Implications of The Metals Company Pre-Feasibility Study for Next Steps by the Company

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ABSTRACT

The Metals Company (TMC), a publicly-traded company on the NASDAQ, has released a Pre-Feasibility Study prepared by AMC Consultants Pty Ltd (2025) for the mining of deep-sea nodules in the Clarion Clipperton Zone in the northeast Pacific Ocean. The nodules would be processed into nickel-cobalt-copper matte and manganese silicate with converter slag as a waste product at the PAMCO pyrometallurgical facility in Japan and at an unidentified pyrometallurgical facility in Indonesia. Beginning in Year 6, the nickel-cobalt-copper matte would be refined into nickel sulfate, cobalt sulfate, and copper cathode with ammonium sulfate as a waste product at a hydrometallurgical refinery to be constructed in the US. TMC is seeking an exploitation permit from the US National Oceanic and Atmospheric Administration (NOAA), rather than from the International Seabed Authority (ISA), which has not yet developed the regulatory framework for issuing exploitation permits. The objective of this report is to assess the implications of the Pre-Feasibility Study for TMC and any investors.

Although Securities and Exchange Commission (SEC) regulations require a detailed plan for mine waste management in a Pre-Feasibility Study, the TMC Pre-Feasibility Study includes zero plan for mine waste management because it does not regard the sediment-laden return water as mine waste, it claims that the converter slag will be sold for construction aggregate or an unidentified industrial application, and it claims that the ammonium sulfate will be sold for fertilizer. Although any industrial mining operation would produce zero waste if all of the outputs were marketable products, such an operation has never existed. The Pre-Feasibility Study includes no information on the quantity or potential toxicity of the converter slag or ammonium sulfate. The incomplete recovery of nickel, cobalt, and copper into nickel sulfate, cobalt sulfate, and copper cathode could render the remaining ammonium sulfate too toxic to be sold as fertilizer. Even without any concentration of the rejected elements into the ammonium sulfate, the levels of arsenic, cadmium, chromium, lead, molybdenum, and thallium in the nodules would render the ammonium sulfate too toxic to be sold as fertilizer.

While the total mineral resources inclusive of reserves are 363 million wet metric tons and the total mineral resources exclusive of reserves are 274 million wet metric tons for a difference of 89 million wet metric tons, the Pre-Feasibility Study identifies 51 million wet metric tons of reserves, so that 38 million wet metric tons of nodules have gone missing. This same arithmetic discrepancy is repeated throughout the Pre-Feasibility Study. Since the most important part of a mining project disclosure is the estimation of mineral resources and mineral reserves, the inability of the report produced by AMC Consultants Pty Ltd (2025) to provide arithmetically consistent estimates of resources and reserves raises serious questions regarded its validity as a Pre-Feasibility Study. In fact, the report by AMC Consultants Pty Ltd (2025) is

filled with inconsistent numbers and arithmetic errors. It is not the intention of this report to "proofread" the report by AMC Consultants Pty Ltd (2025), nor to document every numeric and arithmetic discrepancy.

As opposed to SEC regulations that regard only mineral reserves as economically mineable, the economic analysis is based on 51 million wet metric tons of reserves and an additional 113.1 million wet metric tons of resources. In fact, the Pre-Feasibility Study predicts that, based upon reserves alone, the project will terminate in eight years with zero profit. The Pre-Feasibility Study also converts a portion of the inferred resources into mineral reserves, which is inconsistent with SEC regulations. The Pre-Feasibility Study was largely prepared by TMC employees, which is not prohibited by SEC regulations, although the practice is unusual and would be inconsistent with Canadian regulations.

The economic assumptions are a collection of best-case and near-best-case scenarios. The assumed life-of-mine average price for nickel metal of 20,295 USD per metric ton is 38.3% higher than the current price of 14,671 USD per metric ton (monthly average for November 2025) and 13.1% higher than the average monthly price of 17,943 USD per metric ton for the period 2005-2025. The assumed life-of-mine average price for cobalt metal of 56,117 USD per metric ton is 16.6% higher than the current price of 48,139 USD per metric ton and 41.0% higher than the average monthly price of 39,795 USD per metric ton for the period 2005-2025. The assumed life-of-mine average price for copper cathode of 11,440 USD per metric ton is 5.8% higher than the current price of 10,812 USD per metric ton and 61.5% higher than the average monthly price of 7085 USD per metric ton for the period 2005-2025. Although the period 2005-2025 has seen a slight upward trend in copper cathode price, that trend would not intersect the assumed price until the end of 2047. The assumed nickel recovery rates (96.91% for ore to alloy and 94.76% for ore to matte are at the upper end of what is reported in the literature (90-97% for ore to alloy and 77-97% for ore to matte), while the assumed cobalt recovery rate of 93.06% from ore to alloy is much higher than the literature value of 80%. The US royalty rate is assumed to be zero. The discount rate is assumed to be only 8%, while the discount rate for a project at the stage of a Pre-Feasibility Study with ore processing to be carried out in Indonesia should be at least 16%. In contrast to assumed future prices, future costs are assumed to be the same as at present. The closure costs in the Pre-Feasibility Study do not include any costs for rehabilitation of the seafloor or closure of mine waste management facilities.

The existence of the smelting and refining facilities necessary for processing of the deep-sea nodules is highly speculative. The use of manganese silicate as a feedstock for silico-manganese (a component of steel) is highly speculative because there are currently no silico-manganese facilities that are accepting manganese silicate as a feedstock. If manganese silicate cannot be sold for steelmaking, its only markets are low-value products such as road aggregate or sand-blasting medium or as filler for ceramics, cement, or bricks. Moreover, the use of the PAMCO facility assumes that the Japanese and Indonesian governments will overlook the importation of deep-sea mining products in violation of the UN Convention on the Law of the Sea. The assumption that there will be excess smelting capacity in Indonesia is also highly speculative and also assumes that the Indonesian government will overlook the importation of deep-sea mining products.

The Pre-Feasibility Study does not take into account any consideration of the known radioactivity of deep-sea nodules, which was thoroughly investigated in the 1960s, 70s, and 80s. A partial list of the unconsidered risk factors associated with radioactivity include the following:

1) increased costs and delays in the completion of the production and transport vessels

2) unwillingness of the PAMCO facility in Japan or the unidentified pyrometallurgical facility in Indonesia to accept deep-sea nodules as a feedstock
3) decrease in the payable terms offered to TMC by the PAMCO facility in Japan or the unidentified pyrometallurgical facility in Indonesia
4) unwillingness of the Japanese or Indonesian governments to allow importation of deep-sea nodules
5) unwillingness of the unidentified refineries to accept the nickel-cobalt-copper matte as a feedstock
6) unwillingness of the governments of the unidentified refineries or of the US government to allow the importation of the nickel-cobalt-copper matte as a feedstock
7) unsuitability of the final products (manganese silicate, nickel sulfate, cobalt sulfate, copper cathode) for the intended markets (steel, batteries)
8) unsuitability of the by-products (converter slag, ammonium sulfate) for the intended markets (construction aggregate, fertilizer)
9) eco-toxicity of the sediment-laden return water largely due to dissolved metals and radioactive isotopes

The recommendation of this report is that The Metals Company should abandon the proposal to mine and process deep-sea nodules and should close the project in a financially responsible manner.

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EXECUTIVE SUMMARY

The Metals Company (TMC), a publicly-traded company on the NASDAQ, has released a Pre-Feasibility Study prepared by AMC Consultants Pty Ltd (2025) for the mining of deep-sea nodules from a depth of 4500 meters below sea level in the Clarion Clipperton Zone in the northeast Pacific Ocean between Hawaii and Mexico. The proposed project would mine and process 164.1 million wet metric tons of nodules over 20 years. A nodule dewatering system on the production vessel would separate the nodules from the sediment-laden return water, which would be re-injected to a depth of 2000 meters. The nodules would be processed into nickel-cobalt-copper alloy and manganese silicate using rotary kiln calcining and electric furnace smelting (RKEF) at the PAMCO pyrometallurgical facility in Japan and at an unidentified pyrometallurgical facility in Indonesia. The use of convertor sulfidation at the same facilities would process the nickel-cobalt-copper alloy into nickel-cobalt-copper matte with converter slag as a waste product. Beginning in Year 6, the nickel-cobalt-copper matte would be refined into nickel sulfate, cobalt sulfate, and copper cathode with ammonium sulfate as a waste product at a hydrometallurgical refinery to be constructed in the US. TMC is seeking an exploitation permit from the US National Oceanic and Atmospheric Administration (NOAA), rather than from the International Seabed Authority (ISA), which has not yet developed the regulatory framework for issuing exploitation permits.

The Pre-Feasibility Study is a critical step in the stage-gate process for mine planning. At the conclusion of the preparation of the Pre-Feasibility Study (the stage), the mining company chooses one of the following next steps (called the gates):

1) abandon the project
2) pause the project
3) re-do an earlier stage, such as the Preliminary Economic Assessment
4) re-do the Pre-Feasibility Study
5) proceed to the Feasibility Study

For publicly traded companies, such as TMC, the Pre-Feasibility Study must also be made publicly available. Since TMC trades on the NASDAQ, the content of the Pre-Feasibility Study must comply with the regulations set by the US Securities and Exchange Commission (SEC).

The objective of this report is to assess the implications of the Pre-Feasibility Study in terms of the next steps for The Metals Company. The objective is subdivided into addressing the following questions:

1) Does the Pre-Feasibility Study include a detailed plan for mine waste management as required by SEC regulations?
2) Is the economic analysis in the Pre-Feasibility Study based on mineral reserves as required by SEC regulations?
3) Was the Pre-Feasibility Study prepared by independent parties?
4) Are the economic assumptions in the Pre-Feasibility Study reasonably conservative?
5) Is the smelting and refining capacity assumed in the Pre-Feasibility Study reasonably likely to exist?
6) Has the known radioactivity of deep-sea nodules been adequately taken into account?

In order to facilitate reading by non-specialists, this report includes a tutorial on key aspects of mine planning, including the distinction between mineral resources and mineral reserves, the discount rate and net present value, the Pre-Feasibility Study and the stage-gate process, and a comparison between SEC regulations and the corresponding regulations in other jurisdictions.

SEC regulations require a detailed plan for mine waste management in a Pre-Feasibility Study. In a similar way, because mine waste management is so often the critical weakness for a mining project, the industry standard is that, although <10% of the overall engineering of a project needs to be complete at the stage of a Pre-Feasibility Study, 15-20% of the engineering for mine waste management should be complete. By contrast, the TMC Pre-Feasibility Study includes zero planning for mine waste management because it does not regard the sediment-laden return water as mine waste, it claims that the converter slag will be sold for construction aggregate or an unidentified industrial application (such as sand-blasting medium), and it claims that the ammonium sulfate will be sold for fertilizer. Although any industrial mining operation would produce zero waste if all of the outputs were marketable products, such an operation has never existed. In this respect, deep-sea mining is in no way different from terrestrial mining, which always produces mine waste.

The Pre-Feasibility Study includes no information on the quantity or potential toxicity of the converter slag or ammonium sulfate, which would determine whether the converter slag or ammonium sulfate are suitable for any market. The ore processing flowsheet has the purpose of recovering nickel, cobalt, copper, and manganese into nickel sulfate, cobalt sulfate, copper cathode, and manganese silicate, respectively, while rejecting all other elements of the deep-sea nodules (except potentially sulfur and silicon) into the waste products of converter slag and ammonium sulfate. Thus, a wide range of potentially toxic elements from the deep-sea nodules could render the converter slag unsuitable for road aggregate or sand-blasting medium. Moreover, the incomplete recovery of nickel, cobalt, and copper into nickel sulfate, cobalt sulfate, and copper cathode could render the remaining ammonium sulfate too toxic to be sold as fertilizer. In fact, even without any concentration of the rejected elements into the ammonium sulfate, the levels of arsenic, cadmium, chromium, lead, molybdenum, and thallium in the nodules would render the ammonium sulfate too toxic to be sold as fertilizer. Finally, the sediment-laden return water should also be regarded as a waste product because stable sediment has been converted into suspended sediment, which could be detrimental to marine life. By analogy, the sediment that is obtained from dredging a harbor (typically referred to as "dredge spoil") and that is dumped into another water body or farther out to sea would certainly be regarded as a waste product.

While the total mineral resources inclusive of reserves are 363 million wet metric tons and the total mineral resources exclusive of reserves are 274 million wet metric tons for a difference of 89 million wet metric tons, the Pre-Feasibility Study identifies 51 million wet metric tons of reserves, so that 38 million wet metric tons of nodules have gone missing. This same arithmetic discrepancy is repeated throughout the Pre-Feasibility Study. Since the most important part of a mining project disclosure is the estimation of mineral resources and mineral reserves, the inability of the report produced by AMC Consultants Pty Ltd (2025) to provide arithmetically consistent estimates of resources and reserves raises serious questions regarding its validity as a Pre-Feasibility Study. In fact, the report by AMC Consultants Pty Ltd (2025) is filled with inconsistent numbers and arithmetic errors. It is not the intention of this report to "proofread" the report by AMC Consultants Pty Ltd (2025), nor to document every numeric and arithmetic discrepancy.

As opposed to SEC regulations that regard only mineral reserves as economically mineable, the economic analysis in the Pre-Feasibility Study is based on the 51 million wet metric tons of reserves plus an additional 113.1 million wet metric tons of resources. In fact, the Pre-Feasibility Study predicts that, based upon reserves alone, the project will terminate in eight years with zero profit. The Pre-Feasibility Study also converts a portion of the inferred resources into mineral reserves, which is inconsistent with SEC regulations. The Pre-Feasibility Study was largely prepared by TMC employees, which is not prohibited by SEC regulations although the practice is unusual and would be inconsistent with Canadian regulations.

The economic assumptions in the Pre-Feasibility Study are a collection of best-case and near-best-case scenarios. Reasonably conservative assumptions for future prices are that they will be no higher than the trend for a comparable period in the past. By contrast, the assumed life-of-mine average price for nickel metal of 20,295 USD per metric ton is 38.3% higher than the current price of 14,671 USD per metric ton (monthly average for November 2025) and 13.1% higher than the average monthly price of 17,943 USD per metric ton for the period 2005-2025. The assumed life-of-mine average price for cobalt metal of 56,117 USD per metric ton is 16.6% higher than the current price of 48,139 USD per metric ton and 41.0% higher than the average monthly price of 39,795 USD per metric ton for the period 2005-2025. The assumed life-of-mine average price for copper cathode of 11,440 USD per metric ton is 5.8% higher than the current price of 10,812 USD per metric ton and 61.5% higher than the average monthly price of 7085 USD per metric ton for the period 2005-2025. The period 2005-2025 did not show any upward trend for nickel or cobalt prices. In fact, the price of nickel dropped from 33,924 to 14,671 USD per metric ton from March 2022 to November 2025, while the price of cobalt dropped from 81,790 to 21,721 USD per metric ton from April 2022 to February 2025. Although the period 2005-2025 has seen a slight upward trend in copper cathode price, that trend would not intersect the assumed price until the end of 2047. The assumed price of 545 USD per metric ton for manganese silicate is highly uncertain, owing to the lack of any global commodity price for manganese silicate at the present time.

Although the current ratio of the price of nickel contained in nickel sulfate to the price of nickel metal is 1.023, the Pre-Feasibility Study assumes a life-of-mine average ratio of 1.066. The assumed nickel recovery rates (96.91% for ore to alloy and 94.76% for ore to matte are at the upper end of what is reported in the extractive metallurgical literature (90-97% for ore to alloy and 77-97% for ore to matte), while the assumed cobalt recovery rate of 93.06% from ore to alloy is much higher than the literature value of 80%. The assumed nickel recovery rate for processing from nodule to sulfate (94.60%) is also much higher than the range of 53-90% with a median of 83% that is reported on a compilation of company websites. The US royalty rate is assumed to be zero, which is the best-case scenario by definition. The discount rate is assumed to be only 8%, while, according to industry standards, the discount rate for a project at the stage of a Pre-Feasibility Study with ore processing to be carried out in Indonesia should be at least 16%, not even taking into account the additional uncertainty associated with a new technology and a new type of ore deposit. In contrast to assumed future prices, future costs are assumed to be the same as at present. The closure costs in the Pre-Feasibility Study do not include any costs for rehabilitation of the seafloor or closure of mine waste management facilities, which also reflects a best-case scenario in which no one requires TMC to either rehabilitate the seafloor or properly close mine waste management facilities.

The existence of the smelting and refining facilities necessary for processing of the deep-sea nodules is highly speculative. The use of manganese silicate as a feedstock for silico-manganese (a component of steel) is highly speculative because there are currently no silico-manganese facilities that are accepting manganese silicate as a feedstock. If manganese silicate cannot be sold for steelmaking, its only markets are low-value products such as road aggregate or sand-blasting medium or as filler for ceramics, cement, or bricks. In this respect, it should be noted that the Pre-Feasibility Study predicts that 28.4% of project revenue will come from the sale of manganese silicate. Moreover, the use of the PAMCO facility in Japan assumes that the Japanese government will overlook the importation of deep-sea mining products in violation of the UN Convention on the Law of the Sea. The assumption that there will be excess smelting capacity in Indonesia is also highly speculative, especially in light of the current Indonesian ban on the export of nickel ore or nickel concentrates. Moreover, the assumption of excess smelting capacity in Indonesia is certainly inconsistent with the additional assumption of skyrocketing global nickel prices. Finally, just as with Japan, the assumption of excess smelting capacity also assumes that the Indonesian government will overlook the importation of deep-sea mining products in violation of the UN Convention on the Law of the Sea.

Although the elevated radioactivity of deep-sea sediments has been known since 1908 and the elevated radioactivity of deep-sea sediments and nodules (relative to continental crust and continental sediments) was thoroughly investigated in the 1960s, 70s, and 80s, the Pre-Feasibility Study does not discuss at all the implications of radioactivity for the ability of TMC to carry out the mining and processing project. This shortcoming, in fact, ties together many of the concerns expressed in this report. A partial list of the implications of the radioactivity of the deep-sea nodules, none of which are discussed in the Pre-Feasibility Study is as follows:

1) There could be increased costs and delays in the completion of the production and transport vessels due to the need to provide radiation protection.
2) Either the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia could be unwilling to accept radioactive deep-sea nodules as a feedstock.
3) There could be a decrease in the payable terms offered to TMC by the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia due to the costs of installing equipment for radiation protection.
4) Either the Japanese or Indonesian governments could refuse to allow importation of deep-sea nodules due to their radioactivity.
5) The nickel-cobalt-copper matte that would be produced by the pyrometallurgical facilities might be radioactive, in which case, the unidentified refineries might be unwilling to accept the nickel-cobalt-copper matte as a feedstock,
6) If the nickel-cobalt-copper matte is excessively radioactive, the governments of the refineries, including the US government, might refuse to allow the importation of the nickel-cobalt-copper matte.
7) The final products (manganese silicate, nickel sulfate, cobalt sulfate, copper cathode) might be excessively radioactive for the intended markets (steel, batteries).
8) The by-products (converter slag, ammonium sulfate) might be excessively radioactive for the intended markets (construction aggregate, fertilizer)
9) The sediment-laden return water could be eco-toxic due to the inclusion of small radioactive nodules and nodule fragments.

It is tempting to the author to recommend that the Pre-Feasibility Study be completely re-written by independent parties with special attention to the following:

1) The Pre-Feasibility Study should be checked for numeric consistency and should be free from arithmetic errors.
2) The sediment-laden return water should be regarded as mine waste and a detailed plan should be developed for management of the waste. The management plan should take into account the potential eco-toxicity of the return water due to the inclusion of small radioactive nodules and nodule fragments.

3) The quantity and chemical composition of the converter slag and ammonium sulfate should be determined. Based on the above, potential markets should be assessed for the converter slag and ammonium sulfate. The quantities of converter slag and ammonium sulfate that are too toxic for potential markets or are otherwise unmarketable should be regarded as mine waste and a detailed mine waste management plan should be developed. The toxicity of the converter slag and ammonium sulfate should include potential radioactivity.
4) The economic analysis should be based upon mineral reserves alone.
5) Inferred resources should not be converted into mineral reserves.
6) Prices for nickel metal, cobalt metal, copper cathode, nickel sulfate, cobalt sulfate, and manganese silicate should be based upon trends over the period 2005-2025.
7) The economic analysis should include the possibility that no silico-manganese facility will accept manganese silicate as a feedstock.
8) A reasonable non-zero US royalty rate should be assumed.
9) The assumed discount rate should be at least 16%.
10) Assumed metal recovery rates should be consistent with values in the extractive metallurgical literature.
11) Closure costs should take into account the cost of rehabilitation of the sea floor and proper closure of mine waste management facilities.
12) The intended countries for ore processing should include only those countries that can legally accept deep-sea mining products, that is, only countries that are not signatories to the UN Convention on the Law of the Sea.
13) The cost and completion schedule of the production and transport vessels should take into account the need for radiation protection.
14) The unwillingness of the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia to accept deep-sea nodules as a feedstock due to their radioactivity should be included as a risk factor.
15) The estimation of the payable terms offered to TMC by the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia should take into account the need to develop adequate radiation protection.
16) The unwillingness of the Japanese or Indonesian governments to allow importation of deep-sea nodules due to their radioactivity should be included as a risk factor.
17) The unwillingness of the unidentified refineries to accept the nickel-cobalt-copper matte as a feedstock due to its potential radioactivity should be included as a risk factor.
18) The unwillingness of the governments of the unidentified refineries or of the US government to allow the importation of the nickel-cobalt-copper matte as a feedstock due to its potential radioactivity should be included as a risk factor.
19) The unsuitability of the final products (manganese silicate, nickel sulfate, cobalt sulfate, copper cathode) for the intended markets (steel, batteries) due to their potential radioactivity should be included as a risk factor.

However, the author does not make the above recommendation because, based upon the Pre-Feasibility Study, the proposal for mining and processing of deep-sea nodules appears to be completely hopeless. In particular, even given the assumptions of elevated future prices, a zero US royalty rate, and a reduced discount rate, based upon the mineral reserves alone, which according to SEC regulations are the only economically mineable part of mineral resources, the proposed project will terminate after eight years with zero profit. Therefore, the recommendation of this report is that The Metals Company should abandon the proposal to mine and process deep-sea nodules and should close the project in a financially responsible manner.

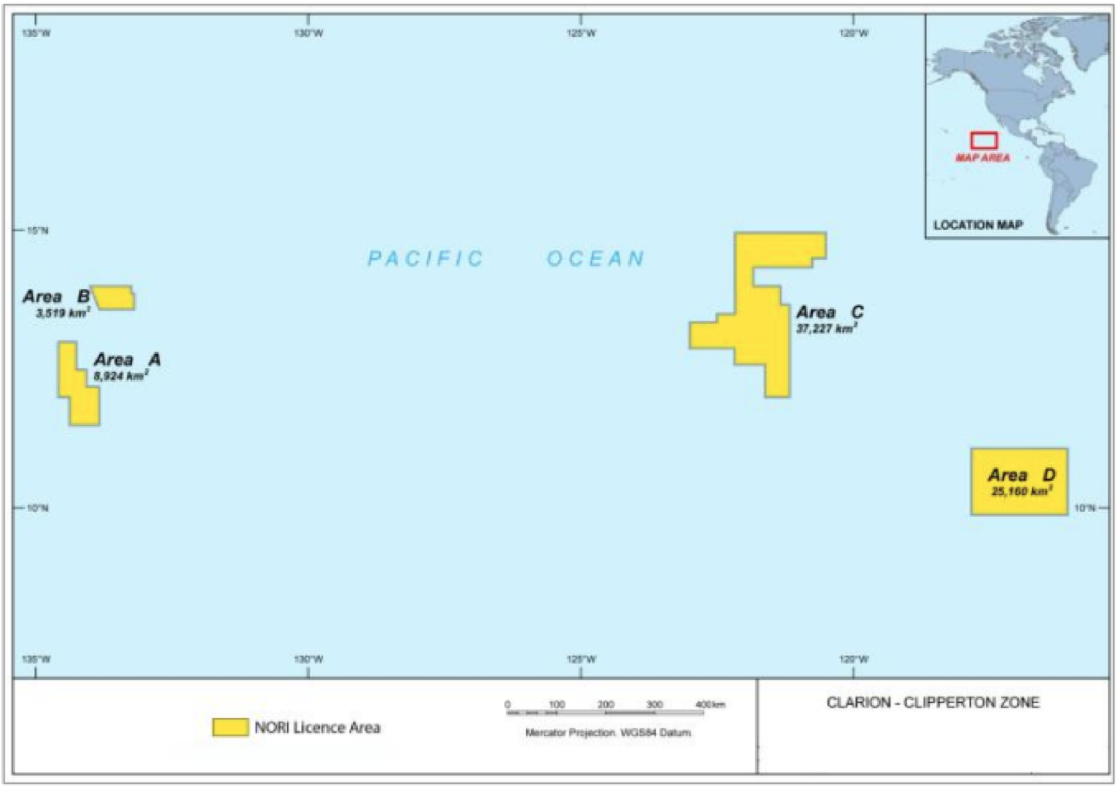
OVERVIEW

The Metals Company (TMC), a publicly-traded company on the NASDAQ, has released a Pre-Feasibility Study (AMC Consultants Pty Ltd, 2025) for the mining of deep-sea nodules from a depth of 4500 meters below sea level in the Clarion Clipperton Zone in the northeast Pacific Ocean between Hawaii and Mexico (see Fig. 1). The proposal for the world's first deep-sea mining project involves multiple technologies that are still under development. The nodule collection system would involve a collector that would be 15 meters wide and would be remotely operated and self-propelled (see Figs. 2a-b). The collector would be attached to a production vessel by a flexible jumper hose, riser-and-air-lift vertical transport system (VTS) for raising the nodules to the production vessel (see Figs. 3a-b), and communication and power cables (umbilical) (see Fig. 2a). On the production vessel, a gas-liquid-solid separator would remove excess water from the nodules. The sediment-laden "return water" that would be produced by the nodule dewatering system would be re-injected into the ocean at a depth of 2000 meters (see Figs. 3a-b). Finally, the partially dewatered nodules would be transferred to another vessel for shipment to a land-based ore processing facility (see Fig. 2a). According to the Pre-Feasibility Study, "Through June 2025 Production Vessel engineering was 21.6% complete" (AMC Consultants Pty Ltd, 2025), which is oddly precise.

The proposed project would mine and process 164.1 million wet metric tons of nodules over 20 years (see Fig. 4), beginning in 2027 (AMC Consultants Pty Ltd, 2025). Initially, the nodules would be processed at the PAMCO (Pacific Metals Company) pyrometallurgical complex in Japan, which would use rotary kiln calcining and electric furnace smelting (RKEF) to produce a nickel-cobalt-copper alloy plus manganese silicate (see Fig. 5a). The manganese silicate would be sold as a feedstock for the production of silico-manganese (a component of steelmaking), although there are no silico-manganese facilities that are accepting manganese silicate as a feedstock at the present time. Over the next 18-24 months, PAMCO would develop the capacity to carry out converter sulfidation to transform the nickel-cobalt-copper alloy into nickel-cobalt-copper matte plus a converter slag (see Fig. 5a). Converter sulfidation adds sulfur to transform nickel, cobalt, and copper from the metallic to the sulfide phases with reduction of the iron content, which is rejected into the converter slag. Prior to Year 6, all of the nickel-cobalt-copper matte would be sold to an unidentified hydrometallurgical refinery to produce the final products of nickel sulfate, cobalt sulfate, copper cathode, and ammonium sulfate (see Fig. 5b).

The PAMCO facility would process a maximum of 1.3 million wet metric tons of nodules per year (AMC Consultants Pty Ltd, 2025) with all excess, up to a maximum of 12 million wet metric tons per year, to be processed into nickel-cobalt-copper alloy and then nickel-cobalt-copper matte at an unidentified RKEF facility in Indonesia. Beginning in Year 6, half of the nickel-cobalt-copper matte would be shipped to a hydrometallurgical refinery in the US that has not yet been constructed for the production of the final products. Beginning in Year 10, all of the matte would be processed at the new hydrometallurgical refinery in the US.

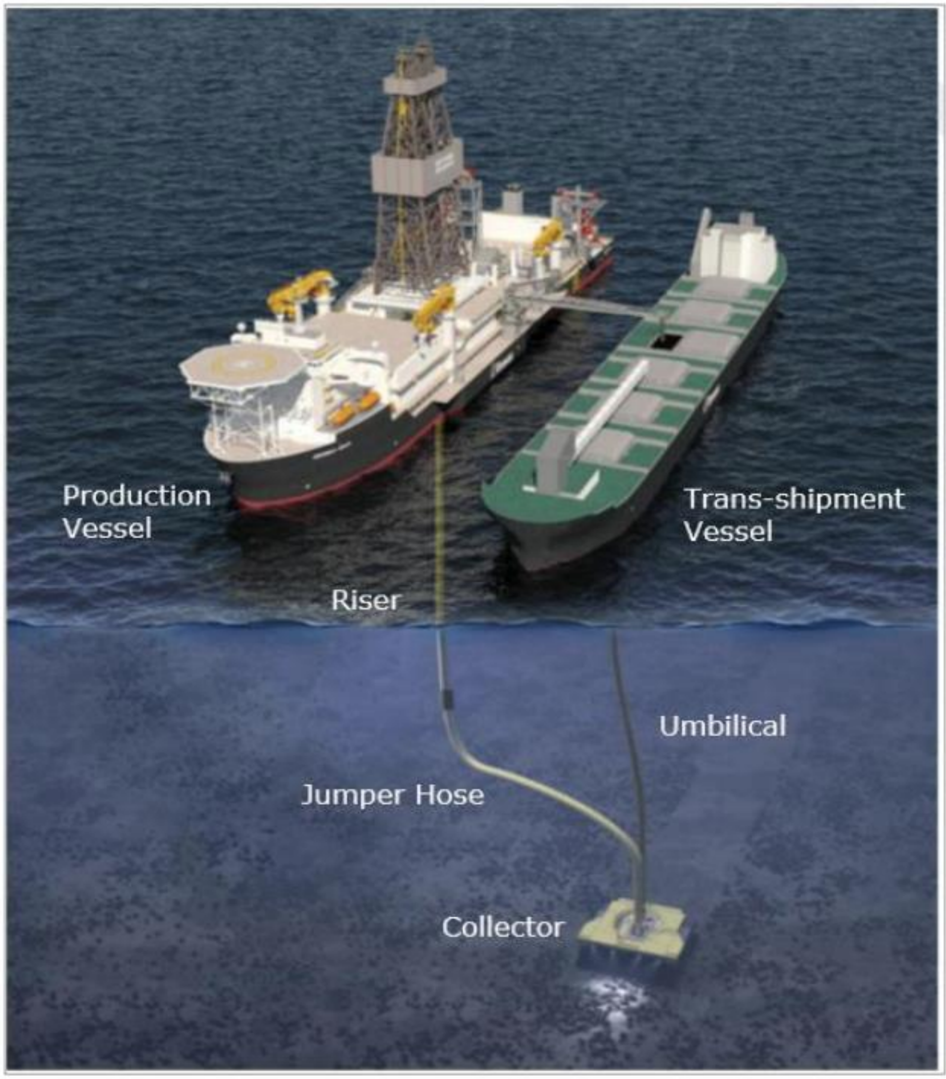
Figure 3.4 Location of NORI blocks in the CCZ



Source: NORI

Figure 1. The Metals Company (TMC) has released a Pre-Feasibility Study for the mining of deep-sea nodules in NORI (Nauru Ocean Resources Inc.) Area D of the Clarion Clipperton Zone in the northeast Pacific Ocean between Hawaii and Mexico. Figure from AMC Consultants Pty Ltd (2025).

