3.5. SURFACE WATER HYDROLOGY

This section describes the affected environment and addresses potential surface water quantity and quality impacts from the proposed Project. The Project is located in the upper portion of the Sheep Creek drainage (see **Figure 3.5-1**). Sheep Creek, a fifth-order stream, flows out of the Little Belt Mountains and discharges into the Smith River, which in turn is a tributary to the Missouri River. Sheep Creek drains an area of 194 square miles and runs approximately 34 river miles from its headwaters down to the Smith River. The Project area is approximately 19 river miles above the confluence with the Smith River. Sheep Creek flows in a meandering channel through a broad alluvial valley upstream of the Project site and enters a constricted bedrock canyon just downstream of the Project site (Hydrometrics, Inc. 2017a).

A number of named and unnamed tributaries flow into Sheep Creek, including Little Sheep Creek and Coon Creek in the immediate vicinity of the Project (see **Figure 3.5-2**). The Holmstrom Ditch is another feature in the vicinity of the Project. This diversion ditch was constructed in 1935 to divert water from Sheep Creek for irrigation, and continues to operate seasonally (Hydrometrics, Inc. 2017a).

3.5.1. Analysis Methods

3.5.1.1. Regulatory Context of the Analysis

The following relevant and applicable water acts, regulations, required permits/certificates, and enforcing agencies were identified for the Project:

- Federal Clean Water Act: USEPA, USACE
- Montana Water Quality Act: Montana DEQ, Water Quality Division, Water Protection Bureau
- MPDES: Montana DEQ, Water Quality Division, Water Protection Bureau
- Total Maximum Daily Load (TMDL): Montana DEQ, Water Quality Division, Water Protection Bureau
- Public Water Supply Act/Permit: Montana DEQ, Public Water and Subdivisions Bureau
- Montana Water Use Act: Montana DNRC

3.5.1.2. Surface Water Quantity

The Proponent initiated water resources baseline monitoring for the Project in 2011. Surface water quantity data from May 2011 through July 2015 is provided in the "Baseline Water Resources Monitoring and Hydrogeologic Investigations Report" (Hydrometrics, Inc. 2017a). Additional data were collected after the Baseline Water Resources Monitoring and Hydrogeologic Investigations Report was completed and are available through to December 2017 (Hydrometrics, Inc. 2018b).

Surface water monitoring was established at 11 sites to characterize the stream flow for the Project area (see **Figure 3.5-2**). Quarterly flow and stage monitoring have been conducted at these sites since 2011. Since 2014, additional monthly flow measurements have been collected at the two surface water sites along Sheep Creek (SW-1 and SW-2). The Sheep Creek Gaging Station (see **Figure 3.5-2**) was installed at SW-1 in November 2012 to record detailed seasonal baseline data. A stage-discharge rating curve was developed for SW-1 and was used to generate a discharge hydrograph. Beginning in May 2014, additional monthly flow measurements have been conducted at a former U.S. Geological Survey (USGS) gaging site (06077000) along Sheep Creek upstream of the baseline monitoring sites. Concurrent flow measurements between the upstream USGS station and SW-1 and SW-2 were used to correlate stream flow between the sites.

The Holmstrom Ditch (see **Figure 3.5-2**) was constructed in 1935 to divert water from Sheep Creek for irrigation use. The diversion occurs to the east of the Project area near USGS gauging site 06077000, which is approximately 1.9 miles upstream of SW-2. Flow is diverted toward the south to irrigated lands near Newlan Creek, and does not return to Sheep Creek. Baseline flow monitoring for the Project along Sheep Creek occurred below the diversion and thus it is a component of the baseline conditions of the affected environment.

In addition to the stream flow monitoring, baseline investigations identified nine seeps and 13 springs in the Project area (see **Figure 3.5-3**). Generally, the sites consisted of small springs or seeps in the ephemeral headwater channels of small tributary streams. These formed small boggy areas with limited flow that generally re-infiltrated into the channels within a few hundred feet. Of the identified springs, five were developed springs for stock watering to feed livestock watering tanks (see **Figure 3.5-3**). A series of flow measurements were obtained to characterize the discharge from the seeps and springs.

3.5.1.3. Surface Water Quality

Surface water quality sampling was conducted at 14 surface water sites (see **Figure 3.5-2** and **Table 3.5-1**). Baseline surface water monitoring for the Project has been conducted since 2011 (Hydrometrics, Inc. 2017a; Tintina 2017).

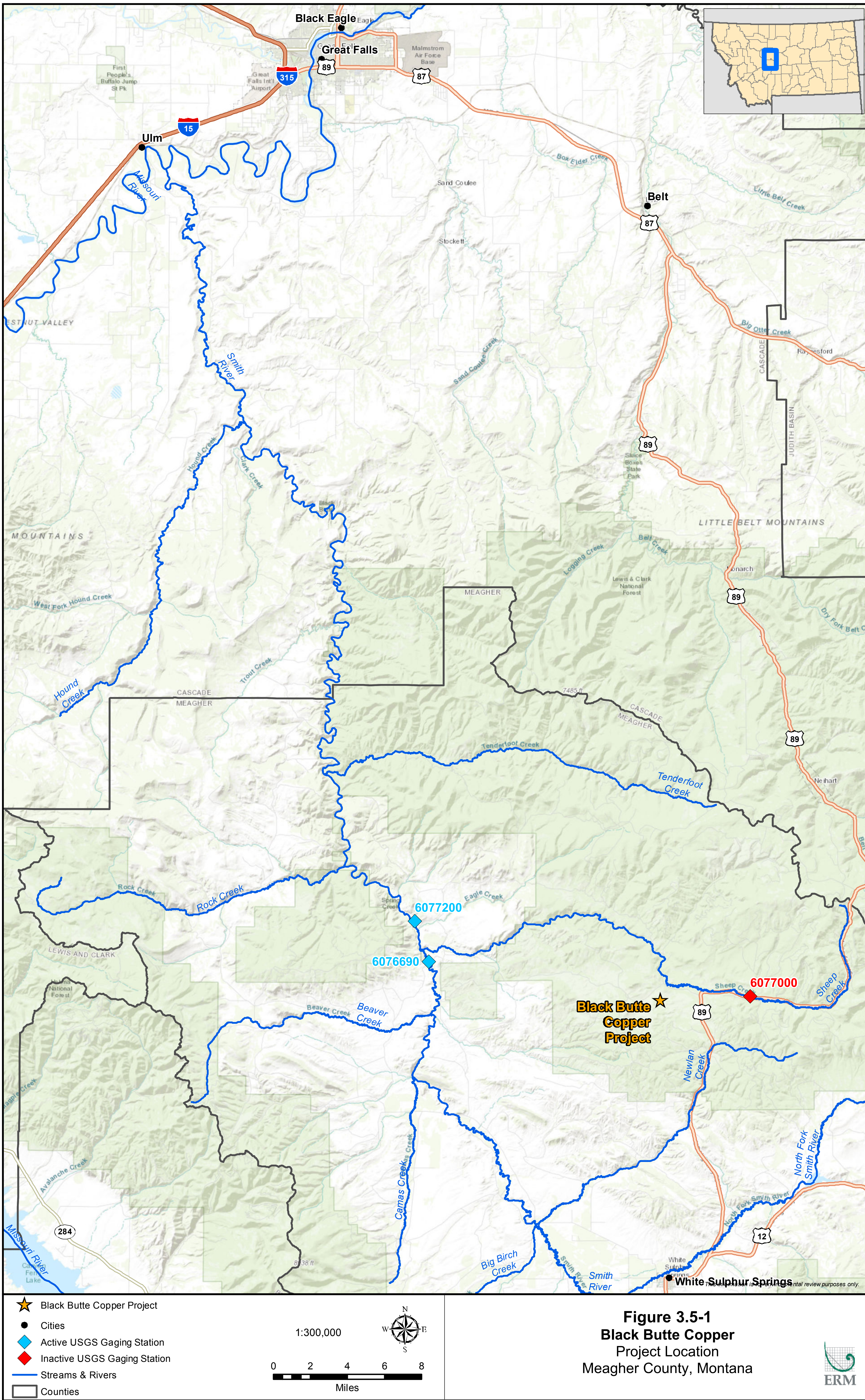
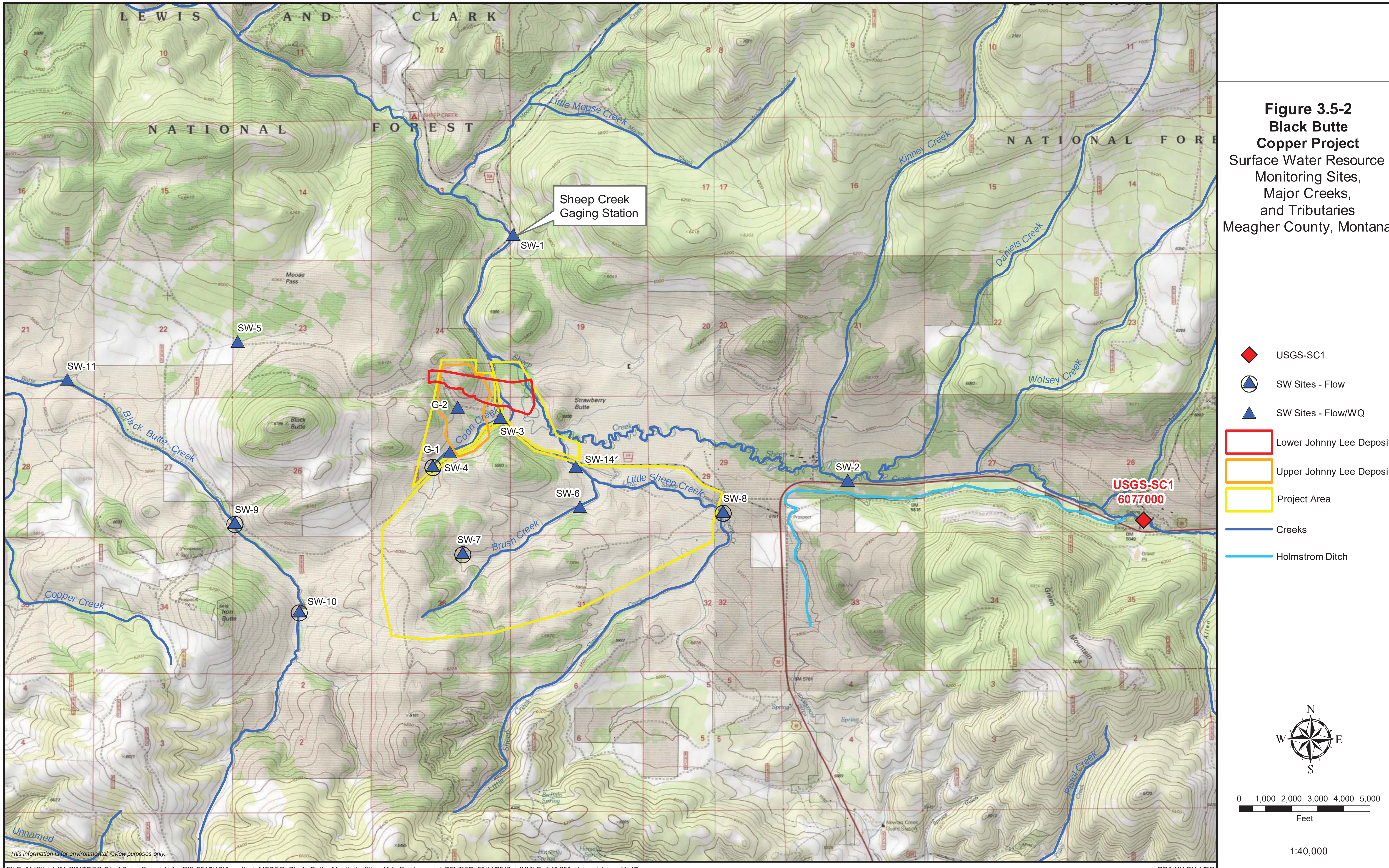


