Pebble Project

Preliminary Economic Assessment

NI 43-101 Technical Report

Pebble Project, Alaska, USA

Effective Date: September 9, 2021

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Important Notice

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1 SUMMARY

1.1 Introduction

The Pebble deposit was originally discovered in 1989 and was acquired by Northern Dynasty Minerals Ltd. (Northern Dynasty) in 2001. Since that time, Northern Dynasty and, subsequently, the Pebble Limited Partnership (Pebble Partnership) in which Northern Dynasty currently owns a 100% interest, have conducted significant mineral exploration, environmental baseline data collection, and engineering studies to advance the Pebble Project (the Project).

Since the acquisition by Northern Dynasty, exploration has led to an overall expansion of the Pebble deposit, as well as the discovery of several other mineralized occurrences along an extensive northeast-trending mineralized system underlying the property. Over 1 million feet of drilling has been completed on the property, a large proportion of which has been focused on the Pebble deposit.

Comprehensive deposit delineation, environmental, socioeconomic and engineering studies of the Pebble deposit began in 2004 and continued through 2013. As described in previous technical reports, the estimates indicate that the Pebble deposit contains significant amounts of copper, gold, molybdenum, silver, and rhenium.

In December 2017, Pebble Partnership filed an application for permits under the Clean Water Act (CWA) and River and Harbors Act (RHA), triggering the requirement for an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA). The EIS was prepared by the US Army Corps of Engineers (USACE) with the Final EIS (FEIS) published in July 2020. The Project Description required under NEPA was updated during the EIS process. The final version, which was submitted with the Revised Project Application in June 2020, is attached to the FEIS. In November 2020, USACE issued its Record of Decision (ROD) denying Pebble Partnership's application. Pebble Partnership submitted a Request for Appeal (RFA), which was accepted by USACE in February 2021 and the request is currently under adjudication.

In September 2020, Northern Dynasty published a Technical Report on the Project. The purpose of that report was to document recent studies of the occurrence of rhenium and to estimate the rhenium mineral resources in the deposit. Previous work also determined palladium is present, at least in parts of the deposit; however, insufficient analyses have been completed to date to undertake a resource estimate for that metal. The report also updated the proposed plan for the Project as documented in the FEIS. In March 2021, Northern Dynasty published a Technical Report that updated the status of the Appeal of the ROD. Information on closure was added to the Project Description and Permitting Section.

The purpose of this Preliminary Economic Assessment (2021 PEA) is to present the projected economics of the production plan and a corresponding project configuration which aligns with the June 2020 Revised Project Application (the Proposed Project). The 2021 PEA also explores potential expansion scenarios for the Project. The 2021 PEA is based on, and no changes have been made to, the resource estimate from the September 2020 Technical Report.

1.2 Forward Looking Information and Other Cautionary Factors

The 2021 PEA includes certain statements that may be deemed "forward-looking statements" under the United States Private Securities Litigation Reform Act of 1995 and under applicable provisions of Canadian provincial securities laws. All statements in the 2021 PEA, other than statements of historical facts, which address permitting, development and production for the Project are forward-looking statements. These include statements regarding:

- the mine plan for the Project, the financial results of the 2021 PEA, including net present value and internal rates of return, and the ability of the Pebble Partnership to secure the financing to proceed with the development of the Project, including any stream financing and infrastructure outsourcing;
- the social integration of the Project into the Bristol Bay region and benefits for Alaska;
- the political and public support for the permitting process;
- the ability to successfully appeal the negative Record of Decision and secure the issuance of a positive Record of Decision by the U.S. Army Corps of Engineers and the ability of the Pebble Project to secure all required Federal and State permits;
- the right-sizing and de-risking of the Project, including any determination to pursue any of the expansion scenarios for the Pebble Project or to incorporate a gold plant;
- the design and operating parameters for the Project mine plan, including projected capital and operating costs;
- exploration potential of the Project;
- future demand for copper and gold and the metals prices assumed for the financial projections including the 2021 PEA;
- the potential addition of partners in the Project; and
- the ability and timetable of Northern Dynasty to develop the Project and become a leading copper, gold and molybdenum producer.

Although Northern Dynasty believes the expectations expressed in these forward-looking statements are based on reasonable assumptions, such statements should not be in any way be construed as guarantees that the Project will secure all required government permits, establish the commercial feasibility of the Project, achieve the required financing or develop the Project. Such forward-looking statements or information related to the 2021 PEA include but are not limited to statements or information with respect to the mined and processed material estimates; the internal rate of return; the annual production; the net present value; the life of mine (LOM); the capital costs, operating costs estimated for each of the Proposed Project and the potential expansion scenarios for the Project; and other costs and payments for the proposed infrastructure for the Project (including how, when, where and by whom such infrastructure will be constructed or developed); projected metallurgical recoveries; plans for further development, and securing the required permits and licenses for further studies to consider expansion of the operation; and market price of precious and base metals; or other statements that are not statement of fact.

Forward-looking statements are necessarily based upon a number of factors and assumptions that, while considered reasonable by Northern Dynasty as of the date of such statements, are inherently subject to significant business, economic and competitive uncertainties and contingencies. Assumptions used by Northern Dynasty to develop forward-looking statements include:

- the Project will obtain all required environmental and other permits and all land use and other licenses without undue delay;
- any feasibility studies prepared for the development of the Project will be positive;

- Northern Dynasty's estimates of Mineral Resources will not change, and Northern Dynasty will be successful in converting Mineral Resources to Mineral Reserves;
- Northern Dynasty will be able to establish the commercial feasibility of the Project; and
- Northern Dynasty will be able to secure the financing required to develop the Project.

The likelihood of future mining at the Project is subject to a large number of risks and will require achievement of a number of technical, economic and legal objectives, including:

- obtaining necessary mining and construction permits, licenses and approvals without undue delay, including without delay due to third party opposition or changes in government policies;
- finalization of the mine plan for the Project;
- the completion of feasibility studies demonstrating that any Pebble Project mineral resources that can be economically mined;
- completion of all necessary engineering for mining and processing facilities;
- the inability of Northern Dynasty to secure a partner for the development of the Project; and
- receipt by Northern Dynasty of significant additional financing to fund these objectives as well as funding mine construction, which financing may not be available to Northern Dynasty on acceptable terms or on any terms at all.

Northern Dynasty is also subject to the specific risks inherent in the mining business as well as general economic and business conditions, such as the current uncertainties with regard to COVID-19. Investors should also consider the risk factors identified in its Annual Information Form for the year ended December 31, 2020, as filed on SEDAR and included in the Company's annual report on Form 40-F filed by the Company with the SEC on EDGAR.

The NEPA EIS process requires a comprehensive "alternatives assessment" be undertaken to consider a broad range of development alternatives, the final project design and operating parameters for the Project and associated infrastructure may vary significantly from that currently contemplated. As a result, the Company will continue to consider various development options and no final project design has been selected at this time, and no determination has been made to pursue any of the potential expansion scenarios identified in the 2021 PEA.

For more information on Northern Dynasty, investors should review Northern Dynasty's filings with the United States Securities and Exchange Commission at www.sec.gov and its home jurisdiction filings that are available at www.sedar.com.

1.3 Project Setting

The Pebble deposit is located in southwest Alaska, approximately 200 miles southwest of Anchorage, 17 miles northwest of the village of Iliamna, 100 miles northeast of Bristol Bay, and approximately 60 miles west of Cook Inlet (Figure 1-1).

Figure 1-1: Property Location Map

Note: Prepared by NDM, 2021.

1.4 Property Description

Northern Dynasty holds, indirectly through Pebble East Claims Corporation and Pebble West Claims Corporation, wholly-owned subsidiaries of the Pebble Partnership, a 100% interest in a contiguous block of 2,402 mining claims and leasehold locations covering approximately 417 square miles (which includes the Pebble deposit).

1.5 Project Description

On December 22, 2017, the Pebble Partnership submitted its permit application under the CWA and RHA. The Project Description in the permit application envisaged the Pebble deposit would be developed as an open pit mine with associated on and off-site infrastructure. Over the course of the subsequent 30 months, additional engineering work completed to support the environmental assessment process, as well as recommendations from USACE in the FEIS, resulted in some modifications to the plan and the Project Description was updated accordingly. The Proposed Project as described in the 2021 PEA corresponds to the Project Description issued with the June 2020 Revised Project Application, which is attached to the FEIS. Project infrastructure includes:

- a 270-megawatt (MW) power plant located at the mine site;
- a 6-MW power plant located at the marine terminal;
- a 164-mile natural gas pipeline connecting existing supply on the Kenai Peninsula to the power plants at the marine terminal and mine sites, respectively;
- an 82-mile transportation corridor from the mine site to the marine terminal, located north of Diamond Point in Iliamna Bay on Cook Inlet, consisting of:
    - a private two-lane unpaved road that also connects to the existing Iliamna/Newhalen road system;
    - the on-shore portion of the natural gas pipeline, buried adjacent to the road;
    - a concentrate pipeline to transport copper-gold concentrate from the mine site to the port with a return water pipeline to the mine site, both buried adjacent to the road;
- a marine terminal incorporating:
    - concentrate dewatering, storage and handling;
    - fuel and supply storage; and
    - barge docks for receiving supplies and to facilitate bulk transhipment of concentrate to an offshore location in Iniskin Bay for loading onto bulk carriers.

The mine site layout is shown in Figure 1-2.

Figure 1-2: Mine Site Layout

Source: NDM, 2021

Following four and a half years of construction activity, the Proposed Project would operate for 20 years, with conventional drill-blast-shovel-truck operations in an open pit feeding a conventional copper porphyry flotation process plant. The mining rate would average approximately 70 million tons per year, with 66 million tons of mineralized material processed through the process plant each year (180,000 tons per day), for an extremely low life-of-mine waste to mineralized material ratio (strip ratio) of 0.12:1.

The development proposed in Pebble Partnership's Project Description is substantially smaller than previous iterations, and presents significant new environmental safeguards, including:

- a development footprint less than half the size previously envisaged;
- the consolidation of most major site infrastructure in a single drainage (the North Fork Koktuli River) and the absence of any primary mine operations in the Upper Talarik Creek drainage;
- more conservative tailings storage facility (TSF) designs, including enhanced buttresses, flatter slope angles and improved factors of safety;
- separation of pyritic tailings, which are potentially acid generating (PAG), from bulk tailings (non-PAG), with the pyritic tailings stored in a fully-lined TSF;

- a comprehensive tailings and water management plan including a flow through design for the bulk TSF main embankment;
- no permanent waste rock piles; and
- no secondary gold recovery plant.

The development plan outlined in the Proposed Project uses a portion of the currently estimated Pebble mineral resources. This does not preclude future development of additional resources, but such development would require additional evaluation and would be subject to separate permitting processes.

1.6 Mineral Tenure, Surface Rights, Water Rights, Royalties and Agreements

Northern Dynasty currently does not own any surface rights associated with the mineral claims that comprise the Pebble property. All mineral claims are on lands held by the State of Alaska and surface rights may be acquired from the State once areas required for mine development have been determined and permits awarded.

The access corridor is owned by a number of landowners, including the State of Alaska, Alaska Native Village Corporations, and private individuals. Pebble Partnership has completed access agreements with two Native Village Corporations and a private individual. Under the terms of these agreements, the Native Village Corporations could receive significant sums over the life of the mine. Negotiations have advanced with other Native Village Corporations and individuals, but no agreements are in place. In June 2021, one of the Native Village Corporations announced they had signed an agreement whereby a fund has obtained an option to buy portions of their land to create a conservation easement. The fund must exercise its option by the end of 2022. If the fund closes this agreement with the Native Village Corporation, Pebble Partnership would be required to identify an alternate route to the proposed marine terminal on Cook Inlet.

A portion of the mineral claims are subject to a Net Profits Interest (NPI) royalty payable to Teck Resources Limited (Teck). However, the portion of the deposit to be mined by the Proposed Project lies outside the portion subject to the NPI and is therefore not subject to the Teck royalty. The Project is subject to a State of Alaska royalty.

