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Technical Memorandum

To: Paul Eger, MDNR
From: Tina Pint, Bill Dehler
Subject: PolyMet Tailings Basin Permeabilities
Date: August 28, 2008
Project: 23/69-862 006 001
c: Jim Scott, PolyMet Mining

This memorandum presents information on the permeabilities of material associated with the existing LTVSMC Tailings Basin (Section 1), the predicted permeability of material associated with the PolyMet Tailings Basin (Section 2) and the permeability values used in the various modeling efforts that have been conducted in support of the EIS (Section 3).

In order to help facilitate an easier understanding of the various permeability data and values used in the models that are described herein, the following terminology/nomenclature related to the PolyMet tailings will be used throughout this memorandum:

Bulk Tailings: The term "bulk tailings" is used to refer to the PolyMet tailings that are discharged from the beneficiation process. This represents the entire spectrum of tailings that will be sent to the Tailings Basin.

Undersized Tailings: The term "undersized tailings" is used to refer to the finer grained tailings that would be segregated from bulk tailings by use of a cyclone. As described later in this memorandum, an assumed gradation is used for the undersized tailings.

Oversized Tailings: The term "oversized tailings" is used to refer to the coarser grained tailings that would be segregated from bulk tailings by use of a cyclone. As described later in this memorandum, an assumed gradation is used for the oversized tailings.

Fine Beach: The term "fine beach" is used to refer to the portion of the PolyMet tailings basin beach that will in general be composed of finer grained material that will result from the hydraulic segregation caused by the spigoting of tailings.

Coarse Beach: The term "coarse beach" is used to refer to the portion of the PolyMet tailings basin beach that will in general be composed of coarser grained material that will result from the hydraulic segregation caused by the spigoting of tailings.

The terms "fine tailings" and "coarse tailings" have purposely been avoided when referring to PolyMet flotation tailings. These terms have been applied to the LTVSMC tailings to represent specific ranges in grain size distributions.

1.0 LTVSMC Tailings Basin Permeabilities

The main parameter associated with seepage analysis is the hydraulic conductivity of the tailings and tailings dam materials. In geotechnical practice, the term permeability is often used to describe the hydraulic conductivity parameter, and that term will be used in the remainder of this text. Table 1-1 summarizes the permeabilities used by previous investigators for seepage analysis and was compiled through a review of reports discussing the stability of the Erie Mining Company and LTVSMC tailings basin.

Many of the values are estimates based on grain size distribution and experience of previous investigators. In fact, many previous studies (pre-2000) used monitoring data from piezometers to create a phreatic surface for stability analyses to calculate pressure heads rather than incorporating permeability into the seepage models.

Table 1-1: Permeability Postulated by Previous Investigators

Unit	Sitka Corp. - Mar. 1995	Barr Engineering Co. - Jan. and Mar. 2000
	Permeability [cm/s]	**Permeability [cm/s]**
LTVSMC Coarse Tailings	1.00E-03	1.00E-02
LTVSMC Fine Tailings	1.00E-04	1.50E-06 to 2.50E-05
LTVSMC Slimes	1.00E-05	8.40E-07 to 5.80E-06
Virgin Peat	1.00E-02 to 1.00E-04	1.00E-03 to 1.00E-07
Compressed Peat	1.00E-06 to 1.00E-07	-
Till	1.00E-02 to 1.00e-04	4.30E-04 to 5.40E-03

The following report sections describe the updated permeability values and how they were developed through the recent testing program.

