADAPTER (RESTRAINED)
SEE NOTE 12 ON SHEET E1 FOR JUNCTION BOX CONNECTION TO CASING PIPE (TYPICAL)
2 - 2" WALL PIPE PENETRATIONS FOR 1/4" PE AIR BUBBLER LINES. MAKE WATER-TIGHT CONNECTION BETWEEN WALL PIPE AND BUBBLER LINES. CAP AND LABEL ENDS OF BUBBLER LINES FOR FUTURE USE
(6) 3" FLGxFLG WALL PIPE WITH SEEP RING AIR PURGE LINES
THRUST RESTRAINT AND SEEP RING WELDED TO 28" WELDED STEEL PIPE
28" SCH 40 STEEL PIPE
COUPLING
28" HDPE PIPE
STA. 1+10 BEGIN CONC. ENCASEMENT

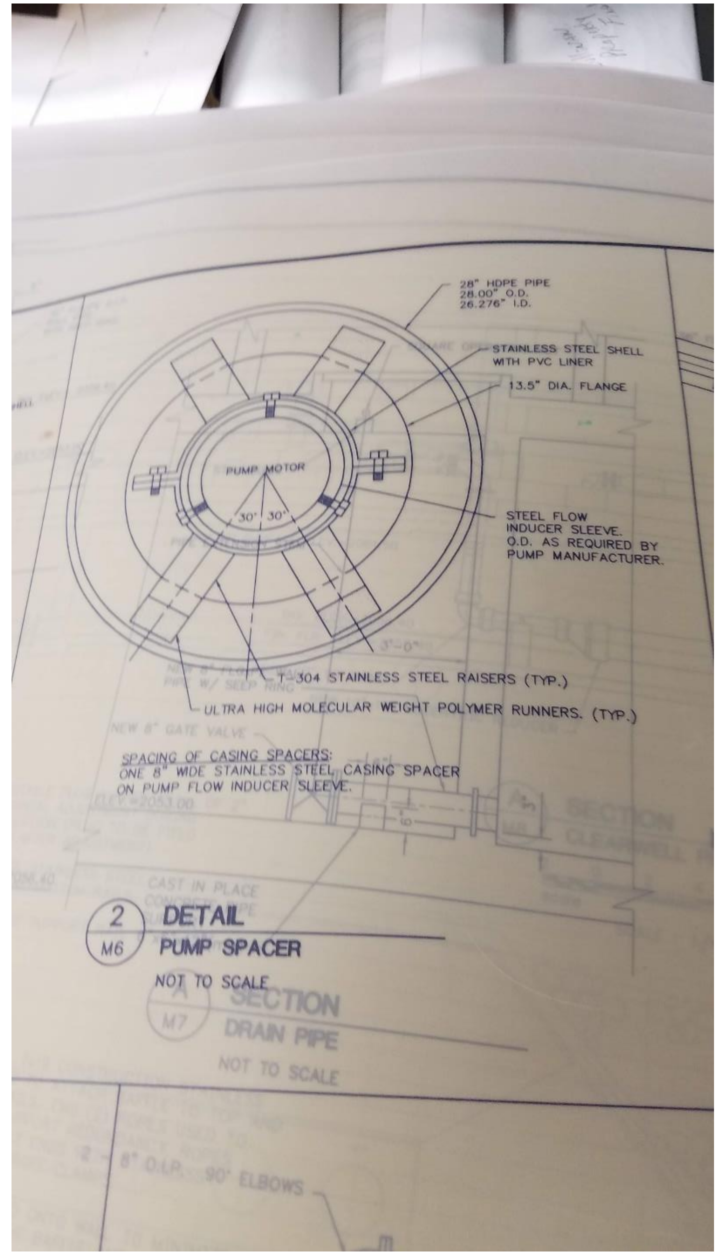


SEE DETAIL 5 ON THIS SHEET SPACE AT 10' INTERVALS.
12" HDPE
SIMILAR TO DETAIL 4 ON THIS SHEET
DESIGN MINIMUM WATER SURFACE ELEVATION 2036.80
TOP OF PUMP ELEV.=2034.00 MAX
STAINLESS STEEL CASING SPACER TO BE FIELD LOCATED SEE DETAIL 1 THIS SHEET.
24"
30" HDPE PIPE
ELEV.=2028.00
28" HDPE CASING PIPE
PUMP SEE DETAIL 6 ON THIS SHEET
36" HDPE HEADER PIPE
STAINLESS STEEL CASING SPACER TO BE FIELD LOCATED SEE DETAIL 2 THIS SHEET.
3
M6
DETAIL
INTAKE
NOT TO SCALE
Project No. 6M032.139
M6.DWG
Date FEB. 1999
Designed PS
Drawn RJA
Checked JT
WATER TREATMENT PLANT IMPROVEMENTS
GLENDIVE, MONTANA
RIVER INTAKE PUMPS AND DETAILS


PROVIDE NOTCH IN FLOW INDUCER SLEEVE FOR CABLE GUARD
THREADED FLANGE
8" CHECK VALVE
12"x8" REDUCER
STEEL FLOW INDUCER SLEEVE. O.D. AS REQUIRED BY PUMP MANUFACTURER
4"
PUMP MOTOR
6"
PUMP BOWLS
PUMP SPACER SEE DETAIL 2 THIS SHEET
3 3/8" STAINLESS STEEL CENTERING BOLTS SPACED ON MOTOR AT 120° LOCATED TO REST ON THE JUNCTION OF THE STAINLESS STEEL MOTOR HOUSING AND THE THRUST BEARING.
36" WALL PIPE
6
M6
DETAIL
PUMP
NOT TO SCALE

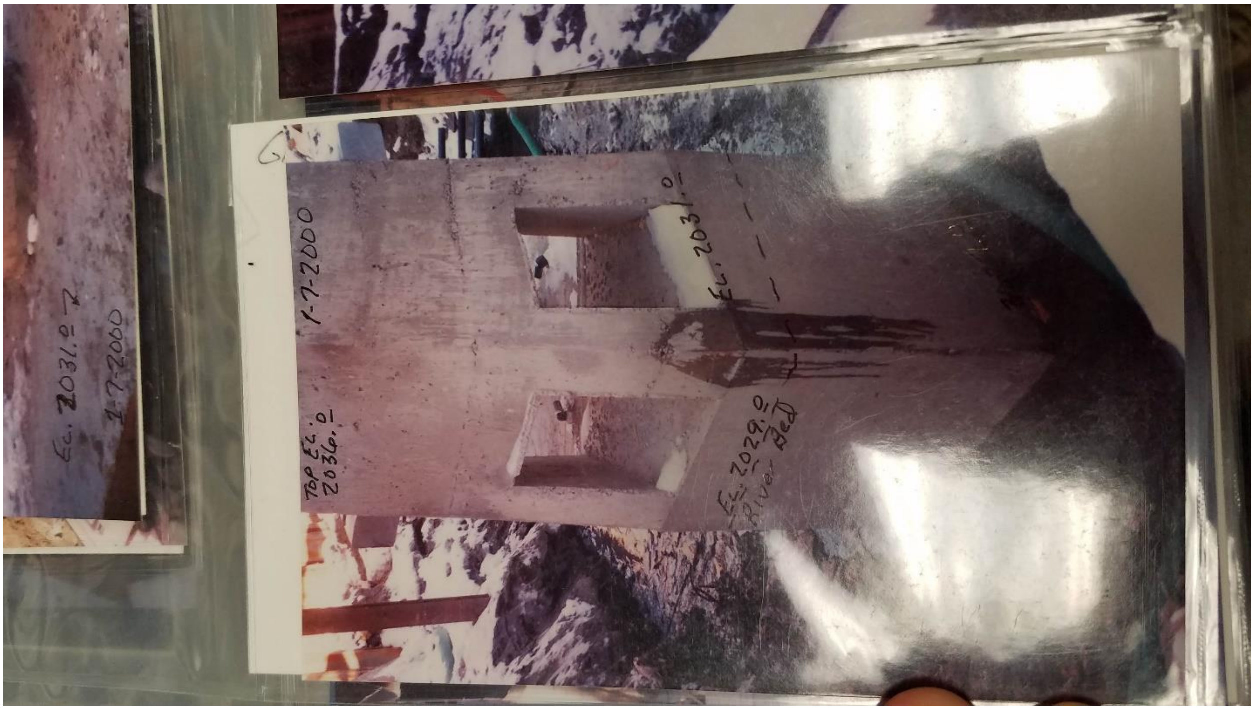

WELD 12" STEEL PIPE TO BOTH SIDES OF BOLTED FLANGE.
BOLTED FLANGE
28" STEEL CASING
S.S. BACK-UP RING
4
M6
DETAIL
JOINING STEEL TO HDPE
NOT TO SCALE
2 - S.S. BACK-UP RINGS
2 - HDPE FLANGE ENDS
HDPE
BUTT FUSE FLANGE END TO PIPE
S.S. BOLTS
5
M6
DETAIL
HDPE DISCHARGE JOINT
NOT TO SCALE
12"x8" RED


28" HDPE PIPE
28.00" O.D.
26.276" I.D.
STAINLESS STEEL SHELL
WITH PVC LINER
19" DIA. FLANGE
12" SDR 17
HDPE PIPE 12.75" O.D.
30° 30°
T-304 STAINLESS STEEL RAISERS
ULTRA HIGH MOLECULAR WEIGHT POLYMER RUNNERS.
SPACING OF CASING SPACERS:
TWO 8" WIDE STAINLESS STEEL CASING SPACERS
PER JOINT OF THE HDPE DISCHARGE PIPE.
1
M6
DETAIL
PIPE SPACER
NOT TO SCALE
40'-6"
CONTROL POINT
STA. 3+77.00
N 1203.78
E 538.04
7'-0"
1" TAP AND
BALL VALVE
12" STEEL PIPE
TO BOTH SIDES
BOLTED FLANGE
BOLTED FLANGE
12" STEEL PIPE
WITH FLANGE


28" HDPE PIPE
28.00" O.D.
26.276" I.D.
STAINLESS STEEL SHELL
WITH PVC LINER
13.5" DIA. FLANGE
PUMP MOTOR
30° 30°
STEEL FLOW
INDUCER SLEEVE.
O.D. AS REQUIRED BY
PUMP MANUFACTURER.
T-304 STAINLESS STEEL RAISERS (TYP.)
ULTRA HIGH MOLECULAR WEIGHT POLYMER RUNNERS. (TYP.)
SPACING OF CASING SPACERS:
ONE 8" WIDE STAINLESS STEEL CASING SPACER
ON PUMP FLOW INDUCER SLEEVE.
2
M6
DETAIL
PUMP SPACER
NOT TO SCALE


#3
1-7-2000


1-7-2000
4


EL. 2031.0
1-7-2000
TOP EL. 2036.0
1-7-2000
EL. 2031.0
EL. 2029.0
River Bed

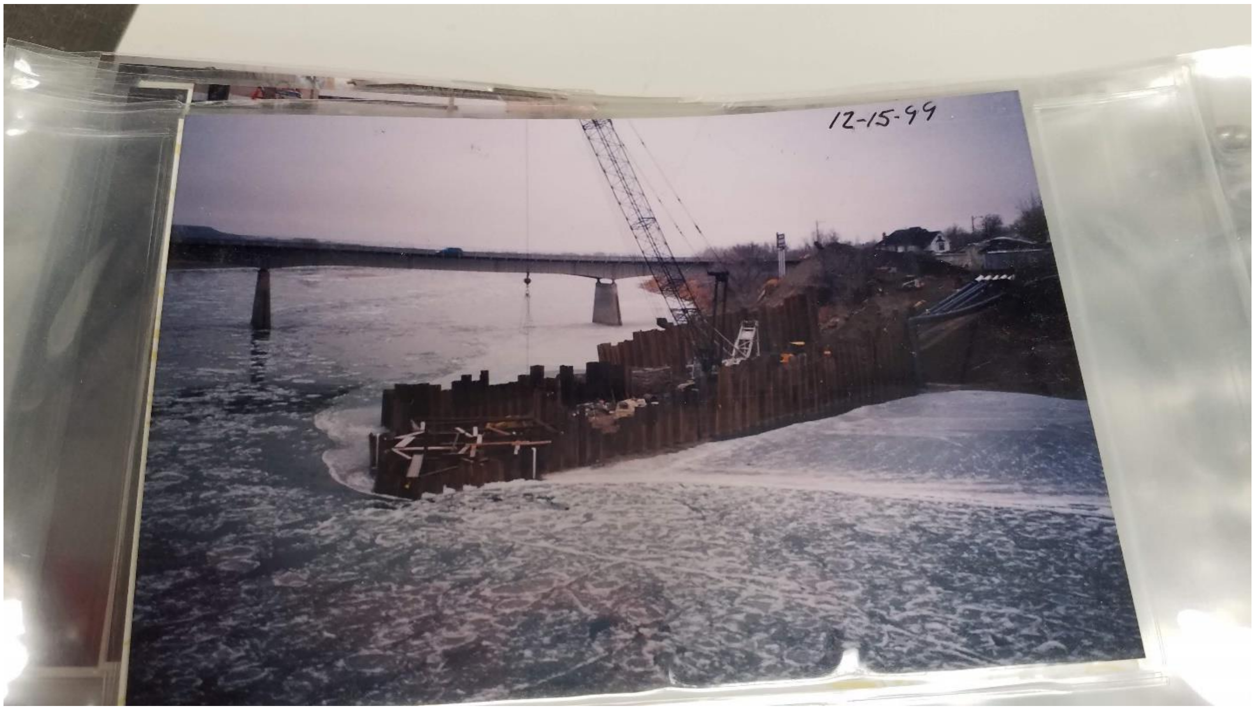

3"
18"
EL. 2031.0
1-7-2000


1-7-2000

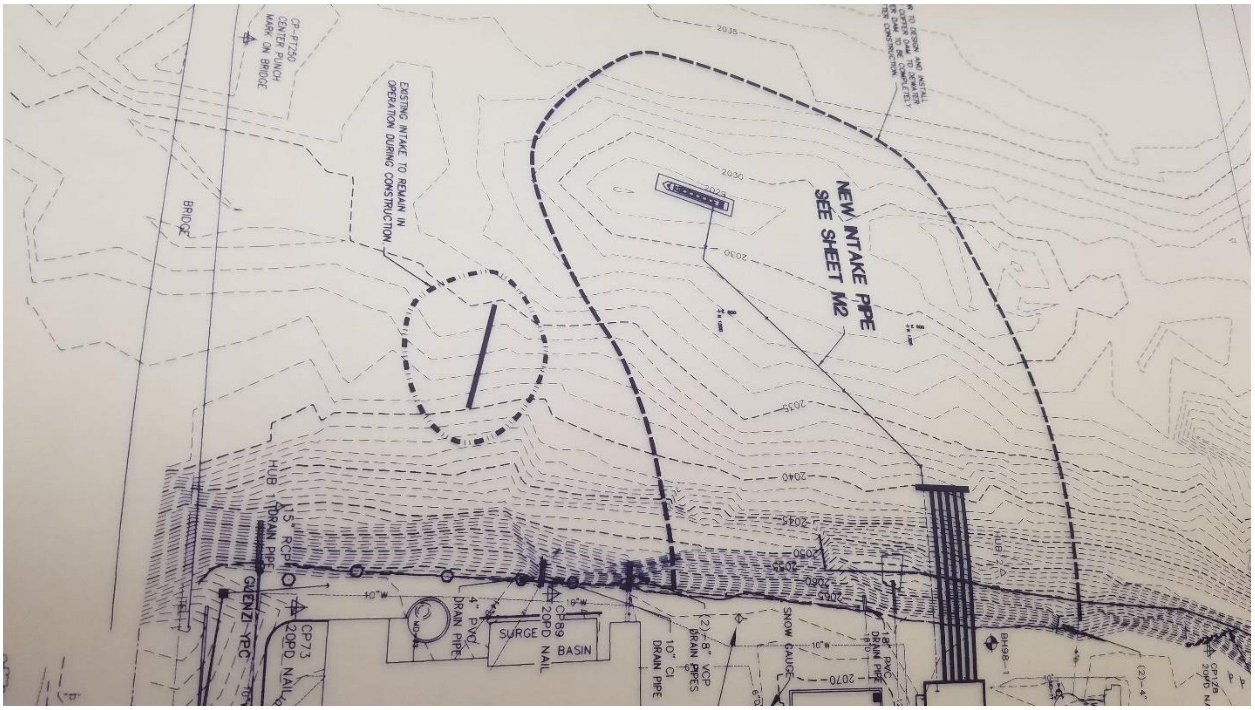

1-10-2000


12-21-99
18"

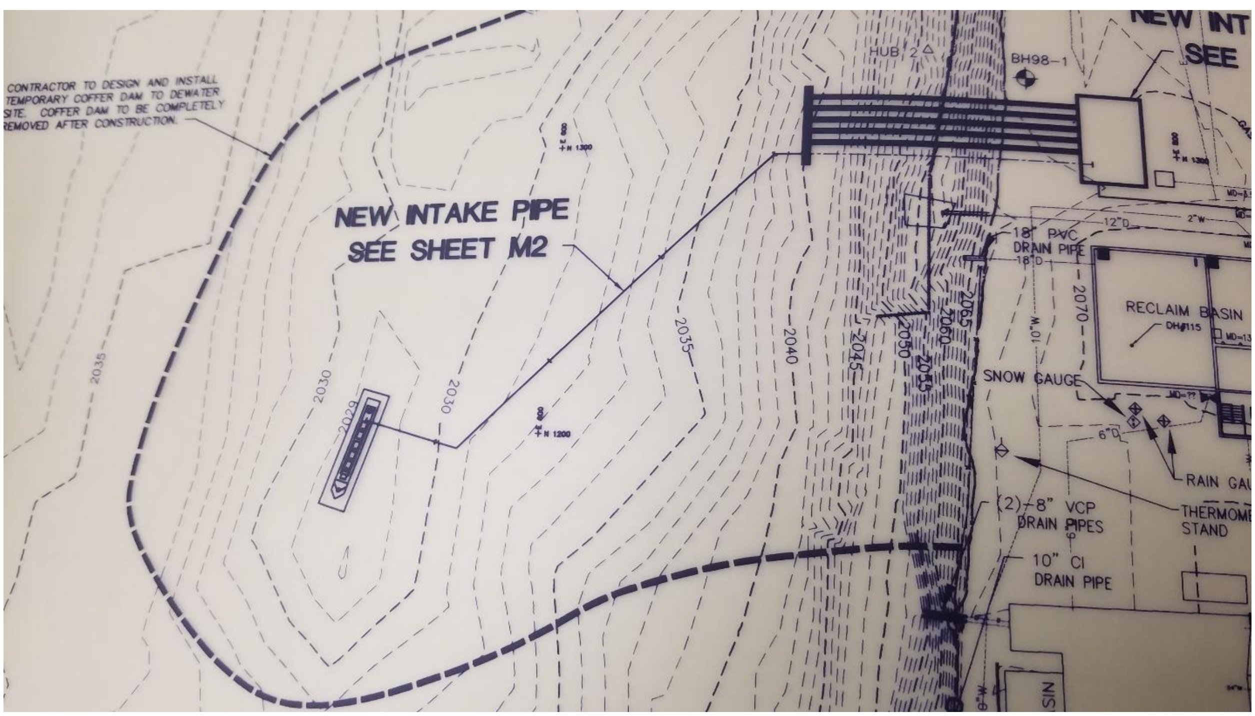

3"
18"
12-21-99


12-15-99

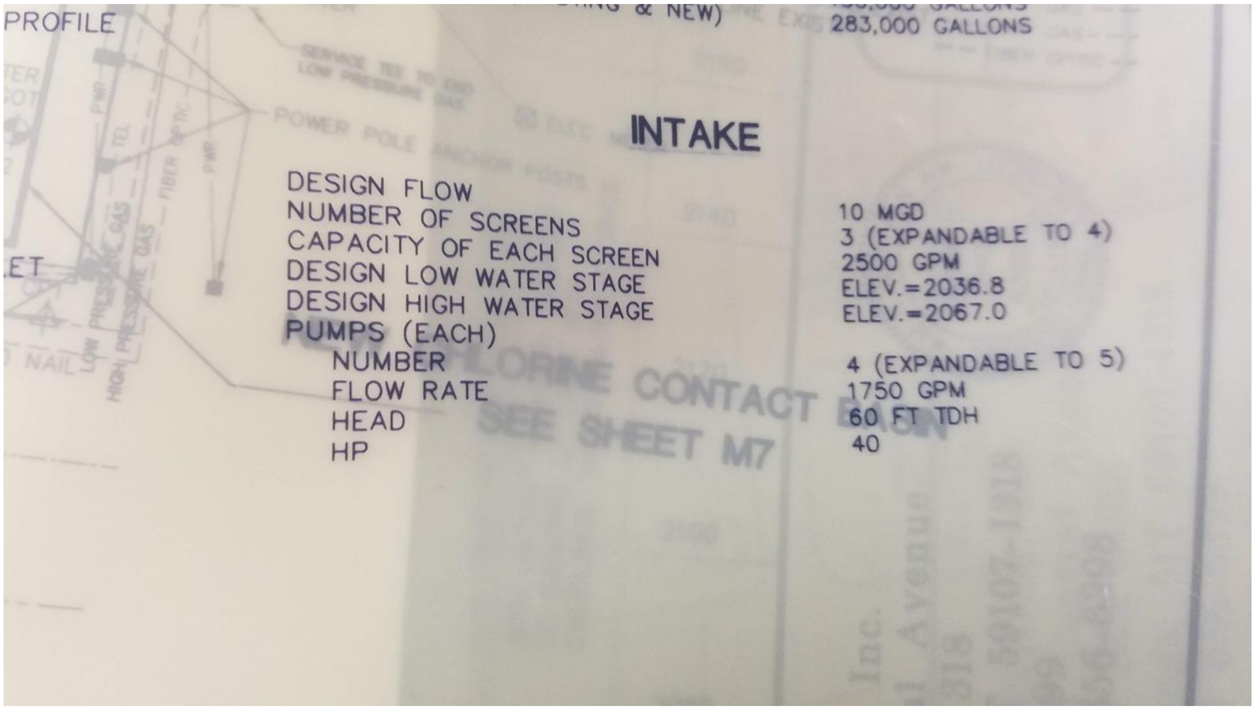

12-15-99

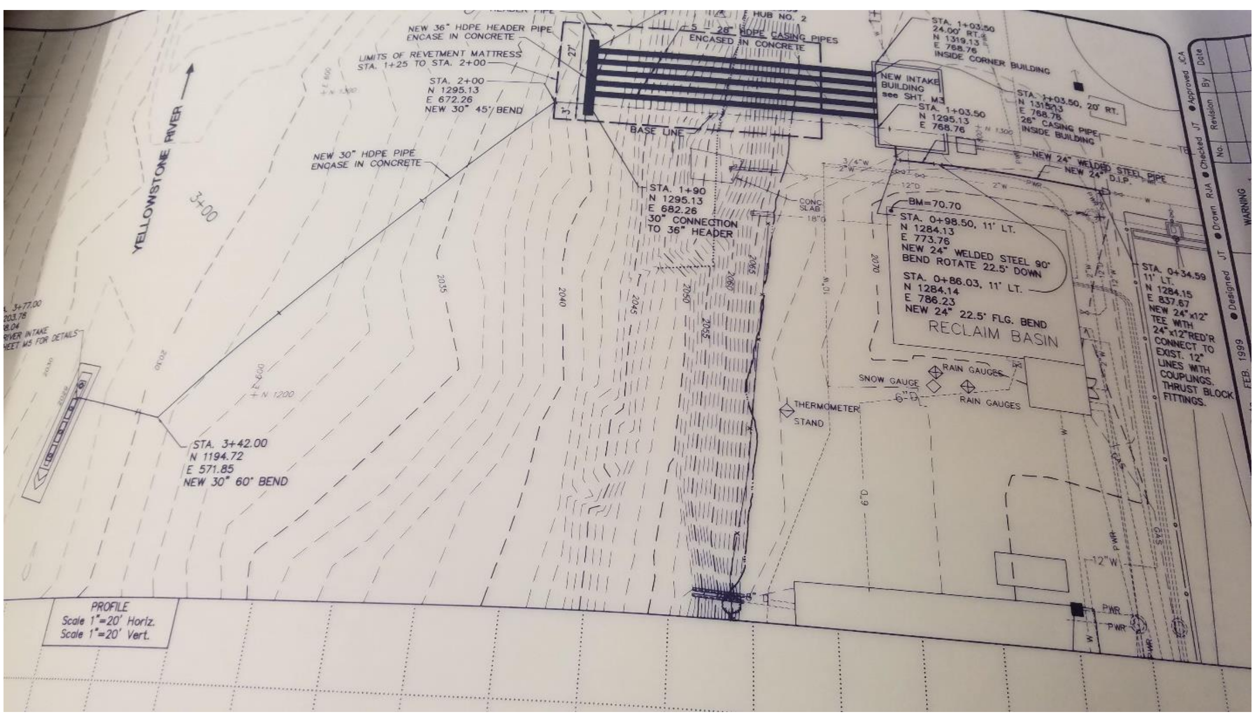


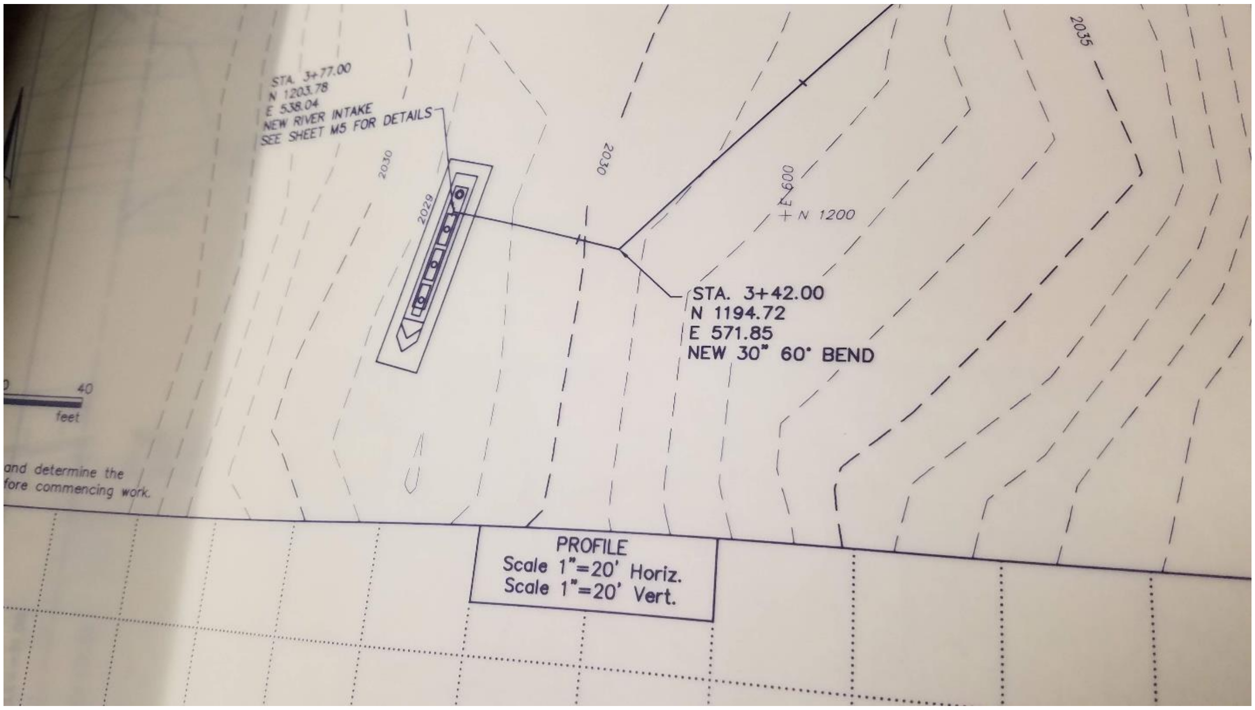
EXISTING INTAKE TO REMAIN IN OPERATION DURING CONSTRUCTION.
CP-P250 CENTER PUNCH MARK ON BRIDGE
BRIDGE
NEW INTAKE PIPE SEE SHEET M2
2035
2030
2040
15" RCP DRAIN PIPE
HUB
GUENZI YPC
CP73 20PD NAIL
4" PVC DRAIN PIPE
CP89 20PD NAIL
SURGE BASIN
10" CI DRAIN PIPE
(2)-8" VCP DRAIN PIPES
SNOW GAUGE
18" PVC DRAIN PIPE
BH98-1