Figure 3.5-1
Black Butte Copper
Project Location
Meagher County, Montana

Source: Tintina 2017



Source: Tintina 2017

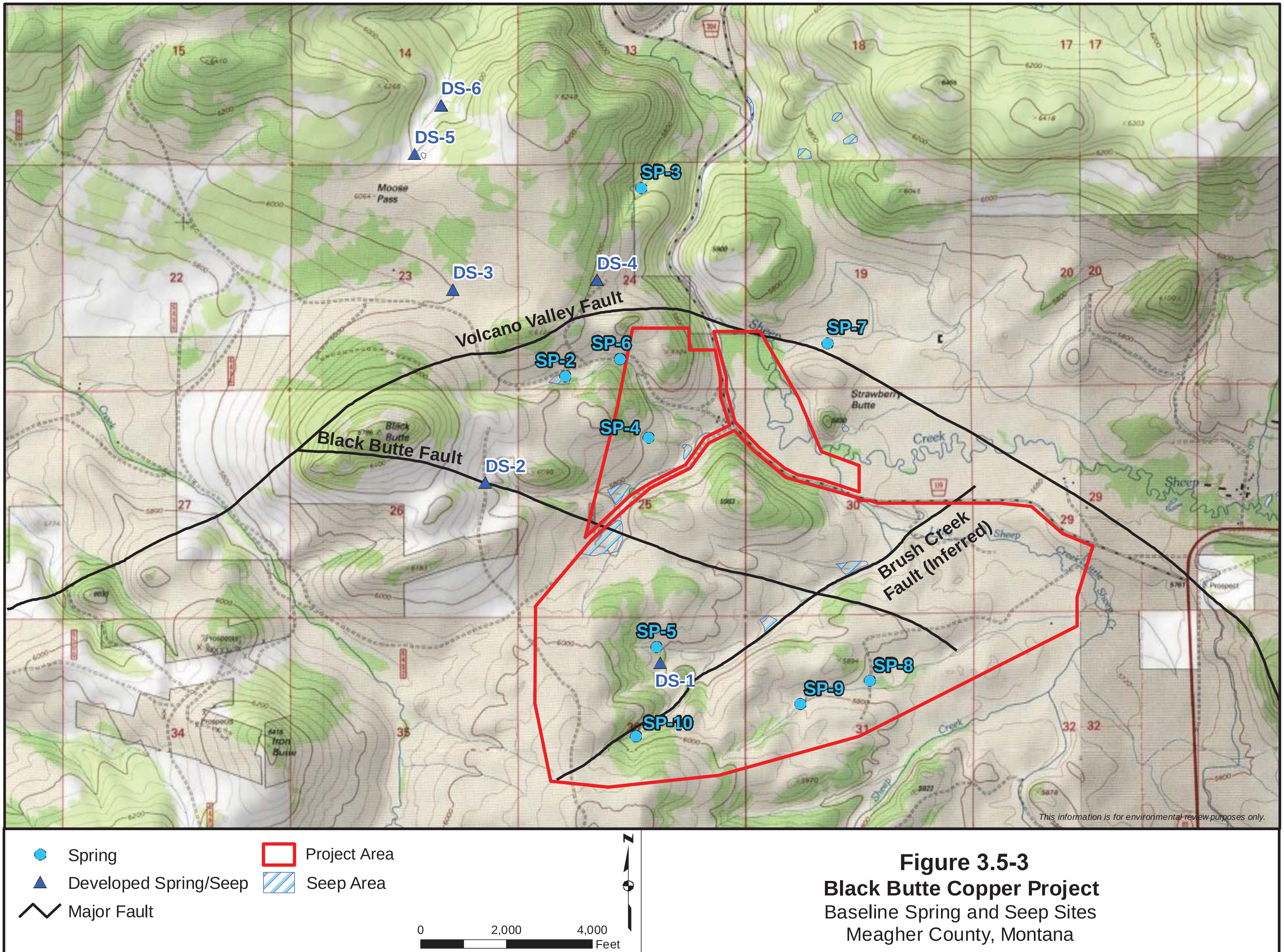


Figure 3.5-3
Black Butte Copper Project
Baseline Spring and Seep Sites
Meagher County, Montana

FILE: M:\Clients\M-O\MTDEQ_ArcGIS\2018\04\Appendix_Figures_AppB_Springs_Seeps.mxd | REVISED: 04/11/2018 | SCALE: 1:36,000 DRAWN BY: JPB

Source: Hydrometrics 2017a

Table 3.5-1
Sampling Summary for Baseline Surface Water Quality Monitoring

Monitoring Site	Monitoring Frequency	Period of Record	Field Parameters	Lab Parameters	Comments
SW-1	Monthly	2011-2017	X	X	
SW-2	Monthly	2011-2017	X	X	
SW-3	Quarterly	2011-2017	X	X	
SW-4	Quarterly	2011-2017	X	not analyzed	
SW-5	Quarterly	2011-2017	X	X	Typically dry
SW-6	Quarterly	2011-2017	X	X	
SW-7	Quarterly	2011-2017	X	2012, 2015	
SW-8	Quarterly	2011-2017	X	not analyzed	
SW-9	Quarterly	2011-2017	X	not analyzed	
SW-10	Quarterly	2011-2017	X	2015	Added lab WQ for TMDL
SW-11	Quarterly	2011-2017	X	X	
SW-14	Monthly	2016-2017	X	X	
USGS-SC1	Monthly	2014-2017	X	X	
G-1	Single Event	July 2011	X	X	Data collected once only in July 2011
G-2	Single Event	July 2011	X	X	Data collected once only in July 2011

G = gossan; SC = Sheep Creek; SW = surface water; TMDL = total maximum daily load; USGS = U.S. Geological Survey; WQ = water quality; X = analyzed

Water quality sampling and analytical methods for the Project are summarized in the “Water Resources Monitoring Field Sampling and Analysis Plan” (Hydrometrics, Inc. 2016a), which is included as Appendix U of the MOP Application (Tintina 2017).

3.5.2. Affected Environment

3.5.2.1. Surface Water Quantity

The existing surface water conditions for the Project area are described in the “Baseline Water Resources Monitoring and Hydrogeologic Investigations Report” (Hydrometrics, Inc. 2017a). Stream flows have been monitored at various locations since 2011 as described in Section 3.5.1.2. Monitored streams ranged from small seasonal streams where the highest measured flow was 0.3 cubic feet per second (cfs), to Sheep Creek where the highest flow was estimated at 613 cfs. The range of measured flows for each of the sites is provided in **Table 3.5-2**.

Table 3.5-2
Stream Flow Ranges from 2011–2017

Monitoring Station	Stream	Dec - Apr	May - Jun	Jul - Nov
		Measured Stream Flow (cfs)		
SW-1	Sheep Creek	NF (Ice) -103	21–613[a]	NF (Ice)–64
SW-2	Sheep Creek	31-82	14–250	NF (Ice)-47
SW-3	Coon Creek	NF (Ice)-0.22	0.03–4.9	NF (Ice)–0.34
SW-4	Coon Creek	NF (Ice)-0.23	0.02–2.0	0.004–0.04

Monitoring Station	Stream	Dec - Apr	May - Jun	Jul - Nov
		Measured Stream Flow (cfs)		
SW-6	Brush Creek	NF (Ice)-0.26	0.11–4.1	0.04–0.33
SW-7	Brush Creek	NF (Ice) – 0.4	0–0.3	0.001–0.01
SW-8	Little Sheep Creek	NF (Ice) - 1.7	0.48–9.1	0.09–1.1
SW-9	Black Butte Creek	0.32–2.5	0.67–13	0.28–0.83
SW-10	Black Butte Creek	NF (Ice)- 1.5	0.48–15	0.15–0.54
SW-11	Black Butte Creek	1.0–2.9	0.61–21	NF (Ice) –1.1
SW-14	Little Sheep Creek	NF (Ice) -4.0	1.5-12	0.40-1.9

Source: Hydrometrics, Inc. 2018b

cfs = cubic feet per second; NF (Ice) = not flowing (ice to ground); SW = surface water
Note:
[a] High flows estimated, not measured due to depths and velocities being too high to accurately measure

The discharge hydrograph generated for monitoring site SW-1 on Sheep Creek, presented on **Figure 3.5-4,** illustrates the seasonal stream flow pattern across the monitoring period. The highest stream flows at SW-1 occur from mid-May through mid-June, when flows exceeded 100 cfs. Annual peak flows captured in the data record ranged from over 200 cfs in 2015 to just above 800 cfs in 2014, going above the measured/estimated flows observed during the site visits. Following the high-flow period, flows receded to an average monthly flow of 15 to 30 cfs by late summer. Winter base flow was determined to be approximately 15 cfs across the monitoring period (Hydrometrics, Inc. 2017a). DEQ calculated additional low flow statistics for the MPDES Permit. The annual 7-day 10-year low flow (7Q10) and summer 14-day 5-year low flow (14Q5) values were determined for the proposed discharge point located on Sheep Creek less than 2 miles upstream of SW-1. Methods for determining low flow statistics generally followed DEQ standards (DEQ 2017) and are detailed in the document, “DEQ Low Flow Stats Calculations for the Black Butte Copper Project MPDES Permit” (DEQ 2018). The 7Q10 value for the Sheep Creek discharge point was determined to be 5.67 cfs, and the 14Q5 was determined to be 11.8 cfs.

Spring flow rates in the Project area ranged from no flow during certain dry or frozen periods in the year to greater than 100 gpm. Minimum, maximum, and average flow rates from 15 baseline spring monitoring sites in the Project area are summarized in **Table 3.5-3**.

3.5.2.2. Surface Water Quality

Updated data for each of the surface water quality monitoring sites, including detailed summary statistics by parameter, are compiled in Appendix I. Surface water quality summary statistics for SW-1 are presented in Appendix I, **Table 1**.

Surface water results show slightly acidic to slightly alkaline pH values (5.3 to 8.7), and low to moderate specific conductance (49 to 497 micro mhos per centimeter). Isolated field pH measurements less than 6.5 were attributed to cold winter conditions affecting the probe, which is susceptible to error at low temperatures.

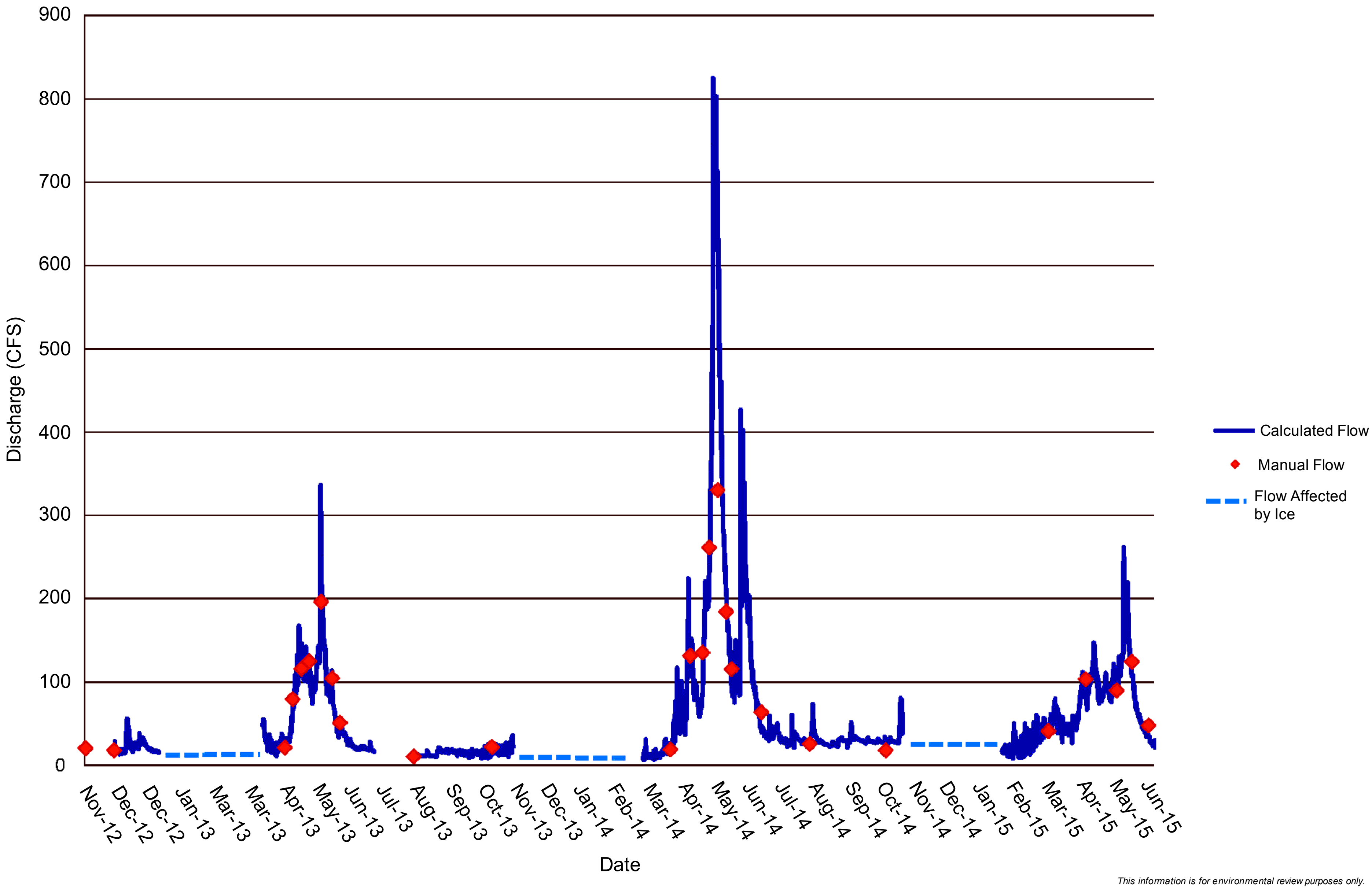


Figure 3.5-4

Black Butte Copper Project

Hydrograph of SW-1 Sheep Creek

Monitoring Site

Meagher County, Montana

FILE: M:\Clients\M-O\MTDEQ_ArcGIS\2018\04\Appendix_Figures_AppB_Hydrograph_Sheep_Creek.mxd | REVISED: 06/25/2018 | SCALE: 1:14,275 DRAWN BY: JPB

Source: Hydrometrics 2017a

Table 3.5-3
Spring Flow Ranges from 2011–2017

Site Name	Flow Rate (gpm)		
	Minimum	Maximum	Average
SP-1	NF	65	13.8
SP-2	NF	9.4	3.2
SP-3	NF	5.4	1.3
SP-4	0.18	27	6.1
SP-5	NF	128	8.0
SP-6	NF	3.0	0.84
SP-7	6.7	112	23.9
SP-8	0.6	8.1	5.4
SP-9	1.9	15	6.3
SP-10	NF	8.1	3.4
DS-1	NF	35	7.5
DS-2	NF	1.79	0.38
DS-3	NF	22	4.8
DS-4	NF	20	1.8
DS-5	NF	18	3.8
DS-6	NF	18	3.8

Source: Hydrometrics, Inc. 2018a

DS = developed spring; gpm = gallons per minute; SP = undeveloped spring; NF = not flowing

Calcium and bicarbonate dominate the major ion chemistry of surface waters. With the exception of SW-5, which only has flow during spring runoff, hardness (not measured for SW-4, SW-8, SW-9, SW-12 and SW-13) ranges from approximately less than 7 mg/L to 267 mg/L (as $CaCO_3$). Metals data show some infrequent values above DEQ-7 water quality standards (DEQ 2012, 2017) for selected metals. Samples collected from gossan[1] sites G-1 and G-2 were similar to the long-term water quality monitoring sites and; therefore, they were not added to the long-term baseline water resource monitoring program.