1.1 LTVSMC Coarse Tailings

No evidence of previous permeability testing for support of previous LTVSMC coarse tailings design parameters was uncovered in the review of published data. Therefore the LTVSMC coarse tailings were tested for permeability by two methods: in-situ dissipation testing performed during cone penetration tests and laboratory permeability testing on remolded samples. The coarse, granular nature of these tailings generally results in quick dissipation of excess pore-water pressure during cone advancement and therefore makes interpretation of the in situ permeability difficult. Therefore, the resulting LTVSMC coarse tailings permeability used in the current modeling is based upon six remolded laboratory specimens created from bulk samples obtained from test pits performed in Cell 2W. The specimens were remolded to dry densities ranging from 96.4 to 114.9 pcf and tested using the constant head – rigid wall permeability test method (ASTM D5856). Table 1-2 shows the range in values interpreted from the test results.

Table 1-2: Range of Permeability of LTVSMC Coarse Tailings

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	3.20E-03	5.33E-05	1.62E-03
Maximum	6.90E-03	1.15E-04	3.51E-03
Average	5.03E-03	8.39E-05	2.56E-03
St Dev	1.65E-03	2.76E-05	8.41E-04
GeoMean	4.80E-03	8.00E-05	2.44E-03

1.2 LTVSMC Fine Tailings

No evidence of previous permeability testing for support of old LTVSMC fine tailings design parameters was uncovered while reviewing published data. During the recent explorations, the LTVSMC fine tailings were tested for permeability by in-situ dissipation testing performed during cone penetration tests. However, similar to the coarse tailings, the interpretation of the dissipation testing was found to be difficult at the locations tested. Difficulty in interpretation is likely due to the low piezometric levels within the tailings basin leading to minimal pore water pressure response during cone advancement and subsequent dissipation. The majority of the tailings have dewatered at the locations tested, reducing the pore-water pressure response during cone advancement. The relative coarseness of the fine tailings also hinders the ability to measure pore-water pressure dissipation because the tailings are fairly permeable and any pressure created during cone penetration testing dissipates fairly quickly.

Laboratory analysis of LTVSMC fine tailings for permeability was not performed due to lack of sufficient undisturbed samples of representative grain size distribution. Upon review of all of the materials encountered on the site, the grain size distributions of the LTVSMC fine and PolyMet bulk tailings were found to be similar. The PolyMet bulk tailings are characterized as the overall bulk tailings to be produced at the plant and pumped to the tailings basin. The average grain size distribution of the PolyMet bulk tailings was determined during previous studies when testing was performed to evaluate change in permeability of the material with change in overburden pressure. A permeability of 1.77 x 10^{-6} ft/sec (1.16 x 10^{-4} cm/sec) was used as a basis for current seepage analyses and is equivalent to an effective overburden pressure of 2.75 tsf as discussed further in Section 2.1. This overburden pressure was selected for four reasons:

1) 2.75 tsf is approximately equivalent to the minimum pressure exerted on the LTVSMC fine tailings beneath the crest of the existing dam (assuming a unit weight of 90 pcf for approximately 60 feet of overlying soil).

2) 2.75 tsf is equivalent to the minimum pressure exerted on the LTVSMC fine tailings beneath the proposed PolyMet dam between the basin and existing crest zones (assuming a unit weight of 120 pcf for the approximate minimum 45 feet of overlying soil beneath the first lift of the proposed dam).

3) At an effective overburden pressure of 2.75 tsf, the corresponding permeability is within the same range as the high permeability slimes (for which tests are available), with which the LTVSMC fine tailings are intermingled in the area of the existing basin.

4) Following construction of approximately 60 feet of the proposed tailings basin raises, the LTVSMC fine tailings will be under at least 2.75 tsf overburden pressure within the area of the existing basin (assuming a conservative overburden unit weight of 90 pcf).

1.3 LTVSMC Slimes

The LTVSMC slimes are generally found within the interior portion of the tailings basin or located in isolated areas under the existing dams. Attempts were made to test the permeability of the slimes by two methods: in-situ dissipation testing performed during cone penetration tests and laboratory permeability testing on undisturbed samples. The in-situ dissipation testing was performed at 46 locations and depths within Cells 1E and 2E. The time to reach 50 % of the peak pore-water pressure, t_{50}, was determined. Published correlation charts for piezocone analyses were used to obtain the estimated permeability values (Lunne, Robertson and Powell, 1997). Falling head, flexible wall, laboratory permeability testing of six undisturbed samples obtained form thin-wall (Shelby) tubes at three boring locations showed permeability values within the same range as those determined from dissipation testing. The laboratory values appeared to be slightly lower, possibly due to slight disturbance during sampling or the variability between horizontal permeability as measured by CPTu and vertical permeability as measured in the lab.

