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Technical Memorandum

To: Stuart Arkley
From: Tom Radue and Tina Pint
Subject: Tailings Basin Area Geologic and Hydrogeologic Setting
Date: April 2, 2009
Project: 23690862.00 022A 011
c: Jim Scott, PolyMet Mining Inc.

This memorandum presents the geologic and hydrogeologic setting for the PolyMet Tailings Basin Area (Figure 1), which includes the Hydrometallurgical Residue Cells and the Flotation Tailings Basin. While this information has been presented in various Technical Design Evaluation Reports (RS13, RS13B, RS74B), it has been compiled here in response to a request from the MDNR in conjunction with their request for Draft 02 of the PolyMet Flotation Tailings Basin Geotechnical Evaluation. It should also be noted that the CPDEIS provides a similar summary of the geology (Section 4.1.1.9; pages 4.1-32 through 4.1-36) and hydrogeology (Section 4.1.1.11, pages 4.1-38 through 4.1-40).

Geology

Quaternary Geology

In general, the Quaternary geology of the region is a thin (0-30 feet) blanket of glacial deposits including till, lacustrine materials, and outwash. In the vicinity of the Embarrass River, the unconsolidated deposits thicken to over 150 feet thick. Low spots are generally peat bog or open wetland. Topography is subdued and drainage is poor. Site- specific geologic studies of the glacial deposits have not been conducted.

Lehr and Hobbs (1992) mapped the area as part of the Wampus Lake Moraine. The Minnesota Geologic Survey's regional surficial geology map (Map M-164; Jennings and Reynolds, 2005, includes GIS database) categorizes all glacial deposits in the area as Rainy Lobe till and resedimented glacial deposits, overlain locally by post- glacial peat.

Based on borings completed by Braun in 1976, the till is described as heterogeneous clayey-to-silty sand with fine-to-medium-grained sand and some gravel and boulders (Sitka, 1995). Surficial geology is shown on Figure 2.

Test pits for preliminary PolyMet engineering studies at the Mine Site and informal observations of sumps and other small excavations confirm the description above. Glacial deposits in most areas consist of unsorted sand, silt, and clay with cobbles and boulders. Boulders on the ground surface can be greater than 10 feet in size and there may be a boulder lag horizon (a surface with a high concentration of boulders) just below the ground surface in some areas.

Based on borings completed by Barr in 2008-2009, similar surficial till units were identified at the Mine Site and north of the Tailings Basin. In both areas, two unique tills were identified. The upper till is typically brown sand and gravel with some fine grained layers. The lower unit is composed of gray fine grained sands and silts with minimal gravel content. Unit thicknesses vary.

Bedrock Geology

In the vicinity of the Tailings Basin, the uppermost bedrock unit is the Giants Range batholith, including quartz monzonite, monzodiorite and monzogranite. Below the southeast corner of Cell 1E of the Tailings Basin, the uppermost bedrock is sedimentary schist with a seam of volcanic schist. Depth to bedrock varies from 0 to 150 feet below ground surface with the greatest depths (>50 feet) occurring at the Tailings Basin (Jirsa, et al., 2005). Bedrock geology is shown on Figure 3. Two cross sections are shown on Figures 4 and 5.

Tailings Basin Stratigraphy

A number of geotechnical borings were placed within the perimeter of the existing tailings basin during the summer of 2007 (Barr, Preliminary Geotechnical Evaluation – PolyMet Flotation Tailings Basin – Draft No. 2, March 2009). The objectives of the geotechnical exploration were primarily related to characterization of the existing tailings for geotechnical engineering and facility design. However, more than twenty of the borings were drilled through the tailings and continued a few feet into the underlying native materials. The borings that did extend through the tailings were concentrated primarily near the northern perimeter of Cell 2E, the southern perimeter of Cell 1E, and the interior of Cell 2W (near the proposed location of the Hydrometallurgical Residue Facility). The native material encountered in these borings is consistent with the glacial materials described above. The majority of the borings encountered

silty sands, with varying amounts of gravel and cobbles (described as till). Thin peat deposits were encountered above the till in some of the borings. Depth of tailings ranged from 13 feet to over 200 feet in the borings.