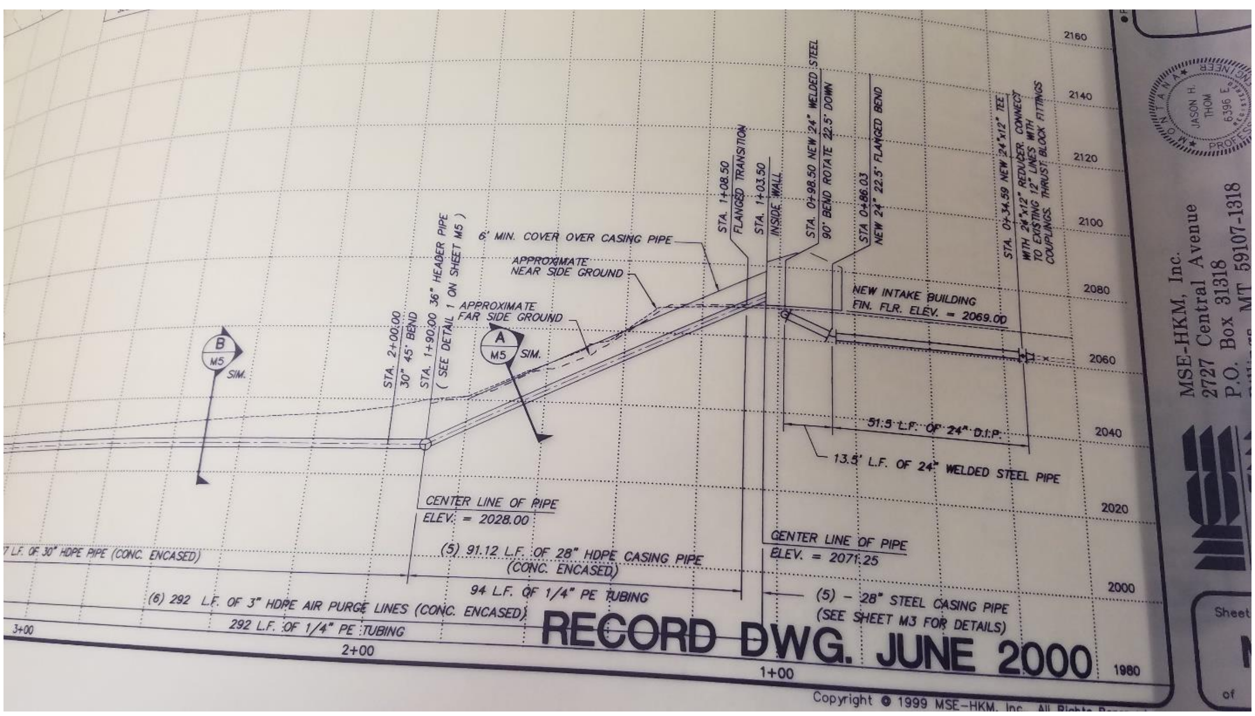


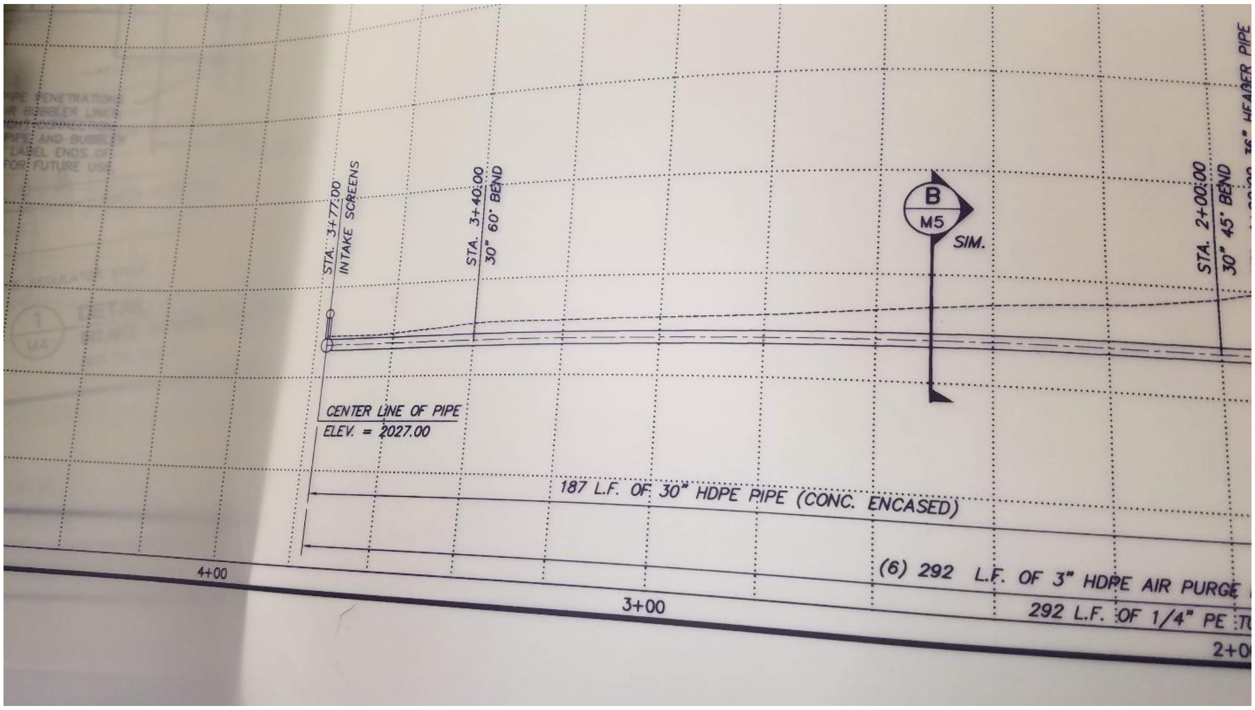
CONTRACTOR TO DESIGN AND INSTALL TEMPORARY COFFER DAM TO DEWATER SITE. COFFER DAM TO BE COMPLETELY REMOVED AFTER CONSTRUCTION.
NEW INTAKE PIPE SEE SHEET M2
HUB 2
BH98-1
18" PVC DRAIN PIPE
RECLAIM BASIN
2035
2030
2029
2040
2045
2050
2055
2060
2065
2070
SNOW GAUGE
(2)-8" VCP DRAIN PIPES
10" CI DRAIN PIPE
STAND

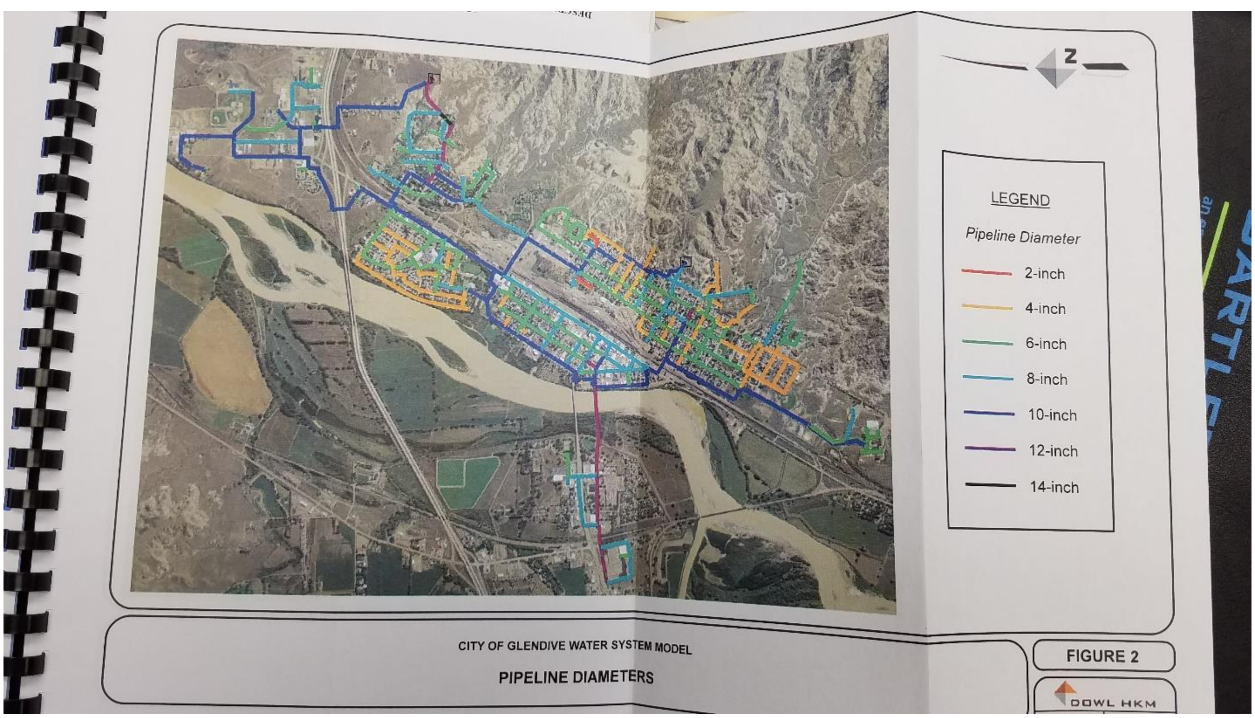

PROFILE
283,000 GALLONS
INTAKE
DESIGN FLOW
10 MGD
NUMBER OF SCREENS
3 (EXPANDABLE TO 4)
CAPACITY OF EACH SCREEN
2500 GPM
DESIGN LOW WATER STAGE
ELEV.=2036.8
DESIGN HIGH WATER STAGE
ELEV.=2067.0
PUMPS (EACH)
NUMBER
4 (EXPANDABLE TO 5)
FLOW RATE
1750 GPM
HEAD
60 FT TDH
HP
40
CONTACT BASIN
SEE SHEET M7


NEW 36" HDPE HEADER PIPE ENCASE IN CONCRETE
LIMITS OF REVETMENT MATTRESS STA. 1+25 TO STA. 2+00
STA. 2+00 N 1295.13 E 672.26 NEW 30" 45° BEND
28" HDPE CASING PIPES ENCASED IN CONCRETE
STA. 1+03.50 24.00' RT. N 1319.13 E 768.76 INSIDE CORNER BUILDING
NEW INTAKE BUILDING see SHT. M3
STA. 1+03.50 N 1295.13 E 768.76
STA. 1+03.50, 20' RT. N 1315.13 E 768.76 26" CASING PIPE, INSIDE BUILDING
NEW 24" WELDED STEEL PIPE
BASE LINE
YELLOWSTONE RIVER
NEW 30" HDPE PIPE ENCASE IN CONCRETE
3+00
STA. 1+90 N 1295.13 E 682.26 30" CONNECTION TO 36" HEADER
CONC SLAB
BM=70.70
STA. 0+98.50, 11' LT. N 1284.13 E 773.76 NEW 24" WELDED STEEL 90° BEND ROTATE 22.5° DOWN
STA. 0+86.03, 11' LT. N 1284.14 E 786.23 NEW 24" 22.5° FLG. BEND
RECLAIM BASIN
STA. 0+34.59 11' LT. N 1284.15 E 837.87 NEW 24"x12" TEE WITH 24"x12" RED'R CONNECT TO EXIST. 12" LINES WITH COUPLINGS, THRUST BLOCK FITTINGS.
RAIN GAUGES
SNOW GAUGE
RAIN GAUGES
THERMOMETER STAND
STA. 3+42.00 N 1194.72 E 571.85 NEW 30" 60° BEND
PROFILE Scale 1"=20' Horiz. Scale 1"=20' Vert.
PWR
FEB. 1999
WARNING


STA. 3+77.00
N 1203.78
E 538.04
NEW RIVER INTAKE
SEE SHEET M5 FOR DETAILS
2030
2029
2030
2035
N 1200
STA. 3+42.00
N 1194.72
E 571.85
NEW 30" 60° BEND
40
feet
and determine the
fore commencing work.
PROFILE
Scale 1"=20' Horiz.
Scale 1"=20' Vert.


6' MIN. COVER OVER CASING PIPE
APPROXIMATE NEAR SIDE GROUND
APPROXIMATE FAR SIDE GROUND
STA. 2+00.00 30° 45' BEND
STA. 1+90.00 36" HEADER PIPE (SEE DETAIL 1 ON SHEET M5)
STA. 1+08.50 FLANGED TRANSITION
STA. 1+03.50 INSIDE WALL
STA. 0+98.50 NEW 24" WELDED STEEL 90° BEND ROTATE 22.5° DOWN
STA 0+86.03 NEW 24" 22.5° FLANGED BEND
STA. 0+34.59 NEW 24"x12" TEE WITH 24"x12" REDUCER. CONNECT TO EXISTING 12" LINES WITH COUPLINGS. THRUST BLOCK FITTINGS
NEW INTAKE BUILDING FIN. FLR. ELEV. = 2069.00
B M5 SIM.
A M5 SIM.
51.5 L.F. OF 24" D.I.P.
13.5' L.F. OF 24" WELDED STEEL PIPE
CENTER LINE OF PIPE ELEV. = 2028.00
CENTER LINE OF PIPE ELEV. = 2071.25
L.F. OF 30" HDPE PIPE (CONC. ENCASED)
(5) 91.12 L.F. OF 28" HDPE CASING PIPE (CONC. ENCASED)
94 L.F. OF 1/4" PE TUBING
(6) 292 L.F. OF 3" HDPE AIR PURGE LINES (CONC. ENCASED)
292 L.F. OF 1/4" PE TUBING
(5) - 28" STEEL CASING PIPE (SEE SHEET M3 FOR DETAILS)
3+00
2+00
1+00
2160
2140
2120
2100
2080
2060
2040
2020
2000
1980
RECORD DWG. JUNE 2000
Copyright © 1999 MSE-HKM, Inc.
MSE-HKM, Inc.
2727 Central Avenue
P.O. Box 31318
MT 59107-1318
JASON H. THOM
Sheet
of


STA. 3+77.00
INTAKE SCREENS
STA. 3+40.00
30" 60° BEND
B
M5
SIM.
STA. 2+00.00
30" 45° BEND
CENTER LINE OF PIPE
ELEV. = 2027.00
187 L.F. OF 30" HDPE PIPE (CONC. ENCASED)
(6) 292 L.F. OF 3" HDPE AIR PURGE
292 L.F. OF 1/4" PE
4+00
3+00


LEGEND
Pipeline Diameter
2-inch
4-inch
6-inch
8-inch
10-inch
12-inch
14-inch
CITY OF GLENDIVE WATER SYSTEM MODEL
PIPELINE DIAMETERS
FIGURE 2
DOWL HKM

The model contains the following system components:

- 946 pipe segments, totaling 189,282 LF (35.85 miles) of pipelines
  - *Subtotals by Material:*

Asbestos Cement	96,852 LF	(51.2%)
Cast Iron	44,362 LF	(23.4%)
Transite	38,819 LF	(20.5%)
PVC	6,982 LF	(3.7%)
Steel	1,721 LF	(0.9%)
Copper	546 LF	(0.3%)

  - *Subtotals by Diameter:*

2-inch	1,104 LF	(0.6%)
4-inch	32,028 LF	(16.9%)
6-inch	59,933 LF	(31.7%)
8-inch	39,903 LF	(21.1%)
10-inch	46,799 LF	(24.7%)
12-inch	9,115 LF	(4.8%)
14-inch	400 LF	(0.2%)

- 283 hydrants
- 555 junctions (i.e., pipeline intersections or demand points)
- 1 water source
- 2 pump stations
  - Water Treatment Plant High Service (4 pumps, all constant-speed)
  - College Booster Station (2 normal operation pumps & 1 fire pump, all variable speed)
- 2 storage tanks
  - Hungry Joe Tank (1.0 MG)
  - Hillcrest Tank (1.1 MG)

With a few minor exceptions, only the City's water mains are included in the model. A few small-diameter lines that could be classified as service lines are included in the model only because they are located in alleys or streets and serve multiple customers (e.g., a 2-inch transite line with 11 services and a 2-inch copper line with ±5 services). Furthermore, most known private water lines (e.g., BNSF pipelines and large-diameter service lines) are excluded from the model unless they are required for proper analysis.

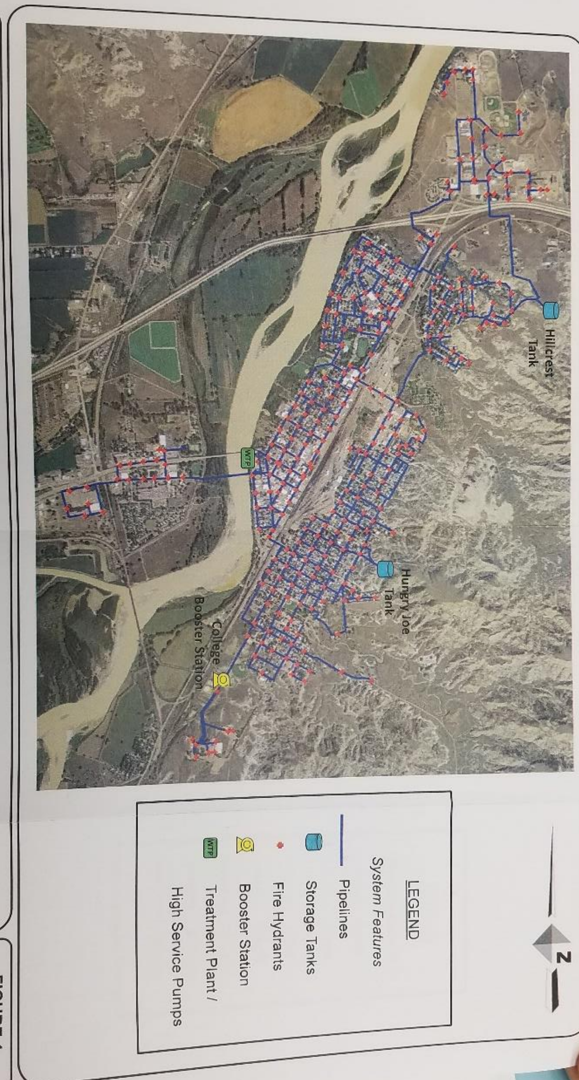
Figure 1 is an overview of the primary features within the Glendive water system. Figures 2 & 3 show pipeline diameters and materials, respectively, throughout the system. Figure 4 displays the installation years and ages of hydrants. Summary reports of the model inventory are included in Appendix A.

Water Demands

Water system demands (i.e., withdrawals from the system) can be input into a WaterCAD model based on metering records or other approximation methods. Typically, the total system demand is determined first, and is then allocated throughout the system to individual model junctions.

Total System Demand

For the Glendive system, meter records from the water treatment plant provide the necessary data to determine total supply to the system. Annual, monthly, and peak day meter records were obtained from recent years and are shown in the following table.

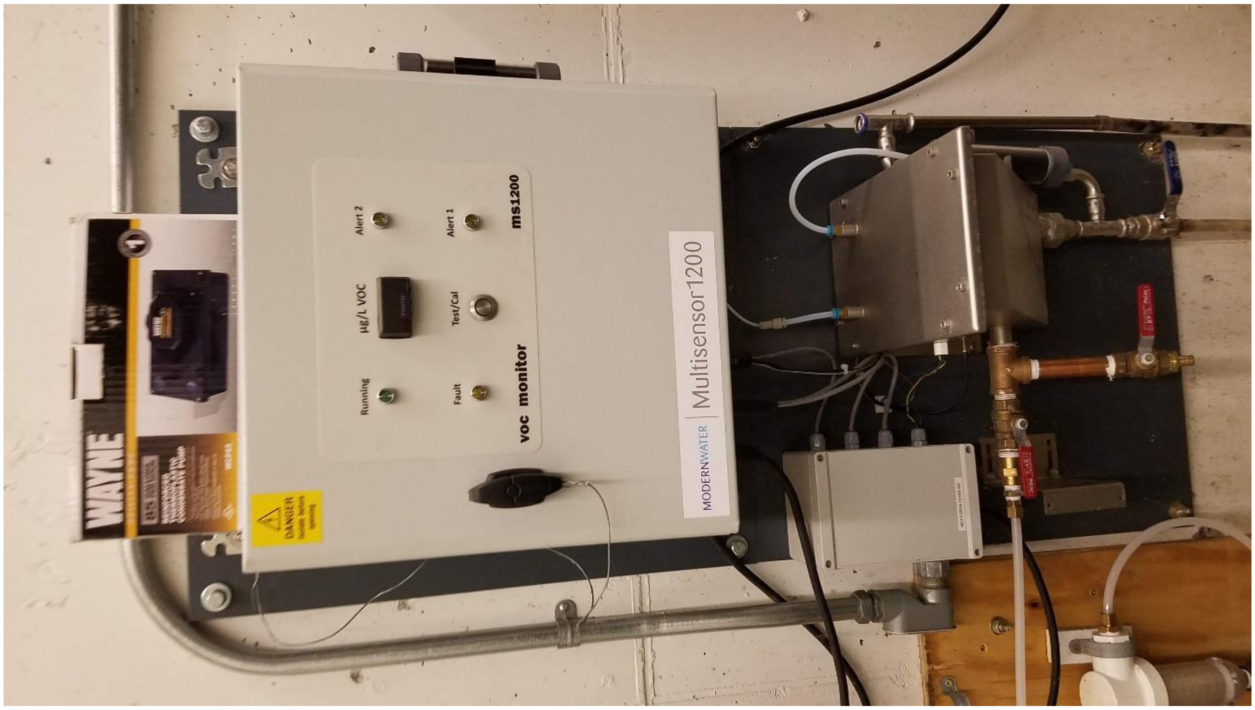


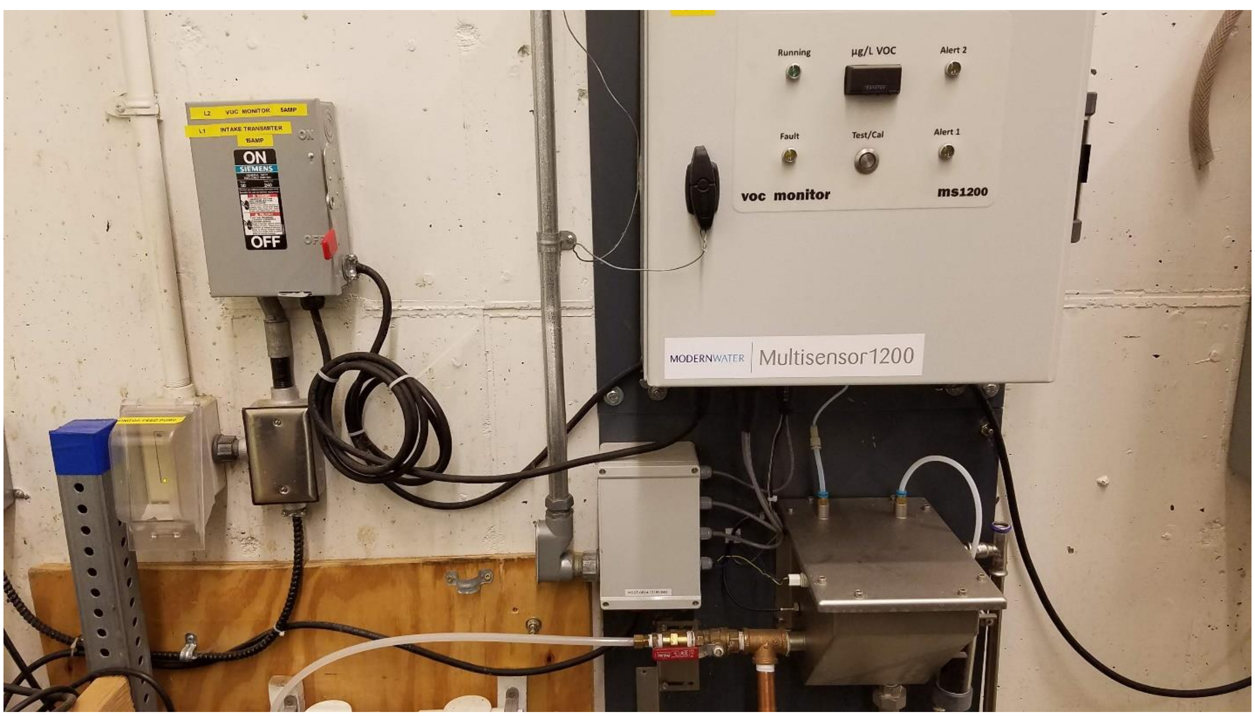
CITY OF GLENDIVE WATER SYSTEM MODEL

SYSTEM OVERVIEW

FIGURE 1

DOWL HKM 4028.20195.01 JULY 2011


voc monitor
Running
Fault
µg/L VOC
Test/Cal
Alert 2
Alert 1
ms1200
MODERNWATER
Multisensor1200
DANGER
WAYNE


L2 VOC MONITOR 5AMP
L1 INTAKE TRANSMITER
15AMP
ON
SIEMENS
OFF
Running
µg/L VOC
Alert 2
Fault
Test/Cal
Alert 1
voc monitor
ms1200
MODERNWATER
Multisensor1200

1 Product Description

The MS1200-SYS is a VOC concentration monitor system designed for surface and ground water monitoring applications. It utilises a contactless measurement technique, sensing headspace gases or volatiles in the environment, and provides a measurement system with very low maintenance requirements.

The MS1200-SYS is accurate to low ppb concentrations and its wide dynamic range allows it to be used in a wide variety of environments

The MS1200-SYS includes the measurement instrument housed in a robust steel enclosure powered from either 90 – 240V AC or 24V DC supplies dependent on the option purchased. Also included is the stainless steel sample tank and associated pipework and control valves. This is mounted on a 12mm PVC board.

Alert signals can be generated on variations from historical norms or absolute concentrations.

Applications

- Protection of raw water intakes
- Water treatment process monitoring
- Outflow compliance guidance
- Borehole monitoring

MODERNWATER

Modern Water Ltd
Unit 17, Cambridge Science Park
Cambridge, CB4 0FQ
+44 (0)1483 696030
www.modernwater.co.uk

MS1200-SYS VOC Monitor

System Operating and Maintenance Manual

Please read the instructions contained in this document carefully before operating the instrument.