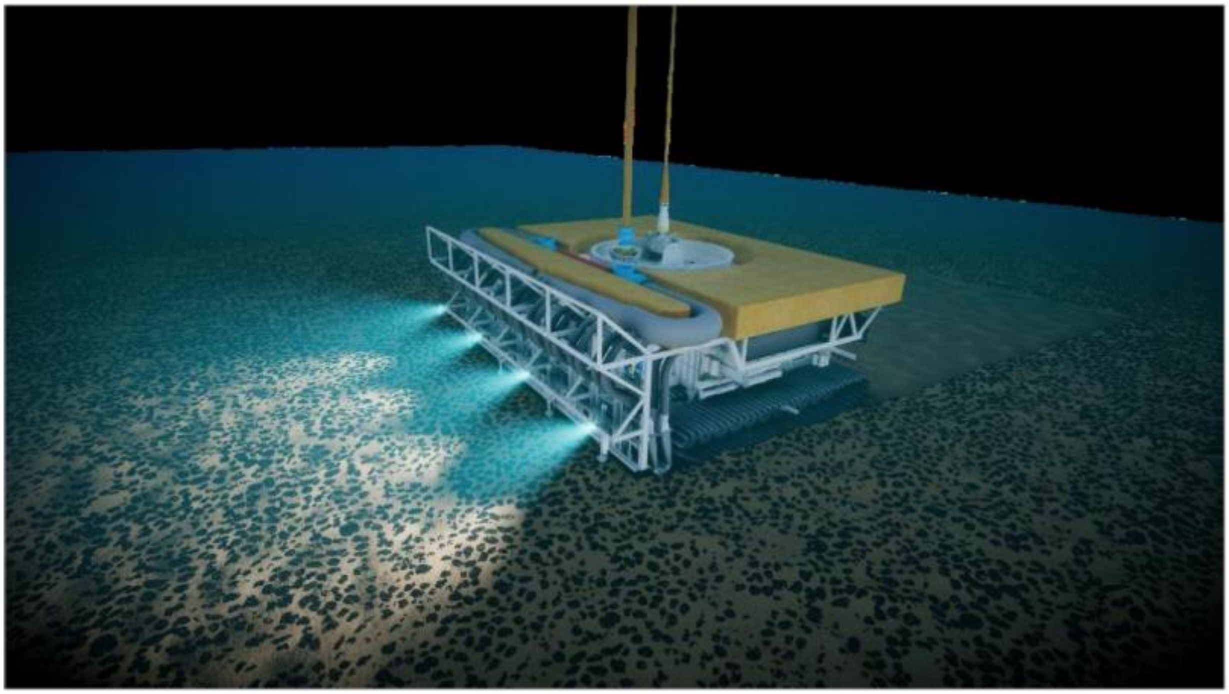
Figure 12.1 Graphic depicting nodule collection system



Source: Allseas 2024.Note in this illustration the vessel referred to as the 'Trans-shipment vessel' is to be considered the same as the Transfer Vessel (TV) as described in section 13.2.8.

Figure 2a. The nodule collection system would involve a collector (see Fig. 2b) attached to a production vessel by a flexible jumper hose, riser-and-air-lift vertical transport system (VTS) (see Figs. 3a-b) and communication and power cables (umbilical). The nodules would be transferred to another vessel for shipment to a land-based ore processing facility. Figure from AMC Consultants Pty Ltd (2025).

Figure 12.2 Graphic depicting the collector

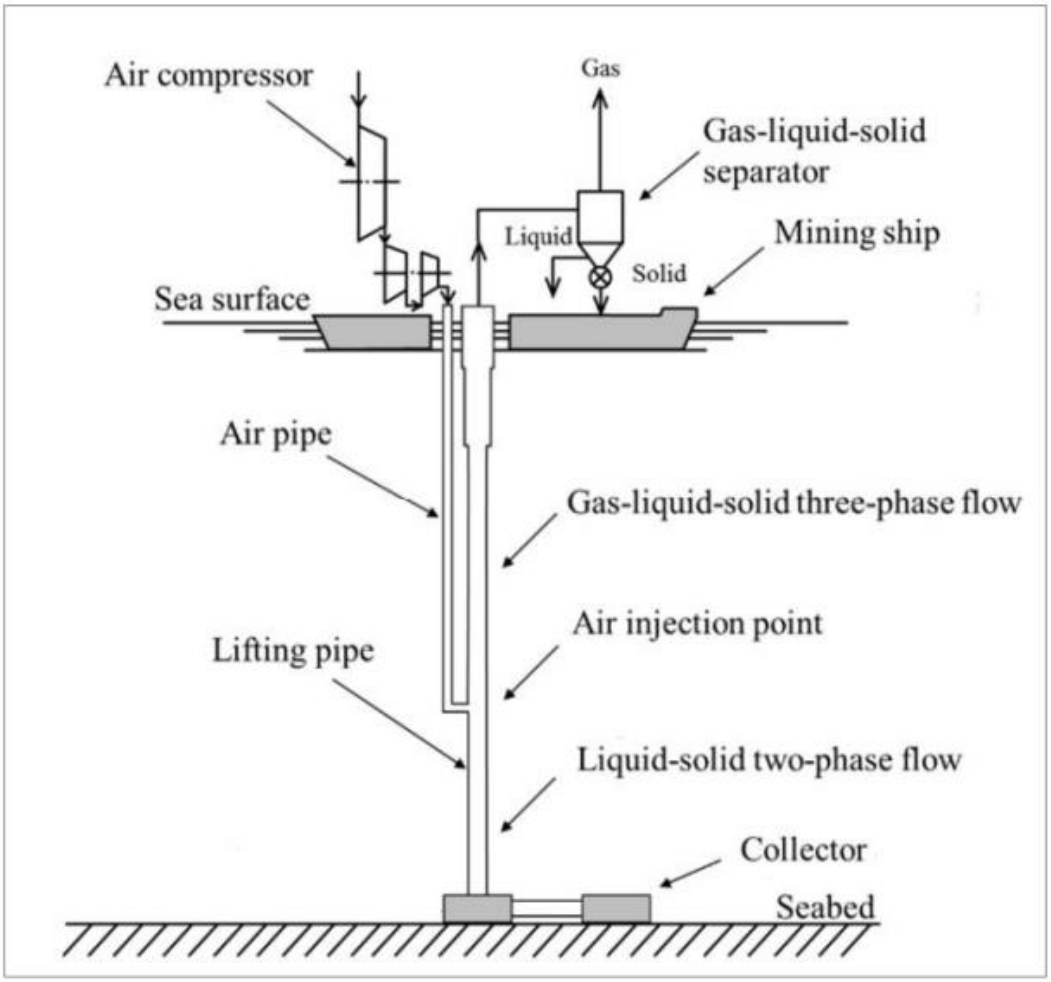


Source: Allseas 2024

Figure 2b. The nodule collector would be 15 meters wide and would be remotely operated and self-propelled. See attachments to production vessel in Fig. 2a. Figure from AMC Consultants Pty Ltd (2025).

The Pre-Feasibility Study states that the nodule processing flowsheet produces zero waste (zero tailings) because all of the outputs are marketable products. The waste that remains after the commodity of value has been removed from an ore body is called the tailings. According to the SME (Society for Mining, Metallurgy and Exploration) Surface Mining Handbook, “Tailings are fine-grained mineral waste that remains after processing and recovery of the minerals of economic interest, along with process water and chemical reagents added during the milling or beneficiation stages” (Snow and Morrison, 2023). In the case of the proposal for mining and processing of deep-sea nodules, the converter slag could be sold for construction aggregate or an unidentified industrial application (such as sand-blasting medium), while the ammonium sulfate could be sold for fertilizer. According to the Pre-Feasibility Study, “The pyrometallurgical process generates a manganese silicate stream that can be sold to the manganese industry and a small converter slag stream that can be used for industrial applications. No value has been ascribed to converter slag … The converting process also produces a slag by-product, which is intended for sale as a construction aggregate” (AMC Consultants Pty Ltd, 2025). The Pre-Feasibility Study continues, “Nickel and cobalt sulfate can be sold as feedstocks for battery production and energy storage, while the ammonium sulfate is sold for use as a fertilizer” (AMC Consultants Pty Ltd, 2025).

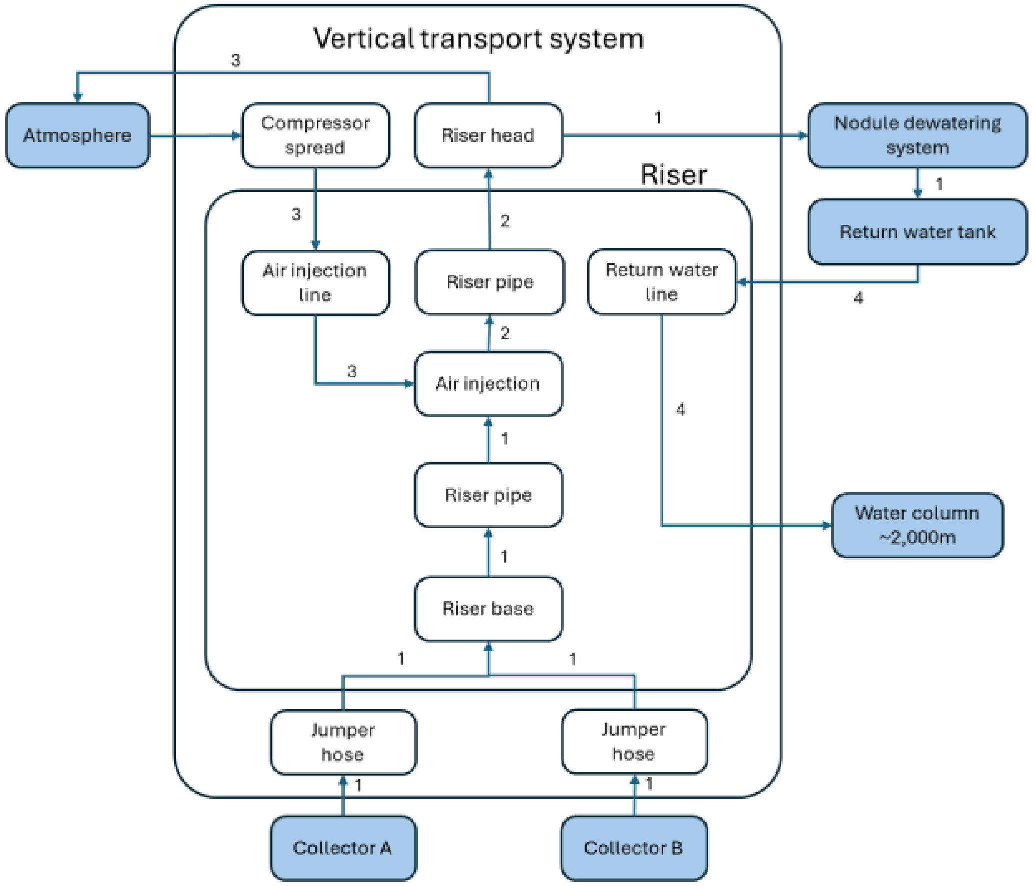
Figure 12.5 Main components of the VTS



Source: Allseas

Figure 3a. The nodules would be lifted from the collector (see Fig. 2b) to the production vessel (see Fig. 2a) using a vertical transport system (VTS). On the production vessel, a gas-liquid-solid separator would remove excess water from the nodules (see detail in Fig. 3b). Figure from AMC Consultants Pty Ltd (2025).

Figure 13.11 Block diagram – VTS



ID	(Compressed) Air	Seawater	Nodules	Sediment
1		x	x	x
2	x	x	x	x
3	x			
4		x		x

Source: Allseas

Figure 3b. The nodule dewatering system would produce sediment-laden "return water" that would be re-injected to a depth of 2000 meters. The Pre-Feasibility Study does not regard this sediment-laden water as waste. The return water should be regarded as waste because stable sediment has been converted to suspended sediment, which could have detrimental impacts on marine life. By analogy, if sediment were dredged from a harbor and deposited into another water body or farther out to sea, it certainly would be regarded as waste. Figure from AMC Consultants Pty Ltd (2025).

Table 12.13 Production targets

Parameter	Units	Value
Production – Year 0	Mwt	0.2
Production – Year 1	Mwt	1.0
Production – Year 2	Mwt	2.0
Production – Year 3	Mwt	5.0
Production – Year 4	Mwt	11.0
Production – Year 5-8	Mwt	10.5
Production – Year 9	Mwt	12.0
Production – Year 10-13	Mwt	10.5
Production – Year 14	Mwt	12.0
Production – Year 15-17	Mwt	10.5
Production – Years 18	Mwt	5.4
Production – Year 19	Mwt	0.0
Total production	**Mwt**	**164.1**

Figure 4. The Pre-Feasibility Study proposes the production of 164.1 million wet metric tons of nodules over a 20-year life of mine. By contrast, the Pre-Feasibility Study identifies only 51 million wet metric tons of reserves (see Fig. 6b). The standard industry practice is to develop the mining plan on the basis of reserves alone, since only reserves can be regarded as economically mineable. According to SEC regulations, "Mineral reserve is an estimate of tonnage and grade or quality of indicated and measured mineral resources that, in the opinion of the qualified person, can be the basis of an economically viable project. More specifically, it is the economically mineable part of a measured or indicated mineral resource" (CFR, 2018; see Table 2b). Table from AMC Consultants Pty Ltd (2025).

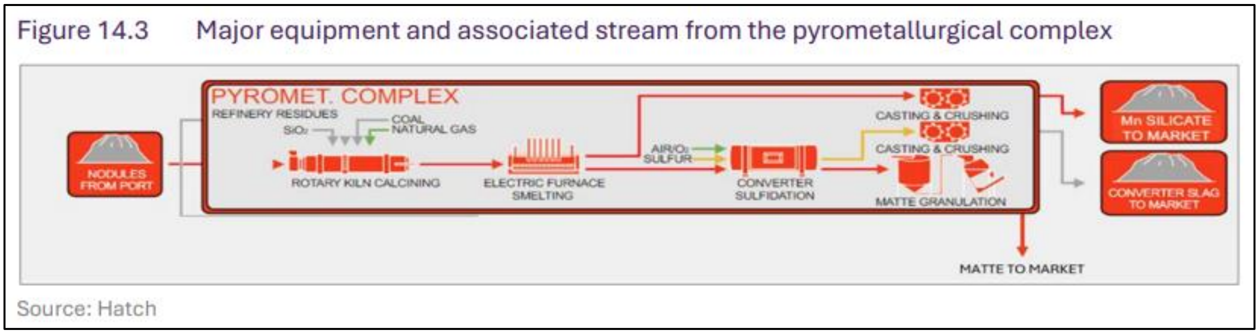


Figure 5a. The Pre-Feasibility Study proposes an ore processing flowsheet in which nodules are processed at a pyrometallurgical complex using rotary kiln calcining and electric furnace smelting (RKEF) to produce a nickel-cobalt-copper alloy and manganese silicate. The nickel-cobalt-copper alloy is then processed using convertor sulfidation to produce a nickel-cobalt-copper matte and a converter slag. The nickel-cobalt-copper matte would be a feedstock for the production of nickel sulfate, cobalt sulfate, and copper cathode at a hydrometallurgical refinery (see Fig. 5b). Although the Pre-Feasibility Study proposes that the manganese silicate could be a feedstock for the production of silico-manganese for steel making, that is speculative at the present time since there are no existing silico-manganese facilities that are accepting manganese silicate as a feedstock. The alternative is that manganese silicate could be used only for low-value products such as road aggregate or sand-blasting medium or as filler in ceramics, cement, or bricks. Although the Pre-Feasibility Study identifies the converter slag as a marketable product, there has been no analysis of the chemical composition of the converter slag, which would determine its suitability as a marketable product. For example, elevated concentrations of elements that would be toxic in soil or groundwater could render the converter slag as unsuitable for road aggregate. If the converter slag cannot be sold as a marketable product, then it constitutes mine tailings. It should be noted that ore processing without the production of tailings has never existed and that the Pre-Feasibility Study does not include any plan for tailings or waste management. Figure from AMC Consultants Pty Ltd (2025).

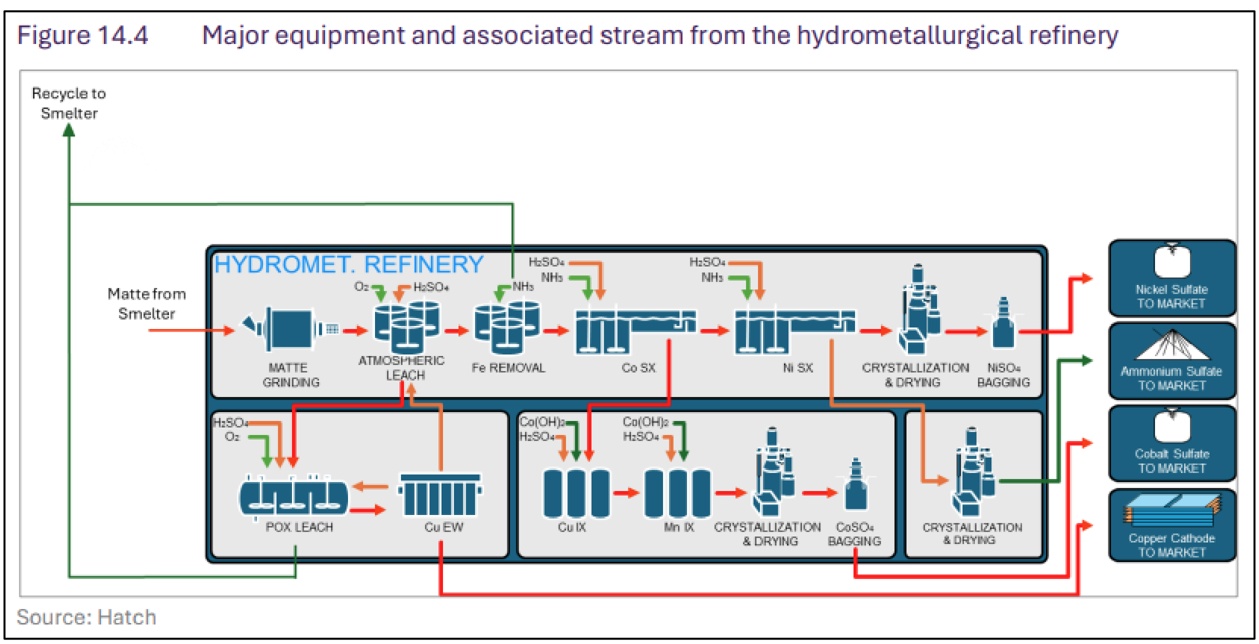


Figure 5b. The Pre-Feasibility Study proposes an ore processing flowsheet in which the nickel-cobalt-copper matte from the pyrometallurgical complex (see Fig. 5a) is further processed at a hydrometallurgical refinery to produce nickel sulfate, cobalt sulfate, and copper cathode, all of which are marketable products. Although the Pre-Feasibility Study also identifies the ammonium sulfate as a marketable product for fertilizer, there has been no analysis of the chemical composition of the ammonium sulfate, which would determine its suitability as fertilizer (compare with Figs. 16-17). If the ammonium sulfate cannot be sold as a marketable product, then it constitutes mine tailings. It should be noted that ore processing without the production of tailings has never existed and that the Pre-Feasibility Study does not include any plan for tailings or waste management. Figure from AMC Consultants Pty Ltd (2025).

A complicating factor in the project is that the elevated radioactivity of deep-sediments has been known since 1908 (Joly, 1908) and the elevated radioactivity of deep-sea nodules (relative to continental crust and continental sediments) was thoroughly investigated in the 1960s, 70s, and 80s (e.g., Nikolayev and Yefimova, 1963; Ku and Broecker, 1967; Margolis and Burns, 1976; Krishnaswami and Cochran, 1978; Krishnaswami et al., 1982; Huh and Ku, 1984; Nozaki and Yang, 1985). More recent publications have reviewed the implications of the radioactivity of deep-sea nodules for the safety of the transport and processing of the nodules (Volz et al., 2023; Kunze et al., 2024; Lüttke et al., 2025).

An additional complicating factor is that TMC is seeking an exploitation permit from the US National Oceanic and Atmospheric Administration (NOAA), rather than from the International Seabed Authority (ISA), which has not yet developed the regulatory framework for issuing exploitation permits. According to ISA (2025), "No commercial exploitation has been approved, as regulations governing deep-sea mining are still under development." Recently, the ISA reiterated its sole authority to grant exploitation permits for deep-sea mining and expressed great concern over the intention of TMC to seek an exploitation permit from the United States alone. According to ISA (2025), "It is important to state that the legal mandate to regulate mineral-related activities in the seabed beyond coastal countries' national jurisdictions (the Area) rests solely with the International Seabed Authority (ISA), as enshrined in the United Nations Convention on the Law of the Sea (UNCLOS). As a result, no private entity or State may undertake such activities outside this framework without contravening the international legal regime, including customary international law, that governs the Area as the common heritage of humankind. Any action outside this multilateral system undermines this principle … In her Statement on the announcement by TMC in March 2025 during Part I of the thirtieth session of ISA, the Secretary-General of ISA, Madam Leticia Carvalho, expressed deep concern over TMC's announcement to seek a US permit for deep-sea mining, bypassing ISA's established framework. Madam Secretary-General emphasized that such unilateral actions violate international law and undermine the principle of the seabed as the common heritage of humankind, as enshrined in the UNCLOS … Following that statement, ISA Member States broadly reiterated their commitment to the ISA and its exclusive role in regulating activities in the Area under international law. In that sense, it was reassuring to see that virtually all States, especially those States that currently have exploration contracts with ISA and could have plans to proceed to the next phases towards exploitation, strongly rejected the possibility of acting outside the system and without ISA."

The Pre-Feasibility Study is a critical step in the stage-gate process for mine planning (Carter and Tolmer, 2023; Turek, 2023; see Table 1). At the conclusion of the preparation of the Pre-Feasibility Study (the stage), the mining company chooses one of the following next steps (called the gates), ranked in order from the most pessimistic to the most optimistic:

1) abandon the project
2) pause the project
3) re-do an earlier stage, such as the Preliminary Economic Assessment
4) re-do the Pre-Feasibility Study
5) proceed to the Feasibility Study

For publicly traded companies, such as TMC, the Pre-Feasibility Study must also be made publicly available. Since TMC trades on the NASDAQ, the content of the Pre-Feasibility Study must comply with the regulations set by the US Securities and Exchange Commission (SEC).

Table 1. Comparison of critical stages in mine planning

Stage	Accuracy of Cost Estimate[1] (%)	Completion of Engineering: Overall[2] (%)	Completion of Engineering: Tailings Management[3] (%)
Conceptual Study	-50 to +100	—	—
Scoping Study[4]	-30 to +50	<3	<5
Pre-Feasibility Study	-20 to +25	<10	15-20
Feasibility Study	-10 to +15	<30	60-80
Definitive Feasibility Study	—	—	70-90

[1]Turek (2023)
[2]Carter and Tolmer (2023)
[3]Henderson and Morrison (2022)
[4]Sometimes called the Preliminary Economic Assessment or the Initial Assessment

The objective of this report is to assess the implications of the Pre-Feasibility Study in terms of the next steps for The Metals Company. In order to facilitate reading by non-specialists, this report includes a tutorial on key aspects of mine planning, including the distinction between mineral resources and mineral reserves, the discount rate and net present value, the Pre-Feasibility Study and the stage-gate process, and a comparison between SEC regulations and the corresponding regulations in other jurisdictions. After the tutorial, there will be a summary of the Pre-Feasibility Study with emphasis on the financial aspects, followed by a subdivision of the overall objective of this report into a set of six questions. As appropriate, this report will summarize other critiques of deep-sea mining (Planet Tracker, 2023; Trytten Consulting Services, 2025) and the recent Pre-Feasibility Study (Barnard and Trytten, 2025; Iceberg Research, 2025a-c; Schwartz, 2025).

TUTORIAL ON KEY ASPECTS OF MINE PLANNING

Mineral Resources and Mineral Reserves

A critical component of mine planning in general and the Pre-Feasibility Study in particular is the estimation of the mineral resources and mineral reserves. The precise meanings of "mineral resources" and "mineral reserves" are defined by SEC regulations (CFR, 2018). The underlying concept of a "mineral deposit" is a geological rather than an economic concept and is not defined by SEC regulations. According to the U.S. Geological Survey, a mineral deposit is "a mineral occurrence of sufficient size and grade that it might, under the most favorable of circumstances, be considered to have economic potential" (Cox et al., 1986). Thus, the exploitation of a mineral deposit is only a theoretical possibility. Up until the present time, deep-sea nodules have only been a mineral deposit.

By contrast, a mineral deposit (a geological concept) becomes a mineral resource (an economic concept) only when there are reasonable prospects for eventual economic exploitation. According to SEC regulations, a mineral resource is "a concentration or occurrence of material of economic interest in or on the Earth's crust in such form, grade or quality, and quantity that there are reasonable prospects for economic extraction. A mineral resource is a reasonable estimate of mineralization, taking into account relevant factors such as cut-off grade, likely mining dimensions, location or continuity, that, with the assumed and justifiable technical and economic conditions, is likely to, in whole or in part, become economically extractable. It is not merely an inventory of all mineralization drilled or sampled" (CFR, 2018).

Mineral resources are then subdivided into inferred resources, indicated resources and measured resources, according to the level of confidence in the existence of the resources, with the greatest confidence placed in measured resources, and the least confidence in inferred resources. CFR (2018) explains, "Inferred mineral resource is that part of a mineral resource for which quantity and grade or quality are estimated on the basis of **limited** geological evidence and sampling. The level of geological uncertainty associated with an inferred mineral resource is too high to apply relevant technical and economic factors likely to influence the prospects of economic extraction in a manner useful for evaluation of economic viability" (emphasis added). On the other hand, "Indicated mineral resource is that part of a mineral resource for which quantity and grade or quality are estimated on the basis of **adequate** geological evidence and sampling. The level of geological certainty associated with an indicated mineral resource is sufficient to allow a qualified person to apply modifying factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit" (emphasis added) (CFR, 2018). Finally, "Measured mineral resource is that part of a mineral resource for which quantity and grade or quality are estimated on the basis of **conclusive** geological evidence and sampling. The level of geological certainty associated with a measured mineral resource is sufficient to allow a qualified person to apply modifying factors, as defined in this section, in sufficient detail to support **detailed** mine planning and **final** evaluation of the economic viability of the deposit" (emphasis added) (CFR, 2018).

The essential difference between mineral resources and mineral reserves is that reserves are economically mineable, as opposed to simply existing in the subsurface. In other words, from the standpoint of mine planning, only reserves are "real" and can be used as the basis for an economic analysis of a proposed mining project. According to SEC regulations, "Mineral reserve is an estimate of tonnage and grade or quality of indicated and measured mineral resources that, in the opinion of the qualified person, can be the basis of an economically viable project. More specifically, it is the **economically mineable** part of a measured or indicated mineral resource, which includes diluting materials and allowances for losses that may occur when the material is mined or extracted" (emphasis added) (CFR, 2018). The determination as to which portion of mineral resources can be regarded as mineral reserves (economically mineable) depends upon a wide range of "modifying factors." According to SEC regulations, "Modifying factors are the factors that a qualified person must apply to indicated and measured mineral resources and then evaluate in order to establish the economic viability of mineral reserves … These factors include, but are not restricted to: Mining; processing; metallurgical; infrastructure; economic; marketing; legal; environmental compliance; plans, negotiations, or agreements with local individuals or groups; and governmental factors. The number, type and specific characteristics of the modifying factors applied will necessarily be a function of and depend upon the mineral, mine, property, or project."

Mineral reserves are then divided into probable reserves and proven reserves, in which, in general, probable reserves are a subset of indicated resources and proven reserves are a subset of measured resources. According to SEC regulations, "Probable mineral reserve is the **economically mineable** part of an indicated and, in some cases, a measured mineral resource … Proven mineral reserve is the **economically mineable** part of a measured mineral resource and can only result from conversion of a measured mineral resource" (emphasis added) (CFR, 2018). SEC regulations explicitly exclude the conversion of inferred resources into mineral reserves.

According to the SEC regulations, "Because an inferred mineral resource has the lowest level of geological confidence of all mineral resources, which prevents the application of the modifying factors in a manner useful for evaluation of economic viability, an inferred mineral resource may not be considered when assessing the economic viability of a mining project, and may not be converted to a mineral reserve" (CFR, 2018).

Discount Rate and Net Present Value

The discount rate is the percentage used to convert future cash flows from a mining project into their present value. The discount rate reflects both the time value of money and the risk of a mining project. The first consideration is that money invested in a mining project could have been invested in a risk-free asset, such as a US Treasury bill, which might yield an interest rate of, say, 5% per year, corresponding to a minimum discount rate for the mining project investment of 5%. Thus, for example, $1 million invested in a mining project is worth no more than $950,000 after one year and no more than $902,500 after two years.

The second consideration is that it is not guaranteed that the money invested in a mining project will ever be recouped. If it becomes clear that all of the invested money has been lost, then the discount rate has risen to 100%. The appropriate value for the discount rate, which reflects the uncertainty in the project, is somewhere between 100% and the interest rate on a risk-free asset. The art of choosing the appropriate discount rate, based upon a rational assessment of the risk, is reviewed in the subsection "The Economic Assumptions are Best-Case or Near-Best-Case Scenarios" of the "Responses" section of this report.

The Net Present Value (NPV) of a mining project can be expressed as

$$NPV = \sum_{i=0}^{n} \frac{C_i}{(1+r)^i}$$

where C_i is the cash flow in year i and r is the discount rate. Clearly, the correct assessment of the NPV depends strongly upon the correct assessment of the discount rate.

The Pre-Feasibility Study and the Stage-Gate Process

Nearly all modern mine planning proceeds through a sequence of studies (called stages) that are followed by critical decisions regarding the mining projects (called gates) (Henderson and Morrison, 2022; Carter and Tolmer, 2023; Clark and Dağdelen, 2023; Turek, 2023). The typical sequence of stages consists of the following (see Table 1):

1) Conceptual Study
2) Scoping Study (or Preliminary Economic Assessment or Initial Assessment)
3) Pre-Feasibility Study
4) Feasibility Study
5) Definitive Feasibility Study

Each successive stage consists of more accurate cost estimates, more detailed planning and engineering, and the reduction of options (such as options for the site of the tailings storage facility).

Each successive stage also consists of more accurate estimates of mineral resources and mineral reserves, with the Pre-Feasibility Study typically being the critical stage at which resources are first identified as reserves. According to SEC regulations, “A pre-feasibility study includes a financial analysis based on reasonable assumptions, based on appropriate testing, about the modifying factors and the evaluation of any other relevant factors that are sufficient for a qualified person to determine if all or part of the indicated and measured mineral resources may be converted to mineral reserves at the time of reporting. The financial analysis must have the level of detail necessary to demonstrate, at the time of reporting, that extraction is economically viable” (CFR, 2018). SEC regulations further define, “Preliminary feasibility study (or pre-feasibility study) is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a qualified person has determined (in the case of underground mining) a preferred mining method, or (in the case of surface mining) a pit configuration, and in all cases has determined an effective method of mineral processing and an effective plan to sell the product … A pre-feasibility study is less comprehensive and results in a lower confidence level than a feasibility study. A pre-feasibility study is more comprehensive and results in a higher confidence level than an initial assessment” (CFR, 2018).

The purpose of the stage-gate process is to complete a significant portion of the planning and engineering early when changes are still relatively easy and inexpensive to make. At the same time, it is important to not spend excessive time and money on a project that is not going to be carried through to completion. Thus, it is essential that the completion of a stage (or the gate) be viewed as a serious opportunity to either proceed to the next stage, to re-do the current stage or an earlier stage, or to pause or abandon the project. According to the SME Surface Mining Handbook, “The stage-gate process is there for a reason. If the criteria are not met, the gate closes … Too many projects have moved through the gates simply to progress to the next step; however, often there is insufficient or incomplete information to justify the advance. Assumptions are made to fill the gaps and the project moves on. Subsequent work and studies are then also completed with incomplete information, often resulting in false expectations. Combined with this disrespect for the process, the result is that the work required never gets completed or never to the level required, resulting in unpleasant surprises or revelations during execution” (Turek, 2023).

Because many regulatory agencies and other stakeholders insist on clarity on the plan for tailings management, the industry standard is that, at each stage, a greater portion of the engineering be completed for tailings management than for other aspects of mine planning. According to the SME Tailings Management Handbook, “The level of engineering complete for a TSF [Tailing Storage Facility] is greater than the level of engineering required for the rest of a mining project to support permitting requirements” (Henderson and Morrison, 2022). For example, at the stage of the Pre-Feasibility Study, less than 10% of the overall mine engineering should be complete, while 15-20% of the engineering for tailings management should be complete (see Table 1). At this stage, the industry standard is that cost estimates should be accurate within the range of 20% less than the best estimate to 25% greater than the best estimate (see Table 1) both for the mining project as a whole and for the tailings management plan (see Table 1) (Turek, 2023). In terms of the overall cost estimates, the SEC regulations are quite similar in stating, “Operating and capital cost estimates in a pre-feasibility study must, at a minimum, have an accuracy level of approximately ±25% and a contingency range not exceeding 15%” (CFR, 2018). Although the SEC regulations do not state a completion percentage for the tailings management plan, they are quite explicit in stating that the Pre-Feasibility must include a detailed plan for tailings management. According to the SEC regulations, “A pre-feasibility study must define, analyze or otherwise address in detail, to the extent material: … (iv) The environmental compliance and permitting requirements, the baseline studies, and the plans for tailings disposal, reclamation, and mitigation” (see Table 2a) (CFR, 2018).