The Pebble Performance Dividend LLP will distribute a 3% Net Profits Royalty Interest in the Project to adult residents of Bristol Bay villages that have subscribed as participants. The Pebble Performance Dividend will distribute a guaranteed minimum annual payment of US$3 million each year the Pebble mine operates beginning at the outset of construction. Total life of mine payments for the Proposed Project could total approximately $200 million to $240 million and could range as high as almost $3.7 billion for the life of the Potential Expansion Scenarios with a gold plant.

The Pebble property is within the Lake and Peninsula Borough and is subject to a 1.5% severance tax. The life of mine severance tax payments for the Proposed Project could total approximately $480 million and range as high as $4.5 billion for the life of the Potential Expansion Scenarios with a gold plant.

Accordingly, the Project could potentially provide more than $8 billion to the Southwest Alaska region through the Pebble Performance Dividend and the Lake and Peninsula Borough severance tax over the life of the potential expansion scenarios. This is in addition to the other significant benefits that could flow from the existing and possible future agreements with Alaska Native Village Corporations.

1.7 Geological Setting and Mineralization

Pebble is a porphyry-style copper-gold-molybdenum-silver-rhenium deposit that comprises the Pebble East and Pebble West zones of approximately equal size, with slightly lower-grade mineralization in the center of the deposit where the two zones merge. The Pebble deposit is located at the intersection of crustal-scale structures that are oriented both parallel and obliquely to a magmatic arc which was active in the mid-Cretaceous and which developed in response to the northward subduction of the Pacific Plate beneath the Wrangellia Superterrane.

The oldest rock within the Pebble district is the Jurassic-Cretaceous age Kahiltna flysch, composed of turbiditic clastic sedimentary rocks, interbedded basalt flows and associated gabbro intrusions. During the mid-Cretaceous (99 to 96 Ma), the Kahiltna assemblage was intruded first by approximately coeval granodiorite and diorite sills and slightly later by alkalic monzonite intrusions. At approximately 90 Ma, hornblende diorite porphyry plutons of the Kaskanak batholith were emplaced. Copper-gold-molybdenum-silver-rhenium mineralization is related to smaller granodiorite plutons and dykes that are similar in composition to, and emplaced near and above the margins of, the Kaskanak batholith.

The Pebble East and Pebble West zones are coeval hydrothermal centers within a single magmatic-hydrothermal system. The movement of mineralizing fluids was constrained by a broadly vertical fracture system acting in conjunction with a hornfels aquitard that induced extensive lateral fluid migration. The large size of the deposit, as well as variations in metal grade and ratios, may be the result of multiple stages of metal introduction and redistribution.

Mineralization in the Pebble West zone extends from surface to approximately 3,000 ft deep and is centered on four small granodiorite plutons. Mineralization is hosted by flysch, diorite and granodiorite sills, and alkalic intrusions and breccias. The Pebble East zone is of higher grade and extends to a depth of at least 5,810 ft; mineralization on the eastern side of the zone was later dropped 1,970 to 2,950 ft by normal faults which bound the northeast-trending East Graben. The Pebble East zone mineralization is hosted by granodiorite plutons and dykes, and by adjacent granodiorite sills and flysch. The Pebble East and West zone granodiorite plutons merge at depth.

Mineralization at Pebble is predominantly hypogene, although the Pebble West zone contains a thin zone of variably developed supergene mineralization overlain by a thin leached cap. Disseminated and vein-hosted copper-gold-molybdenum-silver-rhenium mineralization, dominated by chalcopyrite and locally accompanied by bornite, is associated with early potassic alteration in the shallow part of the Pebble East zone and with early sodic-potassic alteration in the Pebble West zone and deeper portions of the Pebble East zone. Rhenium occurs in molybdenite and high rhenium concentrations are present in molybdenite concentrates. Elevated palladium concentrations occur in many parts of the deposit but are highest in rocks affected by advanced argillic alteration. High-grade copper-gold mineralization also is associated with younger advanced argillic alteration that overprinted potassic and sodic-potassic alteration and was controlled by a syn-hydrothermal, brittle-ductile fault zone located near the eastern margin of the Pebble East zone. Late quartz veins introduced additional molybdenum into several parts of the deposit.

1.8 History

Cominco Alaska, a division of Cominco Ltd., now Teck, began reconnaissance exploration in the Pebble region in the mid-1980s, and in 1984 discovered the Sharp Mountain gold prospect near the southern margin of the current property. Teck staked their first mineral claims on the Property during reconnaissance mapping and sampling programs in the Cone and Sharp Mountain areas in August and September 1984. In November 1987, Teck staked claims on the newly-discovered Sill and Pebble prospects and added claims to these two areas in July 1988. This staking, along with additional claims added in the 1990s, led to the formation of a large continuous claim group. Teck completed a two-part purchase option with Hunter Dickinson Group Inc. (HDGI), which in turn assigned 80% of that option to Northern Dynasty in October 2001.

The first part of the option agreement covered that portion of the property which had previously been drilled and on which the majority of the then known copper mineralization occurred (the Resource Lands Option) and the remaining area outside the Resource Lands (the Exploration Lands). In November 2004, Northern Dynasty exercised the Resource Lands Option and acquired 80% of the Resource Lands. In February 2005, Teck elected to sell its residual 50% interest in the Exploration Lands to Northern Dynasty for US$4 million. Teck still retains a 4% pre-payback advance net profits royalty interest (after debt service) and 5% after-payback net profits interest royalty in any mine production from the Exploration Lands portion of the Pebble property.

In June 2006, Northern Dynasty acquired, through its Alaska subsidiaries, the remaining HDGI 20% interest in the Resource Lands and Exploration Lands by acquiring HDGI from its shareholders and through its various subsidiaries had thereby acquired an aggregate 100% interest in the Pebble Property, subject only to the Teck net-profits royalties on the Exploration Lands.

In July 2007, the Pebble Partnership was created and an indirectly wholly-owned subsidiary of Anglo American plc (Anglo American) subscribed for 50% of the Pebble Partnership's equity effective July 31, 2007. In December 2013, Northern Dynasty exercised its right to acquire Anglo American's interest in the Pebble Partnership and now holds a 100% interest in the Pebble Partnership.

On June 29, 2010, Northern Dynasty entered into an agreement with Liberty Star Uranium and Metals Corp. and its subsidiary, Big Chunk Corp. (together, Liberty Star), pursuant to which Liberty Star sold 23.8 mi^2 of claims (the 95 Purchased Claims) to a U.S. subsidiary of Northern Dynasty in consideration for both a $1 million cash payment and a secured convertible loan from Northern Dynasty in the amount of $3 million. Northern Dynasty later agreed to accept transfer of 199 claims (the Settlement Claims) located north of the ground held 100% by the Pebble Partnership in settlement of the loan, and subsequently both the Purchased Claims and the Settlement Claims were transferred to a Northern Dynasty subsidiary and ultimately to Pebble West Claims Corporation, a subsidiary of the Pebble Partnership.

On January 31, 2012, the Pebble Partnership entered into a Limited Liability Company Agreement with Full Metal Minerals (USA) Inc. (FMMUSA), a wholly-owned subsidiary of Full Metal Minerals Corp., to form Kaskanak Copper LLC. On May 8, 2013, the Pebble Partnership purchased FMMUSA's entire ownership interest in the LLC for a cash consideration of $750,000. As a result, the Pebble Partnership gained a 100% ownership interest in the LLC, the indirect owner of a 100% interest in a group of 464 claims located south and west of other ground held by the Pebble Partnership. In 2014 the LLC was merged into Pebble East Claims Corporation, a subsidiary of the Pebble Partnership, which now holds title to these claims.

On December 15, 2017 Northern Dynasty entered into a Framework Agreement with First Quantum Minerals Ltd. (First Quantum) that contemplated that an affiliate of First Quantum would subsequently execute an option agreement with Northern Dynasty with an option payment of US$150 million staged over four years. This option would entitle First Quantum to acquire the right to earn a 50% interest in the Pebble Partnership for US$1.35 billion. First Quantum made an early option payment of US$37.5 million to Northern Dynasty, applied solely for the purposes of progressing the permitting of the Proposed Project but withdrew from the Project in 2018.

1.9 Exploration

Geological, geochemical and geophysical surveys were conducted in the Project area from 2001 to 2007 by Northern Dynasty and since mid-2007 by the Pebble Partnership.

Geological mapping for rock type, structure and alteration was done between 2001 and 2006 at the entire Project area. This work provided an important geological framework for interpretation of other exploration data and drilling programs.

Geophysical surveys were completed between 2001 and 2010. In 2001, dipole-dipole IP surveys totalling 19.3 line-mi were completed by Zonge Geosciences for Northern Dynasty, following up on and augmenting similar surveys completed by Teck. During 2002, a ground magnetometer survey totalling 11.6 line-mi was completed at Pebble. The principal objective of this survey was to obtain a higher resolution map of magnetic patterns than was available from existing regional government magnetic maps. During 2007, a limited magnetotelluric survey was completed by GSY-USA Inc., under the supervision of Northern Dynasty geologists. The survey focused on the area of drilling in the Pebble East zone and comprised 196 stations on nine east-west lines and one north-south line, at a nominal station spacing of 656 ft. In July 2009, Spectrem Air Limited completed an airborne electromagnetic, magnetic and radiometric survey over the Pebble area. The objectives of this work included provision of geophysical constraints for structural and geological interpretation in areas with significant glacial cover. Between the second half of 2009 and mid-2010, a total of 120.5 line-mi of IP chargeability and resistivity data were collected by Zonge Engineering and Research Organization Inc. The objective of this survey was to extend the area of IP coverage completed prior to 2001 by Teck and during 2001 by Northern Dynasty. During 2010, an airborne electromagnetic (EM) and magnetometer geophysical survey was completed on the Pebble property totalling 4,009 line-mi.

Geochemical surveys were completed between 2001 and 2012. Between 2001 and 2003, Northern Dynasty collected 1,026 soil samples (Rebagliati and Lang, 2009). Samples were more widely spaced near the north, west and southwest margins of the grid. Three very limited surficial geochemical surveys were completed by the Pebble Partnership in 2010 and 2011; no significant geochemical anomalies were identified. A total of 126 samples, comprising 113 till and 13 soil samples, were collected on the KAS claims located in the southern end of the property; samples were on lines spaced approximately 8,000 ft apart with a sample spacing of approximately 1,300 ft. Additional surveys were completed between 2007 and 2012 by researchers from the USGS and the University of Alaska Anchorage. The results of these surveys were largely consistent with the results obtained by earlier soil sampling programs.

1.10 Drilling and Sampling

Samples from the 2002 through 2012 core drilling programs completed by Northern Dynasty and the Pebble Partnership provide 91% of the assays used in the Mineral Resource estimate. These drilling and sampling programs were carried out in a proficient manner consistent with industry standard practices at the time of the programs. Core recovery was typically very good and averaged over 98%; two-thirds of all measured intervals have 100% core recovery. No significant factors of drilling, sampling, or recovery that impact the accuracy and reliability of the results were observed.

The remaining 9% of assays used in the Mineral Resource estimate derive from historical 1988 to 1992 and 1997 Teck core drill programs. Northern Dynasty expended considerable effort to assess the veracity of the Teck drilling over several years. This included: re-survey of drill hole locations, review of remaining half core, extensive re-drilling of areas targeted by Teck, and plotting and comparison of Teck drill holes with nearby Northern Dynasty drill holes. No significant factors of the drilling, sampling or recovery of the Teck program that impact the accuracy and reliability of the results were observed.

QP Eric Titley considers the drill programs to be reasonable and adequate for the purposes of Mineral Resource estimation.

1.11 Metallurgical Testwork

Metallurgical testwork for the Project was initiated by Northern Dynasty in 2003 and continued under the direction of Northern Dynasty until 2008. From 2008 to 2013, metallurgical testwork progressed under the direction of the Pebble Partnership.

