POLYMET
MINING

Permit to Mine Application

NorthMet Project

December 2017

- ***Category 3 Waste Rock:*** Duluth Complex waste rock that has a sulfur content of greater than 0.31% and less than or equal to 0.6%.
- ***Category 4 Waste Rock:*** Duluth Complex waste rock that has a sulfur content of greater than 0.6% and all Virginia formation waste rock.

Waste Water Treatment System (WWTS): the two sets of treatment trains, formerly consisting of the Waste Water Treatment Facility (WWTF) at the Mine Site and the Waste Water Treatment Plant (WWTP) at the Plant Site, that were previously at two locations and would now be housed under one roof at the Plant Site and all associated structures. These treatment trains have been combined to increase efficiency and to allow greater operational flexibility and improvement through the adaptive water management process. While the overall system includes all associated structures, this acronym is specifically used to refer to the building that houses the treatment equipment, which is the primary component of the overall treatment system.

***West Pit discharge*:** discharge from the West Pit after closure to an unnamed tributary to the Partridge River.

Significant effort has been made to evaluate potential FTB dam design options, including modifying bench widths and slopes, with the most probable dam design being provided in the Dam Safety Permit application. Material strengths, porewater pressure, and beach width have been established as part of this design and then varied by performing sensitivity analyses or by evaluating different hydraulic loading conditions to confirm resilience of the design. These design parameters will continue to be reviewed as additional data are obtained throughout the development of the FTB and, in accordance with the Observational Method, the engineering models will be refined, and subsequent design, construction, and operation of the FTB adjusted if needed to maintain specified factors of safety.

The Observational Method employs sequences of data gathering, detailed calculations and performance predictions, additional data gathering and observations, and design modifications as needed to maintain required operating conditions at the Tailings Basin. First, the engineer uses available information to prepare an initial concept and design that will predict the behavior of the basin. As the stages of construction progress, the engineer monitors and tests the site to obtain more detailed information. The predicted behavior is then compared with the measured behavior, enabling the engineer to revise the original predictions. Repeating this process leads to successive refinements in FTB dam design and construction. Tailing basin dams are typically built in stages, thus the Observational Method to design is well suited for minimizing risk.

The planned instrumentation for the FTB dams will monitor changes in water levels and pressure head within the dams, as well as for potential deformation of the slopes, based on modeled behavior. The Contingency Action Plan included with the Dam Safety Permit application will guide the initial response to any unexpected conditions, including unanticipated seepage or slope movement.

If updated stability models project that the planned or constructed FTB dams may not meet required factors of safety, adaptive management actions will include some or all of the following:

- Reconfirm the geometry of previously constructed segments of the FTB dams.
- Initiate any field and/or laboratory studies that may be necessary to update material strength parameters and/or phreatic surface data.
- Update stability modeling using as-built dimensions and in-field and/or in the laboratory (as applicable) data gathering.
- Estimate the effects of potential operational changes such as adjusting tailings deposition procedures to modify beach width or modifying the pond elevation to modify phreatic surface conditions within the dam.
- If operational changes (such as change to slurry density, change to dam lift timing, modified pond operations) can achieve the required factors of safety, implement those changes.
- If stability modeling indicates that operational changes or adaptive engineering controls cannot achieve the required factors of safety, implement contingency mitigations to restore required

factors of safety. Contingency mitigations are outlined in Section 6.4 of Appendix 11.5) and summarized below.

- Continue monitoring and/or modeling to estimate dam stability effects with new or adjusted engineering controls.
- If issues reoccur, reinitiate the adaptive management sequence summarized above as appropriate.

FTB dam slope stability contingency mitigations are available if monitoring or the refined model estimates show that, with operational changes, the FTB dams may not meet required factors of safety. In general, stability can be modified by:

- modifying buttressing to modify resisting force at the toe of the FTB
- adjusting the overall slope angle of future lifts to modify driving force at the toe
- adjusting bench widths of future dam lifts
- adjusting future dam lift offsets
- adjusting future dam lift heights and/or rate of construction
- including free-draining underdrain layers or drains to reduce the phreatic surface in the FTB dams

If drain installation were required after the development of the Tailings Basin dams, the drains would typically be installed using horizontal drilling to install drain casing and drainage media. This technique is applied to various drainage projects such as to natural slopes, railroad embankments, and tailings dams.