Comparison between SEC Regulations and Regulations in other Jurisdictions

The purpose of this subsection is to compare SEC regulations on disclosure of mining projects with the equivalent regulations in Australia, Canada, Europe, and South Africa with regard to the following:

1) need for consideration of tailings management in the Pre-Feasibility Study (see Table 2a)
2) exclusive use of mineral reserves in the economic analysis (see Table 2b)
3) prohibition against conversion of inferred resources into mineral reserves (see Table 2c)
4) independence of authors (see Table 2d)

Need for Consideration of Tailings Management in the Pre-Feasibility Study

The SEC regulations are the most explicit in specifying that the Pre-Feasibility Study must include a detailed plan for tailings management. According to the SEC regulations, “ “A pre-feasibility study must define, analyze or otherwise address in detail, to the extent material: … (iv) The environmental compliance and permitting requirements, the baseline studies, and the plans for tailings disposal, reclamation, and mitigation” (CFR, 2018). On the other hand, the Australian regulations are the most explicit in clarifying that resources do not exist without a plan for tailings management. According to the Australian regulations, “Section 3 Estimation and Reporting of Mineral Resources … Environmental factors or assumptions … Assumptions made regarding possible waste and process residue disposal options. It is always necessary as part of the process of determining reasonable prospects for eventual economic extraction to consider the potential environmental impacts of the mining and processing operation” (JORC, 2012). In a similar way, the South African and European regulations use identical language to require a tailings management plan as a necessary part of the reporting of resources. According to both SAMCODE (2016) and PERC (2021a), the mining project disclosure must “Report in sufficient detail to demonstrate that the necessary facilities have been allowed for (which may include, but not be limited to, processing plant, tailings dam, leaching facilities, waste dumps.” The Canadian regulations are the least explicit in requiring only “where relevant” the … “requirements and plans for waste and tailings disposal” (CIM, 2014; see Table 2a).

Table 2a. Comparative regulations for disclosure of mining projects: Need for consideration of tailings management in Pre-Feasibility Study

Jurisdiction	Key Quotes
USA	"A pre-feasibility study must define, analyze or otherwise address in detail, to the extent material: … (iv) The environmental compliance and permitting requirements, the baseline studies, and the plans for tailings disposal, reclamation, and mitigation."[1]
Australia	Section 3 Estimation and Reporting of Mineral Resources … Environmental factors or assumptions … Assumptions made regarding possible waste and process residue disposal options. It is always necessary as part of the process of determining reasonable prospects for eventual economic extraction to consider the potential environmental impacts of the mining and processing operation … Section 4 Estimation and Reporting of Ore Reserves … Environmental … The status of studies of potential environmental impacts of the mining and processing operation. Details of waste rock characterisation and the consideration of potential sites, status of design options considered and, where applicable, the status of approvals for process residue storage and waste dumps should be reported."[2]
Canada	"In addition, all technical reports must include more detailed maps showing all important features described in the text, relative to the property boundaries, including but not limited to … (c) for properties under development or in production, the location of pit limits or underground development, plant sites, tailings storage areas, waste disposal areas, and all other significant infrastructure features … Requirements for All Technical Reports … Consider and, where relevant, include … (b) requirements and plans for waste and tailings disposal, site monitoring, and water management both during operations and post mine closure … Describe … (e) to the extent relevant to the mineral project, the sufficiency of surface rights for mining operations, the availability and sources of power, water, mining personnel, potential tailings storage areas, potential waste disposal areas, heap leach pad areas, and potential processing plant sites."[3]
Europe	Depending on the stage of the project, the following should be considered: … requirements and plans for waste and tailings disposal, including compliance with applicable tailings management standards and regulations, and monitoring both during operations and post mine closure … Describe (noting any conditions that may affect possible prospecting/mining activities) … potential tailings storage areas, potential waste disposal areas … Report in sufficient detail to demonstrate that the necessary facilities have been allowed for (which may include, but not be limited to, processing plant, tailings dam, leaching facilities, waste dumps … Management of project waste and anticipated requirements for large scale infrastructure for mine waste for future, including but not limited to waste dumps and tailings dams."[4]
South Africa	Describe (noting any conditions that may affect possible prospecting/mining activities) … potential tailings storage areas, potential waste disposal areas, heap leach pad areas, and potential processing plant sites … Report in sufficient detail to demonstrate that the necessary facilities have been allowed for (which may include, but not be limited to, processing plant, tailings dam, leaching facilities, waste dumps …"[5]

[1]CFR (2018)
[2]JORC (2012)
[3]CIM (2014)
[4]PERC (2021a)
[5]SAMCODE (2016)

Table 2b. Comparative regulations for disclosure of mining projects: Exclusive use of mineral reserves in economic analysis

Jurisdiction	Key Quotes
USA	"Mineral reserve is an estimate of tonnage and grade or quality of indicated and measured mineral resources that, in the opinion of the qualified person, can be the basis of an economically viable project. More specifically, it is the economically mineable part of a measured or indicated mineral resource … The pre-feasibility study or feasibility study, which supports the qualified person's determination of mineral reserves, must demonstrate that, at the time of reporting, extraction of the mineral reserve is economically viable under reasonable investment and market assumptions. The study must establish a life of mine plan that is technically achievable and economically viable, which will be the basis of determining the mineral reserve."[1]
Australia	An 'Ore Reserve' is the economically mineable part of a Measured and/or Indicated Mineral Resource … Ore Reserves are those portions of Mineral Resources that, after the application of all Modifying Factors, result in an estimated tonnage and grade which, in the opinion of the Competent Person making the estimates, can be the basis of a technically and economically viable project, after taking account of material relevant Modifying Factors … The term 'economically mineable' implies that extraction of the Ore Reserves has been demonstrated to be viable under reasonable financial assumptions."[2]
Canada	"A Mineral Reserve is the economically mineable part of a measured and/or Indicated Mineral Resource … Mineral Reserves are those parts of Mineral Resources which, after the application of all mining factors, result in an estimated tonnage and grade which, in the opinion of the Qualified Person(s) making the estimates, is the basis of an economically viable project after taking account of all relevant Modifying Factors."[3] If an issuer discloses in writing mineral resources or mineral reserves on a property material to the issuer, the issuer must include in the written disclosure … (e) if the disclosure includes the results of an economic analysis of mineral resources, an equally prominent statement that mineral resources that are not mineral reserves do not have demonstrated economic viability."[4]
Europe	"The words 'ore' and 'reserves' must not be used in stating Mineral Resource estimates (except in the context of common usage such as 'iron ore', etc.) as the terms imply technical feasibility and economic viability … A Mineral Reserve is the economically mineable part of a Measured Mineral Resource and/or Indicated Mineral Resource … Mineral Reserves are those portions of Indicated Mineral Resources and Measured Mineral Resources which, after the application of all relevant Modifying Factors, result in an estimated tonnage and grade or quality which, in the opinion of the Competent Person(s) making the estimates, can be the basis of a viable project or operation."[5]
South Africa	"The words 'Ore' and 'Reserves' must not be used in stating Mineral Resources. These terms imply a level of technical feasibility and economic viability and are appropriate only when all relevant Modifying Factors have been applied. Reports and statements must continue to refer to the appropriate category or categories of Mineral Resources until technical feasibility and economic viability have been established … A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource … The term 'economically mineable' implies that extraction of the Mineral Reserve has been demonstrated as viable and justifiable under a defined set of realistically assumed Modifying Factors and application of the requirements of a Pre-feasibility or Feasibility Study."[6]

[1]CFR (2018)
[2]JORC (2012)
[3]CIM (2014)
[4]CIM (2023)
[5]PERC (2021a)
[6]SAMCODE (2016)

Table 2c. Comparative regulations for disclosure of mining projects: Prohibition against conversion of inferred resources into mineral reserves

Jurisdiction	Key Quotes
USA	"Because an inferred mineral resource has the lowest level of geological confidence of all mineral resources, which prevents the application of the modifying factors in a manner useful for evaluation of economic viability, an inferred mineral resource may not be considered when assessing the economic viability of a mining project, and may not be converted to a mineral reserve."[1]
Australia	"A 'Probable Ore Reserve' is the economically mineable part of an Indicated, and in some circumstances, a Measured Mineral Resource … A 'Proved Ore Reserve' is the economically mineable part of a Measured Mineral Resource … Inferred Mineral Resources are by definition generally additional to Ore Reserves except where included as dilution in the Ore Reserves."[2]
Canada	"An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve … A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proven Mineral Reserve or to a Probable Mineral Reserve … Inferred Mineral Resources are, by definition, always additional to Mineral Reserves."[3]
Europe	"An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve."[4]
South Africa	"An Inferred Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve."[5]

[1]CFR (2018)
[2]JORC (2012)
[3]CIM (2014)
[4]PERC (2021b)
[5]SAMCODE (2016)

Exclusive Use of Mineral Reserves in the Economic Analysis

It was explained in the subsection "Mineral Resources and Mineral Reserves" that, according to SEC regulations, only mineral reserves are economically mineable and only mineral reserves can be the financial basis for an economically viable project (see Table 2b). The SEC regulations continue to explain that "The pre-feasibility study or feasibility study, which supports the qualified person's determination of mineral reserves, must demonstrate that, at the time of reporting, extraction of the mineral reserve is economically viable under reasonable investment and market assumptions. The study must establish a life of mine plan that is technically achievable and economically viable, which will be the basis of determining the mineral reserve" (CFR, 2018). The Australian, Canadian, European, and South African regulations all provide the same message in equating mineral reserves as the only economically mineable part of mineral resources with mineral reserves acting as the sole financial basis for an economically viable project (JORC, 2012; CIM, 2014; PERC, 2021a; SAMCODE, 2016; see Table 2b). The Canadian regulations add the clarifying statement that "If an issuer discloses in writing mineral resources or mineral reserves on a property material to the issuer, the issuer must include in the written disclosure … (e) if the disclosure includes the results of an economic analysis of mineral resources, an equally prominent statement that mineral resources that are not mineral reserves do not have demonstrated economic viability" (CIM, 2023).

Prohibition Against Conversion of Inferred Resources into Mineral Reserves

All of the regulations considered here indicate clearly that no part of inferred resources can be converted into mineral reserves (see Table 2c). In other words, no part of inferred resources can be regarded as economically mineable or as the basis for an economically viable project. According to SEC regulations, "Because an inferred mineral resource has the lowest level of geological confidence of all mineral resources, which prevents the application of the modifying factors in a manner useful for evaluation of economic viability, an inferred mineral resource may not be considered when assessing the economic viability of a mining project, and may not be converted to a mineral reserve" (CFR, 2018).

Table 2d. Comparative regulations for disclosure of mining projects: Independence of authors

Jurisdiction	Key Quotes
USA	"The registrant must state in the filed registration statement or report whether each qualified person who prepared the technical report summary is an employee of the registrant."[1]
Australia	"A company issuing a Public Report shall disclose the name(s) of the Competent Person, state whether the Competent Person is a full-time employee of the company, and, if not, name the Competent Person's employer."[2]
Canada	"A technical report required under any of the following provisions of this Instrument must be prepared by or under the supervision of one or more qualified persons that are, at the effective and filing dates of the technical report, all independent of the issuer."[3] "We consider a qualified person is not independent when the qualified person (a) is an employee, insider, or director of the issuer."[4]
Europe	"Certificate of Competent Person … As the Competent Person responsible for the information on which the Public Report entitled [report title] is based, I hereby state: … 12. I am independent/not independent of [name of reporting entity/issuer]."[5]
South Africa	**"**The author of the Public Report should be satisfied that: his/her work has not been unduly influenced by the organisation, company or person commissioning a report or any report that may be deemed a Public Report … Certificate of Competent Person … As the author of the report entitled [report title], I hereby state:- … 11. I am independent/not independent of [name of issuer]."[6]

[1]CFR (2018)
[2]JORC (2012)
[3]CIM (2023)
[4]CIM (2011)
[5]PERC (2021a)
[6]SAMCODE (2016)

Independence of Authors

The SEC and Australian regulations allow an employee of the mining company to be the author of a mining project disclosure, including a Pre-Feasibility Study, as long as that information is disclosed (see Table 2d). According to the SEC regulations, "The registrant must state in the filed registration statement or report whether each qualified person who prepared the technical report summary is an employee of the registrant" (CFR, 2018). The European and South African regulations require that the author disclose whether he or she is "independent" of the mining company (see Table 2d). The South African regulations add that "The author of the Public Report should be satisfied that: his/her work has not been unduly influenced by the organisation, company or person commissioning a report or any report that may be deemed a Public Report" (SAMCODE, 2016). The Canadian regulations are distinct in requiring that all of the authors be "independent" of the mining company and in clarifying that a company employee cannot be independent. According to the Canadian regulations, "A technical report required under any of the following provisions of this Instrument must be prepared by or under the supervision of one or more qualified persons that are, at the effective and filing dates of the technical report, all independent of the issuer" (CIM, 2023) and "We consider a qualified person is not independent when the qualified person (a) is an employee, insider, or director of the issuer" (CIM, 2011).

SUMMARY OF TMC's PRE-FEASIBILITY STUDY

The purpose of this section is largely to summarize the financial aspects of the Pre-Feasibility Study, with the technical aspects having been summarized in the "Overview" section. According to the Pre-Feasibility, there are 11 million wet metric tons of inferred resources, 347 million wet metric tons of indicated resources, and 5 million wet metric tons of measured resources (see Fig. 6a). Out of the total of 363 million wet metric tons of mineral resources, the Pre-Feasibility Study identifies 51 million wet metric tons of probable reserves and zero proven reserves (see Fig. 6b). The average grades of the probable reserves are 1.4% nickel, 0.13% cobalt, 1.1% copper, and 31% manganese (see Fig. 6b).

Table 1.1	Mineral Resource for NORI Area D, at 30 June 2025, at 4 wet kg/m^2 abundance cut-off inclusive of Mineral Reserve

Category	Tonnes (Mwmt)	Abundance (wet kg/m^2)	Ni (%)	Cu (%)	Co (%)	Mn (%)	Si (%)	Fe (%)	P (%)	MnO: SiO_2
Inferred	11	15.4	1.38	1.14	0.12	30.96	5.46	6.92	0.16	3.42
Indicated	347	17.4	1.40	1.14	0.14	31.15	5.45	6.84	0.16	3.46
Measured	5	20.6	1.41	1.15	0.13	31.91	5.16	6.59	0.15	3.73
All	**363**	**17.4**	**1.40**	**1.14**	**0.14**	**31.15**	**5.44**	**6.83**	**0.16**	**3.46**

Notes:
1. Effective date of the Mineral Resource is 30 June 2025.
2. Moisture content assumed to be 28% (mass of solid/(mass of solid + mass of water).
3. The volcanic outcrop, volcanic high, volcanic cones, sediment drift, and high-slope (>6°) domains were excluded from the estimate.
4. Samples collected by the Pioneer Contractors were excluded due to the lower level of confidence associated with this data and their replacement by box core data collected by TMC.
5. Abundance cut-off and assumption of reasonable prospects for economic extraction are based on the engineering, metallurgical, environmental, scientific and other studies presented in this report.
6. Rounding estimates to two significant figures may result in computational discrepancies.

Figure 6a. The Pre-Feasibility Study identifies 11 million wet metric tons of inferred resources, 347 million wet million metric tons of indicated resources, and 5 million wet metric tons of measured resources, for a total of 363 million wet metric tons of mineral resources. Out of the total, 51 million wet metric tons (14%) have been assigned to the category of mineral reserves, meaning that they can be regarded as economically mineable and, thus, can form the basis for a mining plan and economic analysis (see Table 2b). Nevertheless, the Pre-Feasibility Study develops a mining plan and economic analysis based on the assumed production of 164.1 million wet metric tons of nodules (see Figs. 4 and 10), which is not consistent with industry standards. Table from AMC Consultants Pty Ltd (2025).

Table 1.4	NORI Area D Mineral Reserve at 30 June 2025

Classification	Tonnes (Mwmt)	Co (%)	Cu (%)	Mn (%)	Ni (%)
Proven	-	-	-	-	-
Probable	51	0.13	1.1	31	1.4
Total	**51**	**0.13**	**1.1**	**31**	**1.4**

Notes:
1. Mineral Reserve estimated in Initial Mining Area only with 1,000 m buffers for the lease and seamounts.
2. Measured and Indicated Mineral Resources are converted to probable Mineral Reserves.
3. Grades are quoted on a dry basis.
4. Zero abundance cut-off used, with nodules <4 kg/m^2 used to define the Mineral Resource included as dilution to generate viable mining blocks.
5. Moisture content assumed to be 28% (mass of solid/(mass of solid + mass of water).
6. Metal prices US$20,295/t Ni, US$21,633/t Ni sulfate, US$11,440/t Cu, US$56,117/t Co, US$55,198/t Co sulfate, US$5.45/dmtu Mn in manganese-silicate.
7. Nodule recovery by the Collector is estimated as 77% for Type 1 and 62% for Type 2 and 3 nodules.
8. Metallurgical recovery to sulfate is estimated as 94.6% Ni, 77.2% Co and 86.2% Cu, and to matte is 94.8% Ni, 77.5% Co, 86.4% Cu and for 98.9% for Mn.
9. Rounding estimates to two significant figures may result in computational discrepancies.

Figure 6b. The Pre-Feasibility Study identifies 51 million wet metric tons of probable reserves, meaning that they can be regarded as economically mineable and, thus, can form the basis for a mining plan and economic analysis (see Table 2b). Nevertheless, the Pre-Feasibility Study develops a mining plan and economic analysis based on the assumed production of 164.1 million wet metric tons of nodules (see Figs. 4 and 10), which is not consistent with industry standards. Table from AMC Consultants Pty Ltd (2025).

Table 11.10 Mineral Resource for NORI Area D, at 30 June 2025, at 4 wet kg/m² abundance cut-off exclusive of Mineral Reserve

Category	Tonnes (Mwmt)	Abundance (wet kg/m²)	Ni (%)	Cu (%)	Co (%)	Mn (%)	Si (%)	Fe (%)	P (%)	MnO: SiO₂
Inferred	10	15.4	1.4	1.1	0.12	31	5.46	6.92	0.16	3.42
Indicated	261	17.4	1.4	1.1	0.14	31	5.45	6.84	0.16	3.46
Measured	4	20.6	1.4	1.2	0.13	32	5.16	6.59	0.15	3.73
All	274	17.4	1.4	1.1	0.14	31	5.44	6.83	0.16	3.46

Notes: 1. Effective date of the Mineral Resource is 30 June 2025.
2. Moisture content assumed to be 28% (mass of solid/(mass of solid + mass of water).
3. The volcanic outcrop, volcanic high, volcanic cones, sediment drift, and high-slope (>6°) domains were excluded from the estimate.
4. Samples collected by the Pioneer Contractors were excluded due to the lower level of confidence associated with this data and their replacement by box core data collected by TMC.
5. Abundance cut-off and assumption of reasonable prospects for economic extraction are based on the engineering, metallurgical, environmental, scientific and other studies presented in this report.
6. Si, Fe, P, and $MnO:SiO_2$ are not tracked in Mineral Reserve estimation and Mineral Resource averages are used.
7. Rounding estimates to two significant figures may result in computational discrepancies.

Figure 6c. The Pre-Feasibility Study identifies 10 million wet metric tons of inferred resources, 261 million wet million metric tons of indicated resources, and 4 million wet metric tons of measured resources, for a total of 274 million wet metric tons of mineral resources that are not included among the mineral reserves (see Fig. 6b). Since the total mineral resources includes 11 million wet metric tons of inferred resources, 1 million wet metric tons of inferred resources have been converted into probable reserves, which is inconsistent with SEC regulations (see Table 2c; CFR, 2018). While the total mineral resources inclusive of reserves are 363 million wet metric tons (see Fig. 6a) and the total mineral resources exclusive of reserves are 274 million wet metric tons, for a difference of 89 million wet metric tons, the Pre-Feasibility Study identifies 51 million wet metric tons of reserves (see Fig. 6b), so that 38 million wet metric tons of nodules have gone missing. This same arithmetic discrepancy is repeated throughout the Pre-Feasibility Study. Since the most important part of a mining project disclosure is the estimation of mineral resources and mineral reserves, the inability of the report produced by AMC Consultants Pty Ltd (2025) to provide arithmetically consistent estimates of resources and reserves raises serious questions regarded its validity as a Pre-Feasibility Study. In fact, the report by AMC Consultants Pty Ltd (2025) is filled with inconsistent numbers and arithmetic errors. It is not the intention of this report to "proofread" the report by AMC Consultants Pty Ltd (2025), nor to document every numeric and arithmetic discrepancy. Table from AMC Consultants Pty Ltd (2025).

A comparison of the mineral resources inclusive of reserves (see Fig. 6a) and the mineral resources exclusive of reserves (see Fig. 6c) reveals multiple anomalies. First, although the mineral resources inclusive of reserves includes 11 million wet metric tons of inferred resources (see Fig. 6a), the mineral resources exclusive of reserves includes 10 million wet metric tons of inferred resources, so that 1 million wet metric tons of inferred resources have been converted into reserves. It was discussed in the previous section that SEC regulations, as well as regulations in Australia, Canada, Europe, and South Africa, prohibit the conversion of inferred resources into reserves (see Table 2b). According to SEC regulations, "Because an inferred mineral resource has the lowest level of geological confidence of all mineral resources, which prevents the application of the modifying factors in a manner useful for evaluation of economic viability, an inferred mineral resource may not be considered when assessing the economic viability of a mining project, and may not be converted to a mineral reserve" (CFR, 2018). Although Figs. 6a-c all state "Rounding estimates to two significant figures may result in computational discrepancies" (AMC Consultants Pty Ltd, 2025), the conversion of mineral resources into mineral reserves should not involve any changes at all in the estimation of inferred resources. The second anomaly is that mineral resources inclusive of reserves includes 5 million wet metric tons of measured resources (see Fig. 6a), while mineral resources exclusive of reserves still include 4 million wet metric tons of measured resources (see Fig. 6c), so that only 1 million wet metric tons of measured resources have been converted into reserves. Since there is greater geologic certainty associated with measured resources than either indicated or referred resources, it would typically be expected that measured resources would be converted into reserves in preference to either indicated resources or inferred resources (which cannot be converted into reserves).

The third anomaly is that, while the total mineral resources inclusive of reserves are 363 million wet metric tons (see Fig. 6a) and the total mineral resources exclusive of reserves are 274 million wet metric tons (Fig. 6c), for a difference of 89 million wet metric tons, the Pre-Feasibility Study identifies 51 million wet metric tons of reserves (see Fig. 6b), so that 38 million wet metric tons of nodules have gone missing. This same arithmetic discrepancy is repeated throughout the Pre-Feasibility Study. Since the most important part of a mining project disclosure is the estimation of mineral resources and mineral reserves, the inability of the report produced by AMC Consultants Pty Ltd (2025) to provide arithmetically consistent estimates of resources and reserves raises serious questions regarded its validity as a Pre-Feasibility Study. In fact, the report by AMC Consultants Pty Ltd (2025) is filled with inconsistent numbers and arithmetic errors. It is not the intention of this report to "proofread" the report by AMC Consultants Pty Ltd (2025), nor to document every numeric and arithmetic discrepancy.

Although the Pre-Feasibility Study identifies only 51 million wet metric tons of mineral reserves (see Fig. 6b), the mine production plan calls for the collection and processing of 164.1 million wet metric tons of nodules (see Fig. 4), or 113.1 million wet metric tons more than exist in the reserves. The previous section clarified that, according to SEC regulations, as well as regulations in Australia, Canada, Europe, and South Africa, only reserves are economically mineable and only reserves can be the final basis for an economically viable mining project. The only explanation in the Pre-Feasibility Study are the statements "The development plan then assumes that an additional 113 Mwmt [million wet metric tons] of Mineral Resource (based on the same modifying factors as the Initial Mining area) will be recoverable to market outside the Initial Mining Area (NORI Area D Total = 164 Mwmt)" and "Total extractable resource 164.1 Mwmt (45% of total NORI D Mineral Resource)" (AMC Consultants Pty Ltd, 2025). The improper use of non-reserves as the basis for a mining production plan will be further discussed in the "Responses" section.

The estimation of the metal recovery rates is an important step toward the estimation of the project revenue. The Pre-Feasibility Study estimated the recovery rates for nickel, cobalt, and copper in the transition from nodule to alloy, nodule to matte, and nodule to nickel sulfate, cobalt sulfate, and copper cathode (see Fig. 7). Any nickel, cobalt, or copper that is not recovered from the nodule into the nickel-cobalt-copper alloy is transferred into the manganese silicate (see Fig. 5a). Thus, it is predicted that 3.09% of the nickel, 6.94% of the cobalt, and 6.45% of the copper in the nodules would be transferred into the manganese silicate. The Pre-Feasibility Study further predicts that 98.9% of the manganese would be recovered into the manganese silicate (see Fig. 7), so that 1.1% of the manganese would be transferred into the nickel-cobalt-copper alloy.

Table 16.2 Metallurgical recoveries	
Product	**Recovery (%)**
Alloy – nickel recovery – nodule to alloy	96.91
Alloy – cobalt recovery – nodule to alloy	93.06
Alloy – copper recovery – nodule to alloy	93.55
Matte – nickel recovery – nodule to matte	94.76
Matte – cobalt recovery – nodule to matte	77.54
Matte – copper recovery – nodule to matte	86.43
Sulphate – nickel recovery – nodule to sulfate	94.60
Sulphate – cobalt recovery – nodule to sulfate	77.20
Cathode – copper recovery – nodule to cathode	86.20
Manganese recovery – nodule to Mn Silicate	98.9

Source: TMC, CEA

Figure 7. The assumed recovery rates for nickel during processing from ore to alloy and from ore to matte, as well as the assumed recovery rate for cobalt during processing from ore to alloy are significantly higher or at the upper end for recovery rates that are found in the literature on extractive metallurgy (see Table 4). Other typical recovery rates are not available in the literature. Table from AMC Consultants Pty Ltd (2025).

Since 96.91% of the nickel would be recovered from the nodule to the alloy and 94.76% of the nickel would be recovered from the nodule to the matte, an additional 2.15% of the original nickel in the nodule would be lost in the transition from alloy to matte and, thus, transferred into the converter slag (compare Figs 5a and 7). By the same logic, 15.52% of the original cobalt and 7.12% of the original copper in the nodule would be lost in the transition from alloy to matte and, thus, transferred into the converter slag (compare Figs 5a and 7). Then comparing the nickel recovery rates for nodule to matte and nodule to sulfate yields the result that an additional 0.16% of the original nickel would be lost in the transition from nickel-cobalt-copper matte into nickel sulfate (compare Fig. 5b with Fig. 7). By the same logic, an additional 0.34% of the original cobalt would be lost in the transition from nickel-cobalt-copper matte into cobalt sulfate, and an additional 0.23% of the original copper would be lost in the transition from nickel-cobalt-copper matte into copper cathode (compare Fig. 5b with Fig. 7). With the available information, there is no way to determine whether the nickel that is lost in the transition from nickel-cobalt-copper matte into nickel sulfate would end up as an impurity in the cobalt sulfate, the copper cathode, or the ammonium sulfate, with the same lack of knowledge applying to the other metals. Thus, the nickel, cobalt, and copper contents of the ammonium sulfate are unknown, which could affect its suitability as a fertilizer. Concerns regarding the chemical composition of the converter slag and ammonium sulfate are further discussed in the "Responses" section.

The Pre-Feasibility Study predicts average prices for nickel metal, cobalt metal, and copper cathode of 20,295 USD per metric ton, 56,117 USD per metric ton, and 11,440 USD per metric ton, respectively, over the 20-year life of the mine (2027-2046) (see Fig. 8). The Pre-Feasibility Study further predicts that nickel will be more valuable as contained in nickel sulfate than as a metal with a price ratio of 1.066 (see Fig. 8 and Table 3a), while cobalt will be less valuable as contained in cobalt sulfate than as a metal with a price ratio of 0.984 (see Fig. 8 and Table 3b). Although the Pre-Feasibility Study predicts an average life-of-mine price of 545 USD per metric ton for manganese (see Fig. 8), it is unclear as to whether this price refers to manganese metal, to manganese as contained in manganese silicate, or to manganese silicate. This confusion is further discussed in the "Responses" section.

Table 1.8 Average product prices assumed in PFS

Parameter	Unit	Value
Ni metal (C1 LME)	Avg. US$/t	20,295
Ni contained in Ni sulfate	Avg. US$/t	21,633
Manganese	Avg. US$/t	545
Manganese	Avg. US$/dmtu	5.45
Cu Cathode (C1 LME)	Avg. US$/t	11,440
Co metal (C1 LME)	Avg. US$/t	56,117
Co contained in Co sulfate	Avg. US$/t	55,198

Figure 8. The Pre-Feasibility Study assumes a life-of-mine average price for nickel metal of 20,295 USD per metric ton, which is 38.3% higher than the current price of 14,671 USD per metric ton (monthly average for November 2025) and 13.1% higher than the average monthly price of 17,943 USD per metric ton for the period 2005-2025 (see Fig. 18). Moreover, the Pre-Feasibility Study assumes a life-of-mine average price for cobalt metal of 56,117 USD per metric ton, which is 16.6% higher than the current price of 48,139 USD per metric ton (monthly average for November 2025) and 41.0% higher than the average monthly price of 39,795 USD per metric ton for the period 2005-2025 (see Fig. 19). Finally, the Pre-Feasibility Study assumes a life-of-mine average price for copper cathode of 11,440 USD per metric ton, which is 5.8% higher than the current price of 10,812 USD per metric ton (monthly average for November 2025) and 61.5% higher than the average monthly price of 7085 USD per metric ton for the period 2005-2025 (see Fig. 20a). The assumed price for manganese probably refers to manganese silicate, not manganese metal (compare with Fig. 21). The Pre-Feasibility Study assumes a value of 1.066 for the ratio of the price of nickel contained in nickel sulfate to the price of nickel metal, whereas the current ratio is 1.023 (see Table 3a). Table from AMC Consultants Pty Ltd (2025).

Table 3a. Comparison of ratio of price of nickel contained in nickel sulfate to price of nickel

Price (USD/mt)	Current[1]	Pre-Feasibility Study[2]			
		Life of Mine	2028-2032	2033-2037	2038-2043+
Nickel	15,054.70	20,295	18,833	20,706	20,360
Nickel Sulfate	3438.39	—	—	—	—
Nickel contained in Nickel Sulfate	15,397.95[3]	21,633	19,623	22,007	21,835
Price Ratio[4]	1.023	1.066	1.042	1.063	1.072

[1]December 18, 2025 (SMM, 2025a-b)
[2]AMC Consultants Pty Ltd, 2025 (see Fig. 17)
[3]Calculated as price of nickel divided by ratio of molecular weight of nickel to molecular weight of nickel sulfate ($NiSO4 \cdot 6H_2O$) (0.2233)
[4]Calculated as ratio of price of nickel contained in nickel sulfate to price of nickel metal

Table 3b. Comparison of ratio of price of cobalt contained in cobalt sulfate to price of cobalt

Price (USD/mt)	Current[1]	Pre-Feasibility Study[2]			
		Life of Mine	2028-2032	2033-2037	2038-2043+
Cobalt	51,832.80	56,117	34,172	53,124	62,530
Cobalt Sulfate	11,513.53	—	—	—	—
Cobalt contained in Cobalt Sulfate	54,916.76[3]	55198	31,347	51,336	62,530
Price Ratio[4]	1.059	0.984	0.917	0.966	1.000

[1]December 18, 2025 (SMM, 2025c-d)
[2]AMC Consultants Pty Ltd, 2025 (see Fig. 17)
[3]Calculated as price of cobalt divided by ratio of molecular weight of cobalt to molecular weight of cobalt sulfate ($CoSO4 \cdot 7H_2O$) (0.2097)
[4]Calculated as ratio of price of cobalt contained in cobalt sulfate to price of cobalt metal

The payable terms are the percentage of the metal price that TMC can be expected to receive or retain from either the PAMCO facility in Japan or the unidentified pyrometallurgical facility in Indonesia. The mining company cannot receive or retain 100% of metal prices because the pyrometallurgical facilities need to cover their own costs, including the potential costs of installing new equipment or developing new technology to process the nodules, in addition to their profit margin. The life-of-mine average payable terms range from 44% of the price of cobalt metal for cobalt processed into an alloy to 80% of the price of nickel metal for nickel processed into a matte (see Fig. 9a). For nickel, cobalt, and copper, all payable terms are greater for metals processed into a matte than into an alloy (see Fig. 9a). For clarification, it can be said that the mining company receives a percentage of the metal price if the processing facility buys the raw material and then sells the output. It can be said that the mining company retains a percentage of the metal price if the mining company keeps and sells the output, while paying a toll to the processing facility. According to the Pre-Feasibility Study, the intention of TMC is to pay a toll to all pyrometallurgical processing facilities and to sell the matte to another hydrometallurgical refinery or to process the matte in its own hydrometallurgical refinery to be constructed in the US.

