Barr Engineering Company
4700 West 77th Street • Minneapolis, MN 55435-4803
Phone: 952-832-2600 • Fax: 952-832-2601 • www.barr.com *An EEO Employer*

Minneapolis, MN • Hibbing, MN • Duluth, MN • Ann Arbor, MI • Jefferson City, MO

# Memorandum

**To:** PolyMet Project File

**From:** Greg Williams; Mark Jacobson; Cheryl Feigum

**Subject:** Lined Tailings Basin Alternative - EIS Data Request

**Date:** April 8, 2008

**Project:** 23/69/-862-006-001

The purpose of this memorandum is to evaluate the potential for hydrologic impacts to the Embarrass River Watershed in general, and more specifically to the adjacent wetlands as a result of the lined Tailings Basin alternative. The existing Tailings Basin consists of three discrete cells: Cell 2W, Cell 1E and Cell 2E (Figure 1). Cells 1E and 2E contain water, while Cell 2W is drier. The existing Tailings Basin does not have an overflow or discharge structure. Under both the proposed and the alternative plans, tailings deposition will occur in Cell 1E and Cell 2E. At some point during operations, the two cells will merge and form a single cell, referred as Cell 2E/1E in this memorandum.

## I. Background

Figure 1 shows the location of the existing Tailings Basin within the Embarrass River Watershed. Although very little of the basin contributes direct runoff to the watershed, the majority of the seepage from the Tailings Basin flows north towards the Embarrass River. The portion of Cell 2E/1E that likely contributes seepage to the Embarrass River Watershed (referred to as the "Cell 2E/1E tributary area"; 1,050 acres) is shown on Figure 1. Seepage from the southern portion of Cell 2E/1E flows south, forming the headwaters of Second Creek (or Knox Creek).

Figure 1 shows a portion of the Embarrass River Watershed that is located between Cell 2E/1E and the Embarrass River (referred to as the "evaluation area"; ~3,900 acres). Within the evaluation area, wetlands comprise 2,500 acres, or more than 64 percent of the evaluation area (Figure 2). This evaluation area receives seepage from the Cell 2E/1E tributary area as surface seeps and groundwater recharge. In 2003, one year after the LTV Steel Mining Company (LTVSMC) ceased operation of the Tailings Basin, seepage from the Cell 2E/1E tributary area was estimated to be 700 gallons per minute (gpm; Adams et al., 2004[1]). This seepage rate includes the surface seeps located at the north end of the Tailings Basin and groundwater recharge from the Cell 2E/1E tributary area.

## II. Options for the Future Operation of Cell 2E/1E

Conceptually, there are three options for the future operation of Cell 2E/1E:

1) Option 1: If no future activity occurs in Cell 2E/1E (i.e., no PolyMet mine project), seepage to groundwater from Cell 2E/1E will decrease over time as the remaining pond water in the cells infiltrates and seeps out to the evaluation area. Eventually, the rate of seepage to the evaluation area will reach equilibrium with the rate of infiltration in Cell 2E/1E, which is estimated between 100 and 500 gpm (2 to 9 inches per year over the 1,050-acre Cell 2E/1E tributary area).

[1] The seepage rate was based on the Summer 2003 data which assumed that 100 percent of seepage from Cell 2E and 50 percent of seepage from Cell 1E discharges to the north.

2) Option 2: If Cell 2E/1E is operated under the proposed condition (i.e., an unlined Tailings Basin), the head in Cell 2E/1E will increase during the course of operations, resulting in a larger seepage to the evaluation area than currently exists. All surface seeps will be intercepted on the north side of Cell 2E/1E and recycled back into Cell 2E/1E. The rate of seepage to groundwater from Cell 2E/1E will fluctuate with the head in the pond area during operations, with Draft 03 of RS-13 predicting rates ranging from 1,400 to 2,700 gpm (Barr, 2007). Seepage rates during closure under Option 2 will depend on whether it is determined that a pond must be maintained in the Cell 2E/1E basin. If a pond is not maintained, the seepage from Cell 2E/1E will decrease over time similar to Option 1. If a pond is maintained, seepage rates in closure will remain similar to those predicted during operations, depending upon the size of the pond.

3) Option 3: If Cell 2E/1E is operated as a lined basin, as proposed in the alternative plan under assessment in this memorandum, seepage to groundwater from Cell 2E/1E will decrease over time, as the mound of water located within the basin dissipates, until a new equilibrium is established. The equilibrium rate of seepage to groundwater will be equal to the leakage rate through the basin liner, which will be less than the equilibrium rate for Option 1 discussed above. A conservative estimate of 0 gpm during operations was assumed for the analysis presented in this memorandum.

## III. Estimated Impacts to the Embarrass River Watershed

Future impacts to the hydrology of the Embarrass River Watershed were estimated using the predicted changes in net recharge. Net recharge is defined as precipitation minus evapotranspiration for the Embarrass River Watershed, which includes the evaluation area (~3,900 acres). For the Cell 2E/1E tributary area (1,050 acres), the net recharge was calculated as the total seepage to groundwater (surface seeps plus groundwater recharge) divided by the 1,050-acre area.

The total net recharge in the evaluation area and the Cell 2E/1E tributary area was calculated as the sum of the net recharge outside Cell 2E/1E plus the additional recharge originating in Cell 2E/1E distributed over the 4,950-acre area of interest (1,050 acres plus 3,900 acres). Net recharge values were reported as inches/year and acre-feet/day (calculated by multiplying the net recharge by the area of interest; Table 1). The total net recharge was evaluated for conditions prior to the Tailings Basin construction, existing conditions (defined here as 2003 conditions), and the three future operation options listed above.

### A. Pre-Tailings Basin Condition

The average net recharge in the Embarrass River Watershed is 9.9 inches/year, as calculated using Embarrass River streamflow data collected prior to the construction of the Tailings Basin. This net recharge value is applicable to the ~3,900 acres evaluation area (within the Embarrass River Watershed) and the 1,050 acres that later becomes Cell 2E/1E (Figure 1). This net recharge rate applied over the 4,950 acres between (and including) the area now occupied by Cell 2E/1E and the Embarrass River is equivalent to 11.2 acre-feet/day.

### B. Existing Tailings Basin Condition

The 9.9 inches/year average net recharge determined for the pre-Tailings Basin condition is likely still accurate for the ~3,900-acre evaluation area. The total rate of seepage to groundwater from the Cell 2E/1E tributary area is currently estimated to be 700 gpm. This seepage rate is equivalent to 12.9 inches of net recharge per year over the Cell 2E/1E tributary area. This rate represents an increase of 3 inches/year over the estimated pre-Tailings Basin condition. Distributed evenly across the area between (and including) Cell 2E/1E and the Embarrass River, this value represents an increase of 0.6 inches of net recharge per year (to a value of 10.5 inches/year) over pre-Tailings Basin conditions, or an increase of 6 percent. The net recharge for the existing conditions is equivalent to a flow of 11.9 acre-feet/day.

### C. Option 1: Future Tailings Basin Condition with no new Activities

If no new activity occurs in Cell 2E/1E, the seepage to groundwater from the Cell 2E/1E tributary area will reach an estimated equilibrium rate between 100 and 500 gpm. This range of predicted equilibrium rates of seepage to groundwater is equivalent to a net annual recharge rate of 2 to 9 inches/year over the tributary area of 1,050 acres. Distributed evenly over the 4,950-acre area, the decrease in Cell 2E/1E seepage to groundwater would result in total net recharge values ranging between 8.2 and 9.8 inches (decreases of 17 and 1 percent as compared to pre-Tailings Basin condition, and decreases of 22 and 7 percent as compared to existing conditions), respectively. The equivalent flow ranges from 9.3 to 11.1 acre-feet/day.

### D. Option 2: Future Operations under the Proposed Condition (unlined Tailings Basin)

The future proposed condition does not include a liner for Cell 2E/1E. During operations, the anticipated seepage to groundwater from Cell 2E/1E will increase. As the seepage rate from Cell 2E/1E increases to a rate higher than 700 gpm, the total recharge to the undisturbed area between Cell 2E/1E and the Embarrass River will be greater than the rate estimated for existing conditions (10.5 inches per year, or 11.2 acre-feet per day). The percent increase relative to the pre-tailings basin (more than 6 percent) and existing conditions (more than 0 percent) presented in Table 1 below will depend on the seepage losses from the basin. The maximum anticipated seepage rate from Cells 2E/ 1E will be 2,680 gpm (or 11.8 acre-feet per day).

### E. Option 3: Future Operations under the Alternative Condition (lined Tailings Basin)

The future alternative condition includes the lining of Cell 2E/1E, which will reduce the future seepage rate from the Cell 2E/1E tributary area during operations. To provide a conservative estimate for this analysis, the future seeepage rate was assumed to reach a minimum of zero during operations. Under this option, recharge to the evaluation area will be limited to the net recharge occurring outside the 1,050-acre Cell 2E/1E tributary area. The loss of the tributary area results in a lower equivalent annual net recharge of 7.8 inches/year (a 21 percent decrease from pre-Tailings Basin condition and a decrease of 26 percent from the existing condition). The equivalent flow will be 8.8 acre-feet per day.

**Table 1. Summary of Operating Options**

| Condition / Operating Option | Cell 2E Annual Net Recharge (inch/yr) | Area of Interest Net Recharge (inch/yr) | Equivalent Recharge Rate (acre-ft/day) | Equivalent Recharge Rate (gpm) | Rate relative to pre-Cell 2E/1E conditions (% change) | Rate relative to existing conditions (% change) | Steady state seepage rate for Cell 2E/1E (gpm) |
|---|---|---|---|---|---|---|---|
| Pre-tailings basin condition | --- | 9.9 | 11.2 | 2530 | --- | -6% | --- |
| Existing condition of Cell 2E/1E | 12.9 | 10.5 | 11.9 | 2700 | +6% | --- | 700 |
| Option 1: Future condition with no new activity in Cell 2E/1E (high range) | 9.2 | 9.8 | 11.1 | 2500 | -1% | -7% | 500 |
| Option 1: Future condition with no new activity in Cell 2E/1E (low range) | 1.8 | 8.2 | 9.3 | 2100 | -17% | -22% | 100 |
| Option 2: Future proposed condition of Cell 2E/1E (mine project with no liner) | >12.9 | >10.5 | >11.9 | >2750 | +>6% | +>0% | >700[1] |
| Option 3: Future alternative condition of Cell 2E/1E (mine project with liner) | ---[2] | 7.8 | 8.8 | 2000 | -21% | -25% | 0 |

[1]The unrecovered seepage from Cell 2E/1E will reach a maximum seepage rate of 2,680 gpm in Year 20.
[2]The liner reduces groundwater seepage to zero. Water discharging as surface seeps will be collected and recycled to Cell 2E/1E.

## IV. Potential Impacts on Wetland Hydrology

Although wetland hydrology is a function of many factors, the potential wetland impacts resulting from future changes in the Cell 2E/1E seepage rate will likely be proportional to the predicted changes in annual net recharge. Based on the ratio of the Cell 2E/1E tributary area to the evaluation area (1,050 acres: ~3,900 acres, or 1:4), the change in net recharge in the evaluation area will be approximately one-fourth the magnitude of the change in the Cell 2E/1E seepage to groundwater (e.g., if the seepage rate from Cell 2E/1E increases by 40 percent, the net recharge within the evaluation area will increase by 10 percent).

The analysis presented above implicitly assumes that net recharge is evenly distributed across a large area. Base flows in the Embarrass River suggest that groundwater recharge contributes less than 1 inch of the net recharge. The balance of the net precipitation is likely runoff into the 2,500 acres of wetlands located between Cell 2E/1E and the Embarrass River (Figure 2). In reality, changes in net recharge to the evaluation area are expected to be minimal for wetlands close to the Embarrass River and increase with proximity to Cell 2E/1E. In order to help better predict potential future wetland impacts, a review of historical photographs and on-site information was conducted. This information was used to assess impacts associated with the existing Tailings Basin and to help predict future impacts as a result of the proposed and alternative plans.

### A. Review of Historical Photographs

Wetland conditions were evaluated using historical aerial photographs (Historical Information Gatherers, Inc.) for the years 1940, 1948, 1961, 1972, 1981, 1989, 1999, 2003 and 2006 (select years are found in Figures 3, 4 and 5). The photographs were ortho-rectified using a common coordinate system (NAD 1983, Zone 15N) by aligning features which were common to all years including a northeast-to-southwest transmission line corridor, a north-to-south road that crosses the transmission line corridor and a few small lakes.

A review of the 1940 and 1948 photographs indicate the presence of large wetland complexes that were a mixture of forested and shrub scrub wetlands, which are primarily saturated to the surface with minimal open water areas (Figure 4). These types of wetland complexes are commonly found throughout northeastern Minnesota. Tailings were initially deposited north of the plant in the 1950s that included the area within ¾ to 1 mile north of the plant (in Section 5). The northernmost extent of the perimeter dams was established between 1961 and 1972 (in Section 32). In 1961, logging activities and associated roads are visible in this area. As the Tailing Basin became visible in 1961 (west cells) and 1989 (east cells), a ditch system was developed and later expanded (1981; 1989). By 1989, some forested wetlands adjacent to the Tailings Basin appear to be converting to scrub shrub and open water systems. The 2003 and 2006 aerial photographs show expanded areas where forested wetlands have been converted to shrub scrub wetlands (Figures 3 and 5). Dead trees were observed in some of these areas during a field review in November 2007, indicating a change in the hydrology of some wetlands (Figure 6).

### B. Historical and Current Wetland Impacts

Figures 3, 4, 5 and 6 identify areas that have changed over time based on a review of the historical photographs and field reviews. Changes that were noted between 1940 and 2007 include:

- Constructed areas on the north side of the Tailings Basins that include roads and parking areas;
- Areas adjacent to the north edge of the Tailings Basin and ditch system that have low quality vegetation (cattails, Phragmites, brome, etc.);
- Areas that have outflows from surface seeps, broken pipes or sediment plumes;
- Open water/inundated areas that were previously forested or shrub-scrub wetlands;
- Logging and associated roads; and
- Construction of the Tailings Basins.

## V. Conclusions

The wetlands north of the Tailings Basin have been receiving additional discharge from the Tailings Basin for more than 43 years. The review of the historic photographs, along with field reviews, indicates the greatest changes to the wetlands have occurred in the area adjacent to the Tailings Basins. In addition to infrastructure that has developed in the area (Tailings Basin, roads, etc.), beaver dams are common and also cause inundation of wetlands. Approximately 100 acres of wetlands within a 150-acre area located near the north edge of Cell 2E/1E have clearly been impacted by surface water seepage from the Tailings Basin and other modifications (Figure 3). These wetlands account for just over 4 percent of the wetlands in the evaluation area. Wetlands located further away from the Tailings Basin appear to have assimilated the hydrology changes over time and do not exhibit the obvious changes observed adjacent to the north edge of the Tailings Basin. Under Option 1 (no PolyMet mine project) and Option 3 (lined tailings basin), there will be a decrease in the Cell 2E/1E seepage rate (surface seepage and groundwater recharge) as compared to the existing conditions, however there should not be any additional impacted areas resulting from this decrease in seepage.

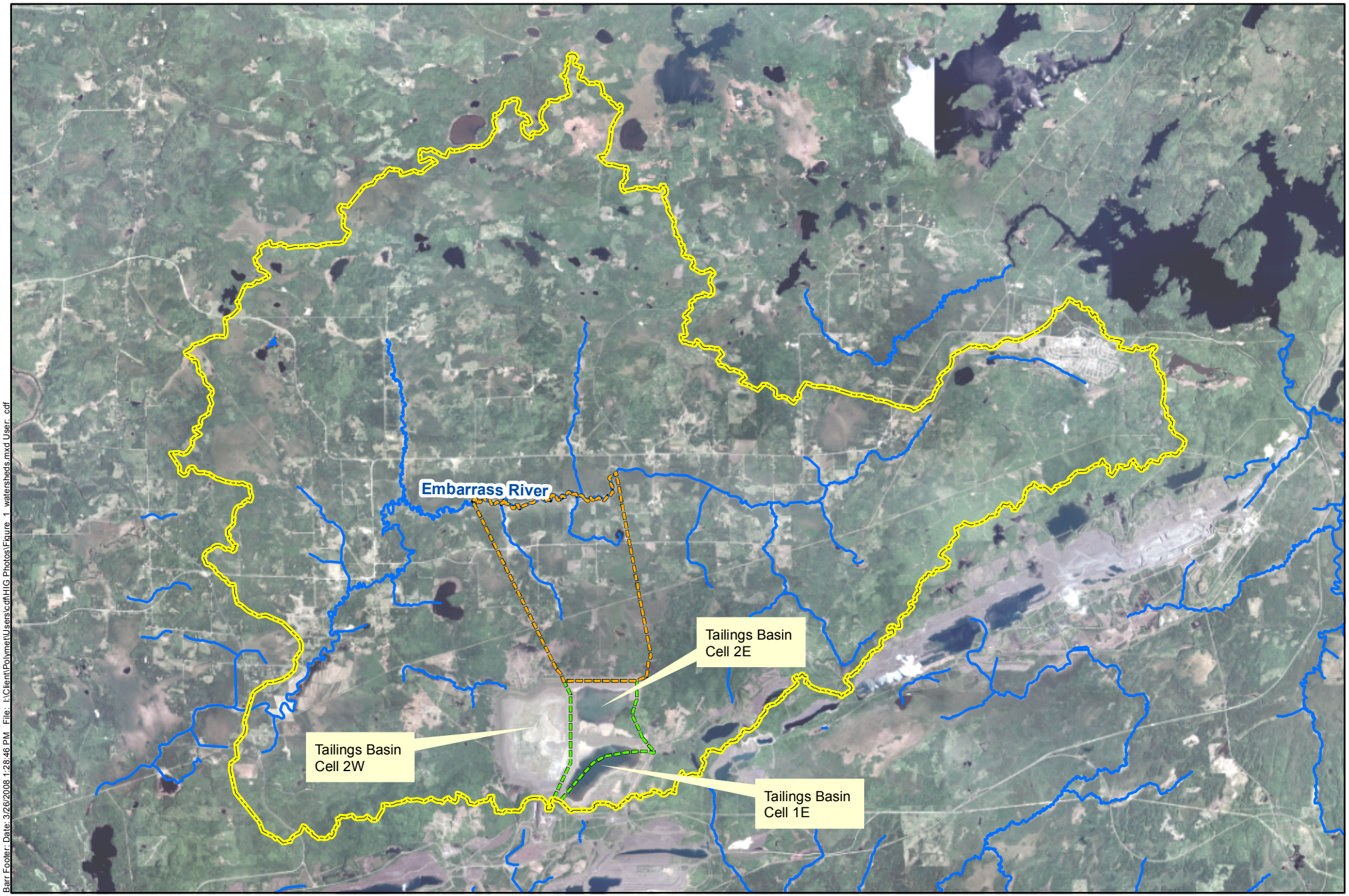
Under Option 2 (unlined tailings basin), the seepage rate to groundwater will increase to a predicted maximum of 2,680 gpm in Year 20. This predicted maximum rate is less than the estimated maximum historical seepage rate from Cell 2W of approximately 4,000 gpm (Draft-03 of RS13). The wetlands immediately adjacent to Cell 2W are visibly impacted from past mining activities, but with decreasing evidence of impacts in the areas further away from the Tailings Basin. Based on this information for Option 2, the wetland impacts north of Cell 2E/1E will continue to be observed adjacent to the north edge of Cell 2E/1E, however there should not be any additional impacts.

Based on the ratio of the Cell 2E/1E tributary area to the evaluation area (1:4), the changes in wetland hydrology are anticipated to be approximately 25 percent of the change in Cell 2E/1E seepage (measured as an equivalent net annual recharge). It is expected that future changes in the seepage rate from Cell 2E/1E would continue to primarily impact the same areas as have occurred in the past. Either one of the future scenarios presented (Tailings basin with or without liner) will change the steady state seepage rate. However, based on the information presented, no loss of wetland hydrology is expected in the 3,900-acre watershed beyond the impacts already documented.

## V. References

Adams, J.T., R.T. Leibfied and E.S. Herr. March 2004. *East Range Hydrology Project – Final Report.* Minnesota Department of Natural Resources. St. Paul.

Barr Engineering Company. November 16, 2007. *Tailings Basin and Hydrometallurigcal Residue Water Balance*. Appendix A to RS39/40T, RS13 Technical Detail Report, Draft-03. Prepared for PolyMet Mining, Inc.




Barr Footer: Date: 3/26/2008 1:28:46 PM File: I:\Client\PolyMet\Users\cdf\HIG Photos\Figure 1 watersheds.mxd User: cdf

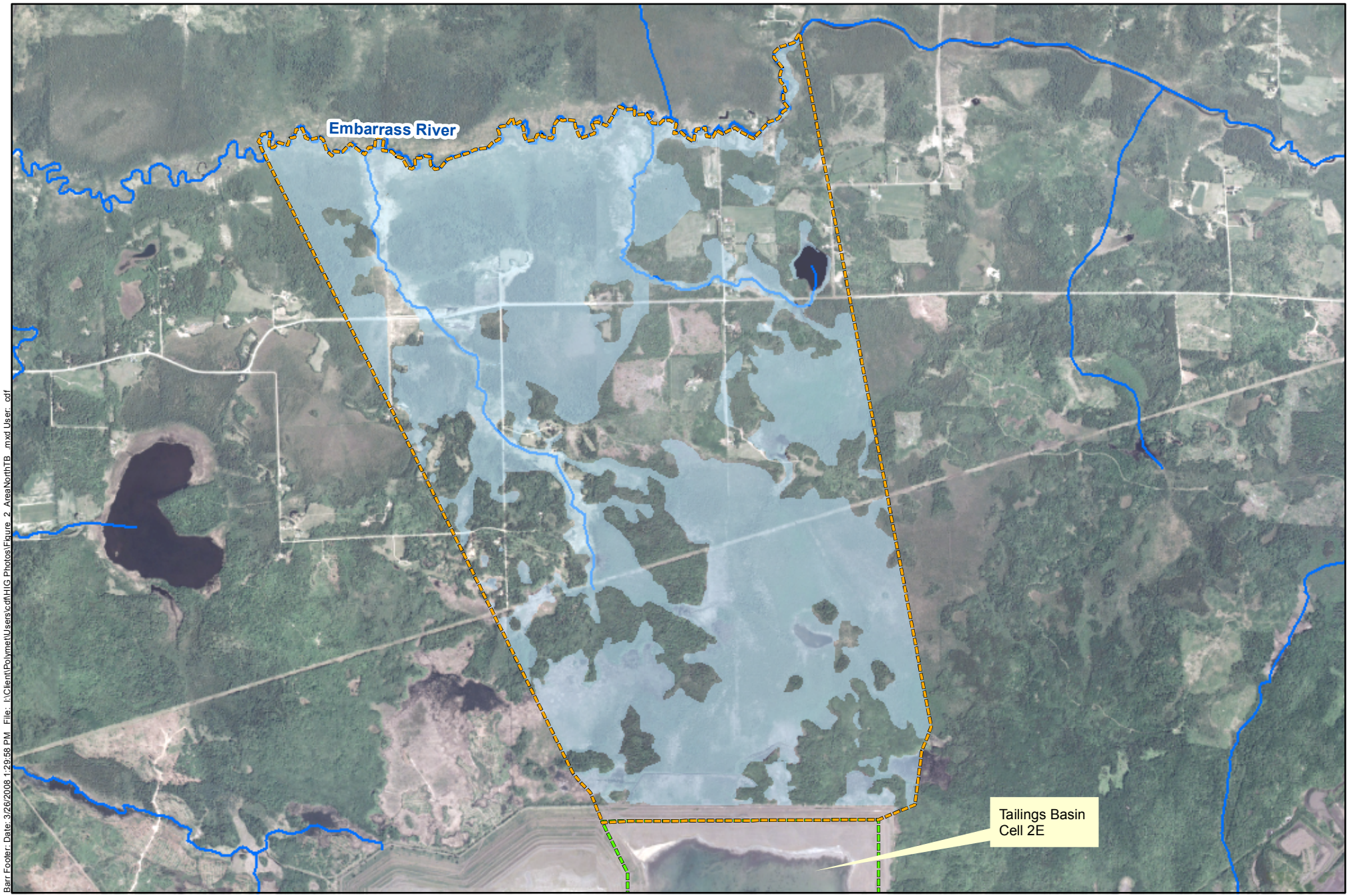
Embarrass River Watershed
Evaluation Area (~3,900 ac)
Cell 2E/1E Tributary Area (1,050 ac)
Streams and Rivers

0 0.5 1 2
Miles

2003 FSA Photograph (NAD 1983, Zone 15N)

Figure 1

LOCATION
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN




Barr Footer: Date: 3/26/2008 1:29:58 PM File: I:\Client\PolymetUsers\cdf\HIG Photos\Figure_2_AreaNorthTB_.mxd User: cdf

Evaluation Area (~3,900 ac)
Cell 2E/1E Tributary Area (1,050 ac)
Wetlands
Streams and Rivers

0 0.25 0.5 1 Miles

2003 FSA Photograph (NAD 1983, Zone 15N)

Figure 2

WETLANDS IN THE EVALUATION AREA
NorthMet Project
PolyMet Mining Inc.
Hoyt Lakes, MN

Ditch with open water and corresponding impacted areas adjacent to ditch

Flagged seep area with a noticeable plume that extends north into the wetland complex

Dead trees visible in this wetland area

Ditch with open water and corresponding impacted areas adjacent to ditch

Phragmites and cattails

Fill in corner of wetland

Phragmites and cattails adjacent to road

Phragmites and cattails along edge

Dead trees visible in this wetland area

Fill area

Sediment and fill areas with cattails in saturated/inundated areas

Brome in upland

Open water area and ditch

Open water area with fill between the open water and the road

Red colored seep areas flow into the open water areas of the alder wetland along the upland/wetland edge below lowest road

Two small isolated wetland areas that are impacted by sediment

Red colored seep area flow into the open water areas of the cedar swamp along the upland/wetland edge below lowest road

Phragmites and cattails adjacent to road

Barr Footer: Date: 3/26/2008 1:32:47 PM File: I:\Client\Polymet\Users\cdf\HIG Photos\Figure_3_impactedWetlands_Adj_mxd User: cdf

Evaluation Area (~3,900 ac)

Cell 2E/1E Tributary Area (1,050 ac)

Open Water Areas - 2003 Aerial Photograph

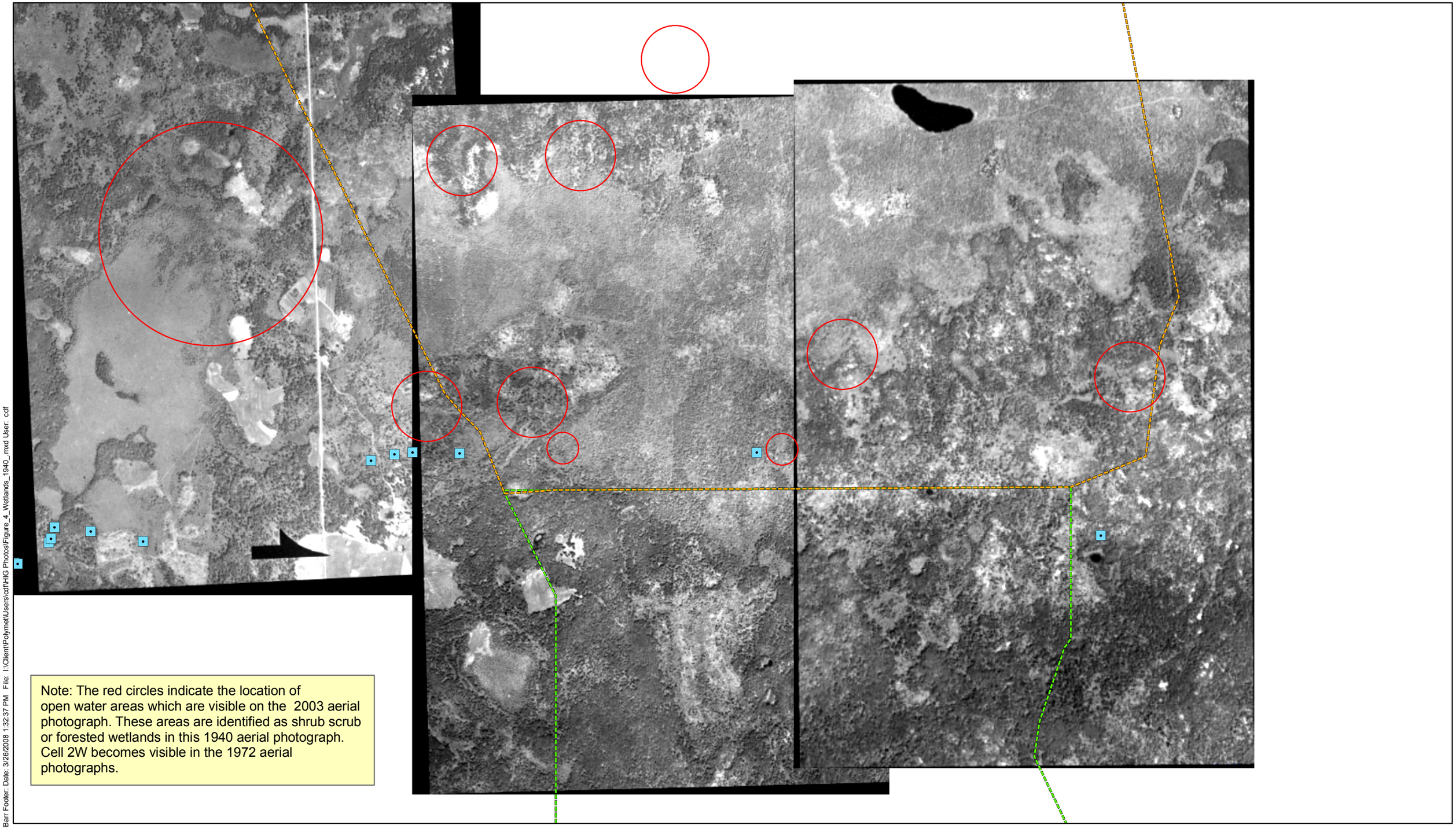
Surface Seep Areas - 2007

0 500 1,000 2,000 Feet

2003 FSA Photograph (NAD 1983, Zone 15N)

Figure 3

FIELD OBSERVATIONS - NOVEMBER 2007
2003 AERIAL PHOTOGRAPH
Tailings Basin 2E Alternative Analysis
PolyMet Mining Company
Hoyt Lakes, Minnesota



Note: The red circles indicate the location of open water areas which are visible on the 2003 aerial photograph. These areas are identified as shrub scrub or forested wetlands in this 1940 aerial photograph. Cell 2W becomes visible in the 1972 aerial photographs.

Evaluation Area (~3,900 ac)

Cell 2E/1E Tributary Area (1,050 ac)

Open Water Areas - 2003 Aerial Photograph

Surface Seep Areas - 2007

0 500 1,000 2,000 Feet

1940 HIG Photograph (NAD 1983, Zone 15N)

Figure 4

WETLAND STATUS - COMPARED TO 2003
1940 AERIAL PHOTOGRAPH
Tailings Basin 2E Alternative Analysis
PolyMet Mining Company
Hoyt Lakes, Minnesota

Barr Footer: Date: 3/26/2008 1:32:37 PM File: I:\Client\Polymet\Users\cdf\HIG Photos\Figure_4_Wetlands_1940_.mxd User: cdf

Evaluation Area (~3,900 ac)

Cell 2E/1E Tributary Area (1,050 ac)

Surface Seep Areas - 2007

0 500 1,000 2,000 Feet

2006 FSA Photograph (NAD 1983, Zone 15N)

Figure 5

WETLAND IMPACTS
2006 AERIAL PHOTOGRAPH
PolyMet Mining Company
Hoyt Lakes, Minnesota

Looking northwest along a sediment area on the north edge of the Cell 2E/1E.

Surface seep on the north edge of Cell 2E/1E.

Looking northeast at an open water wetland with dead trees indicating a change in hydrology.

Figure 6

PHOTOGRAPHS
November 2007