Surface water standard (DEQ 2017) exceedances were observed for the following constituents (Appendix I):

- Total recoverable iron exceedances of the chronic aquatic criterion of 1 mg/L were recorded at all sites except for SW-10 and SW-14 (not measured in SW-4, SW-8, SW-9, SW-12 and SW-13). The exceedances often occurred during peak runoff periods but were occasionally unrelated. Exceedances coincidental with low flow periods (winter and summer) were also observed upon occasion.
- Dissolved aluminum concentrations (not measured in SW-4, SW-8, SW-9, SW-12 and SW-13) often exceeded the chronic aquatic criterion of 0.087 mg/L during periods of high runoff in Sheep Creek (SW-1, SW-2), and in Black Butte Creek (SW-11). The guideline was consistently exceeded at SW-5.

[1] A gossan is an intensely oxidized, weathered, or decomposed rock, usually the upper and exposed part of an ore deposit or mineral vein.

Sheep Creek is included in DEQ's 303(d) list of impaired streams for dissolved aluminum and *Escherichia coli* (*E. coli*), with sources listed as grazing in riparian zones, disturbances associated with human activities, and natural sources. DEQ published a document in 2017 specifically focused on the TMDL for *E. coli* and a framework water quality improvement plan for Sheep Creek in the Sheep Creek TMDL Project Area (DEQ 2017). The iron and aluminum exceedances are likely related to increased turbidity during periods of snowmelt and high runoff (with some exceptions), as the exceedances occur during peak runoff periods when turbidity is high. Elevated dissolved aluminum values associated with high turbidity have been observed in many different geographic areas during high-flow events (e.g., Moose Creek on 303(d) list, tributary to Sheep Creek below the Project area).

DEQ conducted a broad monitoring program in the Sheep Creek drainage for further data collection. The data DEQ collected is being used to develop an aluminum TMDL. The TMDL is necessary as a result of § 75-5-702, MCA, the discharge permit application and the aluminum impairment determination (303[d] list). DEQ conducted a broad water quality monitoring program in the Sheep Creek drainage that was used to update baseline data and existing impairment determinations for several streams, including Sheep Creek. The data were used to complete an *E. coli* TMDL and will be used for an aluminum TMDL. The completion schedule for the aluminum TMDL is linked to the MPDES surface water permit completion schedule to ensure internal DEQ consistency. The aluminum water quality standard is identified in the State of Montana Water Quality Standards (DEQ 2017), and the aquatic life aluminum standards were set at 0.75 mg/L and 0.087 mg/L for acute and chronic standards, respectively.

3.5.3. Environmental Consequences

This section describes the potential impacts of the Project on surface water quantity and quality, including temperature. Groundwater quality is described in section 3.4.

3.5.3.1. Surface Water Quantity

No Action Alternative

Under a No Action Alternative, there would be no environmental consequences to surface water quantity in the Project area. Without the mine, the timing and magnitude of stream and spring flow would be unchanged from the existing conditions of the affected environment.

Proposed Action

The Proposed Action outlined in the Project's MOP Application (Tintina 2017) describes operations that could potentially affect surface water quantity though construction, operations, reclamation, and closure phases. Planned operations and facilities that could have direct or secondary impacts on surface water quantity are listed below:

- Surface disturbance by major facilities that could result in the interception and storage of surface water;
- Diversion of stream flow to the NCWR using the wet well during high-flow conditions;

- Dewatering associated with underground mine operations (access tunnels, ventilation shafts, mining stopes); and
- Operation of the Sheep Creek Alluvium UIG.

The following discussion of the Project's potential impacts on surface water quantity is organized by each of the planned operations.

Interception and Storage of Surface Water

Construction and operations of the mine would result in areas of surface disturbance that may result in changes to surface runoff patterns. Mining operations would also store and treat contact water prior to being discharged to the environment. **Table 2.2-1** lists the Project's facilities, features, and access roads and presents the measured acres of disturbance associated with each facility (Tintina 2017).

The total disturbed surface area is 310.9 acres, including a 10 percent construction buffer zone that would potentially affect the pattern and volume of surface runoff. Storm water runoff would be collected from the mill area, areas of direct underground mining support, WRS pad, copper-enriched rock storage pad, and the CTF, which would cover an area of approximately 112.3 acres (see **Table 2.2-1**). Contact storm water runoff from these facilities would be collected and stored in a CWP. Water from the CWP would be treated via the WTP and released to the environment through the alluvial UIG. To reduce the volume of contact storm water runoff in the disturbance area, storm water control and management BMPs would be implemented as required for the Storm Water Pollution Prevention Plan. BMPs are provided in the MOP Application (Tintina 2017) as well as Section 4.5 of the Integrated Discharge Permit Application Narrative (Hydrometrics, Inc. 2018c). BMPs would be used to minimize erosion and sedimentation, and to control surface and storm water runoff at the Project site. BMPs include but are not limited to:

- Suspend construction dirt work during periods of heaviest precipitation and runoff to minimize soil disturbance and erosion.
- Hydroseed or revegetate cut and fill slopes and disturbed natural slopes as early as possible.
- Use mulches and other organic stabilizers to minimize erosion until vegetation is established on sensitive areas.
- Isolate cleared areas and building sites with diversion channels, ditches, and swales to redirect runoff.
- Retain natural drainage patterns wherever possible.
- Install runoff diversion ditches that are primarily located at surface facilities and separate contact storm water and non-contact storm water.
- Line unavoidably steep interceptor or conveyance ditches with filter fabric, rock, polyethylene lining, or armoring to prevent channel erosion.
- Construct stable, non-erodible ditches, and inlet and outlet structures.
- Construct, operate, and maintain sediment control ponds.

The disturbed surface area (310.9 acres) is a relatively small area within the overall Sheep Creek watershed, which drains a total of 124,160 acres at its mouth. The disturbed area is also a small area relative to the total drainage area monitored by surface water gaging station SW-1, located just greater than 1 mile downstream of the Project area (50,162 acres). The percent disturbance (including a 10 percent buffer zone) is less than 1 percent of both the entire Sheep Creek drainage area and of the watershed area associated with station SW-1. Based on the small percentage of disturbed area, it is not expected that surface runoff would change; therefore, impacts on surface water quantity in the affected watershed would not be adverse.

Several tributaries to Sheep Creek are in the immediate vicinity of the Project including Coon Creek and Little Sheep Creek, which converges with Brush Creek southeast of the Project. Surface runoff in these smaller drainages could potentially be affected due to surface disturbance, but impacts would not extend outside the immediate area and therefore are considered low within the greater Sheep Creek watershed.

Within the jurisdictional study and lease boundary area from USACE (**Figure 3.14-1**), a total of 327.4 acres of wetlands and 16.3 miles of streams were identified. A variety of locations were considered for proposed facilities to identify a practicable alternative with minimal impacts to wetlands and streams. The Proposed Action would disturb only 0.85 acre of the wetlands and 696 lineal feet of the streams, which account for less than 1 percent of the total area of each of these surface water features. Additionally, BMPs would be implemented to reduce impacts on these features including the use of half-culverts spanning the channels of Brush Creek and Little Sheep Creek where the main access road intersects them and the use of a directional utility installation drill to avoid impacts on streams and wetlands during the installation of underground pipelines. Impact on surface water quantity in the streams and wetlands due to surface disturbance are insignificant based on the proposed BMPs detailed in the MOP Application (Tintina 2017) and the relatively small percentage of the total area of these features that would be impacted through construction disturbance.

Diversion of Stream Flow to the Non-Contact Water Reservoir

The purpose of the design and operation of the NCWR is water storage for stream flow augmentation to address depletion of surface water flow in the affected watersheds associated with consumptive use of groundwater during operations (mine dewatering). Water stored in the NCWR would be used for mitigation of residual depletion in surface waters during operations and for approximately 20 years after the end of mine dewatering (Tintina Montana, Inc. 2018b). A high-flow water rights application package was submitted to the DNRC on September 7, 2018. The Proponent proposes to fill the NCWR using a wet well with the point of diversion located approximately 60 feet west of the private road in the hay meadow adjacent to Sheep Creek (NW ¼, SE ¼, NW ¼, Section 30, Township 12N, Range 07E depicted on **Figure 2-1**). Water from the wet well would be pumped to the NCWR during high-flow conditions from May through July, and only when flow in Sheep Creek exceeds 84 cfs, which is equal to the total flow of the appropriated water rights (including instream flow reservations) on Sheep Creek downstream of the diversion (where the wet well would operate). Water would be diverted at a maximum rate of 7.5 cfs during the high-flow period with a maximum total annual volume of

291.9 acre-feet. Water from the NCWR would then be available for release to affected watersheds (e.g., Coon Creek watershed; see subsection below) during the non-irrigation portion of the year to offset impacts on base flow due to groundwater drawdown associated with mine dewatering. Additionally, seepage from the NCWR is intended to offset a portion of the mine's consumptive groundwater use. As the NCWR would be used for transfer of water between Sheep Creek and other streams, discharges from the NCWR would not require coverage under an MPDES permit (ARM 17.30.1310(1)(g) and 40 CFR 122.3(i)).The measures spelled out in the new high season flow surface water beneficial use permit and six change applications would be used to mitigate potential adverse impacts from the consumptive use of groundwater in the mining and milling process and to mitigate potential indirect impacts to wetlands.

Potential impacts due to the diversion of stream flow to fill the NCWR would be nominal, as the majority of the diversion would occur under a new water right limited to May through July and only when stream flow is in excess of all existing water rights and instream flow requirements (84 cfs). Any diversions during other months would be based on using existing leased water rights along Sheep Creek that are currently being put to beneficial use (pending review and approval by the DNRC). Water diversion would be limited to the irrigation period of the year when water is available and leased water rights permit water withdrawal.

Dewatering Associated with Underground Mine Operations

Drawdown caused by dewatering (especially in the upper HSUs) would capture water that would otherwise ultimately report to surface water. This capture would result in decreasing the base flow and impacts in downgradient surface water resources. As described in Section 3.4.3.2, Proposed Action in Groundwater Hydrology, model simulations show that the greatest rate of mine dewatering drawing from the shallow groundwater hydrostratigraphic units (groundwater in shallow bedrock and in the alluvium) would occur in Year 4 and would correspond to the initial mining stage when the model predicts the highest inflow to the mine workings. As **Figure 3.4-10** shows, the 10-foot drawdown contour would extend into the Black Butte Creek watershed, and to the north close to Coon Creek. The maximum model-computed drawdown of the water table is approximately 290 feet in model layer 1. However, the 10-foot drawdown contour only extends into a small portion of the Sheep Creek alluvial groundwater system along the margin of Sheep Creek Meadows between the upland bedrock area and Coon Creek (Hydrometrics, Inc. 2016b).

The predictive model simulations estimated the following impacts of mine dewatering on base flow in the nearby creeks:

- Moose Creek (shown on **Figure 3.5-2** north of SW-1): Model simulations show no measurable change in stream flow in Moose Creek from mine dewatering.
- Black Butte Creek (shown on **Figure 3.5-2** southwest of SW-1): The estimated steady state base flow at the mouth of Black Butte Creek ranges from 2.6 to 3.2 cfs. The model simulations show a decrease of approximately 0.1 cfs (i.e., 3 to 4 percent of steady state base flow) in Black Butte Creek. The decrease starts to occur in Year 2 and reaches its peak in Year 4.

- Coon Creek (shown at the center of **Figure 3.5-2**): The mine dewatering simulations show a reduction of 0.12 cfs in the lower reach of Coon Creek. The total reduction in Coon Creek is estimated to be approximately 70 percent of the steady state base flow observed in the stream (0.2 cfs at the confluence with Sheep Creek). Water from the NCWR would be pumped into the headwaters of Coon Creek to augment flows within 15 percent of the average monthly flow (Hydrometrics, Inc. 2018c). Additionally, Coon Creek is often fully diverted during the irrigation season and frozen during the winter months. The Proponent has an agreement with the water right holder for Coon Creek to utilize the water right if necessary (change in water use would be dependent on approval by the DNRC). Based on these factors, and pending the approval by the DNRC, the reduction in flow to Coon Creek itself would not have a substantive impact on water resources in the area.
- Sheep Creek: The Sheep Creek watershed upstream of SW-1 has the highest potential to incur dewatering impacts, as it is the closest to the Project of any of the streams except Coon Creek. Sheep Creek has an estimated average base flow of 15.3 cfs. Model simulations at the end of mining show a decrease in the groundwater flow to Sheep Creek from the model domain of 0.35 cfs (157 gpm). The simulated depletion is approximately 2 percent of the total base flow in Sheep Creek at this location upstream of SW-1. Predicted depletion of 0.35 cfs (157 gpm) is less than the quantity of water that would be returned to Sheep Creek alluvium through the UIG, which would be an average of 530 gpm from the WTP (from October through June). When the UIG is not likely to be in operation (July through September), the decrease in stream flow would be less than the limit established in non-degradation rules. Under the rare 7Q10 low flow conditions, Sheep Creek flow is calculated to be 5.67 cfs (2,545 gpm). In those conditions, non-degradation rules limit a decrease in flow to less than 255 gpm. The predicted decrease in flow (157 gpm) does not account for additions to base flow from seepage from the NCWR. If necessary to maintain flow in Sheep Creek, the Proponent may also discharge water diverted to the NCWR from Sheep Creek during high flow conditions back to Sheep Creek via the wet well during other months.

Simulated stream depletions resulting from groundwater drawdown during mine dewatering for all streams in the assessment area, with the exception of Coon Creek, are within 10 percent of the measured base flows and, therefore, are expected to be nominal (Tintina 2017). For Coon Creek, a reduction of approximately 70 percent is estimated. To mitigate this reduction in Coon Creek flow, water would be pumped into the headwaters to maintain flows within 15 percent of the average monthly flow, and pending approval by the DNRC, an agreement with the water right holder for Coon Creek to obtain the water right would be utilized. As required in closed basins by the DNRC, the water rights mitigation plan would offset all the stream depletion in Sheep Creek (and Black Butte Creek if necessary) by mitigating flows via groundwater at a rate equal to the consumptive use of the Project (Tintina 2017).

