Written Testimony Provided by Richard K. Borden, Owner Midgard Environmental Services
Subcommittee on Water Resources and Environment
Transportation and Infrastructure Committee
United States House of Representatives
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The Pebble Mine Project: Process and Potential Impacts

I would like to thank Chairwoman Napolitano, Ranking Member Westerman, and Members of the Subcommittee for the opportunity to present this written testimony on the "Pebble Mine Project: Process and Potential Impacts."

During my 30-year career I have performed permitting, design and environmental work at more than fifty mines and mining projects across the world. The Pebble Project is located in the most sensitive, globally significant and challenging environmental setting of any mining project I have ever reviewed. It will be extremely difficult to construct, operate and close a commercially viable mine in this setting in a way that does not do permanent material harm to the salmon fishery. Even the smaller 20-year mine proposed for permitting by the Pebble Partnership would create very large environmental impacts and risks in the heart of the Bristol Bay salmon fishery.

Despite these challenges, the Environmental Impact Statement (EIS) is scheduled for completion in less than half the time of a typical mine EIS. This overly rushed process has contributed to the deeply-flawed draft EIS that was released six months ago. I have provided almost 50 pages of detailed technical comments on the draft EIS to the Army Corps of Engineers in six separate letters. Much of the EIS analysis contains insufficient detail to determine if the planned actions are adequate or practicable; the document commonly understates potential impacts; essential analyses and designs are deferred to the post-EIS permitting period; and in a number of significant instances, the conclusions are clearly wrong. The draft EIS clearly does not meet industry standard practice.

The proposed EIS project only mines about ten percent of the total Pebble resource and by necessity must process relatively low-grade ore. It would produce only half as much metal for sale as the smallest mine plan that has undergone a rigorous, publicly available financial evaluation by an independent engineering consulting firm. The proposed EIS project by itself is also not the world class resource which is being advertised. Without a significant expansion it is not even in the top 25 ore bodies in the world for contained copper or gold.

Based upon a careful review of the available financial data, it is my professional opinion that the mine plan being evaluated by the EIS is almost certainly not economically feasible, with an estimated negative net present value of three billion dollars. This represents a fatal flaw in the

EIS because a larger mine would almost certainly need to be constructed in order to attain a positive rate of return on the very large initial capital investment. The current EIS is thus almost certainly not evaluating the true environmental impacts and risks associated with a viable mining project. Even a small expansion of the project to extract 20% of the ore body would almost double the size of the disturbed footprint, quadruple water quality risks and likely spread large-scale impacts into three different river drainage basins.

Professional Background

I am a geologist, environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I participated in and contributed to more than twenty financial and technical assessments of new major capital projects, divestments and potential acquisitions. This included over seven years as Head of Environment for Rio Tinto's Copper, Copper & Diamonds and Copper & Coal Product Groups. 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, issues and costs posed by the responsible development, operation and closure of large copper mines.

Pebble Project Environmental Setting, Impacts and Risks

The Pebble copper-gold ore body is located on a drainage divide between the headwaters of three important river systems in the center of the Bristol Bay watershed. This watershed hosts the globally significant Bristol Bay salmon fishery. Salmon are very sensitive to direct disturbance and to water quality changes within spawning rivers and surrounding wetlands. Most of the deposit is chemically reactive and would be prone to acid rock drainage formation if exposed to surface weathering conditions by mining. The site also has a very wet climate and is in a pristine, remote and seismically active location. All of these factors contribute to the very high innate environmental risk posed by any development of the ore body. Any commercial mining would, by necessity, result in widespread direct disturbance to wetlands, streams and upland areas. It would also create a contaminated water management liability which will certainly persist for decades and likely persist for centuries after mining is completed.

The mine plan submitted for the EIS by the Pebble Partnership seeks to control these environmental impacts and risks by 1) only mining ten percent of the ore body; 2) minimizing the disturbed footprint; and 3) implementing design and engineering controls. These efforts have reduced, but by no means have they eliminated all the impacts and risks associated with the project. The 20-year mine plan proposed for the EIS would still result in direct disturbance of roughly 14 square miles and the permanent loss of eight miles of salmon river and stream habitat. Approximately 13,000 gallons per minute of contaminated water would need to be reliably captured and treated during operations and over 5000 gallons per minute would need to be managed in perpetuity after closure. Over one billion tons of bulk tailings would also need to be managed in perpetuity. The closure of the small mine would be complex and the total closure cost liability created would almost certainly exceed 1.5 billion dollars. As shown in the table below, if an economically-viable full scale mine were ever developed at the site, most impacts and risks would increase by factors of three to five times and some would increase by more than one hundred times compared to the mine plan currently being evaluated by the EIS process.

	Proposed 20-year EIS mine plan	Expanded 78-year Development Scenario	Relative increase
Direct Disturbance	14 square miles	> 46 square miles	3.3 times greater
Permanent Direct Wetland Disturbance	5.5 square miles	>19 square miles	3.5 times greater
Permanent Loss of Salmon Habitat	8 miles of streams and rivers	42 miles of streams and rivers	5 times greater
Bulk Tailings Production	1140 million tons	5700 million tons	5 times greater
Pyritic Tailings Production	155 million tons	800 million tons	5 times greater
Non-Acid-Generating Waste Rock Production	95 million tons	13600 million tons	140 times greater
Acid-Generating Waste Rock Production	50 million tons	3400 million tons	70 times greater
Fugitive Dust and Mobile Equipment Emissions	250,000 tons/day of material moved	900,000 tons/day of material moved	3.6 times greater
Open Pit Footprint	608 acres	3600 acres	6 times greater
Maximum Pit Groundwater Inflow	2400 gallons per minute	12,000 gallons per minute	5 times greater
Operational Spill Risk Duration	20 years	78 years	3.9 times greater
Green House Gas Emissions	>22 million tons of CO_2 equivalents	>160 million tons of CO_2 equivalents	7 times greater

Source: Pebble Project Draft EIS; Wardrop, Preliminary Assessment of the Pebble Project, 2011 (commissioned by Northern Dynasty Minerals); and independent calculations

Pebble Mine Project Economics

In 2011, Northern Dynasty Minerals Limited commissioned Wardrop (an independent mining engineering consulting firm) to complete a “Preliminary Assessment of the Pebble Project”. This study performed financial evaluations on 25-, 45- and 78-year mine scenarios that targeted approximately 17, 32 and 55% of the total ore body respectively. This is the last publicly available, rigorous and independent economic evaluation of the Pebble ore body. The 20-year mine plan being evaluated by the EIS only produces half as much metal for sale as the smallest mine plan evaluated by Wardrop. In sum the value per ton of ore mined by the 20-year EIS mine plan is also about 21% lower than the average ore mined by the 25-year Wardrop plan. Given both project scenarios would have roughly the same very high initial capital costs for infrastructure construction, this has a profound negative impact on the likely economics of the mine being evaluated by the EIS. A comparison of the profits generated by concentrate sales from the two projects can be made using the life of mine average net smelter return per ton of ore calculated in 2011 minus the average total operating costs per ton of ore. For the 25-year mine plan this equates to $32 billion and for the 20-year mine plan this equates to $17 Billion. Thus, the mine currently being evaluated in the EIS process makes $15 billion less profit from concentrate sales. When this difference is apportioned by year and a discount rate of seven percent per year is applied, this equates to a five-billion-dollar reduction in net present value (NPV) between the 25-year plan evaluated in 2011 and the 20-year EIS case. It is certainly acknowledged that these are approximate, back-of-the-envelope calculations but the strategic implications for overall project economics are significant and will be extremely difficult to offset.

The initial mine construction costs assumed by Wardrop were anomalously low compared to other large copper mines that have been studied or built over the past five to ten years. Part of the apparent discrepancy in capital cost can be attributed to the removal of $1.3 billion in capital from the 2011 Wardrop construction cost estimate because "it has been assumed in the financial evaluation that the Pebble Partnership will enter into strategic partnerships as needed to develop, finance and operate a number of infrastructure assets – including the transportation corridor (port and road) and the power plant." However, it is unclear who would partner with the Pebble project in order to provide this extra capital. As such, this assumption is considered speculative. Adding this $1.3 billion back into the capital cost estimate for the Pebble 25-year mine case brings the total construction cost up to six billion dollars which is a little more in line with other recent mining projects.

The Wardrop study also significantly underestimated annual water treatment costs and did not include even a placeholder cost for closure of the Pebble mine. As shown in the table below, when the higher construction costs; higher operational expenditures for water treatment; closure costs and much lower revenue from concentrate sales are factored into the Wardrop study's 25-year mine plan economic evaluation, the 20-year mine plan being considered by the Pebble EIS has a negative NPV of approximately three billion dollars. This should only be considered a conceptual level approximation of the project's actual NPV. While a new rigorous economic evaluation may make the NPV less or more negative, I believe it is very unlikely to make the project have a positive rate of return on what is likely to be an extremely large and risky capital investment.

	NPV
Estimated NPV of the 2011 Wardrop 25-Year Mine Plan	+$3.8 Billion
Capital for Access Corridor and Power Plant added back into construction cost	-$1.3 Billion
Lost revenues from decreased concentrate sales	-$5 Billion
Refined operational water treatment costs	-$0.3Billion
Discounted Closure Cost	-$0.4 Billion
Conceptual NPV of the EIS 20-Year Mine Plan	**-$3 Billion**

The conceptual financial analysis provided by the Pebble Limited Partnership for the 20-year mine plan in the draft EIS is fatally flawed. It ignores smelter and refining costs, understates capital and operating costs and fails to provide even a placeholder cost for closure. With the incorporation of just these limited corrections, the Pebble Limited Partnership financial evaluation also has a strongly negative net present value. The draft EIS is thus evaluating a mine plan that does not meet its own alternatives screening criteria including the requirement that each alternative be "practical or feasible from the technical and economic standpoint".

If the base case mine plan assumed for the EIS is not economic, then the entire permitting process is compromised because the impacts and risks being evaluated are much smaller than those required for a full-scale economically viable project. In other words, the EIS is not evaluating the "least environmentally damaging practicable alternative." This situation would also place prospective developers in a difficult situation because in order to create a profitable operation they would either need to 1) immediately begin a new EIS for a larger economically viable mine plan or 2) knowingly permit, fund and build an uneconomic mine in the hopes that a later EIS and permitting process would allow a larger, economically viable operation.

For additional detail of the full economic evaluation submitted to the Army Corps of Engineers during the draft EIS public comment period see Appendix A attached to this written testimony.

Environmental Impact Statement Process

The draft EIS document for the Pebble Project was written in only eleven months. This is almost three times faster than the 2.6 years to complete the average draft EIS in the United States between 2010 and 2017 (Executive Office of the President, Council on Environmental Quality, December 2018). This short timeline is unprecedented for such a large, complex mining project which will have unavoidable, material and long-term impacts to a sensitive, globally significant ecosystem. It has almost certainly compromised the technical rigor and reliability of the EIS process.

Based upon a careful review of the Pebble Project draft EIS it is my professional opinion that the document and associated analysis is fatally flawed. The draft EIS contains an unacceptable number of deficiencies, omissions and errors. Due to the global significance of the salmon fishery, any EIS within the Bristol Bay watershed should be held to the highest standard, but the Pebble draft EIS does not even meet industry standard practice. Much of the analysis contains insufficient detail to determine if the planned actions are adequate or practicable; the document commonly understates potential impacts; essential analyses and designs are deferred to the post-EIS permitting period; and in a number of significant instances, the conclusions are clearly wrong. The analysis of key project components such as water management, geotechnical stability, reclamation & closure, wetlands mitigation and air quality are clearly inadequate. In particular the failure to consider the profound impacts that would result from large-scale catastrophic tailings dam failure means that the draft EIS ignores one of the largest environmental risks posed by the project. The cumulative effects evaluation of the more-credible 78-year mine plan significantly understates and, in some cases, grossly underestimates the much larger impacts and risks associated with an expanded mining operation. There are also several important alternatives which could significantly reduce the environmental impacts and risks of the project which were either not evaluated or were eliminated prematurely.

I have provided almost 50 pages of detailed technical comments on the draft EIS to the Army Corps of Engineers in six separate letters. These letters are publicly available at the Army Corps Pebble Project EIS website and are also attached as Appendix A to this written testimony. Given the substantial flaws in the draft EIS, I have urged the Army Corps of Engineers to restart the process with an analysis based on an economically-credible mine plan; and supported by an independent, rigorous economic analysis to demonstrate that the project is the least environmentally damaging practicable alternative. The EIS process will be severely compromised if the deficiencies of the current document are not fully addressed. This would almost certainly require, as a minimum, the completion of a Supplemental Environmental Impact Statement.

Appendix A

Technical Comment Letters on the Pebble Project Draft Environmental Impact Statement

Submitted to the United States Army Corps of Engineers during the 2019 Public Comment Period

March 4, 2019

Shane McCoy
Program Manager
United States Army Corps of Engineers
645 G Street
Suite 100-921
Anchorage, Alaska 99501

Subject: Pebble Project Environmental Impact Statement Schedule

Dear Mr. McCoy,

I write to express my deep concern about the extraordinarily short time lines allowed for the preparation of the Environmental Impact Statement (EIS) for the proposed Pebble Mine in the Bristol Bay region of Alaska.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I performed environmental and permitting 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 provided oversight and support to the design and permitting of new mines in Michigan, Arizona, Australia, Asia, Europe, Africa and South America. In particular I worked closely with the EIS permitting and environment team at Resolution Copper until my recent retirement. 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 development, operation and closure of large copper mines.

Discussion of the Pebble Project EIS

The United States Army Corps of Engineers (USACE) has promulgated a schedule of less than 2.5 years for the Pebble Project EIS, from the published notice of intent in March 2018 to issuance of a final record of decision (ROD) in mid-2020. This has necessitated completion of a draft EIS in only eleven months. These short time frames are unprecedented for such a large, complex mining project which will have unavoidable, material and long-term impacts to a sensitive globally significant ecosystem. I believe these short time lines will almost certainly compromise the technical rigor and reliability of the EIS outcomes.

In order to successfully design, develop and operate the Pebble Mine, potential environmental impacts and risks that will need to be controlled will almost certainly include: mineral waste environmental geochemistry; groundwater and surface water quality; dewatering and discharge impacts to in-stream flow regime; direct disturbance to land and water resources within the mine and transportation corridor footprints; geotechnical stability of tailings, open pits and waste rock piles; minimization of other upset conditions such as spills of reagents, hydrocarbons and concentrate; air emissions and noise; construction-specific impacts; ferry and port operations; and a complex and costly mine closure that will likely require permanent care and maintenance. Each of these areas requires the collection of field baseline data, but generally also laboratory analytical characterization, conceptual modelling of system behavior, numeric modelling predictions, management strategy development and detailed options analysis.