Geometallurgical studies were initiated by the Pebble Partnership in 2008 and continued through 2012. The principal objective of this work was to quantify significant differences in metal deportment that may result in variations in metal recoveries during mineral processing. The results of the geometallurgical studies indicate that the deposit comprises several geometallurgical (or material type) domains. These domains are defined by distinct, internally consistent copper and gold deportment characteristics that correspond spatially with changes in silicate and sulphide alteration mineralogy.

Metallurgical testwork and associated analytical procedures were performed by recognized testing facilities with extensive experience with these tests and analyses, with this type of deposit, and with the Project. The samples selected for the comminution, copper-gold-molybdenum bulk flotation, and copper-molybdenum separation testing were considered to be representative of the various types and styles of mineralization at the Pebble deposit.

A conventional flotation process is proposed to produce saleable copper-gold and molybdenum concentrates. The flotation test results on variability samples derived from the 103 locked cycle flotation and the subsequent copper-molybdenum separation flotation tests indicate that marketable copper and molybdenum concentrates can be produced. The copper concentrate will also contain gold and silver contents that meet or exceed payable levels in representative smelter contracts; the molybdenum concentrate will contain significant rhenium (Re), with a reported grade range from 791 to 832 g/t Re observed in the locked cycle test (LCT) results of the copper-molybdenum separation.

Gravity gold recovery tests were completed on three composite samples in 2010 and on four composite samples from the continuous testwork program. These demonstrated gold was recoverable by gravity and accordingly treatment of a side stream from the regrind circuit, with 1% overall gold recovery to a gravity concentrate. In the flowsheet for the Proposed Project, the gravity concentrate would be bagged and shipped off-site to a refinery. In the potential expansion scenarios with a secondary gold plant, the gravity concentrate would comprise a portion of the secondary gold plant feed.

A preliminary hydrometallurgical test program was performed on rougher and cleaner molybdenum concentrates to investigate the production of the marketable products of molybdenum trioxide (MoO_3) and ammonium perrhenate (NH_4ReO_4). The test program included pressure oxidation leach, a series of metal extractions/purifications from the pregnant leach solution, and a calcination process. The tested methods were found technically feasible. Satisfactory dissolution rates of molybdenum and rhenium were obtained from the rougher molybdenum concentrate samples while additional alkaline leach is required on the pressure oxidation leach residues for the cleaner molybdenum concentrate samples.

In the 2021 PEA, the overall metal recovery projections of copper, gold, silver and molybdenum to concentrate are adjusted to an increased primary grind size (from 125 µm to 135 µm) from those published in the 2018 technical report. A rhenium recovery estimate at a high level has been completed and included. Table 1-1 provides projected metals recoveries via flotation concentration. The recovery estimate bases are summarized as follows:

- The initial metal recovery projections of copper, gold, silver and molybdenum were published in 2014 based on a combined flotation and cyanide leach method. A total of 111 LCTs on the 103 samples representing 8 geometallurgical domains across the east and west of Pebble deposit were reviewed to establish the copper, gold and molybdenum distributions to the bulk copper-molybdenum concentrate. Ten of the 111 LCTs with silver assay results were utilized to estimate the silver recovery to the bulk flotation concentrate.

- The 2018 metal recoveries were updated to reflect the changes of the proposed processing methods, including the exclusion of the cyanide leach process and the implementation of a coarser primary grind particle size.

- The 2020 metal recovery projections were further updated to include rhenium recovery from the molybdenum concentrate. The estimated rhenium recovery was 70.8%, based on the 10 LCT results of the rhenium recovery to the bulk concentrate, a one LCT stage recovery result in the subsequent separation of copper and molybdenum, as well as a recovery adjustment due to the change of primary grind size.

Table 1-1: Projected Metallurgical Recoveries

Domain	Flotation Recovery %				
	Cu Con, 26% Cu			Mo Con, 50% Mo	
	Cu	Au	Ag	Mo	Re
Supergene:					
Sodic Potassic	74.7	60.4	64.1	51.2	70.8
Illite Pyrite	68.1	43.9	64.1	62.6	70.8
Hypogene:					
Illite Pyrite	91.0	46.2	67.5	77.1	70.8
Sodic Potassic	91.0	63.8	67.7	80.9	70.8
Potassic	93.0	63.1	66.0	84.8	70.8
Quartz Pyrophyllite	95.0	65.5	64.6	80.7	70.8
Sericite	91.0	41.3	67.5	77.1	70.8
Quartz Sericite Pyrite	90.5	33.3	67.5	86.8	70.8
LOM Average[1]	87	60	67	75	71

Note: prepared by Tetra Tech, 2021. An additional 1% Au recovery to the gravity concentrate is expected.

1.12 Mineral Resource Estimation

The current resource estimate is based on approximately 59,000 assays obtained from 699 drill holes. The resource was estimated by ordinary kriging and is presented in Table 1-2. The tabulation is based on copper equivalency (CuEq) that incorporates the contribution of copper, gold and molybdenum. Although the estimate includes silver and rhenium, neither were used as part of the copper equivalency calculation in order to facilitate comparison with previous estimates which did not consider the minor economic contribution of either of these metals. The highlighted 0.3% CuEq cut off is considered appropriate for deposits of this type in the Americas.

[1] Per financial model.

Table 1-2: Pebble Resource Estimate August 2020

MEASURED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.64	531,000,000	0.33	0.35	177	1.7	0.31	3.87	5.96	0.21	28.4	167,000
0.2	0.64	530,000,000	0.33	0.35	177	1.7	0.32	3.87	5.96	0.21	28.4	167,000
0.3	0.65	527,000,000	0.33	0.35	178	1.7	0.32	3.83	5.93	0.21	28.1	167,000
0.4	0.66	508,000,000	0.34	0.36	180	1.7	0.32	3.81	5.88	0.20	27.4	163,000
0.6	0.77	279,000,000	0.40	0.42	203	1.8	0.36	2.46	3.77	0.12	16.5	100,000
1.0	1.16	28,000,000	0.62	0.62	302	2.3	0.52	0.38	0.56	0.02	2.0	14,000

INDICATED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.73	6,409,000,000	0.39	0.32	233	1.6	0.39	54.38	66.56	3.29	328.5	2,500,000
0.2	0.73	6,305,000,000	0.39	0.33	236	1.6	0.40	54.20	66.08	3.28	326.0	2,497,000
0.3	0.77	5,929,000,000	0.41	0.34	246	1.7	0.41	53.58	64.81	3.21	316.4	2,443,000
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	0.44	51.42	58.35	2.98	291.7	2,271,000
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	0.51	41.88	45.54	2.27	221.1	1,748,000
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	0.60	23.96	23.15	1.07	109.9	853,000

MEASURED+INDICATED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.72	6,941,000,000	0.38	0.33	228	1.6	0.39	58.29	72.53	3.49	357.1	2,672,000
0.2	0.73	6,835,000,000	0.39	0.33	231	1.6	0.39	58.15	72.08	3.49	354.5	2,666,000
0.3	0.76	6,456,000,000	0.40	0.34	240	1.7	0.41	56.92	70.57	3.42	344.6	2,615,000
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	0.43	55.21	64.06	3.18	320.3	2,431,000
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	0.50	44.44	49.22	2.40	237.7	1,848,000
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	0.60	24.12	23.61	1.08	112.0	867,000

INFERRED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.45	6,435,000,000	0.20	0.23	174	1.1	0.28	28.22	47.38	2.47	232.1	1,789,000
0.2	0.48	5,819,000,000	0.22	0.24	190	1.1	0.30	27.57	44.34	2.44	212.2	1,763,000
0.3	0.55	4,454,000,000	0.25	0.25	226	1.2	0.36	24.54	35.80	2.22	170.4	1,603,000
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	0.44	19.24	25.52	1.57	119.1	1,154,000
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	0.51	13.90	15.63	0.85	75.6	673,000
1.0	1.20	361,000,000	0.68	0.45	377	2.3	0.69	5.41	5.22	0.30	26.3	251,000

- David Gaunt, P. Geo, a qualified person who is not independent of Northern Dynasty is responsible for the estimate.
- Copper equivalent (CuEq) calculations use the following metal prices: US$1.85 /lb for Cu, US$902 /oz for Au and US$12.50 /lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).

- Contained metal calculations are based on 100% recoveries.
- The base case Mineral Resource estimate (bolded) is reported above a 0.30% CuEq cut-off.
- The Mineral Resource estimate is constrained by a conceptual pit shell that was developed using a Lerchs-Grossmann algorithm and is based in the following parameters: 42 degree pit slope; metal prices and recoveries for gold of US$1,540.00/oz and 61% Au, for copper of US$3.63/lb and 91% Cu, for silver of US$20.00/oz and 67% Ag and for molybdenum of US$12.36/lb and 81% Mo, respectively; a mining cost of US$1.01/ton with a US$0.03/ton/bench increment and other costs (including processing, G&A and transport) of US$6.74/ton.
- The terms "Measured Resources", "Indicated Resources" and "Inferred Resources" are recognized and required by Canadian regulations under 43-101. The SEC has adopted amendments to its disclosure rules to modernize the mineral property disclosure required for issuers whose securities are registered with the SEC under the US Securities Exchange Act of 1934, effective February 25, 2019, that adopt definitions of the terms and categories of resources which are "substantially similar" to the corresponding terms under Canadian Regulations in 43-101. Accordingly, there is no assurance any mineral resources that we may report as Measured Resources, Indicated Resources and Inferred Resources under 43-101 would be the same had we prepared the resource estimates under the standards adopted under the SEC Modernization Rules. Investors are cautioned not to assume that all or any part of mineral deposits in these categories will ever be converted into Mineral Reserves or be legally or economically mineable. In addition, Inferred Resources have a great amount of uncertainty as to their economic and legal feasibility. Under Canadian rules, estimates of Inferred Resources may not form the basis of feasibility or pre-feasibility studies, or economic studies except for a Preliminary Economic Assessment as defined under 43-101.
- Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
- The Mineral Resource estimates contained herein have not been adjusted for any risk that the required environmental permits may not be obtained for the Project. The risk associated with the ability of the Project to obtain required environmental permits is a risk to the reasonable prospects for eventual economic extraction of the mineralization and the classification of the estimate as a Mineral Resource.

1.13 Mining Methods

The 2021 PEA is preliminary in nature and includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results will be realized. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

The mining operations are planned to use conventional open pit mining methods and equipment. The proposed Pebble mine would be a conventional drill, blast, truck, and shovel operation with an average mining rate of approximately 70 million tons per year and an overall strip ratio of 0.12 ton of waste per ton of mineralized material.

The open pit would be developed in stages, with each stage expanding the area and deepening the previous stage. The final dimensions of the open pit would be approximately 6,800 ft long and 5,600 ft wide, with depths to 1,950 ft.

The projected mining schedule was generated using five pushbacks and was based on a maximum processing capacity of 180,000 ton/d. Based on the selected ultimate pit, final pit design and the generated production schedule, the Project's total LOM is 21 years, including 1 year of pre-stripping followed by 20 years of production.

1.14 Recovery Methods

The proposed processing plant is designed to process mineralized feed material at a rate of 180,000 tons per day. The designed process to treat feed material contemplates methods that are conventional and well-proven in the industry. The comminution and recovery processes proposed are used widely in commercial practice, with no significant elements of technological innovation.