Operation of the Underground Infiltration Gallery

Contributions of treated water back to the groundwater system would have a secondary impact on surface water. Water not used in the milling or mining process would be treated and discharged back to the groundwater system through an alluvial UIG. The alluvial UIG would be located in non-wetland areas beneath the floodplain of Sheep Creek southwest of Strawberry Butte. The capacity and designed usage of the UIG is detailed in Section 3.4.3.2.

It is unlikely that operating the UIG would result in any negative secondary impacts on surface water quantity. Instead, it would partially compensate for the potential loss of base flow in Sheep Creek.

Impact Assessment

The combined impacts on surface water quantity based on the Proposed Action outlined in the Project description of this document are expected to be minor:

- Minimal surface disturbance would result in insignificant impacts on surface runoff.
- Diversion of water to the NCWR, other than during peak spring runoff (Sheep Creek flow in excess of 84 cfs), falls within existing leased water rights (pending review and approval of the DNRC).
- Secondary impacts on base flow of Sheep Creek as a result of mine dewatering and disposal of treated water to the UIG are expected to be insignificant and to partially offset one another. A more significant impact upon base flow would be possible for Coon Creek, with the total reduction in Coon Creek estimated to be approximately 70 percent of the steady state base flow. Impacts to Coon Creek would be mitigated by pumping water from the NCWR into the headwaters of Coon Creek to augment flows within 15 percent of the average monthly flow (Hydrometrics, Inc. 2018c). Nominal impacts are expected for Black Butte Creek, with a predicted reduction of 3 to 4 percent of steady state base flow. The Proponent has proposed to DRNC that some water from the NCWR also be routed to Black Butte Creek to offset the predicted stream flow depletion. No other creeks are present within the area of a 10-foot drawdown of the water table, as computed by the groundwater model.

A summary of the Project’s impact on surface water quantity is presented in **Table 3.5-4.**

Table 3.5-4
Project's Potential Consequences Regarding Surface Water Quantity

Project Phases	Project Facilities/Activities	Notes
Mine Construction (Phases I and II; Project Years 1–4)	Surface disturbance affecting runoff	Surface disturbance is less than 1% of local watershed area. BMPs and the relatively small percentage of the total area (<1%) of stream and wetland features would be impacted through surface disturbance during construction.
	Diversion of stream flow to the NCWR	Based on existing leased water rights along Sheep Creek (pending review and approval by the DNRC).
	Mine dewatering	Simulated base flow depletion for all streams except Coon Creek is less than 10% and therefore is expected to be nominal. Coon Creek base flow reduction would be offset with water from the NCWR and through an agreement with the water rights holder to utilize the water rights (pending approval with the DNRC).
	Underground infiltration gallery	Partially compensates for the potential loss of base flow in Sheep Creek.
Mine Production (Phase III; Project Years 5–15)	Surface disturbance affecting runoff	Surface disturbance is less than 1% of local watershed area.
	Diversion of stream flow to the NCWR	Based on existing leased water rights along Sheep Creek.
	Mine dewatering	Simulated base flow depletion is less than 10% and therefore is expected to be nominal.
	Underground infiltration gallery	Partially compensates for the potential loss of base flow in Sheep Creek.
Post-Mine Period (Mine Closure and Post-Closure; Phase IV)	Surface disturbance affecting runoff	Surface disturbance is less than 1% of local watershed area.
	Diversion of stream flow to the NCWR	Based on existing leased water rights along Sheep Creek and a new water right limited to high flow conditions. The NCWR would be used for mitigation of residual depletion in surface waters for approximately 20 years after the end of mine dewatering.
	Mine dewatering	Base flow depletion is expected to cease within 2 years after dewatering stops. Where required, base flow reduction would be offset with water from the NCWR. The NCWR would be used for mitigation of residual depletion in surface waters for approximately 20 years after the end of mine dewatering.
	Underground infiltration gallery	No discharge to UIG after underground mine is closed and water treatment no longer necessary.

BMP = best management practice; DNRC = Montana Department of Natural Resources and Conservation; NCWR = Non-Contact Water Reservoir; UIG = Underground Infiltration Gallery

Smith River Assessment

The Smith River is located approximately 19 river miles downstream of the Project and is the receiving waters for Sheep Creek. Two active USGS gaging stations (USGS 06076690 and 06077200) are located upstream and downstream of the confluence with Sheep Creek. Average monthly flows at the upstream station (06076690) range from 18 to 3,200 cfs, and downstream of Sheep Creek (06077200), they range from 30 to 3,800 cfs (Hydrometrics, Inc. 2017a). The percentage of flow that Sheep Creek contributes to the Smith River cannot be directly quantified using the two USGS stations, as another tributary discharges between them (Eagle Creek). An inactive USGS station 06077000 (data from 1941 to 1972) on Sheep Creek upstream of the Project reported monthly average flows ranging from 9 to 115 cfs, which provides an approximation of the flow in Sheep Creek near the Project relative to the Smith River upstream of the confluence (from 30 percent during base flow periods to 4 percent during high-flow periods). Several tributaries merge with Sheep Creek downstream from the Project site, before its confluence with the Smith River (e.g., Coon Creek, Moose Creek, Indian Creek, Cameron Creek, Calf Creek, and Black Butte Creek).

The contributions of Sheep Creek to the Smith River provide the context to understand how impacts of the Proposed Action may translate downstream. As discussed in the previous section, based on the Proposed Action description, impacts on surface water quantity in Sheep Creek are expected to be minor, and therefore potential impacts on water quantity in the Smith River would be insignificant. The Smith River is included in DEQ's 303(d) list of impaired streams for flow regime modification due to agricultural irrigation, from the North and South Forks to the mouth at the Missouri River. Those activities which impact surface water quantity are not associated with the Project and are likely to continue in the future.

Agency Modified Alternative

The modifications identified in the AMA would result in impacts similar to those described for the Proposed Action. Modifications to the Proposed Action include an additional backfill of mine workings component. Additional backfill of the mine workings with low hydraulic conductivity material would help prevent air and groundwater flow within certain mine workings. Hydraulic simulations in the predictive groundwater models showed that if grouting of the declines was implemented (Proposed Action) there would not be any reduction in the impacts to steady state base flow in the larger watersheds and the depletion of base flow in Coon Creek would be reduced by only 4 gpm through reducing drawdown in the alluvium. Similarly, the additional backfill of mine workings would be expected to have a positive but very minimal impact on base flow reduction.

Smith River Assessment

The impacts of the AMA on water quantity in the Smith River would be the same as described for the Proposed Action. As described previously based on the Proposed Action description, impacts on surface water quantity in Sheep Creek are expected to be minor, and therefore potential impacts on water quantity in the Smith River would be negligible.

3.5.3.2. Surface Water Quality and Temperature

No Action Alternative

The No Action Alternative would not introduce additional loads to receiving surface waters compared to baseline conditions. No impacts on surface water quality are anticipated. However, the baseline impacts to water quality noted in Section 3.5.2.2 are anticipated to continue.

Proposed Action

The Proponent has used hydro-geochemical monitoring, hydrogeological modeling, and geochemical testing data to design its underground workings, temporary WRS pad, CTF, PWP, CWP, WTP, and TWSP to minimize potential impacts on water quality. Apart from groundwater in the underground workings at the end of the closure phase, water from all facilities would be collected and treated to meet non-degradation criteria prior to discharge (Hydrometrics, Inc. 2016c).

The Proponent has developed water quality model predictions for key facilities during operations and at closure (Enviromin 2017a, which is included as Appendix N of the MOP Application [Tintina 2017]). Models predict future water quality and calculate uncertainty based on sensitivity analyses for the four locations discussed below.

- Underground workings: Water quality is predicted at Year 6 of mining operations and again under post-closure conditions, when the water table has recovered to near pre-mining conditions (Section 3.4).
- WRS: Seepage from the WRS would be collected and transported to the CWP. Water quality is predicted at the end of Year 2, at the beginning of dismantling the WRS pad that would provide material for the tailing impoundment interior protective layer and interior basin drain system on top of a liner.
- CTF: No process water is to be discharged, but it may be routed to a separate WTP circuit from which it reports back to the mill circuit as make-up water. Water quality is predicted for Year 6 of tailings production and at the start of closure, before placing the cover designed to eliminate subsequent infiltration and seepage.
- PWP: Updated water quality predictions were generated for the PWP, based on CTF and RO brine predictions in Year 6 of production.

As part of mine operations, the Proponent anticipates discharging water seasonally from the WTP and/or TWSP via the UIG, which would flow into a segment of Sheep Creek after being discharged to the adjacent alluvial groundwater system. The discharge would be governed by an MPDES permit. Therefore, the Proponent has developed predictions regarding potential thermal effects resulting from the UIG discharge on Sheep Creek. Montana administrative rules applicable to B1 classified streams such as Sheep Creek restrict temperature changes to a 1 °F maximum increase above naturally occurring water temperatures, and a 2 °F decrease below naturally occurring water temperatures.

Water Quality Model Methods and Results

To develop a mass-load calculation of water quality for each facility under base case and sensitivity scenarios, the operational plans described in Section 3 of the MOP Application (Tintina 2017) were combined with the following data:

- Groundwater quality data (Hydrometrics, Inc. 2017a), which are included as Appendix B of the MOP Application (Tintina 2017);
- Geochemical test results (Enviromin 2017b), which are included as Appendix D of the MOP Application (Tintina 2017);
- Hydrogeological modeling results (Hydrometrics, Inc. 2016b), which are included as Appendix M of the MOP Application (Tintina 2017); and
- Water treatment design data (Amec Foster Wheeler 2017), which are included as Appendix V of the MOP Application (Tintina 2017).

These data are described in detail in Appendix N (Enviromin 2017a) of the MOP Application (Tintina 2017). Conceptual models, assumptions, and modeling details unique to each of the four models are described in the following sections including the model results.

<u>Underground Mine</u>

The access tunnels, decline, access drifts, and stope workings would transect various rock types in the subsurface, as shown in **Figure 3.4-5** (Section 3.4 of the EIS, Groundwater Hydrology) and in **Figure 3.6-3** (Section 3.6 of the EIS, Geology & Geochemistry). Detailed modeling methods and results are provided in Section 4 of Appendix N (Enviromin 2017a) of the MOP Application (Tintina 2017). To be consistent with groundwater flow data (Hydrometrics, Inc. 2017a), the underground model was divided into seven HSUs as shown in **Figure 3.4-6** (Section 3.4 of the EIS, Groundwater Hydrology) and **Figure 3.6-3** (Section 3.6 of the EIS, Geology & Geochemistry). Mine water would be collected during dewatering operations for treatment, so the predicted chemistry after closure is the most important from an environmental perspective because water from the underground workings would no longer be treated. Each of the units was assigned a total flow, a surface area (based on operational plans), and a rock type that correlates with kinetic test data. For the model, each unit can be conceptually viewed as a large kinetic test and scaled based on surface area and flow rate. Further detail is provided in Section 4.3.3 of Appendix N (Enviromin 2017a) of the MOP Application (Tintina 2017). The mixed solution incorporated inflow from all seven units and was allowed to reach geochemical equilibrium, using the USGS PHREEQC[2] software to calculate mineral precipitation and metal sorption, with an analytical model of metal attenuation by sulfides in the exposed bedrock (Parkhurst and Appelo 1999). Removal of solutes via mineral precipitation and sorption allows calculation of final water quality for the mine sump, which is then collected for treatment to meet water quality standards and non-degradation criteria (Hydrometrics, Inc. 2016c).

[2] Original acronym was defined as: pH-REdox-EQuilibrium, written in the C programming language. The program is a widely used public-domain geochemical modelling software available from the USGS.

Model predictions for underground water are described in detail in Appendix N (Enviromin 2017a) of the MOP Application (Tintina 2017). Operational exceedances of DEQ groundwater quality standards were identified to include nitrate, uranium, strontium, and thallium. However, because all water would be collected for treatment to meet groundwater and surface water non-degradation criteria, the identified operational exceedances would not affect downgradient water. A TWSP would be in place to store WTP effluent during periods when total nitrogen in the treated water (estimated to be 0.57 mg/L) exceeds non-degradation effluent limits (0.097 mg/L). The total nitrogen effluent limit is only in effect 3 months per year (July 1 to September 30). During that time period, treated water from the WTP would be pumped through a 6-inch (150 mm) diameter HDPE pipeline to the TWSP. Water would be stored in the TWSP until the total nitrogen effluent limit is no longer in effect, and then it would be pumped back to the WTP via a 6-inch (150mm) diameter HDPE pipeline, where it would be mixed with the WTP effluent. The blended water would be sampled prior to being discharged to the alluvial UIG per the MPDES permit (Zieg et al. 2018).

At mine closure, much of the underground workings would be backfilled and the open portions of the workings would be flooded with unbuffered RO permeate (treated water), to dissolve and rinse soluble minerals from mine surfaces. This contact water would then be pumped out of the mine and treated at the WTP, and additional RO permeate would be injected into the mine again. Non-degradation criteria within the underground workings openings are expected to be achieved after repeated flooding/rinsing, which is conservatively estimated to take between six to ten cycles. Until that time (estimated to take 7 to 13 months), water from the underground workings would continue to be captured and treated. Treatment of water from the underground mine would likely occur late in the closure phase. The total closure period (during which the months of rinsing would occur) is 2 to 4 years. Upon confirmation that the quality of contact groundwater meets the proposed groundwater non-degradation criteria, the contact water would no longer be pumped and treated, and the WTP would shut down as part of the post-closure phase (Hydrometrics, Inc. 2016c). At that time, all inflow to the workings would consist of groundwater recovering to pre-mining elevations, and the workings would remain flooded.

The predicted post-closure underground water quality is presented in **Table 3.5-5** (from Appendix N [Enviromin 2017a] of the MOP Application [Tintina 2017]). Compared to operations, higher pH (6.79), slightly lower alkalinity (145 mg/L), sulfate (120 mg/L), and metal concentrations are predicted in post-closure, as sulfide oxidation would be inhibited in the flooded workings. The predicted changes to water quality after closure (see **Table 3.5-5**) are minor relative to background water quality (pH of 6.97, with alkalinity of 193 mg/L and sulfate of 111 mg/L). Only thallium would be dissolved in contact groundwater at concentrations exceeding DEQ Groundwater Standards by a factor of two, but dissolved thallium would be at concentrations below the estimated groundwater non-degradation criteria (Hydrometrics, Inc. 2016c).