Hydrogeology

The Rainy Lobe glacial deposits form the major surficial aquifer in the region that encompasses the Tailings Basin. Underlying the glacial deposits is Precambrian crystalline and metamorphic bedrock. The bedrock is assumed to have a significantly lower hydraulic conductivity (i.e., several orders of magnitude) than the glacial deposits and is assumed to be relatively impermeable. In some locations, peat deposits have been encountered between the tailings and the glacial deposits. These peat deposits are likely discontinuous and can be ignored at the scale at which the Tailings Basin is being evaluated for this analysis. On top of the glacial deposits are numerous wetlands and minor surface-water drainages. These features are assumed to represent surficial expressions of the water table.

Regionally, groundwater flows primarily northward, from the Embarrass Mountains to the Embarrass River (Figure 2). At the southern end of the Tailings Basin, there is some groundwater flow to the south from Cell 1E, forming the headwaters of Second Creek. As the Tailings Basin was built up over time, a groundwater mound formed beneath the basin due to seepage from the basin, altering local flow directions and rates. Active seeps have been identified on the south, west, and north sides of the Tailings Basin. The number of active seeps has declined since the January 2001 termination of tailings deposition activities. The east side of the Tailings Basin is bounded by low-permeability bedrock uplands and there is likely little or no water that seeps out in this direction. In addition to the visible seeps, groundwater likely flows out from beneath the tailing basin into the surrounding glacial deposits to the south, west, and north of the basin. Approximate existing groundwater elevations, based on modeling results presented in Technical Design Evaluation Report (TDER) RS13 (Barr, 2007), elevation data for surface water features, and data presented in Siegel and Ericson (1980) are shown on Figure 6.

Estimated hydraulic properties of the units found near the Tailings Basin and for the future PolyMet flotation tailings vary over several orders of magnitude (from RS13B; Barr, 2008). Estimated hydraulic conductivities range from approximately 0.0002 feet/day for bedrock, to approximately 0.03 feet/day for the existing LTVSMC slimes, approximately 0.2 to 1 feet/day for the remaining LTVSMC tailings and future Polymet tailings, and approximately 70 feet/day for the glacial till.

References

Barr Engineering Company, 2007. "Tailings Basin and Hydrometallurgical Residue Facility Water Balance, RS13, Appendix A to Technical Design Evaluation Report RS39/40T Technical Detail Report." March 2007.

Barr Engineering Company, 2008. "Tailings Basin – Mitigation Design Water Balance, RS13B Draft-01". Prepared for PolyMet Mining Corp., September 2008.

Barr Engineering Company, 2009. "Preliminary Geotechnical Evaluation – PolyMet Floatation Tailings Basin – Draft No. 2." March 2009.

Jennings, C.E., and Reynolds, W.K., 2005. Surficial Geology of the Mesabi Iron Range, Minnesota: Minnesota Geological Survey, Miscellaneous Map M-164, scale 1:100,000.

Jirsa, M.A., Setterholm, D.R., Bloomgrem, B.A., Bauer, E.J., and R.S. Lively, 2005. Bedrock Geology, Database, Bedrock Topography, and Depth to Bedrock Maps of the Western Half of the Mesabi Iron Range, Northern Minnesota: Minnesota Geological Survey, Miscellaneous Map M-158, scale 1:100,000.

Lehr, J.D., and Hobbs, H.C., 1992. Glacial Geology of the Laurentian Divide Area, St. Louis and Lake Counties, Minnesota: Minnesota Geological Survey Field Trip Guidebook Series 18. Prepared for the 39th Midwest Friends of the Pleistocene Field Trip, Biwabik, Minnesota, 1992. 73 p., map, 1:250,000.

Siegel, D.I., and D. W. Ericson, 1980. "Hydrology and Water Quality of the Copper-Nickel Study Region, Northeastern Minnesota." U.S. Geological Survey Water-Resources Investigations Open-File Report 80-739.

Sitka Corp., 1995. "Geotechnical Assessment of Tailings Impoundment, Phase I." Prepared for LTV Steel Mining Company. March 1995.