The contingency mitigation measures listed above can be implemented individually or in combinations as needed to achieve the required mitigation outcomes.

Actions associated with contingency mitigation do not necessarily apply to unexpected and potentially hazardous conditions threatening the integrity and performance of the FTB. These conditions are addressed in the FTB Contingency Action Plan, which is Attachment F to the Flotation Tailings Basin Management Plan (Appendix 11.5). The purpose of the FTB Contingency Action Plan is to define responsibilities and provide procedures for identifying and responding to unexpected and potentially hazardous conditions threatening the integrity and performance of the FTB.

PolyMet will develop an overall Project-wide Emergency Action Plan, into which the FTB Contingency Action Plan will be incorporated. The Emergency Action Plan will be prepared when Project construction is nearly complete and permanent staffing has been established, at which time content and delegation of responsibilities will be established. The Emergency Action Plan is not a regulatory document. Rather, it is for the use and safety of operations personnel in the event of unexpected emergencies and will be a compilation of plans such as, but not limited to: FTB Contingency Action Plan, Spill Prevention Control and Countermeasures Plan, Severe Weather Response Plan, and Emergency Notification and Evacuation Plan. Environmental insurance will also be obtained for the Project.

- minimizing ongoing seepage to the environment from the LTVSMC tailings basin and the potential for future seepage from the FTB by installing seepage capture systems
- maximizing subaqueous disposal of tailings to minimize oxidation and potential water quality impacts from the Tailings Basin

To design the FTB and the FTB dams, PolyMet engaged independent professional engineers from Barr, registered in the state of Minnesota who are proficient in the design, construction, operation, and reclamation of tailings basins, dams, and reactive mine waste disposal facilities. Independent professional engineers Dr. Scott Olson and Mr. Richard Davidson, proficient in the applicable subject matter, also assisted in portions of FTB dam design. Appendix 1.10 contains documentation demonstrating the experience of these engineers in this regard. The FTB design process evaluated alternative dam construction and tailing-disposal methods. The selected dam design uses the upstream construction method with existing LTVSMC coarse tailings forming the exterior shell of the dam. The LTVSMC tailings that will underlie the FTB are of suitable strength as a foundation for subsequent dam raises, and are sufficiently permeable to minimize phreatic water level increases within the dams.

The following sections provide an overview of the FTB design requirements and overall design plans.

10.2.3.1 Storage Volume

PolyMet will generate approximately 11.3 million short tons of Flotation Tailings annually (approximately 10.3 million in-place cubic yards annually) for an estimated cumulative total of 225 million short tons (approximately 207 million in-place cubic yards). Table 10-7 and Figure 10-2 present stage-storage calculations and relationships for the FTB design. Table 10-7 presents these relationships relative to the total dam raise increments of 20 feet for Lifts 1 through 7 and 10 feet for Lift 8. Table 10-2 presents a graph of cumulative FTB capacity versus tailings elevation. The permit application support drawing set contained in Appendix 6 contains the layout plan and design of the FTB.

10.2.3.2 Geotechnical Stability

PolyMet will construct and operate the FTB in a manner that is estimated to achieve desired slope stability factors of safety, and in turn, immediate and long-term stability. Achieving the desired factors of safety is an iterative design process wherein the geometry of the dam, the seepage conditions within the dam, and the material characteristics of the dam foundation, the dam, and the tailings are analyzed in concert to arrive at a dam configuration of adequate stability. The design of the FTB dams is based on seepage and slope stability analyses of:

- the existing LTVSMC tailings basin
- the Tailings Basin with the FTB dams at maximum height
- the Tailings Basin with the FTB dams during construction
- the Tailings Basin with the FTB dams subject to various potential liquefaction triggering events

- a flow liquefaction worst case scenario
- the Tailings Basin with the FTB dams during closure and postclosure maintenance

Data used in these analyses, the methods used for seepage and stability modeling, the approach for selection of material strength design parameters, and modeling outcomes are presented in Reference (45).