The following unit operations would be employed to produce three final products: a copper-gold flotation concentrate, a molybdenum flotation concentrate and a gravity gold concentrate:

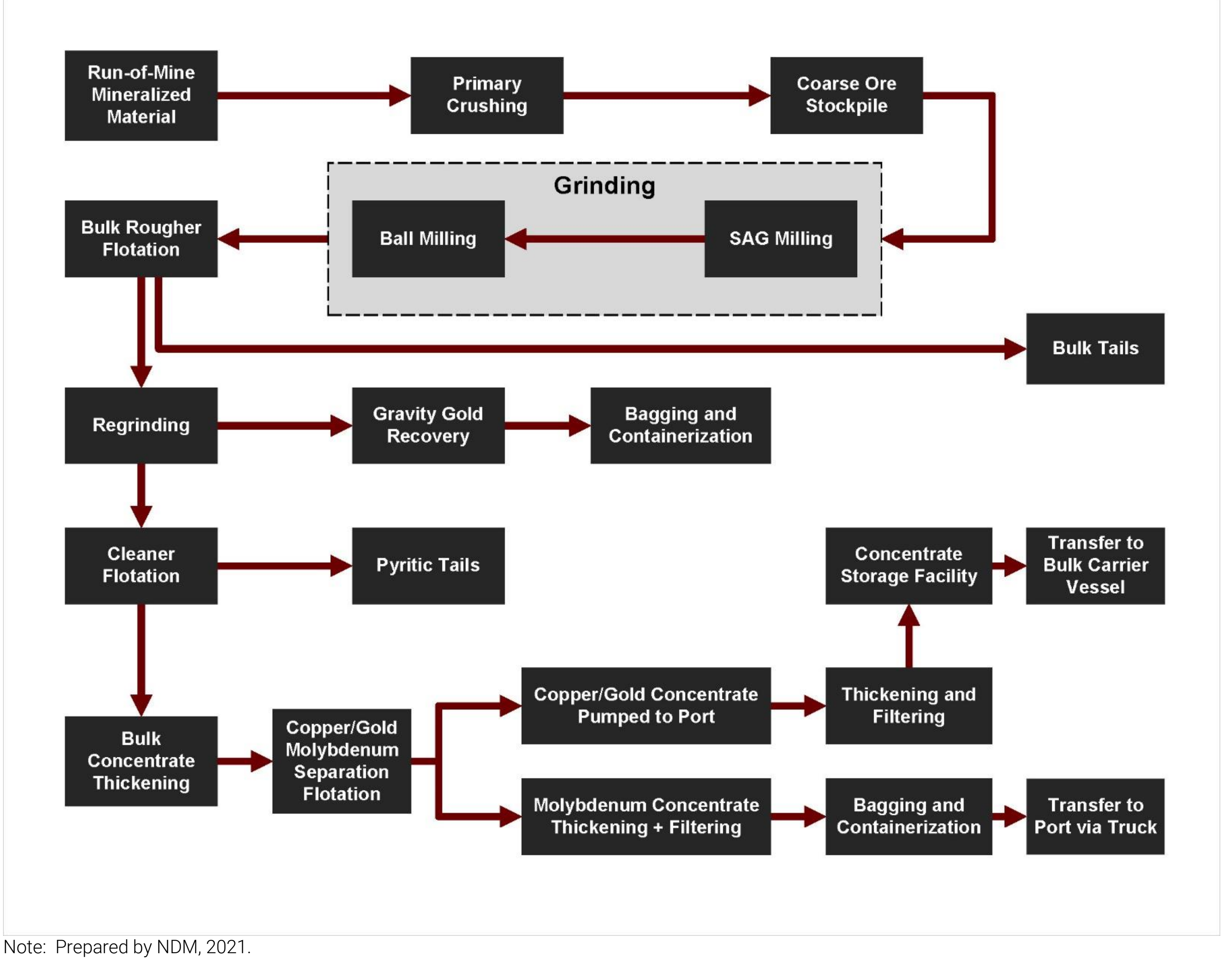
- Primary crushing;
- Grinding with semi-autogenous grinding (SAG) and ball mills;

- Bulk copper-gold-molybdenum flotation;
- Molybdenum flotation to separate a copper-gold flotation concentrate and a molybdenum flotation concentrate; and,

Gravity concentration to produce a gravity gold concentrate.

Figure 1-3 shows a simplified process flow diagram of the entire process route.

Figure 1-3: Simplified Flow Diagram



Note: Prepared by NDM, 2021.

The process plant flowsheet design was based on testwork results, previous study designs and industry standard practices. Further, the testwork results support the recovery projections used in the economic analysis.

The production summary for the Proposed Project is shown in Table 1-3.

Table 1-3: **Proposed Project Production Summary**

Proposed Project	Units	
Mineralized Material	B tons	1.3
Copper Equivalent[2]	%	0.58
Copper	%	0.29
Gold	oz/ton	0.009
Molybdenum	ppm	154
Silver	oz/ton	0.042
Rhenium	ppm	0.28
Waste	B tons	0.2
Open Pit Strip Ratio		0.12
Open Pit Life	Years	20
Life of Mine	Years	20
Metal Production (LOM)		
Copper	M lb	6,400
Gold (in Cu Concentrate)	k oz	7,300
Silver (in Cu Concentrate)	k oz	37,000
Gold (in Gravity Concentrate)	k oz	110
Molybdenum	M lb	300
Rhenium	k kg	230
Metal Production (Annual[3])		
Copper	M lb	320
Copper Concentrate	k tons	559
Gold (in Cu Concentrate)	k oz	363
Silver (in Cu Concentrate)	k oz	1,800
Molybdenum	M lb	15
Molybdenum Concentrate	k tons	14
Rhenium	k kg	12

1.15 Project Infrastructure

The Project is located in an area of Alaska that has minimal development and would require construction of both on-site and off-site infrastructure to support construction and operations of the Proposed Project.

The primary off-site infrastructure would incorporate a natural gas pipeline, marine terminal, access road between the marine terminal and mine site, and a pipeline system to transport concentrate to the marine terminal. The marine terminal facility would include facilities capable of handling barges for concentrate bulk transhipment as well as large ocean barges (400 x 100 ft) for transport of construction materials and operating supplies by container. The access road would provide year-round access between the marine terminal and the mine site for construction and operations. The natural gas and concentrate pipelines would be buried adjacent to the access road.

[2] Copper equivalent (CuEq) calculations use metal prices: US$1.85/lb for Cu, US$902/oz for Au and US$12.50/lb for Mo, and recoveries of 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).
[3] Life of mine volumes ÷ life of mine years.

The onsite facilities would provide all necessary support for construction and operation. These include temporary and permanent worker accommodations, power reticulation, site roads, administration buildings, truck shop, warehouse, maintenance facilities.

The Proposed Project site would also include tailings storage facilities, water management ponds, and water treatment plants (WTPs). Waste and water management at the Project would be an integrated system designed to safely contain these materials, to facilitate water treatment and discharge, and to provide adequate process water to support the operations. The design of these facilities would incorporate a significant climate record, extensive site investigation, and several features intended to ensure safe operation.

The Proposed Project would incorporate a sophisticated water management plan with water collection, treatment, and discharge. That plan requires attention to the annual and seasonal variability of the incoming and receiving flows and achieving very specific water quality standards for the released water. Temporary water treatment facilities would be in place during construction, followed by three WTPs during the operations and closure phases.

Natural gas-fired power plants would be constructed at both the mine site and the marine terminal.

1.16 Environmental, Permitting and Social Considerations

1.16.1 Environmental Considerations

The Pebble deposit is located on State land that has been specifically designated for mineral exploration and development. The Pebble area has been the subject of two comprehensive land-use planning exercises conducted by the Alaska Department of Natural Resources (ADNR), the first in the 1980s and the second completed in 2005 and subsequently revised in 2013. ADNR identified five land parcels (including Pebble) within the Bristol Bay planning area as having "significant mineral potential," and where the planning intent is to accommodate mineral exploration and development. These parcels total 2.7% of the total planning area (ADNR, 2013).

Environmental standards and permitting requirements in Alaska are stable, objective, rigorous and science-driven. These features are an asset to projects like Pebble that are being designed to meet U.S. and international best practice standards of design and performance.

Northern Dynasty began an extensive field study program in 2004 to characterize the existing physical, chemical, biological, and social environments in the Bristol Bay and Cook Inlet areas where the Project might occur. The Pebble Partnership compiled the data for the 2004-2008 study period into a multi-volume Environmental Baseline Document (EBD, PLP, 2012). These studies have been designed to:

- fully characterize the existing biophysical and socioeconomic environment;
- support environmental analyses required for effective input into project design;
- provide a strong foundation for internal environmental and social impact assessment to support corporate decision-making;
- provide the information required for stakeholder consultation and eventual mine permitting in Alaska; and
- provide a baseline for long-term monitoring of potential changes associated with mine development.

Additional data collected from the 2009-2013 period was compiled into the Supplemental EBD (PLP, 2018) and transmitted to USACE. In 2017, select environmental baseline studies were re-initiated and expanded. Monitoring data collected through 2019 has been provided to USACE.

The baseline study program includes:

- surface water hydrology
- groundwater hydrology
- surface and groundwater quality
- geochemistry
- snow surveys
- fish and aquatic resources
- noise
- wetlands
- trace elements
- fish habitat – stream flow modelling
- marine
- wildlife
- air quality
- cultural resources
- subsistence
- land use
- recreation
- socioeconomics
- visual aesthetics
- climate and meteorology
- Iliamna Lake

1.16.2 Closure and Reclamation Considerations

The Pebble Partnership's core operating principles are governed by a commitment to conduct all mining operations, including reclamation and closure, in a manner that adheres to socially and environmentally responsible stewardship while maximizing benefits to state and local stakeholders.

Reclamation and closure of the Proposed Project falls under the jurisdiction of the ADNR Division of Mining, Land, and Water, and the ADEC. A miner may not engage in a mining operation until the ADNR has approved a reclamation plan for the operation. The Pebble Partnership submitted a preliminary closure plan to USACE in support of the EIS analysis. Four phases of closure are envisioned for the Proposed Project.

1.16.3 Permitting Considerations

To prepare its CWA permit application, the Pebble Partnership developed a mine plan of smaller scale and footprint and shorter mine life than had been included in previous analyses. The application under Section 404 of the CWA and Section 10 of the RHA was submitted to USACE on December 22, 2017. On January 8, 2018, USACE deemed the permit application complete and confirmed that an Environmental Impact Statement (EIS) level of analysis was required to comply with its National Environmental Policy Act (NEPA) review of the Proposed Project. The EIS process progressed through the scoping phase in 2018. USACE delivered the Draft EIS in the first quarter of 2019 and completed a public comment period from March to July 2019. In the latter part of 2019 and early 2020, USACE advanced toward a Final EIS. The preliminary Final EIS was circulated to cooperating agencies for review in February 2020. As part of the EIS preparation process, USACE had undertaken a comprehensive alternatives assessment to consider a broad range of development alternatives and announced the conclusions of the draft Least Environmentally Damaging Practicable Alternative (LEDPA) in May 2020. USACE published the Final EIS (FEIS) on July 24, 2020.

The Department of the Army Permit Application was submitted in December 2017 and the permitting process over the next three years involved the Pebble Partnership being actively engaged with USACE on the evaluation of the Proposed Project. There were numerous meetings between representatives of USACE and the Pebble Partnership regarding, among other things, compensatory mitigation for the Proposed Project. The Pebble Partnership submitted several draft compensatory mitigation plans to the USACE, each refined to address comments from the USACE and that the Pebble Partnership believed was consistent with mitigation proposed and approved for other major development projects in Alaska.

The FEIS published by USACE on July 24, 2020 was the culmination of a 2½ year long, intensive review process under the National Environmental Policy Act (NEPA). Led by USACE, the Pebble FEIS also involved eight federal cooperating agencies (including the US Environmental Protection Agency and US Fish & Wildlife Service), three State cooperating agencies (including the Alaska Department of Natural Resources and the Alaska Department of Environmental Conservation), the Lake & Peninsula Borough and two federally recognized tribes.

The FEIS was viewed by Pebble Partnership as positive in that it found impacts to fish and wildlife would not be expected to affect subsistence harvest levels, there would be no measurable change to the commercial fishing industry including prices, and there would be a number of positive socioeconomic impacts on local communities.