Table 16.3 NiCoCu Alloy/Matte Payable terms percentage of LME benchmark prices

Payable Terms	LOM Average	2027-2031	2032-2036	2037-2045
Alloy - Payable Terms – Ni	65%	65%	65%	65%
Alloy - Payable Terms – Co	44%	42%	43%	45%
Alloy - Payable Terms – Cu	60%	60%	60%	60%
Matte - Payable Terms – Ni	80%	80%	80%	80%
Matte - Payable Terms – Co	60%	60%	60%	60%
Matte - Payable Terms – Cu	70%	70%	70%	70%

Source: CRU

Figure 9a. The life-of-mine average payable terms range from 44% of the price of cobalt metal for cobalt obtained as an alloy to 80% of the price of nickel metal for nickel obtained as a matte. For nickel, cobalt, and copper, all payable terms are greater for metals obtained as a matte than as an alloy. Table from AMC Consultants Pty Ltd (2025).

Table 16.4 Forecast payable metal production - metal in alloy						
Metal	LOM Total Kt	Year 0 2027	Year 1 2028	Year 2 2029	Year 3 2030	Year 4 2031
Payable Nickel	11.7	1.2	6.3	4.1	0	0
Payable Cobalt	0.8	0.1	0.4	0.3	0	0
Payable Copper	8.3	0.8	4.5	3.0	0	0

Source: TMC

Figure 9b. The Pre-Feasibility Study predicts production of 11,700 metric tons of payable nickel, 800 metric tons of payable cobalt, and 8300 metric tons of payable copper in the form of nickel-cobalt-copper alloy over Years 0-2 of the deep-sea mining operation. Note payable terms for nickel, cobalt and copper obtained as an alloy in Fig. 9a. According to the Pre-Feasibility Study, nickel-cobalt-copper alloy would be produced in Years 0, 1, and 2, while nickel, cobalt and copper would be produced only in the intermediate form of nickel-cobalt-copper matte beginning in Year 3, with both alloy and matte being produced in Year 2 (compare with Fig. 9c). Table from AMC Consultants Pty Ltd (2025).

The Pre-Feasibility Study predicts production of 11,700 metric tons of payable nickel, 800 metric tons of payable cobalt, and 8300 metric tons of payable copper in the form of nickel-cobalt-copper alloy over Years 0-2 of the deep-sea mining operation (see Fig. 9b). The Pre-Feasibility Study further predicts production of 361,800 metric tons of payable nickel, 22,200 metric tons of payable cobalt, and 235,100 metric tons of payable copper in the form of nickel-cobalt-copper matte over Years 2-9 of the deep-sea mining operation (see Fig. 9c). Finally, the Pre-Feasibility Study predicts production of 1,095,700 metric tons of payable nickel, 89,400 metric tons of payable cobalt, and 813,000 metric tons of payable copper in the final forms of nickel sulfate, cobalt sulfate, and copper cathode over the life of the deep-sea mining operation, beginning in Year 6 (see Fig. 9d). Note that nickel-cobalt-copper alloy would be produced in Years 0, 1, and 2 (see Fig. 9b), while nickel, cobalt and copper would be produced only in the intermediate form of nickel-cobalt-copper matte beginning in Year 3, with both alloy and matte being produced in Year 2 (compare Figs. 9b-c). Fig. 9c further indicates that matte production would cease after Year 9, while Fig. 9d indicates that nickel sulfate, cobalt sulfate, and copper cathode production would begin in Year 6, presumably at the TMC hydrometallurgical refinery to be constructed in the US. It is difficult to understand why matte production would cease after Year 9 (see Fig. 9c), since the Pre-Feasibility Study does not describe any plan for TMC to construct its own pyrometallurgical facility. In the same way, it is unclear as to why Fig. 9d does not indicate any nickel sulfate, cobalt sulfate, and copper cathode production prior to Year 6, when the matte produced at either the PAMCO facility or the RKEF facility in Indonesia would need to be sold to some hydrometallurgical refinery before TMC had completed its own refinery in the US. According to the Pre-Feasibility Study, 36,401,700 metric tons of manganese in the form of manganese silicate would be produced over the life of the deep-sea mining operation, with production occurring in each year of the project (see Fig. 9e).

Table 16.5 Forecast payable metal production - metal in matte

Metal	LOM Total Kt	Year 0 2027	Year 1 2028	Year 2 2029	Year 3 2030	Year 4 2031
Payable Nickel	361.8	--	--	10.3	38.2	84.1
Payable Cobalt	22.2	--	--	0.6	2.3	5.2
Payable Copper	235.1	--	--	6.7	24.8	54.6
Metal	**Year 5 2032**	**Year 6 2033**	**Year 7 2034**	**Year 8 2035**	**Year 9 2036**	**Year 10+ 2037+**
Payable Nickel	80.2	34.4	34.4	34.4	45.8	--
Payable Cobalt	4.9	2.1	2.1	2.1	2.8	--
Payable Copper	52.1	22.3	22.3	22.3	29.8	--

Source: TMC

Figure 9c. The Pre-Feasibility Study predicts production of 361,800 metric tons of payable nickel, 22,200 metric tons of payable cobalt, and 235,100 metric tons of payable copper in the form of nickel-cobalt-copper matte over Years 2-9 of the deep-sea mining operation. Note payable terms for nickel, cobalt and copper obtained as a matte in Fig. 9a. According to the Pre-Feasibility Study, nickel, cobalt and copper would be produced only in the intermediate form of nickel-cobalt-copper matte beginning in Year 3, with both alloy and matte being produced in Year 2 (compare with Fig. 9b). The above figure further indicates that matte production would cease after Year 9, which is difficult since the Pre-Feasibility Study does not describe any plan for TMC to construct its own pyrometallurgical facility. Table from AMC Consultants Pty Ltd (2025).

Table 16.6 Forecast payable refined metal production - metal in sulfate and cathode

Metal	LOM Total Kt	Year 0 2027	Year 1 2028	Year 2 2029	Year 3 2030	Year 4 2031
Payable Nickel in Sulphate	1,095.7	--	--	--	--	--
Payable Cobalt in Sulphate	89.4	--	--	--	--	--
Payable Copper in Cathode	813.0	--	--	--	--	--
Metal	**Year 5 2032**	**Year 6 2033**	**Year 7 2034**	**Year 8 2035**	**Year 9 2036**	**Year 10+ 2037+**
Payable Nickel in Sulphate	--	57.2	57.2	57.2	57.2	866.9
Payable Cobalt in Sulphate	--	4.7	4.7	4.7	4.7	70.7
Payable Copper in Cathode	--	42.5	42.5	42.5	42.5	643.2

Source: TMC

Figure 9d. The Pre-Feasibility Study predicts production of 1,095,700 metric tons of payable nickel, 89,400 metric tons of payable cobalt, and 813,000 metric tons of payable copper in the final forms of nickel sulfate, cobalt sulfate, and copper cathode over the life of the deep-sea mining operation, beginning in Year 6. The above table indicates that nickel sulfate, cobalt sulfate, and copper cathode production would begin in Year 6, presumably at the TMC hydrometallurgical refinery to be constructed in the US. It is unclear as to why the table does not indicate any nickel sulfate, cobalt sulfate, and copper cathode production prior to Year 6, when the matte produced at either the PAMCO facility or the RKEF facility in Indonesia would need to be sold to some hydrometallurgical refinery before TMC had completed its own refinery in the US. Table from AMC Consultants Pty Ltd (2025).

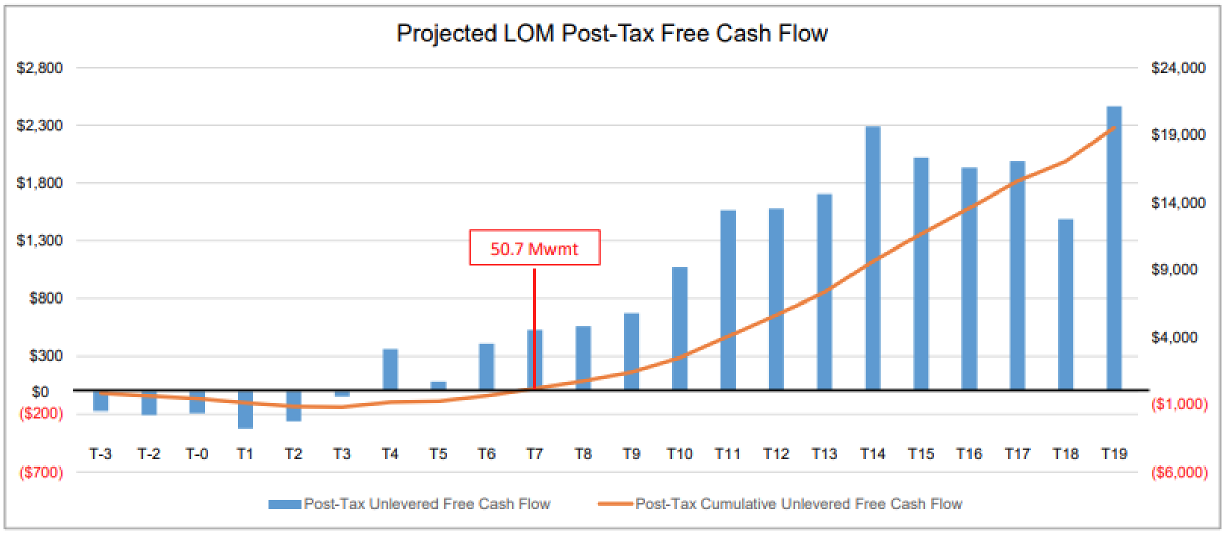
Table 16.7 Forecast production – Mn in Mn silicate

Product	LOM Total Kt	Year 0 2027	Year 1 2028	Year 2 2029	Year 3 2030	Year 4 2031
Mn in Mn Silicate	36,401.7	44.4	221.8	443.6	1,109.1	2,439.9
Product	**Year 5 2032**	**Year 6 2033**	**Year 7 2034**	**Year 8 2035**	**Year 9 2036**	**Year 10+ 2037+**
Mn in Mn Silicate	2,329.0	2,329.0	2,329.0	2,329.0	2,661.8	20,165.0

Source: TMC

Figure 9e. According to the Pre-Feasibility Study, 36,401,700 metric tons of manganese in the form of manganese silicate would be produced over the life of the deep-sea mining operation, with production occurring in each year of the project. Table from AMC Consultants Pty Ltd (2025).

Figure 19.1 Forecast Project post-tax free cash flow (US$ M)



Source: TMC
Note: PP = pre-production

Figure 10. The Pre-Feasibility Study predicts a break-even point after eight years (end of Year 7) with the cumulative production of 50.7 million wet metric tons of nodules. Since the same study identifies 51 million wet metric tons of mineral reserves (see Fig. 6b), the Pre-Feasibility Study is stating that a mining plan and economic analysis based upon reserves alone would terminate after eight years with zero profit. However, only the reserves can be regarded as economically mineable (see Table 2b) and the industry standard is to develop the mining plan and economic analysis based on the reserves alone. Thus, the continuation of the mining plan and economic analysis through Year 19 is inconsistent with SEC regulations. Figure from AMC Consultants Pty Ltd (2025).

The Pre-Feasibility Study predicts a break-even point after eight years with the cumulative production of 50.7 million wet metric tons of nodules (see Fig. 10). Since the same study identifies 51 million wet metric tons of mineral reserves (see Fig. 6b), the Pre-Feasibility Study is stating that a mining plan and economic analysis based upon reserves alone would terminate after eight years with zero profit. In fact, the conclusion that the deep-sea mining operation cannot be profitable based upon mineral reserves alone is fully explicit in the Pre-Feasibility Study. According to the Pre-Feasibility Study, “The project payback is 7 years and the Probable Mineral Reserve in the Initial Mining Area of 51 Mwmt is all mined by the end of year 7 (50.7 Mwmt) with a post-tax cumulative free cash flow of US$170.2M (year 7)” (AMC Consultants Pty Ltd, 2025). The reference to “7 years” in the above quote is somewhat confusing. Note that the first year of nodule production is Year 0 (see Fig. 4) and that all of the reserves would have been mined by the end of Year 7 (the eighth year of operation). Based upon a 20-year project, including the additional mining of 113.1 million metric tons of reserves, the Pre-Feasibility Study predicts total revenue of 69,862.2 million USD (see Fig. 11). The contributions to revenue from nickel, cobalt, copper, and manganese are expected to be 45.0%, 9.3%, 17.3%, and 28.4%, respectively (see Fig. 11). The critical role of manganese silicate as a source of revenue will be discussed in the "Responses" section.

Table 16.8 Revenue Forecast US$ 2025 Real

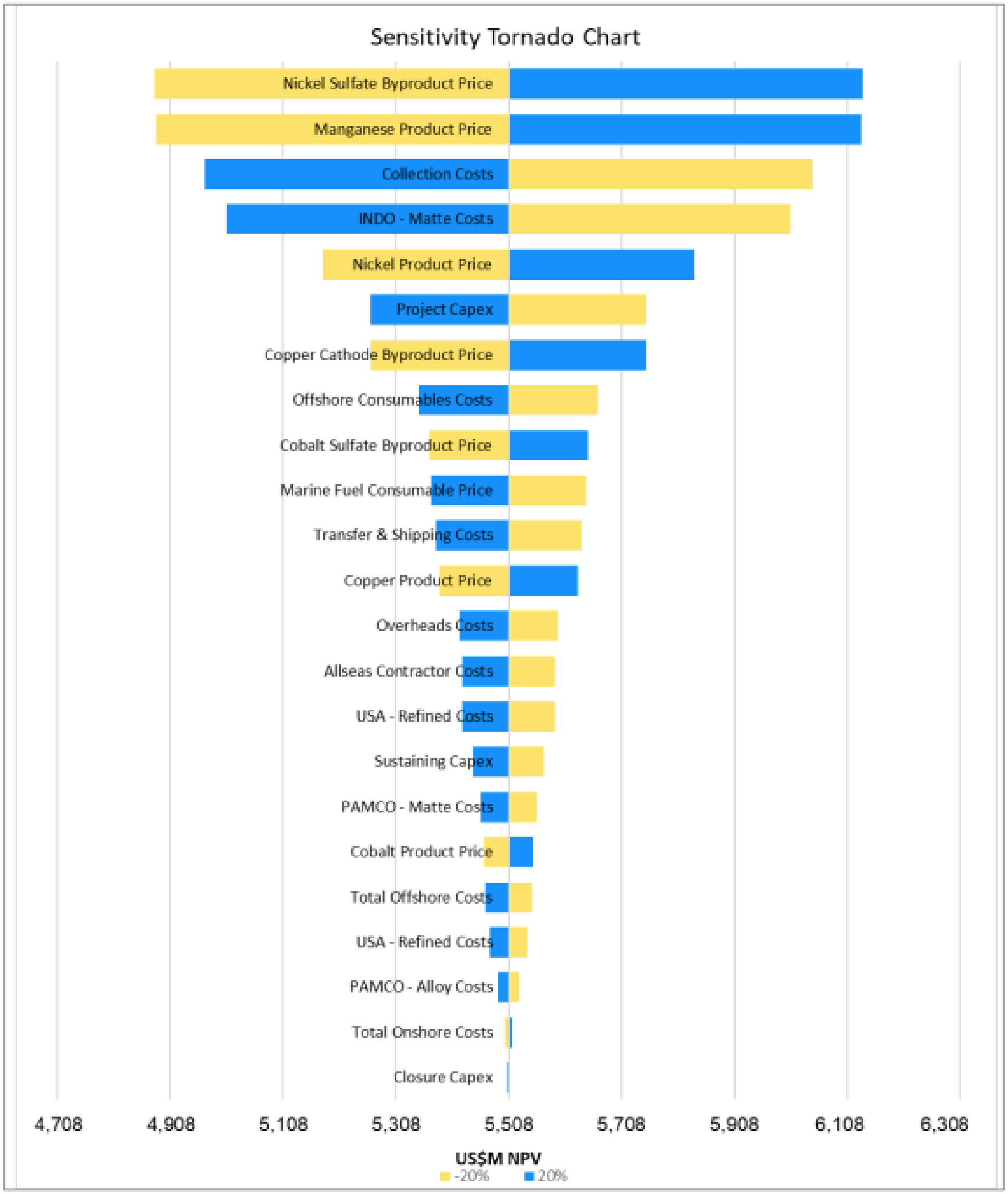
Metal	LOM Total	Year 0 2027	Year 1 2028	Year 2 2029	Year 3 2030	Year 4 2031
Nickel Revenue	31,449.5	19.4	102.2	247.0	706.8	1,647.5
Cobalt Revenue	6,465.7	3.1	15.3	30.9	78.3	176.7
Copper Revenue	12,090.9	7.9	43.7	107.9	284.5	625.8
Manganese Revenue	19,856.1	23.0	115.0	231.9	584.7	1,297.3
Metal	**Year 5 2032**	**Year 6 2033**	**Year 7 2034**	**Year 8 2035**	**Year 9 2036**	**Year 10+ 2037+**
Nickel Revenue	1,684.9	2,031.8	1,949.4	1,949.4	2,182.7	18,928.5
Cobalt Revenue	186.3	282.8	376.9	423.9	467.9	4,423.6
Copper Revenue	597.4	742.4	742.4	742.4	827.7	7,368.9
Manganese Revenue	1,248.8	1,259.2	1,269.7	1,280.1	1,463.0	11,083.4

Source: TMC

Figure 11. According to the Pre-Feasibility Study, over the life of the mine, the contributions to revenue from nickel, cobalt, copper, and manganese are 45.0%, 9.3%, 17.3%, and 28.4%. The assumption is that manganese silicate will be a feedstock for silico-manganese, which is a component of steel making. This assumption is highly speculative, since there is currently no silico-manganese facility that is accepting manganese silicate as a feedstock. If manganese silicate cannot be sold to a silico-manganese facility, then it can be sold only as low-value products such as road aggregate or sand-blasting medium or as filler for ceramics, cement or bricks. Thus, there is significant uncertainty in the assumed revenue from manganese. The numbers presumably refer to million USD. Table from AMC Consultants Pty Ltd (2025).

Assuming the predicted production rates (see Fig. 4), predicted prices (see Fig. 8), predicted payable terms (see Figs. 9a-e), predicted costs (discussed in the "Responses" section), a discount rate of 8%, and zero US royalty rate, the Pre-Feasibility Study arrived at a Net Present Value (NPV) of 5508 million USD for the mining project (see Fig. 12). The "Sensitivity Tornado Chart" then shows the impact on the NPV of decreasing or increasing individual prices or costs by 20% (see Fig. 12). It can be seen that the predicted NPV is most sensitive to the prices of nickel sulfate and manganese silicate, in which reducing the price of either product could reduce the NPV to less than 4900 million USD. The sensitivity analysis does not consider the possibility that multiple prices might be reduced by 20% or that multiple costs might be increased by 20%.

Figure 19.2 Tornado Graph



Source: TMC

Figure 12. Based on assumed nodule production rates (see Fig. 4), assumed metal recovery rates, assumed future prices (see Fig. 8), assumed payabilities (see Fig. 9a), assumed costs (see Figs. 27, 28a-e, 29, and 30), an 8% discount rate, and zero US royalty rate, the Pre-Feasibility Study predicts a net present value (NPV) of 5508 million USD. The prediction is most sensitive to the assumed prices of nickel sulfate and manganese silicate. In particular, a 20% reduction in the price of either nickel sulfate or manganese silicate would reduce the NPV to less than 4900 million USD. Although the sensitivity chart is based upon individually decreasing or increasing critical parameters by 20% of the estimated values, an uncertainty of 20% does not even begin to capture the real uncertainty in the economic assumptions. In particular, the cobalt price could easily be reduced by 40%, while it might be possible to reduce the price for manganese silicate by 100%. It should be noted that the sensitivity chart does not consider any uncertainty in the discount rate or the US royalty rate (see Fig. 12), and does not consider the impact of multiple uncertainties (such as all commodity prices being overestimated). Figure from AMC Consultants Pty Ltd (2025).

QUESTIONS

Based upon the preceding sections, the objective of this report can be subdivided into the following questions:

1) Does the Pre-Feasibility Study include a detailed plan for mine waste management as required by SEC regulations?
2) Is the economic analysis in the Pre-Feasibility Study based on mineral reserves as required by SEC regulations?
3) Was the Pre-Feasibility Study prepared by independent parties?
4) Are the economic assumptions in the Pre-Feasibility Study reasonably conservative?
5) Is the smelting and refining capacity assumed in the Pre-Feasibility Study reasonably likely to exist?
6) Has the known radioactivity of deep-sea nodules been adequately taken into account?

The methodology for addressing each question is discussed in the corresponding subsection of the "Responses" section.

RESPONSES

1: There is Zero Plan for Mine Waste Management

Although the industry standard is that 15-20% of the engineering for the tailings management plan should be complete prior to release of the Pre-Feasibility Study (see Table 1) and although SEC regulations require a detailed plan for tailings management in the Pre-Feasibility Study (see Table 2a), the Pre-Feasibility Study released by The Metals Company (TMC) includes zero plan for mine waste management. The lack of any plan for mine waste management is based upon the assumption that all outputs would be converted into marketable products. The Pre-Feasibility Study considered six options for nodule processing and chose RKEF/Refining largely because it was the only option that would yield "zero solid waste" (see Fig. 13). According to the Pre-Feasibility Study, "The primary differentiating factors for selecting the flowsheet were generation of a manganese product that fits within an existing market and a flowsheet that yields near zero solid waste" (AMC Consultants Pty Ltd, 2025).

The preceding conclusion by the Pre-Feasibility Study reveals a fundamental misunderstanding of mine tailings. Any industrial mining operation could produce zero waste if all of the outputs could be converted into marketable products, which has nothing to do with the processing flowsheet nor any distinction between terrestrial mining and deep-sea mining. The conversion of all outputs into marketable products assumes, first, that there is an actual market for all outputs and, second, that all outputs would be sufficiently non-toxic for the intended markets. If that outcome could be achieved, then it is correct that there would be no tailings (no waste products). However, there has never existed an industrial mining operation that did not produce tailings because there has never existed an operation for which all processing outputs could be converted into marketable products, either because of the lack of a market or the toxicity of some of the outputs.

Table 14.1 Simple screening process for various nodule processing flowsheet options

Flowsheet Option	Recoveries	Battery Grade Products	Mn Product Fits Existing Markets	Zero Solid Waste	Q1 Cash Costs	Cost/Time for Development	Risk/Reward
RKEF/Refining							
Thermal Upgrading							
Nitric Leach							
Cuprion Process							
Sulfuric Leach							
Chloride Leach							

Figure 13. According to the Pre-Feasibility Study, the RKEF/Refining option (see Figs. 5a-b) was the only flowsheet option that produced zero solid waste. The conclusion is misleading because any of the six options could be said to be zero solid waste (zero tailings) if all of the outputs were marketable products. In particular, the RKEF/Refining option would produce zero tailings only if the converter slag could be sold for construction aggregate or an unknown industrial application (such as sand-blasting medium) and if the ammonium sulfate could be sold as fertilizer (see Figs. 5a-b), which assumes that the converter slag and ammonium sulfate were sufficiently non-toxic for the intended application. The Pre-Feasibility Study does not include any discussion of the quantity or chemical composition of the converter slag and ammonium sulfate. Simply based upon the chemical composition of the nodules (see Figs. 14a-b), it is unlikely that the ammonium sulfate could meet fertilizer standards (see Figs. 15-16). It is noteworthy that even a terrestrial mining operation could be regarded as zero solid waste if all of the outputs were marketable products and such a mining operation has never existed. Table from AMC Consultants Pty Ltd (2025).

The Pre-Feasibility Study is completely lacking in any information regarding either the expected quantity or the chemical composition of either the converter slag or the ammonium sulfate. The only hint of information in the Pre-Feasibility Study is that the quantity of converter slag will be "small." In particular, the Pre-Feasibility Study is lacking in any mass balance, neither a material balance that would show how each metric ton of nodules would be proportioned among the various intermediate and final products, nor any elemental balance that would show how each kilogram of each element in a nodule would be distributed among the various intermediate and final products. Without a knowledge of the chemical composition of the converter slag and the ammonium sulfate, there is no basis for claiming that there is a market for these outputs. It is important to note that the function of the processing flowsheet is to transfer nickel, cobalt, copper and manganese into the final products nickel sulfate, cobalt sulfate, copper cathode, and manganese silicate, respectively, and to preferentially transfer all of the other elements (except for sulfur and silicon), including potentially toxic elements, into either the converter slag or the ammonium sulfate. This preferential transfer of potentially toxic elements into tailings is exactly the reason as to why there has never existed an industrial mining operation that has been able to convert all of its tailings into marketable products.

According to the Pre-Feasibility Study, the converter slag would be sold for either construction aggregate (such as road aggregate) or some unidentified industrial application (such as sand-blasting medium). However, even the use of the converter slag as road aggregate presumes that the material is sufficiently non-toxic that it will not cause contamination of soil, surface water, or groundwater. In this case, it is not sufficient to know only the chemical composition of the converter slag, but also the potential for toxic elements to leach out of the slag into the road substrate. Thus, it is also necessary to know the various phases in which toxic elements will occur in the converter slag and to carry out appropriate leaching tests.

Clearly, the suitability of the ammonium sulfate for sale as fertilizer depends upon its load of elements that could be toxic to crops. Even without knowing the chemical composition of the ammonium sulfate, it is useful to compare the chemical composition of the deep-sea nodules (see Figs. 14a-b) with Canadian (Government of Canada, 2025) and European (European Parliament, 2019) fertilizer standards (see Figs. 15-16). Canadian standards include maximum acceptable cumulative metal addition to soil over 45 years of 36 kilograms of nickel per hectare, 30 kilograms of cobalt per hectare, and 150 kilograms of copper per hectare (see Fig. 15), while European standards include a maximum nickel content in fertilizer of 100 milligrams per kilogram of dry fertilizer (see Fig. 16). It was already mentioned that the nickel, cobalt, and copper contents of the ammonium sulfate are unknown, so that the suitability of the ammonium sulfate for fertilizer is unknown.

On the other hand, simply based on the chemical composition of the deep-sea nodules (see Figs. 14a-b), and without considering any preferential transfer of toxic elements into the processing by-products (converter slag and ammonium sulfate), it can be shown that the ammonium sulfate would be unsuitable as a fertilizer. By comparison with Canadian standards (see Fig. 15), the mean nodule concentrations of molybdenum (525.18 ppm) and thallium (9.68 ppm) (see Fig. 14b) greatly exceed the maximum fertilizer concentrations for molybdenum (20 ppm) and thallium (5 ppm) at fertilizer application rate of 4400 kilograms per hectare per year. By comparison with European standards, the mean nodule concentrations of arsenic (74.13 ppm), cadmium (18.74 ppm), chromium (11 ppm), and lead (280 ppm, equivalent to lead oxide concentration of 0.03%) (see Figs. 14a-b) greatly exceed the maximum fertilizer concentrations for arsenic (40 ppm), cadmium (3 ppm), chromium-6 (2 ppm), and lead (120 ppm) (see Fig. 16).

An additional source of mine waste or tailings is the sediment-laden return water that would be re-injected into the ocean at a depth of 2000 meters. The Pre-Feasibility Study does not even mention the possibility that the return water should be regarded as mine waste, although it would certainly be regarded as waste in any other context. For example, if sediment were dredged from a harbor and then deposited into another water body or farther out to sea, it would definitely be regarded as waste and would be referred to as “dredge spoil.” The important point is that stable sediment has been converted into suspended sediment in a different location.

From another perspective, even if the separation of deep-sea nodules from the sediment-laden return water were a purely physical process without the addition of any chemical reagents, the sediment-laden return water would still be regarded as tailings by any industry standard. Although the earlier quote from the SME Surface Mining Handbook (Snow and Morrison, 2023) included process water and chemical reagents as part of the definition of tailings, the use of chemical reagents is not required for the production of tailings. According to the Global Industry Standard on Tailings Management (GISTM), “tailings” are “a by-product of mining, consisting of the processed rock or soil left over from the separation of the commodities of value from the rock or soil within which they occur” (ICMM-UNEP-PRI, 2020). In fact, there are many types of mineral processing that are purely physical, such as the multiple processing steps that are used at heavy mineral sands operations, and the remaining rock, soil, or sediment is universally regarded as tailings.

Table 7.11 Summary statistics of multielement chemistry of nodule samples from box cores

	Count	Minimum	Mean	Maximum	CoV
Al_2O_3_%	457	3.17	4.02	8.82	0.128
BaO_%	457	0.25	0.44	1.24	0.330
CaO_%	457	1.52	2.46	5.89	0.124
CoO_%	457	0.09	0.18	0.58	0.243
CuO_%	457	0.75	1.45	1.90	0.086
Fe_2O_3_%	457	5.42	9.41	15.96	0.136
K_2O_%	457	0.92	1.08	1.97	0.103
MgO_%	457	2.59	3.17	3.81	0.042
MnO_%	457	22.4	40.0	44.5	0.056
Na_2O_%	457	2.23	2.87	4.50	0.072
NiO_%	457	0.97	1.73	1.90	0.069
P_2O_5_%	457	0.24	0.38	2.79	0.453
PbO_%	457	<0.01	0.03	0.07	0.437
SO_3_%	457	0.05	0.29	0.72	0.294
SiO_2_%	457	10.06	12.20	29.09	0.155
TiO_2_%	457	0.18	0.42	1.44	0.190
ZnO_%	457	0.11	0.21	0.33	0.112
Total_%	360	98.0	99.5	102.6	0.008
LOI_%	457	10.7	15.9	18.3	0.061
Ce_ppm	454	85.2	217	388	0.167
Cr_ppm	454	8	11	70	0.449
Cs_ppm	454	0.75	1.07	2.04	0.168
Dy_ppm	454	13.35	26.26	38.5	0.104
Er_ppm	454	6.98	13.55	19.9	0.105
Eu_ppm	454	3.59	7.47	10.9	0.115
Gd_ppm	454	15.85	30.15	44.6	0.107
Hf_ppm	454	1.8	4.77	8.2	0.173
Ho_ppm	454	2.55	4.91	7.25	0.106
La_ppm	454	59	109.12	171	0.130
Lu_ppm	454	0.96	1.94	2.67	0.103
Nb_ppm	454	7.5	18.76	35.6	0.173
Nd_ppm	454	70.8	128.62	190.5	0.116
Pr_ppm	454	16.2	30.31	47.1	0.119

Figure 14a. Particular contaminants of concern in the nodules include chromium, cobalt, copper, lead, nickel, and zinc (compare with fertilizer requirements in Figs. 15-16). Although the intention of the flowsheet is to recover nickel, cobalt and copper into nickel-cobalt-copper matte and then nickel sulfate, cobalt sulfate, and copper cathode, any imperfect recovery of those elements will transfer them into either the converter slag or ammonium sulfate (see Figs. 5a-b). Chromium, lead, and zinc should also be rejected from the nickel sulfate, cobalt sulfate, copper cathode, and manganese silicate and, thus, concentrated into either the converter slag or ammonium sulfate. Even without any concentration into the ammonium sulfate, the chromium and lead levels in the nodules render them too toxic for fertilizer. Compare the mean nodule concentrations of chromium (11 ppm) and lead (280 ppm, equivalent to PbO concentration of 0.03%) with the maximum fertilizer concentrations for Cr-6 (2 ppm) and lead (120 ppm) (see Fig. 16). Table from AMC Consultants Pty Ltd (2025). See continuation of table in Fig. 14b.