The stability modeling determined that PolyMet's proposed Tailings Basin design meets required factors of safety for all expected conditions:

- existing conditions at the LTVSMC tailings basin (before the FTB is constructed)
- interim conditions (while the FTB is under construction), with planned operating conditions
- maximum height, with planned operating conditions of the Tailings Basin
- maximum height, with planned closure and postclosure maintenance conditions of the Tailings Basin

PolyMet's modeling also determined that the proposed Tailings Basin design meets required factors of safety for a series of possible, but increasingly less likely, conditions:

- maximum height, with a plugged drain, a rapid load, or erosion
- maximum height, with an unknown triggering event causing all contractive materials to liquefy
- maximum height, with a seismic event

To assess how these results might be affected by uncertainty and variability in the soil strength values, a sensitivity analysis was conducted. Sensitivity analysis results show the following:

- the likelihood that the factor of safety (FOS) is less than the required value when the dam is at maximum height, under normal operating conditions, is 0%
- cumulative probability that the FOS is less than the required value when the dam is at maximum height, with an unknown triggering event causing all contractive materials to liquefy, is less than 2%
- it is orders of magnitude more probable that the required FOS will be above the required value than it is that a dam failure will occur

Slope stability analyses were carried out for critical dam cross-sections (F, G, and N) shown on Figure 10-3, Figure 10-4, and Figure 10-5, respectively, with stratigraphy or soil profiles interpreted from boring information. Table 10-8 provides a summary of slope stability safety factors computed for each component of the stability analysis.

PolyMet will configure the FTB dams to have a FOS equal to or greater than 1.3 for undrained shear strength stability analysis of yield ($USSA_{yield}$) conditions and equal to or greater than 1.5 for effective strength stability analysis (ESSA) conditions. The FTB dam designs have an overall FOS equal to or greater than 1.1 for the worst-case fully liquefied shear strength analysis of liquefaction ($USSA_{liq}$) baseline case (at end of operations). To achieve stability required for the worst-case $USSA_{liq}$ condition, PolyMet incorporated a toe-of-dam buttress, underdrain, and mid-slope setback into the dam design; these are all common design features used for modifying dam stability.

Finally, during construction of FTB dams, PolyMet will amend the exterior face of the dams with a bentonite layer. As shown on Drawing FTB-024 provided in Appendix 6, the bentonite layer will limit oxygen infiltration into the contained Flotation Tailings. The amendment will also reduce rainwater infiltration into the dams, which has a benefit in terms of increased slope stability safety factor. The QA/QC plan for bentonite layer construction will be prepared following completion of the work outlined in the Template for Pilot/Field Testing of Bentonite Amendment of Tailings, provided as Attachment I of Appendix 11.5, which was also part of the Dam Safety Permit Application.

10.2.3.3 Freeboard Requirements

The FTB design incorporates the freeboard required for the FTB to safely accommodate precipitation events without overtopping the dams. PolyMet conducted a hydrology study to determine the water (pond) level bounce (increase in stage due to flood flow or storm event) in the FTB Pond during the probable maximum precipitation (PMP), 1/3 PMP, and 2/3 PMP events. The hydrology study report is included as Attachment C of the Flotation Tailings Management Plan (Appendix 11.5). The elevation difference between the maximum pond elevation and planned dam elevation will yield freeboard ranging from 5.25 feet (for full PMP) to 26.5 feet (for 1/3 PMP) on the basis of the assumed starting water level elevations. PolyMet will manage the water level so that minimum freeboard, (i.e., 5.25 feet) will not be exceeded during operation. This would mean there would not be a need for an emergency overflow unless there was a rainfall greater than a 35-inch rainfall in 72 hours.

The probability of a PMP event occurring during Project operations and reclamation is low. The PMP utilized for analysis of FTB freeboard requirements, which represents approximately 35 to 38 inches of rainfall in a 72-hour event for the FTB over the 20-year mine life, does not have an assigned return period, but has been estimated to range from 100,000 to 1 billion years (Reference (46)). The 1/3 PMP event represents approximately 11.7 to 12.7 inches, and the 2/3 PMP event represents approximately 23.3 to 25.3 inches for the FTB over the 20-year mine life. These values are dependent on the location and area of land considered and are specific to the area covered by the FTB, which is why a range is provided for each rainfall event. Hence, despite the fact that pond elevations cannot be quickly adjusted in anticipation of a PMP event and elevations may vary from those used for the pond bounce computations, the probability of an emergency discharge occurring during the 20-year operating life of the FTB and prior to the cessation of WWTS operations is very low. However, an emergency overflow channel is incorporated into the dam design in the event that a partial to full PMP event does occur.