In late June 2020, USACE verbally identified a preliminary finding of “significant degradation” of certain aquatic resources, with the requirement of new compensatory mitigation. The Pebble Partnership understood from these discussions that the new compensatory mitigation plan for the Proposed Project would include in-kind, in-watershed mitigation and continued its work to meet these new USACE requirements. USACE formally advised the Pebble Partnership by letter dated August 20, 2020 that it had made preliminary factual determinations under Section 404(b)(1) of the CWA that the Proposed Project would result in significant degradation to aquatic resources. In connection with this preliminary finding of significant degradation, USACE formally informed the Pebble Partnership that in-kind compensatory mitigation within the Koktuli River Watershed would be required to compensate for all direct and indirect impacts caused by discharges into aquatic resources at the mine site. USACE requested the submission of a new compensatory mitigation plan to address this finding within 90 days of its letter.

In response, the Pebble Partnership developed a compensatory mitigation plan (CMP) to align with the requirements outlined by the USACE. This plan envisioned creation of a 112,445-acre Koktuli Conservation Area on land belonging to the State of Alaska in the Koktuli River Watershed downstream of the Project. The plan was submitted to the USACE on November 4, 2020.

On November 25, 2020, USACE issued a ROD rejecting the Pebble Partnership’s permit application, finding concerns with the proposed CMP and determining that the Proposed Project would cause significant degradation and be contrary to the public interest. USACE concluded the proposed CMP was not compliant with USACE regulations.

The Pebble Partnership submitted its request for appeal of the ROD to USACE Pacific Ocean Division on January 19, 2021. The request for appeal reflects the Pebble Partnership’s position that USACE's ROD and permitting decision – including its “Significant Degradation” finding, its “public interest review” findings, and its rejection of the Pebble Partnership's CMP – are contrary to law, unprecedented in Alaska, and fundamentally unsupported by the administrative record, including the Proposed Project FEIS. In a letter dated February 24, 2021, USACE confirmed the Pebble Partnership’s RFA is "complete and meets the criteria for appeal." While federal guidelines suggest the appeal should conclude within 90 days, USACE has indicated the complexity of issues and volume of materials associated with Pebble’s case means the review will likely take additional time.

On January 22, 2021, the State of Alaska, acting in its role as owner of the Pebble deposit, also submitted a request for appeal. The State appeal was rejected on the basis that the State did not have standing to pursue an administrative appeal with USACE.

The Project will require additional Federal permits, in addition to those issued under the CWA and RHA permits, as well as a range of permits issued by the State of Alaska.

1.17 Markets and Contracts

No market studies were completed, but consensus long term metals pricing and industry typical refining terms have been used for the purposes of the economic assessment. The anticipated concentrate analyses suggest there will be no significant penalty elements in the copper or gravity gold concentrates. Copper in the molybdenum concentrate will be at penalty levels, but there is an opportunity at some future phase of the Project to incorporate secondary processing at site to maximize molybdenum payables. Logistics and transportation costs based on Alaskan norms have been used. At this time no contracts have been entered for supply of materials or for off-take of products.

1.18 Capital Cost and Operating Cost Estimates

1.18.1 Capital Cost Estimates

The total initial capital cost for the design, construction, installation, and commissioning of the Proposed Project is estimated to be $6.05 billion, which includes all direct, indirect, and Owner's costs, as well as a contingency. Northern Dynasty believes it is most likely that, if approved, the Proposed Project would be developed with partners who will provide the primary infrastructure (marine terminal, access road, natural gas pipeline, mine site power plant) in return for lease payments or tolls at rates which provide a return on investment to the providers of the infrastructure. The capital cost of this infrastructure which may be provided by third parties is estimated at $1.68 billion, which reduces the cash outlay required for construction. In addition, precious metal streaming is considered a viable project financing alternative and the 2021 PEA assumes $1.14 billion would be available to the Proposed Project in the form of various streaming agreements. The combination of third-party infrastructure financing and precious metal streaming would reduce the required capital investment for the Proposed Project to $3.44 billion; this scenario was evaluated in the economic model as the Base Case. A Full Capital Case, without the benefit of the precious metal stream financing and third-party infrastructure participation, was also evaluated.

Sustaining capital investment in the Proposed Project over the 20-year mine life is limited to TSF improvements, and replacement of mobile equipment for mining and road maintenance. These life cycle costs are applied in the financial model on a year-by-year basis, with a cumulative total of $1.52 billion including indirect and Owner's costs as well as contingency costs.

Initial reclamation trust funding and letter of credit premiums during construction would total $179 million. The remaining mine closure and reclamation costs are not included in the capital or operating costs but are factored into the financial model to account for long term closure and water treatment plant requirements. A reclamation fund of $1,396 million would be accumulated over the mine life comprising $831 million in contributions and $565 million in accrued interest.

Table 1-4 provides the capital cost estimates.

Table 1-4: Pebble Proposed Project – Initial Capital

Description	Cost ($M)
Mining	321
Process	736
Other Infrastructure	345
Tailings	1,278
Pipelines	189
Access Road	296
Port Infrastructure	246
Power Generation	779
Indirect Costs	1,182
Contingency	678
Total Capital Cost Estimate	**6,049**
Add: Reclamation and other funding during construction	211
Initial Capital Investment – Full Capital Case	**6,259**
Less: Outsourced Infrastructure	(1,680)
Less: Pre-production proceeds from gold stream partners	(1,142)
Initial Capital Investment - Base Case	**3,439**

1.18.2 Operating Cost Estimates

The average life of mine operating costs for the Proposed Project Base Case, based on the 180,000 ton/day plant capacity, are estimated to be:

- Average operating cost – $10.98/ton milled
- Average copper C1 cost (co-product basis) – $1.65/lb CuEq
- All-in sustaining cost (AISC) (co-product basis) – $1.88/lb CuEq
- Average gold C1 cost (co-product basis) – $753/oz AuEq
- Average copper C1 cost (by-product basis) – $0.69/lb
- All-in sustaining cost (AISC) (by-product basis) – $1.10/lb
- Average gold C1 cost (by-product basis) – ($1,148)/oz

1.19 Economic Analysis and Sensitivities

1.19.1 Economic Analysis

An economic model was developed to estimate annual pre-tax and post-tax cash flows and sensitivities of the Proposed Project based on a 7% discount rate. By convention, a discount rate of 8% is typically applied to copper and other base metal projects, while 5% is applied to gold and other precious metal projects. Given the polymetallic nature of the Pebble deposit and the large contribution of gold to total revenues, a 7% blended discount rate was selected and is considered appropriate for the purposes of discounted cash flow analyses. The net present value (NPV) is calculated by discounting cash flows to start of construction. The combination of third-party infrastructure financing and precious metal streaming was evaluated in the economic model as the Base Case. A Full Capital Case, without the benefit of the precious metal stream financing and third-party infrastructure participation, was also evaluated.

Calendar years used in the economic analysis are provided for conceptual purposes only. Permits still must be obtained in support of operations and approval to proceed is still required from Northern Dynasty's Board of Directors.

The Proposed Project and the potential alternative scenarios in Section 1.17 in the 2021 PEA are preliminary in nature and include Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results will be realized. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

The results were estimated with forecast long-term prices and sensitivity tested with prevailing metal prices. Both sets of prices are shown in Table 1-5.

Table 1-5: Metal Price Assumptions

Metal	Unit	Long-term ($)	Prevailing ($)
Copper	lb	3.50	4.25
Gold	Oz	1,600	1,800
Molybdenum	Lb	10	18
Silver	Oz	22	24
Rhenium	kg	1,500	1,600

The cost and taxes summary for the proposed Project, both Base Case and Full Capital Case, are shown in Table 1-6. The results of the economic analysis are shown in Table 1-7.

Table 1-6: Proposed Project Cost and Tax Summary

		Base Case	Full Capital
Costs			
Total Initial Capital Cost	$billion	6.05	6.05
Infrastructure Lease	$billion	1.68	-
Net Initial Capital Cost	$billion	4.37	6.05
Sustaining Capital Cost	$billion	1.52	1.54
Life of Mine Operating Cost[4]	$/ton	10.98	8.31
Copper C1 Cost[5]	$/lb CuEq	1.65	1.32
AISC (Co-Product Basis)	$/lb CuEq	1.88	1.56
Gold C1 Cost	$/oz AuEq	753	605
Closure Funding			
Annual Contribution	$million/yr	34	34
Life of Mine Contribution	$billion	0.83	0.83
Life of Mine Bond Premium	$billion	0.16	0.16
Closure Fund[6]	$billion	1.4	1.4
Life of Mine Taxes[7]			
Alaska Mining License	$billion	0.69	0.76
Alaska Royalty	$billion	0.30	0.33
Alaska Income Tax	$billion	0.75	0.87
Borough Severance & Tax	$billion	0.49	0.53
Federal Income Tax	$billion	1.38	1.61
Annual Taxes[8]			
Alaska Mining License	$million	34	38
Alaska Royalty	$million	15	17
Alaska Income Tax	$million	38	44
Borough Severance & Tax	$million	25	26
Federal Income Tax	$million	69	81

[4] Includes cost of infrastructure lease - $2.80/ton milled
[5] C1 costs calculated on co product basis
[6] Maximum value of closure fund during life of mine based on 4% compound interest
[7] Estimated based on current Alaskan statutes
[8] Life of mine taxes ÷ life of mine years

Table 1-7: Proposed Project Forecast Financial Results

Proposed Project			
		Base Case	Full Capital
Revenue[9]			
Annual Gross Revenue	$million	1,700	1,800
Life of Mine Gross Revenue	$million	35,000	37,000
Realization Charges			
Annual Charges	$million	150	150
Life of Mine Charges	$million	2,900	2,900
Net Smelter Return			
Annual NSR	$million	1,600	1,700
Life of Mine NSR	$million	32,000	34,000
Financial Model Results			
Post Tax IRR	%	15.7	11.2
Post Tax NPV_7	$million	2,300	2,000
Payback	Years	4.8	6.1

Table 1-8 provides the sensitivity results when the prevailing metal prices are applied against the Base Case.

Table 1-8: Proposed Project Base Case Forecast Financial Results with Prevailing Metal Prices

		Base Case	Full Capital
Revenue[10]			
Annual Gross Revenue	$million	2,100	2,300
Life of Mine Gross Revenue	$million	43,000	45,000
Realization Charges			
Annual Charges	$million	150	150
Life of Mine Charges	$million	2,900	2.900
Net Smelter Return			
Annual NSR	$million	2,000	2,100
Life of Mine NSR	$million	40,000	43,000
Financial Model Results			
Post Tax IRR	%	23.7	15.4
Post Tax NPV_7	$million	4,700	4,400
Payback	Years	3.1	4.7

[9] Revenue values do not include a gold plant contribution
[10] Revenue values do not include a gold plant contribution

1.19.2 Sensitivity Analysis

The sensitivity of the Proposed Project's pre-tax NPV, and IRR to several project variables, as listed below, were evaluated.

- Copper price
- Gold price
- Molybdenum price
- Initial capital cost
- Operating Cost
- Sustaining capital costs (including potential expansion scenarios)
- Head grade

Each variable, except head grade, was changed in increments of 10% between -30% to +30% while holding all other variables constant. The Proposed Project's NPV at a 7% discount rate is most sensitive to changes in copper price, initial capex, operating costs, gold price, molybdenum price, and sustaining capex. The head grade evaluation tested the sensitivity to a range of ±10%, while holding the other all other variables constant, as variation beyond that range is extremely unlikely given the extent of the drilling defining the Mineral Resource and the methodology used to estimate the Mineral Resource.

The Project's NPV at a 7% discount rate is, from most to least, sensitive to changes in head grade, copper price, initial capital costs, on-site operating costs, gold price, molybdenum price and sustaining capital costs.