The post-closure contact groundwater would be unlikely to affect surface water quality. Such contact groundwater would be subject to mixing and retardation, while migrating via shallow groundwater system toward surficial environments (see discussion in Section 3.4.3). **Figure 3.4-8** included in Section 3.4, Groundwater Hydrology, provides an indication of the magnitude of mixing with other waters that the contact water would undergo (the rates of groundwater flow within the mine footprint: 0.4 gpm contact water, 90 gpm shallow bedrock groundwater, 200 gpm alluvial aquifer groundwater, and 6,700 gpm Sheep Creek base flow).

The combined flow rate of potential contact water from the Proposed Action is expected to be less than about 3 gpm. If 3 gpm of the contact water were to completely mix with Ynl A groundwater, the likely result would be a 30:1 dilution of the COCs present in the Project contact water. Furthermore, complete mixing of the contact water with Sheep Creek surface water would dilute the original COC concentrations by a factor of 2,200 or more (also see Section 3.4.3.2).

The limited variation between the base case and sensitivity scenarios reflects the robust design and plan for management of the underground workings, including the following:

- Open stope areas would be limited through concurrent backfilling with a low transmissivity material;
- Water would be treated during operations and closure;
- Lower workings would be flooded with RO treated water at closure; and
- Upper and lower workings would be isolated using hydraulic plugs.

These measures serve to reduce the impact of flushed oxidation products as the underground mine is flooded.

Table 3.5-5
Model Predictions for Underground Water Quality after Closure

		Underground model predictions at closure, after PHREEQC		Groundwater Standards (MT DEQ-7)	Estimated Groundwater Non-degradation Criteria
		Proposed Action	Agency Modified Alternative		
pH	s.u.	6.79	6.8	NA[a]	6.0-7.8
Aluminum	mg/L	0.016	0.015	NA	0.058
Alkalinity	mg/L $CaCO_3$	145	144	NA[a]	NA
Arsenic	mg/L	0	0	0.01	0.064
Barium	mg/L	0.0163	0.0168	1	0.1928
Beryllium	mg/L	0.0003	0.0002	NA[b]	0.00095
Calcium	mg/L	68	65	NA	NA
Cadmium	mg/L	0.000042	0.000042	0.005	0.0008
Chloride	mg/L	1.8	1.7	NA[a]	NA
Chromium	mg/L	0.0005	0.00049	0.1	0.025
Copper	mg/L	0.0002	0.0002	1.3	0.197
Fluoride	mg/L	0.38	0.37	4	1.2
Iron	mg/L	0	0	NA[b]	NA
Mercury	mg/L	0.000006	0.000006	0.002	0.00001

		Underground model predictions at closure, after PHREEQC		Groundwater Standards (MT DEQ-7)	Estimated Groundwater Non-degradation Criteria
		Proposed Action	Agency Modified Alternative		
Potassium	mg/L	3.4	3	NA	NA
Magnesium	mg/L	21.5	22	NA	NA
Manganese	mg/L	0.054	0.053	NA[b]	NA
Nitrate	mg/L as N	3.3	3.3	10	7.5
Sodium	mg/L	5	4.8	NA	NA
Nickel	mg/L	0.0053	0.005	0.1	0.025
Phosphorus	mg/L	0.001	0.001	NA	NA
Lead	mg/L	0.00001	0.00001	0.015	0.0028
Sulfate	mg/L	120	115	NA[b]	250[b]
Antimony	mg/L	0.0019	0.0015	0.006	0.002
Selenium	mg/L	0.001	0.0009	0.05	0.0085
Silicon	mg/L	1.55	1.55	NA	NA
Strontium	mg/L	2.2	2.1	4	6.48
Thallium	mg/L	0.0037	0.0037	0.002	0.0039
Uranium	mg/L	0.00507	0.00504	0.03	0.008
Zinc	mg/L	0.02	0.018	2	0.317

$CaCO_3$ = calcium carbonate; DEQ = Department of Environmental Quality; mg/L = milligrams per liter; MT = Montana; N = nitrogen; NA = not applicable; pH = potential hydrogen; PHREEQC = geochemical modelling software–pH-REdox-EQuilibrium in the C programming language; s.u. = standard unit
Notes:
[a] narrative standards may exist
[b] secondary standard
Prediction of endpoint, not based on modeling.

Waste Rock Storage Facility

Waste rock would be stockpiled at the temporary WRS facility for approximately 2 years before it can be co-disposed with tailings in the CTF. The waste rock has some potential for acid generation and metal leaching (Appendix D [Enviromin 2017b] of the MOP Application [Tintina 2017]). A liner would collect all seepage from the WRS facility and discharge to an outlet pipe on the south edge of the WRS pad.

Water quality predictions for the WRS at Year 2 of mining were based on precipitation inflow rates into the stockpile and steady-state seepage estimates from the HELP model (Section 3.4.1.6). The predicted flow rate (0.9 gpm) is very low in relation to the size of the WRS facility, so it is unreasonable to assume that all of the waste rock surfaces would be saturated or exposed to infiltration. Using data from humidity cell tests, the most probable chemical and physical properties of the waste rock were used to predict water quality for the “base case”. Modeling incorporated calculations for the surface area and mass of the rock that could react with infiltrating water. The base case scenario is considered to be a conservative estimate because the humidity cell test data were obtained from samples with higher surface areas and higher water:rock ratios than what would be encountered in the WRS.

The base case water quality in Year 2 of mining is predicted to be moderately acidic (pH 5.80) and high in sulfate (2,212 mg/L), with some elevated metals (see **Table 3.5-6**). Sensitivity analyses were conducted to evaluate other hypothetical scenarios in which the changes to the model's numeric inputs may be interpreted a few ways. The scenario that doubled the mass of reactive rock also represents the effects from doubling the reactive surface area, increasing the amount of infiltration, or decreasing the assumed porosity. The scenario that halved the mass of reactive rock also represents the effects from halving the reactive surface area, decreasing the amount of infiltration, or increasing the assumed porosity.

Table 3.5-6
Year 2 Results for Waste Rock Storage Facility

		Model Predictions for WRS at Year 2			Groundwater Standards (MT DEQ-7)
			Model Sensitivities		
		Base Case	Reactive Mass Doubled (e.g., 1-year infiltration OR double surface area OR 20% porosity)	Reactive Mass Halved (e.g., 3-month infiltration OR half surface area OR 80% porosity)	
pH	s.u.	5.80	5.48	6.10	NA[a]
Aluminum	mg/L	0.065	0.172	0.008	NA
Alkalinity	mg/L $CaCO_3$	24	48	12	NA[b]
Arsenic	mg/L	0.0038	0.0075	0.0019	0.01
Barium	mg/L	0.0022	0.0018	0.0031	1
Beryllium	mg/L	0.0011	0.0022	0.0006	0.004
Calcium	mg/L	333	417	167	NA
Cadmium	mg/L	0.00031	0.00061	0.00015	0.00500
Chloride	mg/L	5	9.86	2.47	NA[a]
Chromium	mg/L	0.014	0.028	0.006	0.1
Copper	mg/L	0.032	0.065	0.016	1.3
Fluoride	mg/L	1.43	2.51	0.71	4
Iron	mg/L	0.0026	0.0018	0.0043	NA[b]
Mercury	mg/L	0.0010	0.0020	0.0005	0.0020
Potassium	mg/L	30	60	15	NA
Magnesium	mg/L	407	748	237	NA
Manganese	mg/L	3.4	6.7	1.7	NA[b]

		Model Predictions for WRS at Year 2			Groundwater Standards (MT DEQ-7)
		Base Case	Model Sensitivities: Reactive Mass Doubled (e.g., 1-year infiltration OR double surface area OR 20% porosity)	Model Sensitivities: Reactive Mass Halved (e.g., 3-month infiltration OR half surface area OR 80% porosity)	
Nitrate	mg/L as N	344	344	344	10
Sodium	mg/L	12	24.3	6.1	NA
Nickel	mg/L	0.072	0.144	0.036	0.1
Phosphorus	mg/L	0.008	0.014	0.004	NA
Lead	mg/L	0.0034	0.0068	0.0017	0.0150
Sulfate	mg/L	2212	3811	1111	NA[b]
Antimony	mg/L	0.0022	0.0044	0.0011	0.006
Selenium	mg/L	0.009	0.017	0.004	0.05
Silicon	mg/L	0.62	1.13	0.31	NA
Strontium	mg/L	12.0	9.9	10.5	4
Thallium	mg/L	0.083	0.165	0.041	0.002
Uranium	mg/L	0.0012	0.0025	0.0006	0.03
Zinc	mg/L	0.021	0.042	0.011	2

Source: Enviromin 2017a

$CaCO_3$ = calcium carbonate; DEQ = Department of Environmental Quality; mg/L = milligrams per liter; MT = Montana; N = nitrogen; NA = not applicable; pH = potential hydrogen; s.u. = standard units; WRS = Waste Rock Storage
Notes:
[a] narrative standards may exist
[b] secondary standard
Prediction of endpoint, not based on modeling
Supersaturated phases in base case: alunite, barite, celestite, jarosite
Results include precipitation of supersaturated phases and sorption.

Mineral solubility limits were also considered for the base case and the sensitivity analysis scenarios, with the understanding that if particular solutes increase beyond the solubility limit, minerals would precipitate from the water and result in decreased solute concentrations. Precipitation of alunite ($KAl_3(SO_4)_2(OH)_6$), barite ($BaSO_4$), celestite ($SrSO_4$), and jarosite ($KFe^{3+}{}_3(OH)_6(SO_4)_2$) are predicted, but with no further solute sorption assumed due to lack of ferrihydrite precipitation. Sensitivity analyses show that the model is sensitive to the rock-to-water ratio and surface area (reactive mass) assumptions that influence predicted water quality. The model scenario with double the reactive mass predicts a slightly lower pH of 5.48 and a higher sulfate concentration of 3,811 mg/L. In contrast, the model scenario with half the reactive mass predicts a pH of 6.10 and a sulfate concentration of 1,111 mg/L.

During operation of the WRS, the seepage collected on the liner would discharge to an outlet pipe on the south edge of the WRS pad and would be conveyed for water treatment. The WRS would be removed prior to Year 3, with the waste rock being co-disposed with tailings in the CTF; hence, no closure evaluation was needed past this Project year.

Cemented Tailings Facility

As described above, the Proposed Action includes placing cemented paste tailings (0.5 to 2 percent cement) together with waste rock into a double-lined CTF. The conceptual design of the CTF is presented on Figure 4.20 of the MOP Application (Tintina 2017).

The use of cemented paste tailings in a surface tailings facility provides mitigation against surface water impacts on the environment because:

- Cemented paste tailings are a stable, non-flowable (after placement), low-strength solid when consolidated. This precludes the risk of liquefaction or widespread release of tailings in response to impoundment failure or seismic events;
- Cemented paste tailings establish a 1-2^{o} slope towards the sump, allowing for internal drainage to the CTF sump; and
- Cemented paste properties provide extremely low hydraulic conductivity to tailings on the facility (water flows through at a rate of about 1.6×10^{-6} centimeters per second which is less than 0.05 feet per day).

All mined waste rock would be encapsulated in cemented paste tailings in the lined CTF impoundment, because each of the waste rock units has some, if not significant, potential to generate acid or release concentrations of metals in excess of groundwater quality standards. Furthermore, for MPDES compliance, all water from the CTF and PWP would be recycled in the milling circuit rather than discharged (except that precipitation on the PWP in excess of a 10-year 24-hour storm event may be treated and discharged in order to maintain the water balance, in accordance with Federal Effluent Limitation Guidelines). Potential for impacts on surface and groundwater is therefore low.

Although water would not be stored on the facility, rain and snow would react with the weathered cemented tailing surface, dissolving oxidation products including acidity, sulfate, and metals. This water would mix with water produced during consolidation of cemented paste tailings and react with the deposited waste rock, the ramp, and the rock drain prior to collecting in the wet well sump. Geochemical source terms and modeling assumptions are detailed in Appendix N (Enviromin 2017a) of the MOP Application (Tintina 2017).

Like the WRS modeling described above, the most probable chemical and physical properties for tailings and waste rock in the CTF were used to predict water quality under the Proposed Action as the “base case”. For the CTF, water quality predicted for the base case at Year 6 of mining is acidic (pH 4.13) with 765 mg/L sulfate and elevated metal concentrations (see **Table 3.5-7**). More acidity and metals are contributed by the surface of cemented tailings than from the co-deposited waste rock or access ramp/rock drain, while most sulfate comes from the wet paste and the waste rock contribution. The minerals predicted by PHREEQC to precipitate during operations include alunite, barite, jarosite, and quartz.