Table 10-8 Summary of Slope Stability Analyses for FTB Dams

Cross-Section Location	Cross-Section F			Cross-Section G			Cross-Section N		
Case	USSA yield	ESSA	USSA liquefied	USSA yield	ESSA	USSA liquefied	USSA yield	ESSA	USSA liquefied
Target Factor of Safety	1.3	1.5	1.1	1.3	1.5	1.1	1.3	1.5	1.1
Design Scenario - Steady Stage Seepage									
Existing Conditions	--	1.83	--	--	2.21	--	--	3.11	--
Interim Lift 2	2.26	3.72	--	2.29	3.30	--	--	--	--
Interim Lift 4	1.96	3.72	--	1.95	3.29	--	--	--	--
Interim Lift 6	1.97	3.73	--	1.95	3.29	--	1.88	4.43	--
Lift 8 w/ Normal Pool	1.84	3.72	--	1.86	3.29	--	2.00	4.58	--
Lift 8 w/ PMP Event	1.82	3.67	--	1.85	3.29	--	1.91	4.34	--
Long-Term Stability - Steady State Seepage									
End of Operation	--	3.72	--	--	--	--	--	--	--
20 Years after Closure	--	3.89	--	--	--	--	--	--	--
200 Years after Closure	--	3.86	--	--	--	--	--	--	--
2000 Years after Closure	--	3.87	--	--	--	--	--	--	--
Liquefaction Triggering Analysis									
Baseline	2.13	--	--	--	--	--	--	--	--
Plugged Drain Lift 1	1.91	--	--	--	--	--	--	--	--
Lift 1 Rapid Loading	--	--	1.78	--	--	--	--	--	--
Erosion[1]	1.07	--	--	--	--	--	--	--	--
Plugged Drain Lift 8	2.12	--	--	--	--	--	--	--	--

Cross-Section Location	Cross-Section F			Cross-Section G			Cross-Section N		
Case	USSA yield	ESSA	USSA liquefied	USSA yield	ESSA	USSA liquefied	USSA yield	ESSA	USSA liquefied
Fully Liquefied with Unknown Trigger									
Operation Lift 8	--	--	1.10	--	--	1.10	--	--	1.16
20 Years after Closure	--	--	1.32	--	--	--	--	--	--
200 Years after Closure	--	--	1.68	--	--	--	--	--	--
2000 Years after Closure	--	--	1.74	--	--	--	--	--	--

Notes:
[1] Simplified analysis approach used in Geotechnical Data Package – Vol. 1 – Ver. 8; detailed analysis approach yields FOS >1.10.
Abbreviations:
ESSA = Effective Stress Stability Analysis
FTB = Flotation Tailings Basin
PMP = probable maximum precipitation
USSA = Undrained Strength Stability Analysis
Source: Adapted from Reference (45)

review. Test projects have also been discussed between PolyMet and the DNR for the FTB Pond Bottom Cover System and the Category 1 Waste Rock Stockpile Cover System. Work plans for these two test projects will be submitted to DNR for review and approval during operations prior to implementation.

15.8 Plans to Transition from Mechanical to Non-Mechanical Water Treatment

An important objective of the Project is to provide water treatment for as long as necessary to meet applicable regulatory standards at groundwater and surface water compliance points. The Project includes long-term mechanical treatment at the WWTS with a goal of transitioning to a non-mechanical treatment technology requiring less maintenance over the long term. This goal is consistent with the closure and postclosure maintenance requirements of the PTM Regulations, including the regulatory goals of minimizing and eventually eliminating the need for maintenance.