The average EIS completed in the United States between 2010 and 2017 took 4.5 years from the initial notice of intent to issuance of the final record of decision (Executive Office of President, Council on Environmental Quality, December, 2018). Even more importantly, the average draft EIS took 2.6 years to write; almost three times longer than the time allowed for completion of the draft Pebble EIS. The Executive Council on Environmental Quality further states that the mean time line for EIS completion when the Army Corps of Engineers was the lead agency is 6.1 years, and the average time to produce the draft EIS was 4.2 years. I do not believe the USACE can justify the short Pebble Project EIS time line when compared to their recent requirements and performance on other projects.

Unsurprisingly, Environmental Impact Statements for large, complex projects such as Pebble, which impact sensitive environments, and which are socially and politically contentious, typically take longer to complete than for small, simple projects. Mining project EIS documents also generally take longer to complete than the national average. A report completed for the National Mining Association in 2015 states that, on average, permitting for mining projects in the United States takes seven to ten years. Recent experience for successful mining-related Environmental Impact Statements illustrate the longer time lines required to produce a rigorous and defensible outcome. The Rosemont Mine EIS in Arizona took nine years to complete with a ROD issued in June 2017; the Gold Rock Mine EIS in Nevada took five years to complete with a ROD issued in September 2018; and the Donlin Mine EIS in Alaska took six years to complete with a ROD issued in August 2018. The proposed Resolution Copper Mine in Arizona is currently completing their EIS with a time line of greater than four years. The Pebble Project is generally more complex and located in a more sensitive environmental setting than any of these other mining projects and yet its EIS is proposed for completion in half the time.

The USACE has also proposed a 90-day public comment period on the draft EIS closing on May 31, 2019. This is certainly comparable to the comment periods associated with some other recent but less complex mining-related Environmental Impact Statements from outside Alaska. However, the Donlin Project located in Alaska and with the USACE as the lead agency allowed a six-month public comment period on the Draft EIS in 2016. If the USACE determined that the longer comment period was appropriate for Donlin three years ago, it is unclear how a much shorter time line can be justified by the same agency for a project that poses greater risks. Given the extremely short time line allowed for preparation of the draft EIS, I believe it is particularly important for the public comment period to be extended to insure the draft document can receive a rigorous review.

In my professional opinion, given the site's sensitive environmental setting and the complexity of the necessary management strategies to ensure its responsible development, the extremely short EIS time lines are insufficient to ensure the selection of technically rigorous and defensible solutions to the range of environmental issues and impacts described above.

Sincerely,

Richard K. Borden

Owner Midgard Environmental Services LLC

March 28, 2019

Shane McCoy
United States Army Corps of Engineers – Alaska District
Anchorage Field Office, Regulatory Division (1145) CEPOA-RD
1600 A Street, Suite 110
Anchorage, Alaska 99501-5146

Subject: Pebble Mine Project Economics

Dear Mr. McCoy,

I write to express my professional opinion that the mine plan being evaluated by the Pebble Mine Environmental Impact Statement (EIS) process is almost certainly not economically feasible. I come to this conclusion based upon the only publicly available preliminary economic assessment performed on the Pebble project in 2011 as modified to account for the significantly lower grades, lesser ore production and likely higher initial capital costs of the new project detailed in the December 2018 Draft EIS (DEIS) Project Description. The assumed EIS mine plan produces about half as much metal for sale over its life than the smallest mine plan assumed in the 2011 economic evaluation. Based upon the economic assumptions made in the 2011 assessment, the EIS mine plan will make roughly 15 billion dollars less profit from the sale of concentrate than the smallest 2011 mine scenario and is likely to have a strongly negative net present value (NPV).

While I am aware of the Pebble Partnership's reluctance to share any capital cost information, the technical rigor of the EIS process may be compromised if no cost data are available to help select the "least environmentally damaging practicable alternative." To help ensure the integrity of the EIS process, and in fairness to local communities, the State of Alaska and to shareholders, I believe the Pebble Partnership is obligated to publicly release a new preliminary economic assessment for the proposed smaller and lower-grade mine that the Army Corps of Engineers is currently reviewing.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I participated in and contributed to more than twenty financial and technical assessments of new major capital projects, divestments and potential acquisitions. I have performed environmental and permitting 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 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, issues and costs posed by the responsible development, operation and closure of large copper mines.

The 25-Year Mine Case Evaluated in 2011

In 2011 Northern Dynasty Minerals Limited commissioned Wardrop to complete a Preliminary Assessment of the Pebble Project. The Northern Dynasty website directs interested parties to a web location where this document can be viewed, although the reader is cautioned that the 2011 study "while instructive as to the size and scale of project that the Pebble resource might support, it is now outdated and cannot be relied upon." The preliminary assessment performed financial evaluations on 25-, 45- and 78-year mine scenarios. However, the discussion below is focused on the 25-year mine scenario as this most closely resembles the 20-year mine life proposed in the DEIS Project Description (Appendix N). The 25-year mine case was predicted to have an up-front capital cost of 4.7 billion dollars required to process a total of 1990 million tons of ore. The NPV of the project was predicted to be 3.8 billion (pretax) in 2011 dollars assuming a seven percent annual discount rate.

Because future income and costs are discounted, NPV estimates are highly sensitive to costs and revenue in the early years of the economic assessment. The project value is particularly affected by the construction capital costs which, by necessity, must be incurred before any ore production and concentrate sales can occur. Pebble's assumed construction costs of $4.7 billion are anomalously low compared to other large copper mines that have been studied or built over the past five to ten years. For example, over six billion dollars was spent on construction of the Oyu Tolgoi copper mine in Mongolia which went into production in 2013 after four years of construction. The Las Bambas copper mine in Peru spent more than seven billion dollars on construction before going into production in 2016. The Cobre Panama copper mine is currently in construction but its capital cost estimate from 2012 is also about six billion dollars. All of these copper mines are open pits with conventional concentrators similar to what is proposed at Pebble. The nearby Donlin gold mine in Alaska is also estimated to have a construction cost of seven billion based for the most part upon a 2011 economic evaluation. Part of the apparent discrepancy in capital cost can be attributed to the removal of $1.3 billion in capital from the 2011 Wardrop construction cost estimate because "it has been assumed in the financial evaluation that the Pebble Partnership will enter into strategic partnerships as needed to develop, finance and operate a number of infrastructure assets – including the transportation corridor (port and road) and the power plant." However, it is unclear who would partner with the Pebble project in order to provide this extra capital. As such, this assumption is considered speculative. Adding this $1.3 billion back into the capital cost estimate for the Pebble 25-year mine case brings the total construction cost up to six billion dollars which is a little more in line with these other projects.

However, actual construction costs could be significantly greater than six billion. In every analogue case cited above, 1) the design ore throughput is less than what was proposed in the

2011 study at Pebble, 2) the analogues in many cases are located closer to existing infrastructure and, perhaps most importantly, 3) none of them is located in as sensitive an environmental setting as Pebble. In 2013 Anglo-American withdrew from the Pebble Partnership after expending roughly $500 million on the project. According to a document prepared by Kerrisdale Capital (2017), which reportedly interviewed several of the Anglo-American personnel involved in the Pebble project, the actual capital cost for construction of Pebble could exceed ten billion dollars. If true this would have made the NPV of the 25-year mine case strongly negative. The withdrawal of all other large-scale and experienced mining investors (Mitsubishi in 2011, Rio Tinto in 2014 and First Quantum in 2018) may also have been due, in part, to skepticism about the financial viability of the projects evaluated in 2011 as well as the substantial permitting and environmental risks posed by the project.

Comparison between the 2011 and the 2018 EIS Mine Plans

Given the lower average grades, smaller production totals and likely equal or greater construction capital required for the 2018 EIS mine plan, it is almost certain to be less profitable than the 25-year mine plan evaluated by Wardrop in 2011. Some key differences in project ore feed and contained metal are contained in the table below.

	EIS 20-Year Mine	Wardrop 25-Year Mine	EIS/Wardrop
Copper Grade	0.29%	0.38%	76%
Copper Total Production	7.4 billion pounds	15 billion pounds	49%
Gold Grade	0.27 grams/ton	0.34 grams/ton	79%
Gold Total Production	12.1 million ounces	23 million ounces	53%
Molybdenum Grade	154 ppm	182 ppm	85%
Moly Total Production	398 million pounds	725 million pounds	55%

Almost every mining project attempts to target the highest-grade portions of the ore body early in the mine life in order to pay for the very large up-front capital costs associated with mine construction as soon as possible. However, due to the geometry of the Pebble ore body, and given the absolute need to lower the large environmental impacts and risks associated with mining in the sensitive Pebble setting, the EIS mine plan actually targets relatively low-grade portions of the ore body and only mines about ten percent of the total estimated resource. In sum the value per ton of ore mined by the 20-year EIS plan is about 21% lower than the average ore mined in the 25-year plan. The total mass of all copper, gold and molybdenum produced is almost half. This has a profound negative impact on the likely economics of the mine being evaluated by the EIS. A comparison of the profits generated by concentrate sales from the two projects can be made using the life of mine average net smelter return per ton of ore milled calculated in 2011 minus the average total operating costs per ton of ore milled. For the 25-year mine plan this equates to: ($27.45/ton – $11.16/ton)*1990 million tons of ore = $32 billion. For the 20-year mine plan this equates to: (0.79*$27.45/ton – [$ 11.16/ton – 2.30/ton])*1300 million tons of ore = $17 Billion[1]. Thus, the mine currently being evaluated in the EIS process makes $15 billion less profit from concentrate sales. When this difference is apportioned by year and a discount rate of seven percent per year is applied, this equates to a five billion dollar reduction in NPV between the 25-year plan evaluated in 2011 and the 20-year EIS case. It is certainly acknowledged that these are approximate, back-of-the-envelope calculations but the strategic implications for overall project economics are significant and will be extremely difficult to offset.

The 25-year mine plan also appears to have significantly underestimated operational and closure costs associated with perpetual water treatment. On average the mine area receives more than 50 inches per year of precipitation. This is more than four times the average annual evaporation. The ore body and much of the associated country rock is also prone to acid rock drainage. Given these conditions it is almost certain that any open pit mine will create perpetual water management and treatment liabilities. According to the December 2018 Project Description, the mine will have an annual average surplus of 29 cfs (13,000 gallons per minute) for the maximum mine footprint. This will likely increase to almost 20,000 gpm in the early years of closure when long-term water storage in the tailings pore space is no longer available, before major reclamation works are completed and during the initial stages of tailings drain-down. Even after the potentially acid forming tailings and waste rock are submerged in the fully developed pit lake and the tailings have been capped with an infiltration-limiting cover, a water management liability of roughly 3000 gpm or more will likely persist in perpetuity[2]. DEIS water quality predictions confirm that most of this water will need to be treated to meet the extremely strict water quality criteria needed to protect salmon and other aquatic species.

By necessity, Pebble has proposed a very costly and complex multistage water treatment process which to my knowledge has not been attempted for such high flows anywhere else in the world. Applying a treatment cost of $5.80/1000 gallons[3] to these flows predicts that during operation up to about $40 million/year may be required for water treatment, that early in closure this could raise to $55 million/year and then decline to roughly $8 million/year in perpetuity. However, the 2011 Wardrop study only assumed a water treatment cost of 6.3 million per year during operation and was largely silent about any closure water treatment liabilities. Applying a seven percent discount rate to these values during operation and to the first hundred years after closure yields an NPV cost which is approximately $400 million higher for the life of mine project than assumed in 2011.

Financial and Permitting Implications

As shown in the table below, when the higher construction costs; higher operational and closure expenditures for water treatment; and much lower revenue from concentrate sales are factored into the Wardrop study's 25-year mine plan economic evaluation, the 20-year mine plan being considered by the Pebble EIS has a negative NPV of approximately three billion dollars. This should only be considered a conceptual level approximation of the project's actual NPV. While a new rigorous economic evaluation may make the NPV less or more negative, I believe it is very unlikely to make the project have a positive rate of return on what is likely to be an extremely large and risky capital investment.

	NPV
Estimated NPV of the 2011 Wardrop 25-Year Mine Plan[4]	+$3.8 Billion
Capital for Access Corridor and Power Plant added back into construction cost	-$1.3 Billion
Lost revenues from decreased concentrate sales	-$5 Billion
Refined perpetual water treatment costs	-$0.4 Billion
Conceptual NPV of the EIS 20-Year Mine Plan	**-$3 Billion**

If the base case mine plan assumed for the EIS is not economic, then the entire permitting process risks being compromised because the impacts and risks being evaluated are much smaller than those required for a full-scale economically viable project. In other words, the EIS is not evaluating the "least environmentally damaging practicable alternative." This situation would also place prospective developers in a difficult situation because in order to create a profitable operation they would either need to 1) immediately begin a new EIS for a larger economically viable mine plan or 2) knowingly permit, fund and build an uneconomic mine in the hopes that a later EIS and permitting process would allow a larger, economically viable operation. In either case, a larger open pit mine would almost certainly take on many of the characteristics of the 25-year case assessed by Wardrop in 2011 and the Pebble 2.0 scenario evaluated by the USEPA in 2014 with billions of tons of additional waste rock production, much larger tailings dams and a step-change increase in disturbed footprint.

At a minimum relative capital costs for different development and design options need to be evaluated by the Army Corps of Engineers so a meaningful options analysis can be conducted on practicable alternatives. To help ensure the integrity of the EIS process and in fairness to local communities, the State of Alaska and to shareholders, I believe the Pebble Partnership is obligated to publicly release a new preliminary economic assessment for the proposed smaller and lower-grade mine that the Army Corps of Engineers is currently reviewing.

Sincerely,

Richard K. Borden

Owner Midgard Environmental Services LLC

Footnotes:

[1] Given the assumed long-term metals prices, net smelter return and net operating cost values are from a 2011 study (Wardrop, Preliminary Assessment of the Pebble Project, Southwest Alaska, February 17, 2011) all cost are in 2011 dollars and have not been escalated to 2019 dollars. The net smelter return calculated for the 25-year mine plan in 2011 is multiplied by 0.79 to account for the 21% lower average ore grades (in copper equivalents) of the proposed EIS mine. Similarly, the total operating cost per ton of ore milled is reduced by $2.30 to account for the negligible waste rock stripping of the EIS case compared to a stripping ratio of 1.5 assumed in the 25-year mine plan ([1.5/2.5]*[Wardrop net mining cost per ton of ore]).