This instrument must be installed, commissioned and serviced by a competent person. If you are in any doubt then contact Modern Water Ltd.

Any modification of the instrument including the case invalidates any warranty. Modern Water accepts no liability arising from such actions. This does not affect your statutory rights.

The user is recommended to have the instrument serviced regularly by a competent, qualified engineer using original spares to help maintain the safety, performance and reliability of the instrument.

The unit should be serviced twice annually unless the usage demand or characteristics of the installation dictate otherwise.

This equipment complies with the requirements of EN 61010-1 2010 and UL61010-1. The protection provided may be impaired if the equipment is used in a way not specified by Modern Water Ltd.

Operation, installation or use of the unit which is not in accordance with this manual may impair the protection provided by the unit.

This equipment should only be opened when the power removed. Danger of Electric shock if opened with power connected

1.2 Operating Conditions

1.2.1 Power rating

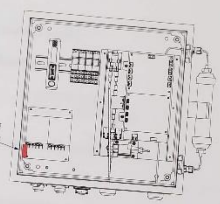
Connector Type: RD24 Circular Connector with screw terminals

A.C. 100V – 240V, 50W, 50 – 60Hz, Protected by 5A Anti-surge fuse
D.C. 24V (19V – 36V), 50W, Protected by 5A Anti-surge fuse

Replacement Fuse: 5A Anti-surge, 20mm x 5mm, Ceramic
e.g. Littelfuse T 5A 215

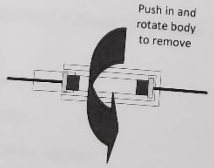
Replacing the Power Fuse

This fuse should only be opened or changed by a qualified person.
Remove from power source before opening cabinet - Danger of electric shock.



Location of Power Fuse in cabinet

To change or inspect the power fuse twist the fuse holder body to undo. Remove fuse. Replacement is the reversal of this procedure. Replacement Fuse: 5A Anti-surge, 20mm x 5mm, Ceramic e.g. Littelfuse T 5A 215



Replacement of power fuse.

1.1 Summary Specification

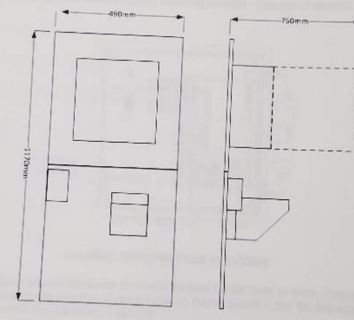
1.1.1 Safety

Conforms to:
UL Std 61010-1
EN 61010-1:2010

1.1.2 EMC

Conforms to:
EN61326-1:2006
FCC CFR Title 47 Telecommunications – Limits; Class A Part 15

1.1.3 Dimensions



1.1.4 Weight

25kg (55lbs)

1.1.5 IP Rating: Enclosure

IP65

1.1.6 Connections: Gas System

Instrument Sample inlet	3.2mm push fit to 3.2mm PTFE tube
Instrument Reference inlet	3.2mm push fit to 3.2mm PTFE tube
Sample Tank out	6mm push fit to 6mm PTFE tube
Sample Tank breather	6mm push fit to 6mm PTFE tube

1.2.2 Water Feed

Pressure: 4 bar max (58 psi)

Flow: 0.5 – 1.0 litres per minute (0.132 - 0.264 US Gallons per minute)

1.2.3 Operating temperature

0 – 40C

1.2.4 Operating Humidity

0 – 85% non-condensing

1.2.5 Sample Temperature

2 – 30C

1.2.6 Sample gas flow

70ml/min ±10 over service period

1.2.7 Sample Presentation System

Volume	3l (0.8 US Gallons)
Headspace	1.4l (0.37 US Gallons)

1.3 Performance

($T_{ambient}$ = 25C, T_{sample} = 20C, using standard calibration setup)

1.3.1 Dynamic Range

1 – 1000 ppb in aqueous phase

1.3.2 Precision

200ppb Total VOC in Water +/- 10% ;

1.3.3 Repeatability

For repeated measurement of 200ppb TVOC in Water: ±2% relative to Toluene

1.3.4 Analysis time

2mins, repetition rate: 20 mins

1.3.5 Measurement Stability

Validation necessary every 180 days

APPENDIX D

Outgoing Irrigation Communication

County Commissions Contacts

Bartlett & West
3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 12, 2018

To Dawson County Commissioners,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for-input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? YES NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available?
4. What would be the impacts of drought or flood on your intake?
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have?
6. Are there any other potential impacts to your water intake?

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin Nygaard, P.E.

Bartlett & West
3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 12, 2018

To Valley County Commissioners,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? YES NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available?
4. What would be the impacts of drought or flood on your intake?
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have?
6. Are there any other potential impacts to your water intake?

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin Nygaard, P.E.

Individual Irrigation Contacts

Bartlett & West

3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 5, 2018

To whom it may concern,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for-input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? YES NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available?
4. What would be the impacts of drought or flood on your intake?
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have?
6. Are there any other potential impacts to your water intake?

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin Nygaard, P.E.

Individual Irrigators Receiving Questionaires

NAME	ADDRESS	CITY	STATE	ZIP	PHONE
ALLEN PIPAL	982 MONTANA HWY 528	WOLF POINT	MT	59201	406-525-3775
BOONE WHITMER	872 NICKWALL RD	WOLF POINT	MT	59201	406-525-3289
BOYD HARDY- #1	13265 HWY 200	FAIRVIEW	MT	59221	406-742-5391
BURT TWITCHEL	12 BALBER ROAD	WOLF POINT	MT	59201	
BUTCH CANDEE #1	31269 COUNTY 143	POPLAR	MT	59255	406-774-3483
CLINT CASTERLINE	374 River Road	WOLF POINT	MT	59201	406-425-3253
DAVID KJELGAARD	2293 PRAIRIE ELK RANCH	WOLF POINT	MT	59201	406-525-3237
DICK IVERSEN #1	13749 COUNTY 332	SIDNEY	MT	59270	406-798-7770
DON HUBERS	425 RIVER ROAD		MT		406-525-3404
DON IVERSEN	BOX 383	FAIRVIEW	MT	59221	406-742-5665
GARY MCREA #1	502 N NICKWALL RD BOX 536	WOLF POINT	MT	59201	406-525-3329
GREG RAUSCHENDORFER	31256 COUNTY 143	POPLAR	MT	59255	406-774-3730
HUSEBY FARMS	743 MAYBERRY RD	CIRCLE	MT	59215	406-485-3466
JAMES CARLISLE	15227 HWY 16	CULBERTSON	MT	59218	406-787-5203
JAMES DEWITT #3	60 DEWITT RAOD	WOLF POINT	MT	59201	406-525-3293
JEAN BENGOCHEA #1	31797 COUNTY 148	BROCKTON	MT	59213	406-774-3435
JEAN BIDEGARAY #1	31600 COUNTY 154	BROCKTON	MT	59213	406-774-3743
LARRY BLEVINS	BOX 215	WOLF POINT	MT	59201	406-525-3275
LARRY DAVIS	52 KILL ROAD	WOLF POINT	MT	59201	406-525-3365
LARRY HANDY #1	15535 COUNTY 315	BROCKTON	MT	59213	406-774-3769
MARK CASTERLINE #1	15299 COUNTY 321	BROCKTON	MT	59213	406-787-5274
MILTON BERGLEE	532 MONTANA HWY 528	WOLF POINT	MT	59201	406-525-3260
NEIL TURNBULL #1	15268 COUNTY 321	CULBERTSON	MT	59218	406-787-6167
PATRICK COLGAN #1	BOX 1595	POPLAR	MT	59255	406-768-7521
PAUL COLGAN #3	BOX 1595	POPLAR	MT	59255	406-768-7521
REX RALSTON #1	31639 COUNTY 154	BROCKTON	MT	59213	406-774-3757
ROBERT RALSTON #1	15511 COUNTY 315	BROCKTON	MT	59213	406-774-3440
ROCKY NORBY #1	35244 COUNTY 126	SIDNEY	MT	59270	406-482-2266
STEVE HACKLEY	30968 COUNTY 149	POPLAR	MT	59255	406-525-3262
TERRIL RAAUM #1	PO BOX 454	CULBERTSON	MT	59218	406-787-5794
TEX GRIBBLE	BOX 2074 HWY 528	WOLF POINT	MT	59201	406-525-3261
TOM COLGAN #1	30761 COUNTY 149	POPLAR	MT	59255	406-525-3667
TOM RUFFATTO	31334 COUNTY 146	BROCKTON	MT	59213	406-774-3493
TOM WHITE #1	1874 MT HYW 528	WOLF POINT	MT	59201	406-525-3705
WILLIAM RATHERT #1	924 5TH AVE N	WOLF POINT	MT	59201	406-653-2344
ZANE PILGRIM #1	142 River Road	WOLF POINT	MT	59201	406-525-3498

Irrigation Districts Contacts

Irrigation Districts Receiving Questionaires

NAME	ADDRESS	CITY	STATE	ZIP	PHONE	WATER BODY
BUFFALO RAPIDS IRRIGATION DISTRICT	PO BOX 907	TERRY	MT	59349	406-635-5586	Yellowstone River
FORT PECK WATER USERS ASSOCIATION	602 6TH AVE N	WOLF POINT	MT	59201	406-768-5905	Missouri River
GLASGOW IRRIGATION DISTRICT	15 IRRIGATION ST	GLASGOW	MT	59230	406-228-2346	Milk River
INTAKE PROJECT	ROUTE 1, BOX 2064	SIDNEY	MT	59270	406-482-1306	Yellowstone River
LOWER YELLOWSTONE IRRIGATION	2327 LINCOLN AVE SE	SIDNEY	MT	59270	406-433-1306	Yellowstone River
MALTA IRRIGATION DISTRICT	509 S 3RD ST E	MALTA	MT	59538	406-654-1440	Milk River
SIDNEY WATER USERS IRRIGATION DISTRICT	1101 11TH STREET SW	SIDNEY	MT	59270		Yellowstone River

APPENDIX E

Received Irrigation Communication

Individual Irrigator Responses

Bartlett & West

3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 5, 2018

To whom it may concern,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? YES (circled) NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available? NO
4. What would be the impacts of drought or flood on your intake? See below
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have? No negative impact
6. Are there any other potential impacts to your water intake?
   Extreme low flows would once again cut me off from water. We pump with desile would love to afford Electric Need 1 mile of 3 phase line extension.

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard (signature)

Colin M. Nygaard, P.E.

My river inlet sits on a hard clay rife. Very stable + very little bank erosion. However in 2011 with extreme high flows the river laid a 500' sand bar and sealed ~~excess~~ access. Since then me off from water the river has been cutting on the sand bar reducing the distance to 175'. So the corp. of engineers allowed me to trench a channel thru bar and once again access irrigation water. First time in 2018 since the 2011 flood.

(signature)

Bartlett & West

3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 5, 2018

To whom it may concern,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? (YES) NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available? no
4. What would be the impacts of drought or flood on your intake?
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have? yes
6. Are there any other potential impacts to your water intake?
   Stream bed erosion!

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin M. Nygaard, P.E.

South side Missouri River — approx ~~5~~ 5+ miles W of Wolf Point

2. Sloped river bank
10" irrigation centrifugal pump mounted on a steel frame.
3500 - 4000 g.p.m.
30+ ft of lift.
electrical Motor

Bartlett & West
3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 5, 2018

To whom it may concern,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for-input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? (YES) NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.) floating River Pump, have problems with Depth
3. Do you have any alternate water sources available? No
4. What would be the impacts of drought or flood on your intake? Changes ability to Reach Water
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have? Yes
6. Are there any other potential impacts to your water intake? No

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin M. Nygaard, P.E.

County Commissioner Responses

Bartlett & West

3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

F

Date: December 12, 2018

To Valley County Commissioners,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? YES NO (circled: NO)
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available?
4. What would be the impacts of drought or flood on your intake?
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have?
6. Are there any other potential impacts to your water intake?

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin Nygaard, P.E.

Valley County, as an entity has no water intakes, therefore just answer to #1.

Bruce Peterson
Valley Co Commission

Bartlett & West

3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 12, 2018

To Dawson County Commissioners,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for-input from individuals drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? (YES) NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.) in bottom of River
3. Do you have any alternate water sources available? NO
4. What would be the impacts of drought or flood on your intake? None
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have? None!
6. Are there any other potential impacts to your water intake? NO

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin Nygaard, P.E.

The Dawson County Commissioners Fully support the Keystone XL Pipeline!

Irrigation District Responses

Bartlett & West
3470 Gabel Road
Billings, MT 59102
ph (406) 200-6920
www.bartwest.com

Date: December 5, 2018

To whom it may concern,

Bartlett & West engineers are working with the Montana Department of Natural Resources and Conservation (DNRC) to conduct a study on water intake resiliency for drinking water and irrigation systems in Eastern Montana. This study will evaluate the impacts of various events on river intakes and diversions and provide mitigation methods if possible.

We are currently in the information gathering stage and are looking for-input from users drawing water from the Missouri, Yellowstone, Milk, or smaller rivers. We would appreciate if you could answer the following questions:

1. Do you have an intake directly into the river? (YES) NO
2. Can you provide a brief description of the intake? (i.e. river source, depth, permanent, flow, construction details, etc.)
3. Do you have any alternate water sources available?
4. What would be the impacts of drought or flood on your intake?
5. Are you aware of the proposed Keystone XL pipeline route and any impact it may have?
6. Are there any other potential impacts to your water intake?

If you can provide us this information, we will ensure you receive a copy of the final report to provide you additional information to help future decision making with your water intake.

Please respond by one of the following methods:

Email: Colin.Nygaard@bartwest.com

Mail: Return these questions in the stamped envelope included.

Phone: 406-200-6910

Thank you,

Colin M. Nygaard

Colin Nygaard, P.E.

2. Our intake is on the Milk River, built into the Vandalia Dam. The Dam is reinforced concrete slab and buttress weir. There are 3 river gates that are 100 feet across for a total of 300 feet that are lowered into place. We have four canal gates that flow into 2 tunnels into our Main Canal. Normal operating depth at Dam is 27.0 feet and the crest elevation is 2116.0 feet. At crest we have a capacity of 300 cfs that can flow into our canal.

3. We do not have alternate source of water

4. We are part of the Milk River Watershed Alliance and the Milk River Joint Board of Control. We have 3 reservoirs in our system that we can access during time of drought: Sherburne, Fresno and Nelson. With a flood we leave our River gates in the position they are in and our canal gates are not affected.

5. We are aware of the proposed Keystone XL Pipeline route. It will cross under the Milk River by Nashua, which is 40 miles downstream of our intake. It will be routed under our Main Canal south of Nashua. Its potential impact upon our District would be very minimal, if at all.

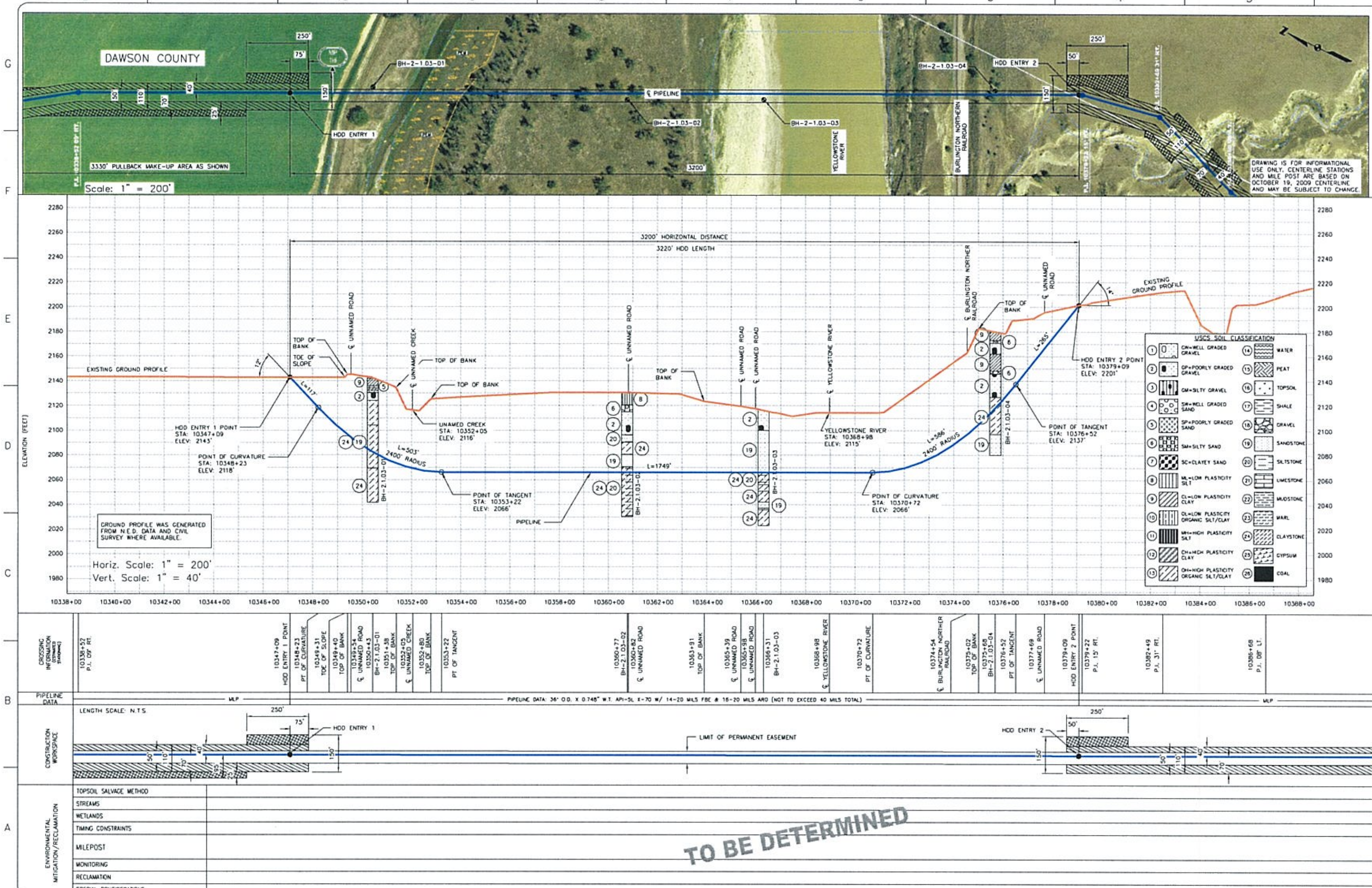
6. One of our biggest potential impacts is the failure of the River gates. If one or more the River gates fail, we will not have the head pressure to push water down our canal.

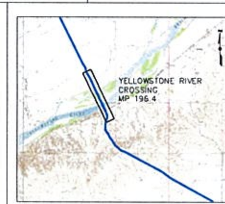
Glasgow Irrigation District

APPENDIX F

TransCanada Maps Referenced


Keystone XL Pipeline:
Yellowstone River
New Valve Locations
at Approx. Milepost 197.1
and 198.1
194
195
196
197
MP 197.1
Motor Operated Valve
198
MP198.1
Check & Manual
Operated Valve
YELLOWSTONE RIVER
199
200
201
202
203
P
Legend
Milepost (MP)
Valves
Pump Station
0 0.5 1 2
Miles
Montana Department of
ENVIRONMENTAL QUALITY





INSTALLATION NOTES

1) ACCESS: ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY FROM PUBLIC OR APPROVED PRIVATE ROADS.
2) VEHICLE AND EQUIPMENT ACCESS CROSSING MAY BE INSTALLED IF APPROVED BY THE ENVIRONMENTAL INSPECTOR.
3) WORK SPACE: WORK SPACE LIMITS ARE DEPICTED. CLEARING WILL BE RESTRICTED TO THE WORK SPACES INDICATED AT THE ENTRY AND EXIT POINTS AND PULLBACK MAKE-UP AREA ALONG THE RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS IS LIMITED TO THE MINIMUM AMOUNT NECESSARY TO STRING LOCATION WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
4) WATER SOURCE: DRILL WATER AND PRE-INSTALLATION HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE. THE CONTRACTOR SHALL SCREEN THE INTAKE HOSE TO PREVENT THE ENTRAINMENT OF FISH OR DEBRIS AND IN ACCORDANCE WITH THE CONSTRUCTION MITIGATION AND RECLAMATION PLAN (CMRP) AND PROJECT REQUIREMENTS. THE HOSE SHALL BE KEPT OFF THE BOTTOM OF THE WATER BODY.
5) HYDROSTATIC TEST: PRE-INSTALLATION HYDROSTATIC TEST SHALL BE CONDUCTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE CONTRACTOR SHALL DISCHARGE HYDROSTATIC TEST WATER IN ACCORDANCE WITH PROJECT PERMITS. DISCHARGES WILL BE BACK TO THE WATER SOURCE UNLESS OTHERWISE DIRECTED BY THE ENVIRONMENTAL INSPECTOR. DISCHARGES SHALL NOT CAUSE EROSION OR SEDIMENTATION. TO REDUCE THE VELOCITY OF THE DISCHARGE, THE CONTRACTOR SHALL UTILIZE AN ENERGY-DISSIPATING DEVICE AS DESCRIBED IN THE CMRP.
6) SPILL-PREVENTION: ALL PUMPS SHALL BE SET IN SECONDARY CONTAINMENT AND IN ACCORDANCE WITH THE SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN (SPCC). EQUIPMENT AND PUMPS OPERATING WITHIN 100 FEET OF ANY WATER BODY OR WETLAND SHALL BE OPERATED AND REFUELED IN ACCORDANCE WITH THE SPCC PLAN. EQUIPMENT REFUELING AND STORAGE OF HAZARDOUS MATERIALS, FUELS, ETC. SHALL BE CONDUCTED AT LEAST 100 FEET FROM WATER BODIES AND WETLANDS. EACH CONSTRUCTION CREW SHALL HAVE ON HAND SUFFICIENT TOOLS AND MATERIALS TO STOP LEAKS AND SUPPLIES OF ABSORBENT AND BARRIER MATERIALS TO ALLOW RAPID CONTAINMENT AND RECOVERY OF SPILLED MATERIALS.
7) EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
8) TOPSOIL SHALL BE STRIPPED AS REQUIRED BY PROJECT SPECIFICATIONS.
9) PRIOR TO PIPE PULLBACK, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO KEYSTONE FOR APPROVAL.
10) INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULLBACK.
11) MUD DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING MUD AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING MUD WHICH INADVERTENTLY EXITS AT POINTS OTHER THAN THE ENTRY AND EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
12) CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN PROJECT DOCUMENTS.
13) NOMINAL WORKING SPACE DIMENSIONS ARE SHOWN. LARGER AREAS MAY BE REQUIRED IN IRREGULAR TERRAIN. UPDATED DIMENSIONS MAY BE PROVIDED AFTER LOCAL TOPOGRAPHICAL SURVEYS ARE PERFORMED.
14) HDD WORK PLAN TO BE DEVELOPED BY THE CONTRACTOR. THE INTERSECT METHOD MAY BE CONSIDERED AT THIS CROSSING BY DRILLING FROM NW TO SE FIRST AND THEN SE TO NW.