This Section 15.8 provides PolyMet's plan for transitioning from mechanical water treatment to non-mechanical treatment technologies after the 20-year mine life. PolyMet plans to transition from mechanical to non-mechanical water treatment as soon as PolyMet can demonstrate that non-mechanical water treatment technologies will effectively treat water to meet the applicable water quality standards. PolyMet will conduct evaluations, including data collection and pilot-studies, during the mine operations and after operations cease to demonstrate the ability to transition to non-mechanical water treatment while maintaining compliance with applicable water quality standards. As described in Section 6.0 of Appendix 11.4, PolyMet's evaluation of non-mechanical treatment systems will include several components of the Project, including the Category 1 Stockpile Groundwater Containment System, West Pit overflow, FTB seepage capture systems, and FTB Closure Overflow (post-mechanical treatment options).

Non-mechanical water treatment technologies are proven methods of water treatment, but they need to be tailored to site-specific conditions, principally those relating to water quality. Non-mechanical water treatment technologies can be thoroughly evaluated in four steps: (1) collecting site-specific information (e.g., hydrology and influent water quality), (2) laboratory testing, (3) pilot-scale-testing, and (4) designing a system for full-scale implementation.

PolyMet to date has collected and analyzed site-specific water quality data. It also has conducted extensive modeling with respect to the anticipated performance of the Project's pollution control systems, including the Tailings Basin and the associated seepage capture systems, the WWTS, and various liners and covers to prevent groundwater infiltration and surface water runoff of constituents of concern. Subject to review and approval by the DNR, PolyMet plans to undertake a number of additional data collection and analyses during operations, such as those summarized below.

At the Tailings Basin, additional site-specific hydrologic information will be collected when the FTB Seepage Containment System is constructed and throughout operations. Also, near the end of the operations phase, the observed water quality at the toe of the basin will provide insight as to the long-term water quality expected at the Tailings Basin related to PolyMet's operation. Thus, the four steps for

evaluating non-mechanical water treatment at the Tailings Basin will be implemented during Project operations, potentially allowing the non-mechanical water treatment system at the Tailings Basin to be put in place shortly after operations are complete and the FTB pond bottom cover is installed. If the transition to non-mechanical treatment is undertaken prior to the completion of West Pit flooding, Colby Lake water possibly could be used to aid in the flooding of the West Pit. If Colby Lake water were used to aid in West Pit flooding, PolyMet would apply for an amendment to its Water Appropriation Permit. Alternatively, West Pit flooding could be extended, depending on water quality results and other considerations.

At the Mine Site, the four steps for evaluating non-mechanical treatment technologies could be finalized in less than the time estimated for completion of the West Pit flooding (e.g., approximately 35 years after the end of Project operations). Additional time is included in PolyMet's current plan, however, because the water quality in the pit may take some time to reach equilibrium after the West Pit has flooded. Therefore, PolyMet anticipates implementing the four evaluation steps during the closure phase (approximately Mine Year 25 – Mine Year 28). As a result, non-mechanical water treatment technology could be implemented at the Mine Site a few years after the West Pit has been flooded during the postclosure maintenance phase, currently projected for Mine Year 55. Additional details regarding the rate and timing of pit flooding are provided in Section 6.1.2.2 of Appendix 16.19.

The water models used to support permitting for the Project were not designed to estimate when treatment for compliance with water quality standards can be ended, nor are they intended to estimate when treatment can transition from mechanical to non-mechanical systems. Rather, PolyMet will assess actual treatment requirements on a recurring basis through operations and the post-operations phases based on the actual results of monitoring discharges, performance of engineering controls, and water resource conditions. This process will rely on monitoring results and additional analyses to continuously protect groundwater and surface water in compliance with applicable water quality standards. Data collected during operations will be used to refine the timeline associated with the transition to non-mechanical treatment.

POLYMET
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NorthMet Project

Adaptive Water Management Plan

Version 12

Issue Date: December 8, 2017

This document was prepared for Poly Met Mining, Inc.
by Barr Engineering Co.