	Count	Minimum	Mean	Maximum	CoV
Rb_ppm	454	13.8	17.97	31.4	0.143
Sc_ppm	38	9	9.82	11	0.073
Sm_ppm	454	16.5	30.62	42.8	0.106
Sn_ppm	454	1	1.52	5	0.440
Sr_ppm	454	519	704.45	882	0.064
Ta_ppm	454	0.1	0.29	1.7	0.382
Tb_ppm	454	2.41	4.60	6.73	0.106
Th_ppm	454	4.53	9.68	22.4	0.211
Tm_ppm	454	1.02	1.98	2.81	0.101
U_ppm	454	2.34	3.97	5.59	0.083
V_ppm	454	331	486.32	648	0.091
W_ppm	454	33	64.96	187	0.178
Y_ppm	454	50.9	85.79	156	0.104
Yb_ppm	454	6.41	12.78	17.25	0.104
Zr_ppm	454	146	321.01	555	0.155
Bi_ppm	411	0.85	3.18	5.76	0.200
Ge_ppm	411	0.26	0.48	0.76	0.257
Se_ppm	411	<0.01	0.73	5	1.791
Te_ppm	411	1.13	2.79	5.35	0.200
Tl_ppm	411	17.3	153.11	232	0.235
As_ppm	411	10	74.13	120	0.332
Cd_ppm	411	5.4	18.74	26.3	0.165
Mo_ppm	411	284	525.18	792	0.101
Sb_ppm	411	19	43.89	60	0.127
Li_ppm	411	60	147.37	340	0.199
Ga_ppm	416	25	36.89	46.1	0.082
Hg_ppm	51	0.034	0.05	0.103	0.238
B_ppm	51	80	106.47	130	0.088
F_ppm	11	230	299.09	420	0.209

Figure 14b. Particular contaminants of concern in the nodules include arsenic, cadmium, mercury, molybdenum, selenium, thallium, and vanadium (compare with fertilizer requirements in Figs. 15-16). All of the preceding elements should be rejected from the nickel sulfate, cobalt sulfate, copper cathode, and manganese silicate and, thus, concentrated into either the converter slag or ammonium sulfate. Even without any concentration into the ammonium sulfate, the arsenic, cadmium, molybdenum, and thallium levels in the nodules render them unsuitable for fertilizer. Compare the mean nodule concentrations of arsenic (74.13 ppm) and cadmium (18.74 ppm) with the maximum fertilizer concentrations for arsenic (40 ppm) and cadmium (3 ppm) (see Fig. 16). Compare also the mean nodule concentrations of molybdenum (525.18 ppm) and thallium (9.68 ppm) with the maximum fertilizer concentrations for molybdenum (20 ppm) and thallium (5 ppm) at fertilizer application rate of 4400 kilograms per hectare per year (see Fig. 15). Table from AMC Consultants Pty Ltd (2025). See beginning of table in Fig. 14a.

Table 1: CFIA fertilizer and supplement metals standards and examples of maximum acceptable metal concentrations based on annual application rates

Metal	Maximum acceptable cumulative metal addition to soil over 45 years (kg metal/ha)	Examples of a maximum acceptable concentration of a metal based on annual application rate (mg metal/kg product)		
		4400 kg/ha per year	2000 kg/ha per year	500 kg/ha per year
Arsenic (As)	15	75	166	666
Cadmium (Cd)	4	20	44	177
Chromium (Cr)	210	1060	2333	9333
Cobalt (Co)	30	151	333	1333
Copper (Cu)	150	757	1666	6666
Mercury (Hg)	1	5	11	44
Molybdenum (Mo)	4	20	44	177
Nickel (Ni)	36	181	400	1600
Lead (Pb)	100	505	1111	4444
Selenium (Se)	2.8	14	31	124
Thallium (Tl) [1]	1	5	11	44
Vanadium (V) [1]	130	656	1444	5777
Zinc (Zn)	370	1868	4111	16444

[1] Not all products require results of analysis for Thallium and Vanadium. These are an example of additional results that may be requested based on product or material type, on a case-by-case basis.

Figure 15. A major concern with the proposal for selling the ammonium sulfate for fertilizer instead of storing it as mine tailings (see Fig. 5b) is that there is a wide range of maximum metal concentrations for fertilizer. Although the intention of the flowsheet is to recover nickel, cobalt and copper into nickel-cobalt-copper matte and then nickel sulfate, cobalt sulfate, and copper cathode, any imperfect recovery of those elements will transfer them into either the converter slag or ammonium sulfate (see Figs. 5a-b). All other elements besides manganese, silicon, and sulfur should also be rejected from the nickel sulfate, cobalt sulfate, copper cathode, and manganese silicate and, thus, concentrated into either the converter slag or ammonium sulfate. Even without any concentration into the ammonium sulfate, the molybdenum and thallium levels in the nodules render them too toxic for fertilizer. Compare the mean nodule concentrations of molybdenum (525.18 ppm) and thallium (9.68 ppm) (see Fig. 14b) with the maximum fertilizer concentrations for molybdenum (20 ppm) and thallium (5 ppm) at fertilizer application rate of 4400 kilograms per hectare per year. Table from Government of Canada (2025).

PFC 1(C)(I): INORGANIC MACRONUTRIENT FERTILISER

1. An inorganic macronutrient fertiliser shall be aimed at providing plants or mushrooms with one or more of the following macronutrients:
   (a) primary macronutrients: nitrogen (N), phosphorus (P) or potassium (K),
   (b) secondary macronutrients: calcium (Ca), magnesium (Mg), sodium (Na) or sulphur (S).

2. Contaminants in an inorganic macronutrient fertiliser must not exceed the following limit values:

(a)	cadmium (Cd)	:	(i) where an inorganic macronutrient fertiliser has a total phosphorus (P) content of less than 5 % phosphorus pentoxide (P2O5)-equivalent by mass: 3 mg/kg dry matter, or (ii) where an inorganic macronutrient fertiliser has a total phosphorus (P) content of 5 % phosphorus pentoxide (P2O5)-equivalent or more by mass ('phosphate fertiliser'): 60 mg/kg phosphorus pentoxide (P2O5);
(b)	hexavalent chromium (Cr VI)	:	2 mg/kg dry matter,
(c)	mercury (Hg)	:	1 mg/kg dry matter,
(d)	nickel (Ni)	:	100 mg/kg dry matter,
(e)	lead (Pb)	:	120 mg/kg dry matter,
(f)	arsenic (As)	:	40 mg/kg dry matter,
(g)	biuret (C2H5N3O2)	:	12 g/kg dry matter,
(h)	perchlorate (ClO4-)	:	50 mg/kg dry matter.

3. The copper (Cu) content in an inorganic macronutrient fertiliser must not exceed 600 mg/kg dry matter, and the zinc (Zn) content in an inorganic macronutrient fertiliser must not exceed 1 500 mg/kg dry matter. However, these limit values shall not apply where copper (Cu) or zinc (Zn) has been intentionally added to an inorganic macronutrient fertiliser for the purpose of correcting a soil micronutrient deficiency and is declared in accordance with Annex III.

Figure 16. A major concern with the proposal for selling the ammonium sulfate for fertilizer instead of storing it as mine tailings (see Fig. 5b) is that there is a wide range of maximum metal concentrations for fertilizer. Although the intention of the flowsheet is to recover nickel, cobalt and copper into nickel-cobalt-copper matte and then nickel sulfate, cobalt sulfate, and copper cathode, any imperfect recovery of those elements will transfer them into either the converter slag or ammonium sulfate (see Figs. 5a-b). All other elements besides manganese, silicon and sulfur should also be rejected from the nickel sulfate, cobalt sulfate, copper cathode, and manganese silicate and, thus, concentrated into either the converter slag or ammonium sulfate. Even without any concentration into the ammonium sulfate, the arsenic, cadmium, chromium, and lead levels in the nodules render them unsuitable for fertilizer. Compare the mean nodule concentrations of arsenic (74.13 ppm), cadmium (18.74 ppm), chromium (11 ppm), and lead 280 ppm, equivalent to PbO concentration of 0.03%) (see Figs. 14a-b) with the maximum fertilizer concentrations for arsenic (40 ppm), cadmium (3 ppm), Cr-6 (2 ppm), and lead (120 ppm). Selection from European Parliament (2019).

The environmental impacts of the sediment-laden return water or "sediment plumes" are largely unknown and could be wide-ranging. According to Planet Tracker (2023), "The main indirect impacts of deep sea mining are associated with the sediment plumes and noise created by mining activity which could have far-reaching impacts on ocean ecosystems. For example, seabed communities could be smothered [Simon-Lledó et al., 2019], toxic metals may be released [Peukert et al., 2018], deep sea fisheries could be contaminated [Washburn et al., 2021] and nutrients could be introduced into otherwise nutrient-poor ecosystems [Washburn et al., 2021]. While these impacts are relatively under studied, existing research indicates they are likely to be very difficult to control and contain due to the highly interconnected and dynamic nature of the ocean. Estimates for the total area of ocean that would be impacted by deep sea mining vary widely. However, scientists agree that noise and sediment plumes from equipment disturbing the seabed and surface de-watering processes could have far-reaching effects on broader ocean ecosystems [Washburn et al., 2021]. Sediment plumes alone could spread hundreds to thousands of km in the water column [Muñoz-Royo et al., 2021], so the overall area affected by deep sea mining would be at least two to four times larger than the area mined." It should be noted that, even if sediment plumes extended only tens of kilometers, the area impacted by the release of dissolved metals and radioactive isotopes could potentially be far larger.

2: The Economic Analysis is not Based on Mineral Reserves

Despite SEC regulations that explicitly state that only mineral reserves are economically mineable and that only mineral reserves can form the financial basis for an economically viable mining operation (see Table 2b), the economic analysis in the TMC Pre-Feasibility Study is based on 51 million wet metric tons of mineral reserves (see Fig. 6b) plus another 113.1 million wet metric tons of mineral resources that were not converted into reserves (see Figs. 4 and 10). In fact, the Pre-Feasibility Study shows that, based on mineral reserves alone, the mining operation would terminate after eight years with zero profit (see Fig. 10). In other words, the economic viability of the mining project has been demonstrated based on mineral resources that have not been shown to be "economically viable" (see Table 2b). The requirement to ground the economic analysis in mineral reserves (the subset of mineral resources that are "economically mineable") (see Table 2b) is not a "gray area" in SEC regulations. It should go without saying that, if the economic analysis can be based upon mineral reserves plus whatever mineral resources are necessary to complete the analysis, then the consideration as to which mineral resources are mineral reserves would be a pointless exercise. As was discussed in the subsection "Comparison between SEC Regulations and Regulations in other Jurisdictions," the Australian, Canadian, European, and South African regulations all provide the same message in equating mineral reserves as the only economically mineable part of mineral resources with mineral reserves acting as the sole financial basis for an economically viable project (JORC, 2012; CIM, 2014; PERC, 2021a; SAMCODE, 2016; see Table 2b).

The same fairly obvious point has also been made in other critiques of the TMC Pre-Feasibility Study. For example, according to Iceberg Research (2025a), "The PFS defines 51mn wet tonnes (wmt) [million wet metric tons] of reserves. Departing from standard practice, the net present value (NPV) was calculated using both reserves and 113mn wmt of resources … Reserves are defined but the NPV is still calculated based on reserves + resources. One of the main objectives of a PFS is to determine mineral reserves, which are the portion of a resource deemed as economically viable for extraction. In this case, TMC reported a mineral reserve of 51mn wet tonnes (wmt). An NPV based on reserves should then be calculated. Unlike an NPV based on resources, it provides greater certainty to investors. Indeed, junior mining companies typically use their reserves to calculate their NPV in a PFS. However, TMC is not your typical miner: the NPV also includes the share of 'recoverable' resources (113mn wmt), for a total of 164mn wmt. TMC and its consultants estimate that these 113 million wmt could be extracted from outside the Initial Mining Area, assuming similar conditions there (e.g., terrain), despite a lack of surveys in those areas. The corporate presentation [TMC, 2025a] does not distinguish between reserves and resources in the NPV calculation. We believe TMC included resources because the NPV based solely on reserves was insufficient. The company stated that the 51mn wmt of reserve would generate only $170.2mn in undiscounted cash flow, an amount that would produce a negative NPV if discounted at 15%." The exact quote in the Pre-Feasibility Study to which Iceberg Research (2025a) is referring is: "The development plan then assumes that an additional 113 Mwmt of Mineral Resource (based on the same modifying factors as the Initial Mining area) will be **recoverable** to market outside the Initial Mining Area (NORI Area D Total = 164 Mwmt)" [emphasis added]. The concept of a "recoverable" resource does not occur anywhere in SEC regulations (CFR, 2018).

As a second example, according to Barnard and Trytten (2025), "Reviewers need to be very careful that they understand the data and the definitions for things like reserves and resources … Use of Resources, not Reserves, in economic modelling beyond 8 years would likely be non-compliant with some other regulatory systems such as Canada's NI43-101." The significance of the period beyond eight years is that the reserves would have been exhausted by the end of Year 7 (the eighth year of operation) (see Figs. 4 and 10), so that any economic analysis carried further in time must be based on resources alone. However, Barnard and Trytten (2025) are incorrect in implying that an economic analysis based on mineral resources would be non-compliant with Canadian regulations, but might be compliant with SEC regulations. On the contrary, nearly identical language is used in both SEC and Canadian regulations.

According to SEC regulations, "Mineral reserve is an estimate of tonnage and grade or quality of indicated and measured mineral resources that, in the opinion of the qualified person, can be the basis of an economically viable project. More specifically, it is the economically mineable part of a measured or indicated mineral resource … The pre-feasibility study or feasibility study, which supports the qualified person's determination of mineral reserves, must demonstrate that, at the time of reporting, extraction of the mineral reserve is economically viable under reasonable investment and market assumptions. The study must establish a life of mine plan that is technically achievable and economically viable, which will be the basis of determining the mineral reserve" (CFR, 2018; see table 2b). In an almost identical way, according to Canadian regulations, "A Mineral Reserve is the economically mineable part of a measured and/or Indicated Mineral Resource … Mineral Reserves are those parts of Mineral Resources which, after the application of all mining factors, result in an estimated tonnage and grade which, in the opinion of the Qualified Person(s) making the estimates, is the basis of an economically viable project after taking account of all relevant Modifying Factors" (CIM, 2014). Canadian regulations do provide the strong clarification that "If an issuer discloses in writing mineral resources or mineral reserves on a property material to the issuer, the issuer must include in the written disclosure … (e) if the disclosure includes the results of an economic analysis of mineral resources, an equally prominent statement that mineral resources that are not mineral reserves do not have demonstrated economic viability" (CIM, 2023).

Iceberg Research (2025a) further questioned whether even the mineral resources had been estimated correctly. According to Iceberg Research (2025a), "One remark buried in the PFS should alert the reader: the abundance cut-off [4 wet kilograms of nodules per square meter; see Fig. 6a] was 'based on estimates developed for the second generation of collection systems described and assessed in the Initial Assessment of NORI and TOML areas (AMC, 2025) rather than the collection system evaluated for the Mineral Reserves in the PFS for NORI Area D.' In other words, TMC's lower future costs have been used to inflate resources even though these second generation collection systems are not expected before 2037."

3: The Pre-Feasibility Study was Largely Written by Company Employees

The first page of the Pre-Feasibility Study lists as "Qualified Persons" five companies and four individuals. The Qualified Persons are the companies or individuals who provided the information that is contained in the Pre-Feasibility Study. According to SEC regulations, "A registrant's disclosure of exploration results, mineral resources, or mineral reserves, as required by §§ 229.1303 and 229.1304, must be based on and accurately reflect information and supporting documentation prepared by a qualified person, as defined in § 229.1300" (CFR, 2018). The four individuals are all employees of The Metals Company (TMC), including Anthony O'Sullivan (Chief Development Officer), Dr. Michael Clarke (Environmental Manager), Rutger Bosland (Chief Innovation and Offshore Technology Officer), and Adam Price (Project Controls Manager).

SEC regulations do not prohibit authorship of a mining project disclosure by company employees. According to SEC regulations, "The registrant must state in the filed registration statement or report whether each qualified person who prepared the technical report summary is an employee of the registrant" (CFR, 2018). The same is true for Australian, European, and South African regulations (see Table 2d). However, even though South African regulations permit authorship by a company employee, the employee should still maintain an "independent mindset." According to South African regulations, "The author of the Public Report should be satisfied that: his/her work has not been unduly influenced by the organisation, company or person commissioning a report or any report that may be deemed a Public Report" (SAMCODE, 2016).

By contrast, the Canadian regulations are very strong on the need for independence on the part of the authors of a mining project disclosure. According to Canadian regulations, "In this Instrument, a qualified person is independent of an issuer if there is no circumstance that, in the opinion of a reasonable person aware of all relevant facts, could interfere with the qualified person's judgment regarding the preparation of the technical report" (CIM, 2011). Moreover, "A technical report required under any of the following provisions of this Instrument must be prepared by or under the supervision of one or more qualified persons that are, at the effective and filing dates of the technical report, all independent of the issuer" (CIM, 2023). On the above basis, Canadian regulations explicitly prohibit authorship by a company employee. According to CIM (2011), "We consider a qualified person is not independent when the qualified person (a) is an employee, insider, or director of the issuer."

In summary, it is not non-compliant for a company that trades on NASDAQ to use company employees to write a Pre-Feasibility Study, although it would be non-compliant for a company that trades on the Toronto or Vancouver Stock Exchanges. On the other hand, the authorship by company employees of a mining project disclosure written in compliance with SEC regulations would certainly be an unusual practice. In fact, the author of this report has never before seen a mining project disclosure written by company employees for a company that was trading on a US stock exchange. On that basis, the lack of independence of the authors of the TMC Pre-Feasibility Study should be an occasion for pause and reflection.

This point has been developed at great length by Iceberg Research (2025a). According to Iceberg Research (2025a), "The crucial sections of the PFS [Pre-Feasibility Study] are written by either TMC employees or small consultants with one or two clients including TMC. For example, the market studies section, which includes the metals price assumptions, is signed off by Anthony O'Sullivan, TMC's Chief Development Officer and former COO of Nautilus." Iceberg Research (2025a) further pointed out that investors might not have been aware that the Pre-Feasibility Study was largely written by company employees or might not have grasped the significance of the lack of independence. According to Iceberg Research (2025a), "On Monday, before the market opened, the PFS was released, pushing the stock up as much as 25%. The rally reversed only after we tweeted that the metal prices projections were extremely aggressive and that key sections of the PFS had been authored by TMC employees rather than independent consultants."

Iceberg Research (2025a) continues, "Initially, we assumed TMC would engage small consulting firms for the critical sections of the PFS, serving as Qualified Persons (QP), as it did for the Initial Assessment (IA) in 2021. However, it appears TMC had to rely on its own staff. Notably, two key sections, the metal prices assumptions and the cost estimates, were prepared by TMC employees. Although permissible, this significantly undermines the credibility of the PFS. Whether Rio Tinto or TMC uses its own staff to prepare a PFS obviously does not carry the same implications. TMC has a lot to do to establish the credibility of its business model: commercial deep-sea mining has never been undertaken before, and part of its management team comes from the now-bankrupt deep-sea mining fiasco Nautilus Minerals. This includes Anthony O'Sullivan, who was Nautilus' COO. QPs are expected to maintain objectivity and fairness. Here are a few photos of these QPs celebrating at the Nasdaq bell-ringing ceremony two weeks ago. No comment needed. Since March 2024, O'Sullivan has been awarded over 1 million shares, according to Form 4 filed with SEC. This is worth more than $5mn at today's share price. Are we supposed to believe this cannot influence his objectivity in preparing the PFS?"

Iceberg Research (2025a) drew further attention to the small sizes of the five companies that were listed as Qualified Persons and to their dependence upon TMC. According to Iceberg Research (2025a), "In addition to the employee contributions, some sections were written by small outfits. We already flagged [Iceberg Research, 2025b] two of them in our earlier report. Margin-Marine Geoscience Innovation is responsible for the geology and exploration component of the PFS, including the key measure of nodule abundance. The firm is a sole proprietorship based in Australia, operated by its principal, Ian Stevenson, who served as Chief Geophysicist and Innovation Lead for Exploration at Nautilus from November 2008 to August 2012. Searches on filings databases indicate that TMC is the only public company that he has worked for. Canadian Engineering Associates Ltd. is responsible for the very important metallurgy section of the PFS. The firm has only five employees. The consultant's only other listed-company engagement was with Horizonte Minerals, which entered administration in May 2024 due to runaway capex. Two new consultants were added. Lanasera Pty Ltd is responsible for the economic analysis section which yields the NPV. It is a little-known Australian consulting firm operating from a residential address. Online searches show that Lepidico, an Australia-listed lithium exploration company, appears to be the only publicly listed client, other than TMC, Lanasera has ever consulted for. Lepidico was placed [Webb, 2024] into administration in December 2024. APYS Subsea Ltd, a little-known British firm [Government of the United Kingdom, 2025] operating from a residential address, is responsible for the geotechnical component of the PFS. It is a micro company with net assets of just £13,342 and only two employees, Briony Buckell and John Buckell (the signing consultant), who appear to be husband and wife … The use of in-house staff or very small consulting firms as QPs undermines the credibility of this PFS."

As a final summary, Barnard and Trytten (2025) wrote, "Lastly, significant portions of the PFS documentation were authored and approved by company insiders, an approach not allowed in many prominent mining jurisdictions. These sections include the capital and operating costs and market analysis including product pricing. Although these are likely all based on independent work, this aspect raises potential concerns regarding the broader credibility and acceptance of the presented analyses and conclusions, regardless of their veracity. More credibility would ensue if a practitioner from a major mining/project development engineering company were to certify the capital and operating costs used."

4: The Economic Assumptions are Best-Case or Near-Best-Case Scenarios

4a: Future Metal Prices

The theme of this section is that the assumptions underlying the economic analysis are a collection of best-case and near-best-case scenarios, which are not the foundation for a reasonably conservative investment strategy. This section will consider in turn assumptions regarding future metals prices, metal recovery rates, the US royalty rate, the discount rate, future costs, and closure costs.

Starting with future metal prices, the Pre-Feasibility Study includes not only predictions of prices over the life of the mine (see Fig. 8), but separate predictions for the periods 2028-2032, 2033-2037, and 2038-2043+ (see Fig. 17). Notable predicted trends are a 55% increase in the price of cobalt metal from 2028-2032 to 2033-2037 and nearly stable copper and manganese prices over the life of the mine (see Fig. 17). Based on the prices in Fig. 17, the ratio of the price of nickel contained in nickel sulfate to the price of nickel metal would be 1.066 over the life of the mine, steadily rising from 1.042 during 2028-2032 to 1.072 after 2038 (see Table 3a). In other words, the Pre-Feasibility Study predicted that nickel would become increasingly more valuable if it were contained in nickel sulfate. Again based on the prices shown in Fig. 17, the ratio of the price of cobalt contained in cobalt sulfate to the price of cobalt metal would be 0.984 over the life of the mine, steadily rising from 0.917 during 2028-2032 to 1.000 after 2038 (see Table 3b), so that cobalt would also be become increasingly more valuable if it were contained in cobalt sulfate.

Table 16.1 Metal and metal sulfate price forecasts 2026 onwards (real US$ 2025)

Commodity Pricing – Real	LOM Average	2028-2032	2033-2037	2038-2043+
Price - Nickel Class 1 LME (US$/t)	20,295	18,833	20,706	20,360
Price - Cobalt LME (US$/t)	56,117	34,172	53,124	62,530
Price - Copper Class 1 LME(US$/t)	11,440	11,317	11,456	11,456
Price - Manganese (US$/DMTU)	5.45	5.29	5.44	5.50
Price – Ni Sulphate (Contained Ni basis)	21,633	19,623	22,007	21,835
Price – Co Sulphate (Contained Co basis)	55,198	31,347	51,336	62,530

Source: CRU,BMI

Figure 17. The Pre-Feasibility Study includes not only predictions of prices over the life of the mine (see Fig. 8), but separate predictions for the periods 2028-2032, 2033-2037, and 2038-2043+. Notable predicted trends are a 55% increase in the price of cobalt metal from 2028-2032 to 2033-2037 and nearly stable copper and manganese silicate prices over the life of the mine. The assumed price for manganese probably refers to manganese silicate, not manganese metal (compare with Fig. 21). The Pre-Feasibility Study also assumes steady increases for both nickel and cobalt in the ratios of the price of the metal to the price of the metal contained as a sulfate (compare with Tables 3a-b). Table from AMC Consultants Pty Ltd (2025).

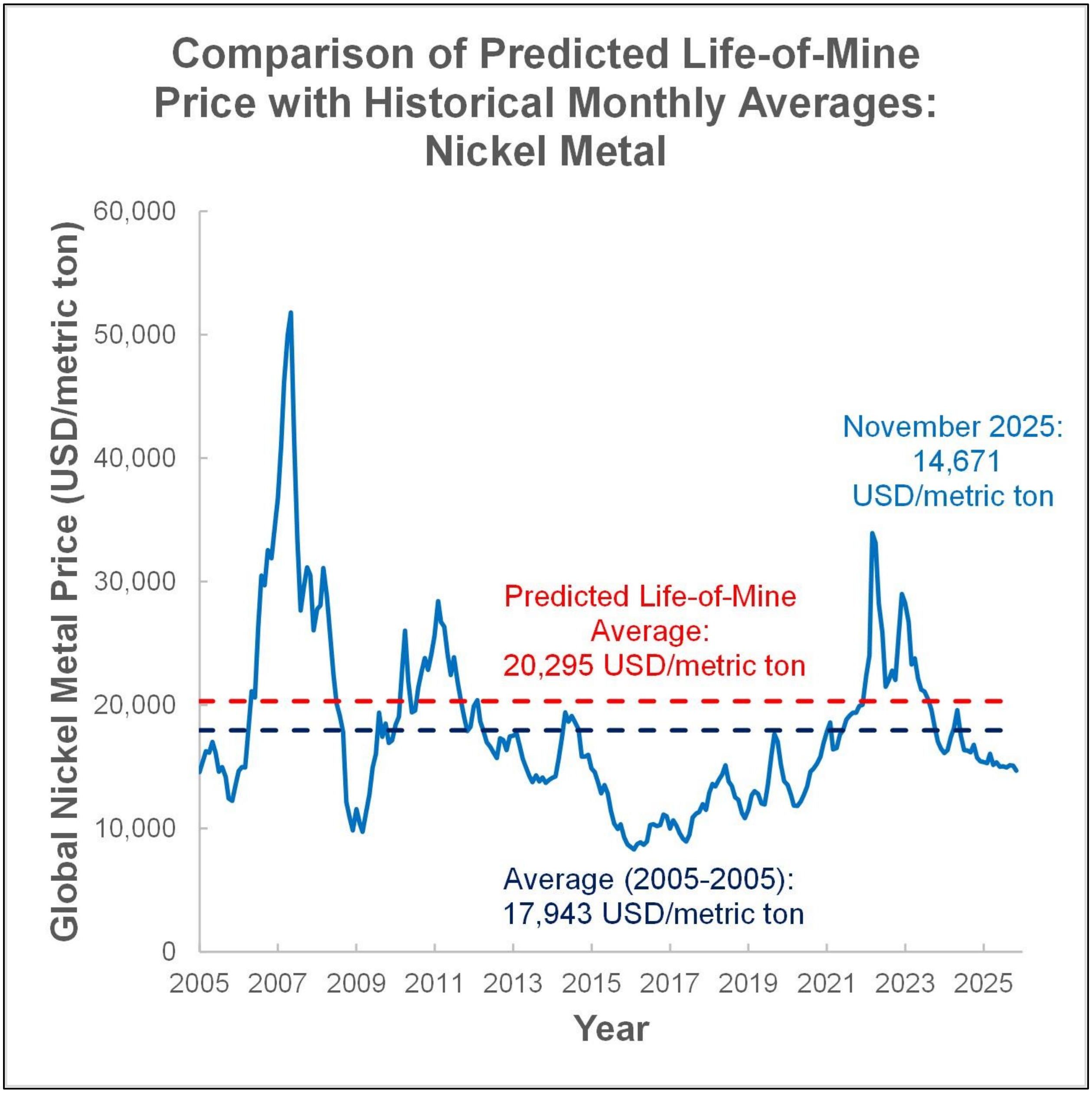


Figure 18. The Pre-Feasibility Study assumes a life-of-mine average price for nickel metal of 20,295 USD per metric ton (see Fig. 17), which is 38.3% higher than the current price of 14,671 USD per metric ton (monthly average for November 2025) and 13.1% higher than the average monthly price of 17,943 USD per metric ton for the period 2005-2025. The period 2005-2025 does not show any upward trend. In fact, the price of nickel dropped from 33,924 to 14,671 USD per metric ton from March 2022 to November 2025. A reasonably conservative assumption for future prices is that they will be no higher than the trend for a comparable period in the past. Data from IMF (2025).

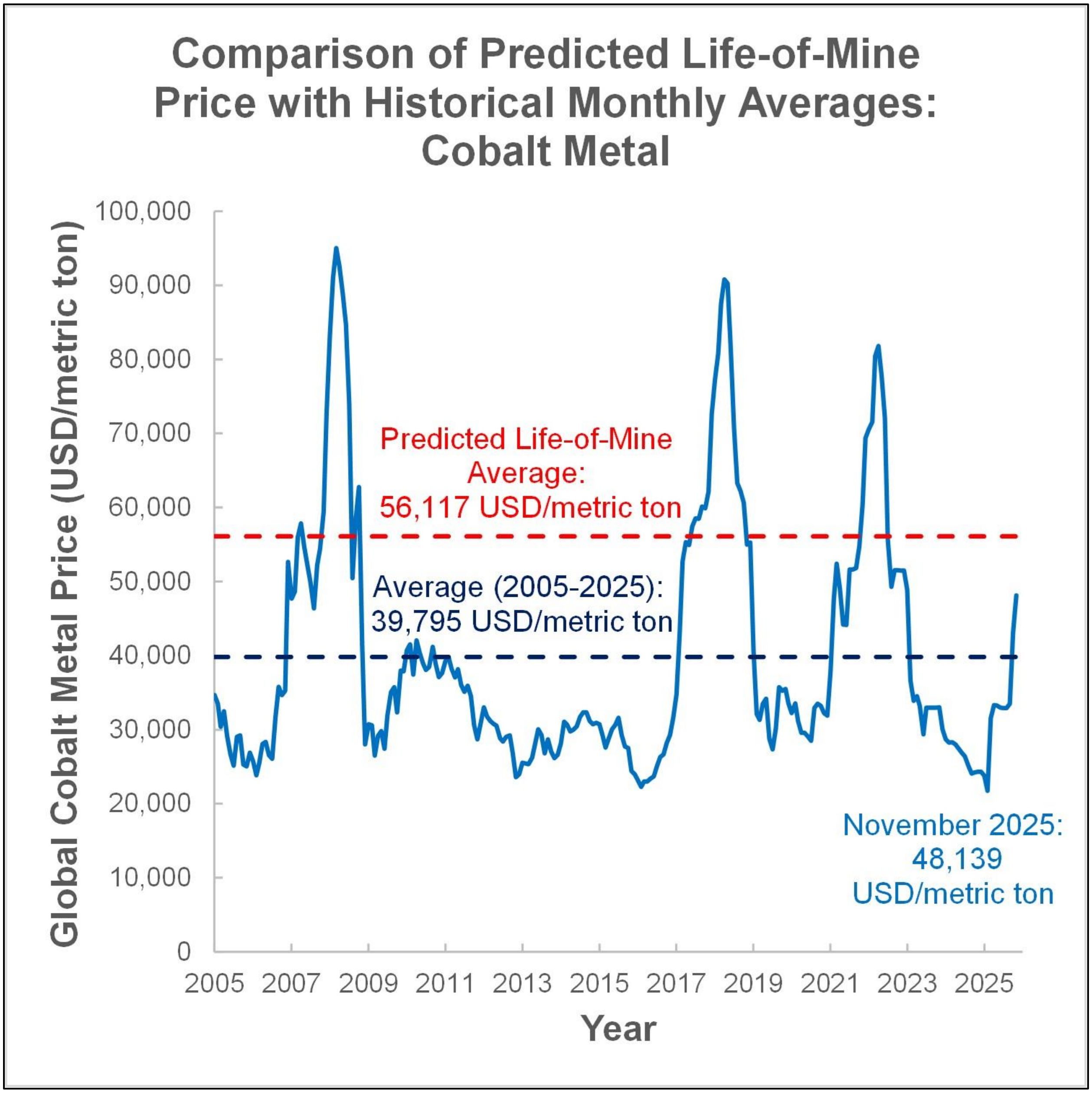


Figure 19. The Pre-Feasibility Study assumes a life-of-mine average price for cobalt metal of 56,117 USD per metric ton (see Fig. 17), which is 16.6% higher than the current price of 48,139 USD per metric ton (monthly average for November 2025) and 41.0% higher than the average monthly price of 39,795 USD per metric ton for the period 2005-2025. The period 2005-2025 does not show any upward trend. In fact, the price of cobalt dropped from 81,790 to 21,721 USD per metric ton from April 2022 to February 2025. A reasonably conservative assumption for future prices is that they will be no higher than the trend for a comparable period in the past. Data from IMF (2025).