LEGEND

- POINT OF INTERSECTION (P.I.)
- ENTRY OR EXIT POINT
- GEOTECHNICAL BOREHOLE
- POWERPOLE
- MAINLINE PIPE
- PIPELINE
- FOREIGN PIPELINE
- EDGE OF WATER
- PRIVATE ACCESS SHOO FLY ROAD
- COUNTY BOUNDARY
- WATER LEVEL
- USACOE CONSTRUCTION REFERENCE POINT
- WETLANDS
- PERMANENT EASEMENT
- TEMPORARY EASEMENT
- ADDITIONAL TEMPORARY WORKSPACE

REFERENCE DRAWINGS

DRAWING No	TITLE

REVISION

REV No	DATE	DESCRIPTION	PROJECT CODE	DRAFTER	DRAFTING CHECKER	DESIGNER	DESIGN CHECKER	PROJECT MANAGER	COMPANY
3	04.21.10	ISSUED FOR DEIS FILING (03.26.10 CL)	2095406	BM	AH	FP	FP	RG	TROW
2	04.21.09	ISSUED FOR REVIEW (02.15.09 CL)	2095406	AH	AH	FP	YC	RG	TROW
1	12.08.08	ISSUED FOR REVIEW (12.01.08 CL)	2095406	JB	AH	HF	RB	RG	TROW
0	11.19.08	ISSUED FOR UNITED STATES DEPARTMENT OF STATE (07.31.08 CL)	2095406	JB	JP	HF	RB	RG	TROW

PROFESSIONAL ENGINEER/RPT: RAYMOND E. WALLACE, JR. PE MT – 19435

PERMIT/ ENG. APPROVAL — DATE

REV. NO.	DATE	PERMIT NUMBER

PRELIMINARY

TransCanada — In business to deliver

PREPARED BY: TROW ENGINEERING CONSULTANTS INC
1300 Metropolitan Boulevard, Suite 200
Tallahassee, Florida, USA 32308
Phone: 1-850-385-5441
Fax: 1-850-385-5523

CIRCLE SECTION

FA # 4362 | CHAINAGE: MP 196.4 | DISCIPLINE # 03

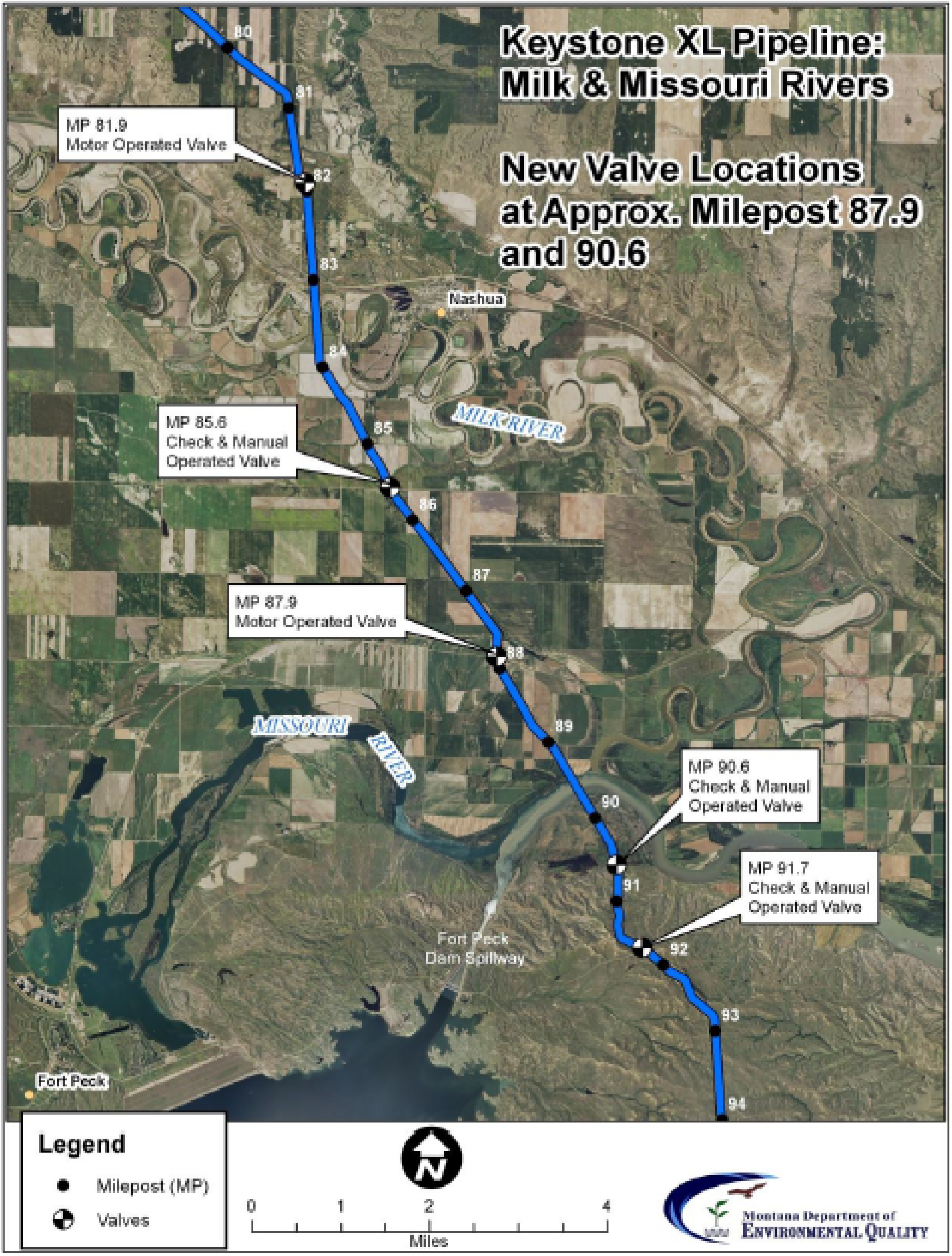
YELLOWSTONE RIVER HDD INSTALLATION
KEYSTONE XL PROJECT
DAWSON & PRAIRIE COUNTY, MONTANA

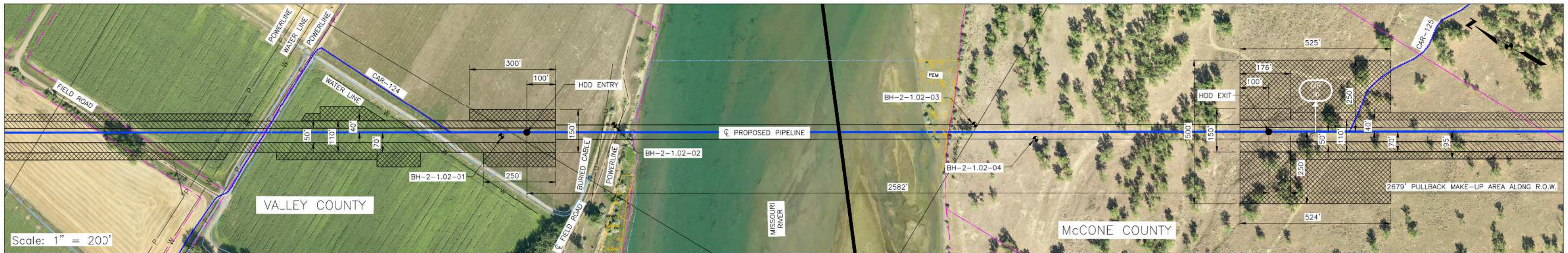
SCALE AS SHOWN | DRAWING No 4362-03-ML-03-001 | REV 0

CADD DRAWING: DO NOT MAKE MANUAL REVISIONS

PLOTTED SIZE: ANSI D (22x34)

TC_UD_BR.DWG 22X34


Keystone XL Pipeline:
Milk & Missouri Rivers
New Valve Locations
at Approx. Milepost 87.9
and 90.6
MP 81.9
Motor Operated Valve
MP 85.6
Check & Manual
Operated Valve
MP 87.9
Motor Operated Valve
MP 90.6
Check & Manual
Operated Valve
MP 91.7
Check & Manual
Operated Valve
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
Nashua
MILK RIVER
MISSOURI
RIVER
Fort Peck
Dam Spillway
Fort Peck
Legend
Milepost (MP)
Valves
0
1
2
4
Miles
Montana Department of
Environmental Quality



INSTALLATION NOTES

1) ACCESS: ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY FROM PUBLIC OR APPROVED PRIVATE ROADS.

2) WORK SPACE: WORK SPACE LIMITS ARE DEPICTED. CLEARING WILL BE RESTRICTED TO THE WORK SPACES INDICATED AT THE ENTRY AND EXIT POINTS AND PULLBACK MAKE-UP AREA ALONG THE RIGHT-OF-WAY. NO CLEARING BETWEEN THE ENTRY AND EXIT POINTS OF THE HDD EXCEPT WHERE APPROVED BY THE ENVIRONMENTAL INSPECTOR.

3) WATER SOURCE: DRILL WATER AND PRE-INSTALLATION HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE. THE CONTRACTOR SHALL SCREEN THE INTAKE HOSE TO PREVENT THE ENTRAINMENT OF FISH OR DEBRIS AND IN ACCORDANCE WITH THE CONSTRUCTION MITIGATION AND RECLAMATION PLAN (CMRP) AND PROJECT REQUIREMENTS. THE HOSE SHALL BE KEPT OFF THE BOTTOM OF THE WATER BODY.

4) HYDROSTATIC TEST: PRE-INSTALLATION HYDROSTATIC TEST SHALL BE CONDUCTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE CONTRACTOR SHALL DISCHARGE HYDROSTATIC TEST WATER IN ACCORDANCE WITH PROJECT PERMITS. DISCHARGES WILL BE SENT TO AN UPLAND LOCATION NEAR THE WITHDRAWAL POINT AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR. DISCHARGES SHALL NOT CAUSE EROSION OR SEDIMENTATION. TO REDUCE THE VELOCITY OF THE DISCHARGE, THE CONTRACTOR SHALL UTILIZE AN ENERGY-DISSIPATING DEVICE AS DESCRIBED IN THE CMRP.

5) SPILL-PREVENTION: ALL PUMPS SHALL BE SET IN SECONDARY CONTAINMENT AND IN ACCORDANCE WITH THE SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN (SPCC). EQUIPMENT AND PUMPS OPERATING WITHIN 100 FEET OF ANY WATER BODY OR WETLAND SHALL BE OPERATED AND REFUELED IN ACCORDANCE WITH THE SPCC PLAN. EQUIPMENT REFUELING AND STORAGE OF HAZARDOUS MATERIALS, FUELS, ETC. SHALL BE CONDUCTED AT LEAST 100 FEET FROM WATER BODIES AND WETLANDS. EACH CONSTRUCTION CREW SHALL HAVE ON HAND SUFFICIENT TOOLS AND MATERIALS TO STOP LEAKS AND SUPPLIES OF ABSORBENT AND BARRIER MATERIALS TO ALLOW RAPID CONTAINMENT AND RECOVERY OF SPILLED MATERIALS.

6) EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.

7) PRIOR TO PIPE PULLBACK, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO KEYSTONE FOR APPROVAL.

8) INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULLBACK.

9) MUD DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING MUD AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING MUD WHICH INADVERTENTLY EXITS AT POINTS OTHER THAN THE ENTRY AND EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE COMPANY REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.

10) CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN PROJECT DOCUMENTS.

11) NOMINAL WORKING SPACE DIMENSIONS ARE SHOWN. LARGER AREAS MAY BE REQUIRED IN IRREGULAR TERRAIN. UPDATED DIMENSIONS MAY BE PROVIDED AFTER LOCAL TOPOGRAPHICAL SURVEYS ARE PERFORMED.

12) CONTRACTOR SHALL FOLLOW REFERENCE SPECIFICATIONS. REFER TO KEYSTONE CMRP, KEYSTONE CONSTRUCTION SPECIFICATIONS, PROJECT ENVIRONMENTAL REQUIREMENTS FOR THIS SITE SPECIFIC DETAIL, PART 195 OF THE CODE OF FEDERAL REGULATIONS (LATEST EDITION), ASME B31.4, AND API 1102.

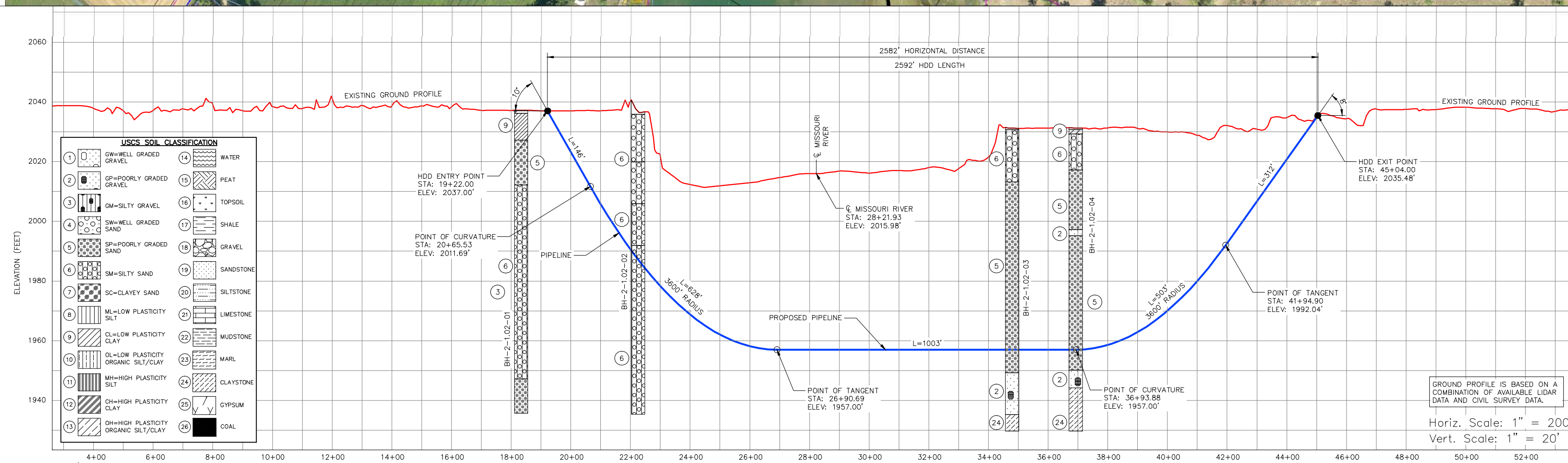
13) 36" O.D. X 0.618" W.T., API 5L PSL 2-X70M W/14-20 MILS & 16-20 MILS ARO (NOT TO EXCEED 40 MILS TOTAL)

14) 36" O.D. X 0.465" W.T., API 5L PSL 2-X70M W/14-20 MILS FBE

15) MAINLINE EQUIPMENT MUST DRIVE AROUND THIS CROSSING ON EXISTING ROADS.

16) EQUIPMENT IS TO BE CLEANED AND DRIED PRIOR TO MOVING TO THE R.O.W. AND BEFORE LEAVING THE DRILL SIDE ON THE SOUTH SIDE OF THE RIVER.

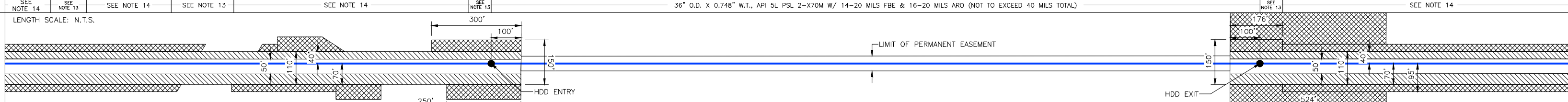
17) MATURE COTTONWOOD TREES SHOULD BE PRESERVED WHERE PRACTICAL ON THE CONSTRUCTION R.O.W. SOUTH OF THE RIVER.



CROSSING INFORMATION (STATIONING): P.I. 13° 20' 14" RT 0+00; 18+33 BH-2-1.02-01; 19+22.00 HDD ENTRY POINT; 20+65.53 PT OF CURVATURE; 21+92 APPROX. ℄ MAN MADE DITCH; 22+24 BH-2-1.02-02; 22+28 ℄ UNNAMED ROAD; 22+63 TOP BANK; 26+90.69 PT OF TANGENT; 28+21.93 ℄ MISSOURI RIVER; 34+33 TOP BANK; 34+79 BH-2-1.02-03; 36+92 BH-2-1.02-04; 36+93.88 PT OF CURVATURE; 41+94.90 PT OF TANGENT; 45+04.00 HDD EXIT POINT

PIPELINE DATA: SEE NOTE 14 — SEE NOTE 13 — SEE NOTE 14 — SEE NOTE 13 — SEE NOTE 14 — SEE NOTE 13 — 36" O.D. X 0.748" W.T., API 5L PSL 2-X70M W/ 14-20 MILS FBE & 16-20 MILS ARO (NOT TO EXCEED 40 MILS TOTAL) — SEE NOTE 13 — SEE NOTE 14

LENGTH SCALE: N.T.S.



ENVIRONMENTAL MITIGATION/RECLAMATION: TOPSOIL SALVAGE METHOD; STREAMS; WETLANDS; TIMING CONSTRAINTS; MILEPOST; MONITORING; RECLAMATION; SPECIAL CONSIDERATIONS

LEGEND

CL P.I.; ENTRY OR EXIT POINT; GEOTECHNICAL BOREHOLE; WARNING SIGN; PIPELINE ROUTE; CATHODIC PROTECTION TEST STATION; ROAD CL; ROAD EDGE; FIELD PATH; RAILWAY; FENCE; FOREIGN PIPELINE; WATER LINE; OVERHEAD POWERLINE; UNDERGROUND UTILITY; TELEPHONE LINE; PROPERTY PARCEL; SECTION LINE; COUNTY LINE; PERMANENT EASEMENT BOUNDARY; TEMPORARY WORKSPACE BOUNDARY; ADDITIONAL TEMPORARY WORKSPACE; PERMANENT ACCESS ROAD; TEMPORARY ACCESS ROAD; EXISTING GROUND; WATER BODY; WETLAND BOUNDARY; HEADCUT AREA; EXCLUSION FENCE

REFERENCE DRAWINGS

DRAWING No	TITLE
4360-03-ML-02-027	ALIGNMENT SHEET

REVISION / APPROVAL

REV No	DATE	DESCRIPTION	PROJECT CODE	DRAFTER	DRAFTING CHECKER	DESIGNER	DESIGN CHECKER	PROJECT MANAGER	COMPANY
00	2013-05-31	ISSUED FOR CONSTRUCTION	2095406	EXP	TLB	BLS	KJM	KJM	EXP
0A	2017-02-03	ISSUED FOR REVIEW	2095406	EXP	ALS	DS	KJM	BW	EXP

PROFESSIONAL ENGINEER/RPT — FIRM: EXP ENERGY SERVICES, INC. FIRM LICENSE: F057873

PERMIT/ ENG. APPROVAL — DATE

REV. NO.	DATE	PERMIT NUMBER:

TransCanada *In business to deliver*

exp Energy Services Inc. t: +1.850.385.5441 | f: +1.850.385.5523 1300 Metropolitan Blvd Tallahassee, FL 32308 USA www.exp.com — exp.

KEYSTONE XL (NPS 36 2014) VALLEY SECTION

FA # 4360 — CHAINAGE: MP 89.65 — DISCIPLINE # 03

MISSOURI RIVER HDD INSTALLATION
KEYSTONE XL PROJECT
VALLEY & McCONE COUNTY, MONTANA

SCALE AS SHOWN — DRAWING No 4360-03-ML-03-002 — REV 0A

TC_UD_BR.DWG 22X34

CADD DRAWING: DO NOT MAKE MANUAL REVISIONS

PLOTTED SIZE: ANSI D (22x34)

APPENDIX G

Table & Figures Supporting Section IV of the Report (Modeling of Contamination)

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MILK	DOMESTIC	-107.244413	48.51188	01/01 to 12/31	12/31/1912	STATEMENT OF CLAIM	PUMP	15 GPM	4	1.5	40J 152193 00
MILK	DOMESTIC	-106.60803	48.167241	04/01 to 09/30	3/13/1961	STATEMENT OF CLAIM	PUMP	18 GPM	0.5	0.33	40O 17925 00
MILK	DOMESTIC	-106.512967	48.151067	04/01 to 11/30	4/20/1982	PROVISIONAL PERMIT	PUMP	50 GPM	5.4	0	40O 46308 00
MILK	DOMESTIC	-106.601238	48.166752	04/01 to 11/30	8/31/1967	STATEMENT OF CLAIM	PUMP	8 GPM	4.1	1.5	40O 130770 00
MILK	IRRIGATION	-107.080171	48.42946	04/01 to 11/01	4/1/1920	STATEMENT OF CLAIM	PUMP	4.9 CFS	0	96	40J 168098 00
MILK	IRRIGATION	-106.546901	48.152122	04/15 to 10/19	5/23/1947	STATEMENT OF CLAIM	PUMP	9 CFS	0	340.6	40O 34643 00
MILK	IRRIGATION	-106.564524	48.158435	04/15 to 10/19	5/23/1947	STATEMENT OF CLAIM	PUMP	9 CFS	0	340.6	40O 34643 00
MILK	IRRIGATION	-106.482528	48.159262	04/15 to 10/19	6/19/1967	STATEMENT OF CLAIM	PUMP	5500 GPM	119.2	59.6	40O 152980 00
MILK	IRRIGATION	-106.475207	48.153259	04/15 to 10/19	6/19/1967	STATEMENT OF CLAIM	PUMP	5500 GPM	119.2	59.6	40O 152980 00
MILK	IRRIGATION	-106.335544	48.115175	04/01 to 11/30	3/15/1961	STATEMENT OF CLAIM	PUMP	7.13 CFS	63.35	18.1	40O 40180 00
MILK	IRRIGATION	-107.13669	48.451174	05/01 to 10/01	5/1/1968	STATEMENT OF CLAIM	PUMP	5.6 CFS	47	23.5	40J 1940 00
MILK	IRRIGATION	-106.393037	48.133624	04/01 to 10/31	12/31/1951	STATEMENT OF CLAIM	PUMP	850 GPM	0	50	40O 166223 00
MILK	IRRIGATION	-106.503382	48.152661	04/01 to 11/30	5/10/1952	STATEMENT OF CLAIM	PUMP	408 GPM	0	24	40O 13076 00
MILK	IRRIGATION	-106.579526	48.159341	05/01 to 10/19	11/10/1951	STATEMENT OF CLAIM	PUMP	29 GPM	0	2	40O 37627 00
MILK	IRRIGATION	-107.065119	48.395928	04/15 to 10/31	5/23/1908	STATEMENT OF CLAIM	PUMP	297.5 GPM	0	12.7	40O 42198 00
MILK	IRRIGATION	-106.739762	48.261225	04/01 to 12/04	12/31/1928	STATEMENT OF CLAIM	PUMP	2500 GPM	0	157.5	40O 13096 00
MILK	IRRIGATION	-106.745208	48.253378	04/01 to 12/04	12/31/1928	STATEMENT OF CLAIM	PUMP	2500 GPM	0	100	40O 13097 00
MILK	IRRIGATION	-106.805101	48.315787	05/01 to 08/04	6/4/1959	STATEMENT OF CLAIM	PUMP	3.03 CFS	0	99.8	40O 166110 00
MILK	IRRIGATION	-106.826373	48.323524	02/20 to 05/19	6/9/1945	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	20.1	40O 178430 00
MILK	IRRIGATION	-106.825261	48.323997	03/28 to 09/30	3/31/1949	STATEMENT OF CLAIM	PUMP	263.5 GPM	0	15.5	40O 178432 00
MILK	IRRIGATION	-106.827982	48.322162	03/28 to 09/30	3/31/1944	STATEMENT OF CLAIM	PUMP	170 GPM	0	10	40O 178429 00
MILK	IRRIGATION	-106.276427	48.095079	04/01 to 10/04	4/30/1938	STATEMENT OF CLAIM	PUMP	2.56 CFS	0	67.6	40O 170810 00
MILK	IRRIGATION	-107.069248	48.416791	04/01 to 10/31	12/31/1930	STATEMENT OF CLAIM	OTHER	3200 GPM	0	215.5	40O 30064385
MILK	IRRIGATION	-106.967651	48.374267	05/01 to 10/31	12/31/1914	STATEMENT OF CLAIM	PUMP	400 GPM	0	40	40O 184682 00
MILK	IRRIGATION	-107.180401	48.496465	03/01 to 03/31	9/12/1968	STATEMENT OF CLAIM	PUMP	13.37 CFS	0	25	40J 20518 00
MILK	IRRIGATION	-107.161386	48.481946	03/01 to 03/31	9/12/1968	STATEMENT OF CLAIM	PUMP	47.99 CFS	0	1258	40J 34644 00
MILK	IRRIGATION	-106.744515	48.264842	04/01 to 10/31	7/27/1953	STATEMENT OF CLAIM	PUMP	5 CFS	0	60	40O 130777 00
MILK	IRRIGATION	-106.749838	48.257107	04/01 to 10/31	7/27/1953	STATEMENT OF CLAIM	PUMP	5 CFS	0	60	40O 130777 00
MILK	IRRIGATION	-107.052347	48.399491	05/01 to 10/31	5/23/1908	STATEMENT OF CLAIM	PUMP	7.6 CFS	0	155	40O 170762 00
MILK	IRRIGATION	-107.086951	48.428526	05/01 to 10/15	12/31/1936	STATEMENT OF CLAIM	PUMP	1.11 CFS	0	117	40J 170593 00
MILK	IRRIGATION	-107.086929	48.421313	05/01 to 10/15	12/31/1936	STATEMENT OF CLAIM	PUMP	1.11 CFS	0	117	40J 170593 00
MILK	IRRIGATION	-107.08285	48.421313	05/01 to 10/15	12/31/1936	STATEMENT OF CLAIM	PUMP	1.11 CFS	0	117	40J 170593 00
MILK	IRRIGATION	-107.081498	48.426608	05/01 to 10/15	12/31/1936	STATEMENT OF CLAIM	PUMP	1.11 CFS	0	117	40J 170593 00
MILK	IRRIGATION	-107.035373	48.383458	05/01 to 10/19	12/31/1961	STATEMENT OF CLAIM	PUMP	500 GPM	0	94.4	40O 170597 00
MILK	IRRIGATION	-107.043382	48.388903	05/01 to 10/19	12/31/1961	STATEMENT OF CLAIM	PUMP	500 GPM	0	94.4	40O 170597 00
MILK	IRRIGATION	-107.033887	48.387998	06/01 to 09/30	12/1/1945	STATEMENT OF CLAIM	HEADGATE	3000 GPM	0	85	40O 22941 00
MILK	IRRIGATION	-107.054261	48.403214	05/01 to 10/31	3/25/1908	STATEMENT OF CLAIM	PUMP	2 CFS	0	20	40O 182929 00
MILK	IRRIGATION	-106.820578	48.313192	04/01 to 12/04	12/31/1949	STATEMENT OF CLAIM	PUMP	2500 GPM	0	112.75	40O 166181 00
MILK	IRRIGATION	-106.805106	48.308542	05/01 to 08/19	6/2/1958	STATEMENT OF CLAIM	PUMP	1200 GPM	0	93	40O 166202 00
MILK	IRRIGATION	-106.734359	48.239307	06/01 to 08/31	6/1/1906	STATEMENT OF CLAIM	PUMP	2.3 CFS	0	156.1	40O 189797 00
MILK	IRRIGATION	-106.492529	48.162944	05/01 to 09/30	12/31/1957	STATEMENT OF CLAIM	PUMP	500 GPM	0	50	40O 168614 00
MILK	IRRIGATION	-106.63284	48.184709	04/01 to 11/19	12/31/1933	STATEMENT OF CLAIM	PUMP	1800 GPM	0	80.36	40O 182935 00
MILK	IRRIGATION	-106.700559	48.234858	04/01 to 10/31	12/30/1981	PROVISIONAL PERMIT	PUMP	5000 GPM	135.54	50.2	40O 48938 00
MILK	IRRIGATION	-106.700542	48.238285	04/01 to 10/31	12/30/1981	PROVISIONAL PERMIT	PUMP	5000 GPM	135.54	50.2	40O 48938 00
MILK	IRRIGATION	-106.612815	48.177537	04/01 to 10/31	12/31/1940	STATEMENT OF CLAIM	PUMP	500 GPM	6	3	40O 170923 00
MILK	IRRIGATION	-106.648346	48.178985	05/01 to 11/04	12/31/1910	STATEMENT OF CLAIM	PUMP	1.6 CFS	0	15	40O 170872 00
MILK	IRRIGATION	-107.017629	48.380731	04/01 to 10/31	12/31/1933	STATEMENT OF CLAIM	DITCH	3600 GPM	0	172	40O 170787 00
MILK	IRRIGATION	-107.017629	48.380731	04/01 to 11/30	12/31/1935	STATEMENT OF CLAIM	DITCH	3600 GPM	0	115	40O 166163 00
MILK	IRRIGATION	-106.851004	48.352109	01/01 to 12/31	12/31/1902	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	90	40O 42221 00
MILK	IRRIGATION	-106.875549	48.348586	01/01 to 12/31	12/31/1902	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	90	40O 42221 00
MILK	IRRIGATION	-106.880263	48.347929	01/01 to 12/31	12/31/1902	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	90	40O 42221 00
MILK	IRRIGATION	-106.880263	48.347929	03/15 to 10/31	4/12/1985	PROVISIONAL PERMIT	PUMP	500 GPM	60.8	22.5	40O 57464 00
MILK	IRRIGATION	-106.849653	48.347567	04/01 to 10/31	4/22/1922	STATEMENT OF CLAIM	PUMP	6.5 CFS	0	172.5	40O 168606 00
MILK	IRRIGATION	-106.846952	48.342108	04/01 to 10/31	4/22/1922	STATEMENT OF CLAIM	PUMP	6.5 CFS	0	172.5	40O 168606 00
MILK	IRRIGATION	-106.833537	48.340331	04/01 to 10/31	4/22/1922	STATEMENT OF CLAIM	PUMP	6.5 CFS	0	172.5	40O 168606 00
MILK	IRRIGATION	-106.833537	48.340331	04/01 to 10/31	4/22/1922	STATEMENT OF CLAIM	PUMP	6.5 CFS	0	172.5	40O 168606 00
MILK	IRRIGATION	-106.838973	48.342092	04/01 to 10/31	4/22/1922	STATEMENT OF CLAIM	PUMP	6.5 CFS	0	172.5	40O 168606 00
MILK	IRRIGATION	-106.831258	48.333995	04/10 to 09/19	5/17/1912	STATEMENT OF CLAIM	PUMP	287.81 GPM	0	16.93	40O 30069252