Table 2-1 Proposed Water Quality Targets (PWQTs) for Mine Water Treatment

Parameter[(1)]	Operations	Reclamation and Closure	Post-closure	Basis
Metals/Inorganics (µg/L, except where noted)				
Aluminum	125	125	125	Minnesota Rules, part 7050.0222 Class 2B (chronic standard)
Antimony	31	31	31	Minnesota Rules, part 7050.0222 Class 2B (chronic standard)
Arsenic	10	10	4	Operations, reclamation and closure: Minnesota Rules, part 7050.0221 Class 1 (Primary MCLs) Postclosure maintenance: preliminary impact assessment
Barium	2,000	2,000	2,000	MN Groundwater (HRL, HBV, or RAA)
Beryllium	4	4	4	Minnesota Rules, part 7050.0221 Class 1 (Primary MCLs)
Boron	500	500	500	Minnesota Rules, part 7050.0224 Class 4A (chronic standard)
Cadmium[(2)]	5.1	4.2	2.5	Minnesota Rules, part 7052.0100 Class 2B (chronic standard)
Chromium[(3)]	11	11	11	Minnesota Rules, part 7052.0100 Class 2B (chronic standard)
Cobalt	5	5	5	Minnesota Rules, part 7050.0222 Class 2B (chronic standard)
Copper[(2)]	20	17	9.3	Minnesota Rules, part 7052.0100 Class 2B (chronic standard)
Iron	300	300	300	Minnesota Rules, part 7050.0221 Class 1 (Secondary MCLs)
Lead[(2)]	10.2	7.7	3.2	Minnesota Rules, part 7050.0222 Class 2B (chronic standard)
Manganese	50	50	50	Minnesota Rules, part 7050.0221 Class 1 (Secondary MCLs)
Nickel[(2)]	113	94	52	Minnesota Rules, part 7052.0100 Class 2B (chronic standard)
Selenium	5	5	5	Minnesota Rules, part 7052.0100 Class 2B (chronic standard)
Silver	1	1	1	Minnesota Rules, part 7050.0222 Class 2B (chronic standard)
Thallium	0.56	0.56	0.56	Minnesota Rules, part 7050.0222 Class 2B (chronic standard)