[2] In order to prevent groundwater outflow from the pit, the pit lake will need to be maintained at a lower level than the surrounding groundwater surface in perpetuity. The water removed from the pit lake will require treatment before release. This is conservatively assumed to be 1300 gpm based solely on the ultimate pit footprint, annual average precipitation and annual evaporation. In this extremely wet climatic setting a good infiltration-limiting soil cover on the bulk tailings storage facility is likely to allow infiltration of approximately 20% of incident rainfall based on historic cover performance across the world. Based on the bulk tailings footprint, annual rainfall and this rate of infiltration, seepage of about 1400 gpm is likely to persist in perpetuity even after operational drain down is complete.

[3] In 2013 the Canadian Mine Environmental Neutral Drainage program completed a study of more than 100 mine water treatment plants which were predominantly located in the USA and Canada. The average water treatment plant operational cost in the study was $1.54 per 1000 liters ($5.82 per 1000 gallons). The US and Canadian dollar were at near parity for 2013 when the study was completed. In reality the Pebble water treatment strategy is much more complex than the average treatment plant in the review and so its costs per 1000 gallons are likely to be higher. (Review of Mine Drainage Treatment and Sludge Management Operations, MEND Report 3.43.1, 2013).

[4] Given the lack of any new published capital cost data for the EIS mine plan, this assumes construction capital costs are roughly the same for the 25-year and 20-year projects. There are likely to be some incremental capital cost savings for the 20-year mine because ore throughput is about 20% lower, so construction costs for the concentrator and associated support infrastructure will also likely be lower. Initial truck and shovel fleets are likely to be less costly for the 20-year mine plan because of the much lower waste rock stripping ratios. The length of the access road corridor is also less in the new mine plan. However, these cost savings will almost certainly be offset by capital cost increases associated with new or redesigned infrastructure such as: 1) a new complex stand-alone pyrite tailings management system covering 1.7 square miles, 2) much larger and more costly water management infrastructure than envisioned in 2011; 3) construction of two ferry terminals on Lake Iliamna and the purchase of large ice-breaking ferry; and 4) tailings embankment construction with a more stable embankment outer slope of 2.6:1 (horizontal to vertical) versus the 2:1 slope assumed in

2011 which will likely require significantly more material quarrying and movement. Similarly, there is a lack of any information on sustaining capital for the 20-year plan, so it is assumed that sustaining capital requirements are the same for the first twenty years of the two plans. Although the 25-year mine plan has additional sustaining capital requirements for years 21 to 25, at a seven percent discount rate the value of any late capital expenditures is reduced by roughly 80% in the NPV calculations and has a negligible impact on overall project economics.

May 13, 2019

Shane McCoy
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Subject: Pebble Mine Draft EIS Comments on Geotechnical and Spill Risks

Dear Mr. McCoy,

Given the very high innate geotechnical risk of the Pebble Mine setting and the extreme sensitivity of the downstream receiving environment, the Draft Environmental Impact Statement (DEIS) analysis of tailings and untreated water release is clearly inadequate. The DEIS fails to definitively demonstrate the geotechnical stability of tailings embankments, water storage facilities and pit walls throughout operation and closure. Large-scale catastrophic release of tailings and contact water is one of the most significant risks posed by the Pebble project and the DEIS' intentional failure to evaluate the impacts of any catastrophic release events cannot be justified. Even a release of just five percent of the bulk or pyritic tailings is likely to have profound, permanent negative impact on downstream aquatic ecosystems and fisheries.

In particular, by ignoring all potential catastrophic failure events, the release scenarios evaluated by the DEIS are anomalously small, representing only 1) 0.004% of produced bulk tailings which must be contained on-site forever; 2) 0.6% of produced pyritic tailings which must be contained on-site during operation; and 3) 0.4% of untreated process water which must be contained on-site during operation. The only bulk tailings release scenario that is evaluated by the DEIS assumes a brief six-hour pipeline break and therefore does not even consider containment failure associated with the tailings storage facility itself. There is also no DEIS evaluation of the significant perpetual closure risk of post-flooding pit wall failure which creates a seiche wave that would destroy water management infrastructure, could result in employee fatalities and could release billions of gallons of untreated pit lake water to the environment.

It is certainly acknowledged that, if implemented as designed, the proposed centerline and downstream construction techniques (with slopes of 2.6:1 or less) will reduce but not eliminate the likelihood of embankment geotechnical failure. The large-scale catastrophic release of tailings and/or of untreated mine contact water would thus represent a low probability but very high consequence event. These sorts of risks are routinely identified and analyzed within the mining industry so that appropriate controls can be implemented. The intentional omission of large-scale catastrophic geotechnical failure scenarios from the Pebble evaluation is particularly difficult to justify given the 1) acknowledged “early phase conceptual level” of the embankment designs (DEIS Section 4.27.6) and 2) lack of any geotechnical evaluation of seismic events specific to the proposed embankment designs or to the fully-flooded open pit in this extremely active seismic setting. Given the extremely wet climate and highly variable precipitation at Pebble, the lack of any catastrophic overtopping release scenarios related to insufficient water storage capacity is also not justified.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I participated in tailings review boards and was a primary or contributing author on several mineral waste and tailings management standards and guidance documents. I have performed environmental and permitting 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 published numerous papers on mine environmental performance and management in peer reviewed scientific journals, conference proceedings and books. I am experienced in the management of environmental challenges, issues and costs posed by the responsible design, operation and closure of large tailings and water storage facilities.

Pebble Project’s High Innate Geotechnical Risk

Pebble’s active seismic setting, wet climate, sensitive receiving environment and large mass of chemically reactive tailings all contribute to a very high innate risk of catastrophic release.

As noted in Appendix K (4.15) and Chapter 3.15 of the DEIS: “the mine site is situated in a seismically active area” and “both shallow crustal earthquakes and deeper earthquakes associated with the subduction zone megathrust affect this region”. The active Lake Clark - Castle Mountain Fault is only 15 miles away and there are several potential seismic events which could trigger earthquakes of magnitude 7.5 or greater. The maximum credible earthquake has been estimated to produce ground accelerations of 0.61 g at the mine. According to the United States Geologic Survey, ground accelerations of 0.34 to 0.65 g will typically produce severe shaking and moderate to heavy damage.

The mine site receives between 50 and 57 inches of precipitation on average each year which is at least four times greater than the annual evaporation. This extremely wet climate produces abundant excess water for runoff and infiltration. According to the Pebble project description (Appendix N), the mine will need to treat and release an average of 13,000 gallons per minute of excess water. Precipitation is also highly variable with almost half occurring in August through October. Available environmental baseline data show monthly precipitation as high as 12.2 inches measured in September, 2007 (Chapter 2, Pebble Environmental Baseline Document 2004-2008). Much longer-term precipitation records at Iliamna indicate that annual precipitation may vary by almost a factor of three from year to year. This very wet and highly variable climatic setting will make it very challenging for Pebble to consistently contain contact water on-site so that it can always be treated and released in a controlled manner. It also ensures that the majority of the bulk tailings will remain saturated in perpetuity after closure.

Any untreated water or tailings released from site will discharge directly into the North and/or South Forks of the Koktuli River. Although this release would occur near the river's headwaters, both have substantial flow which could rapidly transport released tailings downstream. Immediately downstream of the proposed mine, both rivers' annual average flow is more than 100 cubic feet per second (>45,000 gallons per minute) and peak flows in excess of 700 cfs (>300,000 gpm) have been recorded (Section 3.16). These rivers, which are at the heart of the Bristol Bay ecosystem and fishery, would be unavoidably impacted by any release due to sedimentation and water quality degradation. Unfortunately, aquatic ecosystems in general and salmon in particular are very sensitive to dissolved copper. Any untreated water release will almost certainly contain dissolved copper concentrations that are tens to hundreds of times greater than allowable limits (Appendix K, 4.18). Similarly, any tailings release will almost certainly contain copper concentrations that are an order of magnitude greater than sediment quality guidelines. Sulfide minerals in any released tailings are likely to become hydrologically sorted in the river system and may become concentrated on bars and beaches where they would be more prone to rapid acidification and metals release.

The Pebble twenty-year mine plan will generate 1100 million tons of bulk tailings and 155 million tons of pyritic tailings. Almost 400 million additional tons of specially quarried rock will be required to construct all necessary embankments for tailings and contact water containment on site (Appendix K, 4.15). Given the topographic constraints this will necessitate construction of a 545 ft tall main embankment to contain the bulk tailings. This will be among the tallest tailings storage facilities on Earth and will almost certainly be taller than 99% of the tailings impoundments constructed to date. The pyritic tailings impoundment will be up to 425 feet tall and will also almost certainly be taller than 90% of existing tailings impoundments. The total length of all major embankments will ultimately exceed 12 miles. The construction, monitoring and maintenance of these embankments will represent a huge engineering, operational and financial commitment. The level of effort required for the embankments is a particular concern given Northern Dynasty Minerals' complete lack of experience in this area, and the almost certain marginal economics of the DEIS mine plan (Borden Pebble DEIS comments letter dated March 28, 2019).

Tailings and Water Storage Facility Catastrophic Containment Failure

As noted in Section 4.27.6 of the DEIS, there are typically one to two major tailings dam failures per year around the world and furthermore that "other recent tailings dam failures in China, Mexico and Australia demonstrate that modern, well-engineered tailings facilities are subject to failure". The five largest and best documented tailings dam failures over the past five years are listed in the table below and are compared to the anomalously small bulk tailings release scenario evaluated in the DEIS:

Name	Date	Location	Responsible Company	Volume Released (m^3)[1]	Volume Compared to DEIS Bulk Tailings Release Scenario
Mount Polley	Aug, 2014	Canada	Imperial Metals	25 million	560 times larger
Samarco	Nov, 2015	Brazil	BHP/ Vale	32 million	720 times larger
Cieneguita	June, 2018	Mexico	Minera Rio Tinto[2]	0.44 million	10 times larger
Candia	Mar, 2018	Australia	Newcrest Mining	1.3 million	30 times larger
Corrego do Feijao	Jan, 2019	Brazil	Vale	12 million	270 times larger

[1] Includes both tailings solids and untreated contact water; [2] Note this is a different company than the large global mining corporation Rio Tinto LLC.

Several of these large incidents are not described in the DEIS discussion of recent tailings dam failures despite their clear pertinence to the risks at Pebble. All five events are one to two orders of magnitude larger than the anomalously small bulk tailings scenario evaluated at Pebble, despite the fact that the proposed bulk tailings dam at Pebble will be larger than the dams at these other locations. Several of these incidents also released tailings into river systems with similarities to Pebble's setting, and the tailings were rapidly transported far downstream. In the case of Samarco, tailings reached the ocean 400 miles away within three weeks.

Despite the significant seismic hazards at Pebble, there has been no seismic stability analysis conducted for the specific embankment designs proposed in the DEIS. The DEIS instead relies upon an old 2011 pseudo-static analysis performed on an outdated design for the main bulk tailings impoundment alone. No seismic stability analysis appears to have been completed on the current bulk tailings impoundment designs or the embankments required to contain the pyritic tailings and untreated contact water. As stated in Appendix K, Section 4.15: "Estimates of horizontal and vertical displacement for mine site embankments would be analyzed further for current embankment designs during future seismic analysis as part of the detailed design work undertaken in fulfillment of the ADSP review process. That work is anticipated to be performed after the EIS is complete." Furthermore, according to Knight Piesold (2018c) "The embankment designs and stability analyses will be updated accordingly to reflect actual foundation conditions”. Thus, the stability of all key containment structures in response to seismic events and actual foundation conditions has not been definitively demonstrated and there are no plans to do so for the EIS. This is a potential fatal flaw for all impoundments, but for the bulk tailings impoundment in particular, because it must ensure containment forever, not just during operation. Given its long design life, it is much more likely to experience a very large seismic event which approaches the maximum credible earthquake in its intensity. Also given the extremely wet climate of the site and likely high infiltration rates through the planned soil cover, most of the bulk tailings mass is almost certain to remain saturated in perpetuity. The risk posed by a catastrophic geotechnical failure is unlikely to decline as significantly as implied by the term “dry closure” used in the DEIS.

As stated in Section 4.27.6 of the DEIS: “Massive catastrophic releases that were deemed extremely unlikely were also ruled out for analysis in the EIS”. It is unclear how this statement can be justified given 1) the high innate risk posed by the site; 2) the acknowledgement that large-scale tailings failures regularly occur even for recently constructed facilities; 3) the lack of any seismic geotechnical analysis specific to the current DEIS embankment designs; and 4) the current low level of foundation knowledge and engineering design actually available for the embankments. As stated in the Pebble EIS-Phase Failure Modes and Effects Analysis Workshop Report (AECOM 2018l): “The current Pebble Project embankment designs are at an early phase conceptual level, with geotechnical investigations still under way at the major embankment sites. This current conceptual design level inherently results in uncertainties”. Simply stating that no catastrophic failure scenarios need to be evaluated because the facilities will not be designed or built to fail is inadequate justification for ignoring one of the greatest risks posed by the project.

In order to fill these substantial deficiencies, the EIS process must at a minimum:

1) Conduct seismic analysis for the bulk tailings (both north and south embankments), pyritic tailings and all water management ponds in order to confirm the designs can withstand the operational basis earthquake and for the bulk tailings impoundment the maximum credible earthquake.
2) Perform additional environmental consequences analysis on larger bulk tailings, pyritic tailings and untreated contact water spills. In particular the impact of a catastrophic bulk tailings dam failure in response to a large post-closure earthquake needs to be evaluated. A large-scale overtopping event which releases untreated mine contact water during an exceedingly wet year or years would also be a critical failure scenario to evaluate.
3) The post-closure hydrogeologic behavior of the bulk tailings storage facility also needs to be evaluated. This will require much more detailed designs of how the upper surface is to be recontoured to avoid ponding, how water is to be transmitted off the tailings in a non-erosive manner and how the cover will be constructed and maintained in

perpetuity. Net infiltration and its impact on bulk tailings saturation will then need to be modelled.