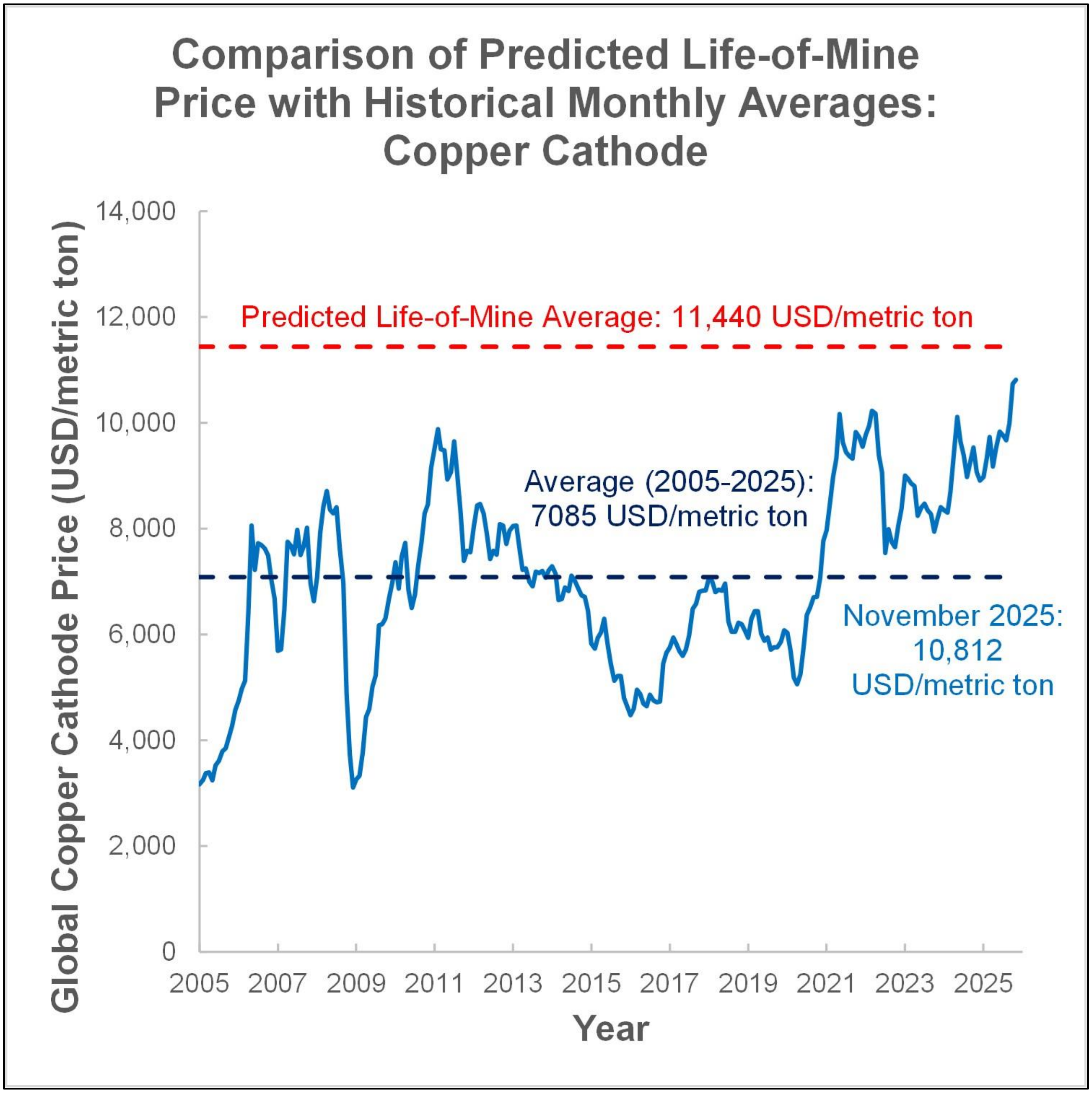


Figure 20a. The Pre-Feasibility Study assumes a life-of-mine average price for copper cathode of 11,440 USD per metric ton (see Fig. 17), which is 5.8% higher than the current price of 10,812 USD per metric ton (monthly average for November 2025) and 61.5% higher than the average monthly price of 7085 USD per metric ton for the period 2005-2025. A reasonably conservative assumption for future prices is that they will be no higher than the trend for a comparable period in the past. The period 2005-2025 does show a slight upward trend, which is analyzed in Fig. 20b. Data from IMF (2025).

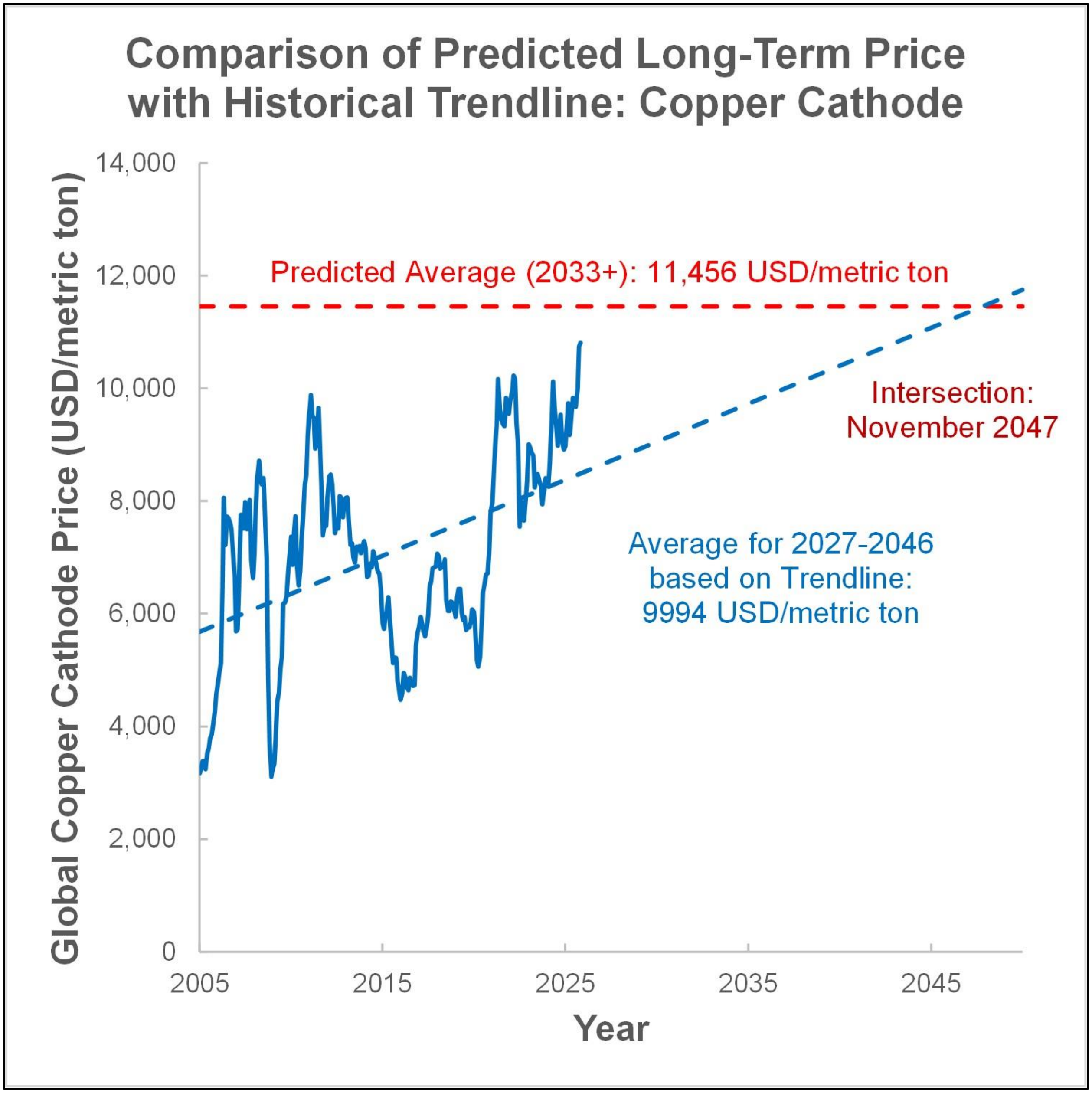


Figure 20b. The Pre-Feasibility Study assumes a long-term (2033+) price for copper cathode of 11,456 USD per metric ton (see Fig. 17). A reasonably conservative assumption for future prices is that they will be no higher than the trend for a comparable period in the past. Based on the slight upward trend for the period 2005-2025, copper cathode prices will not reach the assumption of the Pre-Feasibility Study until November 2047. Moreover, based on the historical trendline, the average copper cathode price during the life of the mine (2027-2046) will be 9994 USD per metric ton, or 14.5% lower than the assumed life-of-mine price of 11,440 USD per metric ton (see Fig. 17). Data from IMF (2025).

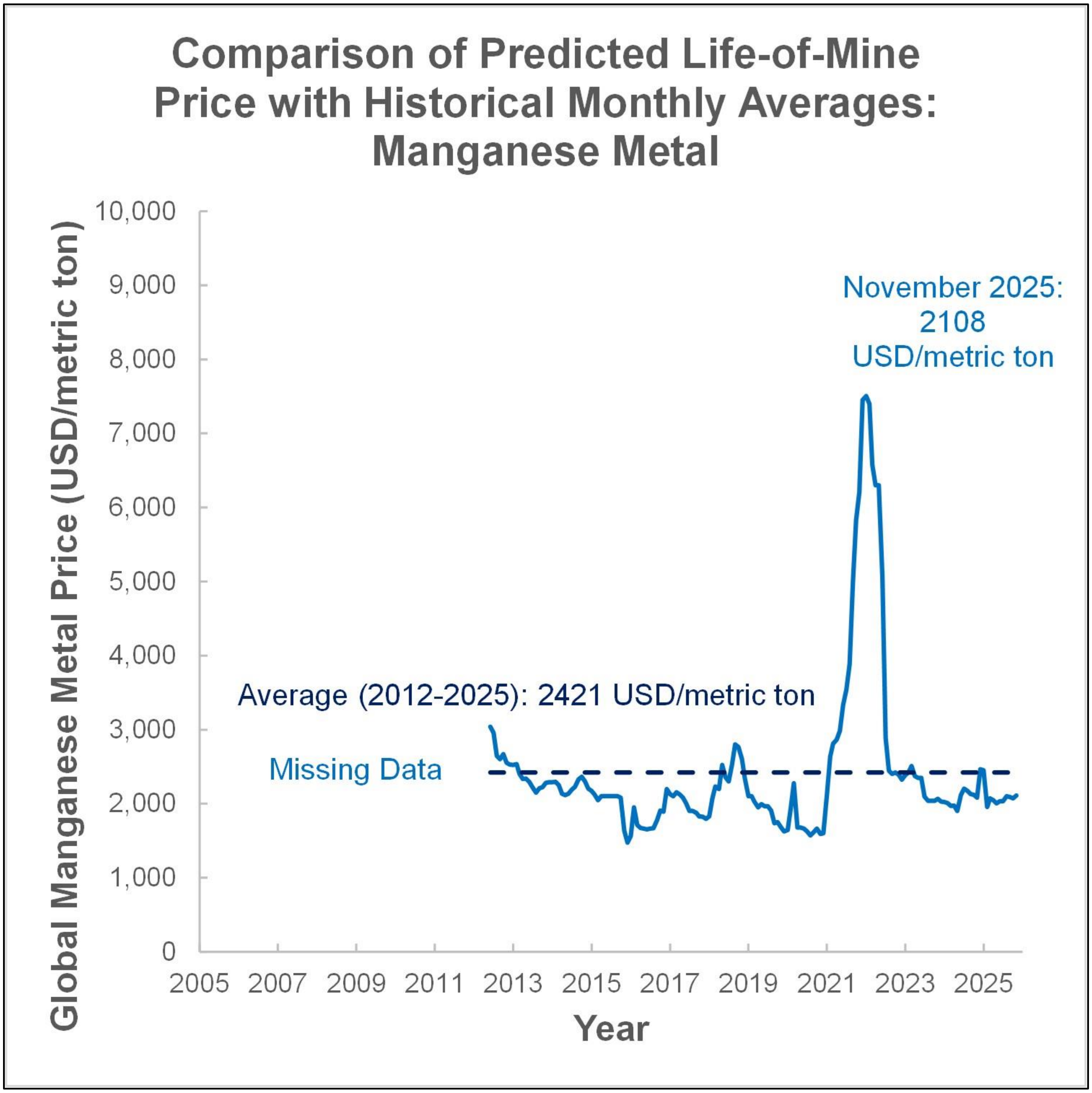


Figure 21. The Pre-Feasibility Study assumes a life-of-mine average price for manganese of 545 USD per metric ton (see Fig. 17). Since the current price for manganese metal is 2108 USD per metric ton (monthly average for November 2025) with an average monthly price of 2421 USD per metric ton for the period 2012-2025, the Pre-Feasibility Study is probably referring to a price for manganese silicate, rather than manganese metal. Any assumed future price for manganese silicate should be regarded as highly speculative, since there is currently no global commodity price for manganese silicate. Data from IMF (2025).

The Pre-Feasibility Study assumes future metal prices that are substantially higher than current prices, which are taken as the monthly average for November 2025 (IMF, 2025). The Pre-Feasibility Study assumes a life-of-mine average price for nickel metal of 20,295 USD per metric ton (see Fig. 17), which is 38.3% higher than the current price of 14,671 USD per metric ton (see Fig. 18). Moreover, the Pre-Feasibility Study assumes a life-of-mine average price for cobalt metal of 56,117 USD per metric ton (see Fig. 17), which is 16.6% higher than the current price of 48,139 USD per metric ton (see Fig. 19). Furthermore, the Pre-Feasibility Study assumes a life-of-mine average price for copper cathode of 11,440 USD per metric ton (see Fig. 17), which is 5.8% higher than the current price of 10,812 USD per metric ton (see Figs. 20a-b). Finally, the Pre-Feasibility Study assumes a life-of-mine average price for manganese of 545 USD per metric ton (see Fig. 17). Since the current price for manganese metal is 2108 USD per metric ton (see Fig. 21), the Pre-Feasibility Study is probably referring to a price for manganese silicate, rather than manganese metal. There is currently no global commodity price for manganese silicate, so that the assumed future price cannot be compared with a current price. It should also be noted that the assumed future ratios of the price of nickel contained in nickel sulfate to the price of nickel metal is substantially greater than the current ratio of 1.023 (SMM, 2025a-b; see Table 3a).

Other reviews of the Pre-Feasibility Study have also noted the discrepancies between assumed future metal prices and current prices. Each of the reviews cites different values for the discrepancies between current and assumed future prices, depending upon the month in which the review was written, which draws further attention to the current extreme volatility in metal prices (see Figs. 17, 19, 20a-b, and 21). According to Schwartz (2025) (written in October 2025), "From the report, we can see that the PFS assumes commodity prices are around 10% to 30% above current prices. That may seem reasonable given most of these minerals are 'cheap,' but TMC also estimates its production may be among the highest in the world, boosting global supply. If demand does not rise significantly, TMC's impact should exacerbate the ongoing glut … Overall, my outlook for TMC is bearish, downgraded from neutral. Yes, based on its PFS and IA [Impact Assessment] studies, it may still be trading a bit below its net present value. However, I think those studies may overestimate commodity selling prices and underestimate production and capital investment costs. If we change those assumptions, the NPV could easily be half or less of its estimate." According to Barnard and Trytten (2025) (written in August 2025), "Economic modeling within TMC's report uses product prices substantially higher than current market levels, while holding cost inputs at current-dollar valuations."

Finally, according to Iceberg Research (2025a) (written in August 2025), "With costs and nodule production deteriorating, TMC resorted to aggressive assumptions to manufacture a positive NPV. One such tactic was adopting a metals price forecast not only above current market levels (e.g. cobalt price 68% higher than current price) but also higher than the assumption used in its 2021 Initial Assessment (IA) when there were fears of nickel/cobalt shortage … If costs and nodule production have worsened significantly, how does TMC still project a NPV of $5.5bn for its PFS, compared to the NPV of $6.8b for its 2021 IA? This is where our journey to Wonderland starts … Changes in metals prices have the most important impact on NPV, in particular for nickel and manganese, as recognised by TMC. In order to offset the soaring costs, TMC came up with price assumptions not only substantially higher than current prices but also higher than those in its 2021 IA, which was published when metal prices were higher than today, except for copper. The purpose of a PFS is to test a project's viability, even under stressed conditions. What TMC has done here is the opposite. The price assumption section was prepared by Anthony O'Sullivan based on inputs from Benchmark Mineral and CRU International. Due to the inconsistent wording in the PFS, it is unclear whether TMC used Benchmark Mineral and CRU International's forecasts for the entire period, or only for the early years while using its own numbers for the later years … TMC used a cobalt and nickel price 68% and 34% higher than current price. Nickel and cobalt, expected to account for 52% of projected revenue, have seen their demand projections revised downward, largely due to the growing adoption [Iceberg Research, 2025b] of lithium iron phosphate (LFP) batteries, which require neither metal. These metals are being substituted, a structural challenge, not a cyclical one. The Democratic Republic of the Congo, world's largest cobalt producer, has implemented [Kasongo and Rolley, 2025] an export ban since February 2025. The lifting of this export ban will drive prices down. These inflated metal prices also explain the reported low cash cost of $1,065/t of nickel. Using current prices, we estimate the cash cost would rise by over 400% to $5,407/t of nickel. This represents cash cost and, by definition, does not account for CAPEX, royalties, or taxes."

Although there are published studies that predict future supply and demand for nickel, cobalt, and copper (e.g, International Energy Agency, 2025), there are many fewer predictions of future prices. Prices are far more complex than supply and demand and any simplistic assumptions that prices will rise until the supply matches the demand should be rejected out of hand. Barnard and Trytten (2025) listed many of the complicating factors. According to Barnard and Trytten (2025), "Overall, significantly rising prices for nickel products may be a fantasy of western project proponents. Indonesia — with the Chinese control of the vast majority of their nickel production capacity — has increasingly talked about being the OPEC of nickel. This hearkens back to a time when Inco controlled the majority of the global nickel market and Zaire controlled the majority of the global cobalt market. The world operated on a 'producer price' basis for these metals. The dominant player would set the price, to which all other market players would adapt. This effective monopoly model can be utilized to stabilize prices, ensuring a reasonable margin for producers and stable input costs for consumers, but can also be used to ensure that prices are not sufficient to incent significant new producers operating on a market economy footing. Cobalt scenarios are similar to nickel ones, with the key features of mineral source dominance, refining dominance, and potential gaps being on the smaller side. The IEA [International Energy Agency, 2025] scenarios suggest cobalt demand falling after 2030, unlike nickel and copper … Betting on higher prices for an easily copied approach to an extraordinarily large unowned resource seems ill-advised. Should nodule extraction be as technically and commercially viable as TMC suggests, it would be very reasonable to assume that at least China (the global leader in resource development and the only jurisdiction that has developed the sophisticated project deployment systems and state supports to enable reliable development of economic nickel-cobalt projects) would follow suit and in their characteristic fashion quickly come to dominate the market leading to price depression."

The great uncertainty in future prices, especially over decades, is illustrated in the great differences among existing future price predictions, nearly all of which are lower than the predictions in the TMC Pre-Feasibility Study. For example, future prices predicted by Impossible Metals, a competing deep-sea mining company, are 19,358 USD per metric ton for nickel (4.5% lower than the TMC Pre-Feasibility Study), 40,959 USD per metric ton for cobalt (27.0% lower than the TMC Pre-Feasibility Study), and 8483 USD per metric ton for copper (25.8% lower than the TMC Pre-Feasibility Study) (data from Barnard and Trytten, 2025). According to Trytten Consulting Services (2025), "Considering the market dynamics, appropriate long-term market prices in current dollars for the metals of interest are considered to be US$18,000/t nickel [11.3% lower than the TMC Pre-Feasibility Study], US$40,000/t cobalt [28.7% lower than the TMC Pre-Feasibility Study], US$10,000/t copper [12.6% lower than the TMC Pre-Feasibility Study]. These are considered to be reasonable, and not overly optimistic or conservative. These prices are above average recent prices (last 12 and 24 months)."

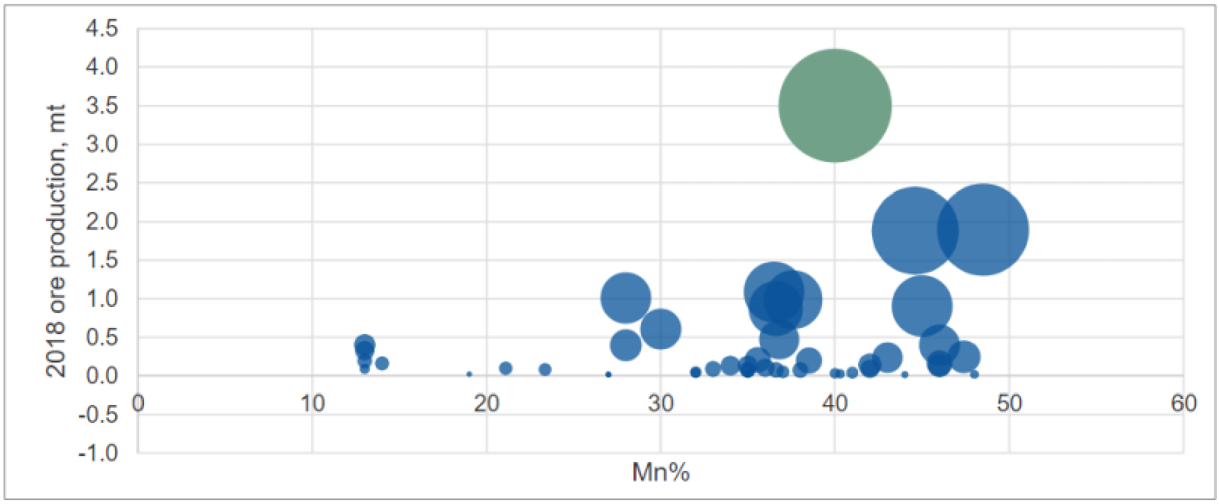
The practice of this author has been that a reasonably conservative assumption for future prices is that they will be no higher than the trend for a comparable period in the past. This principle can be applied to each of the future metal prices predicted by the TMC Pre-Feasibility Study. Thus, the assumed life-of-mine average price for nickel metal of 20,295 USD per metric ton (see Fig. 17) is 13.1% higher than the average monthly price of 17,943 USD per metric ton for the period 2005-2025 (see Fig. 18). The period 2005-2025 does not show any upward trend for nickel. In fact, the price of nickel dropped from 33,924 to 14,671 USD per metric ton from March 2022 to November 2025 (see Fig. 18). The assumed life-of-mine average price for cobalt metal of 56,117 USD per metric ton (see Fig. 17) is 41.0% higher than the average monthly price of 39,795 USD per metric ton for the period 2005-2025 (see Fig. 19). The period 2005-2025 also does not show any upward trend for cobalt. In fact, the price of cobalt dropped from 81,790 to 21,721 USD per metric ton from April 2022 to February 2025 (see Fig. 19). The assumed life-of-mine average price for copper cathode of 11,440 USD per metric ton (see Fig. 17), is 61.5% higher than the average monthly price of 7085 USD per metric ton for the period 2005-2025 (see Fig. 20a). By contrast with nickel and cobalt, the period 2005-2025 does show a slight upward trend for copper cathode (see Fig. 20b). However, based on the slight upward trend, copper cathode prices will not reach the assumed long-term (2033+) price for copper cathode of 11,456 USD per metric ton (see Fig. 17) until November 2047 (see Fig. 20b). Moreover, based on the historical trendline, the average copper cathode price during the life of the mine (2027-2046) will be 9994 USD per metric ton, or 14.5% lower than the assumed life-of-mine price of 11,440 USD per metric ton (see Fig. 20b). The period 2005-2025 certainly does not show any upward trend for the price of manganese metal (see Fig. 21), although, as discussed, it is difficult to connect historical and current prices for manganese metal with assumed future prices for manganese silicate.

It should be noted that the practice that a reasonably conservative assumption for future prices is that they will be no higher than the trend for a comparable period in the past is not even the most conservative practice in the mining industry and mining finance. In fact, the SEC has proposed that an assumed future price should not exceed the average price over the previous two years, regardless of the future time frame over which the price is being predicted. According to the document entitled "Modernization of Property Disclosures for Mining Registrants," "When estimating mineral prices for the cut-off grade estimation, we proposed to require the qualified person to use a commodity price that is no higher than the average spot price during the 24-month period prior to the end of the last fiscal year, determined as an unweighted arithmetic average of the daily closing price for each trading day within such period, unless prices are defined by contractual arrangements … When explaining our reasons for proposing the 24-month trailing average price requirement, we stated our belief that the qualified person must use commodity price estimates that are reasonable and justifiable and represent long term market trends in mineral resource and reserve estimation" (SEC, 2019).

The assumed future price of 545 USD per metric ton for (presumably) manganese silicate requires particular consideration. In this regard, the assumption that the sale of manganese silicate would constitute 28.4% of the revenue from the project should be borne in mind (see Fig. 11). According to the Pre-Feasibility Study, "The development of nodule projects will have a significant impact on the global manganese markets. Figure 14.1 [Fig. 22 in this report] presents the world's existing manganese mines, with the manganese production 60,000 ktpa [thousand metric tons per year] nickel equivalent nodule project overlaid in green. This operation will represent a 6% increase in the current supply of manganese on a 2023 basis" (AMC Consultants

Pty Ltd, 2025). However, it is entirely unclear as to how potentially flooding the market with manganese could affect the commodity price. The future price of manganese silicate should be regarded as highly uncertain, especially considering the lack of any global commodity price at the present time. The existence of any market for manganese silicate is discussed in the subsection “Existence of Smelting and Refining Facilities is Highly Speculative.”

Figure 14.1 2018 production of manganese ore (blue) compared to TMC’s equivalent project (green)



Source: CRU 2019. The bubble size indicates the total contained manganese in ore production

Figure 22. According to the Pre-Feasibility Study, the proposed deep-sea mining operation would be the world’s largest producer of manganese ore and would represent a 6% increase in the current supply of manganese. Thus, if the deep-sea mining operation actually came to fruition, there would be considerable potential for an oversupply of manganese and a drop in price. On that basis, the assumed future price of 545 USD per metric ton for manganese silicate (see Figs. 17 and 21) should be regarded as highly speculative, also taking into account the lack of any current global commodity price for manganese silicate. Figure from AMC Consultants Pty Ltd (2025).

In a similar vein, Iceberg Research (2025a) wrote, “Manganese, which accounts for 27% of projected revenue, is an abundant commodity. About 90% of manganese is used in steel, a mature and slow-growth industry, while batteries account for less than 2% of demand. The volume of manganese extracted could represent more than 13% of the world market at peak output, flooding the market, a risk that TMC itself has acknowledged [TMC, 2025b]. (TMC peak production in 2036: 2,662kt vs 2024 world mine production: 20,000kt [USGS, 2025]).” Iceberg Research (2025a) is referring to the quote: “In addition, our proposed full scale production plans would involve placing a large percentage of global manganese production in the market, and we may be constrained in our ability to sell such large volumes, or such production may negatively impact the market price of manganese, which would, in either case, negatively impact our overall economic position” (TMC, 2025b).

In summary, based upon historical trends for nickel, cobalt, and copper prices over the period 2005-2025 (see Figs. 18, 19, and 20a-b), reasonably conservative assumptions for metal prices over the period 2027-2046 are 17,943 USD per metric ton for nickel (13.1% lower than the value assumed in the Pre-Feasibility Study), 39,795 USD per metric ton for cobalt (41.0% lower than the value assumed in the Pre-Feasibility Study), and 9994 USD per metric ton for copper cathode (14.5% lower than the value assumed in the Pre-Feasibility Study). The above are nearly identical to the values of 18,000 USD per metric ton for nickel, 40,000 USD per metric ton for cobalt, and USD 10,000 per metric ton for copper cathode that were predicted by Trytten Consulting Service (2025). The future price of manganese silicate is quite difficult to predict and subsection "5: Existence of Smelting and Refining Facilities is Highly Speculative" will suggest the possibility that the manganese silicate might have no value at all. Based on the preceding estimates, the sensitivity tornado chart in the Pre-Feasibility Study (see Fig. 12) does not even begin to capture the uncertainty in the calculation of the net present value (NPV). Although the sensitivity chart is based upon individually decreasing or increasing critical parameters by 20% of the estimated values, an uncertainty of 20% does not even begin to capture the real uncertainty in the economic assumptions. In particular, the cobalt price could easily be reduced by 40%, while it might be possible to reduce the price for manganese silicate by 100%. It should be noted that the sensitivity chart does not consider any uncertainty in the discount rate or the US royalty rate (see Fig. 12), and does not consider the impact of multiple uncertainties (such as all commodity prices being overestimated).

4b: Metal Recovery Rates

The metal recovery rates for each step in the RKEF processing and hydrometallurgical refining that were assumed in the Pre-Feasibility Study (see Fig. 7) were compared with values available in the extractive metallurgical literature (see Table 4 and Fig. 23a). Metal recovery rates in the extractive metallurgical literature are available only for recovery of nickel in processing from ore to alloy and for ore to matte and only for recovery of cobalt in processing from ore to alloy (see Table 4). While the Pre-Feasibility Study assumed nickel recovery rate in processing from nodule to alloy of 96.91%, literature values range from 90 to 97% (see Table 4), so that the Pre-Feasibility Study is assuming the upper end of what is available in the literature. In a similar way, while the Pre-Feasibility Study assumed nickel recovery in processing from nodule to matte of 94.76%, literature values range from 77 to 97% (see Table 4), so that the Pre-Feasibility Study is assuming near the upper end of what is available in the literature. By contrast, the assumed cobalt recovery rate (93.06%) is vastly greater than the single value of 80% that has been reported in the literature (see Table 4). In summary, just as with future metal prices, the Pre-Feasibility Study is assuming the best-case to near-best case scenario for metal recovery rates.

Table 4. Comparison of metal recovery rates in Pre-Feasibility Study and extractive metallurgy literature

	Pre-Feasibility Study[1]	Literature
	Nickel	
Ore to alloy	96.91	90-95[2], 97[2], 90-95[3], 90-95[4]
Ore to matte	94.76	90[4], 92-97[5], 77-90[6], 90-95[7]
	Cobalt	
Ore to alloy	93.06	80[2]

[1]AMC Consultants Pty Ltd (2025) (see Fig. 7)
[2]Wei et al. (2020)
[3]Keskinkilic (2019)
[4]Marzoughi and Pickles (2024)
[5]SMM (2025e)
[6]Zhang et al. (2024)
[7]Dry and Taylor (2014-2016)

Table 7. Metal recovery rate [a] during process stage.