Table 3.5-7
Predicted Water Quality in the Cemented Tailing Facility Sump at Year 6, Including Sensitivity Analyses

		Model Predictions for CTF at Year 6 of Mining					Groundwater Standards (MT DEQ-7)
		Base Case	Model Sensitivities				
			Waste Rock Surface Area Doubled	Paste Cement Surface Area Doubled	Paste Cement Surface Area Halved	4% binder Paste Cement Surface	
pH	s.u.	4.13	4.11	3.80	4.38	5.28	NA[a]
Aluminum	mg/L	17.73	16.18	38.26	4.80	0.08	NA
Alkalinity	mg/L $CaCO_3$	97	92	92	86	111	NA[a]
Arsenic	mg/L	0.031	0.033	0.048	0.016	0.017	0.01
Barium	mg/L	0.004	0.003	0.003	0.005	0.015	1
Beryllium	mg/L	0.0051	0.0051	0.0102	0.0026	0.0008	0.004
Calcium	mg/L	132	137	246	75	42	NA
Cadmium	mg/L	0.00141	0.00142	0.00281	0.00071	0.00005	0.0050
Chloride	mg/L	34.3	34.3	38.0	32.4	31.7	NA[a]
Chromium	mg/L	0.012	0.013	0.023	0.007	0.006	0.1
Copper	mg/L	61.3	0.0	121.8	31.0	0.7	1.3
Fluoride	mg/L	0.68	0.73	1.24	0.40	0.24	4
Iron	mg/L	0.573	0.463	1.955	0.497	0.022	NA[b]
Mercury	mg/L	0.000127	0.000141	0.000240	0.000071	0.000066	0.002000
Potassium	mg/L	0.00003	0.00005	0.00000	0.00004	3.46125	NA
Magnesium	mg/L	95	100	148	68	2	NA
Manganese	mg/L	2.68	2.73	5.30	1.36	0.06	NA[b]
Nitrate	mg/L as N	34.4	34.4	34.4	34.4	34.4	10
Sodium	mg/L	13	13.6	15.9	12.1	12.6	NA
Nickel	mg/L	8.5	8.5	17.1	4.3	0.0	0.1
Phosphorus	mg/L	0.26	0.26	0.50	0.05	0.02	NA
Lead	mg/L	0.027	0.028	0.030	0.025	0.025	0.015
Sulfate	mg/L	765	797	1481	406	97	NA[b]
Antimony	mg/L	0.015	0.015	0.016	0.014	0.014	0.006

		Model Predictions for CTF at Year 6 of Mining					Groundwater Standards (MT DEQ-7)
		Base Case	Model Sensitivities				
			Waste Rock Surface Area Doubled	Paste Cement Surface Area Doubled	Paste Cement Surface Area Halved	4% binder Paste Cement Surface	
Selenium	mg/L	0.003	0.003	0.005	0.002	0.001	0.050
Silicon	mg/L	0.001	1.142	1.129	0.74	0.12	NA
Strontium	mg/L	2.62	2.92	4.67	1.59	0.86	4
Thallium	mg/L	0.016	0.017	0.030	0.009	0.003	0.002
Uranium	mg/L	0.019	0.015	0.021	0.008	0.003	0.03
Zinc	mg/L	0.826	0.826	1.650	0.413	0.010	2

Source: Enviromin 2017a

$CaCO_3$ = calcium carbonate; CTF = Cemented Tailings Facility; DEQ = Department of Environmental Quality; mg/L = milligrams per liter; MT = Montana; N = nitrogen; NA = not applicable; pH = potential hydrogen; s.u. = standard units
Notes:
[a] narrative standards may exist
[b] secondary standard
Estimate - most nitrate removed by flotation
Supersaturated phases in base case: alunite, barite, jarosite, quartz
Results include precipitation of supersaturated phases.

Sensitivity analyses were conducted to evaluate other hypothetical scenarios in which the changes to the model's numeric inputs were used to represent changes to the surface area of co-disposed waste rock, the surface area of cemented paste tailings, and doubling the binder content of the cemented paste (from 2 percent up to 4 percent). Water quality predictions for the CTF are sensitive to the calculated surface area, implying that the surface area should be managed to limit weathering through frequent placement of fresh lifts of paste tailings. Cemented paste would be discharged into the facility in thin lifts with the upper surface of these lifts being exposed for up to 30 days (average range 7 to 15 days) before a new lift is deposited over the top. Higher concentrations of cement (e.g., 4 percent) could be used to reduce disaggregation of the surface if a delay in operations prevents frequent placement of fresh lifts. The drain should also be designed to avoid plugging with secondary minerals. However, the drain is unlikely to be fully saturated with the predicted flow of seepage, leaving multiple paths for water flow.

The CTF foundation drain system has the following three components:

- Drains on the CTF Basin Floor;
- Drains beneath CTF Embankments (areas of fill); and
- Outlet drain to the foundation drain collection pond.

The foundation drain collection pond is a small facility requiring only a 0.7 acre construction footprint and is located at the downstream toe of the CTF embankment (Figure 3.35 of the MOP

Application [Tintina 2017]). Collected water would be pumped directly to the WTP or alternatively transferred to the PWP as shown in Figure 3.43 of the MOP Application (Tintina 2017).

The CTF closure model accounts for the increased surface area of the cemented paste and removes the contribution from dewatered paste. However, the Proponent plans to seal the entire CTF upon closure. The CTF would be covered with a welded HDPE cover, followed by regraded fill, subsoil, topsoil (at a slope designed to preclude standing water), and revegetated. Covering the CTF with subsoil and topsoil to support vegetation and contouring the CTF to preclude standing water would minimize the amount of precipitation that infiltrates into the reclaimed CTF. Eliminating long-term exposure to oxygen and water and precluding hydraulic head inside the double-lined facility should eliminate seepage from the cemented tailings mass. This measure is important for minimizing the risk of acid generation from material stored within the CTF.

The CTF wet well sump would continue to be pumped in closure until water can no longer be effectively removed from the sump and minimum volume objectives are met. The time estimate for the CTF sump pumping in closure is expected to be approximately 30 days since the CTF is designed to contain mostly solids (e.g., cemented paste tailings and waste rock) and only minor volumes of water. However, the pump and piping for dewatering the sump would remain in place as necessary until agreement is reached with DEQ that it can be removed. The closure predictions shown here thus represent water quality at the end of tailing production, prior to cover placement, when the entire surface remains exposed to oxygen and water. After placement of the cover, there would be no more water in the CTF. The mass loads for each input source are shown with results in **Table 3.5-8**.

Table 3.5-8
Predicted Water Quality in the CTF Sump at Closure, Including Sensitivity Analyses

		Model Predictions for CTF at Closure				Groundwater Standards (MT DEQ-7)
			Model Sensitivities			
		Base Case	Waste Rock Surface Area Doubled	Paste Cement Surface Area Doubled	Paste Cement Surface Area Halved	
pH	s.u.	4.95	4.95	4.65	5.25	NA[a]
Aluminum	mg/L	0.020	0.020	0.039	0.010	NA
Alkalinity	mg/L $CaCO_3$	53	53	106	53	NA[a]
Arsenic	mg/L	0.0082	0.0086	0.0160	0.0043	0.01
Barium	mg/L	0.018	0.017	0.011	0.028	1
Beryllium	mg/L	0.0016	0.0016	0.0031	0.0008	0.004
Calcium	mg/L	54	54	108	27	NA
Cadmium	mg/L	0.000066	0.000067	0.000130	0.000033	0.005000
Chloride	mg/L	2.6	2.6	5.1	1.3	NA[a]

		Model Predictions for CTF at Closure				Groundwater Standards (MT DEQ-7)
		Base Case	Model Sensitivities			
			Waste Rock Surface Area Doubled	Paste Cement Surface Area Doubled	Paste Cement Surface Area Halved	
Chromium	mg/L	0.010	0.01	0.020	0.005	0.1
Copper	mg/L	0.0056	0.0056	0.0111	0.0028	1.3
Fluoride	mg/L	0.27	0.29	0.53	0.14	4
Iron	mg/L	0.012	0.012	0.007	0.021	NA[b]
Mercury	mg/L	0.000111	0.000111	0.000223	0.000056	0.002000
Potassium	mg/L	4.2	4.4	8.30000	2.2	NA
Magnesium	mg/L	0.9	1.3	0.7	7.4	NA
Manganese	mg/L	0.018	0.018	0.03	0.009	NA[b]
Nitrate	mg/L as N	3.4	3.4	3.4	3.4	10
Sodium	mg/L	4.0	4.1	7.9	2.1	NA
Nickel	mg/L	0.019	0.019	0.037	0.009	0.1
Phosphorus	mg/L	0.021	0.021	0.042	0.010	NA
Lead	mg/L	0.00047	0.00049	0.00092	0.00024	0.015
Sulfate	mg/L	90	93	177	46	NA[b]
Antimony	mg/L	0.0011	0.0011	0.0021	0.0006	0.006
Selenium	mg/L	0.0020	0.0021	0.0040	0.0011	0.050
Silicon	mg/L	0.11	0.12	0.22	0.06	NA
Strontium	mg/L	0.65	0.66	1.29	0.33	4
Thallium	mg/L	0.0022	0.0022	0.0044	0.0011	0.002
Uranium	mg/L	0.0011	0.0018	0.0015	0.0009	0.03
Zinc	mg/L	0.019	0.019	0.039	0.010	2

Source: Enviromin 2017a

$CaCO_3$ = calcium carbonate; CTF = Cemented Tailings Facility; DEQ = Department of Environmental Quality; mg/L = milligrams per liter; MT = Montana; N = nitrogen; NA = not applicable; pH = potential hydrogen; s.u. = standard units

Notes:

[a] narrative standards may exist

[b] secondary standard

Estimate - most nitrate removed by flotation

Supersaturated phases in base case: barite, jarosite

Results include precipitation of supersaturated phases.

At closure, following placement of a 4 percent binder cemented paste lift immediately prior to cover placement, a more neutral solution (pH 4.95 s.u.) is predicted, with no exceedances of groundwater standards for metals predicted for the base case following precipitation of barium arsenate, barite, and jarosite (see **Table 3.5-8**). Limited exceedances of groundwater standards for arsenic and thallium were predicted for the high surface area sensitivity scenario in closure. As noted above, the CTF wet well sump would continue to be pumped in closure until water could no longer be effectively removed from the sump, and minimum volume objectives are met. The planned reclamation procedures (e.g., welded HDPE cover, revegetation) are not accounted for in the model, which predicts water quality prior to use of the cover to eliminate infiltration. The proposed reclamation would minimize the infiltration of water into the CTF after closure.

Process Water Pond Facility

All water from the CTF and some water from the WTP would report to the PWP where it would mix with water from the mill (i.e., thickener overflow), direct precipitation, and run-on. In the PWP model, solutions were mixed and the solution was equilibrated using PHREEQC.

Water quality predictions for the CTF facility and the RO brine from the WTP were used in the PWP model. Process water chemistry and RO brine chemistry were provided in Appendix V (Amec Foster Wheeler 2017) of the MOP Application (Tintina 2017). In addition to these solutions, run-on, and direct precipitation (assumed to be deionized water) would be added and water would be removed as evaporation. A combination of run-on, direct precipitation, and evaporation add up to a net influx of 353,147 cubic feet per year of water, which dilutes the system by only a small amount. The final mixed solution is equilibrated in PHREEQC to predict the PWP chemistry.

The model predicts that the overall chemistry of the PWP is dominated by the thickener overflow from the mill, which provides 93 percent of the flow. The predicted solution has a pH of 5.81, moderate sulfate (903 mg/L), and elevated concentrations of nitrate and metals, including arsenic, copper, nickel, lead, antimony, strontium and thallium (see **Table 3.5-9**). Mixing with process water raises the alkalinity of the solution. PHREEQC modeling predicts that alunite, barium arsenate, barite, and jarosite could form based on mineral solubility limits, with no sorption of metals to ferrihydrite. These minerals would then settle out of the water column, reducing the concentrations of some dissolved solutes. Predicted water quality in the PWP would pose little acute threat to waterfowl that may land on the pond, precluding the need for netting to limit avian access. Water contained within the PWP would not be discharged.

Table 3.5-9
Predicted Water Quality in PWP at Year 6

			Aquatic Life Standard	Aquatic Life Standard	Human Health Standard
		Model Prediction of PWP	Acute (MT DEQ-7)	Chronic (MT DEQ-7)	Surface Water (MT DEQ-7)
pH	s.u.	5.81	NA	NA	NA
Aluminum [a]	mg/L	0.016	0.75	0.087	NA
Alkalinity	mg/L $CaCO_3$	205	NA	NA	NA
Arsenic	mg/L	0.0330	0.34	0.15	0.01
Barium	mg/L	0.004	NA	NA	1
Beryllium	mg/L	0.0002	NA	NA	0.004
Calcium	mg/L	509	NA	NA	NA
Cadmium [b]	mg/L	0.00009	0.0074	0.0024	0.005
Chloride	mg/L	141	NA	NA	4
Chromium	mg/L	0.004	5.61	0.27	0.1
Copper [b]	mg/L	4.0	0.052	0.030	1.3
Fluoride	mg/L	0.55	NA	NA	4
Iron	mg/L	0.004	NA	1	NA
Mercury	mg/L	0.000011	0.0017	0.00091	0.00005
Potassium	mg/L	28	NA	NA	NA
Magnesium	mg/L	1	NA	NA	NA
Manganese	mg/L	0.1	NA	NA	NA
Nitrate	ppm as N	87	NA	NA	10
Sodium	mg/L	44	NA	NA	NA
Nickel[b]	mg/L	0.197	1.52	0.17	0.1
Phosphorus	mg/L	0.10	NA	NA	NA
Lead[b]	mg/L	0.092	0.48	0.019	0.015
Sulfate	mg/L	903	NA	NA	NA
Antimony	mg/L	0.023	NA	NA	0.0056
Selenium	mg/L	0.001	0.02	0.005	0.05
Silicon	mg/L	0.255	NA	NA	NA
Strontium	mg/L	4.22	NA	NA	4
Thallium	mg/L	0.009	NA	NA	0.00024
Uranium	mg/L	0.009	NA	NA	0.03

			Aquatic Life Standard	Aquatic Life Standard	Human Health Standard
		Model Prediction of PWP	Acute (MT DEQ-7)	Chronic (MT DEQ-7)	Surface Water (MT DEQ-7)
Zinc[b]	mg/L	0.258	0.39	0.39	7.4

Source: Enviromin 2017a

$CaCO_3$ = calcium carbonate; DEQ = Department of Environmental Quality; mg/L = milligrams per liter; Mn = manganese; MT = Montana; N = nitrogen; NA = not applicable; pH = potential hydrogen; ppm = parts per million; PWP = Process Water Pond; s.u. = standard units
Notes:
Acute standard defined as one-hour average concentration; Chronic standard is 96-hour average concentration
[a] Aluminum standard applicable for dissolved concentrations, with pH from 6.5 to 9.0 only
[b] Aquatic life standards are calculated based on hardness. With predicted solution hardness >400 mg/L, the standards are calculated with hardness = 400 mg/L, per guidance in DEQ-7
Prediction based on assumed 33 ppm from underground and WTP balance.
Supersaturated phases: alunite, $Ba_3(AsO_4)$, barite, jarosite
Results include precipitation of supersaturated phases and sorption.