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MILK	IRRIGATION	-106.555849	48.159347	04/01 to 09/30	12/31/1968	STATEMENT OF CLAIM	PUMP	1700 GPM	0	100	40O 130653 00
MILK	IRRIGATION	-107.180401	48.496465	04/01 to 10/31	11/2/1903	STATEMENT OF CLAIM	PUMP	820 CFS	0	43493	40J 40932 00
MILK	IRRIGATION	-107.161386	48.481946	04/01 to 10/31	11/2/1903	STATEMENT OF CLAIM	PUMP	820 CFS	0	43493	40J 40932 00
MILK	IRRIGATION	-106.793132	48.312123	05/01 to 11/04	5/1/1959	STATEMENT OF CLAIM	PUMP	2000 GPM	0	17	40O 168590 00
MILK	IRRIGATION	-106.293793	48.096987	04/15 to 11/14	12/31/1938	STATEMENT OF CLAIM	PUMP	2000 GPM	0	83	40O 171152 00
MILK	IRRIGATION	-106.495395	48.155728	05/10 to 09/30	6/15/1933	STATEMENT OF CLAIM	PUMP	832 GPM	0	51.8	40O 170326 00
MILK	IRRIGATION	-106.590358	48.16022	04/01 to 10/04	12/31/1958	STATEMENT OF CLAIM	PUMP	66 GPM	0	11	40O 28939 00
MILK	IRRIGATION	-106.815967	48.308545	05/01 to 10/31	12/31/1962	STATEMENT OF CLAIM	PUMP	3200 GPM	21.6	18	40O 170895 00
MILK	IRRIGATION	-106.815967	48.308545	05/01 to 10/31	12/31/1962	STATEMENT OF CLAIM	PUMP	5000 GPM	33	7.6	40O 170894 00
MILK	IRRIGATION	-107.042019	48.398649	04/15 to 09/30	3/25/1908	STATEMENT OF CLAIM	PUMP	6.7 CFS	0	229.06	40O 17929 00
MILK	IRRIGATION	-107.054261	48.403214	04/01 to 11/04	12/31/1942	STATEMENT OF CLAIM	PUMP	9.06 CFS	0	325	40O 152270 00
MILK	IRRIGATION	-106.973008	48.374568	03/15 to 10/31	7/24/1908	STATEMENT OF CLAIM	DIVERSION DAM	350 CFS	0	18051.47	40O 40929 00
MILK	IRRIGATION	-106.270862	48.099838	04/01 to 10/04	4/30/1936	STATEMENT OF CLAIM	PUMP	300 GPM	0	79	40O 130657 00
MILK	IRRIGATION	-107.052347	48.399491	03/01 to 10/31	5/23/1908	STATEMENT OF CLAIM	PUMP	7.6 CFS	0	15.3	40O 182916 00
MILK	IRRIGATION	-107.064599	48.398288	03/01 to 10/31	12/31/1930	STATEMENT OF CLAIM	PUMP	924 GPM	0	14.6	40O 30027189
MILK	IRRIGATION	-107.052347	48.399491	04/15 to 10/04	5/23/1908	STATEMENT OF CLAIM	PUMP	7.6 CFS	0	61.7	40O 178421 00
MILK	IRRIGATION	-106.680496	48.196589	04/01 to 10/31	12/31/1931	STATEMENT OF CLAIM	PUMP	3264 GPM	176	88	40O 166148 00
MILK	IRRIGATION	-106.293608	48.097066	06/01 to 10/15	10/11/1973	PROVISIONAL PERMIT	PUMP	10 CFS	284	142	40O 676 00
MILK	IRRIGATION	-106.382572	48.129972	05/01 to 09/30	10/28/1905	STATEMENT OF CLAIM	PUMP	3.78 CFS	0	42.9	40O 32209 00
MILK	IRRIGATION	-106.382556	48.127105	05/01 to 09/30	10/28/1905	STATEMENT OF CLAIM	PUMP	3.78 CFS	0	42.9	40O 32209 00
MILK	IRRIGATION	-106.671731	48.202961	04/01 to 11/04	4/23/1951	STATEMENT OF CLAIM	PUMP	2250 GPM	0	60	40O 30043232
MILK	IRRIGATION	-106.671731	48.202961	04/01 to 11/04	12/31/1933	STATEMENT OF CLAIM	PUMP	2250 GPM	0	10	40O 170578 00
MILK	IRRIGATION	-106.350254	48.122582	05/01 to 09/30	3/11/1937	STATEMENT OF CLAIM	PUMP	2800 GPM	0	195	40O 170648 00
MILK	IRRIGATION	-106.359292	48.123563	04/01 to 10/31	4/30/1935	STATEMENT OF CLAIM	PUMP	935 GPM	0	55	40O 215962 00
MILK	IRRIGATION	-107.15325	48.451177	04/15 to 10/15	12/31/1958	STATEMENT OF CLAIM	PUMP	8.91 CFS	67	67	40J 37456 00
MILK	IRRIGATION	-107.069248	48.416791	04/01 to 11/01	12/31/1921	STATEMENT OF CLAIM	OTHER	5400 GPM	0	1046.65	40O 30064388
MILK	IRRIGATION	-107.069248	48.416791	04/01 to 11/04	12/31/1931	STATEMENT OF CLAIM	OTHER	6000 GPM	0	900	40O 30064389
MILK	IRRIGATION	-106.595711	48.162943	04/01 to 10/31	12/31/1943	STATEMENT OF CLAIM	PUMP	350 GPM	0	25	40O 130713 00
MILK	IRRIGATION	-106.723654	48.250207	04/15 to 10/31	5/20/1912	STATEMENT OF CLAIM	PUMP	2200 GPM	0	67.3	40O 1702 00
MILK	IRRIGATION	-106.583718	48.158757	04/01 to 11/30	12/31/1954	STATEMENT OF CLAIM	PUMP	100 GPM	0	24	40O 102313 00
MILK	IRRIGATION	-107.069248	48.416791	04/01 to 10/31	12/31/1931	STATEMENT OF CLAIM	OTHER	7900 GPM	0	650	40O 30046559
MILK	IRRIGATION	-107.074676	48.413167	04/15 to 10/19	12/31/1960	STATEMENT OF CLAIM	PUMP	3200 GPM	0	100	40O 37462 00
MILK	IRRIGATION	-106.670893	48.210203	04/15 to 10/19	12/31/1910	STATEMENT OF CLAIM	PUMP	1479 GPM	0	87	40O 152268 00
MILK	IRRIGATION	-106.670893	48.210203	04/15 to 10/19	11/9/1938	STATEMENT OF CLAIM	PUMP	1479 GPM	0	87	40O 214268 00
MILK	IRRIGATION	-106.671225	48.217447	04/15 to 10/19	11/9/1938	STATEMENT OF CLAIM	PUMP	1479 GPM	0	87	40O 214268 00
MILK	IRRIGATION	-106.315349	48.063189	05/01 to 10/31	10/30/1930	STATEMENT OF CLAIM	PUMP	4000 GPM	0	389.1	40O 186 00
MILK	IRRIGATION	-106.367277	48.127222	05/15 to 08/15	6/9/1975	PROVISIONAL PERMIT	PUMP	5.57 CFS	111	37	40O 5643 00
MILK	IRRIGATION	-106.36917	48.126328	04/01 to 11/30	8/1/1951	STATEMENT OF CLAIM	PUMP	8 CFS	0	137.6	40O 152963 00
MILK	IRRIGATION	-106.777818	48.297572	04/01 to 10/04	12/31/1953	STATEMENT OF CLAIM	PUMP	1800 GPM	198	70	40O 36822 00
MILK	IRRIGATION	-106.718316	48.250622	04/01 to 10/04	12/31/1938	STATEMENT OF CLAIM	PUMP	1500 GPM	79	26	40O 36823 00
MILK	IRRIGATION	-106.711387	48.251029	04/01 to 10/04	12/31/1938	STATEMENT OF CLAIM	PUMP	1500 GPM	79	26	40O 36823 00
MILK	IRRIGATION	-106.283821	48.107147	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.270645	48.090694	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.276056	48.081606	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.28143	48.083418	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.26018	48.087061	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.26018	48.087061	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.277832	48.08858	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.282786	48.093759	04/01 to 10/31	12/4/1915	STATEMENT OF CLAIM	PUMP	500 GPM	0	343	40O 170664 00
MILK	IRRIGATION	-106.831258	48.333995	04/10 to 09/19	5/17/1912	STATEMENT OF CLAIM	PUMP	964.07 GPM	0	56.71	40O 113792 00
MILK	IRRIGATION	-107.052893	48.398663	05/15 to 09/30	3/28/1912	STATEMENT OF CLAIM	PUMP	4.4 CFS	0	4	40O 214802 00
MILK	IRRIGATION	-106.643848	48.173979	03/01 to 10/31	6/30/1910	STATEMENT OF CLAIM	PUMP	3000 GPM	0	134.5	40O 12974 00
MILK	IRRIGATION	-106.660137	48.199293	03/01 to 10/31	12/31/1942	STATEMENT OF CLAIM	PUMP	3000 GPM	177.14	88.57	40O 30030377
MILK	IRRIGATION	-106.660137	48.199293	03/01 to 10/31	4/4/1903	STATEMENT OF CLAIM	PUMP	3000 GPM	99.06	49.53	40O 12973 00
MILK	IRRIGATION	-106.649373	48.185574	03/01 to 10/31	12/31/1953	STATEMENT OF CLAIM	PUMP	3000 GPM	81.8	40.9	40O 30030376
MILK	IRRIGATION	-106.655747	48.18837	03/01 to 10/31	12/31/1941	STATEMENT OF CLAIM	PUMP	3000 GPM	80.6	40.3	40O 12972 00
MILK	IRRIGATION	-106.649373	48.185574	03/01 to 10/31	8/31/1903	STATEMENT OF CLAIM	PUMP	3000 GPM	40	20	40O 12971 00
MILK	IRRIGATION	-106.653024	48.191981	03/01 to 10/31	12/31/1941	STATEMENT OF CLAIM	PUMP	1200 GPM	29.4	14.7	40O 12970 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MILK	IRRIGATION	-106.674541	48.221064	04/15 to 10/19	12/31/1910	STATEMENT OF CLAIM	PUMP	3000 GPM	0	296.8	40O 152269 00
MILK	IRRIGATION	-106.674541	48.221064	04/01 to 10/31	4/27/1949	STATEMENT OF CLAIM	PUMP	3000 GPM	0	296.8	40O 214269 00
MILK	IRRIGATION	-106.455098	48.148335	04/01 to 10/31	9/19/1947	STATEMENT OF CLAIM	PUMP	7.35 CFS	0	109	40O 43813 00
MILK	IRRIGATION	-106.464873	48.152754	04/01 to 10/31	9/1/1976	PROVISIONAL PERMIT	PUMP	8.01 CFS	140	56.2	40O 9359 00
MILK	IRRIGATION	-106.568592	48.160452	04/01 to 11/04	11/10/1951	STATEMENT OF CLAIM	PUMP	592 GPM	0	35	40O 43787 00
MILK	IRRIGATION	-106.579526	48.159341	05/01 to 10/19	11/10/1951	STATEMENT OF CLAIM	PUMP	971 GPM	0	30	40O 30013288
MILK	IRRIGATION	-106.817325	48.305789	04/01 to 10/31	6/30/1900	STATEMENT OF CLAIM	PUMP	10 CFS	0	511.2	40O 170708 00
MILK	IRRIGATION	-106.820046	48.305788	04/01 to 10/31	6/30/1900	STATEMENT OF CLAIM	PUMP	10 CFS	0	511.2	40O 170708 00
MILK	IRRIGATION	-106.822749	48.309462	04/01 to 10/31	6/30/1900	STATEMENT OF CLAIM	PUMP	10 CFS	0	511.2	40O 170708 00
MILK	IRRIGATION	-106.781841	48.289369	03/01 to 06/30	7/15/1977	PROVISIONAL PERMIT	PUMP	5000 GPM	450	405	40O 14167 00
MILK	IRRIGATION	-106.77091	48.278497	03/01 to 06/30	7/15/1977	PROVISIONAL PERMIT	PUMP	5000 GPM	450	405	40O 14167 00
MILK	IRRIGATION	-106.768184	48.273041	03/01 to 06/30	7/15/1977	PROVISIONAL PERMIT	HEADGATE	5000 GPM	450	405	40O 14167 00
MILK	IRRIGATION	-106.293565	48.071683	04/20 to 09/10	6/15/1984	PROVISIONAL PERMIT	PUMP	2000 GPM	407	151	40O 55531 00
MILK	IRRIGATION	-106.623264	48.188448	04/01 to 10/31	1/1/1924	STATEMENT OF CLAIM	PUMP	100 GPM	0	10	40O 10027 00
MILK	IRRIGATION	-107.069248	48.416791	03/01 to 10/31	4/30/1967	STATEMENT OF CLAIM	OTHER	5200 GPM	0	317	40O 30064387
MILK	IRRIGATION	-106.374131	48.118225	03/01 to 11/04	10/24/1914	STATEMENT OF CLAIM	PUMP	46.4 GPM	0	5.8	40O 5153 00
MILK	IRRIGATION	-106.983677	48.378016	03/01 to 10/31	5/20/1901	STATEMENT OF CLAIM	PUMP	3800 GPM	0	331.7	40O 171142 00
MILK	IRRIGATION	-107.069248	48.416791	04/01 to 11/30	10/31/1971	STATEMENT OF CLAIM	OTHER	27200 GPM	0	3811	40O 30064386
MILK	IRRIGATION	-106.306993	48.111632	04/15 to 11/04	12/31/1970	STATEMENT OF CLAIM	PUMP	3000 GPM	0	146	40O 28914 00
MILK	IRRIGATION	-106.305199	48.115297	04/01 to 11/19	12/31/1935	STATEMENT OF CLAIM	PUMP	3000 GPM	0	146	40O 46545 00
MILK	IRRIGATION	-106.681829	48.215949	01/01 to 12/31	12/31/1940	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	77	40O 171154 00
MILK	IRRIGATION	-106.676359	48.214986	01/01 to 12/31	12/31/1940	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	77	40O 171154 00
MILK	IRRIGATION	-106.689029	48.219708	01/01 to 12/31	12/31/1940	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	77	40O 171154 00
MILK	IRRIGATION	-106.688029	48.217215	01/01 to 12/31	12/31/1940	STATEMENT OF CLAIM	NATURAL OVERFLOW	NOT LISTED	0	77	40O 171154 00
MILK	IRRIGATION	-106.676359	48.214986	03/01 to 11/04	12/31/1940	STATEMENT OF CLAIM	PUMP	1500 GPM	0	59	40O 171155 00
MILK	IRRIGATION	-106.886406	48.363141	04/15 to 11/04	4/30/1966	STATEMENT OF CLAIM	PUMP	5500 GPM	340.4	346	40O 2408 00
MILK	IRRIGATION	-106.985034	48.378887	04/15 to 10/19	12/31/1934	STATEMENT OF CLAIM	PUMP	2500 GPM	0	331.53	40O 170776 00
MILK	IRRIGATION	-106.886382	48.355838	04/15 to 11/04	12/31/1968	STATEMENT OF CLAIM	PUMP	4000 GPM	0	75	40O 2409 00
MILK	IRRIGATION	-106.793132	48.312123	05/01 to 09/04	5/1/1959	STATEMENT OF CLAIM	PUMP	2000 GPM	0	38	40O 28878 00
MILK	IRRIGATION	-106.682917	48.226485	04/01 to 09/30	12/31/1910	STATEMENT OF CLAIM	PUMP	3800 GPM	0	320	40O 42118 00
MILK	IRRIGATION	-106.677472	48.237341	04/01 to 09/30	12/31/1910	STATEMENT OF CLAIM	PUMP	3800 GPM	0	320	40O 42118 00
MILK	IRRIGATION	-106.699203	48.226507	04/01 to 09/30	12/31/1910	STATEMENT OF CLAIM	PUMP	3800 GPM	0	320	40O 42118 00
MILK	IRRIGATION	-106.671731	48.202961	06/01 to 09/30	6/1/1931	STATEMENT OF CLAIM	PUMP	2250 GPM	0	12	40O 170582 00
MILK	IRRIGATION	-106.309836	48.064307	04/01 to 11/19	6/1/1932	STATEMENT OF CLAIM	PUMP	11.14 CFS	646.45	184.7	40O 40279 00
MILK	IRRIGATION	-107.173604	48.508395	10/15 to 04/15	2/23/1981	PROVISIONAL PERMIT	PUMP	6000 GPM	390	260	40J 31899 00
MILK	IRRIGATION	-107.169506	48.503695	05/01 to 09/15	6/10/1976	PROVISIONAL PERMIT	PUMP	2300 GPM	264	115	40J 8865 00
MILK	IRRIGATION	-107.172238	48.507568	05/01 to 09/15	6/10/1976	PROVISIONAL PERMIT	PUMP	2300 GPM	264	115	40J 8865 00
MILK	IRRIGATION	-107.194034	48.509167	05/01 to 09/15	6/10/1976	PROVISIONAL PERMIT	PUMP	2300 GPM	264	115	40J 8865 00
MILK	IRRIGATION	-106.696429	48.246436	05/01 to 11/19	9/19/1907	STATEMENT OF CLAIM	PUMP	2244 GPM	0	106	40O 42186 00
MILK	IRRIGATION	-106.692324	48.237814	04/01 to 11/04	12/31/1947	STATEMENT OF CLAIM	PUMP	1600 GPM	0	50	40O 170581 00
MILK	IRRIGATION	-107.213115	48.509158	04/01 to 11/30	6/30/1961	STATEMENT OF CLAIM	PUMP	136 GPM	8	8	40J 182610 00
MILK	IRRIGATION	-106.261279	48.082819	04/01 to 11/19	12/31/1932	STATEMENT OF CLAIM	PUMP	2890 GPM	0	109.7	40O 170794 00
MILK	IRRIGATION	-106.924349	48.370414	03/15 to 07/15	12/30/1976	PROVISIONAL PERMIT	PUMP	11.13 CFS	160	70	40O 7528 00
MILK	IRRIGATION	-106.919009	48.359224	04/15 to 11/04	4/30/1966	STATEMENT OF CLAIM	PUMP	5500 GPM	79.6	39.8	40O 2407 00
MILK	IRRIGATION	-106.540155	48.140347	04/01 to 09/30	12/31/1930	STATEMENT OF CLAIM	PUMP	1200 GPM	0	52	40O 130652 00
MILK	IRRIGATION	-106.599884	48.162052	04/15 to 10/15	3/18/1976	PROVISIONAL PERMIT	PUMP	421.87 GPM	207	90	40O 7750 00
MILK	LAWN AND GARDEN	-106.591375	48.158414	04/15 to 10/04	12/31/1944	STATEMENT OF CLAIM	PUMP	35 GPM	3.12	1.25	40O 28932 00
MILK	LAWN AND GARDEN	-106.375497	48.118271	01/01 to 12/31	11/9/1981	PROVISIONAL PERMIT	PUMP	10 GPM	2.7	0	40O 39487 00
MILK	LAWN AND GARDEN	-106.745225	48.246588	04/01 to 10/31	6/19/1919	STATEMENT OF CLAIM	PUMP	35 GPM	10	5	40O 170855 00
MILK	MULTIPLE DOMESTIC	-106.973008	48.374568	03/15 to 10/31	7/24/1908	STATEMENT OF CLAIM	DIVERSION DAM	NOT LISTED	60	0	40O 40930 00
MISSOURI	AG. SPRAYING	-105.808062	48.023144	01/01 to 12/31	12/31/1952	STATEMENT OF CLAIM	PUMP	100 GPM	2	0	40S 184738 00
MISSOURI	DOMESTIC	-104.123993	48.044264	01/01 to 12/31	10/15/1976	PROVISIONAL PERMIT	PUMP	1.67 CFS	60	29	40S 9852 00
MISSOURI	DOMESTIC	-104.12399	48.046073	01/01 to 12/31	10/15/1976	PROVISIONAL PERMIT	PUMP	1.67 CFS	60	29	40S 9852 00
MISSOURI	DOMESTIC	-105.039945	48.055227	01/01 to 12/31	1890-12-31	STATEMENT OF CLAIM	PUMP	75 GPM	2.5	0.5	40S 214733 00
MISSOURI	DOMESTIC	-104.128917	48.051522	01/01 to 12/31	12/31/1937	STATEMENT OF CLAIM	PUMP	5 GPM	3	1	40S 187284 00
MISSOURI	INDUSTRIAL	-104.105265	48.007165	01/01 to 12/31	10/27/2017	TEMPORARY PERMIT	PUMP	4.2 CFS	96.7	0	40S 30112328
MISSOURI	INDUSTRIAL	-104.612412	48.140191	01/01 to 12/31	1888-05-31	STATEMENT OF CLAIM	PUMP	224.4 GPM	135	0	40S 142790 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MISSOURI	INDUSTRIAL	-104.093105	48.032482	01/01 to 12/31	5/31/1913	STATEMENT OF CLAIM	PUMP	400 GPM	0	0	40S 142799 00
MISSOURI	INDUSTRIAL	-104.105265	48.007165	01/01 to 12/31	6/11/2018	TEMPORARY PERMIT	PUMP	4.2 CFS	580	0	40S 30117875
MISSOURI	IRRIGATION	-104.593008	48.115049	04/01 to 11/01	7/1/1985	CONSERVATION DISTRICT RECORD	ELECTRIC PUMP	2000 GPM	459	229	40S 30022265
MISSOURI	IRRIGATION	-104.598592	48.126815	04/01 to 11/01	7/1/1985	CONSERVATION DISTRICT RECORD	FUELED PUMP	2000 GPM	459	229	40S 30022265
MISSOURI	IRRIGATION	-105.782317	48.025068	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1.5 CFS	182	79	40S 30006333
MISSOURI	IRRIGATION	-104.80873	48.120564	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6.55 CFS	312.5	125	40S 114741 00
MISSOURI	IRRIGATION	-105.56199	48.082407	04/15 to 10/19	10/15/1971	STATEMENT OF CLAIM	PUMP	1.12 CFS	0	35	40S 178482 00
MISSOURI	IRRIGATION	-105.305372	48.076786	03/01 to 11/30	1/19/1981	PROVISIONAL PERMIT	PUMP	4500 GPM	4450	1745	40S 34798 00
MISSOURI	IRRIGATION	-105.305372	48.076786	03/01 to 11/30	3/1/1982	PROVISIONAL PERMIT	PUMP	6700 GPM	0	1745	40S 42690 00
MISSOURI	IRRIGATION	-105.714825	48.033957	04/01 to 11/04	12/31/1936	STATEMENT OF CLAIM	PUMP	4800 GPM	0	243	40S 36976 00
MISSOURI	IRRIGATION	-104.617873	48.129615	06/01 to 09/01	2/27/1975	PROVISIONAL PERMIT	PUMP	564 GPM	232	252	40S 30022924
MISSOURI	IRRIGATION	-104.617873	48.129615	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	3.9 CFS	272.8	252	40S 30027588
MISSOURI	IRRIGATION	-104.420033	48.086728	04/15 to 10/15	4/15/1955	STATEMENT OF CLAIM	PUMP	1300 GPM	0	386	40S 186742 00
MISSOURI	IRRIGATION	-104.406209	48.09232	05/01 to 10/01	6/20/1977	PROVISIONAL PERMIT	PUMP	1000 GPM	324	120	40S 13498 00
MISSOURI	IRRIGATION	-104.427657	48.092001	05/01 to 10/01	6/20/1977	PROVISIONAL PERMIT	PUMP	1000 GPM	324	120	40S 13498 00
MISSOURI	IRRIGATION	-104.406208	48.077954	05/01 to 10/01	6/20/1977	PROVISIONAL PERMIT	PUMP	1000 GPM	324	120	40S 13498 00
MISSOURI	IRRIGATION	-104.406209	48.09232	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.1 CFS	804	527	40S 106914 00
MISSOURI	IRRIGATION	-104.427657	48.092001	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.1 CFS	804	527	40S 106914 00
MISSOURI	IRRIGATION	-104.406208	48.077954	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.1 CFS	804	527	40S 106914 00
MISSOURI	IRRIGATION	-104.427657	48.092001	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	3.9 CFS	520	260	40S 106915 00
MISSOURI	IRRIGATION	-105.015556	48.066033	05/10 to 10/19	4/15/1964	STATEMENT OF CLAIM	PUMP	5000 GPM	0	189.3	40S 46465 00
MISSOURI	IRRIGATION	-105.056267	48.054963	03/15 to 11/15	4/15/1975	PROVISIONAL PERMIT	PUMP	3.34 CFS	600	165	40S 5257 00
MISSOURI	IRRIGATION	-105.048099	48.051642	04/01 to 09/30	8/31/1971	STATEMENT OF CLAIM	PUMP	1900 GPM	0	92	40S 2400 00
MISSOURI	IRRIGATION	-105.012852	48.06603	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.2 CFS	272	136	40S 30024907
MISSOURI	IRRIGATION	-105.692292	48.051346	04/15 to 10/15	9/12/1978	PROVISIONAL PERMIT	PUMP	2500 GPM	222	100	40S 20289 00
MISSOURI	IRRIGATION	-105.692246	48.051974	04/15 to 10/15	9/1/1981	PROVISIONAL PERMIT	PUMP	500 GPM	270	100	40S 35714 00
MISSOURI	IRRIGATION	-104.617273	48.144206	06/01 to 08/15	2/24/1978	PROVISIONAL PERMIT	PUMP	600 GPM	216	80	40S 17844 00
MISSOURI	IRRIGATION	-105.94358	48.010445	04/15 to 09/01	4/9/1986	PROVISIONAL PERMIT	PUMP	1.4 CFS	156	60	40S 61832 00
MISSOURI	IRRIGATION	-104.100543	48.027957	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.6 CFS	145	58	40S 104510 00
MISSOURI	IRRIGATION	-105.615408	48.072008	05/01 to 10/19	4/7/1965	STATEMENT OF CLAIM	PUMP	4420 GPM	0	15	40S 46346 00
MISSOURI	IRRIGATION	-104.542444	48.124323	04/01 to 09/30	10/5/1949	STATEMENT OF CLAIM	PUMP	544 GPM	0	32	40S 101303 00
MISSOURI	IRRIGATION	-105.201476	48.062827	05/01 to 10/31	11/29/1949	STATEMENT OF CLAIM	PUMP	3000 GPM	0	181	40S 168962 00
MISSOURI	IRRIGATION	-104.126686	48.045172	03/01 to 11/30	4/1/1937	STATEMENT OF CLAIM	PUMP	750 GPM	0	25	40S 130516 00
MISSOURI	IRRIGATION	-105.332661	48.097044	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	9 CFS	1420	710	40S 102771 00
MISSOURI	IRRIGATION	-104.571768	48.112516	04/01 to 10/31	6/1/1935	STATEMENT OF CLAIM	PUMP	860 GPM	0	41.4	40S 163084 00
MISSOURI	IRRIGATION	-104.974763	48.087565	06/01 to 09/19	2/19/1964	STATEMENT OF CLAIM	PUMP	2601 GPM	0	153	40S 171835 00
MISSOURI	IRRIGATION	-104.974782	48.08214	06/01 to 09/19	2/19/1964	STATEMENT OF CLAIM	PUMP	2601 GPM	0	153	40S 171835 00
MISSOURI	IRRIGATION	-105.010123	48.073276	06/01 to 09/19	12/31/1935	STATEMENT OF CLAIM	PUMP	3000 GPM	0	135	40S 171834 00
MISSOURI	IRRIGATION	-105.155987	48.073706	04/10 to 10/10	10/26/1989	PROVISIONAL PERMIT	PUMP	3500 GPM	540	200	40S 71788 00
MISSOURI	IRRIGATION	-105.155987	48.073706	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4 CFS	590	295	40S 104421 00
MISSOURI	IRRIGATION	-104.534455	48.125825	03/01 to 12/04	5/1/1968	STATEMENT OF CLAIM	PUMP	1700 GPM	0	139	40S 1508 00
MISSOURI	IRRIGATION	-105.35707	48.089523	04/15 to 10/19	2/17/1959	STATEMENT OF CLAIM	PUMP	12 CFS	0	88	40S 106040 00
MISSOURI	IRRIGATION	-105.35707	48.089523	04/01 to 11/30	2/17/1959	STATEMENT OF CLAIM	PUMP	1.41 CFS	0	40.3	40S 166063 00
MISSOURI	IRRIGATION	-105.580443	48.079284	05/01 to 11/04	9/22/1952	STATEMENT OF CLAIM	PUMP	5000 GPM	0	170	40S 46368 00
MISSOURI	IRRIGATION	-104.922491	48.122709	04/01 to 10/31	10/1/1935	STATEMENT OF CLAIM	PUMP	9000 GPM	0	475	40S 130507 00
MISSOURI	IRRIGATION	-104.922491	48.122709	04/01 to 10/31	7/29/1935	STATEMENT OF CLAIM	PUMP	9000 GPM	0	80	40S 130506 00
MISSOURI	IRRIGATION	-104.922491	48.122709	04/15 to 10/15	3/5/1974	PROVISIONAL PERMIT	PUMP	6000 GPM	219	73	40S 1666 00
MISSOURI	IRRIGATION	-105.611347	48.072986	04/01 to 10/31	9/22/1983	PROVISIONAL PERMIT	PUMP	5000 GPM	216	80	40S 53280 00
MISSOURI	IRRIGATION	-105.896153	48.015005	05/01 to 07/31	6/2/1934	STATEMENT OF CLAIM	PUMP	4800 GPM	0	144	40S 8836 00
MISSOURI	IRRIGATION	-105.889723	48.018603	05/15 to 10/15	7/2/1974	PROVISIONAL PERMIT	PUMP	3100 GPM	233	75.4	40S 2799 00
MISSOURI	IRRIGATION	-105.884616	48.027372	05/15 to 10/15	7/2/1974	PROVISIONAL PERMIT	PUMP	3100 GPM	233	75.4	40S 2799 00
MISSOURI	IRRIGATION	-104.620525	48.11686	06/01 to 09/01	2/27/1975	PROVISIONAL PERMIT	PUMP	852 GPM	350	382	40S 4947 00
MISSOURI	IRRIGATION	-104.617873	48.129615	06/01 to 09/01	2/27/1975	PROVISIONAL PERMIT	PUMP	852 GPM	350	382	40S 4947 00
MISSOURI	IRRIGATION	-104.598592	48.126815	04/01 to 10/31	4/20/1990	PROVISIONAL PERMIT	PUMP	500 GPM	120	60	40S 74355 00
MISSOURI	IRRIGATION	-104.620525	48.11686	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6 CFS	413.6	382	40S 30012791
MISSOURI	IRRIGATION	-104.617873	48.129615	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6 CFS	413.6	382	40S 30012791
MISSOURI	IRRIGATION	-105.521513	48.075664	03/15 to 11/04	1/12/1963	STATEMENT OF CLAIM	PUMP	5500 GPM	0	214	40S 171349 00
MISSOURI	IRRIGATION	-105.482447	48.087931	03/01 to 10/31	12/28/1963	STATEMENT OF CLAIM	PUMP	12 CFS	0	118	40S 4236 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MISSOURI	IRRIGATION	-105.470198	48.093487	04/01 to 09/04	5/31/1966	STATEMENT OF CLAIM	PUMP	6.68 CFS	0	26.5	40S 113898 00
MISSOURI	IRRIGATION	-105.636964	48.059445	05/01 to 10/15	3/25/1977	PROVISIONAL PERMIT	PUMP	6.68 CFS	162	60	40S 11975 00
MISSOURI	IRRIGATION	-105.766855	48.029567	04/01 to 10/31	4/25/1991	PROVISIONAL PERMIT	PUMP	2000 GPM	999	326	40S 77523 00
MISSOURI	IRRIGATION	-105.779689	48.032317	04/01 to 10/04	10/2/1952	STATEMENT OF CLAIM	PUMP	2000 GPM	0	100	40S 16376 00
MISSOURI	IRRIGATION	-105.755344	48.023343	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4100 GPM	966	420	40S 30050269
MISSOURI	IRRIGATION	-104.183417	48.060594	03/15 to 10/31	9/18/1961	STATEMENT OF CLAIM	PUMP	9000 GPM	0	531	40S 3227 00
MISSOURI	IRRIGATION	-104.183417	48.060594	04/15 to 10/19	5/22/1973	STATEMENT OF CLAIM	PUMP	9000 GPM	0	205	40S 30030363
MISSOURI	IRRIGATION	-105.521541	48.086202	04/15 to 10/15	4/27/1978	PROVISIONAL PERMIT	PUMP	2500 GPM	77	28.5	40S 18593 00
MISSOURI	IRRIGATION	-104.296221	48.049736	04/01 to 09/15	9/13/1990	PROVISIONAL PERMIT	PUMP	1000 GPM	540	200	40S 74618 00
MISSOURI	IRRIGATION	-104.296221	48.049736	05/01 to 09/30	9/19/1996	PROVISIONAL PERMIT	PUMP	1000 GPM	309.7	114.7	40S 99060 00
MISSOURI	IRRIGATION	-105.519031	48.08959	04/01 to 10/31	5/25/1965	STATEMENT OF CLAIM	PUMP	2244 GPM	0	26	40S 170297 00
MISSOURI	IRRIGATION	-104.214422	48.034331	04/01 to 10/15	5/5/1999	PROVISIONAL PERMIT	PUMP	4788 GPM	0	974	40S 109529 00
MISSOURI	IRRIGATION	-104.192872	48.048848	04/01 to 10/15	5/5/1999	PROVISIONAL PERMIT	PUMP	4788 GPM	0	974	40S 109529 00
MISSOURI	IRRIGATION	-104.19282	48.034322	04/01 to 10/15	5/5/1999	PROVISIONAL PERMIT	PUMP	4788 GPM	0	974	40S 109529 00
MISSOURI	IRRIGATION	-104.23598	48.034319	04/01 to 10/15	5/5/1999	PROVISIONAL PERMIT	PUMP	4788 GPM	0	974	40S 109529 00
MISSOURI	IRRIGATION	-104.214422	48.034331	04/01 to 10/15	3/26/1976	PROVISIONAL PERMIT	PUMP	2000 GPM	2125	860	40S 7832 00
MISSOURI	IRRIGATION	-104.192872	48.048848	04/01 to 10/15	3/26/1976	PROVISIONAL PERMIT	PUMP	2000 GPM	2125	860	40S 7832 00
MISSOURI	IRRIGATION	-104.19282	48.034322	04/01 to 10/15	3/26/1976	PROVISIONAL PERMIT	PUMP	2000 GPM	2125	860	40S 7832 00
MISSOURI	IRRIGATION	-104.23598	48.034319	04/01 to 10/15	3/26/1976	PROVISIONAL PERMIT	PUMP	2000 GPM	2125	860	40S 7832 00
MISSOURI	IRRIGATION	-104.242611	48.030891	04/15 to 10/15	6/22/2015	PROVISIONAL PERMIT	PUMP	1800 GPM	396.4	198.2	40S 30072269
MISSOURI	IRRIGATION	-104.214422	48.034331	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	21.4 CFS	282	974	40S 109530 00
MISSOURI	IRRIGATION	-104.192872	48.048848	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	21.4 CFS	282	974	40S 109530 00
MISSOURI	IRRIGATION	-104.19282	48.034322	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	21.4 CFS	282	974	40S 109530 00
MISSOURI	IRRIGATION	-104.23598	48.034319	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	21.4 CFS	282	974	40S 109530 00
MISSOURI	IRRIGATION	-105.412288	48.095161	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4.9 CFS	628.1	314.05	40S 111429 00
MISSOURI	IRRIGATION	-105.411148	48.093477	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.67 CFS	240	120	40S 30006005
MISSOURI	IRRIGATION	-105.186533	48.072823	04/01 to 10/31	1/17/1991	PROVISIONAL PERMIT	PUMP	3500 GPM	189	70	40S 77141 00
MISSOURI	IRRIGATION	-104.701203	48.116849	04/01 to 10/04	12/31/1951	STATEMENT OF CLAIM	PUMP	1500 GPM	0	186	40S 46549 00
MISSOURI	IRRIGATION	-104.701203	48.116849	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1.6 CFS	125.95	57.25	40S 30006748
MISSOURI	IRRIGATION	-106.186244	48.031924	04/01 to 10/31	3/1/1989	PROVISIONAL PERMIT	PUMP	3300 GPM	33	13	40S 71190 00
MISSOURI	IRRIGATION	-104.596267	48.134984	04/01 to 11/01	7/8/1960	STATEMENT OF CLAIM	PUMP	800 GPM	0	160	40S 178504 00
MISSOURI	IRRIGATION	-105.703361	48.045027	04/01 to 10/31	7/1/1940	STATEMENT OF CLAIM	PUMP	4100 GPM	0	125.5	40S 172353 00
