*Appendix B*

# *Underground Mining Alternative Assessment for the NorthMet Mining Project and Land Exchange Environmental Impact Statement*

# Underground Mining Alternative Assessment for the NorthMet Mining Project and Land Exchange Environmental Impact Statement

**Co-lead Agencies:**

Minnesota Department of Natural Resources

United States Army Corps of Engineers

United States Forest Service




**September 27, 2013**

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# 1.0 INTRODUCTION

Section 1502.14 of the National Environmental Policy Act requires that Environmental Impact Statements (EISs) examine all reasonable alternatives to the proposed project. The Council on Environmental Quality defines reasonable alternatives as those that are practical or feasible from technical and economic standpoints and use common sense (Council on Environmental Quality 1981).

Under the Minnesota Environmental Protection Act, an EIS shall compare the potentially significant impacts of the proposed action with other reasonable alternatives to the project. However, *Minnesota Rule* 4410.2300 states that an alternative may be excluded from analysis in the EIS if it would not meet the underlying need or purpose of the project (State of Minnesota 2009).

In the Draft Environmental Impact Statement (DEIS) for the NorthMet Project, the Minnesota Department of Natural Resources (MDNR) and United States Army Corps of Engineers considered underground mining as an alternative to the proposed open pit(s) (MDNR and United States Army Corps of Engineers 2009). This alternative was eliminated because an underground mine would have a significantly reduced rate of operation that would not be considered economically feasible, and, therefore, would not meet the Purpose and Need of the NorthMet Project.

Following tribal and public comment on the DEIS, the Co-lead Agencies, who now include the United States Forest Service, reconsidered underground mining as an alternative to the NorthMet Project in preparation of a Supplemental Draft Environmental Impact Statement (SDEIS). This position paper provides an overview of the alternative screening process undertaken and the decision on whether to undertake a full evaluation of underground mining as an alternative in the SDEIS.

## *1.1 PURPOSE OF ASSESSMENT*

Following its elimination from further consideration in the DEIS, tribal and public comments on the DEIS, as well as discussions during scoping of the Land Exchange, suggested the Co-lead Agencies reconsider underground mining as an alternative in the SDEIS.

The main reasons for reconsideration provided by the public and Bands were:

- the environmental benefits of underground mining compared to open pit mining, and
- that underground mining could be undertaken without the need for a Land Exchange.

## *1.2 ASSESSMENT MATERIAL*

The information in the following subsections was used to inform a semi-qualitative screening analysis of the alternative. A detailed underground mine plan was not developed because PolyMet Mining Corporation (PolyMet) made the business decision to eliminate underground mining as a possible mining method at the NorthMet Deposit based on information that indicated it would not be economically feasible. Therefore, it was not possible to undertake a quantitative, side-by-side assessment of the underground mining alternative.

### 1.2.1 United States Steel

In the 1970s, the NorthMet Deposit was investigated by United States Steel (U.S. Steel) to evaluate the potential to mine the deposit using underground methods. The MDNR reviewed documentation relating to the U.S. Steel investigation (Patelke and Severson 2005; PolyMet 2007) and found the following was concluded by U.S. Steel:

- mineralization at the NorthMet Deposit was below the expected grades, and
- metallurgical technology available at that time was not sufficient to produce separate, distinct nickel and copper concentrates.

Consequently, the U.S. Steel information alone was not indicative of the potential economic viability of underground mining for the NorthMet Project.

### 1.2.2 PolyMet

PolyMet, through its consultant (Foth Infrastructure & Environment, LLC), assessed the economic feasibility of underground mining at the NorthMet Deposit based on the proposed open pit deposit (Foth 2012). The findings of this assessment are included in the *Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project*, included with this paper as Attachment 1. A supplemental memorandum was also prepared by Foth to provide further information on the boundaries and model used in the analysis (Foth 2013). This memorandum, *Response to USEPA Questions Regarding: Economic Assessment of Underground Mining Report Dated October 2012*, is provided with this paper as Attachment 2. The information provided by PolyMet was reviewed by technical staff at the MDNR and was determined to be sufficient for a screening-level review of the feasibility of underground mining at the NorthMet Deposit.

# 2.0 SCREENING OF THE UNDERGROUND MINING ALTERNATIVE

The underground mining alternative for the NorthMet Project was reconsidered for the SDEIS using the same screening criteria as in the DEIS. The screening criteria were used to determine if the alternative would:

- offer significant environmental and/or socioeconomic benefits (over the Proposed Action or other alternatives),
- be available (legally, through surface access and mineral rights),
- be technically feasible (physically possible to construct and underground mine),
- be economically feasible (provide sufficient income to cover: operating, capital, and other costs with an adequate return to investors), and
- meet the Purpose and Need for the project.

The alternative would need to meet all of these criteria to merit further evaluation in the SDEIS. Evaluations of the underground mining alternative against each of the screening criteria are presented in the following subsections.

## *2.1 SIGNIFICANT ENVIRONMENTAL AND/OR SOCIOECONOMIC BENEFITS*

Compared to the proposed open pit mine, the underground mining alternative would offer some significant environmental benefits, including:

- fewer direct effects on surface resources, including wetlands;
- less mine dewatering and, therefore, less water to be managed;
- less waste rock, which would result in:
  - a smaller surface footprint; and
  - reduced effects on surface water and groundwater.
- less ore mined at a slower rate, which would result in:
  - less tailings and hydrometallurgical residue to be managed;
  - fewer effects on surface water and groundwater; and
  - reduced air emissions from mining, transporting, and processing the ore, and constructing the Tailings Basin and Hydrometallurgical Residue Facility.

However, compared to the proposed open pit, an underground mining alternative for the NorthMet Deposit would have a reduced mining rate and life of mine. Consequently, a smaller mining operation would employ fewer workers for a shorter period of time, and would also reduce tax revenues to the state and localities (refer to Section 2.4, Economic Feasibility). Thus, the underground mining alternative would reduce the socioeconomic benefits, as compared to the proposed open pit.

Although the underground mining alternative would offer environmental benefits, it would result in reduced socioeconomic benefits. Additionally, because an underground mine at the NorthMet Deposit would not be profitable (refer to 2.4 Economic Feasibility), a for-profit company like PolyMet would not move forward with the project, thus any potential environmental or socio-economic benefits associated with this alternative are moot.

## *2.2 AVAILABILITY*

Minerals are available for PolyMet to mine at the NorthMet Deposit through private mineral lease agreements. Surface use could be available through the Land Exchange or other United States Forest Service approvals if an underground mining alternative were deemed viable and adopted by PolyMet.

The underground mining alternative is available at the NorthMet Deposit.

## *2.3 TECHNICAL FEASIBILITY*

Technical feasibility considers whether or not it would be physically possible to create an underground mine at the NorthMet Deposit, disregarding economic feasibility and other considerations.

The NorthMet Deposit is a shallow, large-tonnage, low- to medium-grade mineral resource. Such deposits typically require backfilling, if mined using underground methods, to prevent caving. PolyMet considers that the following methods of underground mining could be technically possible at the NorthMet Deposit:

- Long-hole open stoping (backfilled). This involves the development of large stopes or caved rooms within a steeply dipping orebody. Caving is accomplished by long drill holes and blasting to collection shoots below.
- Short-back open stoping (backfilled). This is similar to long-hole open stoping, but smaller-caved stopes are created within a moderately dipping ore deposit.
- Room and pillar (backfilled). This involves mining the ore deposit (steep or shallow dipping) in tabular layers, with pillars of ore left in place to support the roof (hang wall). Rooms are created by drilling horizontally, blasting, and rubber tired hauling away.
- Mechanized cut and fill (backfilled). This is similar to room and pillar, except that no pillars are left behind. Instead, backfill sand or rock is placed during mining to support the roof.

The underground mining alternative is technically feasible for the NorthMet Deposit.

## 2.4 ECONOMIC FEASIBILITY

Economic feasibility is based on the balance of costs and profit margins against the value of the mineable material. Since PolyMet is a private sector and for-profit company, the value of the saleable material would need to provide sufficient income to cover operating cost (which includes, but is not limited to, the cost of mining, processing, transportation, and waste management), capital cost (to build and sustain facilities), an adequate return to investors, reclamation, and closure costs and taxes.

While low-confidence mineralization is known to extend along the strike beyond the proposed open pit outline, this material has not been evaluated in detail, there is no mine plan for it, and it is not included as part of the proposed NorthMet Project. A mine plan has only been developed for the proposed open pit. The following discussion is based on qualitative information and the experience of PolyMet and its consultants.

### 2.4.1 Mineralization at the NorthMet Deposit

The NorthMet Deposit is considered to be a near-surface, bulk, low-grade mineralization of copper, nickel, cobalt, platinum, palladium, and gold. The contained metal value of mineralization at the NorthMet Deposit has been modeled with a high level of confidence in the area proposed to be mined as part of the NorthMet Project (20 year open pit), and with lower confidence beyond the proposed open pit outline. The metal prices used in calculating the contained metal values (dollars per ton) at the NorthMet Deposit for this assessment are listed below:

- Copper = $3.56 per pound,
- Nickel = $9.47 per pound,
- Cobalt = $11.69 per pound,
- Platinum = $1,689 per troy ounce,
- Palladium = $684 per troy ounce, and
- Gold = $1,485 per troy ounce.

These metal prices were calculated on June 30, 2012, and are consistent with the National Instrument 43-101 reporting standard that is used for public disclosure of information relating to mineral properties on bourses supervised by the Canadian Securities Administrators.

For each specific pre-extraction tonnage, an *in situ* average net metal value per ton was calculated based on the grade of ore and accounting for reasonable dilution and extraction losses (refer to Section 2.3, Technical Feasibility). Results showed that there is a generally linear relationship between the total cumulative tonnage of material and its average net metal value (Figure 1)—i.e., there is progressively less material available at higher net metal values. There are 85,614 short tons (cumulative) that have an average net metal value of $96.77 per short ton, and 227,017,162 short tons (cumulative) that have an average net metal value of $33.18 per short ton.