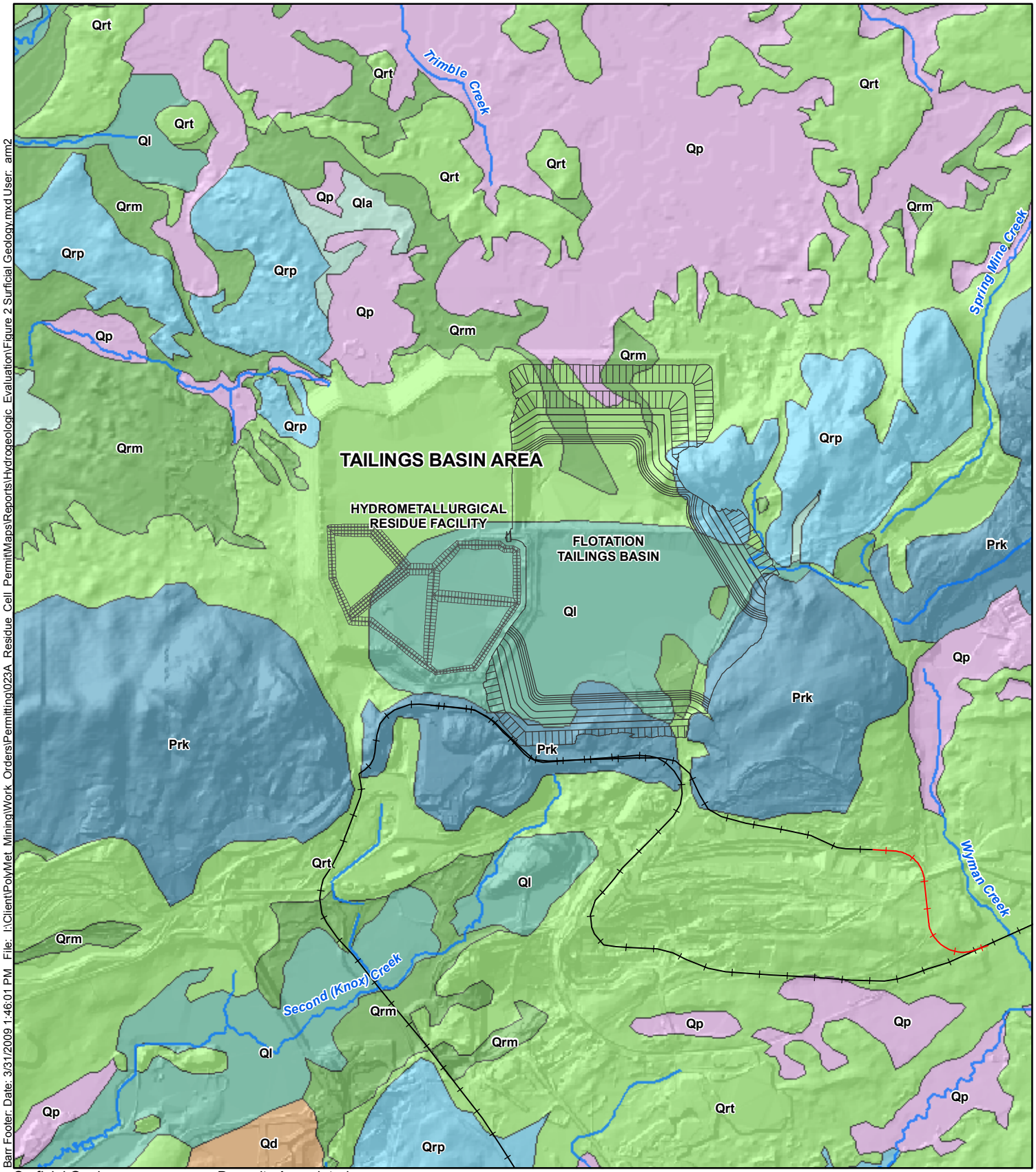
Barr Footer: Date: 3/31/2009 11:37:44 AM File: I:\Client\PolyMet Mining\Work Orders\Permitting\023A Residue Cell Permit\Maps\Reports\Hydrogeologic Evaluation\Figure 1 Site Layout.mxd User: arm2