	Case 1-Ni	Case 2-NiO	Case 3-FeNi	Case 4-NPI
Beneficiation	Ni: 90%	-	-	-
Calcination	-	Ni: 30%; Co: 22%; Fe: 7%;	Ni: 25%; Co: 20%; Fe: 5%;	(no loss) [b]
Smelting	Ni: 94.8%; Cu: 80%; Co: 75%; Fe: 13.8%; S: 21%	Ni: 93.5%; Co:65%; Fe: 20.5%	Ni: 93%; Co: 54%; Fe: 24%	Ni: 97%; Co: 80%; Fe: 92%
Settling	Ni: 98%; Cu: 70%; Co: 70%; Fe: 17%; S: 100%	-	-	-
Converting	Ni: 97.3%; Cu: 60%; Co: 43.5%; Fe: 1.7%; S: 35%	Ni: 97.6%; Co: 80%; Fe: 0.6%; S: 76%	-	-
Refining	Ni: 99%; Co: 98%		C: 99%; S: 9%; P: 66%	-
Roasting		S: 2% (1st roasting) S: 0.5% (2nd roasting)	-	-

[a] The recovery rate is defined as the ratio between the element content in intermediate/final product and the total element content in the charged materials. The unrecovered element is lost either through slag, gas or dust. The recovery rate is determined based on the analysis of input and output materials. [b] Assuming no metal loss during sintering process for producing NPI.

Figure 23a. According to the Pre-Feasibility Study, "Nickel pig iron processing is closely related to nodule processing for TMC's product" (AMC Consultants Pty Ltd, 2025). Wei et al. (2020) found a recovery rate for cobalt during RKEF processing for the production of nickel pig iron to be 80%, which is much lower than the recovery rate of 93.06% that was assumed in the Pre-Feasibility Study (see Fig. 7 and Table 4). Table from Wei et al. (2020).

Iceberg Research (2025b) took a different approach in comparing nickel recovery rates during processing of nickel ore into nickel sulfate using RKEF followed by hydrometallurgical refining (see Figs. 5a-b) based on information from company websites (see Fig. 23b). These nickel recovery rates range from 53% to 90% with a median of 83% (see Fig. 23b). According to Iceberg Research (2025b), "Nickel recovery factor is likely overestimated. Recovery percentage in metallurgy refers to the proportion of the total valuable metal or mineral contained in the ore that is successfully extracted and recovered during processing. TMC assumes [AMC Consultants Pty Ltd, 2021] an extremely high nickel recovery rate of 95%, compared to a peer median of 83%, despite the company's claim of using conventional processing methods." Iceberg Research (2025b) does not clarify whether the nickel recovery rates shown in Fig. 23b all refer to RKEF plus hydrometallurgical refining to convert nickel ore into nickel sulfate or whether some refer to only the use of RKEF to convert nickel ore into nickel matte. The distinction probably does not matter, since the Pre-Feasibility Study estimates a nickel recovery rate of 94.76% for conversion from nodule to matte and a nickel recovery rate of 94.60% for conversion from nodule to sulfate, both of which round to 95% (see Fig. 7). In their review of the Pre-Feasibility Study, Iceberg Research (2025a) continued, "As we pointed [Iceberg Research (2025b)] out in our previous report, TMC assumed an extremely high nickel recovery rate of 95%, compared to peer median of just 83%. It remains unclear how TMC expects to achieve recovery rates far in excess of industry norms when TMC insists it will use the same technologies. Allseas CEO confirmed in a May 2025 podcast interview (21:44) [Studio Energie, 2025] that the recovery rate is likely to be lower: 'They [PAMCO] don't do it in the most efficient manner, so you have about a 75% yield.' Yet, the same erroneous assumption is still used in the PFS."

Company	Project	Recovery
Igo Ltd	Nova	81%
Igo Ltd	Forrrestania	90%
First Quantum	Ravensthorpe	85%
Sheritt	PSA Plant	85%
Magna Mining	Crean Hill	78%
Ardea Resources	Kalgoorlie	89%
Alliance Nickel	NiWest	79%
Sama Resources	Samapleu	53%
TMC	**NORI D**	**95%**
Median		**83%**

Source: Companies website

Figure 23b. Based on information from company websites, nickel recovery rates during processing of nickel ore into nickel sulfate using RKEF followed by hydrometallurgical refining (see Figs. 5a-b) range from 53% to 90% with a median of 83%. Table from Iceberg Research (2025b).

Barnard and Trytten (2025) also urged caution in accepting the metal recovery rates assumed in the Pre-Feasibility Study, especially in terms of cobalt recovery. According to Barnard and Trytten (2025), "Caution is urged in accepting specific product types and destinations at this time, as well as specific recovery rates; the paper [Boulby et al., 2024] concluded only that certain products could be generated in a lab testing environment. Based on typical compositions as shown in the 2021 NORI Technical Report [AMC Consultants Pty Ltd, 2021] Indicated Resources (1.4% Ni, 1.14% Cu, 0.14% Co), the matte produced in the referenced testwork implies cobalt recovery around ~70%. If the assays reported by Verbaan [Verbaan and Johnson, 2024] are more representative of the testing, the cobalt recovery is much worse and the nickel recovery is also poor. Poor cobalt recovery in this kind of smelting process is well-known — the RKEF process used for nickel saprolites results in a nickel-iron alloy which is not considered to have commercial cobalt levels." For comparison, the Pre-Feasibility Study assumed a cobalt recovery rate of 77.54% in the conversion from nodule to matte (see Fig. 7).

4c: US Royalty Rate

The Pre-Feasibility Study assumed that the US would impose zero royalties on the deep-sea mining project, which would be the best-case scenario by definition. A zero US royalty rate is certainly possible, but is in no way guaranteed. According to the Pre-Feasibility Study, "Under the Deep Seabed Hard Mineral Resources Act (DSHMRA), royalties and taxes payable on any future commercial recovery of polymetallic nodules by U.S. entities in areas beyond national jurisdiction are governed by domestic U.S. law rather than international frameworks such as UNCLOS, to which the U.S. is not a party. DSHMRA does not prescribe specific royalty rates, it authorizes the National Oceanic and Atmospheric Administration (NOAA) to issue exploration licenses and commercial recovery permits, with terms and conditions that may include financial obligations. These obligations are determined on a case-by-case basis during the permitting process and are designed to ensure that U.S. seabed mining activities are conducted responsibly and in alignment with national interests, specifically the sourcing of critical minerals. NOAA's regulatory framework under DSHMRA includes provisions for public comment and environmental review but does not currently mandate a fixed royalty or taxation regime akin to the ISA's proposed ad valorem models. As such, financial terms are negotiated individually and may evolve with future legislative or executive directives, such as the April 2025 Executive Order promoting U.S. leadership in seabed mineral recovery" (AMC Consultants Pty Ltd, 2025). The Pre-Feasibility Study did acknowledge that some royalties and continuity payments would be made to Nauru Continuity Benefits and Low Carbon Royalty, Inc.

The assumption of zero US royalty payments was sharply criticized by Iceberg Research (2025a). According to Iceberg Research (2025a), "TMC assumes zero US royalties payable but admits it has no idea what the actual amount might be. This section of the PFS was written by a tiny Australian consultant, Lanasera. TMC assumes it will pay just $4 of royalty per wet tonne of nodule, down sharply from the $28/wet tonne estimated in the 2021 IA. That single change adds about $4bn to projected cash flow, one of the reasons the NPV stays positive despite the higher costs we discussed above. By going through the US permitting route, TMC logically slashed the royalties it expects to pay compared with the ISA regime. Only $194mn is earmarked to Nauru. An additional $465mn is paid to Low Carbon Royalties Inc. Nothing has to be paid to the US government. However, the assumption that the US government will not impose any royalty on TMC has no basis. TMC itself acknowledges [AMC Consultants Pty Ltd, 2025] that while US deep-sea mining law 'does not prescribe royalty rates,' it authorizes the National Oceanic and Atmospheric Administration (NOAA) to issue licenses 'with terms and conditions that may include financial obligations.' In other words, the law does not state there is no royalty, it simply has not been defined. For reference, the US currently imposes [Iceberg Research, 2025b] an 18.75% royalty on offshore oil and gas production in waters deeper than 200 meters."

4d: Discount Rate

The discount rate of 8% that was assumed for the economic analysis in the Pre-Feasibility Study is an example of a scenario that would be even better than the best-case scenario. The assumed discount rate can be compared with mining industry practice, as has been described in multiple papers and presentations by Smith (1994, 2002, 2003, 2005, 2013). The primary control on the discount rate is the level of uncertainty in the magnitude and grade of the mineral reserves, which should be reflected in the stage of mine planning. Smith (2013) showed that the industry practice was to apply a discount rate of 13% (with a standard deviation of 4.5%) to a base-metal project (which would include nickel, cobalt, copper, and manganese) at the stage of the Pre-Feasibility Study (see Fig. 24). Thus, a discount rate of 8% would be less than the lower bound (or one standard deviation below the mean) of a base-metal project at the stage of the Pre-Feasibility Study, even if there were no other sources of uncertainty. In fact, a discount rate of 8% would even be less than the mean discount rate (8.5%) for a mine that was already in operation (see Fig. 24).

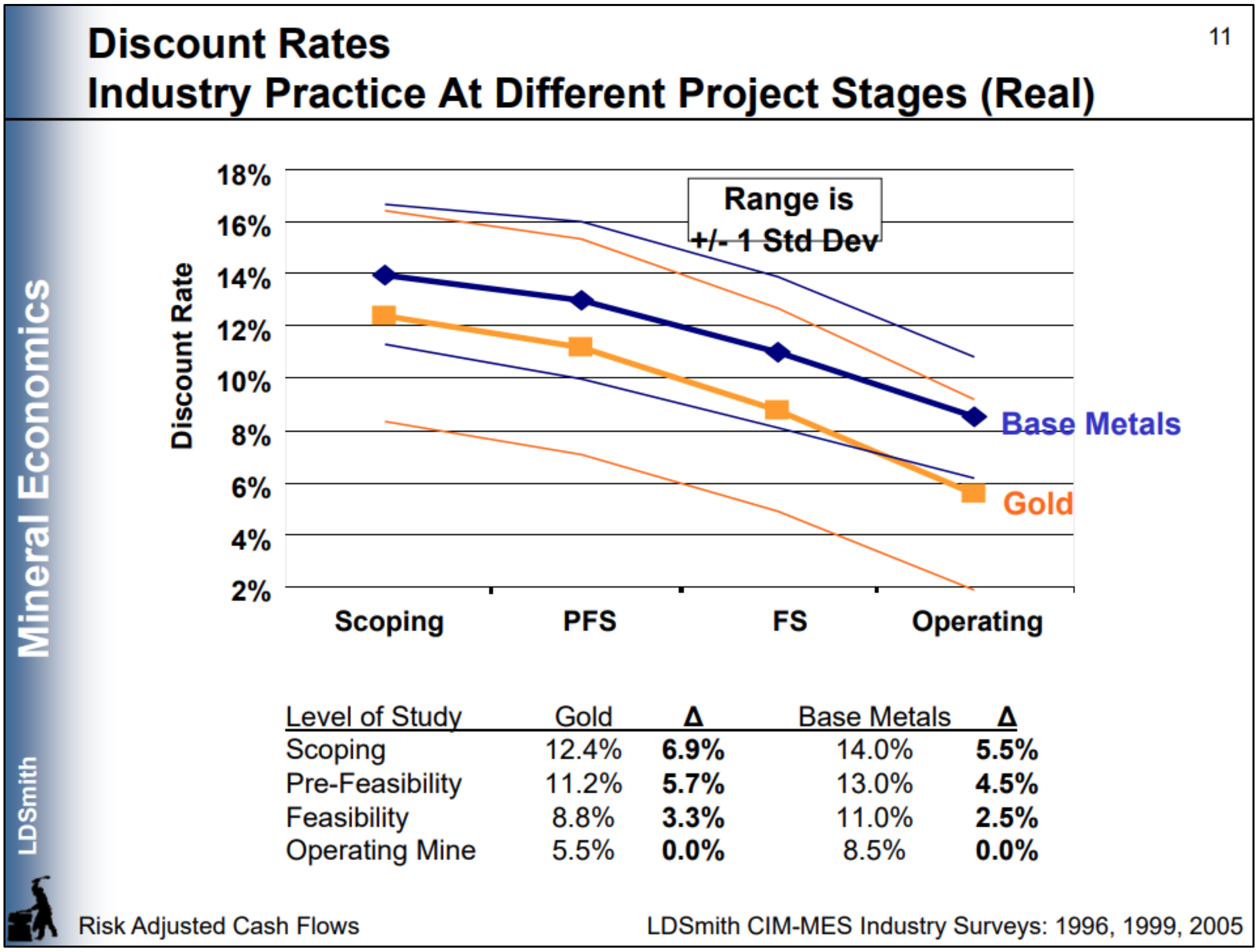


Figure 24. The Pre-Feasibility Study assumes a discount rate of only 8%, which would be appropriate for the level of risk associated with expansion of an operating base-metal mine. By contrast, based on industry surveys, a typical discount rate for a proposed base-metal mine at the level of uncertainty associated with the Pre-Feasibility Study is 13.0% with a standard deviation of 4.5%. Slide from Smith (2013).

Smith (2002) showed that, after uncertainty in the magnitude and grade of mineral reserves, the second most important source of uncertainty (second most important control on the discount rate) was found in the country or political environment of the proposed or existing mine (see Fig. 25). This "country risk" encompasses a wide variety of risks, including government stability, foreign ownership policy (risk of nationalization), taxation instability, land claims and protected areas, currency stability, labor relations, and many others (Smith, 2002). The industry practice as of 2013 was that carrying out a mining project in Indonesia added another 3% to the discount rate (see Fig. 26). Thus, at a minimum, the discount rate for the proposed deep-sea mining operation by TMC should be 16%, not even taking into account additional uncertainties related to the technology that is still under development and the legal obstacles related to carrying out deep-sea mining without a permit from the International Seabed Authority (ISA).

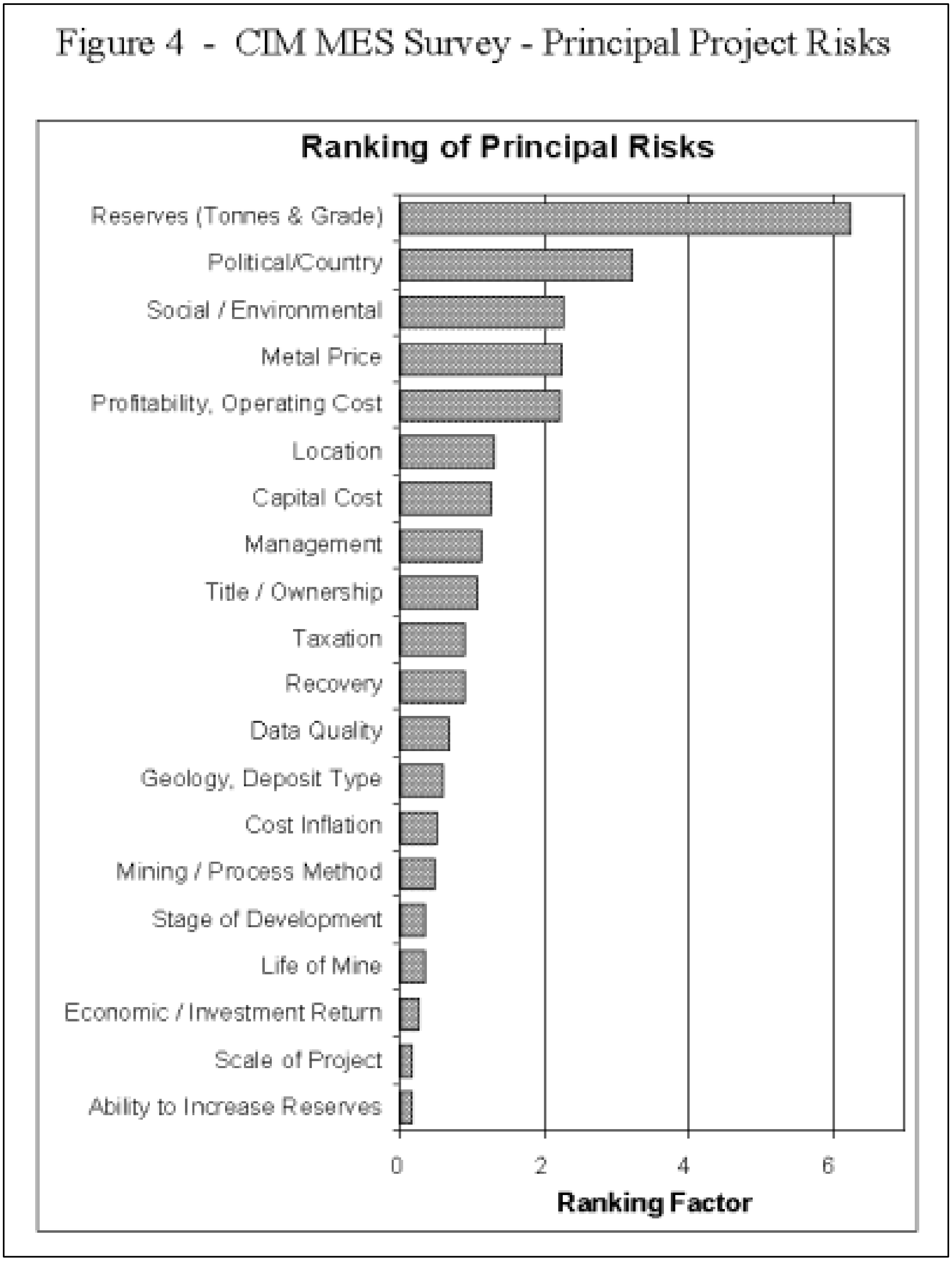


Figure 25. According to industry surveys, the principal source of risk in a mining project is uncertainty in the quantity and grade of mineral reserves with the second being political instability and the risks associated with mining in particular countries. Figure from Smith (2002).

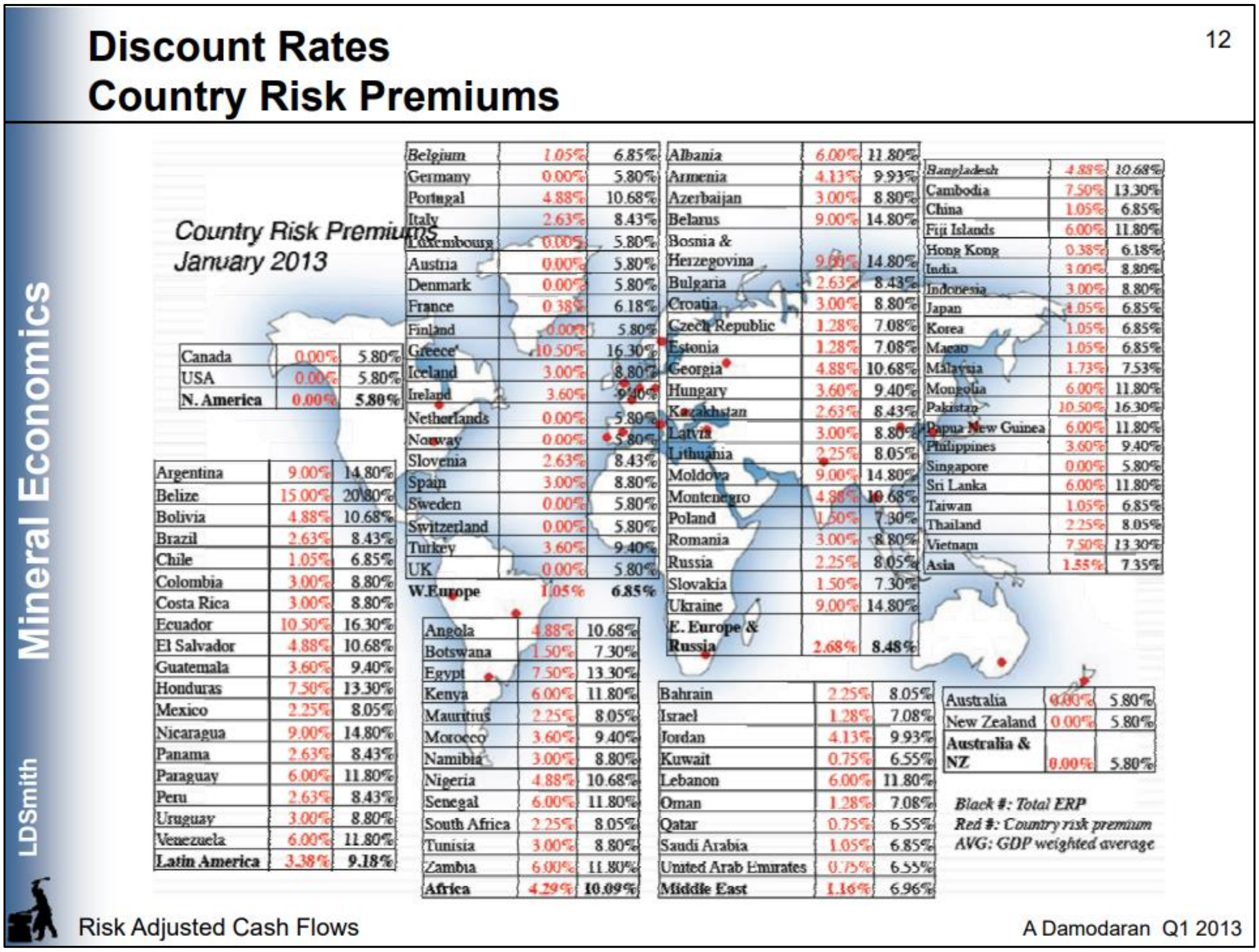


Figure 26. The additional discount rate corresponding to the risk of mining in Indonesia has been estimated as 3%. Since the nodule processing would be carried out in Indonesia and since the project is still at the stage of the Pre-Feasibility Study (corresponding to a discount rate of 13%), the total discount rate for the proposed deep-sea mining operation should be at least 16%, or much greater than the discount rate of 8% that was assumed in the Pre-Feasibility Study. Slide from Smith (2013).

Iceberg Research (2025a) proposed a discount rate of 15%, which is remarkably similar to the discount rate proposed in this report. According to Iceberg Research (2025a), “The discount rate is 8%, even lower than the 9% in the 2021 IA … This is now the same as the rates typically used for land-based open-pit mining projects, even though commercial deep-sea mining has never been undertaken. How can this company be taken seriously when mechanical operations at depths of 4,500 meters, far deeper than offshore oil, and never done commercially, are considered no riskier than open-pit mining? Not to mention the legal risks that TMC is facing. Had the QPs done their job rigorously, they would never have accepted such a discount rate. This adjustment is yet another example of TMC and its consultants stretching their Excel model to manufacture a positive NPV.”

4e: Future Costs

In contrast to future metal prices, which are assumed to be much higher than would be consistent with current prices and historical trends (see Figs. 18, 19, 20a-b, and 21), the project costs listed in the Pre-Feasibility Study are largely assumed to be the same as present or consistent with historical trends. The point was made by Barnard and Trytten (2025), who noted that, although there were some escalation costs, they were likely underestimated and were applied to a very small subset of the total costs. According to Barnard and Trytten (2025), "Economic modeling within TMC's report uses product prices substantially higher than current market levels, while holding cost inputs at current-dollar valuations. A significant portion of capital expenditures is deferred several years into the future, with notable expenses placed on European contracting partners, who may face operational and financial constraints working with TMC … Stated escalation costs appear substantially underestimated. The declared 3% escalation is only applied to a limited subset of costs, totaling approximately $55 million. Applying a realistic 3% annual escalation across all future capital expenditures would increase capital costs by over $1 billion, significantly affecting project economics."

Many of the cost categories in the Pre-Feasibility Study explicitly clarify the assumption that costs will remain at current or historical levels. As a first example, according to the Pre-Feasibility Study, "Operations facilities initial setup CAPEX [Capital Expenses] of US$2.3M is based on historical information" (AMC Consultants Pty Ltd, 2025) (see Fig. 27). The reliance on current and historic levels is then emphasized throughout the discussion of the various components of the operating expenses (OPEX) (see Fig. 28a). With regard to the transfer and shipping OPEX, the Pre-Feasibility Study states, "Key inputs and assumptions used in the cost estimate were: …

- Bulk Carrier CCZ to INDO – Capesize: – Market pricing used for all in day rate …
- Bulk Carrier INDO to Texas – Handymax: – Market pricing used for all in day rate … MGO fuel price of US$700/t, this is based on end of Q1 2025 data obtained from Ship and bunker spot pricing. – Fuel consumption was calculated by industry norms.
- Bulk Carrier INDO to PAMCO – Handymax: – Market pricing used for all in day rate" (AMC Consultants Pty Ltd, 2025)" (see Fig. 28b).

Table 18.6 Operations Facilities CAPEX

Description	US$ M
San Diego/Long Beach - Offshore Support Facility	1.2
USA - In Country Operations Facility	1.2
Operations Facilities Total	**2.3**

Figure 27. Although the Pre-Feasibility Study assumes much higher future metal prices in comparison to current and historical prices, it also assumes that costs will remain at current or historical levels. According to the Pre-Feasibility Study, "Operations facilities initial setup CAPEX of US$2.3M is based on historical information" (AMC Consultants Pty Ltd, 2025). Table from AMC Consultants Pty Ltd (2025).

With regard to consumables (offshore fuel) costs, the Pre-Feasibility Study states, "Key inputs and assumptions used in the cost estimate were:

- Fuel - Production Vessel – MGO fuel price of US$700/t, this is based on end of Q1 2025 data obtained from Ship and bunker spot pricing" (AMC Consultants Pty Ltd, 2025) (see Fig. 28c).

With regard to processing costs, the Pre-Feasibility Study states, "INDO Matte Tolling Charge – All in tolling charge estimated by SMM [Shanghai Metals Market] Information & Technology Co., Ltd processing cost study as detailed in Table 15.4. Benchmarked against known/published nickel pig iron processing cost in Indonesia. Nickel pig iron processing is closely related to nodule processing for TMC's product" (AMC Consultants Pty Ltd, 2025) (see Fig. 28d). Finally, with regard to corporate costs, the Pre-Feasibility Study states, "Key inputs and assumptions used in the cost estimate were: …

- Campaign/EMMP [Environmental Management and Monitoring Plan] cost estimated by TMC based on actual campaign and EMMP costs including: – Research vessel and crew.
  – AUV [Autonomous Underwater Vehicle] and ROV's [Remotely Operated Vehicle].
  – Environmental monitoring equipment and personnel.
  – Fuel.
- Offshore operations support facilities cost estimated by TMC based on historical knowledge and actual costs of operations support facilities including:
  – Contractor personal [personnel] – office and site.
  – TMC personal [personnel].
  – Service contracts
  – waste, security etc.
  – Office/laydown/warehouse lease costs.
  – Office/laydown/warehouse material, equipment, supplies.
- OPEX contingency" (AMC Consultants Pty Ltd, 2025) (see Fig. 28e).

Table 18.13 OPEX Summary

OPEX Component	Total LOM (US$M)	LOM (%)
Collection Costs	12,343.6	30.9%
Transfer & Shipping Costs	3,070.7	7.7%
Contractor (offshore) Costs	1,855.1	4.6%
Consumables (offshore fuel) Costs	3,848.3	9.6%
Processing Cost	13,621.8	34.1%
Refining Cost	3,253.7	8.1%
Corporate Cost	1,984.6	5.0%
Total OPEX	**39,977.8**	**100%**

Figure 28a. Although the Pre-Feasibility Study assumes much higher future metal prices in comparison to current and historical prices, it also assumes that costs will remain at current or historical levels. Specific components of operating expenses (OPEX) are considered in Figs. 28b-e. Table from AMC Consultants Pty Ltd (2025). Table from AMC Consultants Pty Ltd (2025).

Table 18.16 Transfer and Shipping OPEX

OPEX Component	Total LOM (US$M)	Average LOM (US$/wmt)
Transfer vessel CCZ	1,045.0	6.4
Bulk Carrier CCZ to INDO - Capesize	1,713.1	10.4
Bulk Carrier INDO to Texas - Handymax	161.9	1.0
Bulk Carrier INDO to Japan - Handymax	132.1	0.8
INDO inbound Handling	18.5	0.1
Transfer and Shipping Costs Total	**3,070.7**	**18.7**

Figure 28b. Although the Pre-Feasibility Study assumes much higher future metal prices in comparison to current and historical prices, it also assumes that costs will remain at current or historical levels. For example, according to the Pre-Feasibility Study, "Key inputs and assumptions used in the cost estimate were: … • Bulk Carrier CCZ to INDO – Capesize: – Market pricing used for all in day rate … • Bulk Carrier INDO to Texas – Handymax: – Market pricing used for all in day rate … MGO fuel price of US$700/t, this is based on end of Q1 2025 data obtained from Ship and bunker spot pricing. – Fuel consumption was calculated by industry norms. • Bulk Carrier INDO to PAMCO – Handymax: – Market pricing used for all in day rate" (AMC Consultants Pty Ltd, 2025). Table from AMC Consultants Pty Ltd (2025).

Table 18.18 Consumables (offshore fuel) Costs

OPEX Component	Total LOM (US$M)	Average LOM (US$/wmt)
Fuel - Production Vessel	658.2	4.0
Fuel - Collectors	1,012.7	6.2
Fuel - Transfer vessel	373.0	2.3
Fuel - Supply Vessel	263.3	1.6
Fuel - Bulk Carrier CCZ to INDO - Capesize	1,541.0	9.4
Consumables (offshore fuel) Costs Total	**3,848.3**	**23.4**

Figure 28c. Although the Pre-Feasibility Study assumes much higher future metal prices in comparison to current and historical prices, it also assumes that costs will remain at current or historical levels. For example, according to the Pre-Feasibility Study, "Key inputs and assumptions used in the cost estimate were: • Fuel - Production Vessel – MGO fuel price of US$700/t, this is based on end of Q1 2025 data obtained from Ship and bunker spot pricing" (AMC Consultants Pty Ltd, 2025). Table from AMC Consultants Pty Ltd (2025).

Table 18.19 Processing Costs

OPEX Component	Total LOM (US$M)	Average LOM (US$/wmt)
PAMCO Alloy Toll Charge	241.0	1.5
PAMCO Matte Toll Charge	764.0	4.7
INDO Matte Toll Charge	12,616.8	80.0
Processing Cost Total	**13,621.8**	**83.0**

Figure 28d. Although the Pre-Feasibility Study assumes much higher future metal prices in comparison to current and historical prices, it also assumes that costs will remain at current or historical levels. For example, according to the Pre-Feasibility Study, "INDO Matte Tolling Charge – All in tolling charge estimated by SMM Information & Technology Co., Ltd processing cost study as detailed in Table 15.4. Benchmarked against known/published nickel pig iron processing cost in Indonesia. Nickel pig iron processing is closely related to nodule processing for TMC's product" (AMC Consultants Pty Ltd, 2025). Table from AMC Consultants Pty Ltd (2025).

Table 18.21 Corporate Costs

OPEX Component	Total LOM (US$M)	Average LOM (US$/wmt)
Overhead - Corporate	475.0	2.9
Campaign/EMMP	569.6	3.5
Offshore operations support	164.3	1.0
OPEX Contingency	775.7	4.7
Corporate Cost Total	**1,984.6**	**12.1**

Figure 28e. Although the Pre-Feasibility Study assumes much higher future metal prices in comparison to current and historical prices, it also assumes that costs will remain at current or historical levels. For example, according to the Pre-Feasibility Study, "Key inputs and assumptions used in the cost estimate were: … • Campaign/EMMP cost estimated by TMC based on actual campaign and EMMP costs including: – Research vessel and crew. – AUV and ROV's. – Environmental monitoring equipment and personnel. – Fuel. • Offshore operations support facilities cost estimated by TMC based on historical knowledge and actual costs of operations support facilities including: – Contractor personal – office and site. – TMC personal. – Service contracts - waste, security etc. – Office/laydown/warehouse lease costs. – Office/laydown/warehouse material, equipment, supplies. • OPEX contingency" (AMC Consultants Pty Ltd, 2025). Table from AMC Consultants Pty Ltd (2025).