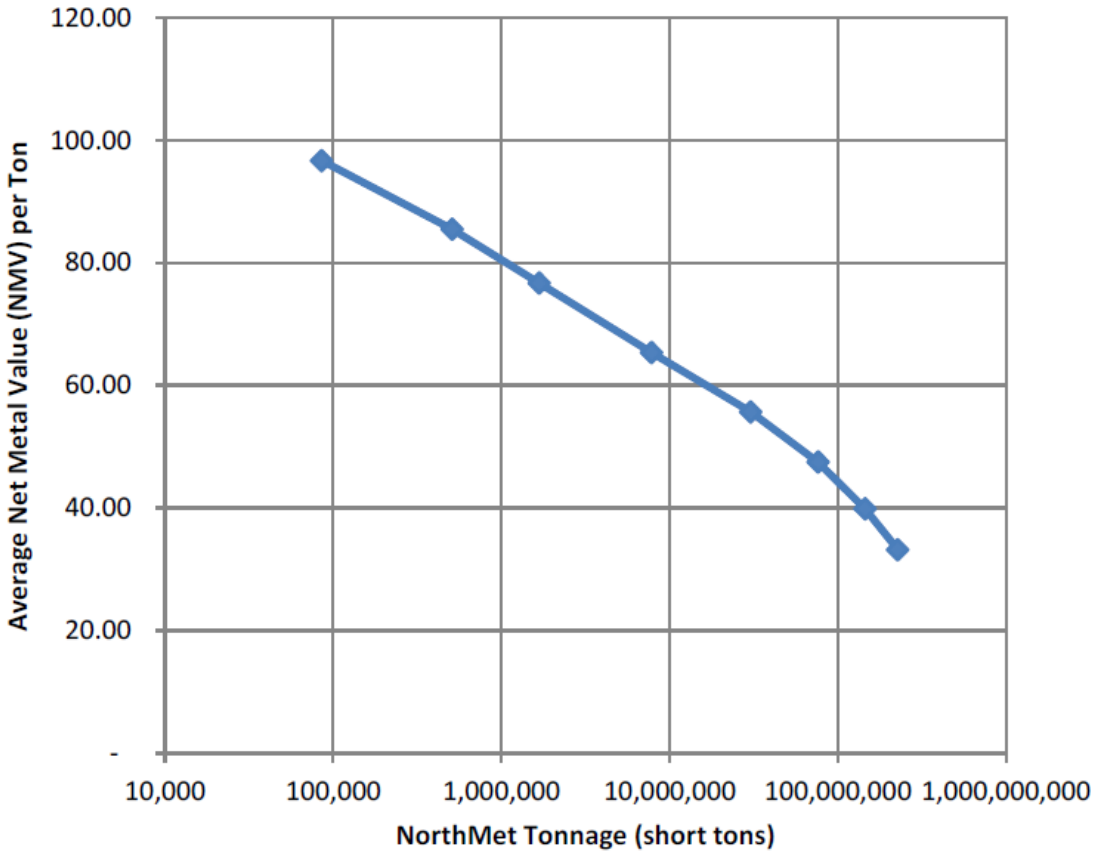


***Figure 1 Tonnage vs. Average Net Metal Value***

Using underground mining would result in most of the NorthMet Deposit left unmined because of its low metal value (i.e., less value than the cost of mining and mineral processing). Other material would have to be left in place for safety reasons, to prevent collapse. The underground rate of extraction for mining with backfilling is typically between 90 and 99 percent. PolyMet assumed a 95 percent rate of extraction for its economic assessment of the underground mining alternative. Mined ore could also be diluted between 5 and 30 percent by waste rock, as a result of overblasting and blending at ore-to-waste boundary lines. A dilution of 5 percent was used by PolyMet for the economic assessment of underground mining.

### *2.4.2 Underground Mining Costs*

The estimated operating and capital costs vary depending on the rate and method of mining and processing. For the purpose of the economic assessment, PolyMet estimated operating costs and pre-production capital costs for underground mining and mineral processing at the NorthMet Deposit based on published cost models that were validated by comparable projects and mines (Table 1).

***Table 1 Estimated Costs for an Underground Mine at the NorthMet Deposit***

| Tons per Day | Operating Mining and Mineral Processing Cost per Ton ($) | Pre-production Capital Costs ($ million) |
|---|---|---|
| 2,000 | 74 | 125 |
| 5,000 | 56.5 | 200 |
| 7,500 | 49 | 250 |
| 10,000 | 48.5 | 300 |
| 15,000 | 47 | 400 |

### *2.4.3 Economic Feasibility*

Based on an optimal formula, the productive life of an underground mine was determined for increments of tonnages, from fewer than 4 million to 100 million tons. From these numbers, the daily rate of production was calculated. The net metal value of that extracted material was calculated based on the average metal value for that tonnage minus 5 percent royalty costs that would apply at the NorthMet Deposit. To estimate the total operating cost, the extracted tonnage was multiplied by the total operating cost per ton. To calculate the life-of-mine profit balance, the total costs were subtracted from the net value of the mined material (Table 2).

***Table 2 Economic Assessment of a Sample of Underground Mining Scenarios Considered***

| Extracted Tonnage (million short tons) | Net extracted net metal value ($ million) | Tons per Day | Productive Life of Mine (years) | Total Operating Cost ($ million) | Pre-production Capital Costs ($ million) | Profit: Metal Value – Costs ($ million) |
|---|---|---|---|---|---|---|
| 5 | 302 | 2,000 | 7 | 370 | 125 | -$193 |
| 20 | 1,077 | 5,000 | 11 | 1,130 | 200 | -$253 |
| 30 | 1,552 | 7,500 | 11 | 1,470 | 250 | -$168 |
| 50 | 2,386 | 10,000 | 14 | 2,450 | 300 | -$364 |
| 100 | 4,143 | 15,000 | 18 | 4,700 | 400 | -$957 |

Results show that for all tonnages the net profit is negative—i.e., underground mining is not economically feasible for the NorthMet Deposit.

## *2.5 PURPOSE AND NEED*

The Purpose and Need of the NorthMet Project (Attachment 3) includes the ability to extract and process metals in a technically and economically feasible manner that generates sufficient income to cover: operating costs, capital costs, an adequate return to investors, reclamation, and closure costs and taxes.

Preliminary economic screening undertaken by PolyMet determined that the sale of metal precipitates and concentrates produced from an underground mining alternative would not be economically feasible to meet the requirements of the Purpose and Need. Because of this, the alternative was eliminated from further evaluation and a site-specific engineered underground mine plan was not developed.

The underground mining alternative does not meet the Purpose and Need for the project.

# 3.0 CONCLUSION

Alternatives need to meet all of the screening criteria to merit further evaluation. The summary of the screening results for the underground mining alternative are shown in Table 3.

The Co-lead Agencies found that while underground mining is technically feasible, available, and would offer significant environmental benefits over the proposed NorthMet Project, it would not be economically feasible and would not meet the Purpose and Need.

Since the underground mining alternative would not meet all of the screening criteria, it is not considered to be a reasonable alternative. Therefore, the underground mining alternative was eliminated from further evaluation in the SDEIS.

***Table 3 Underground Mining Alternative Screening Table***

| **Potentially Offer Significant Environmental or Socioeconomic Benefits?** | **Available?** | **Technically Feasible?** | **Economically Feasible?** | **Meets the Purpose and Need?** |
|---|---|---|---|---|
| Yes* | Yes | Yes | No | No |

*The underground mining alternative would offer significant environmental benefits, but would offer reduced socioeconomic benefits.

# REFERENCES

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# ATTACHMENTS

Attachment 1 Foth 2012, Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project

Attachment 2 Foth 2013, Memorandum: Response to USEPA Questions Regarding: Economic Assessment of Underground Mining Report Dated October 2012

Attachment 3 NorthMet Project and Land Exchange Purpose and Need Statement

# Attachment 1
# Foth 2012, Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project

Report

# Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project

**Project I.D.: 12P778**

**Poly Met Mining, Inc.**
**St. Paul, Minnesota**

**October 2012**


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# Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project

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Figure 3 Tonnage Versus Average Net Metal Value per ton for the NorthMet Deposit

# Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project

## Executive Summary

This report assesses the prospects of the economic viability of extracting any portion of the NorthMet deposit by underground mining. While a Canadian National Instrument 43-101 (NI 43-101) compliant mineral resource has been published for NorthMet on the basis of open-pit mining, no mineral resource has been defined for NorthMet on the basis of underground mining. This report has been prepared to provide information to agencies preparing the Environmental Impact Statement (EIS) for the NorthMet Project, in order to help them comply with National Environmental Policy Act (NEPA) and Minnesota Environmental Policy Act (MEPA) by adequately considering alternative mine development methods, such as underground mining.

There is no prospect of economically viable extraction of a portion of the shallow large tonnage low-to-medium grade NorthMet deposit by underground mining based on the analysis in this report. The tonnage/volume and grade (amount of metals) of rock within the NorthMet deposit does not generate enough revenue to pay for all costs associated with underground mining. The analysis of economic viability demonstrates that the value of metals per ton of rock, using metal prices defined in 2012, is too low to cover reasonable total operating costs and total pre-production capital costs, defined by cost models, resulting in a negative operating profit (operating loss) or a negative project profit (capital loss). Underground mining is not economically viable for the NorthMet project which is consistent with early studies at NorthMet, general rules for assessment of economic viability and similar mining operations elsewhere.

## List of Abbreviations, Acronyms, and Symbols

| | |
|---|---|
| AGP | AGP Mining Consultants |
| CIM | Canadian Institute of Mining, Metallurgy and Petroleum |
| EIS | Environmental Impact Statement |
| Foth | Foth Infrastructure & Environment, LLC |
| MEPA | Minnesota Environmental Policy Act |
| MSL | Mean Sea Level |
| NEPA | National Environmental Policy Act |
| NI | National Instrument |
| Poly Met | Poly Met Mining, Inc. |
| SEC | Securities and Exchange Commission |
| SEDAR | System for Electronic Document Analysis and Retrieval |

# 1 Introduction

NorthMet is a large tonnage and low-to-medium grade polymetallic copper-nickel-cobalt-palladium-platinum-gold deposit hosted by thick intrusive rocks located in St. Louis County in northeastern Minnesota (Poly Met, 2007). The concentration of metals occurs in four broadly defined horizons dipping between 15o to 25o to the southeast as determined by data from drill holes. Figure 1 shows the location of the deposit within the open-pit projected upwards to the surface. NorthMet was discovered in 1969 and early studies concluded that the tonnages and grades were not high enough to support underground mining. Subsequent work by Poly Met Mining, Inc. (Poly Met) has led to a delineated polymetallic mineral resource capable of being extracted by open-pit mining. The purpose of this report is to answer the question: Is there a prospect of economically viable extraction of a portion of the NorthMet deposit by underground mining?

## 1.1 Definition of a Mineral Resource

Poly Met's parent company, PolyMet Mining Corp., is a Canadian company and, therefore, reports under Canadian securities guidelines. Regulations and guidelines associated with National Instrument (NI) 43-101 establish the reporting standards of a mineral resource by a public Canadian company to the Canadian Securities Administrators.

While there are similarities between Canadian and U.S. reporting, there is an important distinction between the two standards for reporting resources and reserves. Poly Met's filings in the U.S. include the following cautionary note: the terms "measured and indicated mineral resource", "mineral resource", and "inferred mineral resource" used in this Management Discussion and Analysis are Canadian geological and mining terms as defined in accordance with NI 43-101, Standards of Disclosure for Mineral Projects (NI 43-101) under the guidelines set out in the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Standards on Mineral Resources and Mineral Reserves. U.S. investors are advised that while such terms are recognized and required under Canadian regulations, the Securities and Exchange Commission (SEC) does not recognize these terms. Mineral resources do not have demonstrated economic viability. It cannot be assumed that all or any part of a mineral resource will be upgraded to mineral reserves. Under Canadian rules, estimates of inferred mineral resources may not form the basis of or be included in feasibility or other studies. U.S. investors are cautioned not to assume that any part of an inferred mineral resource exists, or is economically or legally mineable. The terms mineral resources and reserves as used in this report conform to the definitions contained in NI 43-101. Mineral resources are not reserves and do not have demonstrated economic viability. Reserves are contained within the envelope of "measured" and "indicated" mineral resources. All economic calculations are done in U.S. Dollars.