MISSOURI	IRRIGATION	-105.413798	48.09523	04/01 to 10/31	6/18/1954	STATEMENT OF CLAIM	PUMP	1846.2 GPM	0	108.6	40S 215784 00
MISSOURI	IRRIGATION	-105.412288	48.095161	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4.9 CFS	676.5	338.25	40S 111430 00
MISSOURI	IRRIGATION	-104.625943	48.109615	06/01 to 09/01	2/27/1975	PROVISIONAL PERMIT	PUMP	584 GPM	240	166	40S 30022935
MISSOURI	IRRIGATION	-106.28801	48.041847	04/01 to 11/30	12/31/1940	STATEMENT OF CLAIM	PUMP	6700 GPM	0	140	40S 10030 00
MISSOURI	IRRIGATION	-106.292077	48.039397	04/15 to 11/15	1/6/1977	PROVISIONAL PERMIT	PUMP	8.01 CFS	270	100	40S 11184 00
MISSOURI	IRRIGATION	-106.28801	48.041847	04/01 to 11/30	1/19/1981	PROVISIONAL PERMIT	PUMP	6700 GPM	89	33	40S 31904 00
MISSOURI	IRRIGATION	-104.05543	48.003144	05/01 to 10/31	9/26/1980	PROVISIONAL PERMIT	PUMP	320 GPM	108	40	40S 31832 00
MISSOURI	IRRIGATION	-105.424522	48.094989	04/01 to 09/30	7/18/1954	STATEMENT OF CLAIM	PUMP	14.24 CFS	0	376	40S 117928 00
MISSOURI	IRRIGATION	-105.610007	48.073761	03/01 to 11/19	5/20/1958	STATEMENT OF CLAIM	PUMP	316.2 GPM	0	18.6	40S 170296 00
MISSOURI	IRRIGATION	-105.216786	48.075359	03/01 to 11/30	3/1/1953	STATEMENT OF CLAIM	PUMP	1190 GPM	0	70	40S 165479 00
MISSOURI	IRRIGATION	-105.244403	48.094796	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	3100 GPM	1114	557	40S 106983 00
MISSOURI	IRRIGATION	-104.407857	48.076932	04/15 to 10/19	7/30/1960	STATEMENT OF CLAIM	PUMP	7000 GPM	0	752	40S 171255 00
MISSOURI	IRRIGATION	-105.617539	48.075658	04/15 to 10/15	4/12/1993	PROVISIONAL PERMIT	PUMP	2700 GPM	300.8	150.4	40S 84881 00
MISSOURI	IRRIGATION	-105.591326	48.084181	04/01 to 11/19	7/1/1962	STATEMENT OF CLAIM	PUMP	5.3 CFS	222.65	118.2	40S 170287 00
MISSOURI	IRRIGATION	-105.617539	48.075658	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2692.8 GPM	421.25	168.5	40S 30004260
MISSOURI	IRRIGATION	-104.798414	48.122338	05/01 to 09/30	5/1/1975	PROVISIONAL PERMIT	PUMP	7.2 CFS	1290	430	40S 5421 00
MISSOURI	IRRIGATION	-104.770245	48.123548	05/01 to 09/30	5/1/1975	PROVISIONAL PERMIT	PUMP	7.2 CFS	1290	430	40S 5421 00
MISSOURI	IRRIGATION	-104.80873	48.120564	04/01 to 10/15	10/20/2000	CONSERVATION DISTRICT RECORD	PUMP	5.08 CFS	242.5	97	40S 30104519
MISSOURI	IRRIGATION	-104.202276	48.069681	04/01 to 11/01	2/12/1993	PROVISIONAL PERMIT	PUMP	13000 GPM	1700	970	40S 84851 00
MISSOURI	IRRIGATION	-104.202276	48.069681	04/15 to 10/15	3/26/1976	PROVISIONAL PERMIT	PUMP	5.56 CFS	380	127	40S 7826 00
MISSOURI	IRRIGATION	-105.228465	48.068298	04/01 to 10/31	10/25/1977	PROVISIONAL PERMIT	PUMP	1000 GPM	351	130	40S 15984 00
MISSOURI	IRRIGATION	-104.578579	48.110495	04/01 to 10/31	12/31/1965	STATEMENT OF CLAIM	PUMP	1.06 CFS	0	28.1	40S 178507 00
MISSOURI	IRRIGATION	-104.534455	48.125825	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	800 GPM	176.9	73	40S 30044041
MISSOURI	IRRIGATION	-104.534455	48.125825	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.5 CFS	360	180	40S 103671 00
MISSOURI	IRRIGATION	-104.064915	48.004465	04/15 to 11/04	5/31/1958	STATEMENT OF CLAIM	PUMP	2000 GPM	0	70	40S 171290 00
MISSOURI	IRRIGATION	-104.078423	48.003855	04/15 to 11/04	5/31/1958	STATEMENT OF CLAIM	PUMP	2000 GPM	0	70	40S 171290 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MISSOURI	IRRIGATION	-105.138381	48.07184	04/01 to 10/31	1/7/1985	PROVISIONAL PERMIT	PUMP	1300 GPM	720	240	40S 57388 00
MISSOURI	IRRIGATION	-106.08363	48.018513	04/15 to 10/15	7/18/1974	PROVISIONAL PERMIT	PUMP	4500 GPM	1000	500	40S 3034 00
MISSOURI	IRRIGATION	-106.086794	48.010262	04/15 to 10/19	7/1/1952	STATEMENT OF CLAIM	PUMP	15 CFS	0	470	40S 46358 00
MISSOURI	IRRIGATION	-106.086788	48.00854	04/01 to 11/19	4/4/1952	STATEMENT OF CLAIM	PUMP	9.24 CFS	0	244	40S 46344 00
MISSOURI	IRRIGATION	-106.055584	48.023265	04/01 to 10/31	5/31/1958	STATEMENT OF CLAIM	PUMP	6.44 CFS	0	170	40S 172440 00
MISSOURI	IRRIGATION	-106.088091	48.007269	04/15 to 11/15	6/12/1975	PROVISIONAL PERMIT	PUMP	10.01 CFS	560	145	40S 5686 00
MISSOURI	IRRIGATION	-106.088091	48.007269	04/15 to 11/15	6/12/1975	PROVISIONAL PERMIT	PUMP	10.01 CFS	560	145	40S 5686 00
MISSOURI	IRRIGATION	-106.083592	48.027549	04/01 to 10/31	5/4/1953	STATEMENT OF CLAIM	PUMP	2210 GPM	0	130	40S 172439 00
MISSOURI	IRRIGATION	-106.091071	48.007764	04/15 to 11/15	9/30/1975	PROVISIONAL PERMIT	PUMP	8.9 CFS	390	115	40S 6549 00
MISSOURI	IRRIGATION	-106.064547	48.030115	04/01 to 11/19	9/16/1957	STATEMENT OF CLAIM	PUMP	10 CFS	0	80	40S 46345 00
MISSOURI	IRRIGATION	-106.049962	48.012133	04/01 to 11/19	9/16/1957	STATEMENT OF CLAIM	PUMP	10 CFS	0	80	40S 46345 00
MISSOURI	IRRIGATION	-106.064547	48.030115	04/15 to 11/04	1/23/1951	STATEMENT OF CLAIM	PUMP	10 CFS	0	63	40S 122034 00
MISSOURI	IRRIGATION	-106.083592	48.027549	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1870 GPM	262.5	105	40S 30044022
MISSOURI	IRRIGATION	-106.051933	48.019213	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1870 GPM	262.5	105	40S 30044022
MISSOURI	IRRIGATION	-104.16445	48.036269	04/01 to 11/30	2/20/1912	STATEMENT OF CLAIM	PUMP	41.1 CFS	0	1085	40S 172261 00
MISSOURI	IRRIGATION	-104.12938	48.042462	04/15 to 10/15	3/22/1976	PROVISIONAL PERMIT	PUMP	6.68 CFS	1500	580	40S 7775 00
MISSOURI	IRRIGATION	-104.16445	48.036269	04/15 to 10/15	3/22/1976	PROVISIONAL PERMIT	PUMP	6.68 CFS	1500	580	40S 7775 00
MISSOURI	IRRIGATION	-104.272265	48.040536	05/01 to 10/01	10/28/1974	PROVISIONAL PERMIT	PUMP	6000 GPM	1440	450	40S 4010 00
MISSOURI	IRRIGATION	-104.588043	48.105996	04/15 to 10/31	12/4/1995	PROVISIONAL PERMIT	PUMP	5.8 CFS	795	446	40S 96357 00
MISSOURI	IRRIGATION	-104.196929	48.040628	05/01 to 09/19	12/30/1959	STATEMENT OF CLAIM	PUMP	9 CFS	0	170	40S 41349 00
MISSOURI	IRRIGATION	-104.194391	48.039696	04/20 to 10/01	7/1/1988	PROVISIONAL PERMIT	PUMP	4000 GPM	408	136	40S 66293 00
MISSOURI	IRRIGATION	-104.272265	48.040536	05/01 to 10/01	3/2/1978	PROVISIONAL PERMIT	PUMP	4000 GPM	200	70	40S 17852 00
MISSOURI	IRRIGATION	-104.27587	48.039499	04/20 to 10/01	7/1/1988	PROVISIONAL PERMIT	PUMP	4000 GPM	165	55	40S 66294 00
MISSOURI	IRRIGATION	-104.588043	48.105996	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.8 CFS	927	446	40S 101074 00
MISSOURI	IRRIGATION	-104.16445	48.036269	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.2 CFS	340	170	40S 114723 00
MISSOURI	IRRIGATION	-104.196929	48.040628	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	10 CFS	408	136	40S 111449 00
MISSOURI	IRRIGATION	-104.16445	48.036269	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.6 CFS	150	53	40S 106912 00
MISSOURI	IRRIGATION	-105.978721	48.016376	05/01 to 10/15	2/19/1976	PROVISIONAL PERMIT	PUMP	3.34 CFS	616	228	40S 7532 00
MISSOURI	IRRIGATION	-106.0111	48.005734	05/01 to 10/15	5/20/1976	PROVISIONAL PERMIT	PUMP	2.67 CFS	520	185	40S 8354 00
MISSOURI	IRRIGATION	-106.011096	48.014782	04/01 to 11/30	4/1/1958	STATEMENT OF CLAIM	PUMP	9000 GPM	0	150	40S 130479 00
MISSOURI	IRRIGATION	-105.958443	48.01042	04/01 to 11/30	5/29/1936	STATEMENT OF CLAIM	PUMP	7340 GPM	0	118	40S 130478 00
MISSOURI	IRRIGATION	-105.961147	48.010422	04/01 to 11/30	5/29/1936	STATEMENT OF CLAIM	PUMP	7340 GPM	0	118	40S 130478 00
MISSOURI	IRRIGATION	-106.01914	48.022025	04/01 to 11/30	7/28/1958	STATEMENT OF CLAIM	PUMP	9000 GPM	0	90	40S 130481 00
MISSOURI	IRRIGATION	-105.507981	48.098703	04/15 to 11/19	12/23/1961	STATEMENT OF CLAIM	PUMP	9.7 CFS	0	256	40S 168893 00
MISSOURI	IRRIGATION	-105.73143	48.032618	05/10 to 10/31	5/30/1974	PROVISIONAL PERMIT	PUMP	10 CFS	500	251.6	40S 2448 00
MISSOURI	IRRIGATION	-105.747216	48.023347	04/10 to 11/14	1/13/1959	STATEMENT OF CLAIM	PUMP	4500 GPM	0	181	40S 46354 00
MISSOURI	IRRIGATION	-106.04609	48.005795	05/01 to 10/15	5/23/1974	PROVISIONAL PERMIT	PUMP	2.22 CFS	1200	405	40S 2354 00
MISSOURI	IRRIGATION	-106.046383	48.01068	04/01 to 11/30	11/24/1958	STATEMENT OF CLAIM	PUMP	1190 GPM	0	70	40S 101309 00
MISSOURI	IRRIGATION	-104.493873	48.11454	05/01 to 10/19	12/31/1920	STATEMENT OF CLAIM	PUMP	2800 GPM	0	695	40S 101292 00
MISSOURI	IRRIGATION	-105.579185	48.080582	03/15 to 10/31	1/29/1981	PROVISIONAL PERMIT	PUMP	5000 GPM	674	227	40S 31900 00
MISSOURI	IRRIGATION	-105.559218	48.074382	04/10 to 11/30	4/6/1951	STATEMENT OF CLAIM	PUMP	2890 GPM	0	170	40S 121994 00
MISSOURI	IRRIGATION	-106.053226	48.02893	04/01 to 10/31	9/2/1954	STATEMENT OF CLAIM	PUMP	7276 GPM	0	428	40S 171570 00
MISSOURI	IRRIGATION	-106.067624	48.03563	04/01 to 10/31	9/1/1971	STATEMENT OF CLAIM	PUMP	884 GPM	0	52	40S 184731 00
MISSOURI	IRRIGATION	-106.047275	48.017985	04/01 to 10/31	9/1/1940	STATEMENT OF CLAIM	PUMP	714 GPM	0	42	40S 187312 00
MISSOURI	IRRIGATION	-106.278833	48.047592	04/01 to 11/30	3/12/1963	STATEMENT OF CLAIM	PUMP	6900 GPM	0	166	40S 168938 00
MISSOURI	IRRIGATION	-104.868747	48.13857	04/01 to 10/01	4/6/1992	PROVISIONAL PERMIT	PUMP	2000 GPM	741	274.5	40S 80553 00
MISSOURI	IRRIGATION	-105.381172	48.093712	05/01 to 09/04	5/1/1955	STATEMENT OF CLAIM	PUMP	1600 GPM	0	173.2	40S 215786 00
MISSOURI	IRRIGATION	-105.611347	48.072986	03/01 to 11/19	5/20/1958	STATEMENT OF CLAIM	PUMP	11.58 CFS	0	305.8	40S 4249 00
MISSOURI	IRRIGATION	-104.760043	48.119495	04/15 to 10/15	6/20/1988	PROVISIONAL PERMIT	PUMP	2000 GPM	700	310	40S 66284 00
MISSOURI	IRRIGATION	-104.818179	48.118758	04/01 to 11/01	1/24/1985	PROVISIONAL PERMIT	PUMP	1250 GPM	486	167	40S 57404 00
MISSOURI	IRRIGATION	-104.839878	48.118986	04/01 to 11/01	1/24/1985	PROVISIONAL PERMIT	PUMP	1250 GPM	486	167	40S 57404 00
MISSOURI	IRRIGATION	-104.827681	48.117764	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	ELECTRIC PUMP	1.1 CFS	161	0	40S 30104412
MISSOURI	IRRIGATION	-104.100543	48.027957	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	3.4 CFS	203	78	40S 114722 00
MISSOURI	IRRIGATION	-105.920713	48.003964	04/01 to 10/31	6/10/1958	STATEMENT OF CLAIM	PUMP	2.47 CFS	0	65	40S 172441 00
MISSOURI	IRRIGATION	-105.256824	48.08659	04/15 to 10/19	12/8/1958	STATEMENT OF CLAIM	PUMP	5000 GPM	0	183	40S 17220 00
MISSOURI	IRRIGATION	-105.258172	48.086077	04/15 to 10/15	2/15/1977	PROVISIONAL PERMIT	PUMP	2.22 CFS	465	175	40S 11394 00
MISSOURI	IRRIGATION	-105.258172	48.086077	03/01 to 11/30	10/17/1977	PROVISIONAL PERMIT	PUMP	400 GPM	94.5	35	40S 16093 00
MISSOURI	IRRIGATION	-104.457282	48.109053		7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4.2 CFS	636	318	40S 106990 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MISSOURI	IRRIGATION	-104.560948	48.124053	05/01 to 09/30	12/12/1968	STATEMENT OF CLAIM	PUMP	650 GPM	0	60	40S 5134 00
MISSOURI	IRRIGATION	-104.563674	48.116795	05/01 to 09/19	4/1/1967	STATEMENT OF CLAIM	PUMP	450 GPM	0	40	40S 11957 00
MISSOURI	IRRIGATION	-104.854918	48.125702	05/15 to 09/19	12/31/1960	STATEMENT OF CLAIM	PUMP	50 GPM	0	13	40S 3215 00
MISSOURI	IRRIGATION	-104.860129	48.126868	04/01 to 11/19	5/20/1949	STATEMENT OF CLAIM	PUMP	1250 GPM	0	110	40S 125402 00
MISSOURI	IRRIGATION	-104.85762	48.127462	05/01 to 11/01	2/1/1978	PROVISIONAL PERMIT	PUMP	1430 GPM	0	110	40S 17166 00
MISSOURI	IRRIGATION	-104.827681	48.117764	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1.73 CFS	224	112	40S 30072073
MISSOURI	IRRIGATION	-104.860129	48.126868	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6.7 CFS	68	31	40S 116904 00
MISSOURI	IRRIGATION	-104.497885	48.117487	04/01 to 10/31	6/3/1991	PROVISIONAL PERMIT	PUMP	2000 GPM	1202	445.2	40S 78203 00
MISSOURI	IRRIGATION	-105.120809	48.060926	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.7 CFS	364	182	40S 104484 00
MISSOURI	IRRIGATION	-104.118591	48.026122	04/01 to 10/31	7/19/1949	STATEMENT OF CLAIM	PUMP	2.5 CFS	0	110	40S 46536 00
MISSOURI	IRRIGATION	-105.114355	48.080793	01/01 to 12/31	5/25/1990	PROVISIONAL PERMIT	PUMP	6000 GPM	370	136.8	40S 74573 00
MISSOURI	IRRIGATION	-105.111377	48.080771	04/01 to 11/30	7/31/1961	STATEMENT OF CLAIM	PUMP	1360 GPM	0	80	40S 171300 00
MISSOURI	IRRIGATION	-105.546978	48.072413	05/01 to 09/30	12/28/1981	PROVISIONAL PERMIT	PUMP	3000 GPM	270	100	40S 42322 00
MISSOURI	IRRIGATION	-104.534455	48.125825	04/01 to 10/31	1/18/2008	PROVISIONAL PERMIT	PUMP	2800 GPM	0	139	40S 30030883
MISSOURI	IRRIGATION	-104.202276	48.069681	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1350 GPM	330	160	40S 30004263
MISSOURI	IRRIGATION	-104.086457	47.998599	05/01 to 06/30	10/28/1977	PROVISIONAL PERMIT	PUMP	25.06 CFS	3340	800	40S 19231 00
MISSOURI	IRRIGATION	-104.086457	47.998599	07/01 to 09/30	7/23/1973	PROVISIONAL PERMIT	DITCH	25.06 CFS	3340	800	40S 30 00
MISSOURI	IRRIGATION	-105.616759	48.072954	04/01 to 10/04	9/22/1952	STATEMENT OF CLAIM	PUMP	5500 GPM	0	215.6	40S 10026 00
MISSOURI	IRRIGATION	-105.594147	48.09681	05/01 to 11/04	10/9/1963	STATEMENT OF CLAIM	PUMP	20 CFS	0	130.7	40S 15087 00
MISSOURI	IRRIGATION	-105.061382	48.058047	04/15 to 10/15	9/27/1994	PROVISIONAL PERMIT	PUMP	1949 GPM	139.5	56	40S 91841 00
MISSOURI	IRRIGATION	-105.077729	48.068857	04/15 to 10/15	9/27/1994	PROVISIONAL PERMIT	PUMP	1949 GPM	139.5	56	40S 91841 00
MISSOURI	IRRIGATION	-104.628409	48.123507	04/01 to 10/31	9/28/1981	PROVISIONAL PERMIT	PUMP	480 GPM	162	60	40S 38071 00
MISSOURI	IRRIGATION	-104.849626	48.125763	04/15 to 10/15	4/16/1997	PROVISIONAL PERMIT	PUMP	3300 GPM	1272	636	40S 101076 00
MISSOURI	IRRIGATION	-104.866137	48.140459	04/15 to 10/04	6/3/1963	STATEMENT OF CLAIM	PUMP	9 CFS	0	438	40S 172266 00
MISSOURI	IRRIGATION	-104.860444	48.131033	04/15 to 10/04	6/3/1963	STATEMENT OF CLAIM	PUMP	9 CFS	0	438	40S 172266 00
MISSOURI	IRRIGATION	-104.849626	48.125763	04/15 to 10/15	7/1/1985	PROVISIONAL PERMIT	PUMP	2.22 CFS	640	270	40S 10761 00
MISSOURI	IRRIGATION	-104.849626	48.125763	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	3.6 CFS	636	318	40S 101092 00
MISSOURI	IRRIGATION	-104.849626	48.125763	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1314 GPM	284	315	40S 106984 00
MISSOURI	IRRIGATION	-105.356587	48.089373	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	12 CFS	571	194.8	40S 30044048
MISSOURI	IRRIGATION	-105.337582	48.09329	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	12 CFS	571	194.8	40S 30044048
MISSOURI	IRRIGATION	-105.26086	48.086098	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.7 CFS	980	490	40S 102763 00
MISSOURI	IRRIGATION	-105.836753	48.011021	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	18 CFS	712	267	40S 30002538
MISSOURI	IRRIGATION	-105.611347	48.072986	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	11.6 CFS	119.8	40	40S 30050326
MISSOURI	IRRIGATION	-105.219369	48.089835	05/01 to 09/30	6/6/1926	STATEMENT OF CLAIM	PUMP	600 GPM	0	37	40S 171321 00
MISSOURI	IRRIGATION	-104.123997	48.042454	04/15 to 10/15	3/21/1977	PROVISIONAL PERMIT	PUMP	750 GPM	184	104	40S 11818 00
MISSOURI	IRRIGATION	-104.149617	48.048795		3/1/1990	PROVISIONAL PERMIT	PUMP	4000 GPM	130	50	40S 74095 00
MISSOURI	IRRIGATION	-104.183417	48.060594	04/01 to 10/31	3/1/1990	PROVISIONAL PERMIT	PUMP	4000 GPM	130	50	40S 74095 00
MISSOURI	IRRIGATION	-104.183417	48.060594	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4000 GPM	159.6	60.2	40S 30043999
MISSOURI	IRRIGATION	-104.866137	48.140459	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4.9 CFS	569	284.5	40S 30002059
MISSOURI	IRRIGATION	-104.854972	48.12752	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4.9 CFS	569	284.5	40S 30002059
MISSOURI	IRRIGATION	-105.639675	48.054036	04/10 to 10/31	6/14/1961	STATEMENT OF CLAIM	PUMP	4000 GPM	0	80.5	40S 14674 00
MISSOURI	IRRIGATION	-106.049285	48.014043	04/15 to 10/19	12/2/1969	STATEMENT OF CLAIM	PUMP	4022.2 GPM	0	236.6	40S 47541 00
MISSOURI	IRRIGATION	-104.547366	48.127639	04/15 to 10/19	5/1/1968	STATEMENT OF CLAIM	PUMP	1615 GPM	0	95	40S 42906 00
MISSOURI	IRRIGATION	-104.16449	48.056964	04/15 to 10/15	2/11/2008	PROVISIONAL PERMIT	PUMP	1200 GPM	168.7	58.6	40S 30031187
MISSOURI	IRRIGATION	-104.183417	48.060594	04/15 to 10/15	2/11/2008	PROVISIONAL PERMIT	PUMP	1200 GPM	168.7	58.6	40S 30031187
MISSOURI	IRRIGATION	-104.407857	48.076932	04/01 to 11/04	6/18/1901	STATEMENT OF CLAIM	PUMP	1.44 CFS	0	38	40S 215560 00
MISSOURI	IRRIGATION	-104.547366	48.127639	04/15 to 10/19	4/15/1955	STATEMENT OF CLAIM	PUMP	1.02 CFS	0	27	40S 42905 00
MISSOURI	IRRIGATION	-104.355748	48.06461	04/15 to 11/15	5/10/1977	PROVISIONAL PERMIT	PUMP	3600 GPM	1388	514	40S 12708 00
MISSOURI	IRRIGATION	-104.329812	48.048048	04/15 to 11/15	5/10/1977	PROVISIONAL PERMIT	PUMP	3600 GPM	1388	514	40S 12708 00
MISSOURI	IRRIGATION	-105.551139	48.066651	03/15 to 10/31	12/15/1961	STATEMENT OF CLAIM	PUMP	8700 GPM	0	115	40S 8745 00
MISSOURI	IRRIGATION	-106.303117	48.050841	04/15 to 10/15	2/26/1975	PROVISIONAL PERMIT	PUMP	16 CFS	840	280	40S 4929 00
MISSOURI	IRRIGATION	-106.278833	48.047592	04/01 to 11/30	3/12/1963	STATEMENT OF CLAIM	PUMP	6900 GPM	0	185	40S 182895 00
MISSOURI	IRRIGATION	-106.202751	48.025363	04/01 to 10/01	7/7/1975	PROVISIONAL PERMIT	PUMP	26.72 CFS	645	260	40S 5904 00
MISSOURI	IRRIGATION	-106.149038	48.030868	04/01 to 10/31	6/1/1950	STATEMENT OF CLAIM	PUMP	5000 GPM	0	199	40S 130435 00
MISSOURI	IRRIGATION	-106.137405	48.031407		6/1/1950	STATEMENT OF CLAIM	PUMP	5000 GPM	0	199	40S 130435 00
MISSOURI	IRRIGATION	-106.205718	48.026333	04/01 to 10/31	9/1/1949	STATEMENT OF CLAIM	PUMP	4000 GPM	0	143	40S 171305 00
MISSOURI	IRRIGATION	-104.054057	47.99624	05/01 to 09/30	11/22/1974	PROVISIONAL PERMIT	PUMP	4000 GPM	176	118	40S 4213 00
MISSOURI	IRRIGATION	-105.268501	48.092564	01/01 to 12/31	9/29/1926	STATEMENT OF CLAIM	PUMP	80 CFS	0	4075	40S 187281 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MISSOURI	IRRIGATION	-105.334099	48.092828	01/01 to 12/31	9/29/1926	STATEMENT OF CLAIM	PUMP	80 CFS	0	4075	40S 187281 00
MISSOURI	IRRIGATION	-105.312862	48.078145	01/01 to 12/31	9/29/1926	STATEMENT OF CLAIM	PUMP	80 CFS	0	4075	40S 187281 00
MISSOURI	IRRIGATION	-105.291613	48.078245	01/01 to 12/31	9/29/1926	STATEMENT OF CLAIM	PUMP	80 CFS	0	4075	40S 187281 00
MISSOURI	IRRIGATION	-105.319018	48.120586	01/01 to 12/31	9/29/1926	STATEMENT OF CLAIM	PUMP	80 CFS	0	4075	40S 187281 00
MISSOURI	IRRIGATION	-105.222123	48.126055	01/01 to 12/31	9/29/1926	STATEMENT OF CLAIM	PUMP	80 CFS	0	4075	40S 187281 00
MISSOURI	IRRIGATION	-106.112836	48.007903	03/01 to 11/15	9/5/1980	PROVISIONAL PERMIT	PUMP	10 CFS	742.5	275	40S 30543 00
MISSOURI	IRRIGATION	-105.168361	48.104376	05/01 to 09/30	7/20/1950	STATEMENT OF CLAIM	PUMP	3 CFS	0	45.68	40S 171295 00
MISSOURI	IRRIGATION	-105.109978	48.05843	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.6 CFS	364	182	40S 30001844
MISSOURI	IRRIGATION	-106.064547	48.030115	04/01 to 11/19	10/6/1961	STATEMENT OF CLAIM	PUMP	4600 GPM	0	160	40S 46546 00
MISSOURI	IRRIGATION	-105.842062	48.007794	03/01 to 10/31	9/11/1972	STATEMENT OF CLAIM	PUMP	12000 GPM	0	630	40S 214922 00
MISSOURI	IRRIGATION	-105.615408	48.072008	05/01 to 10/19	4/7/1965	STATEMENT OF CLAIM	PUMP	4420 GPM	0	245	40S 30108456
MISSOURI	IRRIGATION	-105.834729	48.014862	03/15 to 10/31	12/19/1963	STATEMENT OF CLAIM	PUMP	8700 GPM	0	127	40S 214921 00
MISSOURI	IRRIGATION	-105.842062	48.007794	03/15 to 10/31	12/19/1963	STATEMENT OF CLAIM	PUMP	8700 GPM	0	127	40S 214921 00
MISSOURI	IRRIGATION	-105.842062	48.007794	03/15 to 10/31	3/7/1953	STATEMENT OF CLAIM	PUMP	8700 GPM	0	85	40S 8744 00
MISSOURI	IRRIGATION	-105.788766	48.022103	03/15 to 10/31	3/7/1953	STATEMENT OF CLAIM	PUMP	8700 GPM	0	85	40S 8744 00
MISSOURI	IRRIGATION	-104.899347	48.145131	04/01 to 10/31	5/1/1944	STATEMENT OF CLAIM	PUMP	1615 GPM	0	95	40S 182909 00
MISSOURI	IRRIGATION	-104.862994	48.129162	05/01 to 09/30	6/8/1977	PROVISIONAL PERMIT	PUMP	6000 GPM	189	70	40S 13878 00
MISSOURI	IRRIGATION	-104.523593	48.124013	04/01 to 10/31	1/18/2008	PROVISIONAL PERMIT	PUMP	1200 GPM	0	274	40S 30030881
MISSOURI	IRRIGATION	-104.523593	48.124013	03/01 to 12/04	5/1/1968	STATEMENT OF CLAIM	PUMP	3300 GPM	0	274	40S 30046592
MISSOURI	IRRIGATION	-104.07298	47.997131	03/01 to 11/01	5/13/1977	PROVISIONAL PERMIT	PUMP	6000 GPM	540	203	40S 12810 00
MISSOURI	IRRIGATION	-104.072986	48.000806	03/01 to 11/01	5/13/1977	PROVISIONAL PERMIT	PUMP	6000 GPM	540	203	40S 12810 00
MISSOURI	IRRIGATION	-105.185581	48.070102	05/01 to 09/15	9/18/1973	PROVISIONAL PERMIT	PUMP	3200 GPM	300	100	40S 384 00
MISSOURI	IRRIGATION	-104.860129	48.126868	05/01 to 09/30	12/31/1954	STATEMENT OF CLAIM	PUMP	500 GPM	0	58	40S 130565 00
MISSOURI	IRRIGATION	-105.185581	48.070102	04/01 to 11/01	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6 CFS	802	401	40S 30041682
MISSOURI	IRRIGATION	-104.860129	48.126868	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	3.6 CFS	560	280	40S 101055 00
MISSOURI	IRRIGATION	-104.625943	48.109615	04/01 to 10/15	4/1/1985	CONSERVATION DISTRICT RECORD	PUMP	4.1 CFS	283.6	262	40S 30027595
MISSOURI	IRRIGATION	-104.860129	48.126868	04/01 to 11/01	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	225 GPM	60	30	40S 30043641
MISSOURI	IRRIGATION	-104.758035	48.122415	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1.45 CFS	92	46	40S 30063091
MISSOURI	IRRIGATION	-104.100543	48.027957	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	5.1 CFS	302	121	40S 111301 00
MISSOURI	IRRIGATION	-105.169442	48.075547	05/01 to 09/30	5/31/1961	STATEMENT OF CLAIM	PUMP	1.44 CFS	0	38	40S 3220 00
MISSOURI	IRRIGATION	-104.900889	48.147333	04/01 to 10/01	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.8 CFS	228	76	40S 30025552
MISSOURI	IRRIGATION	-104.80873	48.120564	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1.57 CFS	75	30	40S 30104520
MISSOURI	IRRIGATION	-104.123997	48.042454	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	700 GPM	60	30	40S 30069082
MISSOURI	IRRIGATION	-104.123997	48.042454	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	Not listed	24	104	40S 30003106
MISSOURI	IRRIGATION	-104.123997	48.042454	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	150 GPM	20	10	40S 30015443
MISSOURI	IRRIGATION	-104.148267	48.055212	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	1.3 CFS	147	49	40S 103653 00
MISSOURI	IRRIGATION	-104.920811	48.130895	04/01 to 10/31	12/14/1961	STATEMENT OF CLAIM	PUMP	4200 GPM	0	273	40S 168965 00
MISSOURI	IRRIGATION	-104.184092	48.058898	04/01 to 10/31	5/12/1972	STATEMENT OF CLAIM	PUMP	4726 GPM	0	278	40S 130566 00
MISSOURI	IRRIGATION	-104.186035	48.069672	04/01 to 10/01	3/21/1991	PROVISIONAL PERMIT	PUMP	5000 GPM	416	160	40S 77506 00
MISSOURI	IRRIGATION	-104.148267	48.055212	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6.7 CFS	536	225	40S 30010979
MISSOURI	IRRIGATION	-105.505276	48.098709	04/01 to 10/31	4/1/1951	STATEMENT OF CLAIM	PUMP	6817 GPM	0	401	40S 215783 00
MISSOURI	IRRIGATION	-105.505276	48.098709	05/01 to 11/30	12/31/1929	STATEMENT OF CLAIM	PUMP	170 GPM	0	10	40S 15093 00
MISSOURI	IRRIGATION	-104.928914	48.127815	05/10 to 09/24	6/6/1937	STATEMENT OF CLAIM	PUMP	6000 GPM	0	340.64	40S 171797 00
MISSOURI	IRRIGATION	-105.693646	48.051846	02/01 to 10/31	10/27/1952	STATEMENT OF CLAIM	PUMP	2400 GPM	0	46	40S 1511 00
MISSOURI	IRRIGATION	-105.039954	48.053422	04/15 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	6 CFS	768	384	40S 30005493
MISSOURI	IRRIGATION	-104.424543	48.085603	05/01 to 09/30	10/28/1996	PROVISIONAL PERMIT	PUMP	1200 GPM	542.7	201	40S 97742 00
MISSOURI	IRRIGATION	-104.424543	48.085603	04/01 to 10/15	7/1/1985	CONSERVATION DISTRICT RECORD	PUMP	2.7 CFS	451	201	40S 114654 00
MISSOURI	IRRIGATION	-105.553804	48.0719	05/01 to 11/01	2/2/1978	PROVISIONAL PERMIT	PUMP	2800 GPM	331	115	40S 17179 00
MISSOURI	IRRIGATION	-104.977472	48.094805	05/01 to 10/31	8/21/1973	PROVISIONAL PERMIT	PUMP	5.57 CFS	500	250	40S 137 00
MISSOURI	IRRIGATION	-104.977472	48.094805	04/01 to 10/31	1/19/1989	PROVISIONAL PERMIT	PUMP	3500 GPM	454	143.51	40S 70237 00
MISSOURI	IRRIGATION	-104.977472	48.094805	04/01 to 10/31	4/14/1994	PROVISIONAL PERMIT	PUMP	1500 GPM	0	143.51	40S 89101 00
MISSOURI	IRRIGATION	-104.977472	48.094805	05/01 to 10/31	4/14/1994	PROVISIONAL PERMIT	PUMP	1750 GPM	292.5	128.85	40S 89100 00
MISSOURI	IRRIGATION	-104.128917	48.051522	04/01 to 10/31	12/31/1937	STATEMENT OF CLAIM	PUMP	800 GPM	0	95	40S 171828 00
MISSOURI	IRRIGATION	-104.148267	48.055212	04/01 to 10/31	12/31/1937	STATEMENT OF CLAIM	PUMP	800 GPM	0	95	40S 171828 00
MISSOURI	IRRIGATION	-104.57586	48.119545	01/01 to 12/31	4/21/1904	RESERVED CLAIM	DIKE	NOT LISTED	304	152	40S 30073871
MISSOURI	IRRIGATION	-104.570433	48.123166	01/01 to 12/31	4/21/1904	RESERVED CLAIM	DIKE	NOT LISTED	304	152	40S 30073871
MISSOURI	IRRIGATION	-104.58128	48.119554	01/01 to 12/31	4/21/1904	RESERVED CLAIM	DIKE	NOT LISTED	304	152	40S 30073871
MISSOURI	IRRIGATION	-104.570579	48.119115	01/01 to 12/31	4/21/1904	RESERVED CLAIM	DIKE	NOT LISTED	304	152	40S 30073871