Table 1-3: Range of Permeability of LTVSMC Slimes

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	1.80E-07	3.00E-09	9.14E-08
Maximum	1.38E-04	2.30E-06	7.01E-05
Average	2.18E-05	3.64E-07	1.11E-05
St Dev	2.65E-05	4.42E-07	1.35E-05
GeoMean	1.098E-05	1.83E-07	5.58E-06

1.5 Glacial Till

Based upon a review of previous reports, the permeability of the glacial till had apparently never been measured. The values used in previous analyses appear to be generalized permeabilities for sandy to clayey till soils. To better evaluate the seepage characteristics of the foundation tills, a sampling program was implemented to retrieve till samples on which laboratory testing could be performed. Although the sampling program used Pitcher barrel sampling methods, which uses a cutting head and retractable thin-wall sampling tube for relatively undisturbed sampling, sufficient samples could not be obtained due to the nature of the formation. The till contained not only varying amounts of clay and sand but also cobbles and boulders that could not be penetrated, even with the cutting teeth of the sampling device. An alternate method, slug testing, was then employed to estimate the permeability of the formation.

The in situ slug tests, performed in standpipe piezometers installed in August, 2007, were performed along the north dam of Cell 2W. The slug testing consisted of preparing a standpipe piezometer by first flushing it of all soils and then filling it with a volume of water. The water was allowed to dissipate and drain from the piezometer into the till and the depth to water was recorded over a measured period of time until equilibrium was reached. The range of values obtained from the testing program is reported in Table 5.

Table 1-5: Range of Permeability of Glacial Till from Slug Tests

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	1.72E-04	1.17E-05	3.57E-04
Maximum	1.44E-03	2.40E-05	7.32E-04
Average	1.03E-03	1.72E-05	5.24E-04
St Dev	3.75E-04	6.24E-06	1.90E-04
GeoMean	9.90E-04	1.65E-05	5.03E-04

1.6 Peat

Organic matter consisting of peat occurs throughout the tailings basin perimeter and just outside the current toe of the dams. Many areas within Cell 2E contain peat deposits covered by years of tailings deposition. In areas along the toe of the tailings basin, natural (uncompressed) peat, relatively unaltered by the construction of the tailings basin, still exists.

Permeability of the compressed peat was determined using two methods to represent permeabilities of the peat in the vertical and horizontal directions. The vertical permeability was determined from falling head, flexible wall permeability tests of four relatively undisturbed peat samples tested at confining stresses ranging from 1.5 to 6.0 tsf, while the horizontal permeability was measured using in situ pore pressure dissipation testing. The difference in permeability between the horizontal and vertical directions is attributed to the way in which peat is formed and varies highly with confining pressure, with horizontal to vertical permeability ratios as high as 15 reported under 180 kPa confining pressure (Ajlouni, 2000). The confining pressures at the PolyMet site are significantly higher and significantly higher ratios of horizontal to vertical permeability should be expected. The permeability of the virgin peat (north of the dam), is unknown. However, peat permeabilities ranging from 10^{-2} to 10^{-4} cm/sec were previously recommended by Sitka and are consistent with this site (Sitka, 1995). The range in permeability for the peat material is shown in Table 1-6.