NI 43-101 regulations and associated guidelines define a mineral resource as a concentration or occurrence of metals "in such form and quantity and of such a grade that it has reasonable prospects for economic extraction" (CIM, 2010). The reasonable

prospect of economically viable extraction is determined by the total cost of extraction as compared to the total extractable value of the ore. The cost of extraction depends on, among other costs, the cost of mining and mineral processing. Since the cost of open-pit mining is considerably lower than the cost of underground mining, it is common that an economically viable open-pit mineral resource cannot be viably extracted by underground mining due to the higher cost of underground mining. Thus, a concentration of metals classified as a mineral resource under NI 43-101 by open-pit mining is not a mineral resource by underground mining unless proven to have a reasonable prospect of economically viable extraction by that mining method.

Those concentrations with a prospect for economically viable extraction are subdivided into three classifications on the basis of geological confidence. A "measured" mineral resource is "so well established that they can be estimated with confidence sufficient to allow the appropriate application of technical and economic parameters, to support production planning and evaluation of the economic viability of the deposit" (CIM, 2010). An "indicated" mineral resource is less well characterized but, is sufficiently characterized to support evaluation of economic viability. An "inferred" mineral resource is only reasonably assumed to exist and since it is not sufficiently characterized it "must be excluded from estimates forming the basis of feasibility or other economic studies" (CIM, 2010).

The amount of geological data, the geological and grade continuity, and the mining method are factors (and others) in classifying a mineral resource as "measured", "indicated", or "inferred". An open-pit mineral resource classified as "measured" or "indicated" or "inferred" may be classified differently on the basis of underground mining. Since generally more data are needed to characterize an underground mineral resource, the degree of confidence is more likely to be lower on the basis of underground mining.

Poly Met has defined an open-pit mineral resource at NorthMet and has subdivided this open-pit resource into "measured", "indicated", and "inferred" categories (Poly Met, 2007). Since the cost of open-pit mining is considerably lower than the cost of underground mining, there is no reason to assume that any of this open-pit mineral resource has a reasonable prospect of economically viable extraction by underground mining. No underground mineral resource has been defined at NorthMet.

Although the NorthMet open-pit mineral resource includes "measured", "indicated", and "inferred" levels of geological confidence, one cannot assume that any of these resources would be classified at the same level with respect to underground mining. Using "measured" and "indicated" mineral resources classified on the basis of open-pit mining for economic assessment of underground mining will result in an optimistic economic assessment when underground mining criteria are applied.

## 1.2 Mining of Shallow Large Tonnage Low-to-Medium Grade Deposits

Shallow large tonnage low-to-medium grade deposits are typically mined by open-pit methods. Underground mining of low-to-medium grade materials may not be economically viable because of the much higher cost of extracting the rock by underground mining methods as compared to open-pit mining methods. Economic viability considerations would lead to only the higher grade sections of the open-pit resource being mined via underground mining methods leaving behind lower grade materials that could otherwise be utilized. From a socio-economic perspective, the value of the material left behind is lost. For comparison, Kevista Mine is a large tonnage and low-to-medium grade polymetallic copper-nickel-cobalt-palladium-platinum-gold deposit hosted by thick intrusive rocks in Finland and scheduled for production in 2012 (First Quantum, 2011). The tonnage and grades are similar to NorthMet and the Kevista mineral resource will be extracted using open-pit mining. While mineralized rock at Kevista extends below the open-pit, future extraction of it is speculative.

## 1.3 Disclaimer

This report relies upon information provided by Poly Met, AGP Mining Consultants (AGP), and publically available documents. The assessment of the prospects for economically viable extraction utilizes simplifications, generalizations, assumptions, and qualifications within the scope of the assignment and is believed to be substantially correct. While NI 43-101 reports are relied upon and referred to in this report; this independent report is not a NI 43-101 technical report.

# 2 Boundaries of the NorthMet Resources

The boundaries of the open-pit mineral resource as defined by NI 43-101 compliant technical report (Poly Met, 2007) are the same boundaries that will be used to assess the prospects of economic viability of extraction by underground mining (Figure 1). This underground evaluation will use “measured” and “indicated” open-pit mineral resources even though these may be an over statement of the sufficiently characterized volume/tonnage of mineralized rock with respect to underground mining or, in other words, using open-pit defined resource numbers may result in an overly optimistic economic assessment. “Inferred” open-pit mineral resources are excluded from this economic assessment. *The term NorthMet deposit used in this report will refer to NI43-101 compliant measured and indicated mineral resources within the open-pit.*

There is mineralized rock outside of the volume of rock contained within the proposed open-pit. This mineralized rock occurs below the open-pit. While this mineralized rock is excluded from this report, speculatively it may be possible for it to be economically viable to extract decades in the future. Only approximately 10% of the measured and indicated resource is below the open-pit (Poly Met, 2007). The majority of inferred resource defined by Poly Met (2007) is below the open-pit. There is a lack of geological data to characterize the deep mineralized rock that in turn results in a lack of geological

confidence leading to the inferred classification. Mineralized rock below the open-pit is, in general, too poorly characterized to justify inclusion in this economic assessment.

# 3 Approach to Analysis of Economic Viability

To assess the prospect for economically viable extraction by underground mining of the NorthMet deposit, the total cost of extraction of the metals must be compared to the total revenue from the metals that are extracted. For underground mining to have the potential to be economically viable, the extracted net metal value must be greater than the total operating cost by a sufficient margin to pay for capital costs, taxes, and provide a reasonable profit.

At the earliest stages of evaluating a mineral occurrence, costs are approximated by using cost models, such as from InfoMine. The cost predicted using cost models will be compared to and supplemented by data from selected existing and proposed mines. At the next stage in project evaluation, scoping or preliminary economic assessment, costs are refined, but complete site data can be lacking. Cost models are still used at this stage to estimate costs as well as to validate site specific cost estimates. The costs used in this report for the economic assessment are comparable to the earlier stages of evaluation. The revenue estimates in this report use metal prices applicable to later, feasibility, stage of evaluation, and are of lesser error than cost estimates. The grade and tonnage are maximum estimates as they are defined by open-pit rather than underground mining criteria.

Wellmer (Wellmer, 1998) describes several general approaches for evaluating the productive life of a mine. Generally, mining companies will use a minimum of 10 years to average out the risk of the variation of metal prices. The optimal productive life of a mine calculated by empirical formula yields values such as extracted tonnage of 5 to 25 million tons mined for 9.5 to 14 years at a rate of production of about 1,250 to 6,000 tons per day upwards to extracted tonnage of 100 million tons mined for 21 years at a rate of production of about 14,000 tons (Wellmer, 1998). To simplify the economic assessment in this report, increments of total and daily production are used which are roughly similar to those obtained from the empirical formula.

# 4 Mining Method

Poly Met has proposed to mine the NorthMet deposit using open-pit mining which will result in the maximum economically viable recovery of the metals. Using underground mining would result in a significant fraction of the NorthMet deposit being left unmined because the unmined rock is too low of value to be viably extracted by underground methods. Underground mining is being assessed as an alternative to open-pit mining to ensure that the Environmental Impact Statement (EIS) is in full compliance with National Environmental Policy Act (NEPA) and Minnesota Environmental Policy Act (MEPA) and that alternative mine development methods, such as underground mining, are considered.

Underground mining of large tonnages at shallow depths has the potential to lead to collapse of the mine openings unless they are backfilled. If mine openings are allowed to collapse, the collapse is likely to result in caving and fracturing of the overlying bedrock and could lead to land surface subsidence. This in turn disrupts ground water and surface water (Kendorski, 2006). The NorthMet deposit has a shallow dip of between $15^{o}$ to $25^{o}$ to the southeast, a strike length of about 2.5 miles, with probable thickness of mining of 45 to 100 feet when extractable tonnage is on the order of 10 million tons (AGP, 2011) (Figure 2; blocks in open pit resource greater than $65 net metal value per ton represent approximately 8 million tons). To minimize environmental impact by underground mining, the chance of collapse of the overlying rock must be minimized. Thus, this report is based on the assumption that backfilling of the mine will be required to minimize the chance of collapse of the overlying rock.

AGP (AGP, 2011) has assessed the applicable mining methods and concluded that possible mining methods include long-hole open stoping (backfilled), room and pillar (no back fill), or short back open stoping (no back fill) for a mine on the order of 10 million extractable tons. The latter two are considered unacceptable in this report unless backfilled to minimize the chance of collapse; only methods including backfill will be considered in this report. Mechanized cut and fill (backfilled) is another possible mining method. The underground rate of extraction for mining with backfilling is typically between 90 and 99% removal of the resource. For this report, the rate of extraction is assumed to be 95% removal of the resource.

Several factors can result in dilution of the ore such as overbreaking of rock by drill and blasting during underground mining and poor estimation of the boundary between valuable rock to be mined and waste rock. Dilution results in more tons of material to process and lowering of the overall grade of the material to be processed. In general, dilution varies between 5 and 30% (Wellmer, 1998); a value of 5% will be used in this report. At NorthMet the impact of dilution is small as higher value rock is surrounded by successively lower value rock. The diluting rock is assumed to have a value equivalent to the rock adjacent to the extracted tonnage along the tonnage-value curve described in Section 7.

# 5 Metal Prices

Evaluation of a mining project at the earliest stages may use metal prices that are lower than at a later stage to compensate for unknown risks. At later stages of evaluation when the start-up of a mine is nearer, pre-feasibility or feasibility study, metal prices often closely reflect current market conditions. NI 43-101 compliant feasibility studies use the three-year average metal prices, but also often include forecasts of price and demand for the purpose of evaluating the validity of using such metal prices. For the purpose of this report, the only metal prices used will be the three-year average metal price to June 30, 2012 provided to Theodore J. Bornhorst, LLC by Poly Met (personal communication) (Table 1); these metal prices are consistent with prices currently used in NI 43-101 feasibility and pre-feasibility studies published on System for Electronic Document Analysis and Retrieval (SEDAR) operated by Canadian Securities

Administrators. These metal prices are consistent with or higher than long-term forecasts.

# 6 Rates of Metal Recovery

The valuable rock extracted by underground mining is crushed, ground to a fine grain size, and subjected to a sequence of mineral processing steps to concentrate the minerals containing the metals of value. Due to imperfect mineral processing, some minerals containing metals of value are lost to the waste tailings. Laboratory testing quantifies the rate of recovery during processing of the valuable rock (ore) to a mineral concentrate. The metals in the concentrate are recovered by further processing (smelting or hydrometallurgy and refining); these rates have been quantified. The rates of recovery from rock to concentrate and from concentrate to metal are those specific to NorthMet as given in Table 1.