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
MISSOURI	IRRIGATION	-105.90106	48.007747	01/01 to 12/31	4/21/1904	RESERVED CLAIM	DIKE	NOT LISTED	50	25	40S 30073883
MISSOURI	IRRIGATION	-105.636965	48.061247	03/21 to 12/21	4/30/1962	STATEMENT OF CLAIM	PUMP	8000 GPM	0	165	40S 130527 00
MISSOURI	IRRIGATION	-105.639671	48.068472	03/21 to 12/21	4/30/1962	STATEMENT OF CLAIM	PUMP	8000 GPM	0	165	40S 130527 00
MISSOURI	IRRIGATION	-104.094324	48.02253	05/01 to 08/31	8/1/1966	STATEMENT OF CLAIM	PUMP	4500 GPM	0	350	40S 5477 00
MISSOURI	IRRIGATION	-104.091763	48.031573	05/01 to 08/31	8/1/1966	STATEMENT OF CLAIM	PUMP	4500 GPM	0	350	40S 5477 00
MISSOURI	IRRIGATION	-104.081124	48.004005	05/01 to 08/31	8/1/1966	STATEMENT OF CLAIM	PUMP	1200 GPM	0	25	40S 5479 00
MISSOURI	IRRIGATION	-105.893751	48.014081	05/01 to 09/30	6/2/1934	STATEMENT OF CLAIM	PUMP	5.11 CFS	0	135	40S 2834 00
MISSOURI	MUNICIPAL	-104.474924	48.126298	01/01 to 12/31	12/31/1964	STATEMENT OF CLAIM	PUMP	800 GPM	257.35	0	40S 1549 00
MISSOURI	MUNICIPAL	-104.473644	48.122873	01/01 to 12/31	7/1/1985	WATER RESERVATION	OTHER DIVERSION	305.55 GPM	365	0	40S 77646 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
YELLOWSTONE	DOMESTIC	-104.693189	47.133152	04/15 to 11/01	2/5/1976	PROVISIONAL PERMIT	PUMP	20 GPM	2	2	42M 7421 00
YELLOWSTONE	DOMESTIC	-104.693189	47.133152	04/15 to 11/01	2/5/1976	PROVISIONAL PERMIT	PUMP	20 GPM	2	2	42M 7421 00
YELLOWSTONE	DOMESTIC	-104.753669	47.091443	04/01 to 11/01	4/1/1957	STATEMENT OF CLAIM	PUMP	30 GPM	4	2	42M 163311 00
YELLOWSTONE	DOMESTIC	-104.530826	47.281597	04/15 to 10/19		IRRIGATION DISTRICT	DAM	4.06 CFS	1489.7	0	42M 40814 00
YELLOWSTONE	DOMESTIC	-104.530826	47.281597	04/15 to 10/19	5/14/1910	STATEMENT OF CLAIM	DIVERSION DAM	3.98 CFS	1460	0	42M 40815 00
YELLOWSTONE	DOMESTIC	-104.530826	47.281597	04/15 to 10/19	11/14/1944	STATEMENT OF CLAIM	DIVERSION DAM	8.98 GPM	6.3	0	42M 40816 00
YELLOWSTONE	DOMESTIC	-104.530826	47.281597	04/15 to 10/19	8/14/1946	STATEMENT OF CLAIM	DIVERSION DAM	26.93 GPM	23.4	0	42M 40817 00
YELLOWSTONE	INDUSTRIAL	-104.529961	47.28127	10/01 to 02/29	10/10/1926	STATEMENT OF CLAIM	DIVERSION DAM	58.43 CFS	17500	0	42M 40818 00
YELLOWSTONE	INDUSTRIAL	-104.156534	47.67886	01/01 to 12/31	8/19/1958	STATEMENT OF CLAIM	PUMP	65.5 CFS	47422	0	42M 165230 00
YELLOWSTONE	INDUSTRIAL	-104.159256	47.678864	01/01 to 12/31	11/22/1928	STATEMENT OF CLAIM	PUMP	8.91 CFS	2163	0	42M 31493 00
YELLOWSTONE	IRRIGATION	-104.702582	47.130419	04/01 to 10/31	8/30/1963	STATEMENT OF CLAIM	PUMP	10.91 CFS	0	288	42M 49235 00
YELLOWSTONE	IRRIGATION	-104.711966	47.124787	04/01 to 10/15	12/5/1963	STATEMENT OF CLAIM	PUMP	3.94 CFS	0	145	42M 163478 00
YELLOWSTONE	IRRIGATION	-104.973029	46.878515	04/15 to 10/15	2/9/1972	STATEMENT OF CLAIM	PUMP	2.92 CFS	0	77	42M 117162 00
YELLOWSTONE	IRRIGATION	-104.717338	47.116818	04/01 to 11/01	12/5/1963	STATEMENT OF CLAIM	PUMP	6.7 CFS	0	177	42M 163184 00
YELLOWSTONE	IRRIGATION	-104.717666	47.112547	04/01 to 11/01	12/5/1963	STATEMENT OF CLAIM	PUMP	6.7 CFS	0	177	42M 163184 00
YELLOWSTONE	IRRIGATION	-104.866792	46.945259	04/15 to 10/15	3/1/1974	PROVISIONAL PERMIT	PUMP	459 GPM	213.2	70.2	42M 30010138
YELLOWSTONE	IRRIGATION	-104.877486	46.941709	04/15 to 10/15	3/11/1977	PROVISIONAL PERMIT	PUMP	88 GPM	40.35	14.5	42M 30010143
YELLOWSTONE	IRRIGATION	-104.739963	47.086829	04/01 to 10/31	12/31/1958	STATEMENT OF CLAIM	PUMP	2.84 CFS	0	75	42M 163263 00
YELLOWSTONE	IRRIGATION	-104.882126	46.937192	03/15 to 11/15	9/22/1976	PROVISIONAL PERMIT	OTHER DIVERSION	8.9 CFS	631.53	210.51	42M 9584 00
YELLOWSTONE	IRRIGATION	-104.335438	47.413325	04/15 to 10/01	4/6/1960	STATEMENT OF CLAIM	PUMP	11 CFS	0	397	42M 101415 00
YELLOWSTONE	IRRIGATION	-104.330743	47.431625	04/15 to 10/01	4/6/1960	STATEMENT OF CLAIM	PUMP	340 GPM	0	20	42M 101416 00
YELLOWSTONE	IRRIGATION	-104.148464	47.680106	05/01 to 09/01	9/17/1974	PROVISIONAL PERMIT	PUMP	1347 GPM	118.3	35	42M 3656 00
YELLOWSTONE	IRRIGATION	-104.764222	47.080268	04/15 to 10/31	5/6/1964	STATEMENT OF CLAIM	HEADGATE	3.98 CFS	0	105	42M 163446 00
YELLOWSTONE	IRRIGATION	-104.761544	47.076464	04/15 to 10/31	11/22/1976	PROVISIONAL PERMIT	PUMP	2 CFS	210	70	42M 10675 00
YELLOWSTONE	IRRIGATION	-104.764213	47.074658	04/15 to 10/31	11/22/1976	PROVISIONAL PERMIT	DAM	2 CFS	210	70	42M 10676 00
YELLOWSTONE	IRRIGATION	-104.746776	47.045861	05/15 to 10/15	3/11/1976	PROVISIONAL PERMIT	PUMP	6.68 CFS	82	23	42M 7682 00
YELLOWSTONE	IRRIGATION	-104.749392	47.046708	04/01 to 10/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	2.7 CFS	96	31	42M 102770 00
YELLOWSTONE	IRRIGATION	-104.734619	47.099576	04/01 to 10/31	7/15/1927	STATEMENT OF CLAIM	PUMP	204 GPM	0	12	42M 101518 00
YELLOWSTONE	IRRIGATION	-104.639862	47.219784	03/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	2.6 CFS	320	160	42M 114739 00
YELLOWSTONE	IRRIGATION	-104.665776	47.190023	05/15 to 09/30	9/16/1976	PROVISIONAL PERMIT	PUMP	14.99 CFS	190	63	42M 9516 00
YELLOWSTONE	IRRIGATION	-104.667464	47.193637	05/15 to 09/30	7/31/1933	STATEMENT OF CLAIM	PUMP	2.45 CFS	0	33.7	42M 2403 00
YELLOWSTONE	IRRIGATION	-104.666663	47.189988	05/15 to 09/30	7/31/1933	STATEMENT OF CLAIM	PUMP	2.45 CFS	0	33.7	42M 2403 00
YELLOWSTONE	IRRIGATION	-104.226258	47.603137	04/01 to 11/01	6/20/1913	STATEMENT OF CLAIM	DIKE	1.72 CFS	0	45.4	42M 28971 00
YELLOWSTONE	IRRIGATION	-104.766668	46.996245	05/01 to 10/15	1895-10-09	STATEMENT OF CLAIM	PUMP	5.57 CFS	0	226	42M 163688 00
YELLOWSTONE	IRRIGATION	-104.090775	47.734455	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	8.7 CFS	870	290	42M 80579 00
YELLOWSTONE	IRRIGATION	-104.086808	47.720751	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	8.7 CFS	870	290	42M 80579 00
YELLOWSTONE	IRRIGATION	-104.051027	47.792082	04/15 to 10/15	1/25/1977	PROVISIONAL PERMIT	PUMP	4.45 CFS	175	65	42M 11187 00
YELLOWSTONE	IRRIGATION	-104.769305	47.027314	04/01 to 10/31	12/31/1955	STATEMENT OF CLAIM	PUMP	187 GPM	0	11	42M 163485 00
YELLOWSTONE	IRRIGATION	-104.430637	47.333308	04/01 to 09/30	4/1/1968	STATEMENT OF CLAIM	PUMP	3.03 CFS	0	80	42M 154246 00
YELLOWSTONE	IRRIGATION	-104.464304	47.302536	04/01 to 09/30	4/1/1952	STATEMENT OF CLAIM	PUMP	425 GPM	0	25	42M 163487 00
YELLOWSTONE	IRRIGATION	-104.748093	47.07959	04/01 to 09/30	12/31/1963	STATEMENT OF CLAIM	PUMP	232.9 GPM	0	13.7	42M 163649 00
YELLOWSTONE	IRRIGATION	-104.749452	47.095147	04/01 to 09/30	6/30/1922	STATEMENT OF CLAIM	PUMP	2.92 CFS	0	40.85	42M 178324 00
YELLOWSTONE	IRRIGATION	-104.249132	47.539905	04/01 to 10/31	12/10/1952	STATEMENT OF CLAIM	PUMP	22.28 CFS	0	728	42M 215790 00
YELLOWSTONE	IRRIGATION	-104.25166	47.514581	04/01 to 10/31	12/10/1952	STATEMENT OF CLAIM	PUMP	22.28 CFS	0	728	42M 215790 00
YELLOWSTONE	IRRIGATION	-104.255319	47.52012	04/01 to 10/31	12/10/1952	STATEMENT OF CLAIM	PUMP	22.28 CFS	0	728	42M 215790 00
YELLOWSTONE	IRRIGATION	-104.259263	47.520049	04/01 to 10/31	4/12/1978	PROVISIONAL PERMIT	PUMP	4700 GPM	761.5	600	42M 18839 00
YELLOWSTONE	IRRIGATION	-104.253663	47.514598	04/01 to 10/31	4/12/1978	PROVISIONAL PERMIT	PUMP	2000 GPM	499.5	185	42M 18838 00
YELLOWSTONE	IRRIGATION	-104.378161	47.377789	04/01 to 10/01	5/7/1981	PROVISIONAL PERMIT	PUMP	650 GPM	198.45	73.5	42M 32939 00
YELLOWSTONE	IRRIGATION	-104.66702	47.187292	04/01 to 10/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	3 CFS	384	192	42M 30011028
YELLOWSTONE	IRRIGATION	-104.880161	46.942531	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	7.1 CFS	1300	630	42M 56488 00
YELLOWSTONE	IRRIGATION	-104.633107	47.238774	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1.6 CFS	170	63	42M 30006008
YELLOWSTONE	IRRIGATION	-104.633107	47.238774	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	314.16 GPM	54	27	42M 114769 00
YELLOWSTONE	IRRIGATION	-104.590621	47.25028	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	4.5 CFS	860	344	42M 74875 00
YELLOWSTONE	IRRIGATION	-104.589416	47.25119	03/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1.8 CFS	500	250	42M 111464 00
YELLOWSTONE	IRRIGATION	-104.501127	47.286804	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	7.13 CFS	435	145	42M 85551 00
YELLOWSTONE	IRRIGATION	-104.660219	47.157708	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	4 CFS	578	289	42M 30001427
YELLOWSTONE	IRRIGATION	-104.474943	47.294578	04/20 to 09/20	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1.8 CFS	200	100	42M 71445 00
YELLOWSTONE	IRRIGATION	-104.710791	47.143271	05/01 to 09/30	10/25/1977	PROVISIONAL PERMIT	DAM	NOT LISTED	1	0.5	42M 16100 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
YELLOWSTONE	IRRIGATION	-104.66702	47.187292	03/15 to 10/15	3/11/1977	PROVISIONAL PERMIT	PUMP	1000 GPM	330	110	42M 11681 00
YELLOWSTONE	IRRIGATION	-104.648295	47.167702	04/01 to 11/01	12/31/1956	STATEMENT OF CLAIM	PUMP	204 GPM	0	12	42M 163708 00
YELLOWSTONE	IRRIGATION	-104.933286	46.89658	01/01 to 12/31	8/23/1961	STATEMENT OF CLAIM	PUMP	3.45 CFS	0	91	42M 23876 00
YELLOWSTONE	IRRIGATION	-104.918663	46.907575	03/01 to 10/31	12/31/1932	STATEMENT OF CLAIM	PUMP	8.5 GPM	0	0.5	42M 169031 00
YELLOWSTONE	IRRIGATION	-104.877486	46.941709	04/15 to 10/15	3/11/1977	PROVISIONAL PERMIT	PUMP	345 GPM	158.05	56.8	42M 11687 00
YELLOWSTONE	IRRIGATION	-104.743987	47.084139	05/01 to 09/20	12/31/1964	STATEMENT OF CLAIM	PUMP	1.04 CFS	0	27.4	42M 206680 00
YELLOWSTONE	IRRIGATION	-104.744505	47.080479	05/01 to 09/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	3.3 CFS	82	32.4	42M 56487 00
YELLOWSTONE	IRRIGATION	-104.655765	47.210802	02/15 to 11/30	3/11/1977	PROVISIONAL PERMIT	PUMP	3500 GPM	405.6	135.2	42M 11679 00
YELLOWSTONE	IRRIGATION	-104.549383	47.277403	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1.9 CFS	262	131	42M 111403 00
YELLOWSTONE	IRRIGATION	-104.7265	47.095823	01/01 to 12/31	9/3/1976	PROVISIONAL PERMIT	PIT	399.43 GPM	160	60	42M 9405 00
YELLOWSTONE	IRRIGATION	-104.73722	47.094072	04/01 to 10/15	2/4/1977	PROVISIONAL PERMIT	PUMP	6.66 CFS	84	28	42M 11244 00
YELLOWSTONE	IRRIGATION	-104.729147	47.095013	04/01 to 10/31	10/28/1977	PROVISIONAL PERMIT	PUMP	5000 GPM	270	90	42M 15999 00
YELLOWSTONE	IRRIGATION	-104.73722	47.094072	04/01 to 10/31	10/28/1977	PROVISIONAL PERMIT	DITCH	5000 GPM	90	30	42M 17035 00
YELLOWSTONE	IRRIGATION	-104.731857	47.095031	04/01 to 10/15	2/4/1977	PROVISIONAL PERMIT	PUMP	6.66 CFS	252	84	42M 11245 00
YELLOWSTONE	IRRIGATION	-104.600241	47.258745	04/15 to 09/15	4/20/1954	STATEMENT OF CLAIM	PUMP	7.3 CFS	0	193	42M 117142 00
YELLOWSTONE	IRRIGATION	-104.619081	47.236594	04/15 to 10/15	4/20/1954	STATEMENT OF CLAIM	PUMP	6.67 CFS	0	176	42M 117143 00
YELLOWSTONE	IRRIGATION	-104.866792	46.945259	04/15 to 10/15	3/1/1974	PROVISIONAL PERMIT	PUMP	3069 GPM	1426.8	469.8	42M 1646 00
YELLOWSTONE	IRRIGATION	-104.277365	47.46374	04/01 to 10/31	3/30/1960	STATEMENT OF CLAIM	PUMP	12.9 CFS	1410	470	42M 2137 00
YELLOWSTONE	IRRIGATION	-104.302094	47.447018	04/15 to 10/15	3/2/1979	PROVISIONAL PERMIT	UNKNOWN	6500 GPM	528.7	196	42M 22002 00
YELLOWSTONE	IRRIGATION	-104.530826	47.281597	04/15 to 10/19		IRRIGATION DISTRICT	DAM	1360 CFS	379746	58640.7	42M 40805 00
YELLOWSTONE	IRRIGATION	-104.530826	47.281597	04/15 to 10/15	10/30/1905	STATEMENT OF CLAIM	DIVERSION DAM	1000 CFS	0	55407	42M 40806 00
YELLOWSTONE	IRRIGATION	-104.530826	47.281597	04/15 to 10/15	6/27/1939	STATEMENT OF CLAIM	DIVERSION DAM	300 CFS	0	55407	42M 40807 00
YELLOWSTONE	IRRIGATION	-104.530826	47.281597	04/15 to 10/15	8/14/1946	STATEMENT OF CLAIM	DIVERSION DAM	42 CFS	0	2423.6	42M 40809 00
YELLOWSTONE	IRRIGATION	-104.530826	47.281597	04/15 to 10/15	11/14/1944	STATEMENT OF CLAIM	DIVERSION DAM	18 CFS	0	829	42M 40808 00
YELLOWSTONE	IRRIGATION	-104.653676	47.205386	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.636304	47.220439	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.636412	47.213397	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.657659	47.206216	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.657658	47.199103	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.64038	47.211699	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.657684	47.188184	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.646912	47.206264	04/01 to 10/20	1/28/1907	STATEMENT OF CLAIM	PUMP	7.77 CFS	0	200	42M 163442 00
YELLOWSTONE	IRRIGATION	-104.57271	47.266618	03/01 to 11/30	8/20/1976	PROVISIONAL PERMIT	PUMP	4410 GPM	853	308	42M 9251 00
YELLOWSTONE	IRRIGATION	-104.57621	47.268904	03/01 to 11/30	8/20/1976	PROVISIONAL PERMIT	PUMP	4410 GPM	853	308	42M 9251 00
YELLOWSTONE	IRRIGATION	-104.560024	47.256879	04/01 to 10/01	6/10/1973	STATEMENT OF CLAIM	PUMP	5.66 CFS	0	440	42M 117141 00
YELLOWSTONE	IRRIGATION	-104.493085	47.288294	04/01 to 10/31	5/26/1953	STATEMENT OF CLAIM	PUMP	4.73 CFS	0	125	42M 37556 00
YELLOWSTONE	IRRIGATION	-104.218113	47.578233	04/15 to 10/29	5/1/1903	STATEMENT OF CLAIM	PUMP	3.12 CFS	0	494	42M 16408 00
YELLOWSTONE	IRRIGATION	-104.218113	47.578233	04/15 to 10/29	5/1/1903	STATEMENT OF CLAIM	PUMP	3.12 CFS	0	494	42M 16408 00
YELLOWSTONE	IRRIGATION	-104.218142	47.572766	04/15 to 10/29	5/1/1903	STATEMENT OF CLAIM	PUMP	3.12 CFS	0	494	42M 16408 00
YELLOWSTONE	IRRIGATION	-104.226098	47.55275	04/15 to 10/29	5/1/1903	STATEMENT OF CLAIM	PUMP	3.12 CFS	0	494	42M 16408 00
YELLOWSTONE	IRRIGATION	-104.247329	47.543504	04/15 to 10/29	5/1/1903	STATEMENT OF CLAIM	PUMP	3.12 CFS	0	494	42M 16408 00
YELLOWSTONE	IRRIGATION	-104.298634	47.478974	04/01 to 10/31	6/1/1959	STATEMENT OF CLAIM	PUMP	4.46 CFS	0	60	42M 122061 00
YELLOWSTONE	IRRIGATION	-104.286439	47.480583	04/01 to 10/31	6/1/1955	STATEMENT OF CLAIM	PUMP	4.46 CFS	0	203	42M 122059 00
YELLOWSTONE	IRRIGATION	-104.291804	47.480672	04/01 to 10/31	6/1/1955	STATEMENT OF CLAIM	PUMP	4.46 CFS	0	203	42M 122059 00
YELLOWSTONE	IRRIGATION	-104.298501	47.479904	04/01 to 10/31	6/1/1955	STATEMENT OF CLAIM	PUMP	4.46 CFS	0	203	42M 122059 00
YELLOWSTONE	IRRIGATION	-104.74498	47.081398	04/01 to 09/30	12/31/1959	STATEMENT OF CLAIM	PUMP	214.2 GPM	0	12.6	42M 164209 00
YELLOWSTONE	IRRIGATION	-104.065776	47.79333	04/15 to 10/15	6/5/1984	PROVISIONAL PERMIT	PUMP	6000 GPM	275.4	307.2	42M 55525 00
YELLOWSTONE	IRRIGATION	-104.060411	47.793189	04/15 to 10/15	6/5/1984	PROVISIONAL PERMIT	PUMP	6000 GPM	275.4	307.2	42M 55525 00
YELLOWSTONE	IRRIGATION	-104.055049	47.793051	04/15 to 10/15	6/5/1984	PROVISIONAL PERMIT	PUMP	6000 GPM	275.4	307.2	42M 55525 00
YELLOWSTONE	IRRIGATION	-104.049686	47.792987	04/15 to 10/15	6/5/1984	PROVISIONAL PERMIT	PUMP	6000 GPM	275.4	307.2	42M 55525 00
YELLOWSTONE	IRRIGATION	-104.065776	47.79333	04/15 to 10/15	11/22/1976	PROVISIONAL PERMIT	PUMP	4.45 CFS	554	205.2	42M 10468 00
YELLOWSTONE	IRRIGATION	-104.060411	47.793189	04/15 to 10/15	11/22/1976	PROVISIONAL PERMIT	PUMP	4.45 CFS	554	205.2	42M 10468 00
YELLOWSTONE	IRRIGATION	-104.055049	47.793051	04/15 to 10/15	11/22/1976	PROVISIONAL PERMIT	PUMP	4.45 CFS	554	205.2	42M 10468 00
YELLOWSTONE	IRRIGATION	-104.049686	47.792987	04/15 to 10/15	11/22/1976	PROVISIONAL PERMIT	PUMP	4.45 CFS	554	205.2	42M 10468 00
YELLOWSTONE	IRRIGATION	-104.048342	47.792085	05/01 to 10/15	3/8/1977	PROVISIONAL PERMIT	PUMP	5.57 CFS	270	100	42M 11655 00
YELLOWSTONE	IRRIGATION	-104.754825	47.091571	04/15 to 10/31	12/24/1979	PROVISIONAL PERMIT	PUMP	25 GPM	10	2	42M 27405 00
YELLOWSTONE	IRRIGATION	-104.790391	46.961399	04/01 to 12/01	12/31/1936	STATEMENT OF CLAIM	PUMP	1.89 CFS	0	50	42M 163656 00
YELLOWSTONE	IRRIGATION	-104.774606	47.01275	04/01 to 10/31	6/26/1973	STATEMENT OF CLAIM	PUMP	408 GPM	0	24	42M 163660 00