1.20 Potential Expansion Scenarios

The Proposed Project evaluated in the 2021 PEA would extract only a small portion of the total Mineral Resources estimated at Pebble. To evaluate the possible extent of opportunities for the Project, seven potential expansion scenarios were identified for consideration. Six of these potential expansion scenarios contemplate an expansion of the open pit mine and increased mill throughput over a significantly longer mine life. These scenarios were modeled on an expanded scenario outlined in a response to a Request for Information from USACE during the EIS process and which is incorporated in the EIS administrative record. Three of these six scenarios consider the addition of an onsite gold plant. The seventh potential expansion scenario contemplates the addition of the onsite gold plant to the Proposed Project without changes to its throughput or mine life. Each of the potential expansion scenarios would require additional permitting and environmental regulatory review, and there is no certainty that any of the potential expansion scenarios could be pursued. The potential expansion scenarios are designated by the year in which the contemplated expanded process plant would commence operation. They utilize the same life of mine open pit design, with variations based on the year of the expansion and the expanded throughput rate. The Year 21 scenario is based on the scenario outlined in the EIS, with the plant expanded to 250,000 tons per day. The expanded rate in the other two scenarios is 270,000 tons per day.

Table 1-9 provides the production information from these potential expansion scenarios and compares them to the Proposed Project.

Table 1-9: Summary Potential Expansion Case Scenario Production Information

		Proposed Project	Potential Expansion Scenarios		
			Year 21	Year 10	Year 5
Mineralized Material	B tons	1.3	8.6	8.6	8.6
CuEq[11]	%	0.57	0.72	0.72	0.72
Copper	%	0.29	0.39	0.39	0.39
Gold	oz/ton	0.009	0.01	0.01	0.01
Molybdenum	ppm	154	208	208	208
Silver	oz/ton	0.042	0.047	0.046	0.046
Rhenium	ppm	0.28	0.36	0.36	0.36
Waste	B tons	0.2	14.4	14.4	14.4
Open Pit Strip Ratio		0.12	1.67	1.67	1.67
Open Pit Life	Years	20	78	73	68
Life of Mine	Years	20	101	91	90
Metal Production (LOM)					
Copper	M lb	6,400	60,400	60,400	60,400
Gold (in Cu Concentrate)	k oz	7,300	50,400	50,500	50,500
Silver (in Cu Concentrate)	k oz	37,000	267,000	267,000	267,000
Gold (in Gravity Concentrate)	k oz	110	782	783	782
Molybdenum	M lb	300	2,900	2,900	2,900
Rhenium	k kg	200	2,000	2,000	2,000
Metal Production (Annual[12])					
Copper	M lb	320	600	660	670
Copper Concentrate	k tonne	559	1,000	1,200	1,200
Gold (in Cu Concentrate)	k oz	363	500	560	560
Silver (in Cu Concentrate)	k oz	1,800	2,600	2,900	3,000
Molybdenum	M lb	15	29	32	32
Molybdenum Concentrate	k tonnes	14	26	29	29
Rhenium	k kg	12	20	22	22

The estimated costs for the potential expansion scenarios are shown in Table 1-10. The economic analysis for all potential expansion scenarios included third party infrastructure and precious metal streaming partners. The results are shown in Table 1-10 based on long-term metal prices.

[11] CuEQ calculations use metal prices: US$1.85/lb for Cu, US$902/oz for Au and US$12.50/lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).
[12] Life of mine volumes ÷ life of mine years

Table 1-10: Potential Expansion Scenarios Estimated Costs

		Potential Expansion Scenarios		
		Year 21	Year 10	Year 5
Costs				
Total Initial Capital Cost	$billion	6.05	6.05	6.05
Infrastructure Lease	$billion	1.68	1.68	1.68
Net Initial Capital Cost	$billion	4.37	4.37	4.37
Sustaining Capital Cost	$billion	16.9	17.0	17.2
Life of Mine Operating Cost[13]	$/ton	12.46	12.14	12.21
Copper C1 Cost[14]	$/lb CuEq	1.56	1.53	1.54
AISC (Co-Product Basis)	$/lb CuEq	1.77	1.74	1.74
Gold C1 Cost[8]	$/oz AuEq	712	699	702
Closure Funding				
Annual Contribution	$million/yr	9	10	11
Life of Mine Contribution	$billion	1.00	0.97	1.01
Life of Mine Bond Premium	$billion	1.14	0.78	0.85
Closure Fund[15]	$billion	3.2	3.3	3.1
Life of Mine Taxes[16]				
Alaska Mining License	$billion	8.16	8.34	8.32
Alaska Royalty	$billion	3.61	3.68	3.68
Alaska Income Tax	$billion	10.20	10.46	10.40
Borough Severance & Tax	$billion	4.34	4.33	4.34
Federal Income Tax	$billion	18.94	19.42	19.31
Annual Taxes[17]				
Alaska Mining License	$million	81	92	93
Alaska Royalty	$million	36	41	41
Alaska Income Tax	$million	101	115	116
Borough Severance & Tax	$million	43	48	47
Federal Income Tax	$million	188	213	215

[13] Includes cost of infrastructure lease:

Year 21 Expansion - $0.54/ton milled
Year 10 Expansion - $0.53/ton milled
Year 5 Expansion - $0.53/ton milled

[14] C1 costs calculated on co product basis
[15] Maximum value of closure fund during life of mine based on 4% compound interest
[16] Estimated based on current Alaskan statutes
[17] Life of mine taxes ÷ life of mine years

Table 1-11: Potential Expansion Scenarios Financial Results[18]

		Potential Expansion Scenarios		
		Year 21	Year 10	Year 5
Revenue[19]				
Annual Gross Revenue	$million	3,100	3,400	3,500
Life of Mine Gross Revenue	$million	312,000	312,000	312,000
Realization Charges				
Annual Charges	$million	270	300	310
Life of Mine Charges	$million	28,000	28,000	28,000
Net Smelter Return				
Annual NSR	$million	2,800	3,100	3,200
Life of Mine NSR	$million	285,000	285,000	285,000
Financial Model Results				
Post Tax IRR	%	18.1	19.5	21.5
Post Tax NPV_7	$million	5,700	7,300	8,500
Payback	Years	4.4	4.4	5.0

The gold plant included in the potential expansion scenarios was based of metallurgical testwork results for a specific gold recovery technology. However, other technologies may be applicable for the Pebble deposit. Further, the addition of a gold plant under any scenario will require additional testwork and engineering and will require the receipt of pertinent Federal and State permits prior to implementation.

The onsite gold plant would process the pyrite concentrate in conjunction with the gravity concentrate to produce a precious metal doré. In all but the Year 5 scenario, the gold plant capacity would match the 180,000 tons per day process plant capacity. In the Year 5 scenario, it would match the expanded plant capacity while in the Year 10 and Year 21 scenarios, it would be expanded with the process plant.

Table 1-12 provides the total metal production from these scenarios.

[18] Includes infrastructure partners and precious metal streaming
[19] Revenue values do not include a gold plant contribution

Table 1-12: Summary Gold Plant Potential Expansion Scenarios Information

		Proposed Project	Expansion Scenarios		
			Year 21	Year 10	Year 5
Concentrate (LOM)					
Copper	M lb	6,500	61,200	61,200	61,200
Gold (in Cu Concentrate)	k oz	7,300	50,400	50,500	50,500
Silver (in Cu Concentrate)	k oz	37,000	267,000	267,000	267,000
Molybdenum	M lb	300	2,900	2,900	2,900
Rhenium	k kg	200	2,000	2,000	2,000
Gold Plant (LOM)					
Gold (as Doré)	k oz	1,800	14,500	14,500	14,400
Silver (as Doré)	k oz	2,600	22,600	22,600	22,500
Total Production (LOM)					
Gold	k oz	9,000	65,000	65,100	64,900
Silver	k oz	39,000	289,000	289,000	289,000

Table 1-13: Potential Gold Plant Scenario Financial Results[20]

		Proposed Project	Expansion Scenarios		
			Year 21	Year 10	Year 5
IRR	%	16.5	18.8	20.3	22.7
NPV_7	$million	2,700	6,600	8,400	9,700
Payback	Years	4.9	4.6	4.5	5.0

1.21 Risks and Opportunities

A number of risks and opportunities are identified through the 2021 PEA. This section highlights several of these but is not an exhaustive list nor a summary of those contained in the body of the 2021 PEA.

1.21.1 Opportunities

A number of opportunities exist to enhance the Project.

1.21.1.1 Resource

- The Pebble property includes a number of opportunities to expand the Mineral Resource estimate through future exploration. The most significant opportunity is obtained in drill hole 6348 which intersected 949 ft with an average grade of 1.24% copper, 0.74 g/t gold and 0.042% molybdenum, or 1.92% CuEq. This drill hole lies east of the ZG1 Fault and follow up drilling of the Cretaceous host rocks to this mineralization has not yet been completed, thereby leaving the extent of this high-grade mineralization unknown.
- Geophysical and geochemical surveys and reconnaissance exploration drilling have identified several targets located well outside the current Pebble resource estimate area that warrant future exploration.

[20] Proposed Project and Potential Expansion Scenarios include infrastructure partners and precious metal streaming.

- Elevated levels of palladium, vanadium, titanium and tellurium have been noted in raw analytical data and in metallurgical studies and represent opportunities to further benefit the economics of the Pebble deposit.

1.21.1.2 Mining

The Proposed Project mine plan was developed using conventional mining technology. Three areas which could improve the mining results are:

- Use of trolley-assist haulage. Trolley-assist has been shown to improve cycle times and improve engine life at other mines, both of which would reduce operating costs. To accomplish this, additional capacity would likely be required for the power plant.

- In-pit crushing. While the mine plan for the potential expansion scenarios incorporates in-pit crushing, further evaluation for the Proposed Project as well as extending the in-pit crushing for the potential expansion scenarios may prove beneficial.

- Autonomous operation. Mine operations are increasingly moving to autonomous equipment with remote operations centres. These have seen real benefits, particularly in a remote operation such as envisioned at Pebble.

1.21.1.3 Processing

- Flotation. A number of measures have been developed recently which could improve flotation performance at Pebble, including advances in coarse particle flotation. Further analysis of these advances could benefit Pebble.

- Supergene flotation performance. The supergene domains at Pebble would contribute a significant portion of the process plant feed during the first several years of operation. Additional testwork and analysis could determine if alternate strategies could be employed to improve recoveries in these zones.

- Pre-sorting. Pre-sorting techniques have become accepted components of many new process plants. A study is warranted to determine if pre-sorting could enhance Pebble outcomes.

- Gold recovery. Analysis of alternate secondary gold recovery technologies could improve the financial results and enhance the permitting process.

- Molybdenum refinery. The molybdenum concentrate production creates the opportunity to add a molybdenum concentrate refinery to produce a value-added product in Alaska and reduce overall carbon footprint by reduced shipping.

- Concentrate pipeline. Optimization of the concentrate pipeline design could improve costs of the proposed concentrate and water return pipelines.

1.21.1.4 Infrastructure

- Water treatment. Further detailed analysis of the influent water quality and water treatment schemes could see reductions in complexity and cost.

1.21.1.5 Environment

- Carbon footprint. Evaluation of carbon dioxide capture, and sequestration opportunities could reveal an opportunity to reduce the Project's carbon emissions.

1.21.2 Risks

1.21.2.1 Resource

- Inferred Mineral Resources. The 2021 PEA includes the use of Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results will be realized.

- The Mineral resources estimates may ultimately be affected by a broad range of environmental, permitting, legal, title, socio-economic, marketing and political factors pertaining to the specific characteristics of the Pebble deposit (including its scale, location, orientation and polymetallic nature) as well as its setting (from a natural, social, jurisdictional and political perspective).

- Factors that may affect the Mineral Resource estimate include:
    - changes to the geological, geotechnical and geometallurgical models as a result of additional drilling or new studies;
    - the discovery of extensions to known mineralization as a result of additional drilling;
    - changes to the Re:Mo correlation coefficients and resultant regression equation due to additional drilling;
    - changes to commodity prices resulting in changes to the test for reasonable prospects for eventual economic extraction; and
    - changes to the metallurgical recoveries resulting in changes to the test for reasonable prospects for eventual economic extraction.

- Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

- The Mineral Resource estimates contained have not been adjusted for any risk that the required environmental permits may not be obtained for the Project. The uncertainty associated with the ability of the Project to obtain required environmental permits is a risk to the reasonable prospects for eventual economic extraction of the mineralisation and the classification of the estimate as a Mineral Resource.