# 7 Net Metal Value

Net metal value per ton of rock represents the value of metal recoverable and payable from the rock at the assumed metal prices model after accounting for the rates of recovery and deduction of refining costs (described in Poly Met, 2007).

The total cumulative tonnage with grades higher than a specific level can be quantified by rigorous study (described in Poly Met, 2007). Using the open-pit model described by Poly Met (2007), AGP (personal communication) provided Theodore J. Bornhorst, LLC with a series of cumulative tonnages and average grades for the NorthMet deposit. The average net metal value per ton was calculated for each of these average grades (Table 2). The log cumulative tonnage versus average net metal value per ton has a well-defined regular variation (Figure 3). This relationship is adequate for the prediction of cumulative tonnage and average net metal value per ton for an economic assessment of underground mining of the NorthMet deposit.

# 8 Operating Costs of Mining

For this economic assessment, operating costs are estimated from cost models, such as InfoMine USA, Inc. Selected operating and proposed mines are used to compare and supplement the operating costs assumed for this report. While adjustments are made to the comparables to account for obvious differences with a possible NorthMet setting, there is no assurance these adjustments are adequate.

Operating cost models are usually subdivided according to mining or processing method and daily rate of production. Operating costs are linearly related to daily rate of production for the range of 1,000 to 5,000-7,500 tons per day depending on mining method (InfoMine USA, 2009). Above 5,000-7,500 tons per day the rate of change in operating cost decreases as operating costs approach a ‘minimum’. All costs are inflated to 2012 level based on the average rate of change in InfoMine cost models from 1998 to 2009. Increments of extractable tonnage and daily rate of production will be used in this study and for each increment a 2012 total operating cost will be assigned;

total operating cost is the sum of underground mining, mineral processing, and "general and contingency" costs (general is not central to production of saleable metal and contingency is added to cover uncertainties in cost estimates).

## 8.1 Discussion of Operating Costs at Rates of Production up to 5,000 Tons Per Day

The operating cost of room and pillar underground mining using shaft access without backfill from InfoMine cost model (InfoMine USA, 2009) is approximately $40 and $32 per ton for 2,000 and 5,000 tons per day production respectively without "general and contingency". Cemented backfill typically represents roughly 20% of mining operating costs (Grice, 1998; Stebbins and Schumacher, 2001). The operating cost of room and pillar underground mining with backfill is projected to be about $50 and $40 per ton for 2,000 and 5,000 tons per day production without "general and contingency". Long-hole open stoping with sand backfill and shaft access from InfoMine (InfoMine USA, 2009) is about $32 and $20 per ton for 2,000 and 5,000 tons per day production respectively without "general and contingency", but at NorthMet cementing of backfill will likely be necessary which will increase the model cost. AGP (AGP, 2011) estimated that long-hole open stoping with backfill operating cost was in the range of $44 to $52 at 5,000 tons per day suggesting that the InfoMine estimates are too low. Mechanized cut and fill is about $49 for 2,000 tons per day. The Podolsky Mine, Levack Mine, McCreedy West Mine in the Sudbury district utilize a combination of long-hole open stoping with cemented and uncemented backfill, cut and fill, and shrinkage mining methods with a range of mining operating costs of $76 to $38 for 1,250 and 2,250 tons per day without "general, administration and contingency" (FNX, 2009). *The estimated 2012 underground mining operating costs for this report are $51 for 2,000 tons per day and $40 for 5,000 tons per day without "general and contingency".*

A three concentrate flotation mill cost model from InfoMine (InfoMine USA, 2009) is the closest approximation to mineral processing of a complex ore such as NorthMet with cost of about $19.5 and $13 per ton for 2,000 and 5,000 tons per day production respectively without "general and contingency". For comparison, a one concentrate mineral processing InfoMine cost model at 5,000 tons per day is about $12.5 per ton as compared to the one concentrate Copperwood, Michigan prefeasibility mill cost estimate of $11.75 per ton at 5,000 tons per day without "general, administration, and contingency" (Orvana, 2011). A preliminary economic assessment for Lac des Iles in Thunder Bay, Ontario for complex ore with a similar suite of metals uses a mineral processing operating cost of $14 per ton at about 6,000 tons per day production without "general, administration, and contingency" (North American Palladium, 2010). *The estimated 2012 mineral processing operating costs for this report are $19.5 per ton for 2,000 tons per day and $13 per ton for 5,000 tons per day without "general and contingency".*

For copper and nickel Lac des Iles in Thunder Bay, Ontario (North American Palladium, 2010) the "general" and administration costs used in preliminary economic assessment were $3.30 per ton and "contingency" was $2.00 per ton (not inflated to 2012). For

Copperwood, Michigan the "general" and administration prefeasibility estimate was $3.35 per ton (Orvana, 2011; not inflated to 2012). *The 2012 "general and contingency" for this report are $3.50 per ton.*

## 8.2 Total Operating Costs at Rates of Production up to 5,000 Tons Per Day

This report will use 2012 total operating costs of $74 per ton at 2,000 tons per day and $56.5 at 5,000 tons per day with an assumed rate of extraction of 95% removal of the resource. These costs will be linearly extrapolated and applied to rates of production between 1,000 and 5,000 tons per day. Based on the optimal life of mine formula as described above, 5,000 tons per day operating cost will be applied to total extracted tonnage of up to 26 million tons (Table 3).

For comparison, total operating costs at copper – nickel-PGE Lac des Iles deposit are estimated at about $56 per ton (scaled to include backfill) at about 6,000 tons per day (North American Palladium, 2010). The lead-zinc-silver-copper Pitarrilla property pre-feasibility study reported total operating costs adjusted for shaft access and inflation of $39.5 per ton for a combination of backfilled room and pillar and long-hole stoping mining at the rate of 4,000 tons per day (Silver Standard, 2009). The nickel-copper-PGE-gold Eagle's Nest property has estimated total operating cost of $79 per ton for bulk stoping with cemented backfill at 4,500 tons per day production (Noront Resources, 2011). AGP (AGP, 2011) long-hole open stoping mining costs when combined with mineral processing and "general and contingency" costs yield total operating costs of between about $50 and $59 at 5,000 tons per day of production. The copper-nickel-PGE Podolsky Mine, Levack Mine, McCreedy West Mine in the Sudbury district utilize a combination of long-hole open stoping with cemented and uncemented backfill, cut and fill, and shrinkage have an average total operating cost of $88 per ton between 1,250 and 2,250 tons per day (FNX, 2009). The nickel-copper Lockerby Mine, in the Sudbury district, has estimated total operating costs of approximately $160 per ton using sublevel long-hole stoping with cemented backfill at approximately 1,000 tons per day production (First Nickel, 2011) as contrasted with the nickel-copper-cobalt-PGE-gold Bucko Mine, Manitoba which has estimated total operating costs of approximately $72 per ton using Long-hole stoping with cemented backfill at approximately 1,000 tons per day production (Crowflight Minerals Inc., 2009). In comparison, the linearly projected 1,000 ton per day total operating cost to be used in this report is approximately $80. While these comparisons demonstrate the difficulty in assigning a total operating cost lacking site specific data, they nevertheless support that the 2012 total operating costs used in this report are reasonable and within the level of error usually assumed at this level of assessment.

## 8.3 Discussion of Operating Costs at Rates of Production Between 5,000 to 15,000 Tons Per Day

The technical feasibility of mining of more than 50 million tons by underground methods from the shallow open-pit (Figure 2) is speculative. AGP (AGP, 2011) describes

probable openings of 45 to 100 feet high for extracted tonnage on the order of 10 million tons. For larger amounts of extracted tonnage (> 26 million tons) larger cumulative openings will increase the difficulty of mining. In spite of this technical uncertainty, tonnages up to 100 million will be assessed with rates of extraction of up to 15,000 tons per day.

Above 5,000-7,500 tons per day the rate of change in operating costs decreases as operating costs approach a 'minimum.' Estimating the operating cost of underground mining large tonnages at such shallow depths while avoiding collapse is difficult. InfoMine cost models are for standard underground mining and thus, will provide a cost minimum that is likely to be too low as applied to mining large tonnages underground at NorthMet in the shallow confines of the open-pit. InfoMine cost models (InfoMine USA, 2009) demonstrate that operating cost for long-hole open stoping with sand backfill begins to approach a "minimum" cost at about 3,600 tons per day; the rate of change from 3,600 to 7,200 tons per day is less. The operating cost of room and pillar mining and other mining methods, including backfill, tend to approach a "minimum" cost between 4,000 to 10,000 tons per day production. Applying the rate of change associated with backfilled room and pillar mining to a $40 per ton mining operating cost at 5,000 tons per day, yields an estimated underground mining operating cost of $28 per ton at 7,500 tons per day. Applying the rate of change associated with long-hole open stoping with sand backfill, to a $40 per ton mining operating cost at 5,000 tons per day, yields an estimated operating cost of $39 per ton at 7,500 tons per day production. Since long-hole open stoping reaches a minimum operating cost near 5,000 tons per day the difference between the mining operating cost at 5,000 and 7,500 tons per day is small.

As daily production increases from 7,500 to 15,000 tons per day it is expected that operating costs may be lower due to increased efficiencies related to scale but equally likely it is expected that operating costs may be even higher than increased efficiencies due to complexities of removal of such a large thickness of rock at such shallow depths while avoiding collapse. *Hence, for this report the same underground mining operating cost estimate will be used for 7,500, 10,000 and 15,000 tons per day production; $33 per ton 2012 underground mining operating cost without "general and contingency".*

Comparisons of mining costs from operating or proposed mines for high daily rates of underground production are more difficult to obtain and large daily rates of underground extraction with backfill are less common. In addition, differences with a possible NorthMet setting may render the comparison invalid. The Young-Davidson gold mine in Ontario utilizes a combination of sublevel caving, long-hole shrinkage, and longitudinal retreat with paste backfill and unconsolidated rock fill (www.auricogold.com). The underground mining operating cost is $32 to $34 per ton at 8,000 tons per day (www.auricogold.com). The Blue River tantalum-niobium mine, BC Canada, proposes using room and pillar mining with paste backfill to recover 70% of the orebody at a 2012 estimated mining cost of $32 per ton at 7,500 tons per day (AMEC, 2012). A Press Release by Commerce Resources Corp. states that the $32 per ton mining cost can be lowered to $22 with the elimination of backfilling (www.commerceresources.com); the

latter $22 is consistent with InfoMine (InfoMine USA, 2009) room and pillar mining with no backfill cost estimate of $23. These comparisons demonstrate the 2012 underground mining operating costs used in this report are reasonable and within the level of error usually assumed at this level of assessment.

Cost models for mineral processing at all levels of daily production are applicable for this economic assessment. A three concentrate flotation mill cost model from InfoMine (InfoMine USA, 2009) is the closest approximation to mineral processing of a complex ore such as NorthMet with costs of about $12.5, $12, and $10.5 per ton for 7,500, 10,000 and 15,000 tons per day production respectively without "general and contingency". *The 2012 operating cost for mineral processing used in this report will be $12.5, $12, and $10.5 per ton for 7,500, 10,000 and 15,000 tons per day production respectively without "general and contingency".*

*The same "general and contingency" used for 1,000 to 5,000 tons per day production will be used for higher levels of daily production.*

## 8.4 Total Operating Costs at Rates of Production Between 5,000 to 15,000 Tons Per Day

Total 2012 operating costs in this report will be $49, $48.5, and $47 per ton for 7,500, 10,000 and 15,000 tons per day production.