Table G-1
Surface Water Rights
Project Area

River	Use	Longitude	Latitude	Period of Diversion	Priority Date	Water Right Tye	Method of Diversion	Max. Flow	Max. Volume (ac-ft/yr)	Max. Acres	WRNUMBER
YELLOWSTONE	IRRIGATION	-104.774606	47.01275	04/01 to 10/31	12/31/1960	STATEMENT OF CLAIM	PUMP	7.9 CFS	0	209	42M 30049749
YELLOWSTONE	IRRIGATION	-104.774606	47.01275	04/01 to 10/31	12/31/1957	STATEMENT OF CLAIM	PUMP	4.9 CFS	0	131	42M 30049751
YELLOWSTONE	IRRIGATION	-104.774606	47.01275	04/01 to 10/31	6/26/1973	STATEMENT OF CLAIM	PUMP	4.9 CFS	0	130	42M 30049741
YELLOWSTONE	IRRIGATION	-104.675875	47.154023	04/15 to 11/20	4/7/1975	PROVISIONAL PERMIT	PUMP	11.14 CFS	900	300	42M 5174 00
YELLOWSTONE	IRRIGATION	-104.660202	47.176228	04/15 to 10/01	2/24/1976	PROVISIONAL PERMIT	PUMP	2650 GPM	492	164	42M 30010295
YELLOWSTONE	IRRIGATION	-104.656385	47.158626	04/15 to 10/01	2/24/1976	PROVISIONAL PERMIT	PUMP	716 GPM	489	163	42M 7563 00
YELLOWSTONE	IRRIGATION	-104.656385	47.158626	03/15 to 11/30	2/15/1978	PROVISIONAL PERMIT	PUMP	4784 GPM	216	72	42M 17726 00
YELLOWSTONE	IRRIGATION	-104.870469	46.928056	04/15 to 10/31	7/23/1971	STATEMENT OF CLAIM	PUMP	17.9 CFS	0	834	42M 30065865
YELLOWSTONE	IRRIGATION	-104.874446	46.934437	04/01 to 10/15	2/9/1977	PROVISIONAL PERMIT	PUMP	5.56 CFS	330	110	42M 11290 00
YELLOWSTONE	IRRIGATION	-104.627104	47.224588	05/01 to 11/01	12/31/1950	STATEMENT OF CLAIM	PUMP	40 GPM	0	5	42M 163151 00
YELLOWSTONE	IRRIGATION	-104.870469	46.928056	04/15 to 10/31	7/23/1971	STATEMENT OF CLAIM	PUMP	7.1 CFS	0	310	42M 165796 00
YELLOWSTONE	IRRIGATION	-104.624333	47.2529	04/15 to 10/15	6/30/1918	STATEMENT OF CLAIM	PUMP	5.9 CFS	0	94	42M 34432 00
YELLOWSTONE	IRRIGATION	-104.201042	47.608536	04/01 to 10/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	10.7 CFS	1540	1026	42M 89849 00
YELLOWSTONE	IRRIGATION	-104.803585	46.964931	04/15 to 10/15	3/21/1977	PROVISIONAL PERMIT	PUMP	6.66 CFS	54	18	42M 11817 00
YELLOWSTONE	IRRIGATION	-104.340096	47.427061	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	3.79 CFS	512	256	42M 114746 00
YELLOWSTONE	IRRIGATION	-104.108096	47.693494	04/01 to 10/15	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	4.7 CFS	913	452.5	42M 104422 00
YELLOWSTONE	IRRIGATION	-104.108096	47.693494	04/01 to 10/15	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1.1 CFS	136	68	42M 30051296
YELLOWSTONE	IRRIGATION	-104.378996	47.380588	04/01 to 10/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	650 GPM	54	20	42M 56629 00
YELLOWSTONE	IRRIGATION	-104.382962	47.377922	04/01 to 10/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1800 GPM	727	303	42M 56628 00
YELLOWSTONE	IRRIGATION	-104.092072	47.718936	04/01 to 11/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	1.7 CFS	271	134	42M 114728 00
YELLOWSTONE	IRRIGATION	-104.092072	47.718936	04/01 to 10/01	12/15/1978	CONSERVATION DISTRICT RECORD	PUMP	2.1 CFS	412	198	42M 104509 00
YELLOWSTONE	IRRIGATION	-104.05873	47.759522	05/01 to 09/15	11/5/1975	PROVISIONAL PERMIT	PUMP	12 CFS	2200	1485	42M 6815 00
YELLOWSTONE	IRRIGATION	-104.190316	47.613787	04/01 to 10/31	12/31/1970	STATEMENT OF CLAIM	PUMP	13.37 CFS	0	352	42M 30048245
YELLOWSTONE	IRRIGATION	-104.205683	47.595204	04/01 to 10/31	12/31/1970	STATEMENT OF CLAIM	PUMP	13.37 CFS	0	352	42M 30048245
YELLOWSTONE	IRRIGATION	-104.205683	47.595204	04/01 to 10/31	6/1/1961	STATEMENT OF CLAIM	PUMP	5.57 CFS	0	300	42M 122088 00
YELLOWSTONE	IRRIGATION	-104.188765	47.603506	05/01 to 09/15	6/4/1975	PROVISIONAL PERMIT	PUMP	5 CFS	300	110	42M 5610 00
YELLOWSTONE	IRRIGATION	-104.689145	47.152175	05/01 to 10/01	9/16/1976	PROVISIONAL PERMIT	PUMP	2 CFS	112	37.1	42M 9517 00
YELLOWSTONE	IRRIGATION	-104.689145	47.152175	05/01 to 10/01	12/31/1964	STATEMENT OF CLAIM	PUMP	443.7 GPM	0	26.1	42M 164459 00
YELLOWSTONE	IRRIGATION	-104.530826	47.281597	04/01 to 10/31	6/27/1996	PROVISIONAL PERMIT	DAM	14 CFS	0	2186.3	42M 97792 00
YELLOWSTONE	IRRIGATION	-104.782564	46.97985	04/01 to 09/30	6/2/1977	PROVISIONAL PERMIT	PUMP	6687 GPM	525	175	42M 15937 00
YELLOWSTONE	IRRIGATION	-104.666957	47.196346	03/15 to 11/15	3/11/1977	PROVISIONAL PERMIT	PUMP	5500 GPM	645.9	215.3	42M 11680 00
YELLOWSTONE	IRRIGATION	-104.183567	47.612683	04/01 to 10/31	NOT LISTED	IRRIGATION DISTRICT	PUMP	133.22 CFS	37845	6525	42M 119268 00
YELLOWSTONE	IRRIGATION	-104.158231	47.66969	04/01 to 10/31	NOT LISTED	IRRIGATION DISTRICT	PUMP	133.22 CFS	37845	6525	42M 119268 00
YELLOWSTONE	IRRIGATION	-104.118761	47.683855	04/01 to 10/31	NOT LISTED	IRRIGATION DISTRICT	PUMP	133.22 CFS	37845	6525	42M 119268 00
YELLOWSTONE	IRRIGATION	-104.086808	47.720751	04/01 to 10/31	NOT LISTED	IRRIGATION DISTRICT	PUMP	133.22 CFS	37845	6525	42M 119268 00
YELLOWSTONE	IRRIGATION	-104.086808	47.720751	04/01 to 10/31	9/7/1937	STATEMENT OF CLAIM	PUMP	133.22 CFS	0	5282	42M 119269 00
YELLOWSTONE	IRRIGATION	-104.183373	47.613779	04/01 to 10/31	9/7/1937	STATEMENT OF CLAIM	PUMP	133.22 CFS	0	5282	42M 119269 00
YELLOWSTONE	IRRIGATION	-104.155933	47.668788	04/01 to 10/31	9/7/1937	STATEMENT OF CLAIM	PUMP	133.22 CFS	0	5282	42M 119269 00
YELLOWSTONE	IRRIGATION	-104.117413	47.683465	04/01 to 10/31	9/7/1937	STATEMENT OF CLAIM	PUMP	133.22 CFS	0	5282	42M 119269 00
YELLOWSTONE	IRRIGATION	-104.866792	46.945259	04/15 to 10/15	3/1/1974	PROVISIONAL PERMIT	PUMP	399.43 GPM	186	62	42M 7014 00
YELLOWSTONE	IRRIGATION	-104.865466	46.946098	05/01 to 10/31	5/1/1961	STATEMENT OF CLAIM	PUMP	2.23 CFS	0	60	42M 20470 00
YELLOWSTONE	IRRIGATION	-104.34683	47.401108	04/01 to 10/31	4/27/1961	STATEMENT OF CLAIM	PUMP	7.58 CFS	0	200	42M 115112 00
YELLOWSTONE	IRRIGATION	-104.341966	47.4429	04/01 to 10/15	2/18/1977	PROVISIONAL PERMIT	PUMP	5 CFS	275.4	102	42M 11398 00
YELLOWSTONE	IRRIGATION	-104.619032	47.255069	04/15 to 10/15	6/30/1918	STATEMENT OF CLAIM	PUMP	2.01 CFS	0	73	42M 34430 00
YELLOWSTONE	LAWN AND GARDEN	-104.750708	47.092389	01/01 to 12/31	6/1/1959	STATEMENT OF CLAIM	PUMP	35 GPM	7	1.8	42M 36815 00
YELLOWSTONE	LAWN AND GARDEN	-104.753465	47.092463	06/01 to 10/01	12/31/1957	STATEMENT OF CLAIM	PUMP	17 GPM	2	1	42M 163637 00
YELLOWSTONE	LAWN AND GARDEN	-104.750694	47.09426	05/01 to 10/31	6/23/1983	PROVISIONAL PERMIT	PUMP	34 GPM	4	1	42M 51980 00
YELLOWSTONE	LAWN AND GARDEN	-104.695096	47.132179	04/01 to 12/01	5/9/1988	PROVISIONAL PERMIT	PUMP	15 GPM	2.5	1	42M 66255 00
YELLOWSTONE	LAWN AND GARDEN	-104.69385	47.134459	03/15 to 11/15	6/13/2003	PROVISIONAL PERMIT	PUMP	30 GPM	9.3	3.72	42M 30006470
YELLOWSTONE	MUNICIPAL	-104.717683	47.106803	01/01 to 12/31	8/18/1961	STATEMENT OF CLAIM	PUMP	7.58 CFS	1952	0	42M 163756 00
YELLOWSTONE	MUNICIPAL	-104.717683	47.106803	01/01 to 12/31	4/26/1906	STATEMENT OF CLAIM	PUMP	4 CFS	1116.5	0	42M 163757 00
YELLOWSTONE	MUNICIPAL	-104.741227	47.100611	NOT LISTED	12/15/1978	WATER RESERVATION	UNKNOWN	4.53 CFS	3281	0	42M 9938 00

Table G-2
Municipal Surface Water Supply Intakes in Project Area
Missouri and Yellowstone Rivers, Montana

River	Missouri		Yellowstone	
Intake Authority	ASRWSS**	City of Culbertson*	City of Glendive	Montana Dakota Utilities Co*
Place Name	Wolf Point	Culbertson	Glendive	Sidney
Longitude	-105.535	-104.475	-104.72	-104.157
Latitutude	48.0668	48.12502	47.10606	47.67814
Population Served	10439	NA	5500	25
Dist. Downstream of Pipeline (mi.)	66.8	147.4	27.0	91.0

Notes:

* Currently not in use.

** ASRWSS - Assiniboine and Sioux Water Supply System supplies drinking water for the Dry Prairie Rural Water System.

Table G-3

Pipeline Spill Simulation Results for Exceedance of Benzene Drinking Water Standard (MCL); Municipal Surface Water Supply Intakes in Project Area; Missouri River (ASRWSS Intake), Montana

Flow Regime	All		Winter	
	Benzene (kg)	Oil (bbl)	Benzene (kg)	Oil (bbl)
Low	44,000	197,460	61	274
Average	6,500	29,170	74	332
High	3,100	13,912	92	413

Table G-4

Pipeline Spill Simulation Results for Exceedance of Benzene Drinking Water Standard (MCL); Municipal Surface Water Supply Intakes in Project Area; Yellowstone River (Glendive Intake), Montana

Flow Regime	All		Winter	
	Benzene (kg)	Oil (bbl)	Benzene (kg)	Oil (bbl)
Low Flow	65	292	8	34
Average Flow	29	128	11	47
High Flow	33	148	13	57

Table G-5

Pipeline Spill Simulation Sensitivity Analysis Results for Exceedance of the Benzene Drinking Water Standard (MCL); Missouri River (ASRWSS Intake), Montana

Flow Regime	All			Winter		
	Percentage of Volume			Percentage of Volume		
	100	95	80	100	95	80
	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)
Low	0.005	0.005	0.004	0.005	0.005	0.004
Average	0.005	0.005	0.004	0.005	0.005	0.004
High	0.005	0.005	0.004	0.005	0.005	0.004

Table G-6

Pipeline Spill Sensitivity Analysis Results for Exceedance of the Benzene; Yellowstone River (Glendive Intake), Montana

Flow Regime	All			Winter		
	Percentage of Volume			Percentage of Volume		
	100	95	80	100	95	80
	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)	Benzene (mg/l)
Low	0.005	0.005	0.004	0.005	0.005	0.004
Average	0.005	0.005	0.004	0.005	0.005	0.004
High	0.005	0.005	0.004	0.005	0.005	0.004