1.21.2.2 Mining

- Pit wall slopes. The pit wall slope assessments were completed to a prefeasibility level of confidence. Additional field work and analysis are required to confirm these designs for operations.

1.21.2.3 Process

- Process recoveries. The metallurgical testwork completed on the Pebble deposit has been extensive but additional work is required to complete a feasibility study and design.

- Deleterious elements. The metallurgical testwork highlighted the low levels of impurity elements in the Project feed materials and correspondingly low deportment to saleable products, and likewise the process plant design incorporated no special treatment steps to manage impurities in the feed. There is a risk that pockets of the Pebble deposit will contain elevated levels of deleterious elements that could report to the concentrates products at levels which could incur penalty charges or adversely influence the saleability of the products. Operational controls could avoid these potential impacts.

1.21.2.4 Project Execution

- Weather. Adverse weather conditions and other factors such as pandemics could impact on the construction schedule.

- Labour. The construction schedule and operations performance require deployment of sufficient numbers of adequately trained and experienced personnel. Inability to realize this deployment could impact the construction schedule and operational results.

1.21.2.5 Tailings and Water Management

- Tailings structures designs. The tailings and water management pond structures designs have been completed to a preliminary level. Significant additional field data and design are required to prepare these structures for construction.

- Alaska dam permitting. The tailings and water management structures will be subject to an extensive design review and permitting process in Alaska. The process may result in changes to the designs.

- Groundwater. Additional field work and analysis are required to confirm specific design criteria for open pit wall and tailings structures.

1.21.2.6 Social Issues

- Land tenure. While the Pebble deposit lies within claims on State land, for which there is an identified path forward to gaining tenure, the transportation corridor crosses land belonging to Native Village Corporations and private individuals and agreements have not been reached with several of these entities. One of the Native Village Corporations has signed an agreement whereby a fund has obtained an option to buy portions of their land to create a conservation easement. The fund must exercise its option by the end of 2022. If the fund closes this agreement with the Native Village Corporation, the Pebble Partnership would be required to identify an alternate route to the proposed marine terminal on Cook Inlet.

- Project opposition. The Project is the subject of significant public opposition in Alaska and elsewhere in the United States.

1.21.2.7 Legal

- Legal actions. Northern Dynasty is party to several class action legal complaints and Pebble Partnership is subject to a government investigation regarding public statements made regarding the project. While these matters do not directly affect the development of the Project, they could negatively impact Northern Dynasty's and the Pebble Partnership's ability to finance the development of the Project or the ability to obtain required permitting.

- EPA. The EPA has announced it plans to re-initiate the process of making a CWA Section 404(c) determination for the waters of Bristol Bay, which would set aside the 2019 withdrawal of that action that was based on a 2017 settlement agreement between the EPA and Pebble Partnership. The 2019 withdrawal was contested by Project opponents and is currently subject to ongoing litigation. Such EPA activity could negatively affect the ability of the Pebble Partnership to obtain required permitting and develop the Project.

1.21.2.8 Permitting

- USACE Record of Decision. In November 2020, USACE denied Pebble Partnership's permit application. That decision is currently under appeal. The Proposed Project cannot proceed unless and until the ROD is overturned and all necessary permits, including the CWA 404 Permit, are obtained. There is no certainty that these permits will be obtained.

- Bristol Bay Forever. Bristol Bay Forever was a public initiative approved by Alaskan voters in November 2014. Based on that initiative, development of the Proposed Project requires legislative approval upon securing all other permits and authorizations.

1.21.2.9 Financial Results

- Cost estimates. The cost estimates contained in the 2021 PEA are completed to a preliminary level. Additional analysis and engineering are required to confirm these results.

- Metal prices and realization costs. Metal prices and realization costs are subject to significant fluctuation, particularly over the periods identified for the Proposed Project and potential expansion scenarios. These fluctuations could have a significant impact on the financial results of future studies and the actual results achieved by an operating mine.

- Taxation. The Proposed Project is subject to taxation at three government levels (local, State, and Federal). These tax regimes may change over time, resulting in different results than those identified in the 2021 PEA.

1.22 Interpretation and Conclusions

The Pebble property hosts a globally significant copper-gold-molybdenum-silver-rhenium deposit. The exploration and drilling programs completed thus far are appropriate to the type of the deposit. The exploration, drilling, geological modelling, and research work support the interpreted genesis of the mineralization and the domaining employed in the resource estimation.

The drill database for the Pebble deposit is reliable and sufficient to support the Mineral Resource estimate.

Estimations of mineral resources for the Project conform to industry best practices and are reported using the 2014 CIM Definition Standards.

Products from mining this deposit, including rhenium, support development of alternative energy supply and other purposes of strategic national significance. The Project would have significant regional economic importance for southwest Alaska and the entire state through the creation of high-wage jobs and training opportunities, supply and service contracts for local businesses, and government revenue.

The results of the 2021 PEA indicate the Pebble project could provide significant economic returns on investment. Further, the potential expansion and gold plant scenarios indicate potential economic upside through the expansion of processing capacity over an extended mine life. Based on the work carried out, this study should be followed by further technical and economic studies leading to an advancement to the next level of development.

1.23 Recommendations

1.23.1 Resource

- A small portion of the Mineral Resource forecast to be mined in the Proposed Project is classified as Inferred and should be upgraded for a future prefeasibility or feasibility study.
- The resource model should be further updated as additional data are acquired from drilling and metallurgical testwork.
- A scoping level study is recommended to assess how best to complete follow up drilling to test the compelling exploration potential of drill hole 6348.
- A scoping level program is recommended to determine the deportment and distribution of additional metals, as well as the best approach to their quantification.
- The estimated cost of the recommended program, including drilling, is $10.2 million.

1.23.2 Mining

- Detailed mine planning should be completed to understand potential bottlenecks and to assess other technologies, such as in-pit crushing and conveying and autonomous trucking and blast hole drilling,
- Detailed geotechnical studies should be conducted to better define the appropriate pit slope angles and design parameters for the pit, stockpiles, and overburden stockpiles.
- The estimated cost to complete the recommended work is $8.1 million, including drilling additional geotechnical investigation holes.

1.23.3 Metallurgy and Processing

- Future testwork is required to provide additional data to define silver recovery to the copper concentrate, rhenium recovery to the molybdenum concentrate, and precious metals to the gravity concentrate.
- Additional analysis and circuit optimization are recommended for treatment of supergene material. This should include collection of additional metallurgical samples from drilling these specific metallurgical domains.
- Complete an initial assessment of potential treatment methods of molybdenum concentrates to optimize the value of molybdenum and rhenium.
- Continued analysis is recommended to determine the optimum grinding circuit configuration and to evaluate coarse particle and column or other means of flotation.

- The estimated cost to complete the recommended metallurgical program, including sample collection, is $8.5 million.

1.23.4 Infrastructure

- Studies are recommended to finalize the location of the facilities and to determine site conditions.
- Additional data are required to finalize the access road alignment and to optimize costs.
- Additional data are required to advance the tailings and water and waste management designs.
- An Independent Review Panel should be established and the permitting process through the Alaska Dam Safety Program initiated.
- The estimated cost to complete the recommended infrastructure programs is $19.5 million.

2 INTRODUCTION

2.1 Introduction

Ausenco Engineering Canada (Ausenco) prepared this Technical Report on the Pebble Project (the Project), located in Alaska (

Figure 2-1), on behalf of Northern Dynasty Minerals Ltd. (Northern Dynasty). It summarizes the results of an updated Preliminary Economic Assessment (PEA) for the Project (the 2021 PEA).

Figure 2-1: Project Location Plan

Note: Figure prepared by Northern Dynasty. Operating mines and late stage development projects shown on the figure are held/operated by third parties and not by Northern Dynasty.

Northern Dynasty holds the Project indirectly through its wholly-owned subsidiary the Pebble Partnership, which in turn indirectly wholly-owns the subsidiaries Pebble East Claims Corporation and Pebble West Claims Corporation.

2.2 Terms of Reference

The 2021 PEA supports disclosures by Northern Dynasty in a news release dated 9 September 2021 entitled "Northern Dynasty: Preliminary Economic Assessment for Alaska's Pebble Project presents robust projected financial results and globally significant potential metal production with excellent optionality".

The 2021 PEA is an update to a Technical Report prepared for the Pebble Project in 2011 (the 2011 PEA) that has since been determined to be outdated, and the proposed project discussed therein has been superseded by the Project Description that the Pebble Partnership submitted for permitting in December 2017. This application triggered the requirement for an Environmental Impact Statement (EIS) through the National Environmental Policy Act (NEPA), a process led by the US Army Corps of Engineers (USACE). The Project Description was updated several times during the NEPA process, and that which is described in this 2021 PEA corresponds to the version submitted with the Revised Project Application in June 2020 and is attached to USACE Final EIS (FEIS) dated July 2020.

During the NEPA process, Pebble Partnership received a Request for Information (RFI) from USACE requesting a description of a concept for an expanded Project. The response to this RFI is included in the EIS Administrative Record. No engineering was done at the time but the 2021 PEA does contain, as a potential expansion scenario, an analysis of that concept along with indicative costs and financial results. Two additional scenarios, with different expansion dates and expanded throughput rates, are also analyzed as potential expansion scenarios.

The Report currency is the United States (US) dollar (US$ or $). The Report uses US customary units unless otherwise specified. The Pebble Partnership uses the US State Plane Coordinate System (as Alaska 5005) as the preferred grid, measured in feet (ft).

Mineral Resources and Mineral Reserves are reported in accordance with the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards for Mineral Resources and Mineral Reserves (May 2014; the 2014 CIM Definition Standards). Mineral Resources and Mineral Reserves were estimated in accordance with the 2019 CIM Estimation of Mineral Resources & Mineral Reserves Best Practice Guidelines (November 2019; the 2019 Best Practice Guidelines).

2.3 Sources of Information and Data

Reports and documents listed in Section 3 and Section 27 of this Report were used to support preparation of the Report. Additional information was provided by Northern Dynasty personnel as requested. Supplemental information was also provided to the QPs by third-party consultants retained by Northern Dynasty in their areas of expertise.

2.4 Qualified Persons

The following serve as the qualified persons for this Technical Report as defined in National Instrument 43-101, Standards of Disclosure for Mineral Projects, and in compliance with Form 43-101F1:

- Robin Kalanchey, P.Eng., Ausenco Engineering Canada Inc.;
- Hassan Ghaffari, P.Eng., Tetra Tech Canada Inc.;
- Sabry Abdel Hafez, P.Eng., Tetra Tech Canada Inc.;
- Les Galbraith, P.Eng., P.E., Knight Piésold Ltd.;
- J. David Gaunt, P.Geo., Hunter Dickinson Services Inc.;
- Eric Titley, P.Geo., Hunter Dickinson Services Inc.;
- Stephen Hodgson, P.Eng. Hunter Dickinson Services Inc.; and
- James Lang, P.Geo., J M Lang Professional Consulting Inc.;

2.5 Site Visits and Scope of Personal Inspection

QP Robin Kalanchey has not visited the Pebble site but has relied on the information provided in site visit reports as produced by Mr. Paul Staples, P.Eng., of Ausenco, who visited the site previously and during such visit observed the mine site, the site of the proposed marine terminal, and the data collection activities taking place at the time of the visit.

QP Hassan Ghaffari visited the Pebble site on September 1 and 2, 2010. The reasons for that visit were to witness the drilling program, then underway, to collect metallurgical samples, inspect core storage, and observe the Project site, including the proposed areas for the crushers and processing plant. The site visit included investigation of the possible infrastructure locations at the proposed mine and marine terminal sites and interacting with the site geology team.

QP Sabry Abdel Hafez visited the site on December 10, 2013 to inspect potential open pit, waste dump, stockpile, and pit access road locations.