Streams

4,000 2,000 0 4,000

Feet

Figure 1
SITE LAYOUT
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN



Barr Footer: Date: 3/31/2009 1:46:01 PM File: I:\Client\PolyMet Mining\Work Orders\Permitting\023A Residue Cell Permit\Maps\Reports\Hydrogeologic Evaluation\Figure 2 Surficial Geology.mxd User: arm2

Surficial Geology

Postglacial Deposits

- Qp Peat
- Ql Lake sediment

Deposits of Glacial-Age Lakes

- Qla Lacustrine sediment
- Qd Deltaic sediment

Deposits Associated with the Rainy Lobe

- Qrt Till
- Qrm Till
- Qrp Till, re-sedimented till, and sorted sediment

Mesozoic, Paleoproterozoic and Archean

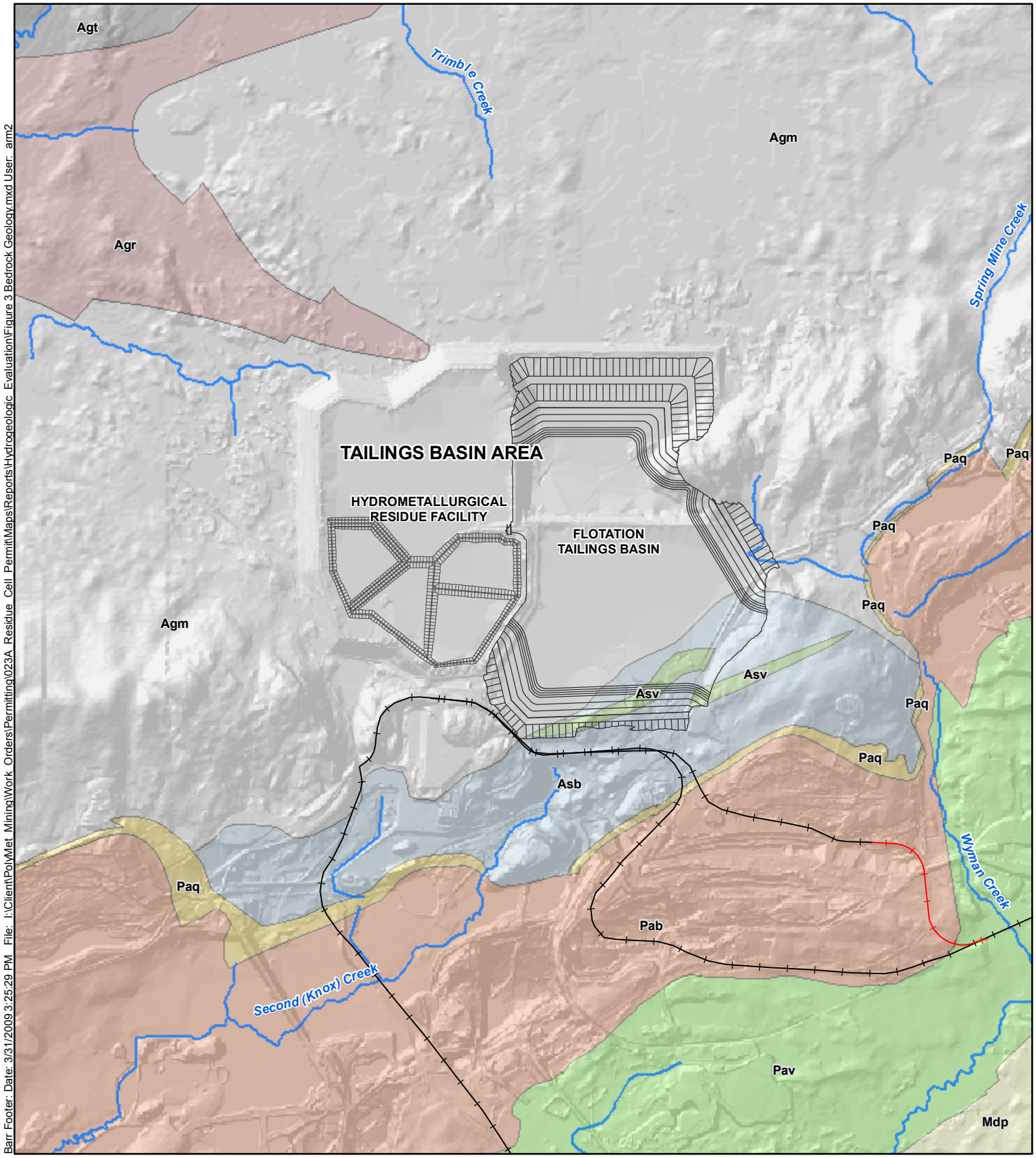
- Prk Bedrock at or near the surface

- Streams
- Proposed Railroad
- Existing Railroad

4,000 2,000 0 4,000

Feet

Figure 2
SURFICIAL GEOLOGY
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN



Barr Footer: Date: 3/31/2009 3:25:29 PM File: I:\Client\PolyMet Mining\Work Orders\Permitting\023A Residue Cell Permit\Maps\Reports\Hydrogeologic Evaluation\Figure 3 Bedrock Geology.mxd User: arm2