4) Based on the results of the geotechnical and environmental consequences analyses for catastrophic failures, embankment designs may need to be refined. Even a release of just five percent of the bulk tailings (greater than 50 million tons) is likely to have profound, permanent negative impact on downstream aquatic ecosystems and fisheries. A low likelihood event which has such catastrophic consequences may warrant additional controls such as using downstream construction techniques for all tailings embankments (Action Alternative 2), paste or dry stacked tailings.

Catastrophic Pit Wall Failure and Seiche Wave Generation

The DEIS has failed to provide any analysis of post-closure fully-flooded pit wall stability and the potential for seiche wave generation. Once water levels in the pit are allowed to recover to the target elevation, a pit lake will form that covers about 500 acres, is over 500 feet deep and will contain over 60 billion gallons of untreated water. The surface of this pit lake will only be about 150 feet below the spill point for the pit. A large-scale failure of the pit wall, likely triggered by a seismic event, would create a large seiche wave. Such a wave would almost certainly damage the water management infrastructure required to maintain pit water levels, could result in worker fatalities and could instantaneously release billions of gallons of untreated water into the Koktuli River system.

This is not a hypothetical scenario. The flooded Berkeley open pit in Butte Montana has experienced at least two large seiche wave events. The first in 1998 deposited the pit lake sampling boat roughly 40 feet above the lake surface and the second in 2013 destroyed pit pumping infrastructure. Because of the high ongoing danger of new seiche waves, access to the pit is now severely restricted and all water samples are collected from an entirely remote-controlled sampling vessel. Modelling of post-flooding pit wall stability and seiche wave generation is becoming a common practice within the mining industry for planned large pit lakes. A brief internet search shows pit wall failure/seiche wave predictive analyses recently performed at the Martha Mine pit in New Zealand, the Black Lake pit in Quebec, the Mitchell pit in British Columbia and for a large un-named pit as detailed at the Golder Associates website.

Although both static and seismic geotechnical modelling has been performed for the open pit, it is not applicable to evaluation of the pit wall failure/seiche scenario highlighted above because:

- Only early closure conditions were evaluated when the open pit and surrounded bedrock were only about half-way reflooded. However, current plans are to allow the pit lake to reflood to within about 150 feet of the pre-mining surface. This will also raise the water table in the surrounding bedrock and could lead to increasing wall instability.

- The DEIS pit wall geotechnical evaluations for seismic events only considered ground accelerations of 0.14 and/or 0.2 g (there are inconsistencies between Appendix K, 4.15 and the original SRK memo dated August 9, 2018). These values may be appropriate for an assessment of risks during the 20-year operational period, but are clearly inadequate for a closure assessment when containment is required for centuries. It would be much more appropriate to perform the analysis using the maximum credible earthquake for closure which has an estimated ground acceleration of 0.61 g.
- Physical and accelerated chemical weathering of acidified, pyrite-bearing wall rock could significantly lower in situ rock strength in the decades after closure.
- The SRK geotechnical analysis was only completed on three cross sections in the pit. The geotechnical stability of the relatively shallow zone of weak rock on the west side of the pit was not evaluated under static or dynamic conditions.

This issue has strategic implications for mine design, operations and closure and needs to be addressed by the EIS process. If the pit walls are not stable under the maximum credible earthquake then containment of the more than 60 billion gallons of untreated pit lake water cannot be ensured after closure. This would almost certainly need to be mitigated by one of the following strategies:

- Maintaining the pit lake surface at a much lower elevation so there is additional freeboard to contain a seiche wave. However, this would increase the in perpetuity pumping rate and, because more of the acid-generating pit high walls would be exposed, would cause pit lake water quality to be worse than currently predicted.
- Performing in situ treatment of the entire pit lake so that if water were released by a seiche wave, it would have less of an environmental impact. However, this would be very costly, technically complex and would likely put workers in harm's way.
- Perpetual post-closure dewatering and depressurization of weaker portions of the pit wall that are prone to failure. However, this would increase the in perpetuity pumping rate and require constant active intervention for centuries.
- Refining acid-forming waste rock placement in the pit so that it remains below the lake surface, but more effectively buttresses weak zones on the pit walls; or moving sufficient non-acid forming waste rock back into the open pit in order to permanently buttress the pit walls. This could effectively control the risk but could represent a very large increase in the early closure costs.
- Reducing final pit slope angles to improve their stability during mining. However, this would dramatically increase the stripping ratio, increase the volume of waste rock that would need to be managed and increase the mine surface disturbance.

In order to address these substantial uncertainties, the EIS must at a minimum:

1) Perform a seismic analysis of pit wall stability for the fully flooded pit lake and wall rock, using ground accelerations associated with the maximum credible earthquake and including sufficient cross sections to characterize all zones of weakness in the ultimate pit. Issues associated with long term chemical and physical weathering which may lower the strength of the wall rock must also be considered.
2) Based on the results of the seismic analysis, perform seiche wave predictions for various pit lake flooding scenarios.
3) If failure-induced seiche waves are demonstrated to pose a credible risk to perpetual pit lake water containment, select and design appropriate mitigation strategies.
4) Evaluate the environmental, operational and closure impacts of the selected mitigation strategy including issues such as hydrogeologic evaluations of increased pumping rates, water quality predictions for changes in pit lake water chemistry and materials balances for new waste rock production and/or backfill requirements.

Sincerely,

Richard K. Borden

Owner Midgard Environmental Services LLC

May 31, 2019

Shane McCoy
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Subject: Pebble Mine Draft EIS Comments on Reclamation and Closure

Dear Mr. McCoy,

Despite the significant post-operational environmental impacts and risks at Pebble, no Reclamation and Closure Plan has been completed and the closure analysis within the Draft Environmental Impact Statement (DEIS) is clearly inadequate.

As noted in this comment letter there are a large number of strategic closure-related omissions, errors and uncertainties within the DEIS and its supporting documents. Closure strategies and commitments are key components of mining Environmental Impact Statements because significant post-operational impacts and risks may persist for centuries after a relatively brief mine life. For this reason, it is common practice for mining projects to complete a Reclamation and Closure Plan during the EIS process. A review of several mining Environmental Impact Statements completed over the past three years shows that five out of six had released closure plans before the EIS was completed. The Donlin Gold Project in particular completed a 458-page Reclamation and Closure Plan with a detailed cost estimate during its EIS process, which was led by the Army Corps of Engineers.

The lack of even a conceptual level Reclamation and Closure Plan is a particular concern because closure of the 20-year Pebble mine will be complex and very costly. The total closure costs are almost certain to exceed 1.5 billion dollars even after discounting later expenses to the first year of closure. This high closure cost poses an even more significant financial risk given that the DEIS 20-year mine plan is almost certainly not economically feasible (Borden DEIS comment letter dated March 28, 2019).

In order to address these major deficiencies in the DEIS, a Reclamation and Closure plan needs to be developed for the Pebble 20-year mine plan as part of the EIS process. To help ensure the integrity of the EIS process and in fairness to local communities, the State of Alaska and to shareholders, I also strongly urge the Pebble Limited Partnership to publish a rigorous closure cost estimate as part of the EIS process.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I designed several successfully-completed closure projects, participated in closure steering committees and was a contributing author on closure standards and guidance notes. I have 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 published numerous papers on mine environmental performance and management in peer reviewed scientific journals, conference proceedings and books. I am experienced in the management of environmental strategies, issues and costs associated with mine closure.

Mining EIS Reclamation and Closure Planning

Closure goals, strategies and commitments are key components of mining Environmental Impact Statements because significant post-operational environmental impacts and risks may persist for centuries after a relatively brief mine life. For this reason, it is common practice for mining projects to complete a Reclamation and Closure Plan during the EIS process. A review of several mining Environmental Impact Statements completed over the past three years shows that five out of six had released closure plans before the EIS was completed. The sixth EIS had a robust reclamation and closure description in Chapter 2 (Proposed Actions and Alternatives) with additional information in many of the supporting chapters. These EIS documents were completed in various States and with various lead agencies: Copper Flats Copper Mine Project (New Mexico, BLM) Rosemont Copper Mine Project (Arizona, USFS), Gold Rock Mine Project (Nevada, BLM), Gold Bar Project (Nevada, BLM), Northmet Project (Minnesota, State DNR) and most significantly the Donlin Gold Project (Alaska, Army Corps of Engineers). Donlin completed a 458-page Reclamation and Closure Plan with a detailed cost estimate during its EIS process. The lack of a Reclamation and Closure plan is also acknowledged as a significant data gap in Section 3.1.6 of the Pebble DEIS. Given how few substantive mine plan alternatives are actually being considered by the DEIS, production of a robust closure plan would certainly not be unduly burdensome at this stage.

Despite the significance of post-operational environmental impacts and risks at Pebble, no Reclamation and Closure Plan has been completed and the closure analysis within the DEIS is clearly inadequate. Furthermore, it appears that the Pebble Limited Partnership intends to wait to produce a closure plan until after the EIS is completed (Sections 2 and 4.22). There are significant closure omissions and errors in the DEIS which are described in the next section of this letter. Many strategic and complex closure components are only described in generalized terms with insufficient detail presented to determine if they are appropriate and practicable.

The DEIS and supporting documents do not provide preliminary engineering drawings for most key closure structures and landforms. Nor does the DEIS provide any materials balances for major earthworks, demolition or topsoil management.

The lack of even a conceptual level Reclamation and Closure Plan is a particular concern because closure of the 20-year Pebble mine will be complex and very costly. As described in Section 4.16, centuries of water treatment will be required for predicted flows in excess of 5000 gallons per minute. Geotechnical risks associated with pit walls and the permanent bulk tailings storage facility will persist in perpetuity in this seismically active area and could result in the catastrophic release of tailings and/or untreated water. As detailed later in this letter, the total closure costs are almost certain to exceed 1.5 billion dollars even after discounting later expenses to the first year of closure. This very high closure cost is a particular concern given that the DEIS 20-year mine plan is almost certainly not economically feasible (Borden DEIS comment letter dated March 28, 2019). The very high closure costs coupled with the marginal overall project economics mean that the 20-year mine plan is almost certainly not the "least environmentally damaging <u>practicable</u> alternative". Should mining be initiated, there will undoubtedly be intense financial pressure to defer these closure expenditures by continued mining as the uneconomic 20-year mine plan approaches its end. A future mine operator may also attempt to avoid backfilling the pit with chemically reactive waste rock and tailings (despite the absolute necessity for acid rock drainage control and to ensure permanent containment) because this could preclude any future resource development in the remaining shallow and more accessible portions of the ore body.

In order to address these major deficiencies in the DEIS, a Reclamation and Closure plan must be developed for the Pebble 20-year mine plan. At a minimum, this plan should provide additional detail and address all omissions, errors and uncertainties highlighted in this letter and other DEIS comments. To help ensure the integrity of the EIS process and in fairness to local communities, the State of Alaska and to shareholders, I also strongly urge the Pebble Limited Partnership to publish a rigorous closure cost estimate as part of the EIS process.

<u>Pebble DEIS Significant Closure-Related Omissions, Errors and Uncertainties</u>

The Pebble DEIS fails to discuss or provides insufficient detail for the following strategic closure issues which would be key components of a robust Reclamation and Closure plan. These issues must be addressed to 1) evaluate the long-term post-closure impacts and risks, some of which could persist for centuries; 2) determine if effective closure is even practicable under the actual environmental, operational and financial conditions of the project; 3) inform mine design so that Pebble can implement its stated "holistic, design-for-closure philosophy" (Section 2); and 4) eventually allow closure cost estimates for financial assurance.

Topsoil Management and Balance – Section 4.22 states that "topsoil and overburden would be salvaged during construction for use as growth media during reclamation" and mine plan figures do show some topsoil stockpiles. However, there are no estimates of topsoil volumes that will be salvaged during construction, no discussion of topsoil salvage or storage techniques at the mine or access corridor, and no estimates of topsoil requirements to successfully revegetate roughly 14 square miles of disturbance. These data are almost always included in a Reclamation and Closure plan.

Revegetation Strategies and Goals – Section 2 states that "sites would be seeded for revegetation" and Section 4.22 does provide a very generic discussion of wetlands re-establishment. However, there are no maps or tables showing what types of vegetation will be established where, and there is not any discussion of seed mixes, seeding techniques or revegetation goals. Successful revegetation of the roughly 14 square miles of disturbance is one of the key requirements to return the land to beneficial post-mining use.

Drainage Re-establishment and Revegetation of Quarries – Section 4.14 states that quarry sites (873 acres) "would not undergo reclamation". No justification is given for why over a square mile of heavily impacted land will not be reclaimed in this extremely sensitive environment. At a minimum a free draining and revegetated landform needs to be re-established. This may require refining the quarry designs to minimize the impounding of water and importation of growth media to allow vegetation establishment on the large low-angle surfaces that are created.

Infrastructure Demolition and Material Disposal – Section 2 of the DEIS states that "all mill and support facilities not required for post-closure…… would be fully reclaimed in accordance with State of Alaska requirements". A very large amount of infrastructure would need to be demolished including truck shops, warehouses, explosives storage, rock crushers, the concentrator, tailings pipelines, more than three square miles of HDPE liner, excess employee housing, excess water treatment capacity and excess power generation capacity. Given the remoteness of the site, almost none of the construction debris is likely to have salvage value and it would all need to be disposed of on site. Although Section 2 does state that the debris would be placed in a specially designated landfill or into the open pit, there are not estimates of debris volumes or conceptual level designs for how it would be safely disposed.

Bulk Tailings Storage Facility (TSF) Recontouring – As stated in Section 2.0 "the bulk TSF would be closed by regrading its surface so that all drainage would be directed off". This regrading is clearly required to minimize infiltration and help ensure long-term tailings containment. However, the DEIS provides no detail on how this large and complex engineering project will be accomplished. As committed in Table 4.16-1 the TSF must be able to contain the potential maximum precipitation event plus the 1 in a 100-year snowpack during operation. At least 2000 feet of beach must also be maintained between the reclamation pond and the embankments. The fine tailings underlying the decant pond will also settle much more than the sands underlying the beaches when they consolidate at closure. Recontouring will almost certainly require tens of millions of cubic yards of material movement to create a free draining convex surface. Just to fill the depression capable of holding the extreme rainfall design event will require backfill of 17 million cubic yards (Knight Piesold 2018g) and the actual volume will almost certainly be much higher.