Table 1-6: Range of Permeability for Compressed Peat Material

Vertical	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	2.50E-08	4.17E-10	1.27E-08
Maximum	2.30E-07	3.83E-09	1.17E-07
Average	8.53E-08	1.42E-09	4.33E-08
St Dev	9.79E-08	1.63E-09	4.97E-08
GeoMean	5.47E-08	9.12E-10	2.78E-08

Horizontal	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	3.46E-06	5.76E-08	1.76E-06
Maximum	1.45E-05	2.41E-07	7.35E-06
Average	8.96E-06	1.49E-07	4.54E-06
St Dev	7.78E-06	1.30E-07	3.96E-06
GeoMean	7.07E-06	1.18E-07	3.60E-06

1.7 Rock Starter Dam

On the north side of Cell 2E, a rock starter dam constructed over the peat deposit was utilized to facilitate future dam construction. The permeability of the rock starter dam was based upon the published grain size distribution (Ebasco, 1977). Due to the size of the material, samples of the rock could not be obtained in any manner that would allow permeability testing. Therefore, an approximation of the permeability was made using the Hazen equation so that the seepage characteristics of the toe of the dam could be modeled:

$$K = cD_{10}^2$$

Where:

K = hydraulic conductivity (permeability) (cm/sec)

c = constant (assumed equal to 1)

D_{10} = diameter of which 10% of the sample by weight is smaller (mm)

The resulting permeability was found to range from 1.3 x 10^{-3} to 94 x 10^{-3} ft/sec (0.034 to 2.865 cm/sec), based upon the grain size distribution selected, with D_{10} ranging from approximately 0.2 to 2 mm and within the acceptable range for use of the Hazen equation (Lindeburg 2006).

2.0 PolyMet Tailings Basin Permeabilities

Laboratory permeability testing has been performed on three different PolyMet grain size distributions: bulk tailings, oversized tailings and undersized tailings. The data from these tests are summarized below.

2.1 PolyMet Bulk Tailings

The permeability of the PolyMet bulk tailings was determined from falling head, flexible wall, laboratory permeability testing performed as a part of the preparation of Technical Design Evaluation Report RS 39/40T by Barr Engineering (Barr, 2007). Six specimens were remolded to dry densities ranging from 89.3 to 100.7 pcf and tested at confining stresses of 0.25 to 7.0 tsf. The results of the laboratory testing on the bulk tailings are shown in Table 2-1.

Table 2-1: Range of Permeability for the PolyMet Bulk Tailings

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	3.90E-05	6.50E-07	1.98E-05
Maximum	9.50E-04	1.58E-05	4.82E-04
Average	4.19E-04	6.99E-06	2.13E-04
St Dev	4.19E-04	6.98E-06	2.13E-04
GeoMean	2.29E-04	3.81E-06	1.16E-04

Plotting the permeability versus confining stress reveals a strong correlation (Figure 1).

2.2 PolyMet Oversized Tailings

The permeability of the PolyMet oversized tailings was determined from laboratory testing performed as a part of the preparation of report RS 39/40T by Barr Engineering (Barr, 2007). The specimens were remolded to dry densities of 88.6 to 104.8 pcf prior to testing at confining pressures ranging from 0.25 to 10.0 tsf. The results of the laboratory testing on the oversized fraction of the tailings are shown in Table 2-2.

Table 2-2: Range of Permeability for the PolyMet Oversized Tailings

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	1.20E-03	2.00E-05	6.10E-04
Maximum	3.40E-03	5.67E-05	1.73E-03
Average	2.27E-03	3.78E-05	1.15E-03
St Dev	8.02E-04	1.34E-05	4.08E-04
GeoMean	0.002271	3.78E-05	1.15E-03

2.3 PolyMet Undersized Tailings

The permeability of the PolyMet undersized tailings was also determined from laboratory testing performed as a part of the preparation of report RS 39/40T by Barr Engineering (Barr, 2007). Six specimens were remolded to dry densities ranging from 85.1 to 99.9 pcf and tested at confining stresses of 0.25 to 10.0 tsf. The results of the laboratory testing on the fine tailings are shown in Table 2-3.