Bedrock Geology

Neoarchean-Giants Range batholith

- Agm — Quartz monzonite, monzodiorite
- Agr — Quartz monzonite, monzogranite
- Agt — Tonalite to granodiorite

Neoarchean-Other intrusive rocks

- Asb — Schist-sedimentary Protolith
- Asv — Schist-volcanic protolith
- Streams

Mesoproterozic-Duluth Complex

- Mdp — Partridge River Intrusion

Paleoproterozoic-Animikie Group

- Pab — Biwabik Iron Formation
- Paq — Pokegama Quartzite
- Pav — Virginia Formation, mudstone
- Proposed Railroad
- Existing Railroad

4,000 2,000 0 4,000

Feet

Figure 3
BEDROCK GEOLOGY
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN

NORTHWEST

CELL 2W

CELL 1E

SOUTHEAST

Tailings: including fine to coarse tailings and slimes

Till: 0 - 50' of discontinuous heterogeneous clayey to silty sand and some gravel and boulders. Peat often present.

Note: Bedrock shown at depth of 20' below till for presentation purposes.

1800
1750
1700
1650
1600
1550
1500
1450
1400

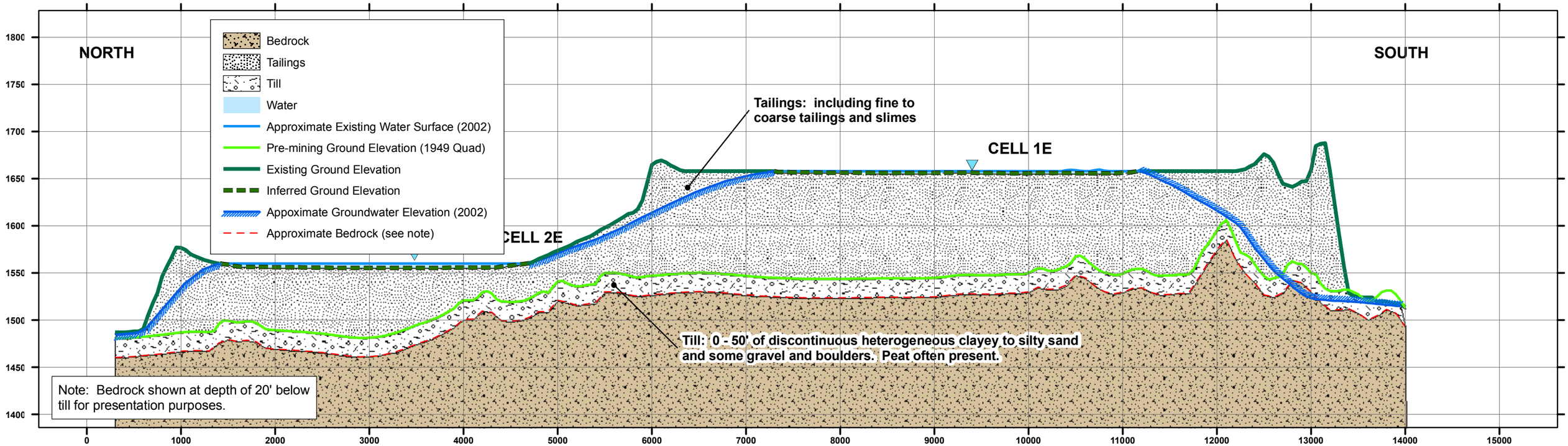
1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000