Bulk TSF Runoff Discharge Structure(s) – Section 2 states that “a spillway will be constructed from the bulk TSF”. This is a critical closure component, but no additional detail is provided. If the spillway failed during a large storm event or a series of events, subsequent erosion could destabilize the embankment and begin transporting tailings into the down-stream river systems. It will be challenging to create a stable, non-erosive spillway capable of transmitting even the 200-year 24-hour storm event with flows greater than 100,000 gallon per minute down a steep 20-degree embankment slope. Flows associated with the potential maximum precipitation event could be roughly five times larger.

Bulk TSF Cover Design and infiltration Modelling – Section 2 states that “the tailings surface would be covered with soil and/or rock and possibly a geomembrane or other synthetic material” and that “a low-permeability soil cover with the ability to support vegetation would be placed over the surface of the tailings”. While the Project Description (Appendix N) states “a capillary break and growth media will be placed over the surface of the tailings”. There are no conceptual level designs available for the proposed cover; no placeholder estimates of cover thickness and materials balances; and no estimates of how much they would (or should) reduce infiltration. Placement of a geomembrane liner over a 2475-acre area is likely to cost well in excess of $100 million. A soil cover is likely to be much less costly but is unlikely to cut infiltration to less than 20% of incident precipitation. Unless a very expensive and complex cover is constructed, seepage from the bulk tailings storage facility which requires treatment is likely to continue indefinitely at rates in excess of 1000 gpm. As stated in Section 2 “seepage water from the bulk TSF embankment SCPs would be collected and either treated in the WTPs or directed to the pit lake until determined to be suitable for discharge – anticipated after approximately year 50 post-closure”. However, even the relative low sulfide bulk tailings are likely to contain in excess of one million tons of sulfur at closure (0.1% S in 1100 million tons of tailings) which will almost certainly take much longer than 50 years to oxidize and be transported out of the tailings mass. It is unclear if the DEIS adequately accounts for this continued water treatment liability after year 50.

Other Embankment Recontouring to Re-Establish Drainage – Section 2 states that the pyritic TSF, main Water Management Pond (WMP) and associated seepage ponds “would be reclaimed, and surface water runoff from the area discharged to the downstream environment” and “embankments associated with reclaimed facilities would be breached and flattened”. Breaching of these embankments is a key closure requirement or they would remain water impounding structures forever and would cut off over three-square miles of surface runoff from the downstream river systems. Unfortunately, the tallest and widest portion of each embankment will lie directly over the existing natural drainage channels. The portion of the pyritic TSF embankment that would need to be removed will be 425 feet high, and the main WMP embankment would be 190 feet high. Preliminary estimates indicate that about 20% of the total embankment volume will need to be removed to establish a stable drainage pathway through the embankments. The steep 2:1 horizontal:vertical slopes of the WMP will also likely need to be reduced to at least 2.5:1 to ensure erosional stability and to allow topsoil placement and revegetation. In total roughly 40 million cubic yards of fill or more may need to be moved.

Management of Other Embankment Seepage – The WMP and pyritic TSF embankments will contain approximately 240 million tons of rock fill and cover roughly 900 acres. Laboratory testing confirms that the rock itself poses minimal risk of acidification. However, even at neutral pH some solutes in seepage water such as selenium, copper and sulfate are likely to exceed discharge criteria (SRK 2018; Geochemical Source Terms for Water Treatment Planning). Even more significantly, because the fill material will be composed of blasted bedrock, it is certain to contain residual blasting agent and to produce seepage water with nitrate concentrations one to two orders of magnitude above water quality requirements. This is particularly true of the significant portions of the embankment that will be covered by an HDPE liner during operation. Assuming a 20% infiltration rate for precipitation that falls on the reclaimed and revegetated embankments, roughly 500 gallons per minute of additional water are likely to require treatment for decades after physical reclamation is completed. This collection and treatment requirement does not appear to be included in the DEIS analysis.

Water Treatment Plant Practicability – The proposed closure water treatment plant design is very complex, still has significant uncertainties and is likely to have very high operating costs. Treatments steps include metals precipitation with lime, ferric chloride and other reagents, second-stage metals precipitation, clarification, ultrafiltration, nanofiltration, followed by multistage gypsum precipitation via lime addition, ultrafiltration and reverse osmosis. I am not aware of a treatment flowsheet of this complexity being applied to such high flows anywhere else in the world. By necessity the entire water treatment strategy is at best conceptual in nature and no laboratory or pilot scale tests have been completed. During an internal review of the proposed treatment processes conducted in October, 2018 (AECOM 2018i) it was stated that "it is difficult to fully assess the treatment process in a meaningful way without confidence in reliability of the design of the treatment process". Given the current uncertainties and inconsistencies in the treatment strategy, and the lack of even preliminary engineering drawings, designs and specifications, the ability of the proposed post-closure water treatment plant to meet required throughputs and discharge water quality requirements has not been demonstrated. These same deficiencies also exist for the operational water treatment plants which are, if anything, more complex than the proposed closure facilities.

Water Treatment Plant Replacement – It is likely that even with good preventative maintenance, the water treatment plant will need to be replaced several times within the first one hundred years of operation. This would be a complex and costly operation at the remote, closed site and needs to be considered in the Reclamation and Closure Plan.

Pipeline and Pump Layout for Perpetual Water Management– Pipelines and pumping infrastructure will be required to transport contaminated water from the open pit, and bulk TSF, pyritic TSF embankment and main water management pond embankment to the water treatment plant. As stated in Chapter 2 “The design of this system would need to be completed as part of the closure [plan].” Given the importance of this closure infrastructure, the Reclamation and Closure Plan will certainly need to have preliminary designs for post-closure seepage collection, pipe and pump station locations and requirements.

Support Infrastructure for Perpetual Water Treatment – In order to maintain and operate all water collection, transport and treatment infrastructure for the first one hundred years, a large number of support facilities will also be required. These will include a power plant, employee housing, workshops, more than 60 miles of road, ports and a ferry. Although mentioned in Chapter 2 no detail is provided as to how this infrastructure will be maintained and how frequently it will need to be replaced. Post-closure power demand is likely to be an order of magnitude lower than during operation and it is not clear that the large gas-fired power plant will be a practicable power source at closure.

Long-Term Environmental Monitoring and Maintenance – After closure there are certain to be ongoing long-term monitoring requirements for surface and groundwater quality, flow and water levels, water treatment plant performance, revegetation success, aquatic ecosystem health and landform erosion performance at many locations both within and down gradient from the disturbed footprint. There will also almost certainly be follow-up reclamation requirements for failed vegetation, erosion mitigation and potentially for water quality issues in some locations. However, no detail on this large body of work is provided in the DEIS, though it is acknowledged in Chapter 2 that “further detail would be developed in support of State permitting and the Reclamation Plan Approval requirements”.

Monitoring and Extraction Well Abandonment – There are likely to be hundreds of dewatering wells, water supply wells, monitoring wells and old exploration boreholes which will no longer be needed at closure. Although not mentioned in the DEIS, all of these boreholes will need to be properly sealed and abandoned.

Contaminated Sites Management – After several years of construction and twenty years of operation even a well-managed mine may create contaminated soil and groundwater sites via spills or leakage of reagents, hydrocarbons or contaminated mine contact waters from TSFs and water management ponds.

<u>Pebble Mine Closure Costs</u>

This section provides a preliminary conceptual-level estimate of closure costs for the 20-year mine plan described in the Pebble DEIS. It is based upon the assumptions and commitments made in the DEIS or, where these are lacking to address a strategic environmental risk or impact, upon mining industry standard closure practice. Closure costs are largely driven by the exceedingly large perpetual water treatment liability created by the 20-year mine plan. These are predicted to average more than 22,000 gallons per minute in early closure declining to more than 5000 gpm in perpetuity (50th percentile treatment requirements, Table 4.16-3). For the conceptual cost estimate water treatment is only considered for the first one hundred years, but in reality, it would likely be required for many centuries should the mine be developed. Cost estimates for individual closure components are summarized in the table below.

Total undiscounted physical closure costs which will be incurred in the first 20 years of closure are estimated to be approximately $500 Million. Total undiscounted water treatment costs which will be incurred in the first 100 years of closure are estimated to be approximately $4 Billion. When these costs are discounted to the year of closure using standard industry accounting practices (a generous risk-free discount rate of 3.5%) the total closure cost almost certainly exceeds $1.5 Billion and will likely exceed $2.0 Billion.

Table 1 – Preliminary Conceptual Level Closure Costs for the Pebble 20-Year Mine Case

Closure Activity	Estimated Cost	Notes
Move pyrite tailings to open pit	\$110 Million	155 Mt at 1.35 t/yd^3 at \$1.00/yd^3 for dredging (1)
Establish drainage through Pyrite TSF and main WMP	\$60 Million	20% of embankment fill moved (40 M yd^3) at \$1.53/yd^3
Move PAG waste rock to open pit	\$50 Million	50 Mt at 1.66 t/yd^3 at \$1.53/yd^3 for truck hauling
Bulk TSF recontouring to promote runoff	\$30 Million	17 M yd^3 at \$1.53/yd^3
Cover placement over bulk TSF interior	\$20 Million	Three ft soil cover over 2475 acres at \$1.53/yd^3
Infrastructure Demolition	\$20 Million	Demolition cost from Donlin Gold Mine 2017 Reclamation and Closure Plan (2)
Topsoil placement, surface preparation and seeding	\$10 Million	6 inches of topsoil on 7500 acres plus \$365/acre for surface prep and seeding (3)
Modification of pit water treatment plant	\$10 Million	Mean capital cost from MEND 2013 for membrane separation plants (4)
Environmental monitoring and maintenance	\$60 Million	20% of the annual operating environmental budget from Wardrop (2011) for 20 years (5)
Access Road Maintenance and Operation	\$40 Million	50% of Wardrop (2011) annual operational road maintenance budget per mile for 77 miles and 20 years
Direct Physical Closure Cost	\$410 Million	

Total Physical Closure Cost	**$520 Million**	**Direct costs plus 28% indirect costs for 20 years of physical closure works (6)**
Direct Water Treatment Cost	$3200 Million	DEIS estimated flows from each phase of closure with mean water treatment costs from MEND 2013 (7)
Total Water Treatment Cost	**$4100 Million**	**Direct costs plus 28% indirect costs for 100 years of water treatment**

(1) Recent average unit costs for bulk earth movement in closure and reclamation plans at the Donlin Mine and Pogo Mine (both SRK, 2017) generally exceeded $2/m^3$, sometimes by a factor of two. $2/m^3$ equates to $1.53/yd^3$ which is the value used for earthmoving cost estimates involving truck hauling. For dredging of pyritic tailings this was reduce to $1.00 /yd^3$ to account for the generally greater cost efficiencies of this method. (2) The Donlin Gold Mine Reclamation and Closure plan had a cost estimate of $22 million for demolition of all infrastructure. This was used as a proxy for demolition costs at Pebble. Actual costs at Pebble are likely to be significantly higher than at Donlin given the larger scale of the required infrastructure. (3) The estimated topsoil/growth media placement thickness of six inches is likely a bare minimum required for successful vegetation establishment and some areas such as the rock quarries will almost certainly require more. Unit costs per acre for ripping/scarifying and seeding are taken from the Pogo Mine Reclamation and Closure plan. (4) Canadian Mine Environmental Neutral Drainage Program (MEND) 2013 report "Review of Mine Drainage Treatment and Sludge Management Operations". (5) Wardrop, 2011, Preliminary Assessment of the Pebble Project, prepared for Northern Dynasty Minerals Ltd. (6) Indirect costs include contract administration, engineering design, insurance, contractor overhead and contingency. Indirect costs assumed in recently completed reclamation and closure plans average more than 30% of the direct costs (28.5% at Donlin, 30% at Chino, 37% at Rosemont, 38.5% at Pogo). (7) Water treatment cost are based upon the 50th percentile flows in DEIS table 4.16-3 for each of the four closure phases and average water treatment costs per thousand liters from a study of more than 100 water treatment plants which were predominantly located in the United States and Canada (MEND 2013 – see footnote 4). The average operation cost in the study was $1.54 per 1000 liters ($5.82 per 1000 gallons). In reality the Pebble water treatment strategy is much more complex than the average treatment plant in the review and so its costs are likely to be higher.

This closure cost estimate is almost certainly an underestimate of the actual closure costs for the proposed 20-year Pebble mine plan because of the conservative assumptions that were made and the many near-certain closure requirements that were not included. Potentially significant closure cost items which are not addressed in this estimate include:

- Employee severance costs when the mine initially closes and when major physical closure works are completed.

- General administration costs to staff, supply and oversee operations in a remote location for the first one hundred years.
- Water treatment and management costs that will be required after one hundred years. In reality water treatment will almost certainly be required for several centuries.
- Power plant operating costs and logistical costs to support a mine camp in a remote location for the first one hundred years.
- Infrastructure replacement costs to periodically build new water treatment plants, employee housing, power plants and other facilities to maintain water treatment for the first one hundred years.
- All environmental monitoring and maintenance activities after year-twenty.
- Costs to operate and maintain the access corridor after year-twenty including ports, ferries and more than 60 miles of roads.
- Initial capital costs for construction and subsequent operational pumping costs to transport water from the open pit, bulk TSF and reclaimed embankments to the water treatment plant.
- Spillway construction costs to safely transmit large storm events off of the bulk TSF in a non-erosive manner.
- Contaminated sites remediation costs.
- Closure costs to seal all monitoring, dewatering and water production wells.
- Major earthworks costs to ensure adequate drainage from, and vegetation establishment on, the 873 acres impacted by rock quarrying.
- Any costs required to stabilize the post-flooding pit walls and ensure they are not prone to failure and seiche wave generation during large seismic events.

Sincerely,

Richard K. Borden

Owner Midgard Environmental Services LLC

June 17, 2019

Shane McCoy
Program Manager
US Army Corps of Engineers
645 G Street
Suite 100-921
Anchorage, AK 99501

Subject: Pebble Mine Draft EIS Comments on Alternatives Analyses, Cumulative Effects, Water Management, Wetlands Mitigation and Air Quality

Dear Mr. McCoy,

The Draft Environmental Impact Statement (DEIS) analysis of alternatives, cumulative effects, water management, wetlands mitigation and air quality for the Pebble Project is clearly inadequate.