Table 2-3: Range of Permeability for the PolyMet Undersized Tailings

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	1.80E-05	3.00E-07	9.14E-06
Maximum	8.90E-05	1.48E-06	4.51E-05
Average	3.79E-05	6.32E-07	1.93E-05
St Dev	2.67E-05	4.44E-07	1.35E-05
GeoMean	3.79E-05	6.32E-07	1.93E-05

2.4 PolyMet Tailings Basin Dams (LTVSMC Bulk Tailings)

The LTVSMC coarse tailings to be excavated for use in construction of the shell along the downstream slope of the future tailings basin dam will likely have minor inclusions of LTVSMC fine tailings and slimes in addition to the coarse tailings that will be targeted for excavation. As a conservative approach, to account for possible minor inclusions of slimes and fine tailings in the excavated coarse tailings, four tailings mixtures were prepared from bulk samples obtained during test pitting in Cell 2W. Each of the mixtures was tested for permeability using the constant head, rigid wall, method (ASTM D5856) with the resulting range of values as shown in Table 2-4.

Table 2-4: Range of Permeability of LTVSMC Bulk Mixtures

	k (ft/min)	k (ft/sec)	k (cm/sec)
Minimum	1.30E-04	2.17E-06	6.61E-05
Maximum	2.00E-04	3.33E-06	1.01E-04
Average	1.60E-04	2.67E-06	8.14E-05
St Dev	3.16E-05	5.27E-06	1.61E-04
GeoMean	1.58E-04	2.63E-06	8.02E-05

3.0 Permeabilities used in Various Models

Different permeability values have been used at different times for different purposes. This section summarizes the values used for each modeling effort and gives the basis for selection of the values that were used.

3.1 Geotechnical Modeling

Permeability values used in the seepage analyses for dam stability modeling for the Tailings Basin-Mitigation Design were selected from the ranges described in Sections 1.0 and 2.0. For the LTVSMC coarse tailings and slimes the average permeabilities of 8.39 x 10^{-5} ft/sec (2.44 x 10^{-3} cm/sec) and 3.64 x 10^{-7} ft/sec (1.11 x 10^{-5} cm/sec), respectively, were used. A permeability of 1.77 x 10^{-6} ft/sec (1.16 x 10^{-4} cm/sec) was used for the LTVSMC fine tailings and is associated with an effective overburden pressure of 2.75 tsf as discussed in Section 1.2. The LTVSMC bulk tailings represent mixtures of the slimes, fine, and coarse tailings as a conservative approximation of the largely coarse tailings to be used to construct the shell along the downstream slope of the future tailings basin dam. An average value of 2.67 x 10^{-6} ft/sec (8.14 x 10^{-5} cm/sec) was used for preliminary design. Permeability values for this portion of the analysis will be modified in future analysis if it is confirmed by visual observation of tailings excavation for dam construction that inclusions of slimes and fine tailings with coarse tailings are minor. A permeability of 1.72 x 10^{-5} ft/sec (5.24 x 10^{-4} cm/sec) was selected as representative of the glacial till. Permeabilities of the compressed and virgin peat zones were selected to best represent the structure of the peat and the direction of seepage. The permeability of the PolyMet bulk tailings is strongly correlated to confining stress (Section 2.1). Accordingly, three representative values of permeability were selected for use in modeling. 1.13 x 10^{-5} ft/sec (3.44 x 10^{-4} cm/sec) for PolyMet bulk tailings under less than 0.45 tsf effective overburden (average for 10 feet of soil with a unit weight of 90 pcf), 3.68 x 10^{-6} ft/sec (1.12 x 10^{-4} cm/sec) for tailings under 1.35 tsf effective overburden (average for 30 feet of soil with unit weight of 90 pcf), and 2.14 x 10^{-6} ft/sec (6.52 x 10^{-5} cm/sec) for tailings under greater than 2.29 tsf effective overburden (average for approximately 50 feet of soil with unit weight of 90 pcf).