Treated Water Storage Pond

There is a contingency to the water management plan that includes storage of treated water during the seasonal period when the total nitrogen standard for surface water of 0.3 mg/L is applicable (July 1 to September 30, for Middle Rockies Ecoregion). This proposed contingency includes the addition of a TWSP to the Project. The TWSP would store treated water from the WTP if the effluent from the WTP does not meet the seasonal effluent limits for total nitrogen in the MPDES permit (Zieg et al. 2018).

The proposed TWSP would be located southeast of the WTP and west of Brush Creek. The design of the TWSP was based on an average seasonal flow rate from the WTP of 405 gpm. The average seasonal flow rate is slightly larger than the average annual discharge due to minor differences in seasonal flows from Mill Catchment Runoff associated with the seasonal precipitation and evaporation at the site. The TWSP has been designed to store up to 53.7 million gallons of treated water to provide enough temporary storage of treated water from July 1 to September 30, at an average flow rate of 405 gpm. The pond would be lined with a 60-mil (0.06 inches) HDPE geomembrane liner installed over a 12 ounce per square yard non-woven geotextile cushion (Zieg et al. 2018).

Treated water from the WTP would be pumped through a 6-inch diameter HDPE pipeline to the TWSP for storage. From October 1st to June 30, treated water stored in the TWSP would be pumped back to the WTP via a 6-inch diameter HDPE pipeline, where it would be mixed with other WTP effluent. The blended water would be sampled prior to being discharged per the MPDES permit. The construction of the TWSP requires excavation of weathered bedrock and fractured and moderately weathered limestone and shale (Knight Piésold 2017). Based on geotechnical information (Knight Piésold 2017), excavated materials should be sufficient for use as embankment fill (Zieg et al. 2018).

The TWSP would be operational prior to dewatering the mine workings. This would allow for storage of water (if necessary) during the growing season while there is active dewatering of the underground workings during construction and operations. The pond would remain operational during closure, until the discharge to the UIG is discontinued. Once storage of treated water is not necessary, the TWSP liner would be removed and hauled off-site for disposal or recycling. Embankment material would be used to re-shape and reclaim the TWSP disturbance footprint. The footprint of the TWSP would be ripped to relieve compaction, the site regraded, soil placed, and the site seeded (Zieg et al. 2018).

Water Temperature Thermal Analysis Methods and Results

As part of the Proposed Action, the Proponent would discharge water from the NCWR and TWSP to creeks via UIG systems and direct discharge via the wet well. This section addresses concerns related to the thermal impact associated with the release of these waters. A summary of conservative thermal analyses conducted by the Proponent indicating the absence of significant temperature effects on creeks is outlined below.

The Proposed Action and AMA require the Proponent to conduct water temperature monitoring related to TWSP discharge. Thermal analyses conducted by the Proponent (Zieg 2019a, 2019b) and outlined below supports the determination of no significant temperature effects on streams.

<u>Non-Contact Water Reservoir</u>

Water output volume from the NCWR as allocated by Zieg (2019a) consists of the following pathways.

- Direct discharge to Sheep Creek (October through April) via the wet well. This represents the most significant NCWR output volume, ranging between 114 gpm in November to 136 gpm in April.
- Seepage to Little Sheep Creek (year-round). Discharge from the NCWR as seepage to groundwater would occur beneath the reservoir. This seepage would migrate as groundwater approximately 1 mile prior to entering Little Sheep Creek more than a mile before its confluence with Sheep Creek, and would represent a limited contribution to the total flow in Sheep Creek (seepage output volume is estimated to range between 5 gpm in April to 24 gpm in July). This contribution is not expected to have a detectable influence on Sheep Creek’s water temperature.
- Discharge to Coon Creek (year-round). This represents the second most significant NCWR output volume, and remains steady year-round at approximately 70 gpm. The water transfer from the NCWR is proposed via buried pipeline to a UIG adjacent to Coon Creek, which would allow for temperature equilibration in the subsurface prior to the water entering Coon Creek. Any temperature increase in Coon Creek would not significantly affect Sheep Creek’s water temperature because Coon Creek base flow amounts to only 1 percent of base flow in Sheep Creek.

- Discharge to Black Butte Creek (May through September), also via a UIG. Although the need to augment losses in Black Butte Creek base flow as a result of mine-dewatering is unlikely, NCWR water (45 gpm) has been allocated in Zieg (2019a). The groundwater model simulations estimate a loss of base flow between 3 and 4 percent of Black Butte Creek steady-state base flow, which is less than the ±15 percent change in base flow allowed per non-degradation threshold criterion (ARM 17.30.715).
- NCWR evaporation (April through October). This output volume ranges between 9 gpm in April to 43 gpm in July.

Future monthly NCWR water temperatures were estimated using Newton's Law of cooling and mass flow equations to calculate (1) the total heat transferred into the reservoir in May and June using an overall heat transfer coefficient, (2) the average area of the reservoir (average of previous and current months), (3) the average temperature of the creek water coming into the reservoir (at station SW-1), and (4) the average site ambient air temperature. The heat transfer coefficient accounts for heat lost by long-wave radiation, convection, and evaporation less the heat gained by short-wave radiation (Williams 1963). The NCWR temperature was estimated July through April using similar methods; however, since the discharge to the reservoir would be small (estimated as 106 gpm during July through September [Zieg 2019a]) compared to the total volume, discharge to the reservoir was not considered during these months. Known factors, inputs, and assumptions are outlined in a July 25, 2019, technical memorandum (Zieg 2019a).

Results indicate that water temperature in the NCWR would be greater than in Sheep Creek during the following 5 months: May (Mean Creek temperature 41.6 °F vs. NCWR water temperature 41.8 °F), June (Mean Creek temperature 49.6 °F vs. NCWR water temperature 49.7 °F), August (Mean Creek temperature 53.2 °F vs. NCWR water temperature 54.7 °F), September (Mean Creek temperature 46.9 °F vs. NCWR water temperature 51.9 °F) and October (Mean Creek temperature 39.7 °F vs. NCWR water temperature 51 °F). Of these 5 months during which NCWR water temperature exceeds Sheep Creek water temperature, the Proponent only proposes to transfer water from the NCWR to Sheep Creek via the wet well during the month of October (Zieg 2019a). Mixing analysis shows that the NCWR discharge to Sheep Creek would only increase the temperature in Sheep Creek during the month of October, and the increase would be about 0.5 °F (Hydrometrics, Inc. 2019), which is less than the 1 degree change allowed for per ARM 17.30.623(2)(e).

Direct discharges via the wet well from the NCWR to Sheep Creek during May to September are not proposed. Seepage from the reservoir (estimated to range from 22 to 26 gpm during summer months) would migrate to Little Sheep Creek via subsurface (groundwater) flow and is expected to equilibrate with ground temperatures prior to entering surface water; therefore, this seepage is not expected to have a detectable influence on the creek's water temperature. Water transfers from the NCWR to Coon Creek and Black Butte Creek are expected to equilibrate with groundwater temperatures as a result of (1) flow through buried pipelines and (2) equilibration with subsurface temperatures following discharge to UIGs.

The Proponent would be required to monitor water temperature in the NCWR and in the water leaving the facility. In the unlikely scenario that transfers of water from the NCWR would cause water temperatures to fall outside regulatory criteria, the Proponent would be required to implement engineering controls such as changing the depth the water is pulled from the NCWR. Changing the depth that NCWR water is pulled from represents a highly effective engineering control allowing for access to deeper, colder water. As long as depletion of water in the NCWR is insignificant, discharge of NCWR water would not result in rising creek temperature.

Treated Water Storage Pond

The rate at which the Project would discharge water to the alluvial aquifer represents a small percentage of Sheep Creek's total discharge. In addition, water discharged via the UIG would migrate through the alluvial aquifer for some distance before discharging to the creek. During that migration, the UIG injected water would equilibrate with ambient groundwater and be influenced by the temperature of the sediments, which generally retain or approach the mean annual surface air temperature year-round. As a result, the difference in temperature between the discharge water and groundwater would decrease.

Regardless, future monthly TWSP water temperatures were estimated by calculating the total heat transferred into the pond for July, August, and September using (1) an overall heat transfer coefficient, (2) the average area of the pond, (3) the average temperature of groundwater being pumped into the reservoir following treatment, and (4) the average site ambient air temperature. The heat transfer coefficient accounts for heat lost by long-wave radiation, convection, and evaporation less the heat gained by short-wave radiation (Williams 1963). The end of the month temperature difference was calculated by dividing the total heat energy in the reservoir. The estimated temperature was calculated by subtracting the temperature difference by the temperature of the incoming water. For all other months (October through June), the TWSP temperature was calculated using the previous month's calculated TWSP water temperature. Known factors, inputs, and assumptions are outlined in an August 1, 2019, technical memorandum (Zieg 2019b).

Results indicate that water temperatures in the TWSP would be lower than the projected maximum allowable temperature for water being discharged to the UIG for all months except October and November. The thermal analysis does not account for equilibration with ambient subsurface temperature during seepage through the alluvial sediments after discharge. Water discharged via the UIG would migrate through the alluvial aquifer for some distance before discharging to the creek. The discharge would be governed by an MPDES permit. The rate at which the Project would discharge water to the alluvial aquifer represents a small percentage of Sheep Creek's total discharge. Thermal analyses conducted by the Proponent (Zieg 2019b) and outlined below supports the determination of no significant temperature effects on streams.

The higher water temperatures introduced by discharge from the TWSP in October and November are expected to be rapidly attenuated. For example, temperature differences between TWSP discharge and the projected maximum allowable temperature in the UIG is 1.5 °F in October and 3.6 °F in November (Zieg 2019b). With consideration for the analyses, it is unlikely there would be thermal impacts as a result of discharging the TWSP water.

The Proponent would be required to monitor water temperature in the TWSP discharge and at the stream monitoring sites. If water temperatures fall outside regulatory criteria, the Proponent would be required to implement engineering controls, including but not limited to (1) changing the depth the water is pulled from the TWSP; (2) managing the combined flows from the TWSP and treated groundwater; and/or (3) installing heat exchange unit(s). These engineering controls would be sufficient to avoid any temperature-related adverse effects.

Engineering Control 1: Changing the depth that water is pulled from the TWSP

The Proponent plans to pull deeper water from the TWSP. As a result, water leaving the TWSP would consist of deeper, colder water. As long as depletion of water in the TWSP is insignificant, discharge of TWSP water would not result in rising creek temperature.

Engineering Control 2: Managing the combined flows from the TWSP and treated groundwater

Mixing TWSP water with water from the WTP represents another engineering control.

The WTP would receive water from the following main sources (Tintina 2018b Figure 3.44):

- Mill catchment runoff (at a rate of 13.1 gpm);
- Water from the foundation drain of the CTF (at a rate of 20 gpm); and
- Water pumped from the mine (at a rate of 499.7 gpm).

Most of the water received by the WTP would be groundwater pumped from the mine and delivered to the WTP via underground pipes. Temperature of that groundwater would be close to average annual air temperature, thereby regulating any seasonal temperature variation. Subsequently, water temperature leaving the WTP is not expected to be significantly higher than the water pumped from the mine. Mixing TWSP water with WTP water at the appropriate proportion may allow for controlling the temperature of the water discharged to the Sheep Creek UIG, such that instream temperatures are not altered. Prior to discharge, the blended water would be sampled/monitored as required in the MPDES permit.

Engineering Control 3: Installing heat exchange units

If engineering controls 1 and 2 outlined above are insufficient to prevent thermal impacts to Sheep Creek, heat exchange units may be installed. Heat exchange units are used to move heat from one medium where it is readily available to another medium that can accept it. Here, routing TWSP water through a refrigeration circuit is proposed. During this process, energy is absorbed from the refrigerant (i.e., TWSP water), thereby lowering the water temperature as needed to comply with set average monthly and maximum daily temperature changes as outlined in the MPDES permit.

Underground Infiltration Gallery

Water not used in the milling or mining process would be treated and discharged back to the groundwater system using an alluvial UIG. As specified in the MOP Application (Tintina 2017), all water would be treated by RO to meet applicable non-degradation standards (Amec Foster Wheeler 2017) prior to discharge via the UIG (Hydrometrics, Inc. 2017b).

It is assumed that all water discharged to the alluvial outfalls would eventually be transported downgradient to discharge to Sheep Creek and Coon Creek. Therefore, based on the operational potentiometric surface there are three different receiving waters that treated water would be discharged to: Sheep Creek alluvial aquifer, Sheep Creek and Coon Creek surface water. Water quality data and statistical analyses for each receiving water through 2016 are included in Appendix G of the integrated discharge permit application narrative (Hydrometrics, Inc. 2018c). The combined impact of treated discharge mixing with the alluvial UIG, and subsequently with Coon Creek and Sheep Creek would be monitored at SW-1.

The Sheep Creek alluvial UIG (Outfall 001) would discharge directly to the Sheep Creek alluvium. The water quality of the Sheep Creek alluvial system is characterized by results from monitoring conducted at monitoring well MW-4A (Figure 3.2 of the integrated discharge permit application narrative [Hydrometrics, Inc. 2018c]). Water in the Sheep Creek alluvium has near neutral pH with low to non-detectable concentration of dissolved metals. Regarding aluminum, DEQ has ensured that non-degradation limits are in the MPDES permit. As a result, there would be no decline in water quality for aluminum caused by the discharge. Regardless, as noted in Appendix V-1 of the MOP Application (Hydrometrics, Inc. 2017b) and Table 3-3 of the Integrated Discharge Permit Narrative, aluminum concentrations in the discharge water are projected to be less than 0.001 mg/L.