Much of the analysis contains insufficient detail to determine if the planned actions are adequate or practicable; the DEIS commonly understates potential impacts; essential analyses and designs are deferred to the post-EIS permitting period; and in a number of significant instances, its conclusions are clearly wrong. In particular:

- There are several important alternatives which could significantly reduce the environmental impacts and risks of the project which were either not evaluated or were eliminated prematurely. Conversely, the proposed 20-year mine plan was selected for evaluation despite the near certainty that it is not economically feasible. The financial analysis that has been provided for the 20-year mine plan is fatally flawed. It ignores smelter and refining costs, understates capital and operating costs and fails to provide even a placeholder cost for closure. With the incorporation of these corrections, the Pebble Limited Partnership financial evaluation has a strongly negative net present value.
- The impacts of the expanded 78-year mine plan are significantly understated in the cumulative effects analysis. For example, the expanded mine would almost certainly lead to measurable and permanent harm to fisheries in the Bristol Bay watershed even if everything were to go according to plan. The innate containment risks posed by the expanded mine plan are also substantially greater. If a large-scale catastrophic failure in tailings containment were to occur, the fish values throughout the Koktukli/Nushagak River System would almost certainly be profoundly and permanently damaged.

- Many of the water management strategies and systems described in the DEIS are flawed or lack sufficient design detail to evaluate if they are adequate and practicable to meet the required very high standard for water management. In particular the proposed water treatment strategy for the mine is extremely complex, still has significant uncertainties, and to my knowledge has not been attempted at this scale anywhere else in the world.
- It will be exceedingly difficult for Pebble to find any meaningful wetland mitigation projects of sufficient size within the Bristol Bay watershed because it is an unimpacted pristine environment which is not threatened by any large-scale development other than the Pebble Project itself. However, many of the mitigation actions presented in the DEIS are so poorly-defined that it is impossible to assess if they if they would provide adequate and meaningful mitigation for the project's significant impacts to an extremely sensitive environment.
- Air quality predictions for the mining operation appear to have omitted tailpipe emissions and thus may have excluded 97% of NOx emissions from the dispersion analysis. If this is correct, potential air quality impacts are grossly underestimated.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I have been involved in the strategic environmental design of several new mines. I have 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 published numerous papers on mine environmental performance and management in peer reviewed scientific journals, conference proceedings and books.

Alternatives Analysis

As detailed in Appendix B, the screening of different development options is intended to "determine reasonable and practicable options for detailed analysis in the EIS". However, there were several important alternatives which could significantly reduce the environmental impacts and risks of the project which were either not evaluated or were eliminated prematurely. This is evident in the anomalously small number of options which were actually selected for evaluation in the DEIS. Conversely the Pebble Limited Partnership's 180,000 tons per day (tpd) concentrator throughput case appears to have been approved without sufficient due diligence to determine if it meets the stated screening criteria that an option must be "practical or feasible from the technical and economic standpoint" (Appendix B).

Option TPD-001 - Option TPD-001 is the mining project proposed by the Pebble Limited Partnership (PLP) with concentrator throughput of 180,000 tons per day (tpd) for 20 years. This option forms the core basis of Action Alternative 1 in the DEIS. According to Appendix B this option has a positive Net Present Value (NPV) of approximately one billion dollars. The supporting documents for this estimate were provided by the PLP in response to Request for Information 059. The PLP NPV analysis is based on the 2011 financial evaluation completed by Wardrop (which the PLP has described as out of date) with minor modifications to account for the smaller mine plan. The PLP analysis is very preliminary and is based upon only two short spreadsheet pages of calculations. Even a cursory review of the estimate reveals several fatal flaws which wrongly increase the estimated 20-year project NPV:

- The PLP analysis is based on the original 2011 construction capital, sustaining capital and operating costs from the Wardrop Study. However, the PLP analysis fails to account for inflation from 2011 to today, which has totaled 13.8%. Cost inflation was ignored despite the fact that the PLP inflated the expected market value for metals sales by about ten percent compared to the Wardrop study. Accounting for inflation in sales revenue but ignoring inflation for costs is a fundamental accounting error which has a profound negative impact on the project NPV when it is corrected.
- The concentrate which is loaded at the port will need to be transported, smelted and refined before the final product can be sold. However, the PLP analysis fails to incorporate transport, smelting and refining charges into the economic analysis despite the fact that they are financially significant and clearly considered in the original Wardop study.
- The PLP analysis fails to provide even a placeholder cost to account for the large closure liability that will be created by the project. As detailed in the DEIS comment letter by Borden (May 31, 2019) the closure cost for the 20-year mine at Pebble is almost certain to exceed $1.5 billion and is likely to exceed $2.0 billion in the year of closure.

There are likely to be other errors in the PLP financial evaluation which would further erode project economics, but these three obvious issues alone reduce the NPV of the 20-year project by more than two billion dollars and make it strongly negative:

	NPV[1]
PLP financial estimate provided in Appendix B and RFI059 Responses	+$1.0 Billion
Construction capital increase to account for inflation since 2011	-$0.5 Billion
Operating expenditure and sustaining capital increase to account for inflation	-$1.0 Billion
Smelting and refining charges	-$0.5 Billion
Closure Costs	-$0.4 Billion
Partially corrected NPV based on initial PLP 2018 Assessment	**-$1.4 Billion**

1 The costs for each item were distributed appropriately over the four-year construction period, the twenty-year operating period and the first year of closure before being discounted at a seven percent rate.

As described in the comment letter by Borden (March 28, 2019) actual project NPV is likely closer to roughly negative three billion after 1) accounting for previously underestimated operational water treatment costs, 2) appropriately correcting for net smelter return and lower grades, and 3) incorporating the large additional capital and operating costs not included in the original 2011 Wardrop estimate such as pyritic tailings storage, quarries, extremely large contact water containment structures and the ferry. As such, the 20-year mine plan would almost certainly fail the DEIS alternatives screening criteria but even more importantly would not meet the overarching strategic goal to select the "least environmentally damaging practicable alternative". Despite this, there is no indication that the Army Corps of Engineers or its contractors performed any due diligence on the reliability of the PLP estimate. Although other mining options are rejected for analysis in the DEIS because they are considered uneconomic, Appendix B merely states that "Because this option [TPD-001] is included in the proposed project (Action Alternative 1) it is presumed to meet the three screening criteria for purposes of detailed environmental review."

Option LAY-005 - Option LAY-005 is based upon the smallest mine plan considered by the 2014 USEPA watershed assessment with total ore production of 230 million tons at 31,100 metric tpd. This development option only processes about 18% as much ore as Action Alternative 1 and was rejected as "not economically practicable" by the DEIS. Although no option-specific financial analysis was completed, this conclusion is certainly reasonable given the extremely large capital costs required for such a small project and the almost certain marginal economics of Action Alternative 1. However, no reasonable smaller mine options that were sized between this extremely small case and the proposed full plan were even considered.

Although I do not believe the 20-year mine plan is economically feasible, if the Army Corps of Engineers has chosen to evaluate it anyway, then a slightly smaller mine with significant reductions in environmental impact should also be considered for evaluation. For example, a mine plan with the planned ore production rate of 180,000 tpd but a mine life of only 16 years instead of 20 would produce 20% less ore than Action Alternative 1. However, because the lost production would occur from years 17 to 20, once a discount rate of 7% is applied to the potential lost revenue, this would likely only reduce overall project NPV by roughly 10%. The environmental benefits of producing only 1050 million ton of ore instead of 1300 million tons could be substantial including: 1) a potential two square mile (>1200 acre) reduction in total disturbed footprint for the bulk tailings storage facility, the pyrite tailings storage facility, the open pit, water management ponds and the quarry sites; 2) a substantial reduction in the final height of the bulk tailings impoundment which will reduce the in perpetuity risk of catastrophic failure; 3) a substantial reduction in water treatment requirements during operation and after closure; 4) a reduction in dewatering impacts associated with the open pit; 5) a reduction in impacts to surface water quality, flow regime and temperature due to water extraction, use and discharge 6) a roughly 20% reduction in the mass of pyritic tailings and potentially acid forming waste rock that must be returned to the open pit at closure; and 7) a shortening of the period of operational risk associated with spills, leakage, noise, air and greenhouse gas emissions from 20 to 16 years.

Option TSF-003 - Option TSF-003 which considered the use of paste tailings in the bulk tailings storage facility was eliminated because "Paste tailings are mostly placed in abandoned underground workings and have minimal surface TSF history and interest. A paste TSF would provide no meaningful environmental benefit above that of the proposed project". The rationale provided for the elimination of a paste tailings option from consideration is incorrect in several ways. Interest in large-scale use of paste and filtered tailings has been growing in recent years in response to several high-profile tailings dam failures. The Independent Expert Engineering Investigation and Review Panel for the Mount Polley TSF failure recommended that "best available technology should be actively encouraged for new tailings facilities" and strongly supported the use of filtered tailings for new impoundments. Both Toromocho in Peru and Minera Centinela in Chile are using paste tailings technology for their surface tailings dams at production rates of 120,000 and 100,000 tpd respectively.

The use of paste tailings at Pebble would also provide significant environmental benefits by reducing the initial volume of stored water within the tailings mass by fifteen percent or more compared to conventionally thickened tailings. Potential benefits include: 1) a more rapidly consolidated and stable tailings mass with lower geotechnical risk; 2) less contained pore water which will require long-term collection and treatment as the tailings slowly consolidate over decades after closure; 3) less makeup water demand for the mill, so that less water will need to be diverted from in-stream flow; 4) a potentially lower tailings dam because of more efficient storage of tailings solids; and 5) more rapid closure of the bulk tailings storage facility because of less settling and early vehicle accessibility on the final tailings surface.

Cumulative Effects

The cumulative effects analysis assumes an expansion of the Pebble project which processes 55% of the delineated resource over a 78-year period. This is the "Resource Case" which was evaluated by the Preliminary Assessment of the Pebble Project (Wardrop, 2011). It is also the same as the Pebble6.5 project subsequently evaluated by the Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay (USEPA, 2014). The cumulative effects analysis for this larger mine is of critical importance at Pebble because the 20-year mine plan being evaluated by the DEIS only processes 10% of the resource and is almost certainly not economically feasible (Borden DEIS comment letter dated March 28, 2019). If the 20-year mine was constructed it is almost certain that a much larger mine would ultimately be developed in an attempt to attain a positive rate of return on the initial investment.

The cumulative effects analysis presented in the DEIS contains insufficient detail, understates the impacts of a larger mine and, in some cases, its conclusions are clearly wrong. The impacts of the 78-year mine are discussed separately in each subsection of Section 4 in the DEIS. This fragmented presentation also makes it difficult for the reader to form a holistic understanding of the much larger impacts and risks posed by the larger mine. The table below compares some of the more significant differences between the 20- and 78- year mine plans.

	Action Alternative 1	Expanded Development Scenario	Relative increase
Direct Disturbance	14 square miles	> 46 square miles	3.3 times greater
Permanent Direct Wetland Disturbance	5.5 square miles	>19 square miles	3.5 times greater
Permanent Loss of Anadromous Fish Habitat	8.2 miles of stream and rivers	42 miles of streams and rivers	5 times greater
Bulk Tailings Production	1140 million tons	5700 million tons	5 times greater
Pyritic Tailings Production	155 million tons	800 million tons[1]	5 times greater
Non-Acid-Generating Waste Rock Production	95 million tons	13600 million tons[2]	140 times greater
Acid-Generating Waste Rock Production	50 million tons	3400 million tons	70 times greater
Fugitive Dust and Mobile Equipment Emissions	250,000 tons per day[3]	900,000 tons per day	3.6 times greater
Open Pit Footprint	608 acres	3600 acres	6 times greater
Maximum Pit Groundwater Inflow	2400 gallons per minute	12,000 gallons per minute[4]	5 times greater
Operational Spill Risk Duration	20 years	78 years	3.9 times greater
Green House Gas Emissions	>22 million tons of CO_2 equivalents[5]	>160 million tons of CO_2 equivalents	7 times greater

[1]Assumes same 12% split between whole tailings and pyrite tailings as described in the Pebble Project Description (Appendix N). [2]Assumes the same 20%/80% split between acid-generating and non-acid-generating waste rock as described in the Wardrop (2011) 25-year mine scenario. Note this results in about 1/3 less acid generating waste rock than assumed in the USEPA 2014 Bristol Bay Watershed Assessment. [3]Total tons of ore, waste rock and embankment fill rock that must be moved each day. The tons per day that must be moved is directly correlated with the amount of fugitive dust and vehicle tail-pipe emissions generated by blasting, loading, vehicle movement on haul roads, dumping and dozing. These sources contribute more than 90% of the emissions load calculated for the operation for NOx, CO and PM10 (Section 4.20). [4]Estimate from Section 4.16.7. [5]Greenhouse gas emissions for the 20-year mine plan are derived directly from the tables in Section 4.20. For the 78-year mine plan the emissions are modified from the 20-year case to account for the extra 58 years of operation, the 39% increase in mill throughput, the 3.6-fold increase in total rock movement due to much higher stripping ratios, and the roughly four billion tons of rock and tailings that must be returned to the open pit at closure.

As clearly shown in the table, most of the individual impacts of the larger mine will be at least three to seven times greater than for the small 20-year mine. However, the geochemical and water quality risks posed by the larger mine would be at least ten times greater. Many of these significantly greater impacts and risks are not identified in the DEIS. Key mischaracterizations in the cumulative effects analysis include:

Geochemical Risks – The total mass of tailings and waste rock that is prone to acid rock drainage formation rises from 205 million tons for the 20-year mine to 4200 million tons for the 78-year mine (a 20-fold increase). Given Pebble's extremely wet climate, all of this waste would pose an extremely high ARD risk to down gradient groundwater, streams and rivers. If not controlled the resultant ARD could have metals concentrations hundreds to tens of thousands of times higher than discharge criteria. All of this material would require complex and costly management during operation; and at closure all of this material would need to be returned to the open pit where it could be permanently saturated.

Closure costs for this material movement alone would likely exceed five billion dollars.

The total mass of tailings and waste rock that is prone to neutral drainage but with concentrations of nitrate, sulfate, copper, molybdenum and selenium elevated above discharge criteria rises from 1235 million tons for the 20-year mine to 19300 million tons for the 73-year mine (a 15-fold increase). This material would pose a lesser, but still significant risk to down gradient groundwater and surface water quality. Given the large increase in chemically reactive rock mass and surface area, and the decades longer exposure period of pit walls, waste rock and tailings before closure, net on-site contaminant release rates are almost certain to be an order of magnitude higher than for the 20-year mine.