Large Table 4 WWTF Ranges of Blended Influent Water Quantity and Quality

WWTF Ranges of Blended Influent Water Quantity and Quality (µg/L unless otherwise specified)	Operations[2]						Closure[3]				Post-Closure[4]			
	East EQ Basin		West EQ Basin		FTB Seepage		Mine Water		FTB Seepage		Mine Water		FTB Seepage	
	10%	90%	10%	90%	10%	90%	10%	90%	10%	90%	10%	90%	10%	90%
Flow (gpm)[1]	1280	1780	115	170	2030	3605	0[6]	1750	3500	3500	250	325	2055	2838
Ag (Silver)	0.138	0.190	23.3	32.5	0.172	0.211	0.194	0.196	0.1440	0.176	0.196	0.200	0.066	0.172
Al (Aluminum)	0.558	1.690	89900.0	526000.0	4.62	11.50	0.768	2.29	5.44	11.2	0.930	2.15	7.83	23.1
Alk (Alkalinity)	18900	42100	2950	15700	75900	114000	20500	55300	72400	109000	34800	51100	111000	159000
As (Arsenic)	74.6	87.4	99.7	99.8	22.9	40.4	136.0	152.0	36.20	44.90	8.6	14.7	11.400	15.800
B (Boron)	85.9	94.3	106	264	164	235	104	111	145	220	100	100	222	325
Ba (Barium)	13.1	17.1	8.3	13.3	24.5	26.7	37.2	45.5	18.300	21.000	26.8	39.3	16.700	21.700
Be (Beryllium)	0.316	0.387	6.210	14.100	0.415	0.483	0.395	0.405	0.347	0.459	0.322	0.400	0.221	0.569
Ca (Calcium)	344000	592000	396000	543000	90800	137000	420000	936000	133000	227000	33600	59200	67500	101000
Cd (Cadmium)	1.960	25.8	17.0	147	0.689	2.01	1.56	36.2	0.644	2.540	0.719	3.63	0.230	0.677
Cl (Chloride)	2670	28900	0	0	19700	24700	83900	115000	17800	23000	7170	13200	11200	15200
Co (Cobalt)	194	1660	2350	20700	11.2	34.4	249	1640	13.10	52.6	16.9	75.0	5.30	17.2
Cr (Chromium)	7.17	8.63	13.30	14.50	4.98	7.02	9.23	9.32	4.57	5.44	2.16	2.73	1.36	1.79
Cu (Copper)	206	7410	84900	110000	247	524	678	11800	194.0	384	119	655	67.6	145
F (Fluoride)	1180	1600	1560	1880	844	1190	2370	3620	665	825	187	297	180	296
Fe (Iron)	52	188	19700	113000	1300	2410	1060	2870	790	1840	46	199	1870	3720
K (Potassium)	37500	47300	29200	45800	20500	29500	88700	103000	25700	29300	7340	12500	10300	14200
Mg (Magnesium)	58700	227000	150000	996000	75000	98300	192000	426000	80800	114000	13700	21000	70200	121000
Mn (Manganese)	594	2230	4180	39500	563	907	1450	3930	500	813	122	190	567	929
Na (Sodium)	73300	199000	51700	218000	62400	75900	281000	515000	65300	78500	24700	49400	30600	49100
Ni (Nickel)	2380	24600	35300	405000	157	476	2580	14300	189	677	266	843	68	195
Pb (Lead)	1.91	5.84	111.00	361.00	27.80	51.20	60.50	76.90	35.30	43.50	5.75	12.00	6.68	10.00
Sb (Antimony)	21.7	67.4	403	1720	7.19	11.4	16.8	80.4	8.72	13.00	6.00	9.46	2.76	5.45
Se (Selenium)	11.4	57.2	58.0	111	1.89	2.89	8.93	79.70	2.720	4.21	0.26	2.85	0.60	1.20
SO4 (Sulfate)	1,280,000	2,450,000	1,940,000	9,010,000	282,000	337,000	997,000	2,840,000	292,000	386,000	52,200	132,000	154,000	278,000
Tl (Thallium)	0.122	0.175	1.31	8.10	0.151	0.191	0.190	0.193	0.1310	0.157	0.0734	0.0884	0.053	0.122
V (Vanadium)	9.370	9.770	36.1	42.3	6.77	9.09	9.65	9.73	6.15	7.04	10.0	10.0	2.300	3.000
Zn (Zinc)	155	1220	1980	16300	66.2	139	174.0	1720.0	61.8	159.0	59.2	223.0	17.9	41.1
TDS (Total Dissolved Solids mg/L)[5]	1820	3626	2811	12064	630	822	2092	5031	690	972	174	341	458	743

(1) Flows are shown as annual average flows (gpm), rounded to the nearest 5 gpm.

(2) Estimates based on Reference (3) non-charged balanced water for Mine Year 14

(3) Estimates based on Reference (3) non-charged balanced water for Mine Year 25

(4) Estimates based on Reference (3) non-charged balanced water for Mine Year 75

(5) TDS estimates are based on sum of all modeled constituents

(6) P10 mine water flows for Mine Year 35 are zero, because in 10% of model runs, East Pit flushing is complete by Mine Year 35.

Appendix 14

Reclamation, Closure, and Postclosure Maintenance Plan

2.2.1.4 Category 1 Stockpile Groundwater Containment System

The Category 1 Stockpile Groundwater Containment System will continue to operate during the reclamation and closure phases. Water collected by the containment system will be collected and routed to the WWTS for treatment prior to being pumped to the East or West Pit.

2.2.2 Maintenance of Reclaimed Areas

Establishment of dense vegetative cover and root mass is among the most effective methods to minimize erosion, so the quality and density of the vegetation will be periodically reviewed after reclamation construction is complete. Reclaimed areas will be inspected at least twice per year (in the spring and fall), as necessary, or as required by Minnesota Rules, part 6132.5200. Any areas that have been damaged by erosion, animal activity, or that have lost vegetation will be identified. A plan to reseed or repair the damage will be developed and implemented.

Reclaimed mine overburden slope erosion will be corrected and re-vegetated as needed. In areas where excess erosion is a repetitive problem, channels and/or outfall structures will be designed for those specific locations.

2.3 Postclosure Maintenance

Once the closure activities described in Section 2.2 are complete, a postclosure maintenance phase will begin. Monitoring will likely occur at a reduced frequency from the closure phase. Monitoring, reporting, and water treatment will continue until release from postclosure maintenance is granted by the DNR in accordance with PTM Regulations. If any of the monitoring data shows that additional work is needed, a plan will be created and implemented.