It was originally assumed that nearly all water that is discharged to the alluvial UIG would eventually discharge to Sheep Creek near the downgradient end (north end of the Project permit boundary area) of the Sheep Creek Valley where the alluvial system is pinched out at the canyon north of the Project site. However, due to groundwater mounding, there is potential for discharge to Coon Creek as well, which discharges into Sheep Creek. Additional monitoring would be implemented on Upper Coon Creek as described in Section 6 of the MOP Application (Tintina 2017). Water quality of Sheep Creek in the vicinity of the Project is best characterized by the ongoing monthly monitoring at site SW-1. Sheep Creek surface water is a calcium/magnesium bicarbonate type water with low to moderate dissolved solids. Chronic aquatic criteria for dissolved aluminum (0.087 mg/L) is often exceeded during periods of high runoff in Sheep Creek. Nutrients are relatively low, with total nitrogen (persulfate method) being below the nutrient criteria during the summer months (less than 0.04 to 0.15 mg/L).

Water treated with RO would contain very low levels of dissolved solids, giving the water a potential to dissolve elements from sediment similar to that of rainwater. To reduce the potential for RO permeate to leach, the water would be buffered by routing it through a calcium carbonate filter, which would give the effluent an alkalinity similar to that of the receiving groundwater. Given the relatively low reactive mass, and the larger volume of discharged water, the predicted solute concentrations are low. As shown in **Table 3.5-10**, the predicted water quality meets non-degradation criteria for both groundwater and surface water settings. Water discharged to the UIG following RO treatment is thus expected to meet both surface and groundwater non-degradation standards under all cases and in all sensitivity scenarios (Hydrometrics, Inc. 2017b).

However, if the total nitrogen concentration is greater than the effluent limit, the treated water would be discharged to the TWSP from July 1 to September 30. Starting October 1, the stored water would be routed back to the WTP and blended with the WTP effluent prior to discharge. Prior to discharge, the blended water would be sampled/monitored as required in the MPDES permit. The only anticipated impact on groundwater in the vicinity of the UIG is dilution by the discharged water resulting in somewhat improved water quality.

Wet Well Diversion

Tintina submitted a Water Right Application Package to the DNRC on September 7, 2018. This package included applications for a new groundwater beneficial use permit for water put to beneficial use in the mining and milling process, a new high-flow season surface water beneficial use permit and six change applications. The new high-flow season surface water beneficial use permit and six change applications would be used to mitigate potential adverse impacts from the consumptive use of groundwater in the mining and milling process and mitigate potential secondary impacts to wetlands. A portion of the mitigation water would be stored in the NCWR. Water stored in the NCWR would be diverted from Sheep Creek through a wet well adjacent to the creek and transferred to the reservoir through a pipeline up to the NCWR (Zieg et al. 2018).

Table 3.5-10
Results of the Proposed Action Water Quality Predictions

	pH s.u.	Sulfate mg/L	Alkalinity mg/L $CaCO_3$	Parameters > MT Groundwater Standards	Metals >MT Non-degradation Criteria
Underground Workings					
Year 6 operations	6.67	304	183	Nitrate, strontium, thallium and uranium	Nitrate
Post-closure	6.79	120	145	Thallium	None
WRS	5.80	2,212	24	Nitrate, strontium and thallium	a
CTF					
Year 6 tailings	4.13	765	97	Nitrate, arsenic, beryllium, copper, nickel, lead, antimony, and thallium	a
Closure	4.95	90	53	Nitrate and thallium	a
PWP	5.81	903	205	Nitrate, arsenic, copper, nickel, lead, antimony, strontium and thallium	a
UIG	8.1	0.16	100.3	None	None

$CaCO_3$ = calcium carbonate; CTF = Cemented Tailings Facility; mg/L = milligrams per liter; MT = Montana; PWP = Process Water Pond; s.u. = standard units; UIG = Underground Infiltration Gallery; WRS = Waste Rock Storage
Notes:
a = Collected water treated by RO to meet non-degradation standards

The majority of the water stored in the NCWR would typically be from the new high season flow surface water right. The high season flow diversion would occur in the months of May through July when flows are greater than 84 cfs, which is equal to the total flow of the appropriated water rights on Sheep Creek downstream of the diversion. The point of diversion would be located approximately 60 feet west of the private road in the hay meadow adjacent to Sheep Creek. The point of diversion would include a wet well that consists of an 8-foot concrete manhole, which is connected to Sheep Creek through a 22-inch HDPE intake pipe. The intake pipe would be extended approximately 6.5 feet into Sheep Creek and be placed on the streambed. The pipe would be equipped with a fish screen over the intake section. The remainder of the intake pipeline would be solid pipe buried beneath the ground surface at an elevation equal to or slightly below the streambed elevation (Zieg et al. 2018).

When the flow in Sheep Creek exceeds 84 cfs, water would be pumped from the wet well, using a vertical turbine pump, through approximately 7,150 feet of 20-inch HDPE transfer pipeline to the NCWR. The transfer pipeline would be placed on the ground surface along the access road within the hay meadow and would remain on surface except where it crosses the Sheep Creek County Road 119. The pipeline would cross Brush Creek in an area with narrow wetland fringe areas and would be suspended above the wetlands and stream channel (Zieg et al. 2018).

The NCWR would be used for mitigation of depletion in surface waters during operations and for approximately 20 years after the end of mine dewatering (Hydrometrics, Inc. 2018e). Once the flow mitigation system is unnecessary, the wet well, intake pipeline, and transfer pipeline to the NCWR would be removed and reclaimed. Reclamation would include removal of all non-native materials (pipelines, concrete structure, and fill material). Excavations would be filled with sand and gravel material to within one foot below grade. The disturbed land would be covered with up to 1 foot of topsoil and seeded with a pasture grass seed mix, similar to the current vegetation in the hay meadow, and as approved by the landowner (Zieg et al. 2018).

Impact Assessment

No impacts on the receiving waters (Sheep Creek and Coon Creek) are anticipated since water from all facilities would be collected and treated to meet non-degradation criteria prior to discharge to the alluvial UIG (Hydrometrics, Inc. 2017b). A 30:1 dilution of the solute concentrations in the original source water is anticipated as a result of mixing with groundwater (Section 3.4). Further dilution occurs when the mixed source water and groundwater reaches Sheep Creek and Coon Creek. Total nitrogen predictions for the receiving environment (75^{th} percentile) are less than 0.12 mg/L for both Sheep Creek and Coon Creek (Hydrometrics, Inc. 2018c), which is below the total nitrogen seasonal standard of 0.3 mg/L prescribed in the Montana Numeric Water Quality Standards, Circular DEQ-12A (DEQ 2014). However, the MPDES seasonal effluent limit on total nitrogen is based on the non-degradation standard (0.09 mg/L). Hence, there is need for a TWSP as there is no assimilative capacity in the creeks during the July through September period.

Within the estimated 2 to 4 years of closure and reclamation after the end of operations, underground mine openings would be flooded/rinsed with RO permeate (treated water), and the contact water would then be pumped to the WTP. Groundwater non-degradation criteria within the mine openings are expected to be achieved after repeated flooding/rinsing, which may take between six to ten cycles. Until that time (estimated to take 7 to 13 months), water from the underground workings would continue to be captured and treated. The readily soluble minerals on mine surfaces would be removed by rinsing and when the mechanism for ARD (sulfide oxidation) is shut down by flooding and reducing oxygen exposure, thus minimal loads would be generated. Groundwater from the underground workings would not be treated after the final closure (i.e., once non-degradation criteria are met).

A summary of the Project's impact on surface water quality based on severity and likelihood ratings is presented in **Table 3.5-11**.

Smith River Assessment

Smith River is located approximately 19 river miles downstream of the Project and is the receiving water for Sheep Creek.

As discussed in the previous section, potential Project impacts on Sheep Creek and Coon Creek water quality would be minimal and associated with treated water discharged to the Sheep Creek alluvial UIG. Water released to the UIG is expected to mix with groundwater and discharge to Sheep Creek and potentially Coon Creek, which discharges into Sheep Creek. Therefore Sheep Creek provides the only pathway of interaction for Project-related discharges to the Smith River. Big Butte Creek discharges to Sheep Creek downstream of SW-1 but is not anticipated to receive contact water from the Project. Several other tributaries merge with Sheep Creek downstream from the Project site before its confluence with the Smith River (e.g., Moose Creek, Indian Creek, Cameron Creek, and Calf Creek). As adverse impacts on Sheep Creek water quality due to the Proposed Action are not predicted, no measurable impacts on Smith River are anticipated.

The Smith River is included in DEQ's 303(d) list of impaired streams for temperature, total phosphorus, *E. coli*, substrate alterations, flow, and stream-side littoral vegetative cover. Agriculture and rangeland grazing are listed as potential sources for those constituents. Nuisance algae growth has been observed in the Smith River, which may be exacerbated by dynamic nutrient concentrations (total nitrogen and phosphorous).

In addition to the aluminum and *E. coli* impairments occurring in Sheep Creek and aluminum impairments in Moose Creek (see Section 3.5.2.2), other tributaries to the Smith River are included in DEQ's 303(d) list of impaired streams. These include Beaver Creek (chlorophyll-a, total nitrogen, total phosphorous, sedimentation), Benton Gulch (*E. coli)*, Camas Creek (*E. coli*), Elk Creek (total nitrogen), Hound Creek (chlorophyll-a, total nitrogen), Newlan Creek (*E. coli*, sedimentation), and Thompson Gulch (total nitrogen, sedimentation). The agricultural activities, rangeland grazing, grazing in riparian or shoreline zones, and irrigated crop production that impact surface water quality in the Smith River watershed are not associated with the Project and are likely to continue in the future.

Table 3.5-11
Project's Potential Consequences Regarding Surface Water Quality

Project Activities	Project Facilities	Notes
Mine Construction (Phases I and II; Project Years 1-4)	Underground mine facilities	Collected water treated by RO to meet non-degradation standards
	Waste rock Storage (WRS)	Collected water treated by RO to meet non-degradation standards
	Process Water Pond (PWP)	Collected water treated by RO to meet non-degradation standards
	Cemented Tailings Facility (CTF)	Collected water treated by RO to meet non-degradation standards
	Contact Water Pond (CWP)	Collected water treated by RO to meet non-degradation standards
	Treated Water Storage Pond (TWSP)	If the total nitrogen concentration is greater than the effluent limit, the treated water would be discharged to the TWSP from July 1 to September 30
	Underground Infiltration Gallery (UIG)	Collected water treated by RO to meet non-degradation standards
Mine Production (Phase III; Project Years 5 - 15)	Underground mine facilities	Collected water treated by RO to meet non-degradation standards
	Waste Rock Storage (WRS)	Collected water treated by RO to meet non-degradation standards
	Process Water Pond (PWP)	Collected water treated by RO to meet non-degradation standards
	Cemented Tailings Facility (CTF)	Collected water treated by RO to meet non-degradation standards
	Contact Water Pond (CWP)	Collected water treated by RO to meet non-degradation standards
	Treated Water Storage Pond (TWSP)	If the total nitrogen concentration is greater than the effluent limit, the treated water would be discharged to the TWSP from July 1 to September 30
	Underground Infiltration Gallery (UIG)	Collected water treated by RO to meet non-degradation standards
Post-Mine Period (Mine Closure; Phase IV)	Underground mine facilities	Collected water treated by RO to meet non-degradation standards
	Waste Rock Storage (WRS)	Collected water treated by RO to meet non-degradation standards
	Process Water Pond (PWP)	Collected water treated by RO to meet non-degradation standards
	Cemented Tailings Facility (CTF)	Collected water treated by RO to meet non-degradation standards
	Contact Water Pond (CWP)	Collected water treated by RO to meet non-degradation standards
	Treated Water Storage Pond (TWSP)	If the total nitrogen concentration is greater than the effluent limit, the treated water would be discharged to the TWSP from July 1 to September 30
	Underground Infiltration Gallery (UIG)	Collected water treated by RO to meet non-degradation standards

Project Activities	Project Facilities	Notes
Post-Mine Period (Post-Closure; Phase V)	Underground mine facilities	Flooded underground with section of ramp exposed above water table Thallium exceeds the Montana Numeric Water Quality Standards
	Waste Rock Storage (WRS)	Decommissioned
	Process Water Pond (PWP)	Decommissioned
	Cemented Tailings Facility (CTF)	Decommissioned
	Contact Water Pond (CWP)	Decommissioned
	Underground Infiltration Gallery (UIG)	No water treatment, no discharge to UIGs

RO = reverse osmosis

Agency Modified Alternative

The intent of the AMA is to backfill all zones of the underground mine workings that contain significant sulfide mineralization. This plan also serves to increase the underground placement of cemented paste tailings. As such, the AMA proposes to backfill more of the USZ underground workings at closure, including 11,352 feet in the primary and secondary access drifts; 361 feet in the main access decline; and 2,526 feet of stopes in the USZ that were previously not planned to be backfilled. In the LSZ, an additional 1,148 feet of previously unfilled stopes and 4,446 feet of main access decline are proposed to be backfilled (Zieg et al. 2018).

The Proposed Action represents a greater increase in dissolved constituents than the AMA, but still falls within range of results reported for the original sensitivity analyses. The reactive surface area of the underground workings in the AMA (169,887 square feet) is approximately 30 percent less than the 240,606 square feet of reactive surface area for the Proposed Action, and would have lower potential for solute release. This suggests that the adoption of the AMA would improve water quality as a result of the reduced area of the underground workings that is in contact with water. Furthermore, backfilling the open mining stopes would potentially improve the geotechnical stability of the walls, which could otherwise crumble over time and expose additional reactive surface area (Zieg et al. 2018).

Smith River Assessment

The impacts of the AMA on water quality in the Smith River would be similar to that described for the Proposed Action Alternative. As described previously based on the Proposed Action description, impacts on surface water quality in Sheep Creek are expected to be negligible to minor, and therefore potential impacts on water quality in the Smith River would be negligible.