If actually implemented as designed in the DEIS, the 20-year mine plan also confines most of the geochemical risks to a single drainage (North Fork Koktuli) but in the expanded case geochemical risks would spread into all three drainages (NFK, SFK and UTC). Despite this order of magnitude, long-term increase in geochemical risk it is not clearly highlighted and in some cases is significantly understated in the cumulative effects descriptions. Section 4.18.7 of the DEIS (Water and Sediment Quality Cumulative Effects) acknowledges that new facilities to store waste rock and tailings "would contribute to cumulative effects on water and sediment quality due to the nearly tripled footprint area and substantially larger duration of mining activity". However, this statement fails to acknowledge the 20-fold increase in geochemically reactive mineral waste and it also wrongly states that "the magnitude of cumulative impacts to water and sediment quality would generally be temporary".

Direct Disturbance – The DEIS consistently highlights a greater than three-fold increase in direct mine disturbance largely related to expanded open pit, tailings and waste rock storage facilities. However, this may significantly understate the required footprint expansion to safely mine and store roughly 16 times more ore, tailings and waste rock. In particular, the proposed mine layout for the 78-year case assumes that the pyritic TSF footprint expands by only 2.5 times despite the fact that this facility must hold five times more pyritic tailings and at least 70 times more acid generating waste rock. It is unclear how so much chemically reactive material could be safely stored under saturated conditions in such an exceedingly small footprint. If the 78-

year mine plan is not designed to store acid generating waste rock in the lined pyritic TSFs, this should be clearly stated because it would increase the acid rock drainage generation rates, water treatment liabilities and metals release to the environment by orders of magnitude.

Groundwater Impacts – The 78-year mine plan would result in at least 20 square miles of new unlined waste rock dumps and tailings embankments. It would also more than double the unlined footprint occupied by bulk tailings. Given the very wet climate, average infiltration rates into these new facilities during operation would almost certainly exceed 10,000 gallons per minute. Most of this water would undoubtedly perch at the bedrock contact or travel via the shallow weathered bedrock flow path where it could be more easily captured. However, some would enter the deeper bedrock flow regime where it would be much more difficult to contain. This would undoubtedly significantly increase the amount of contaminated groundwater that ultimately discharges into down gradient rivers and streams. However, this issue is not addressed in the cumulative effects discussion for Groundwater Hydrology or Water and Sediment Quality.

Water Management Impacts – The 78-year mine plan would result in at least three to five times more contaminated water to be collected and treated than would be required for the 20-year mine plan. This results from the more than three-fold increase in the footprint of the open pit, waste rock dumps and tailings storage facilities as well as a predicted five-fold increase in pit dewatering requirements (Section 4.17.7). Near the end of mine life this would result in an enormous water management liability of 40,000 to 65,000 gallons per minute on average. It would be extremely challenging and costly to consistently collect, store, treat and discharge this much contaminated water. The dewatering impacts and changes in flow regime and temperature would also be much more significant than for the 20-year mine. However, the cumulative effects assessment does not directly address this significant risk.

Geotechnical and Spill Risks – The 78-year mine plan would need to safely contain up to 6.5 billion tons of tailings during operation and 5.7 billion tons of bulk tailings in perpetuity after closure. This is a five-fold increase in the mass of tailings requiring management compared to the 20-year mine. As previously described, the mine would also need to continuously collect, store, treat and discharge at least three to five times more contaminated water. The number of separate storage and collection facilities would more than double. Bulk tailings, pyritic tailings, waste rock dumps, water storage ponds and seepage collection ponds would need to be located in upper Talarik Creek, South Fork Koktuli and North Fork Koktuli instead of a single drainage. All of these facilities would need to be operated for at least 78 instead of 20 years. The risks posed by catastrophic failure and the release of tailings or contaminated water are clearly substantially greater for the expanded mine case. Despite this, the cumulative effects discussion in Section 4.15.6 (Geohazards) states "The magnitude of potential geohazard-related impacts would be similar to the proposed project [the 20-year mine]……"; and Section 4.27.8 (Spill Risk) states "In summary, the cumulative effects of unintentional releases associated with the Pebble Mine Expansion would be similar to those discussed previously in this section [for the 20-year case], but potentially involve larger volumes over a slightly larger geographic area."

Air Emissions – The amount of waste rock, ore and construction fill that would need to be moved every day would increase from 250,000 tpd for the 20-year mine to 900,000 tons per day for the 78-year mine. This is mostly due to the large increase in waste rock stripping required for the expanded mine, but also because of the larger mill throughput planned. This 3.6-fold increase in daily materials movement would require a roughly similar increase in blasting, loading, trucking, dumping and dozing operations. Annual air emissions of NOx, CO and dust would almost certainly more than triple compared to the 20-year mine plan because they are almost entirely generated by mobile equipment and fugitive emissions. For example, particulate matter less than ten microns in diameter (PM10) would almost certainly increase from an estimated 3000 tons per year to over 10,000 tons per year at the mine. Among other impacts, this could have significant implications for metals loading into nearby streams and wetlands. Despite the clear increase in required material movement and air emissions associated with the mine expansion, Section 4.20.10 of the DEIS states "it is not anticipated that [expanded] mine operations would be meaningfully different than those analyzed for Alternative 1" and furthermore that "the expansion would result in similar magnitude, duration and geographic extent of the air quality impacts described under Alternative 1 for a given year". Both of these statements are clearly wrong.

Greenhouse Gas Emissions – The cumulative effects analysis in the DEIS does not address the roughly seven-fold increase in greenhouse gas emissions associated with the 78-year mine plan. This is largely driven by the massive increase in required waste rock stripping, higher mill throughputs, longer mine life and the need to move roughly four billion tons of acid generating waste rock and tailings back into the open pit at closure. During operation it is estimated that annual greenhouse gas emissions will increase from 940,000 tons of CO_2 equivalents to roughly 1,700,000 tons. Despite the clear increase in greenhouse gas emissions associated with the mine expansion, Section 4.20.10 of the DEIS states "it is not anticipated that [expanded] mine operations would be meaningfully different than those analyzed for Alternative 1" and furthermore that "the expansion would result in similar magnitude, duration and geographic extent of the air quality impacts described under Alternative 1 for a given year". Both of these statements are clearly wrong.

Fish Values – Under Section 4.24.6 Cumulative Effects for Fish Values it states that "These impacts [for the 78-year mine] would be similar to those described previously in this section [for the 20-year case] but take place over a geographic area combining components of Alternatives 1 and 3. With the mine expansion, the duration of these impacts would be extended by an additional 58 years of mining and 20 years of additional milling". This statement is clearly wrong and badly misleading given 1) the significant increase in cumulative impacts associated with direct disturbance, geochemical issues, water management and air emissions; 2) the significantly increased risk profile associated with catastrophic release of tailings and/or contaminated water associated with the 78-year mine case; and 3) the permanent harm which will be caused by the massively expanded bulk tailings impoundments, waste rock dumps, open pit and expanded water management infrastructure that would need to exist in perpetuity after closure. The 78-year expanded mine scenario would almost certainly lead to measurable and permanent harm to fisheries in the Bristol Bay watershed even if everything were to go according to plan. If a large-scale catastrophic failure in tailings containment were to occur the fish values throughout the Koktukli/Nushagak River System would almost certainly be profoundly and permanently damaged.

Water Management

Given the very high geochemical risk of the Pebble orebody, the extremely wet climate and the extreme sensitivity of the Bristol Bay watershed, water management at the proposed mine is an issue of critical importance. However, many of the water management strategies and systems described in the DEIS are flawed or lack sufficient design detail to evaluate if they are adequate and practicable to meet the required very high standard for water management. Several of these long-term water-related management issues and their deficiencies are discussed in an earlier DEIS commented letter (Borden May 31, 2019) which addresses closure issues. Problematic operational water management issues discussed in this letter include 1) water treatment practicability, 2) constructability and performance of water containment structures, 3) groundwater quality impacts, and 4) other water treatment requirements.

Water Treatment Practicability – The project proposes to construct and operate two water treatment plants capable of treating up to 19,000 gallons per minute. The proposed water treatment plant designs are extremely complex, still have significant uncertainties and are likely to have very high operating costs. Treatment technologies incorporated into the two plants vary but both include initial metals precipitation with lime, sodium hydroxide and other reagents, secondary metals precipitation using sodium hydrogen sulfide and other reagents, clarification and ultrafiltration. The open pit treatment plant also includes reverse osmosis and a biological reactor for selenium removal. The main water treatment plant also includes nanofiltration, followed by gypsum precipitation via lime addition, clarification, reverse osmosis and evaporation (Chapter 2 and Appendix K, 4.13). According to Section 4-18 of the DEIS “both facilities would employ treatment plant processes commonly used in mining and other industries around the world”. While this is certainly true of individual plant components, I am not aware of a treatment flowsheet of this complexity being applied to such high flows anywhere else in the World. The flows proposed for treatment are almost certainly higher than 90% of mine water treatment plants operating around the world today (MEND 2013, Review of Mine Drainage Treatment and Sludge Management Options). Most operating mine treatment plants also have much simpler treatment strategies, rather than the five to ten steps that must all be consistently be applied in sequence at Pebble. By necessity the entire water treatment strategy is at best conceptual in nature and no laboratory or pilot scale tests appear to have been completed. During an internal review of the proposed treatment processes conducted in

October, 2018 (AECOM 2018i) it was stated that "While lack of specific detail and apparent contradictory information in planning documents is assumed to be a result of the current stage of planning for the project, it is difficult to fully assess the treatment process in a meaningful way without confidence in reliability of the design of the treatment process". The DEIS also acknowledges that even if the plants can consistently operate as designed, solutes could still build up over time in the process water circuit. This could have significant negative environmental and operational consequences.

Given the current uncertainties and inconsistencies in the treatment strategy, the lack of engineering drawings, designs and specifications for review and the lack of any cost estimates, the ability of the proposed water treatment plants to consistently and reliably meet required throughputs and discharge water quality requirements in an economically practicable manner has not been demonstrated.

Constructability and Performance of Water Containment Facilities – The Main Water Management Pond and the Pyritic Tailings Storage Facility will be very large engineered structures covering about 1.5 and 1.7 square miles respectively. However, despite the importance of these facilities for water containment almost no information is provided on how they will be designed and constructed to prevent leakage.

The DEIS and its supporting documents repeatedly state that the two facilities will be "fully lined with HDPE and will be equipped with underdrains". This is insufficient detail to evaluate the effectiveness of the facilities to prevent leakage, to determine their constructability or to accurately predict likely leakage rates to groundwater. Both of these large facilities will contain contaminated water with many solutes that are orders of magnitude above allowable discharge limits. There will consistently be more than 100 feet of head on both liners and the streams immediately downgradient represent an extremely sensitive environmental receptor. In order to protect underlying groundwater and downgradient surface water quality a robust composite liner system with at least a synthetic liner, low permeability compacted soil layer (or equivalent) and a leak detection or pressure relief layer will almost certainly be required. A credible argument could also be made for a full double composite liner system given the extreme sensitivity of the environmental setting. However, it is unclear if such a composite liner system is even feasible because it is not known if there is a local low permeability soil source available. These liners will cover over three-square miles and are much larger than water storage ponds at most other operating mines. They will be extremely challenging to construct at such a large-scale. There will be significant construction and operation risks associated with wind damage, wet- and cold-climate construction, ice damage, freeze-thaw and damage from rock placement. Despite these significant risks the seepage analysis for the DEIS assumes a near-perfect installation with no liner defects. This is almost certainly over-optimistic given the challenging conditions at Pebble and the actual field performance of liners at many other sites around the world. The liner leakage rate assumed in the DEIS is only 30 gallons/acre/day. However, using the same reference cited by Knight Piesold (2018n), but assuming only one small hole in the liner per acre, could result in a leakage rate of 1000 gallons/acre day (Giroud and Bonaparte, 1989). This assumption alone would result in a profound change in loading rates to groundwater from the two facilities with an increase from 40 gallons per minute to 1400 gallons per minute.

The DEIS must clearly state the design of the planned liner system, must detail how such a large liner will be successfully installed and only then can informed assumptions be made about design leakage rates over the three-square mile area. The single leakage scenario detailed in Section 4.27.7 under spill risk only assumes liner leakage of 900 gpm for one month and is clearly significantly undersized compared to a scenario of a poorly installed or badly damaged liner which could leak at rates of 1400 gpm for years.

Groundwater Quality Impacts – As noted in the DEIS there will be mine-impacted water leakage to groundwater from the Bulk TSF, the pyritic TSF and the main water management pond. Though not sufficiently considered in the DEIS there will also be impacted water seepage to groundwater from beneath the two square miles of unlined embankment footprints, seepage collection ponds and from ore and low-grade ore stockpiles. All of these sources in total could result in several hundred gallons per minute of mine impacted water reaching the bedrock groundwater flow system even if all the proposed primary containment systems perform as intended. As discussed in the previous section on performance of containment facilities, if they do not perform as intended, leakage in excess of 1000 gpm could be possible. Nevertheless, the PLP has committed to the performance objective that there will be "no detectable seepage downgradient of the collection and pump back systems (Section 4.18). The mine plan depends upon seepage collection ponds, sumps, grout curtains and extraction wells to recapture the impacted groundwater before it can migrate offsite and discharge into surface streams and rivers. Unfortunately, even the most basic design features of these important facilities such as the likely depth and lateral extent of cutoff walls, grout curtains and sumps is not available for review and as acknowledged in Section 4.18 the containment system designs "are currently conceptual only". As such there is currently an insufficient level of design detail available to determine if the primary and secondary containment systems will be effective, adequate and practicable.

The weathered bedrock zone has relatively high hydraulic conductivities (geomeans of 10^{-3} to 10^{-4} cm/second) which appear to extend to depths of 300 to 500 feet below the ground surface (Appendix K 3.17). Much of the mine-impacted waters which enter the weathered bedrock aquifer could pass beneath the likely shallow sumps, seepage collection ponds and grout curtains, so pump back wells could prove critical for containment. However, as noted in Section 4.18 "the final location and spacing of pump back wells would be determined based on additional hydrogeologic investigation as design progresses". The designs of the primary and secondary containment systems for groundwater need to be developed in greater detail to determine if they are adequate to protect downgradient water resources and to allow likely impacts to sensitive receiving environments to be better quantified.

Other Water Treatment Requirements – The project will need to house up to 2000 employees during construction and 850 employees during operation. The DEIS acknowledges that sewage treatment plants will be needed at the mine and port, but no detail is provided on throughput, sizing or design. It is also likely that tens of employees will need to be housed on site in perpetuity after major closure works are completed, but there is no discussion of sewage treatment requirements after closure.