Comparisons of total operating costs from operating or proposed mines for high daily rates of underground production are more difficult to obtain. The Williams Mine, Marathon, Ontario uses long-hole stoping with paste backfill to underground mine and process simple gold ore with an average grade of about 2.35 g/ton gold at a daily rate of about 8,500 tons per day (www.barrick.com). The total cash operating cost (includes limited amount of lower cost open-pit mining) is about $775 per oz. for 2011 and $834 for the 1$^{st}$ quarter of 2012 (www.barrick.com). The estimated total operating cost is $58.5 per ton for 2011 and $63 per ton for the beginning of 2012. The Brunswick Mine, New Brunswick, Canada uses open stoping and end slicing with paste backfill to mine a zinc, lead, copper, and silver ore with about 8.3% zinc at the rate of about 10,000 tons per day (www.xstrata.com). Presentation materials by Xstrata shows that the Brunswick Mine has total cash operating costs higher than the other principal source of zinc for North America zinc operations and from a cash cost of $0.32 to 0.40 per lb of zinc, an estimated total operating cost is $53 to $66 per ton, but this is an uncertain estimate. The Young-Davidson gold mine in Ontario utilizes a combination of sublevel caving, long-hole shrinkage, and longitudinal retreat with paste backfill and unconsolidated rock fill with estimated total operating cost of $45 to 51 per ton 8,000 tons per day (www.auricogold.com). These comparisons demonstrate the 2012 total operating costs used in this report are reasonable and within the level of error usually assumed at this level of assessment.

# 9 Pre-Production Capital Costs

For this economic assessment, estimates of pre-production capital costs are made from cost models, such as InfoMine USA, Inc., and are compared to and supplemented by selected operating and proposed mines. All costs are inflated to 2012 level based on the average rate of change in InfoMine cost models from 1998 to 2009.

Capital cost models are usually subdivided according to mining or processing method and daily rate of production. Capital costs are linearly related to daily rate of production from about 1,000 to 7,500 tons per day depending on mining and processing method (InfoMine USA, 2009). Increments of extractable tonnage and daily rate of production will be used in this study and for each increment a single capital cost will be assigned.

The pre-production capital cost of room and pillar underground mining using shaft access without backfill from InfoMine (InfoMine USA, 2009) is about $60 million, $95 million, and $125 million for 2,000 and 5,000, 7,500 tons per day production respectively without “contingency”, environment, closure, and reclamation. The capital cost for long-hole open stoping with sand backfill and shaft access from InfoMine (InfoMine USA, 2009) is about $45 million, $80 million, and $115 million for 2,000 and 5,000, 7,500 tons per day production respectively without “contingency”, environment, closure, and reclamation. Capital cost for mechanized cut and fill is about $60 million for 2,000 tons per day production without “contingency”, environment, closure, reclamation. A three concentrate flotation mill cost model from InfoMine (InfoMine USA, 2009) is the closest approximation to mineral processing of a complex ore such as NorthMet with a capital cost of about $47 million, $71 million, and $98 million 2,000, 5,000, and 7,500 tons per day production respectively without “contingency”, environment, closure, reclamation. The InfoMine cost model estimates of total pre-production capital cost are about $110 million, $170 million, and $225 million without “contingency”, environment, closure, reclamation. For comparison, room and pillar mining without backfill and a one concentrate mineral processing plant at Copperwood, Michigan has a prefeasibility estimated pre-production capital cost of approximately $205 million at 7,500 tons per day without closure and sustaining capital (Orvana, 2011). A preliminary economic assessment for Lac des Iles in Thunder Bay, Ontario for complex ore with a similar suite of metals has an estimated pre-production capital cost of approximately $220 million at about 6,000 tons per day including “contingency” capital but without development and sustaining capital (North American Palladium, 2010). AGP (AGP, 2011) estimated that long-hole open stoping with backfill capital cost is approximately $190 million at 5,000 tons per day. The comparisons suggest that the pre-production capital cost InfoMine estimates are reasonable although more likely low because these estimates do not include “contingency” and pre-production expenditures especially exploration, permitting and environmental analysis. To develop underground mining at NorthMet a significant amount of additional exploration drilling is likely.

*The 2012 pre-production capital costs with “contingency” for this report are estimated to be $125 million, $200 million, and $250 million for 1-2,000, 5,000, and 7,500 tons per day production but without environment, closure and reclamation. Linear extrapolation*

*yields 2012 pre-production capital cost of about $300 million and $400 million for 10,000 and 15,000 tons per day production.*

# 10 Other Considerations

Inflation during production is not considered in this report. Inflation of costs is assumed to be offset by increases in the metal prices. The estimated federal and state tax on operating profits after depreciation and depletion is a significant cost that will lower the internal rate of return in cases when operating profit exceeds pre-production capital costs. Pre-production capital costs are assumed to be equity financed and thereby eliminating the cost of debt. The royalty applicable to this report for NorthMet is 5%.

# 11 Analysis of Economic Viability

The economic assessment in this report for the NorthMet deposit uses tonnage and grades specific to NorthMet, rates of recovery and refining deductions specific to NorthMet, current metal prices consistent with NI 43-101 reporting standards, total operating costs and pre-production capital costs from published cost models that are validated by comparable projects and mines, and the actual royalty specific for NorthMet. Based on optimal formula, the productive life of an underground mine was determined for increments of tonnages from <4 to 100 million tons and from these numbers the daily rate of production was calculated (Table 3). For each increment the daily rate of production was fixed to simplify the analysis since total operating costs and total pre-production capital costs are closely related to the daily rate of production; for simple cash flow analysis the productive life of mine rounded to the nearest year based on the life of mine calculated from daily production and total tonnage. A total operating cost and total pre-production capital cost, as in Sections 8 and 9, was assigned to each increment based on daily rate of production (Table 3).

A spectrum of extracted tonnages was assessed (Table 4). For each specific pre-extraction tonnage, an *in situ* average net metal value per ton was calculated by log10 linear extrapolation between adjacent pairs on the tonnage-average net metal value per ton curve. A rate of extraction of 95% removal of the resource was used in determining the total extracted value without dilution. A 5% dilution was used with the diluting average net metal value per ton calculated by log 10 linear extrapolation assuming the diluting rock has a value in continuum with the pre-extraction tonnage. The total net metal value was calculated for the pre-extraction cumulative tonnage and dilution minus the yearly treatment charge (Table 4). The extracted tonnage was multiplied by the total operating cost per ton to estimate the total operating cost. Operating profit was calculated by subtracting total operating cost from total revenue minus royalty. Pre-tax operating profit minus pre-production capital costs is also calculated (Table 4).

The “rules-of-thumb” is that operating cost should be about ½ of the total net metal revenue after royalty and the remaining ½ is generally sufficient to cover taxes, capital costs, and profit (Wellmer, 1998). On this basis, underground mining is not likely to be economically viable at NorthMet.

For tonnages with a negative operating profit or a loss, underground mining is not economically viable. For all extracted tons, except 30 and 35 million, there is a predicted operating loss or underground mining at these tonnages is not economically viable. The total operating profit has to exceed the total pre-production capital cost else the mining project is not economically viable; the initial investment is not recovered. *At all tonnages the total operating profit minus the total pre-production capital cost is negative or in other words for all tonnages underground mining is not economically viable.*

# 12 Discussion and Conclusions

This report assesses the economic viability of extracting the NorthMet deposit by underground mining methods. Due to the higher cost of underground mining as compared to open-pit mining, if the NorthMet deposit was extracted by underground mining a significant amount of the lower grade materials would inevitability be left behind or lost from a socio-economic perspective. This economic assessment utilizes reasonable estimates of input variables to answer the question: Is there a prospect of economically viable extraction of a portion of the NorthMet deposit by underground mining?

The volume/tonnage and grade of mineralized rock are defined using open-pit defined resource numbers rather than potentially more restrictive underground mining criteria and may result in an overly optimistic economic assessment. The metal prices are defined using a three-year trailing average and do not account for the risk of lower prices with no change in costs. While the total operating costs are less precise, they are demonstrably within acceptable error for this level of economic assessment. The operating costs do not include operating capital expenditures. While the total pre-production capital costs are also less precise, they too are demonstrably within acceptable error for this level of economic assessment. These estimates are more likely to be too low than too high since they do not fully account for capital costs associated with the environment, closure and reclamation.

Early studies of the NorthMet deposit concluded that the tonnages and grades were not sufficient to support underground mining. *This economic assessment of conceptual underground mining of the NorthMet deposit demonstrates that underground mining methods are not economically viable. Based on this assessment, there is no prospect of economically viable extraction of a portion of the NorthMet deposit by underground mining.*

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# Tables

# Table 1

## Metal Prices, Recovery, and Refining Costs Used for Economic Assessment of Conceptual Underground Mining at NorthMet

| Metal | Pricing Units | Metal Price[1] $ | Recovery from Ore[2] % | Third Party Processing Concentrate Recovery and Payout[2] % | Refining Cost[2] $ |
|---|---|---|---|---|---|
| Cu | lbs | 3.56 | 94.2 | 96.5 | 0.04 |
| Ni | lbs | 9.47 | 71.2 | 78.0 | 0.16 |
| Co | lbs | 17.69 | 41.2 | 55.1 | 0.00 |
| Pt | troy oz | 1,689 | 77.9 | 92.0 | 4.97 |
| Pd | troy oz | 684 | 74.4 | 81.9 | 4.17 |
| Au | troy oz | 1,485 | 71.7 | 67.7 | 1.83 |

Notes:

1 - Metal Price model calculated as of June 30, 2012 by PolyMet (personal communication).

2 - Recovery from ore to concentrate, third-party payout, refining cost and treatment charge of $3.5 million per year provided to Theodore J. Bornhorst, LLC by Polymet (personal communication); treatment charge applied during economic analysis.

Prepared by: SVK
Checked by: JSL

# Table 2

## Cumulative Measured and Indicated Tonnage and Average Net Metal Value per Ton for NorthMet Deposit

| Cumulative Measured and Indicated Short Tons[1] | Average Net Metal Value ($) per short ton |
|---|---|
| 227,017,162 | 33.18 |
| 145,066,201 | 39.86 |
| 76,373,821 | 47.46 |
| 30,369,759 | 55.66 |
| 7,817,279 | 65.37 |
| 1,682,328 | 76.72 |
| 509,229 | 85.54 |
| 85,614 | 96.77 |

Notes:

1 - Cumulative measured and indicated tonnage and associated grade provided by AGP (personal communication).