4f: Closure Costs

The closure costs listed in the Pre-Feasibility Study might be realistic, except that they do not include any costs for closure of mine waste storage facilities or for rehabilitation of the sea floor (see Fig. 29). Just as with the assumption of zero US royalty rate, the missing costs are also best-case scenarios by definition, since they assume that no government will compel TMC to either responsibly manage the mine waste (the converter slag and ammonium sulfate) that cannot be sold or to carry out any rehabilitation of the sea floor. These missing costs are quite difficult to estimate. It is impossible to estimate the cost of closure of mine waste storage facilities without any information as to the quantities of converter slag and ammonium sulfate that would be generated. With regard to rehabilitation of the sea floor, Planet Tracker (2023) considered the option of replacing deep-sea nodules with artificial clay nodules and concluded that "The cost of restoration would be so high it would be impossible for deep sea mining companies to pay for it and operate at a profit." Based on information in the Impact Assessment (AMC Consultants Pty

Ltd, 2021), Planet Tracker (2023) estimated restoration costs of 5299 million USD. Planet Tracker (2023) cautioned, “However, this does not include the cost of monitoring restoration progress, which could increase this figure significantly given the high cost of transport and remotely operated vehicles needed to access the seabed. In addition, the technology for artificial nodule deployment at scale does not yet exist and if it did, the evidence so far indicates a low chance of successful restoration.”

Table 18.12 Closure CAPEX summary

Closure Capital	US$ M
Vessel Supply	6.8
Mobilisation	1.2
Other Cost	0.4
Fuel	0.9
Onboard personnel/Equipment	0.9
Other Cost	0.2
Third Party Cost	1.1
Total Closure Capital per year	11.5
Total Closure capital 10-year post mining operations	115.0

Figure 29. The closure costs in the Pre-Feasibility Study do not include costs for closure of tailings or waste storage facilities, nor any costs for rehabilitation of the sea floor. Thus, the closure costs are a best-case scenario assuming that all of the nodules could be converted into marketable products and no one will require the company to rehabilitate the sea floor. Table from AMC Consultants Pty Ltd (2025).

4g: Re-Consideration of Net Present Value

Several reviews of the Pre-Feasibility Study have attempted to re-calculate the net present value (NPV) by relaxing some of the best-case or near-best-case scenarios for the economic assumptions. According to Schwartz (2025), “So, that $5.5B net present value target looks exciting, but a small change in assumptions could dramatically alter that. To me, more factors could lower its NPV than improve it.” Barnard and Trytten (2025) found that the NPV could range anywhere from -4.8 billion USD to 5.5 billion USD, depending upon the assumptions that were made. According to Iceberg Research (2025a), “We rebuilt TMC’s discounted cash flow (DCF) model using data from the PFS, adjusting key assumptions to better reflect the economic reality. Specifically, we updated metal prices to market levels, applied a 10% royalty rate (vs. 18.75% for offshore oil & gas), set nickel recovery at 83%, and used a 15% discount rate. Under these assumptions, the model yields a negative NPV of $1.5bn, a 127% decline from the reported NPV of $5.5bn. Even assuming zero royalties, the project’s NPV remains negative at -$571mn.”

5: Existence of Smelting and Refining Facilities is Highly Speculative

The Pre-Feasibility Study makes three assumptions about the existence of smelting and refining facilities, each of which is highly speculative:

1) The nodules would be initially processed first into nickel-cobalt-copper alloy and then into nickel-cobalt-copper matte at the PAMCO pyrometallurgical facility in Japan, up to a maximum of 1.3 million wet metric tons per year.

2) The additional nodules would be processed at an unidentified RKEF facility in Indonesia that has excess capacity.
3) The manganese silicate would be sold to one or more unidentified silicomanganese facilities as a component for steelmaking.

Each of the three assumptions will be considered, starting with the unidentified RKEF facility in Indonesia that supposedly has excess capacity.

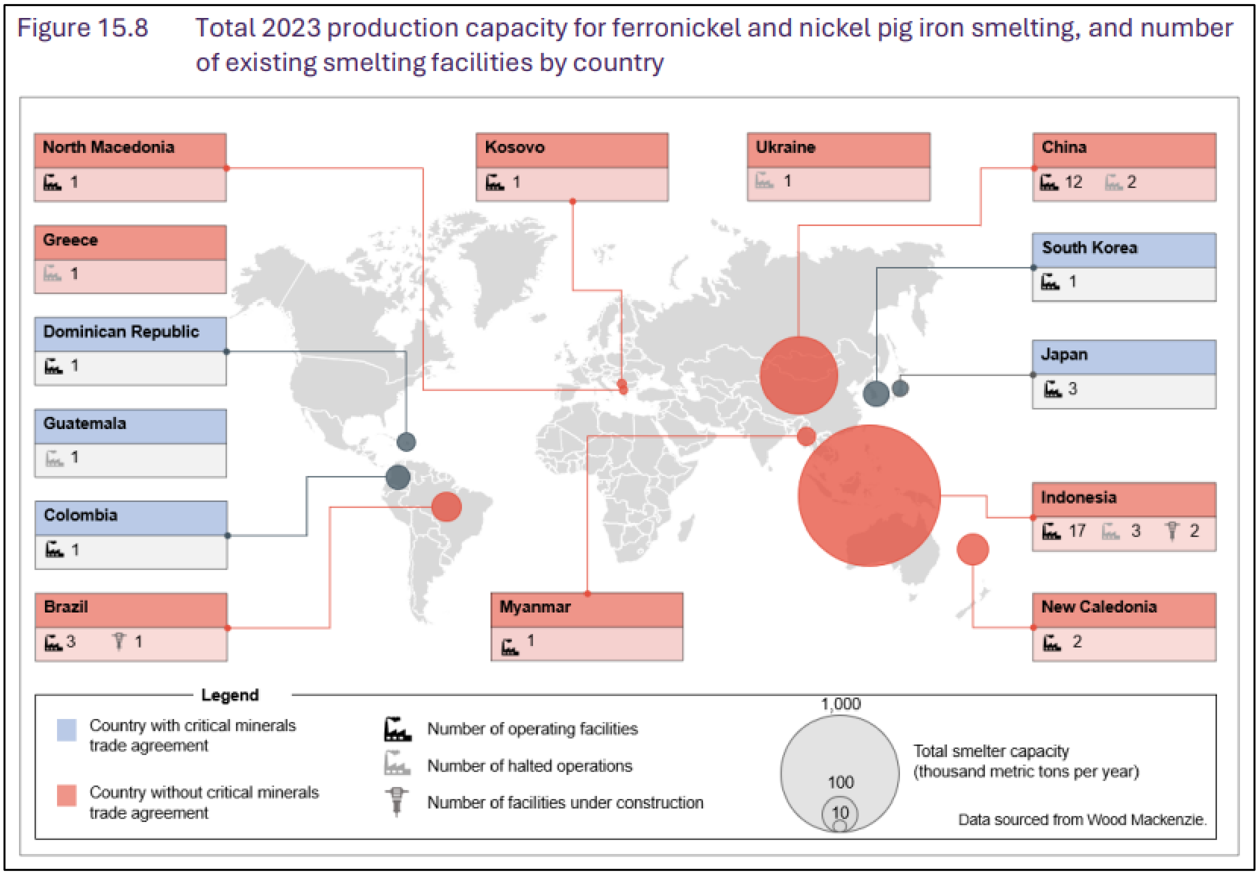


Figure 30. According to the Pre-Feasibility Study, the most likely location for excess RKEF capacity is Indonesia, which has 17 RKEF facilities. However, the assumption that Indonesia will actually have excess RKEF capacity is highly speculative. Moreover, as a signatory of the UN Convention on the Law of the Sea, Indonesia cannot accept deep-sea mining products at the present time. Figure from AMC Consultants Pty Ltd (2025).

According to the Pre-Feasibility Study, "As shown in Figure 15.8 [Fig. 30 in this report] … the biggest opportunity for expansion of onshore capacity beyond PAMCO is in Indonesia" (AMC Consultants Pty Ltd, 2025). The Pre-Feasibility Study points out that Indonesia has 17 operating RKEF facilities and two more under construction (see Fig. 30). Nearly all of these facilities are either owned or controlled by the People's Republic of China, the significance of which is discussed below. The Pre-Feasibility Study fails to be persuasive in arguing that Indonesia either has or will have excess RKEF capacity. In fact, the Pre-Feasibility Study acknowledges that "Following the 2014 ban on raw ore exports which was finalised in 2020, the nation initiated an aggressive downstream policy, prompting a surge in investments—primarily from Chinese firms—in onshore smelters and associated infrastructure" (AMC Consultants Pty Ltd, 2025). It is difficult to understand how a prohibition on the export of nickel ore (which also applies to nickel concentrates), thus requiring smelting and refining of nickel ores within

Indonesia would lead to excess pyrometallurgical capacity. In this regard, the supposed skyrocketing of nickel prices, which has also been assumed in the Pre-Feasibility Study, must be taken into consideration.

Barnard and Trytten (2025) raise the additional issue of the willingness of an Indonesian RKEF facility and its Chinese owners or controllers to modify the technology of an existing RKEF facility to receive deep-sea nodules as a feedstock. According to Barnard and Trytten (2025), "With processing facilities being the chokepoint between resource extraction and market, there is little leverage for the mineral resource owner. There are international facilities (i.e. Indonesia, Korea, Japan, Colombia, New Caledonia, FSU countries) which could be modified but have sufficient feed procurement in place, so utilization of these would require that the economics for the processing facility be competitive with current feeds — capping the purchase price for nodules … One technical difference for nodules is that Indonesian smelters do not typically handle high copper content, which could present additional processing challenges."

Barnard and Trytten (2025) continue, "Facilities used for either of these processes [both HPAL (High-Pressure Acid Leaching) and RKEF] are nominally suitable for processing nodules — although there will be significant differences in the ability to recover the various metals of interest. The facilities for these are largely owned/controlled by Chinese companies, part of the reason that Western pressures for more transparent and responsible operating practices have had little impact. These facilities are operated with ore supplied from domestic — often company-owned — mines, with the raw materials sourced at very low cost. Processing in existing facilities is not likely to be economically efficient — the facilities are not currently set up for high recovery of all primary metals (copper recovery is possible but not an important feature in HPAL with mixed hydroxide precipitation, and is only possible from RKEF via matte production), so investment would be required. In the face of available ores from local mines which are ideally suited to the processing facilities, an economic benefit would have to be considered to re-purpose existing facilities for nodule processing. Given that China also holds 5 claims in the ISA processes, the processing of non-state-licensed nodules would be considered unlikely, and with a significantly capped economic value. Using the Chinese-owned facilities in Indonesia — now responsible for 62% of the global nickel production chain and still expanding — is unlikely to meet the strategic needs of an administration seeking to onshore critical minerals supply chains."

Barnard and Trytten (2025) also critique the plan of TMC to use toll-smelting, meaning that, instead of simply selling the nodules as a feedstock, they will retain control of the output, while paying a toll to the RKEF facility. According to Barnard and Trytten (2025), "TMC's stated strategy to use Indonesian toll-smelting to matte (any excess above PAMCO 1.3M wmt/y for first 5 years, all nodules from Year 6 per Section 18.3) has several critical considerations:

- It seems improbable that Chinese-owned smelters would accept a limited (~10%) profit margin to process third-party feedstock rather than their own feed (whether own-mined or purchased), especially given that internal processing provides greater economic upside and control over end-product marketing. While TMC suggests fiscal distress at some Chinese-owned facilities might incentivize such arrangements, ownership complexities and overall operational viability remain concerns.
- Routing intermediate products through Chinese-controlled facilities poses strategic risks, particularly concerning potential implications for downstream American refining and market acceptance."

Barnard and Trytten (2025) add, "Currently, PAMCO is the only facility that has publicly indicated a willingness to toll-smelt nodules, up to approximately 1 million wet tons per annum.

PAMCO has further indicated interest is contingent upon the finalization of international seabed mining regulations." With regard to the PAMCO pyrometallurgical facility, it should be noted that there is no binding commercial agreement between TMC and PAMCO. According to the Pre-Feasibility Study, "As of the effective date of this Report, no binding commercial agreement has been entered into for the processing of NORI nodules by PAMCO, and all references to tolling or processing in Japan are forward looking and contingent on further negotiation, permitting, and technical validation" (AMC Consultants Pty Ltd, 2025).

Underlying all of the above concerns regarding toll smelting at either the PAMCO facility or an unidentified facility in Indonesia is the fact that, at the present time, it would be illegal for any Japanese or Indonesian processing facility to accept deep-sea mining products that were collected in violation of the UN Convention on the Law of the Sea (UNCLOS). According to Iceberg Research (2025a), "TMC plans to use Japanese and Indonesian smelters throughout the mine's lifespan, with only the final metallurgical stage (refining) occurring in the US, and not before 2033. These Asian companies are not legally permitted [Iceberg Research, 2025c] to be involved in deep-sea mining. For example, PAMCO executives could face imprisonment. The country strictly enforces criminal laws. Similarly, potential processors in Indonesia, another UNCLOS signatory, face the same legal constraints. As a major nickel producer, Indonesia has a vested interest in discouraging deep-sea mining. These legal restrictions extend beyond PAMCO and Allseas to their non-US staff and suppliers, including bulk carrier owners. Expecting a 100% American supply chain for deep-sea mining is unrealistic."

Iceberg Research (2025a) continued, "TMC's management appears to be in an acute state of denial on social media, yet TMC's own filings contradict their optimistic public statements." Iceberg Research (2025a) then quoted TMC (2025c) in stating, "In addition, a commercial recovery permit issued to us under DSHMRA, if any, may not be recognized by countries that are parties to UNCLOS or by the ISA and may be regarded by UNCLOS parties and the ISA as a violation of international law, including UNCLOS, which could affect international perceptions of the project, and could have implications for logistics, processing, and market access in UNCLOS parties for seabed minerals extracted under a U.S. license or permit and for downstream products containing them, or for partnerships involving foreign entities, and could also result in actions, pursuant to UNCLOS, against us under the national laws of UNCLOS parties, any or all of which could have a material adverse effect on our business, financial condition, liquidity, results of operations and prospects."

In fact, PAMCO has clearly indicated to its own investors its unease in acting in violation of UNCLOS. According to Barnard and Trytten (2025), "Related to PAMCO and toll smelting, it seems peculiar that the July 30 2025 TMC PFS does not reference the May 14, 2025 PAMCO Financial Results Briefing for Fiscal Year Ended March 31, 2025 Q&A (Summary) [PAMCO, 2025] which states 'We are carefully discussing the matter with TMC and consider the **establishment of the business via a route that has earned international credibility to be a material issue**. Aiming to achieve the timeline outlined in our current strategy, we will continue to make progress so that we can swiftly launch operations once the international rules are finalized' (emphasis by author). This would seem to be a material risk factor."

The studies to date by TMC have shown only that is possible to use manganese silicate as a feedstock for the production of silicomanganese at the laboratory scale, not that it is possible to use manganese silicate as a feedstock at the plant scale, and not that any existing silicomanganese facility would be willing to accept manganese silicate as a feedstock. According to the Pre-Feasibility Study, "Two programs were conducted for product development …The second program, on the manganese silicate product, was conducted at Norwegian laboratory SINTEF Industri, who specialize in the processing of manganese ores. The SINTEF program was also successful in generating silico-manganese alloy using TMC's manganese silicate as the sole manganese source, first at bench scale and later at the kilogram scale. Silico-manganese alloy is a key additive in steel manufacturing, and the success of this program represents the demonstrated value in use to potential customers in using silico-manganese alloy derived from TMC's manganese silicate product compared with their existing feedstocks." Barnard and Trytten (2025) noted the absence of any testing at even the pilot scale, let alone the plant scale. According to Barnard and Trytten (2025), "TMC has demonstrated production of silicomanganese using manganese silicate from lab-scale smelter tests; however, similar validation at the pilot scale, as completed for RKEF smelting by PAMCO in Japan, has not yet occurred."

The important consideration is that there is currently no silicomanganese facility anywhere in the world that is accepting manganese silicate as a feedstock, which is part of the reason as to why there is no global commodity price for manganese silicate. The fact that manganese silicate can be used as a feedstock for silicomanganese (which has been demonstrated only at the kilogram scale) in no way implies that any silicomanganese facility would be interested in modifying its technology to accept manganese silicate as a feedstock. Thus, many of the concerns that apply to the assumption that an RKEF facility in Indonesia would accept nodules as a feedstock also must apply to the multiple silicomanganese facilities that would be expected to accept manganese silicate as a feedstock. If manganese silicate cannot be sold as a feedstock for steelmaking, then it is suitable only for low-value products such as construction aggregate or sand-blasting medium or as a filler for ceramics, mortar, cement, or bricks, all of which are the current markets for manganese silicate. In summary, the expectation that manganese will contribute 28.4% of the revenue for the proposed deep-sea mining operation (see Fig. 11) requires serious reflection.

6: The Known Radioactivity of Deep-Sea Nodules has not been Considered

The Pre-Feasibility Study contains no information regarding the radioactivity of the deep-sea nodules nor any risk factors related to the collection, transport, storage, processing, and end uses of radioactive nodules. By contrast, Volz et al. (2023) expressed great concern regarding the safety of transporting and processing deep-sea nodules. According to Volz et al. (2023), "In summary, our results demonstrate that the collection, transport, storage and processing of polymetallic nodules (and of deep-sea sediments) should be considered under radiation safety aspects in future activities. The new radioisotope dataset presented in this study validates the alarmingly high activity concentrations published in historic studies and vice versa. These values exceed current national and international exemption levels by up to three orders of magnitude. This exceedance of the exemption limits has, to our knowledge, not yet been taken into consideration for the legal framework of mining operations. We show that the anticipated nodule mining procedure threatens the occupational and public health through the likely inhalation or ingestion of radioactive nodule dust and of emanating Rn-222 gas, potentially through the uptake of alpha emitters via the marine food chain and possibly their concentration during metal extraction on land. In due consideration of the activity concentrations above current exemption levels for several alpha emitters in polymetallic nodules and with associated measures to avoid/reduce health risks, costs for deep-sea mining are expected to rise, questioning its viability."

Lüttke et al. (2025) expressed much less concern regarding the impact of the radioactivity of deep-sea nodules on worker and public health. However, the disagreement with Volz et al. (2023) was based on the standards against which the radioactivity of deep-sea nodules was being assessed, not on the radioactivity levels themselves. According to Lüttke et al. (2025), "Following earlier publications by others on the same topic, Volz et al. measured the specific activity of several naturally occurring nuclides in nodules from the Pacific Ocean. They then assessed them against exemption levels according to Annex 4 of the German Radiation Protection Ordinance and other international guidelines. Volz et al. conclude that the specific activities of these nuclides exceed the exemption levels by up to a factor of 1000, thus potentially imposing serious health risks for the public, workers and environment. This has triggered public concerns about the safety and feasibility of economic exploitation of nodules in general. However, according to German legislation, the exemption levels of Annex 4 were derived for practices with radioactive materials that are used because of their radioactivity, such as nuclear fuels or substances for medical applications. These exemption levels refer to an effective dose threshold of 10 microsieverts per year (10 μSv/a). However, polymetallic nodules are natural materials and are thus treated as naturally occurring radioactive materials (NORM), for which the mentioned exemption levels do not apply. Since the threshold value for activities involving NORM is 1 millisievert per year (1 mSv/a), the exemption levels of Annex 4 should not be applied to polymetallic nodules. The same concept also applies for the European Union Basic Safety Standards directive (EU BSS13). Summarizing, artificial nuclides are evaluated with respect to the 10 μSv/a-criterium, while for NORM the 1 mSv/a has to be accounted for. Thus, the approach of Volz et al. and the conclusions drawn from it, are misguided, both from the conceptual regulatory and the practical perspective."

However, Lüttke et al. (2025) still concluded that proper radiation protection would be necessary for worker safety both during transport and processing. According to Lüttke et al. (2025), "Based on our underlying assumptions, we show that workers in a processing plant may receive an effective annual dose from gamma radiation and the inhalation of dust of 0.6 mSv per year, and potentially an additional dose from exposure to radon gas of 1.87 mSv/a. This result shows that the industrial-scale handling of polymetallic nodules must take due regard of radiation protection measures as a standard requirement."

In particular, Lüttke et al. (2025) recommended the following:

"In accordance with the principle of optimization, the following measures should be considered during plant design to minimize the effective dose:

- Shielding of areas where large quantities of materials with high specific activity are stored, e.g., using steel or concrete walls and/or keeping workplaces at a distance from materials with high specific activity,
- Dust suppression by wetting, ventilation and encapsulation of dust-prone processes,
- Limitation of working hours in areas with elevated gamma dose rates, radon activity concentration and/or dust concentration,
- Use of industry-standard personal protective equipment (FFP masks) in areas with high dust exposures ... "

Lüttke et al. (2025) continued, "To minimize the radon activity concentration at workplaces in line with the principle of optimization for radiation protection, the following measures for plant design and the organization of work are additionally recommended:

- Enclosure of nodule storage areas, crushers, mills, etc. and discharge of ventilation air outdoors,
- Moistening of materials or storage under a closed water cover,
- Positive pressure ventilation of workplaces near to crushers, mills, dryers, etc.,
- Closed, ventilated workplaces (e.g. cabins) for workers within the processing plant,
- Continuous radon monitoring with warning systems (e.g. alarm in case of plant ventilation failure or in radon-prone plant areas),
- Special organizational and technical measures for maintenance work (ventilation of enclosed areas of the plant for a sufficiently long period before entering)."

The lack of any consideration of radioactivity, in fact, ties together many of the concerns expressed in this report. A partial list of the risk factors resulting from the radioactivity of the deep-sea nodules, none of which are discussed in the Pre-Feasibility Study is as follows:

1) There could be increased costs and delays in the completion of the production and transport vessels due to the need to provide radiation protection.
2) Either the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia could be unwilling to accept radioactive deep-sea nodules as a feedstock.
3) There could be a decrease in the payable terms offered to TMC by the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia due to the costs of installing equipment for radiation protection.
4) Either the Japanese or Indonesian governments could refuse to allow importation of deep-sea nodules due to their radioactivity.
5) The nickel-cobalt-copper matte that would be produced by the pyrometallurgical facilities might be excessively radioactive, in which case, the unidentified refineries might be unwilling to accept the nickel-cobalt-copper matte as a feedstock.
6) If the nickel-cobalt-copper matte is excessively radioactive, the governments of the refineries, including the US government, might refuse to allow the importation of the nickel-cobalt-copper matte.
7) The final products (manganese silicate, nickel sulfate, cobalt sulfate, copper cathode) might be excessively radioactive for the intended markets (steel, batteries).
8) The by-products (converter slag, ammonium sulfate) might be excessively radioactive for the intended markets (construction aggregate, fertilizer)
9) The sediment-laden return water could be eco-toxic due to the inclusion of small radioactive nodules and nodule fragments.

DISCUSSION: NOW IS THE TIME TO ABANDON THE PROJECT

It is tempting to the author to recommend that the Pre-Feasibility Study be completely re-written by independent parties with special attention to the following:

1) The Pre-Feasibility Study should be checked for numeric consistency and should be free from arithmetic errors.
2) The sediment-laden return water should be regarded as mine waste and a detailed plan should be developed for management of the waste. The management plan should take into account the potential eco-toxicity of the return water due to the inclusion of small radioactive nodules and nodule fragments.
3) The quantity and chemical composition of the converter slag and ammonium sulfate should be determined. Based on the above, potential markets should be assessed for the

converter slag and ammonium sulfate. The quantities of converter slag and ammonium sulfate that are too toxic for potential markets or are otherwise unmarketable should be regarded as mine waste and a detailed mine waste management plan should be developed. The toxicity of the converter slag and ammonium sulfate should include potential radioactivity.

4) The economic analysis should be based upon mineral reserves alone.
5) Inferred resources should not be converted into mineral reserves.
6) Prices for nickel metal, cobalt metal, copper cathode, nickel sulfate, cobalt sulfate, and manganese silicate should be based upon trends over the period 2005-2025.
7) The economic analysis should include the possibility that no silico-manganese facility will accept manganese silicate as a feedstock.
8) A reasonable non-zero US royalty rate should be assumed.
9) The assumed discount rate should be at least 16%.
10) Assumed metal recovery rates should be consistent with values in the extractive metallurgical literature.
11) Closure costs should take into account the cost of rehabilitation of the sea floor and proper closure of mine waste management facilities.
12) The intended countries for ore processing should include only those countries that can legally accept deep-sea mining products, that is, only countries that are not signatories to the UN Convention on the Law of the Sea.
13) The cost and completion schedule of the production and transport vessels should take into account the need for radiation protection.
14) The unwillingness of the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia to accept deep-sea nodules as a feedstock due to their radioactivity should be included as a risk factor.
15) The estimation of the payable terms offered to TMC by the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia should take into account the need to develop adequate radiation protection.
16) The unwillingness of the Japanese or Indonesian governments to allow importation of deep-sea nodules due to their radioactivity should be included as a risk factor.
17) The unwillingness of the unidentified refineries to accept the nickel-cobalt-copper matte as a feedstock due to its potential radioactivity should be included as a risk factor.
18) The unwillingness of the governments of the unidentified refineries or of the US government to allow the importation of the nickel-cobalt-copper matte as a feedstock due to its potential radioactivity should be included as a risk factor.
19) The unsuitability of the final products (manganese silicate, nickel sulfate, cobalt sulfate, copper cathode) for the intended markets (steel, batteries) due to their potential radioactivity should be included as a risk factor.

However, the author does not make the above recommendation because, based upon the Pre-Feasibility Study, the proposal for mining and processing deep-sea nodules appears to be completely hopeless. In particular, even given the assumptions of elevated future prices, a zero US royalty rate, and a reduced discount rate, based upon the mineral reserves alone, which according to SEC regulations are the only economically mineable part of mineral resources, the proposed project will terminate after eight years with zero profit. In summary, now is the time to abandon the project and avoid further losses.

SUMMARY CONCLUSIONS

The six questions posed in the "Questions" section are repeated below, followed by very brief responses. More complete responses can be found in the "Responses" section.

1) ***Does the Pre-Feasibility Study include a detailed plan for mine waste management as required by SEC regulations?***

No, the Pre-Feasibility Study includes zero plan for mine waste management because it does not regard the sediment-laden return water as mine waste, it claims that the converter slag produced by the pyrometallurgical complex will be sold for construction aggregate or an unidentified industrial application, and it claims that the ammonium sulfate produced by the hydrometallurgical refinery will be sold for fertilizer. Although any industrial mining operation would produce zero waste if all of the outputs were marketable products, such an operation has never existed. The Pre-Feasibility Study includes no information on the quantity or potential toxicity of the converter slag or ammonium sulfate. The incomplete recovery of nickel, cobalt, and copper into nickel sulfate, cobalt sulfate, and copper cathode could render the remaining ammonium sulfate too toxic to be sold as fertilizer. Even without any concentration of the rejected elements into the ammonium sulfate, the levels of arsenic, cadmium, chromium, lead, molybdenum, and thallium in the nodules would render the ammonium sulfate too toxic to be sold as fertilizer.

2) ***Is the economic analysis in the Pre-Feasibility Study based on mineral reserves as required by SEC regulations?***

No, as opposed to SEC regulations that regard only mineral reserves as economically mineable, the economic analysis is based on 51 million wet metric tons of reserves and an additional 113.1 million wet metric tons of resources. In fact, the Pre-Feasibility Study predicts that, based upon reserves alone, the project will terminate in eight years with zero profit. The Pre-Feasibility Study also converted a portion of the inferred resources into mineral reserves, which is inconsistent with SEC regulations.

3) ***Was the Pre-Feasibility Study prepared by independent parties?***

No, the Pre-Feasibility Study was largely prepared by company employees. Although SEC regulations do not prohibit preparation by company employees, the practice is unusual and would be inconsistent with Canadian regulations.

4) ***Are the economic assumptions in the Pre-Feasibility Study reasonably conservative?***

No, the economic assumptions are a collection of best-case and near-best-case scenarios. The assumed life-of-mine average price for nickel metal of 20,295 USD per metric ton is 38.3% higher than the current price of 14,671 USD per metric ton (monthly average for November 2025) and 13.1% higher than the average monthly price of 17,943 USD per metric ton for the period 2005-2025. The assumed life-of-mine average price for cobalt metal of 56,117 USD per metric ton is 16.6% higher than the current price of 48,139 USD per metric ton and 41.0% higher than the average monthly price of 39,795 USD per metric ton for the period 2005-2025. The assumed life-of-mine average price for copper cathode of 11,440 USD per metric ton is 5.8% higher than the current price of 10,812 USD per metric ton and 61.5% higher than the average monthly price of 7085 USD per metric ton for the period 2005-2025. Although the period 2005-2025 has seen a slight upward trend in copper cathode price, that trend would not intersect the assumed price until the end of 2047. The assumed nickel recovery rates (96.91% for ore to alloy and 94.76% for ore to matte are at the upper end of what is reported in the literature (90-97% for ore to alloy and 77-97% for ore to matte), while the assumed cobalt recovery rate of 93.06% from ore to alloy is much higher than the literature value of 80%. The US royalty rate is assumed to be zero. The discount rate is assumed to be only 8%, while the discount rate for a project at the stage of a Pre-Feasibility Study with ore processing to be carried out in Indonesia should be at least 16%. In contrast to assumed future prices, future costs are assumed to be the same as at present. The closure costs in the Pre-Feasibility Study do not include any costs for rehabilitation of the seafloor or closure of mine waste management facilities.

5) ***Is the smelting and refining capacity assumed in the Pre-Feasibility Study reasonably likely to exist?***

No, the use of manganese silicate as a feedstock for silico-manganese (a component of steel) is highly speculative because there are currently no silico-manganese facilities that are accepting manganese silicate as a feedstock. If manganese silicate cannot be sold for steelmaking, its only markets are low-value products such as road aggregate or sand-blasting medium or as filler for ceramics, cement, or bricks. Moreover, the use of the PAMCO facility in Japan assumes that the Japanese government will overlook the importation of deep-sea mining products in violation of the UN Convention on the Law of the Sea. The assumption that there will be excess smelting capacity in Indonesia is also highly speculative and also assumes that the Indonesian government will overlook the importation of deep-sea mining products.

6) ***Has the known radioactivity of deep-sea nodules been adequately taken into account?***

No, the known radioactivity of deep-sea nodules has not been taken into account at all. A partial list of the unconsidered risk factors associated with radioactivity include the following:

a) increased costs and delays in the completion of the production and transport vessels
b) unwillingness of the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia to accept deep-sea nodules as a feedstock
c) decrease in the payable terms offered to TMC by the PAMCO facility in Japan or the unidentified RKEF facility in Indonesia
d) unwillingness of the Japanese or Indonesian governments to allow importation of deep-sea nodules
e) unwillingness of the unidentified refineries to accept the nickel-cobalt-copper matte as a feedstock
f) unwillingness of the governments of the unidentified refineries or of the US government to allow the importation of the nickel-cobalt-copper matte as a feedstock
g) unsuitability of the final products (manganese silicate, nickel sulfate, cobalt sulfate, copper cathode) for the intended markets (steel, batteries)

h) unsuitability of the by-products (converter slag, ammonium sulfate) for the intended markets (construction aggregate, fertilizer)
i) eco-toxicity of the sediment-laden return water largely due to dissolved metals and radioactive isotopes

RECOMMENDATIONS

The recommendation of this report is that The Metals Company should abandon the proposal to mine and process deep-sea nodules and should close the project in a financially responsible manner.

ABOUT THE AUTHOR

Dr. Steven H. Emerman has a B.S. in Mathematics from The Ohio State University, M.A. in Geophysics from Princeton University, and Ph.D. in Geophysics from Cornell University. Dr. Emerman has 31 years of experience teaching hydrology and geophysics, including teaching as a Fulbright Professor in Ecuador and Nepal, and has over 70 peer-reviewed publications in these areas. Since 2018 Dr. Emerman has been the owner of Malach Consulting, which specializes in evaluating the environmental impacts of mining for mining companies, as well as governmental and nongovernmental organizations. Dr. Emerman has evaluated proposed and existing mining projects in North America, South America, Europe, Africa, Asia and Oceania, and has testified on issues of mining and mine waste before the U.S. House of Representatives Subcommittee on Indigenous Peoples of the United States, the European Parliament, the United Nations Permanent Forum on Indigenous Issues, the United Nations Environment Assembly, the Permanent Commission on Human Rights of the Chamber of Deputies of the Dominican Republic, and the Minnesota Senate Environment, Climate and Legacy Committee. Dr. Emerman is the former Chair of the Body of Knowledge Subcommittee of the U.S. Society on Dams and one of the authors of Safety First: Guidelines for Responsible Mine Tailings Management.

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