The DEIS also acknowledges that water treatment capacity will be needed on site during the construction period before significant water storage is available and before the permanent treatment plants are built. Section 4.18 states "before completion of the bulk TSF embankments and water management structures, all contact water not meeting water quality standards would be treated in modular water treatment plants and released". Section 2 describes these modular treatment plants as "high density sludge [lime] treatment with additional polishing steps if required". However, no additional design detail is provided for these modular plants in the DEIS and there is also no discussion of sewage treatment for 2000 employees during the construction phase. This will likely prove to be a very challenging period for water management because without storage capacity any interim water treatment systems would need to be designed to treat maximum flows during the wet season and during storm events. As such, any interim treatment plants would likely need to be significantly oversized compared to average flows.

Without additional detail on design and management of contaminated water during the construction period, it is impossible to determine if the project will be protective of downgradient water resources.

Wetlands Mitigation

Mitigation actions at Pebble will be critically important given the project's unavoidable, permanent large-scale impacts to an extremely sensitive and economically valuable receiving environment. Unfortunately, many of the actions presented in Section 5 and Appendix M are so poorly-defined that it is impossible to assess if they would provide adequate and meaningful mitigation for the project's impacts. In many cases the proposed "actions" are little more than statements of theoretical, generalized principles without any concrete detail; or they are only commitments that the actual designs and management strategies will be developed in the future.

For example, in Table 5-2 it states that "The project would propose fish habitat mitigation measures to enhance or create new habitat outside of the immediate project footprint". However, no actual potential mitigation projects are identified in the DEIS or in the Draft Conceptual Compensatory Mitigation Plan (CMP) (Appendix M). Instead the CMP just discusses generic evaluation criteria for the selection of currently unidentified mitigation projects at some time in the future. It will be exceedingly difficult for Pebble to find any meaningful mitigation projects of sufficient size within the Bristol Bay watershed because, at present, it is an unimpacted pristine environment unthreatened by any large-scale development other than the Pebble Project itself. As acknowledged in the CMP restoration, enhancement and preservation options anywhere in the vicinity of the mine are likely unavailable.

Table 5-2 also states that “Where feasible, mine facilities would be reclaimed in such a manner as to create new wetland areas and ponds”. No additional detail is provided on the location or even the approximate surface area of wetlands that might be re-established to mitigate the planned permanent loss of 3500 acres during mine construction and operation. As detailed in an earlier comment letter (Borden, May 31, 2019) no meaningful detail on closure or revegetation techniques is provided within the DEIS.

The EIS must include more detail on concrete and credible mitigation actions capable of offsetting the large-scale unavoidable impacts to the extremely sensitive Bristol Bay environment.

<u>Air Quality Predictions</u>

According to the project emissions inventory (Section 4.20) the mine will emit 4436 tons of NOx, 2970 tons of CO, 645 tons of $PM_{2.5}$ and 337 tons of volatile organic compounds each year during operation. The effect of these emissions on the surrounding airshed has been predicted with dispersion modelling. However as detailed in Appendix K4.20 and in the response to Request for Information 009, it appears that the dispersion modelling did not consider the impact of tailpipe (mobile) emissions on the surrounding airshed. If tailpipe emissions from haul trucks and other mobile equipment has truly been omitted from the dispersion modelling, this represents a fatal flaw in the air quality predictions, particularly for nitrogen oxides. The DEIS emissions inventory indicates that 97% of all NOx emissions from the mine result from tailpipe emissions. Tailpipe emissions also account for 89% of CO, 25% of $PM_{2.5}$ and 90% of volatile organic compounds. Air quality impacts are likely to be much greater than currently implied by the DEIS and it may be much more difficult for the project to meet air quality standards than currently assumed. If tailpipe emissions were excluded from the dispersion modelling, the current air quality predictions are clearly inadequate and new modelling would need to be performed with the tailpipe emissions incorporated.

Sincerely,

Richard K. Borden
Owner Midgard Environmental Services LLC

June 18, 2019

Shane McCoy
Program Manager
US Army Corps of Engineers
645 G Street
Suite 100-921
Anchorage, AK 99501

Subject: Pebble Mine Draft Environmental Impact Statement Summary Comments

Dear Mr. McCoy,

Based on a careful review of the Pebble Mine Draft Environmental Impact Statement (DEIS), it is my professional opinion that the document and associated analysis is fatally flawed.

The DEIS contains an unacceptable number of deficiencies, omissions and errors for such a large, complex project in an extremely sensitive environment. Due to the global significance of the salmon fishery, any EIS within the Bristol Bay watershed should be held to the highest standard, but the Pebble DEIS does not even meet industry standard practice. I would strongly urge the Army Corps of Engineers to restart the DEIS process with an analysis based on an economically-credible mine plan, supported by an independent and rigorous economic analysis demonstrating that it is the "least environmentally damaging practicable alternative" (LEPDA).

This conclusion is based upon my more than thirty years of experience as an environmental and permitting specialist in the mining and consulting industries. Flaws in the DEIS are detailed in five separate comment letters from Richard K. Borden to the Army Corps of Engineers dated March 4, March 28, May 13, May 31 and June 17, 2019. This final letter provides an integrated overview of my concerns, without superseding any of the specific comments contained in these earlier letters.

The 20-year mine plan evaluated by the DEIS is almost certainly not economically feasible and therefore does not represent the least environmentally damaging <u>practicable</u> alternative for analysis. If the 20-year mine was constructed it is almost certain that a much larger mine would ultimately be developed in an attempt to attain a positive rate of return on a very large and risky initial investment. However, the cumulative effects evaluation of the more-credible 78-year mine plan significantly understates and, in some cases, grossly underestimates the much larger impacts and risks associated with an expanded mining operation. There are also several important alternatives which could significantly reduce the environmental impacts and risks of the project which were either not evaluated or were eliminated prematurely.

Much of the analysis contains insufficient detail to determine if the planned actions are adequate or practicable; the DEIS commonly understates potential impacts; essential analyses and designs are deferred to the post-EIS permitting period; and in a number of significant instances, the conclusions are clearly wrong. The analysis of key project components such as water management, geotechnical stability, reclamation & closure, wetlands mitigation and air quality are clearly inadequate. In particular the failure to consider the profound impacts that would result from large-scale catastrophic tailings dam failure means that the DEIS ignores one of the largest environmental risks posed by the project. The DEIS was completed in less than half the time typical for other mining projects, so it is unsurprising that it bears many of the hallmarks of an overly rushed process.

The DEIS as it is currently written cannot support the statement that "measurable impacts to salmon populations would be unlikely". The smaller mine will likely result in lesser impacts if everything goes exactly according to plan, but this is unlikely given the complexity of, and very high risks posed by, the proposed development. However, the expanded mine scenario is certain to lead to measurable, significant and permanent harm to fisheries in the Bristol Bay watershed. If a large-scale failure of tailings containment were to occur under either mine scenario, the fish values throughout the Koktuli/Nushagak River system would almost certainly be profoundly and permanently damaged.

Given the substantial flaws in the DEIS, I would strongly urge the Army Corps of Engineers to restart the process with an analysis based on an economically-credible mine plan, supported by an independent, rigorous economic analysis demonstrating that the project is the least environmentally damaging practicable alternative. The EIS process will be severely compromised if the deficiencies of the current document are not fully addressed; this would almost certainly require, as a minimum, the completion of a Supplemental Environmental Impact Statement, recirculated in draft for public comment.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I have been involved in the strategic environmental design of several new mines. I have 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 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.

Project Economics

The 20-year mine plan being evaluated by the Pebble Mine EIS process is almost certainly not economically feasible. It only targets about ten percent of the total resource and by necessity must process relatively low-grade ore. It only produces half as much metal for sale as the smallest mine plan economic evaluation which is publicly available (Wardrop, 2011, Preliminary Assessment of the Pebble Project). Based upon an independent analysis of project economics, the mine plan being evaluated by the DEIS has been estimated to have a net present value of roughly negative three billion dollars (Borden, 28 March). Furthermore, the closure of even this relatively small mine is almost certain to cost in excess of 1.5 billion additional dollars (Borden, 31 May). The conceptual financial analysis for the 20-year mine plan provided in the DEIS is fatally flawed. It ignores smelter and refining costs, understates capital and operating costs and fails to provide even a placeholder cost for closure. With the incorporation of just these limited corrections, the Pebble Limited Partnership financial evaluation also has a strongly negative net present value. The DEIS is thus evaluating a mine plan that does not meet its own alternatives screening criteria including the requirement that each alternative be "practical or feasible from the technical and economic standpoint".

If the base case mine plan assumed for the EIS is not economic, then the entire permitting process is compromised because the impacts and risks being evaluated are much smaller than those that would be required for a full-scale economically viable project. In other words, the EIS is not evaluating the "least environmentally damaging practicable alternative". Even a relatively small expansion of the current plan to match the smallest scenario evaluated by Wardrop (a 25-year mine) would more than double most environmental impacts and would increase geochemical/water quality risks by a factor of four.

Cumulative Effects Analysis

The cumulative effects analysis for the expanded mine case evaluated in the DEIS contains insufficient detail, understates the impacts of a larger mine and in some cases its conclusions are clearly wrong. Most of the individual impacts and risks for the 78-year mine will be at least three to seven times greater than for the small 20-year mine (Borden, 17 June). However, the geochemical and water quality risks posed by the larger mine will be at least ten times greater. The mine would also need to manage five times more tailings and one hundred times more waste rock with an associated increase in the risk of catastrophic containment failure. It is certain that this larger mine would lead to measurable, significant and permanent harm to fisheries in the Bristol Bay watershed even if everything were to go according to plan.

Geotechnical and Spill Risks

Given the very high innate geotechnical risk of the Pebble Mine setting and the extreme sensitivity of the downstream receiving environment, the DEIS analysis of tailings and untreated water release is clearly inadequate (Borden, 13 May). The DEIS fails to definitively demonstrate the geotechnical stability of tailings embankments, water storage facilities and pit walls throughout operation and closure.

Large-scale catastrophic release of tailings and contact water is one of the most significant risks posed by the Pebble Project and the DEIS' intentional failure to evaluate the impacts of any catastrophic release events cannot be justified. By ignoring all potential catastrophic failure events, the release scenarios evaluated by the DEIS are anomalously small, representing only 1) 0.004% of produced bulk tailings that must be contained on-site forever; 2) 0.6% of produced pyritic tailings that must be contained on-site during operation; and 3) 0.4% of untreated process water that must be contained on-site during operation. Even a release of just five percent of the bulk or pyritic tailings is likely to have profound, permanent negative impact on downstream aquatic ecosystems and fisheries.

Reclamation and Closure

Despite the significant post-operational environmental impacts and risks at Pebble, no Reclamation and Closure Plan has been completed and the closure analysis within the DEIS is clearly inadequate (Borden, 31 May). The lack of even a conceptual level plan is a particular concern because closure of the 20-year Pebble mine will be complex and very costly (almost certainly exceeding 1.5 billion dollars). Water treatment for flows in excess of 5000 gallons per minute will likely be required for centuries after mining is completed. Completion of a Reclamation and Closure plan during the EIS process is common practice within the mining industry. A pertinent recent example is the Donlin Gold Project in Alaska, whose EIS was led by the Army Corps of Engineers, which completed a 458-page plan with a detailed cost estimate during its EIS process.

There are a large number of closure-related omissions, errors and uncertainties within the DEIS and its supporting documents that make it impossible to assess long-term impacts and risks, or even to determine if the proposed closure strategies are practicable. Key problem areas include: topsoil management, revegetation strategies and goals, reclamation of quarries, infrastructure demolition, bulk tailings storage facility (TSF) recontouring, bulk TSF cover design, bulk TSF runoff structure design, embankment recontouring to re-establish drainage, embankment seepage management, water treatment plant practicability and perpetual water management infrastructure.

Wetlands Mitigation

Mitigation actions at Pebble will be critically important given the project's unavoidable, permanent large-scale impacts to an extremely sensitive and economically valuable receiving environment. Unfortunately, many of the actions presented in the DEIS are so poorly-defined that it is impossible to assess if they would provide adequate and meaningful mitigation for the project's impacts (Borden, 17 June). For example, the DEIS states that "The project would propose fish habitat mitigation measures to enhance or create new habitat outside of the immediate project footprint". However, no actual potential mitigation projects are identified in the DEIS or in the Draft Conceptual Compensatory Mitigation Plan (CMP) (Appendix M). Instead the CMP only discusses generic evaluation criteria for the selection of currently unidentified mitigation projects to be identified at some future time. It will be exceedingly difficult for Pebble to find any meaningful mitigation projects of sufficient size within the Bristol Bay watershed because it is an unimpacted pristine environment currently unthreatened by any large-scale development other than the Pebble Project itself.

Water Management

Given the very high geochemical risk of the Pebble orebody, the extremely wet climate and the extreme sensitivity of the Bristol Bay watershed, water management at the proposed mine is an issue of critical importance. The DEIS estimates that an average of 13,000 gallons per minute of water will require very costly and complex treatment during operation and up to 22,000 gallons per minute on average will need to be treated during closure. Under the 78-year mine scenario, the water management liability would increase to 40,000 to 65,000 gallons per minute on average near the end of mine life. I am not aware of a treatment flowsheet of this complexity being applied to such high flows anywhere else in the world. Many of the water management strategies and systems described in the DEIS are flawed or lack sufficient design detail to evaluate whether they are adequate and practicable to meet the required very high standard for water management (Borden, 17 June). Problematic water management issues include but are not limited to 1) water treatment practicability, 2) constructability and performance of water containment structures, 3) groundwater quality impacts, and 4) water treatment requirements during construction.

Air Quality Predictions

It appears that air quality dispersion modelling did not consider the impact of tailpipe (mobile) emissions on the surrounding airshed (Borden, 17 June). If tailpipe emissions from haul trucks and other mobile equipment have truly been omitted from the dispersion modelling, this represents a fatal flaw in the air quality predictions, particularly for nitrogen oxides (NOx). The DEIS emissions inventory indicates that 97% of all NOx emissions from the mine result from tailpipe emissions. Air quality impacts are likely to be much greater than currently implied by the DEIS and it may be much more difficult for the project to meet air quality standards than currently assumed.

Sincerely,

Richard K. Borden

Owner Midgard Environmental Services LLC