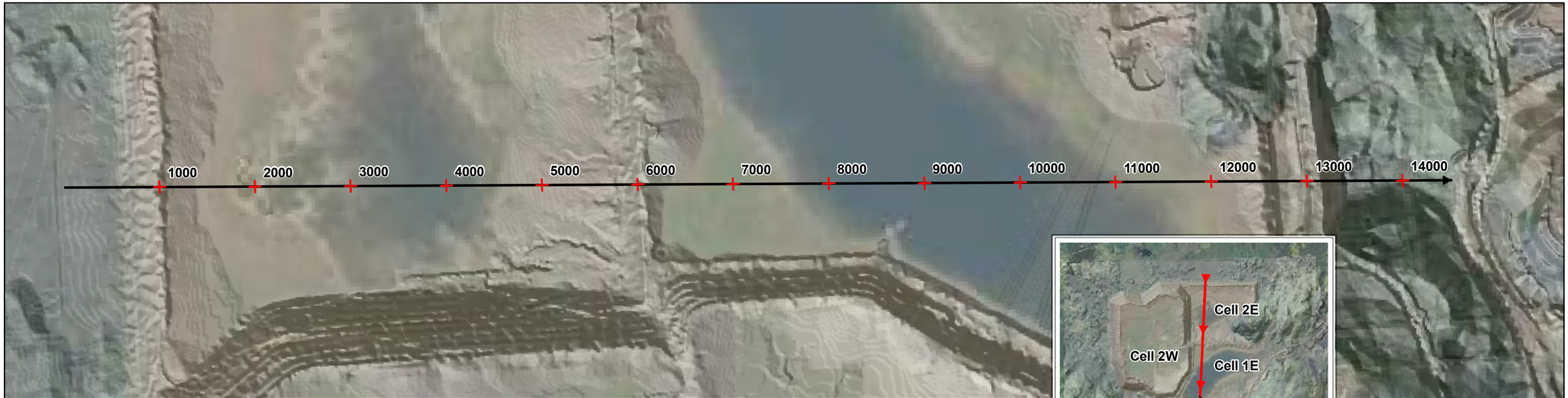
Bedrock
Tailings
Till
Water
Approximate Existing Water Surface(2002)
Pre-mining Ground Elevation (1949 Quad)
Existing Ground Elevation
Inferred Ground Elevation
Approximate Groundwater Elevation(2002)
Approximate Bedrock (see note)

Barr Footer: Date: 3/31/2009 12:11:09 PM File: I:\Client\PolyMet_Mining\Work_Orders\Permitting\023A_Residue_Cell_Permit\Maps\Reports\Hydrogeologic_Evaluation\Figure 4 West to East Profile of Tailings Basin.mxd User: arm2

1,000 500 0 1,000
Feet

Figure 4
WEST TO EAST PROFILE
OF TAILINGS BASIN
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN



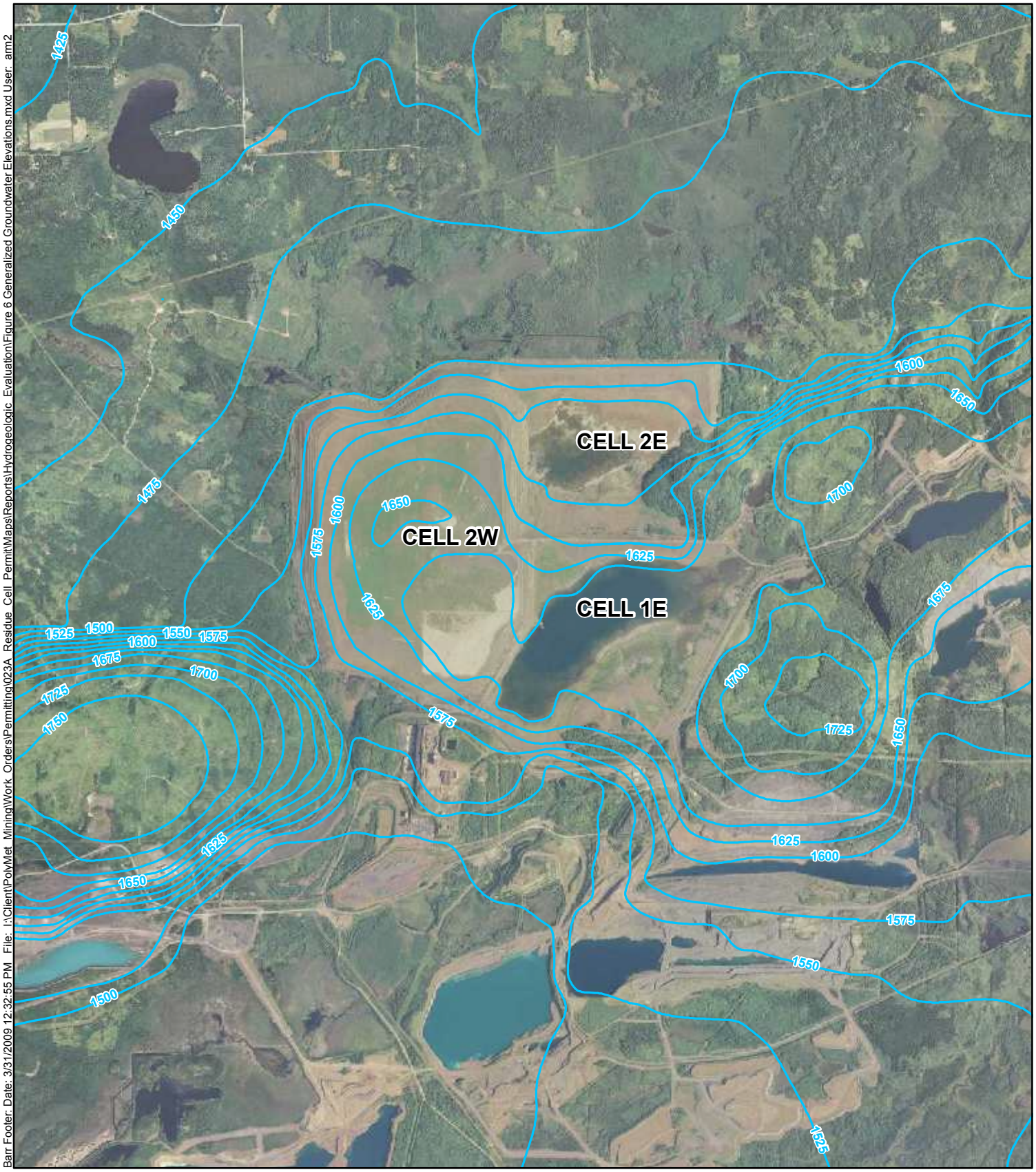


Barr Footer: Date: 3/31/2009 12:19:59 PM File: I:\Client\PolyMet_Mining\Work_Orders\Permitting\023A_Residue_Cell_Permit\Maps\Reports\Hydrogeologic_Evaluation\Figure 5 North to South Profile of Tailings Basin.mxd User: arm2

1,000 500 0 1,000

Feet

Figure 5
NORTH TO SOUTH PROFILE
OF TAILINGS BASIN
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN



Barr Footer: Date: 3/31/2009 12:32:55 PM File: I:\Client\PolyMet Mining\Work Orders\Permitting\023A Residue Cell Permit\Maps\Reports\Hydrogeologic Evaluation\Figure 6 Generalized Groundwater Elevations.mxd User: arm2

Groundwater Elevation Contour, Ft MSL
(Contour Interval = 25ft)

*Groundwater contours based on modeling results presented in RS13, elevation data for surface water features, and data presented in Siegel and Ericson, 1980.

4,000 2,000 0 4,000
Feet

Figure 6
GENERALIZED
GROUNDWATER ELEVATIONS
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN