



March 10, 2022

To: Joel Reynolds and Taryn Kiekow Heimer, Natural Resources Defense Council

From: Richard Borden, Midgard Environmental Services LLC

Subject: Review of the Pebble Mine Project Economic Contribution Assessment

A report titled “Economic Contribution Assessment of the Proposed Pebble Project to the US National and State Economies” was completed by IHS Markit in February 2022 for Northern Dynasty Minerals Limited (NDM). The following technical memorandum, prepared at the request of the Natural Resources Defense Council, summarizes my conclusions from a review of the Economic Contribution Assessment. My review focused on the mine plans assumed as the basis for the assessment. The document’s conclusions on downstream economic benefits were not a primary focus of this review because the very brief report (33 pages) provides almost no supporting documentation to justify its conclusions, and, for that reason, the underlying analysis is not subject to meaningful review. However, several important conclusions can be drawn from the report:

- The report states that the capital costs required to construct a full-scale, long-life mine at the Pebble deposit would be ten billion dollars. This is the first time a document written or commissioned by NDM has publicly and explicitly stated that the capital cost for full-scale, long-life development of the ore body would be so large.
- Construction for the mine expansion is proposed to begin as early as three years after operation of the starter mine commences.
- The much larger mine plans required to pay for the large initial capital investment would increase chemically reactive tailings and waste rock production by more than ten-times compared to the almost certainly uneconomic starter mine analyzed in the Environmental Impact Statement (EIS) and the subsequent Pebble Project Preliminary Economic Assessment (PEA).

- Even if the expanded mining operation was only run for 20 years, the mass of chemically reactive tailing and waste rock production would more than double according to the assumptions made in the Economic Contribution Assessment.
- The assessment fails to acknowledge the threat posed to the Bristol Bay wild salmon fishery's 14,000 jobs and long-term economic benefits by any mine development in the heart of the watershed.
- The assessment fails to acknowledge opportunity costs associated with development of the Pebble ore body. Ten billion dollars could be invested in other less financially and environmentally risky mine development projects in the United States that could provide the copper needed by the nation's economy.

Professional Background

I am an environmental scientist and manager with over thirty-five years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I was involved in the strategic environmental design of several new mines. I also performed environmental, permitting and closure work at over fifty mines, projects and operations. This included over seven years as Head of Environment for Rio Tinto's Copper, Copper & Diamonds and Copper & Coal Product Groups. I have been involved in many economic evaluations of ore bodies and mines as part of due diligence activities. I am currently an independent consultant with Midgard Environmental Services LLC and have provided mining and environmental expertise to more than fifteen industry and NGO clients to date. I have published numerous papers on mine environmental performance and management in peer reviewed scientific journals, conference proceedings and books. I am intimately aware of the environmental challenges and issues posed by the responsible permitting, development, operation and closure of large copper mines.

Capital Costs

Both the PEA and the Economic Contribution Assessment assume the 20-year starter mine that processes 1.3 billion tons of ore analyzed in the EIS process will cost \$6.05 billion to construct. The starter mine would only process about ten percent of the ore body and by necessity would need to target relatively low-grade ore. As has been discussed in other technical memoranda produced by Midgard Environmental Services (March 28, 2019 and November 16, 2021), the starter mine is almost certainly not economic. A much larger mine would ultimately need to be built just to recover the very significant initial capital investment required for ore body development.

Both the PEA and the Economic Contribution Assessment present mine expansion scenarios that would process over 70% of the ore body at higher throughputs during roughly 90 years of

operation. The Economic Contribution Assessment states that a mine expansion from 180,000 tons per day (tpd) ore processing capacity to 270,000 tpd capacity would require an additional capital expenditure of \$3.9 billion (page 9). **The total capital cost for the envisioned full-scale, long-life mining operation at Pebble is thus ten billion dollars. This is the first time a document written or commissioned by NDM has publicly and explicitly stated that the capital cost for full-scale, long-life development of the ore body would be so large.** In the PEA, the capital costs for a full-scale mine were hidden within life of mine sustaining capital costs. I am unaware of any public statement by NDM that has provided the true capital costs for a full-scale, long-life operation.

Construction for the ore throughput expansion would be planned to start in as little as three to seven years after the starter mine begins (page 9). This would likely require the mine operator to begin permitting a larger mine plan while the starter mine is still in construction or shortly after it begins operation. Given the relatively rapid time line proposed for the expansion, it is unclear why NDM has not sought to permit the more profitable full-scale mine right from the start.

Environmental Implications of The Assumed Mine Expansions

The EIS and PEA 20-year starter mine plan was designed so almost no waste rock would be produced. However, as the scale of the mining operation grows, the stripping ratio required to access additional ore increases rapidly. As shown in the table below, even a small expansion of the current 20 year and 180,000 tpd mine results in almost doubling the amount of chemically reactive mineral waste that would need to be managed.

| | Assumed Years of Operation | Tailings Produced (Billions of Tons) ³ | Waste Rock Produced (Billions of Tons) ⁴ | Increase in Mineral Waste Permanently Stored on Site versus Base Case |
|-------------------------------|----------------------------|---|---|---|
| Proposed Project ¹ | 20 | 1.3 | 0.2 | 1.0 times more |
| Expansion Year 10 | 20 | 1.6 | >1.2 | >1.9 times more |
| Expansion Year 5 | 20 | 1.8 | >1.3 | >2.1 times more |
| Full Expansion Scenario | 90 ² | 8.6 | 14.4 | 15 times more |

¹The proposed project used as the base case in the IHS Markit report is consistent with the project assessed in the EIS process (Pebble Project Description, June 2020) and the Preliminary Economic Assessment (September, 2021)

²The assumption made by IHS Markit is that open pit mining would operate for 70 years followed by 20 years of low-grade ore/high grade waste rock processing.

³Based on the assumptions made by IHS Markit for annual ore processing.

⁴Extrapolated from ore production and stripping ratios assumed by: 1) EIS Pebble Project Description, June 2020; 2) Pebble Project Preliminary Economic Assessment, September 2021; and 3) Preliminary Assessment of the Pebble Project, February 2011. Based on IHS Markit assumptions, roughly two billion tons of low grade ore/waste rock is processed and becomes tailings in the last 20 years of operation.

A doubling of the tailings and waste rock production would by necessity significantly increase the impacts and risks associated with direct land disturbance, contaminated water management, geotechnical stability and closure. For the full scale 90-year mining scenario highlighted in the Economic Contribution Assessment, the mass of waste rock and tailings requiring management in perpetuity increases by a factor of 15 times compared to the 20-year starter mine.

Downstream Economic Benefits

Several omissions were noted in the analysis of downstream economic benefits:

- The Economic Contribution Assessment predicts that a net of almost 5700 jobs would be created during the 20-year operational period of the starter mine that NDM is attempting to permit. However, it fails to acknowledge the threat posed to the 14,000 jobs and the long-term economic benefits associated with the Bristol Bay salmon fishery by any mine development in the heart of the watershed.
- The assessment fails to acknowledge lost opportunity costs associated with development of the Pebble ore body. The ten billion dollars of capital required to develop a full-scale, long-life mine would likely reduce the capital available for other more attractive mine development projects (1) that offer a higher likelihood of permitting and a higher rate of return on investment and (2) that pose much lower environmental, social and financial risks. There are many such projects within the development pipeline elsewhere in the United States and the world.
- Although the report highlights the importance of copper to the world's transition to renewable energy, it does not put the proposed Pebble mine into context relative to global supply and demand. If a permit could be obtained, the starter mine would only produce about six percent of US copper demand for a 20-year period (page 16). To have a more significant positive impact on global supply, the much larger mine would need to be analyzed, reviewed, permitted, and built despite an order of magnitude increase in local environmental impacts and risks.