Analysis by: TJB
Prepared by: SVK
Checked by: JSL

# Table 3

## Total Operating and Total Pre-Production Capital Costs Applied to Economic Assessment of Conceptual Underground Mining at NorthMet

| Extracted Tonnage million short tons | Underground Daily Rate of Production tons/day | Productive Life of Mine ~ years | Total Operating Costs $/ton | Total Pre-production Capital Costs $ |
|---|---|---|---|---|
| <4 | 1,000 | 5 to 11 | 80.00 | 125,000,000.00 |
| 4 to 6 | 2,000 | 6 to 8 | 74.00 | 125,000,000.00 |
| 7 to 13 | 3,000 | 6 to 12 | 68.20 | 150,000,000.00 |
| 13 to 18 | 4,000 | 9 to 12 | 62.30 | 175,000,000.00 |
| 18 to 26 | 5,000 | 10 to 14 | 56.50 | 200,000,000.00 |
| 26 to 50 | 7,500 | 10 to 18 | 49.00 | 250,000,000.00 |
| 51 to 75 | 10,000 | 14 to 21 | 48.50 | 300,000,000.00 |
| 75 to 100 | 15,000 | 14 to 18 | 47.00 | 400,000,000.00 |

Note:
Incremental extractable tonnages, total operating costs, and total pre-production capital costs based on text discussion.

Analysis by: TJB
Prepared by: SVK
Checked by: JSL

# Table 4

## Economic Analysis of Underground Mining of the NorthMet Deposit

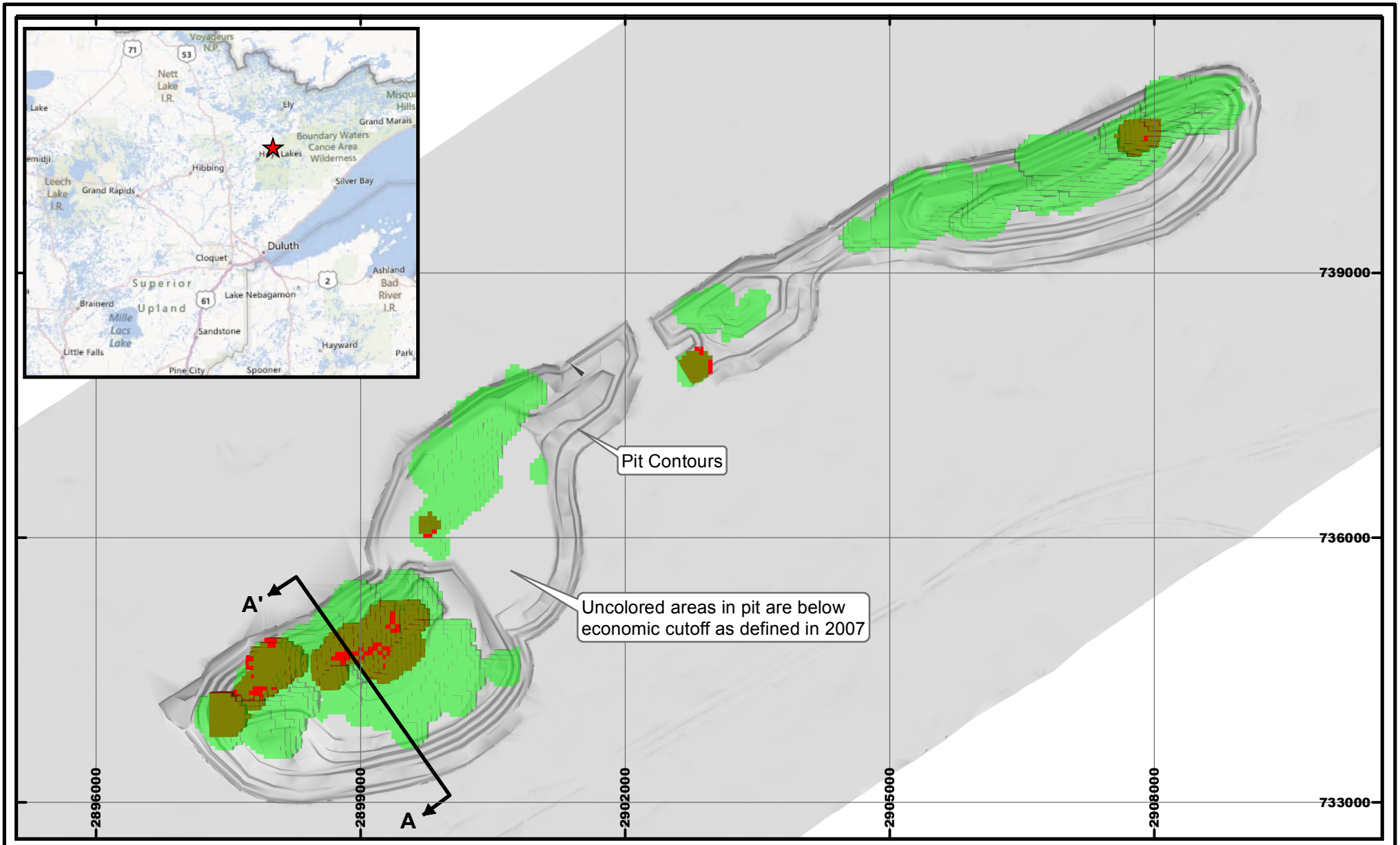
| Extracted Tonnage at 95 % rate of extraction and 5 % dilution tons | Total extracted net metal value $ | Total revenue (average net metal value minus 5 % royalty) $ | Total Operating Cost $ | Operating Profit (Revenue minus operating cost) $ | Pre-production capital cost $ | Operating Profit minus pre-production capital costs $ | Daily production tons | Life of mine for economic analysis years |
|---|---|---|---|---|---|---|---|---|
| 2,000,000 | 129,847,971.83 | 123,355,573.24 | 160,000,000.00 | -36,644,426.76 | 125,000,000.00 | -161,644,426.76 | 1,000 | 6 |
| 5,000,000 | 318,769,570.88 | 302,831,092.34 | 370,000,000.00 | -67,168,907.66 | 125,000,000.00 | -192,168,907.66 | 2,000 | 7 |
| 10,000,000 | 604,406,603.41 | 574,186,273.24 | 682,000,000.00 | -107,813,726.76 | 150,000,000.00 | -257,813,726.76 | 3,000 | 9 |
| 15,000,000 | 875,343,935.13 | 831,576,738.38 | 934,500,000.00 | -102,923,261.62 | 175,000,000.00 | -277,923,261.62 | 4,000 | 10 |
| 20,000,000 | 1,134,125,150.76 | 1,077,418,893.23 | 1,130,000,000.00 | -52,581,106.77 | 200,000,000.00 | -252,581,106.77 | 5,000 | 11 |
| 25,000,000 | 1,376,867,161.05 | 1,308,023,803.00 | 1,412,500,000.00 | -104,476,197.00 | 200,000,000.00 | -304,476,197.00 | 5,000 | 14 |
| 30,000,000 | 1,633,916,992.93 | 1,552,221,143.28 | 1,470,000,000.00 | 82,221,143.28 | 250,000,000.00 | -167,778,856.72 | 7,500 | 11 |
| 35,000,000 | 1,857,679,184.93 | 1,764,795,225.68 | 1,715,000,000.00 | 49,795,225.68 | 250,000,000.00 | -200,204,774.32 | 7,500 | 13 |
| 50,000,000 | 2,511,252,374.91 | 2,385,689,756.16 | 2,450,000,000.00 | -64,310,243.84 | 250,000,000.00 | -314,310,243.84 | 10,000 | 14 |
| 75,000,000 | 3,496,138,949.08 | 3,321,332,001.63 | 3,637,500,000.00 | -316,167,998.37 | 300,000,000.00 | -616,167,998.37 | 10,000 | 21 |
| 100,000,000 | 4,360,816,362.32 | 4,142,775,544.20 | 4,700,000,000.00 | -557,224,455.80 | 400,000,000.00 | -957,224,455.80 | 15,000 | 18 |

Notes:

- In situ average net metal value per ton from Table 2 determined for specific tonnage by log 10 linear extrapolation minus treatment charge.
- Applicable day rate of production and associated total operating costs and pre-production capital costs from Table 3. Economic analysis life of mine based on day rate of production rounded to even year; once life of mine is fixed daily rate of production allowed to vary to accommodate rounding in simple cash flow analysis.
- Rate of extraction and dilution discussed in text. Total extracted net metal value includes deduction for treatment charge as given in Table 1.

Analysis by: TJB
Prepared by: SVK
Checked by: JSL

# Figures




**LEGEND**

- Blocks in Open Pit Resource less than $65/ton average net metal value and above economic cutoff as defined in 2007
- Blocks in Open Pit Resource where less than $65/ton average net metal value rock overlies greater than $65/ton rock
- Blocks in Open Pit Resource Greater than $65/ton average net metal value

**NOTES**

1. Data from block model used in PolyMet (2007) provided by AGP.

PolyMet Mining

Foth

N

| Foth Infrastructure & Environment, LLC | | | |
|---|---|---|---|
| REVISED | DATE | BY | DESCRIPTION |
| | | | |
| | | | |
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| | |
|---|---|
| CHECKED BY: JSL | DATE: SEP. '12 |
| APPROVED BY: TJB | DATE: SEP. '12 |
| APPROVED BY: | DATE: |

POLYMET MINING

**FIGURE 1**

SURFACE PLAN VIEW
BLOCK MODEL FOR NORTHMET

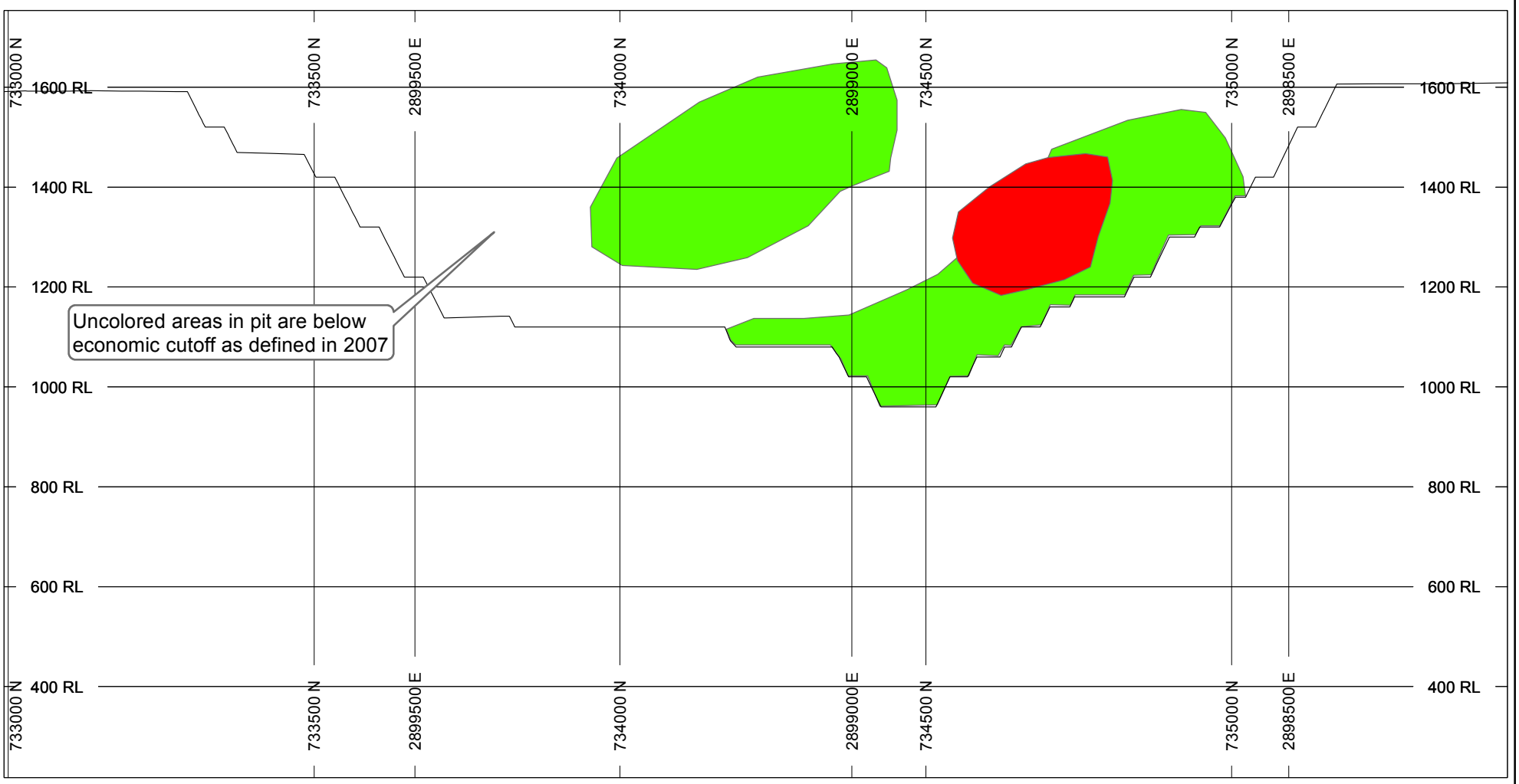
Scale: 0 750 1,500 Feet

Date: AUGUST 2012

Prepared by: DAT

Project No: 12P778

Path: X:\GB\IE\2012\12P778\GIS\mxd\Figure1.mxd Date: 10/22/2012




**LEGEND**

- Blocks in Open Pit Resource less than $65/ton average net metal value and above economic cutoff as defined in 2007
- Blocks in Open Pit Resource Greater than $65/ton average net metal value

**NOTES**

1. Data from block model used in PolyMet (2007) provided by AGP.

PolyMet Mining

Foth

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| Foth Infrastructure & Environment, LLC | | | |
|---|---|---|---|
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|---|---|
| CHECKED BY: JSL | DATE: SEP. '12 |
| APPROVED BY: TJB | DATE: SEP. '12 |
| APPROVED BY: | DATE: |

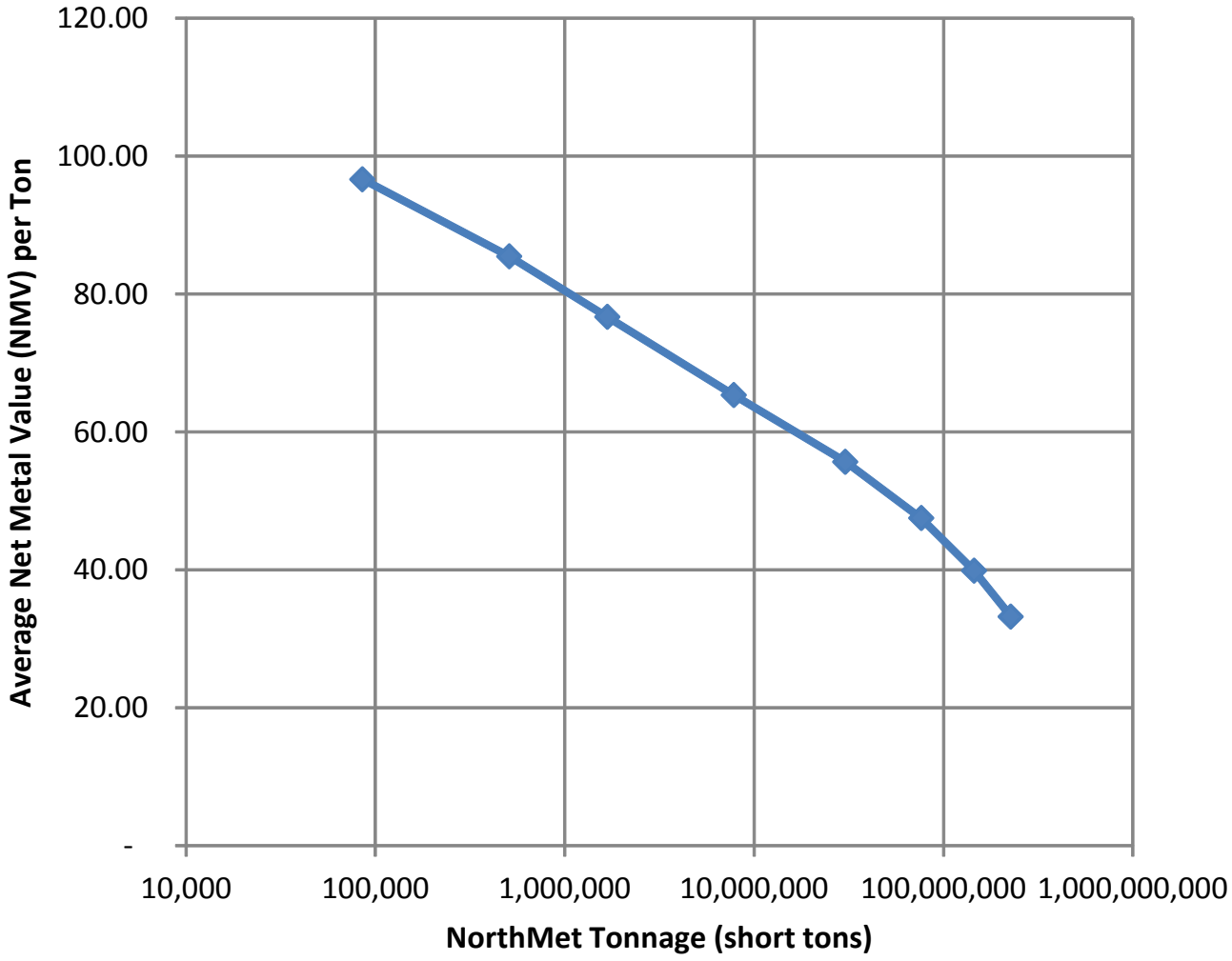
POLYMET MINING

**FIGURE 2**
CROSS SECTION A-A'
BLOCK MODEL FOR NORTHMET.
LOCATION SHOWN IN FIGURE 1.

| | |
|---|---|
| Scale: 0 750 1,500 Feet | Date: AUGUST 2012 |
| Prepared by: DAT | Project No: 12P778 |

Path: X:\GB\IE\2012\12P778\GIS\mxd\Figure2.mxd Date: 10/22/2012

# Fig 3. Tonnage vs. Average Net Metal Value




**NOTES**

1. Data from block model used in PolyMet (2007) provided by AGP.

PolyMet Mining

Foth

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| Foth Infrastructure & Environment, LLC | | | |
|---|---|---|---|
| REVISED | DATE | BY | DESCRIPTION |
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|---|---|
| CHECKED BY: JSL | DATE: SEP, '12 |
| APPROVED BY: TJB | DATE: SEP, '12 |
| APPROVED BY: | DATE: |

POLYMET MINING

**FIGURE 3**

TONNAGE VERSUS AVERAGE NET METAL VALUE PER TON FOR NORTHMET DEPOSIT

| | |
|---|---|
| Scale: AS SHOWN | Date: AUGUST 2012 |
| Prepared by: DAT | Project No: 12P777 |

Path: X:\GB\IE\2012\12P778\GIS\mxd\Figure3.mxd Date: 10/23/2012

# Attachment 2
# Foth 2013, Memorandum: Response to USEPA Questions Regarding: Economic Assessment of Underground Mining Report Dated October 2012

# Memorandum

Foth Infrastructure & Environment, LLC
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P.O. Box 12326 • Green Bay, WI 54307-2326
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www.foth.com

May 10, 2013

TO: Brad Moore, Poly Met Mining, Inc.

CC: Steve Donohue, Foth Infrastructure & Environment, LLC
Master File: 12P778 - 5001

FR: Theodore J. Bornhorst, LLC
Jeff Lynott, Foth Infrastructure & Environment, LLC

RE: Response to USEPA Questions Regarding: Economic Assessment of Underground Mining Report Dated October 2012

The following document addresses the United States Environmental Protection Agency (EPA) comments and suggestions in their memo dated March 19, 2013 related to InfoMine, analog data, and inferred ore deposits.

## InfoMine Parameters/Use of Analog Data

InfoMine cost data is a common source of information for mineral resource evaluation, but it has not been used exclusively to determine the economic viability of underground mining of the NorthMet Deposit. The October 2012 report also includes additional references to other mining project cost estimates to cross-validate the cost estimates used in the report.

The EPA response letter, dated March 19, 2013, requests additional documentation of the parameters and calculations with respect to the cost estimates. A list of costs used to arrive at the total cost is provided in the attached Table A. The mining, processing, and general and contingency costs are described in detail in the text of the report (Sections 8.1, 8.2, 8.3, and 8.4). The InfoMine cost models are given in increments of production rate. InfoMine model cost versus production rate graphs were used to estimate the cost at the production rate cited in the report. In some cases, the InfoMine cost estimates were adjusted to include cemented backfill as cited in the text. All InfoMine 2009 costs were inflated to 2012 levels based on the average rate of change in the InfoMine models from 1998 to 2009. The total operating costs given in Table 4 of the report are derived by multiplication of the extracted tonnage at 95% rate of

extraction and 5% dilution column times the total operating cost from Table 3 for the applicable daily rate of production.

Models at all levels include a degree of uncertainty. The report includes cross-validation of the cost estimates to decrease the degree of uncertainty even though an analysis of uncertainty of the cost estimates is not usually done at the stage of defining a mineral resource as described in the report. However, as suggested in the EPA response letter, dated March 19, 2013, the economic analysis was completed using 5% lower costs (best economic case) as given in the attached Table B. Table C, attached, provides an economic analysis using data from the original Tables 1 and 2 in the report, and Table B provided here, and further demonstrates underground mining is not economically viable.

## Inferred Ore Deposits

Economic evaluation of mineral prospects follows a progressive path beginning with initial determination of a mineral resource, followed by a scoping study or preliminary economic assessment, and then pre-feasibility, and feasibility studies. A mine feasibility study is typically done when there has been sufficient drilling to define an ore body of sufficient size to be economically as well as technically viable. In most cases there is not a hard boundary to the mineralization. Therefore, exploration to define the initial ore body will generally identify mineralization beyond the actual ore body.