The previous sections provided a summary of the analyses used to determine the range in permeability values for the materials encountered in the Tailings Basin. The values selected for design purposes are summarized in Table 3-1. An important component in modeling of tailings basins is calibration of the materials, parameters, and configuration with monitoring data to evaluate the seepage behavior and compare the performance to reality. Deposition of tailings on the beaches as well as separation and compaction using earth moving equipment can yield a wide range in permeability for the materials. The values in Table 3.1 are estimates expected to cover a range of material types and were used as the starting point for the geotechnical model calibration phase of the project.

Table 3-1 –Permeabilities for Stability Models

Material	Permeability (ft/s)	Permeability (cm/s)
LTVSMC Coarse Tailings	8.39×10^{-5}	2.56×10^{-3}
LTVSMC Fine Tailings	1.77×10^{-6}	5.39×10^{-5}
LTVSMC Slimes	3.64×10^{-7}	1.11×10^{-5}
Rock Starter Dam	50×10^{-3}	1.52
Compressed Peat	1.42×10^{-9}	4.33×10^{-8}
Virgin Peat	3.28×10^{-3}	1.00×10^{-1}
Glacial Till	1.72×10^{-5}	5.24×10^{-4}
PolyMet Bulk Tailings	1.13×10^{-5} to 2.14×10^{-6}	6.52×10^{-5} to 3.44×10^{-4}
LTVSMC Bulk Tailings	2.67×10^{-6}	8.14×10^{-5}

3.2 Groundwater Flow Modeling – Proposed Design

Permeability values used in the groundwater flow models that were constructed for the Proposed Design are documented in RS13 Draft-03 Attachment A-6 Table 4-1 and Section 5.2.3 and are summarized here. Permeability values for the LTVSMC tailings were selected to be consistent with the geotechnical modeling that was being conducted simultaneously. Permeability of the native materials, the till and bedrock, were allowed to vary during model calibration within expected ranges. The resulting high permeability value of the till was needed in order to match predicted seepage losses from the basin.

For the Proposed Design, tailings would be spigoted along the perimeter of the dikes which would result in a gradation of grain sizes from course to fine away from the dams. The coarse fractions would be reworked and used for dam construction. For the groundwater modeling, it was assumed that the permeability of the bulk tailings would be representative of the embankment and the portion of the beach nearest the embankment (i.e. the coarse beach) and the permeability of the undersized tailings would be representative of the portion of the beach nearest the pond (i.e. the fine beach) and the material within the pond itself. Permeability values used for the groundwater modeling of the Proposed Design are shown in Table 3-2.

Table 3-2 –Permeabilities used in the Groundwater Models for the Proposed Design

Material	ft/sec	cm/sec
PolyMet Coarse Beach	6.56×10^{-6}	2.00×10^{-4}
PolyMet Fine Beach	5.60×10^{-7}	1.71×10^{-5}
PolyMet Pond/Slimes	5.60×10^{-7}	1.71×10^{-5}
LTVSMC Coarse Beach	1.60×10^{-6}	4.88×10^{-5}
LTVSMC Fine Beach	3.30×10^{-7}	1.01×10^{-5}
LTVSMC Slimes	3.30×10^{-7}	1.01×10^{-5}
Glacial Till	9.26×10^{-4}	2.82×10^{-2}

3.3 Groundwater Flow Modeling – Mitigation Design

Permeability values used in the groundwater flow models that were constructed for the Mitigation Design will be documented in RS13b Draft-01 Attachment A-6 and are summarized here. Permeability values for the LTVSMC tailings were selected to be consistent with the geotechnical modeling that was being conducted simultaneously. These values are different from the values used for the models of the Proposed Design because additional data was collected and analyzed between modeling efforts. The permeability of the till changed slightly in response to changes in permeability of the LTVSMC tailings in order to maintain an acceptable model calibration.