2.3.1 Water Management During Postclosure Maintenance

More details on Mine Site water management in the postclosure maintenance phase are presented in Section 2 of Appendix 11.4 of the Application and summarized in this section. During the postclosure maintenance phase, Mine Site water management tasks presently are anticipated to include the following:

- continued operation of the WWTS, with treated water discharge to a tributary of the Partridge River until the transition to non-mechanical treatment (Section 2.3.1.1)
- select pump and pipe removal, including the CPS and Mine to Plant Pipelines (MPP), once pumping has ceased from the Plant Site to the West Pit (2.3.1.1)
- equalization basin decommissioning and reclamation (2.3.1.1)
- maintenance of the water level in the West Pit below the natural overflow elevation, until the transition to non-mechanical treatment (Section 2.3.1.2)
- continued pumping of the Category 1 Stockpile Groundwater Containment System drainage to the WWTS (Section 2.3.1.3), until the transition to non-mechanical treatment

The ultimate objective is to transition from the mechanical treatment provided by the WWTS to non-mechanical treatment systems as early in the reclamation, closure, and postclosure maintenance phases as possible, as described in Section 8.0. Options for non-mechanical water treatment at the Mine Site during the postclosure maintenance phase are summarized in this section, Section 8.0 , and described in more and water treatment will continue until release from these activities is granted via the PTM. If any of the monitoring data shows that additional work is needed, a plan will be created and implemented to further improve water quality.

3.3.1 Water Management During Postclosure Maintenance

Water management in the postclosure maintenance phase at the Plant Site will continue much the same as during the closure phase. The primary difference will be that after the West Pit is completely flooded, West Pit water will be treated at the WWTS, and WWTS effluent will be discharged at the Mine Site, through an unnamed creek downstream of the future West Pit overflow. Also, during the postclosure maintenance phase, less water is captured by the FTB seepage capture systems as the FTB pond bottom cover system and bentonite-amended beaches and slopes reduce the infiltration through the FTB. Additionally, more WWTS effluent is discharged to the tributaries for stream augmentation than during the closure phase (Large Table 8 of Water Modeling Data Package Vol 2-Plant Site of Appendix 16.20 of the Application). Additional details on water management in the postclosure maintenance phase are presented in Section 4 of Appendix 11.4 of the Application and summarized in this section.

The ultimate objective is to transition from the mechanical treatment provided by the WWTS to non-mechanical treatment systems as early in the reclamation, closure, and postclosure maintenance phases as possible, as described in Section 8.0. Options for non-mechanical water treatment at the Plant Site during postclosure maintenance are summarized in this section and Section 8.0 and described in detail in Section 6 of Appendix 11.4 of the Application. The transition from mechanical to non-mechanical treatment will occur only after the site-specific designs for non-mechanical systems have been proven and approved by the appropriate regulatory agencies.

Two non-mechanical treatment systems at the Plant Site, which are independent of each other, could be used for long-term treatment of water from the FTB seepage capture systems and the FTB Closure Overflow. It is expected that the FTB Non-Mechanical Treatment System to treat tailing basin seepage will be deployed earlier than the FTB Closure Overflow (post-mechanical treatment options). The WWTS will continue to treat tailings basin seepage and FTB pond water until the transition to each of these systems (Section 6.4 and Section 6.5 of Appendix 11.4 of the Application, respectively).

3.3.1.1 WWTS

During the postclosure maintenance phase, the WWTS will continue to treat water collected by the FTB seepage capture systems, any HRF drainage, and excess water from the FTB Pond as needed to prevent overflow or until transition to non-mechanical treatment systems occur for these waters. The WWTS will continue to operate in the same configuration used during the operations and reclamation phases. Solids management may include chemical precipitation. WWTS secondary membrane separation unit concentrate will be precipitated and/or evaporated, with the residual solids disposed at an appropriate permitted landfill. WWTS effluent will continue to be discharged to Second Creek, Unnamed Creek, and Trimble Creek for stream augmentation (Section 3.2.1.5) as well as to an unnamed creek downstream of the future West Pit overflow.