The NorthMet feasibility study and all of the analysis in the environmental review and proposed permit applications relate to the ore body. The company has not considered whether mineralization outside the defined pit envelope may be economically recoverable or by what means it could be economically recoverable, or what additional work would be needed to establish a data base of sufficient statistical quality to be able complete a feasibility study on such mineralization.

In the analysis of underground mining potential, we deliberately used very favorable scoping numbers in order to show potential underground mining economics in a positive light, yet the project still fails on the most fundamental economic grounds – revenues from the sale of product would not cover the cost of building and operating the project. AGP included mineralization that is outside the pit envelope even though there is insufficient information on this mineralization to be able to do more than a speculative, conjectural analysis. As discussed in the report, this mineralization does not meet Securities and Exchange Commission standards to be described as reserves under any mining method. Additionally, inferred mineral resources are speculative and are not allowed in economic assessment studies that conform with NI 43-101.

Attachments

## Table A

**Total Operating and Total Pre-production Capital Costs Applicable for Underground Mining at Incremental Extractable Tonnages**

| Extracted Tonnage million short tons | Underground Daily Rate of Production tons per day | Productive Life of Mine ~ years | Mining Operating Costs dollars per ton | Processing Operating Costs dollars per ton | General and Contingency Costs dollars per ton | Total Operating Costs dollars per ton |
|---|---|---|---|---|---|---|
| <4 | 1,000 | 5 to 11 | 54.67[1] | 21.67[1] | 3.5 | 80[2] |
| 4 to 6 | 2,000 | 6 to 8 | 51 | 19.5 | 3.5 | 74.0 |
| 7 to 13 | 3,000 | 6 to 12 | 47.33[1] | 17.33[1] | 3.5 | 68.2 |
| 13 to 18 | 4,000 | 9 to 12 | 43.67[1] | 15.17[1] | 3.5 | 62.3 |
| 18 to 26 | 5,000 | 10 to 14 | 40 | 13 | 3.5 | 56.5 |
| 26 to 50 | 7,500 | 10 to 18 | 33 | 12.5 | 3.5 | 49.0 |
| 51 to 75 | 10,000 | 14 to 21 | 33 | 12 | 3.5 | 48.5 |
| 75 to 100 | 15,000 | 14 to 18 | 33 | 10.5 | 3.5 | 47.0 |

[1] Linear extrapolation using tons per day

[2] Total rounded up 0.16

Prepared By: JSL
Checked By: TJB

## Table B

**Total Operating and Total Pre-production Capital Costs Applicable for Underground Mining at Incremental Extractable Tonnages**

| Extracted Tonnage million short tons | Underground Daily Rate of Production tons per day | Productive Life of Mine ~ years | Base Case Total Operating Costs dollars per ton | 5% Below Base Case Total Operating Costs dollars per ton | Total Pre-production Capital Costs dollars |
|---|---|---|---|---|---|
| <4 | 1,000 | 5 to 11 | $80.0 | $76.0 | $125,000,000 |
| 4 to 6 | 2,000 | 6 to 8 | $74.0 | $70.3 | $125,000,000 |
| 7 to 13 | 3,000 | 6 to 12 | $68.2 | $64.8 | $150,000,000 |
| 13 to 18 | 4,000 | 9 to 12 | $62.3 | $59.2 | $175,000,000 |
| 18 to 26 | 5,000 | 10 to 14 | $56.5 | $53.7 | $200,000,000 |
| 26 to 50 | 7,500 | 10 to 18 | $49.0 | $46.6 | $250,000,000 |
| 51 to 75 | 10,000 | 14 to 21 | $48.5 | $46.1 | $300,000,000 |
| 75 to 100 | 15,000 | 14 to 18 | $47.0 | $44.7 | $400,000,000 |

Prepared By: TJB
Checked By: JSL

## Table C

### Five Percent Below Base Case Costs Economic Analysis of Underground Mining of the Open-pit Resource at NorthMet

| Extracted tonnage at 95% rate of extraction and 5% dilution tons | Total extracted net metal value dollars | Total revenue (net metal value minus 5% royalty) dollars | Total operating cost 5% below base case dollars | Operating profit (revenue minus operating cost 5% below base case) dollars | Pre-production capital cost dollars | Operating profit minus pre-production capital costs with operating costs 5% below base case dollars | Daily production tons | Life of mine for economic analysis years |
|---|---|---|---|---|---|---|---|---|
| 2,000,000 | $129,847,972 | $123,355,573 | $152,000,000 | -$28,644,427 | $125,000,000 | -$153,644,427 | 1,000 | 6 |
| 5,000,000 | $318,769,571 | $302,831,092 | $351,500,000 | -$48,668,908 | $125,000,000 | -$173,668,908 | 2,000 | 7 |
| 10,000,000 | $604,406,603 | $574,186,273 | $648,000,000 | -$73,813,727 | $150,000,000 | -$223,813,727 | 3,000 | 9 |
| 15,000,000 | $875,343,935 | $831,576,738 | $888,000,000 | -$56,423,262 | $175,000,000 | -$231,423,262 | 4,000 | 10 |
| 20,000,000 | $1,134,125,151 | $1,077,418,893 | $1,074,000,000 | $3,418,893 | $200,000,000 | -$196,581,107 | 5,000 | 11 |
| 25,000,000 | $1,376,867,161 | $1,308,023,803 | $1,342,500,000 | -$34,476,197 | $200,000,000 | -$234,476,197 | 5,000 | 14 |
| 30,000,000 | $1,633,916,993 | $1,552,221,143 | $1,398,000,000 | $154,221,143 | $250,000,000 | -$95,778,857 | 7,500 | 11 |
| 35,000,000 | $1,857,679,185 | $1,764,795,226 | $1,631,000,000 | $133,795,226 | $250,000,000 | -$116,204,774 | 7,500 | 13 |
| 50,000,000 | $2,511,252,375 | $2,385,689,756 | $2,330,000,000 | $55,689,756 | $250,000,000 | -$194,310,244 | 10,000 | 14 |
| 75,000,000 | $3,496,138,949 | $3,321,332,002 | $3,457,500,000 | $208,701,494 | $300,000,000 | -$91,298,506 | 10,000 | 21 |
| 100,000,000 | $4,360,816,362 | $4,142,775,544 | $4,470,000,000 | -$327,224,456 | $400,000,000 | -$727,224,456 | 15,000 | 18 |

Notes:

- All table references refer to the Economic Assessment of Conceptual Underground Mining Option for the NorthMet Project October 2012.
- In situ net metal value from Table 2 determined for specific tonnage by log 10 linear extrapolation.
- Applicable day rate of production and associated total operating costs and pre-production capital costs from Table 3. Economic analysis life of mine based on day rate of production rounded to even year; once life of mine is fixed daily rate of production allowed to vary to accommodate rounding in simple cash flow analysis.
- Rate of extraction and dilution discussed in text. Total extracted net metal value includes deduction for treatment charge as given in Table 1.

Prepared By: TJB
Checked By: JSL

# Attachment 3
# NorthMet Project and Land Exchange Purpose and Need Statement

# *PURPOSE AND NEED*

## *Applicant's Purpose and Need Statement*

The applicant's stated purpose of the NorthMet Project is to exercise PolyMet's mineral lease to continuously mine, via open pit methods, the known ore deposits (NorthMet Deposit) containing copper, nickel, cobalt, and platinum group elements to produce base and precious metal precipitates and flotation concentrates by uninterrupted utilization of the former LTV Steel Mining Company (LTVSMC) processing plant.

The purpose of the proposed Land Exchange is to consolidate the surface and mineral ownership of the lands involved at the Mine Site. PolyMet has a lease to mine the minerals on its NorthMet Deposit, which is surrounded by active and abandoned taconite mines in the mining district near Hoyt Lakes. The surface of these lands is owned by the United States.

The need for the NorthMet Project is driven by domestic and global demand of these products. Demand continues to rise for these metals due to the expansion of the green economy and rising demand from developing countries like India, China, and Brazil. Based on the closure of LTVSMC and other job losses in northeastern Minnesota, there is also a need for jobs and economic development in the area.

## *Co-lead Agencies' Purpose and Need Statements*

### NorthMet Project and Land Exchange Purpose and Need Statement

The Purpose and Need for the Combined Proposed Action is:

- For PolyMet to utilize its leased mineral rights and recover commercial quantities and quality of semi-refined metal concentrates, hydroxides, and precipitates from the NorthMet ore body in northern Minnesota, and to process the recovered ore by reutilizing the former LTVSMC processing plant.
- To extract metals in a safe, environmentally responsible, energy-efficient, and economically feasible manner subject to mitigation measures designed to avoid or minimize environmental effects to the extent practicable.
- To extract and process metals in a technically and economically feasible manner, such that there would be sufficient income to cover: operating cost (which includes but is not limited to the cost of mining, processing, transportation, and waste management), capital cost (needed to build and sustain facilities), an adequate return to investors, reclamation, and closure costs and taxes.
- To eliminate surface and mineral conflicts within the Superior National Forest by exchanging federal lands for non-federal lands that have equal or greater value.

## USDA, Forest Service

The purpose for the United States Forest Service (USFS) is to meet desired conditions in the Superior National Forest Land and Resource Management Plan (Forest Plan), including ensuring the proposed land exchange Proposed Action eliminates existing conflict and ensuring mineral resources are produced in an environmentally sound manner contributing to economic growth.

In regards to desired conditions for land exchange and mineral development, the Superior National Forest's Forest Plan includes the following direction:

> "D-LA-1 – The amount and spatial arrangement of National Forest System land within the proclamation boundary of the Forest are sufficient to protect resource values and interests, improve management effectiveness, eliminate conflicts, and reduce the costs of administering landlines and managing resources." (Forest Plan, Land Adjustment, pg. 2-51)
>
> "D-MN-2 – Ensure that exploring, developing, and producing mineral resources are conducted in an environmentally sound manner so that they may contribute to economic growth and national defense." (Forest Plan, Minerals, pg. 2-9)

PolyMet intends to exercise private mineral rights that were reserved when lands were conveyed to the United States and has proposed the development of a surface mine. This land was purchased by the USFS, for National Forest purposes, under the authority of the Weeks Act (16 USC 515). The USFS has taken the position that the mineral rights that were reserved do not include the right to surface mine as proposed by PolyMet.

In addition, allowing private surface mining would be inconsistent with USFS legal mandates for acquiring and managing these lands. The USFS needs to resolve this fundamental conflict.

## U.S. Army Corps of Engineers

The Purpose and Need of the Proposed Action is to produce base and precious metals precipitates and flotation concentrates from ore mined at the NorthMet Deposit by uninterrupted operation of the former LTVSMC processing plant. The processed resources would help meet domestic and global demand by sale of these products to domestic and world markets.

## Minnesota Department of Natural Resources

The Purpose and Need of the Proposed Action is to produce base and precious metals precipitates and flotation concentrates from ore mined at the NorthMet Deposit by uninterrupted operation of the former LTVSMC processing plant. The processed resources would help meet domestic and global demand by sale of these products to domestic and world markets.