For the Mitigation Design, tailings would be placed in a manner that precludes segregation of the material into fine and coarse fractions. As such, the permeability of the bulk tailings was deemed to be representative of all PolyMet tailings. To account for variability in permeability with confining stress, two different permeabilities were used for the PolyMet tailings; a higher value for the tailings near the surface and a lower value for the tailings at depth in the basin. This is consistent with the material testing presented in Section 2.1. A permeability representative of LTVSMC bulk tailings was used for the embankments of the PolyMet basin which will be constructed out of LTVSMC tailings. In closure, the permeability of the beach and pond area will be lowered via bentonite augmentation. It was assumed that the bentonite augmented layer would be 18 inches thick and would have a permeability of $1\text{x}10^{-6.5}$ cm/sec. Permeability values used for the groundwater modeling of the Mitigation Design are shown in Table 3-3.

Table 3-3 –Permeabilities used in the Groundwater Models for the Mitigation Design

Material	ft/sec	cm/sec
LTVSMC Embankment	2.67E-06	8.14E-05
PolyMet Bulk - Shallow	1.14E-05	3.47E-04
PolyMet Bulk - Deep	2.13E-06	6.50E-05
LTVSMC Coarse Beach	1.77E-06	5.39E-05
LTVSMC Fine Beach	1.77E-06	5.39E-05
LTVSMC Slimes	3.64E-07	1.11E-05
Glacial Till	7.59E-04	2.31E-02
Bedrock	2.81E-09	8.56E-08

3.4 Geochemical Modeling – Proposed Design

The permeability of the PolyMet tailings is used in two different portions of the geochemical modeling: to assess the rate of infiltration associated with the tailings slurry on the beaches and to determine the unsaturated zone moisture profiles needed for water quality predictions (the Hydrus-2D modeling). For the prediction of infiltration in the active delta area, a permeability of $3.9x10^{-5}$ ft/sec (1.19 $x10^{-3}$ cm/sec) was used for the PolyMet coarse beach (representative of oversized tailings) and $7.4x10^{-7}$ ft/sec (2.26 $x10^{-5}$ cm/sec) was used for the PolyMet fine beach (representative of undersized tailings). These values are reported in RS54/RS46 on page 70.

Hydrus-2D modeling was conducted to estimate moisture profiles which were used in the prediction of porewater chemistry. For this work, a permeability of $6.6x10^{-6}$ ft/sec (2.01 $x10^{-4}$ cm/sec) was used for the PolyMet inactive coarse beach and embankment areas and $7.2x10^{-7}$ ft/sec (2.19 $x10^{-5}$ cm/sec) was used for the PolyMet fine beach, which are representative of bulk tailings and undersized tailings respectively, which is consistent with the groundwater flow modeling that is discussed in Section 3.2. These values are reported in RS54/RS46 Appendix D.1 page 1.

3.5 Geochemical Modeling – Mitigation Design

For the prediction of infiltration in the active delta area of the Tailings Basin-Mitigation Design, a permeability of $2.67x10^{-6}$ ft/sec (8.14 $x10^{-5}$ cm/sec) was used for the LTVSMC embankment crest area and $2.14x10^{-6}$ ft/sec (6.52 $x10^{-5}$ cm/sec) was used for the PolyMet bulk tailings. These values are consistent with the values used for the groundwater modeling that is discussed in Section 3.3.

For the proposed mitigation design Hydrus-2D modeling was also undertaken to predict moisture profiles which were used in the prediction of porewater chemistry. For this work, a permeability of 1.78×10^{-6} ft/sec (5.41×10^{-5} cm/sec) was used for the PolyMet beach representative of bulk tailings. A permeability of 3.9×10^{-5} ft/sec (1.2×10^{-3} cm/sec) was adopted for the LTVSMC coarse tailings to be used in the construction of the embankment, which is representative of the PolyMet oversized tailings.

4.0 References

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