QP Les Galbraith most recently visited the site on June 26, 2013 to witness the geotechnical site investigation program being completed by Knight Piésold at this time and complete a visual reconnaissance of potential infrastructure locations. Previous site visits by Les Galbraith were completed in 2012, 2009, and 2006 to witness geotechnical site investigations being completed by Knight Piésold.

QP David Gaunt has made multiple visits to the Project at Iliamna, AK since his involvement in the Project starting in 2001. The most recent visit made by QP Gaunt was completed on September 1st and 2nd, 2010. During this visit a review of drill core logging and sampling was conducted. Also at this time QP Gaunt extensively consulted with project geologists regarding their interpretation of geological units, structure and alteration as it relates to domaining of the Pebble deposit for estimation. These visits ensure that the most accurate geological model was incorporated into the mineral resource estimate.

QP Eric Titley most recently visited the Pebble Project site at Iliamna, AK on September 20 and 21, 2011 to review drill core logging, sampling, quality assurance and quality control (QA/QC) and core storage procedures with geological and technical staff there. QP Titley was accompanied on this visit by a representative of Nicholson Analytical Consultants (NAC). The visit also included a tour of the Fairbanks, AK sample preparation laboratory of ALS Minerals (ALS) and the long-term storage facility for assay rejects at Delta Junction, AK on 19 September 2011. QP Eric Titley previously conducted site visits to the

Iliamna site and these same facilities on August 25 to 27, 2008, with NAC, and with Analytical Laboratory Consultants (ALC) from May 29 to 31, 2007. In 2007, the visit also included visits to active drill rigs in the field. In separate visits, QP Titley and NAC (2008, 2011), and ALC (2007), visited the ALS assay laboratory in North Vancouver, BC, while drill core samples from the Pebble Project were being analyzed. These visits provide assurance that appropriate procedures were followed at these facilities.

QP Stephen Hodgson most recently visited the site on October 17 and 18, 2019. One of the reasons for that visit was to witness the hydro-geological drilling program underway at the time. QP Hodgson first visited the site in 1991 and has visited multiple times since joining the Northern Dynasty team in 2005. These trips included reconnaissance of possible site infrastructure sites and transportation corridors, interacting with the site teams supervising the various drill programs, and meeting with local residents.

QP James Lang was physically present at the Project area every year from 2003 through 2019, for a total of approximately 650 days. His most recent visit was in September 2019. From 2003 until March 2007, he was geological consultant to the Pebble Project and completed numerous studies on the geological characteristics of the Project. From March 2007 through 2010 he was resident Chief Geologist for the Project, and until March 2021 continued to function as Chief Geologist. Since March 2021, QP Lang has assumed the role of consulting Chief Geologist for the Project. During these years of involvement with the Project, QP Lang either personally acquired, supervised the acquisition of, or validated historical geological and related data on the Project. As a consequence, he is familiar with the geology, topography, physical features, access, location and infrastructure of the Project.

2.6 Effective Dates

There are a number of effective dates pertinent to the Report, as follows:

- Effective date of the latest information on environmental and permitting matters: September 9, 2021;
- Database close-out date: August 18, 2020;
- Effective date of the Mineral Resource estimate August 18, 2020; and
- Effective date of the economic analysis that supports the PEA: September 9, 2021.

The overall Report effective date is taken to be the date of the economic analysis that supports the 2021 PEA and is September 9, 2021.

2.7 Previous Technical Reports

Table 2-1: Previous Technical Reports

Name Description	Effective Date
Technical Report (43-101)	May 14, 2003
Technical Report (43-101)	Feb 20 2004
Technical Report (43-101)	May 31 2004
Technical Report (43-101)	Nov 3 2004
Technical Report (43-101)	Mar 31 2005
Technical Report (43-101)	April 1 2005
Technical Report (43-101)	Mar 9 2006
Technical Report (43-101)	Mar 31 2007
Technical Report (43-101)	Apr 5 2007
Technical Report (43-101)	Feb 25 2008
Technical Report (43-101)	Dec 1 2008
Technical Report (43-101)	Dec 31 2009
Technical Report (NI 43-101)	Feb 15 2011
Technical Report (NI 43-101)	Dec 31 2014
Technical Report (NI 43-101)	Dec 22 2017
Technical Report (NI 43-101)	Aug 18 2020
Technical Report (NI 43-101)	Feb 24 2021

2.8 Unit and Name Abbreviations

Table 2-2: Name Abbreviations

Name description	Abbreviation
Above mean sea level	amsl
Acme Analytical Laboratories	Acme
Alaska Department of Environmental Conservation	ADEC
Alaska Department of Fish and Game	ADFG
Alaska Department of Lands	ADL
Alaska Department of Natural Resources	ADNR
Alaska Department of Transport & Public Facilities	ADOT & PF
ALS Minerals in North Vancouver	ALS Vancouver
ALS Minerlas in Fairbanks	ALS Fairbanks
Alaska Peninsula Corporation	APC
Ammonium molybdate	$(NH_4)_2 MoO_4$
Anadromous Waters Catalog	AWC
Acid Potential	AP
Acid Rock Drainage	ARD
Aqua Regia (HNO_3-HCl)	AR
Atomic absorption spectroscopy	AAS
Ball Mill Work Index	BWi
Billion years	Ga
Brittle-ductile fault	BDF
Bureau Veritas Commodities Canada Ltd.	BVCCL
Carbon-In-Leach	CIL
Copper	Cu
Clean Water Act	CWA
Cominco Exploration Research Laboratory	CERL
Differential global positioning system	DGPS
Digital Elevation Model	DEM
Drop weight index	DWi
Electromagnetic	EM
U.S. Environmental Protection Agency	EPA
Final Environmental Impact Statement	FEIS
Fire Assay	FA
Full Metal Minerals USA Inc.	GMMUSA
Global Positioning System	GPS
Gold	Au
Gravity recoverable gold	GRG
G&T Metallurgical Services Ltd.	G&T
Health, safety and environment	HSE
Iliamna Natives Limited	INL
Induced Polarization geophysics	IP
Inductively coupled plasma atomic emission spectroscopy	ICP-AES
Inductively coupled plasma mass spectrometry	ICP-MS

Name description	Abbreviation
International Organization for Standardization	ISO
Ion Exchange	IX
Kaskanak Creek	KC
Kaskanak Copper Limited Liability Company	The LLC
Least Environmentally Destructive Practicable Alternative	LEDPA
Mass in air	MA
Maximum potential acidity	MPA
Metal Leaching	ML
Methyl Isobutyl Carbinol	MIBC
Millions of years	Ma
Molybdenum	Mo
Molybdenum Autoclave Process	MAP
Molybdenum Trioxide	MoO_3
National Environmental Policy Act	NEPA
National Instrument 43-101	NI 43-101
Neutralizing Potential	NP
Neutralization potential ratio	NPR
North Fork Koktuli	NFK
Northern and Southern quartz vein domains	NQV and SQV
Potassium Ethyl Xanthate	PEX
Potentially acid generating	PAG
Pregnant Leach Solution	PLS
Process Research Associates Ltd.	PRA
Quantitative evaluation of materials by scanning electron microscopy	QEMSCAN
Quality Control/Quality Assurance	QA/QC
Qualified Person	QP
Quartz Sericite Pyrite	QSP
Rhenium	Re
Rivers and Harbors Act	RHA
Rod Mill Work Index	RWi
Run of Mine	ROM
Real Time Kinematic	RTK
SAG Mill Comminution	SMC
Semi-autogenous grinding	SAG
SGS Mineral Services	SGS
Silver	Ag
Sodium Ethyl Xanthate	SEX
Sodium Hydrosulfide	NaHS
Solvent Extraction	SX
Sulphidize, acidify, recycle and thicken	SART
South Fork Koktuli	SFK
Teck Resources Limited	Teck
Three dimensional	3D
Three-Dimensional Model	3DM
Total dissolved solids	TDS
Upper Talarik Creek	UTC

Name description	Abbreviation
U.S. Army Corps of Engineers	USACE
United States Geological Survey	USGS
Vibrating wire piezometer	VWP
Water Management Pond	WMP
X-ray Fluorescence	XRF
Zonge Engineering and Research Organization Inc.	Zonge Engineering

Table 2-3: Unit Abbreviations

Unit Description	Abbreviation
Acre	ac
Ampere	A
Annum (year)	a
Billion	B
Centimetre	cm
Cubic centimetre	cm^3
Cubic feet per minute	cfm
Cubic feet per second	ft^3/s
Cubic foot	ft^3
Cubic inch	in^3
Cubic metre	m^3
Day	d
Days per week	d/wk
Days per year (annum)	d/a
Degree	°
Degrees Celsius	°C
Degrees Fahrenheit	°F
Feet	ft
Gram	g
Grams per cubic centimetre	g/cm^3
Grams per litre	g/L
Grams per tonne	g/t
US Gallons	USG
US Gallons per minute	GPM
Greater than	>
Hectare (10,000 m^2)	ha
Horsepower	hp
Hour	h
Hours per day	h/d
Hours per week	h/w
Hours per year	h/a
Inch	in
Kilo (thousand)	k
Kilogram	kg
Kilograms per hour	kg/h
Kilograms per square metre	kg/m^2
Kilometre	km
Kilometres per hour	km/h
Kilopascal	kPa

Unit Description	Abbreviation
Kilovolt	kV
Kilowatt	kW
Kilowatt hour	kWh
Kilowatt hours per tonne (metric ton)	kWh/t
Kilowatt hours per year	kWh/a
Less than	<
Litres	L
Litres per minute	L/m
Megawatts	MW
Megawatt hour	MWh
Metres	m
Metres above sea level	masl
Microns	µm
Mile	mi
Milligram	mg
Milligrams per litre	mg/l
Millilitre	mL
Millimetre	mm
Million	M
Million tonnes	Mt
Minute (plane angle)	(')
Minute (time)	min
Month	mo
Ounce	oz
Parts per million	ppm
Parts per billion	ppb
Percent	%
Pounds	lb
Pounds per square inch	psi
Pounds per ton	lb/ton
Second (plane angle)	"
Second (time)	s
Square centimetre	cm^2
Square foot	ft^2
Square inch	in^2
Square kilometer	km^2
Square metre	m^2
Revolutions per minute	rpm
Tonnes (metric - 1,000 kg)	t
Thousand tonnes	kt
Tons (imperial – 2,000 lb)	ton
Volt	V
Week	wk
Year (annum)	a

3 RELIANCE ON OTHER EXPERTS

3.1 Introduction

The QPs have relied upon the following other expert reports, which provided information regarding mineral rights, surface rights, property agreements, royalties, taxation, and marketing sections of this Report.

3.2 Mineral Tenure

The QPs have not independently reviewed ownership of the Project area and any underlying property agreements, mineral tenure, surface rights, or royalties. The QPs have fully relied upon, and disclaim responsibility for, information derived from Northern Dynasty for this information through the following document:

Thomas, T., 2021: Letter dated October 14, 2021 that provides the reliance; prepared for Stephen Hodgson, P.Eng., and David Gaunt, P.Geo.

This information is used in Section 4 of the Report. It is also used in Section 14 in support of the Mineral Resource estimates and in Section 22 in support of the economic analysis that supports the 2021 PEA.

3.3 Environmental, Permitting, Closure, and Social and Community Impacts

The QPs have fully relied upon, and disclaim responsibility for, information supplied by former staff and experts retained by Northern Dynasty for information related to environmental (including tailings and water management) permitting and social and community impacts as follows:

Ford, L. 2021: Memo dated October 19, 2021, 1 page, that provides the reliance; prepared for Pebble Limited Partnership, copied to Stephen Hodgson, P.Eng. and David Gaunt, P.Geo.

Magee, S., 2021: Letter dated October 14, 2021 that provides the reliance; prepared for Stephen Hodgson, P.Eng.

This information is used in Section 20 of the Report. It is also used in Section 14 in support of the Mineral Resource estimates and in Section 22 in support of the economic analysis that supports the 2021 PEA.

3.4 Taxation

The QPs have fully relied upon, and disclaim responsibility for, information supplied by staff and experts retained by Northern Dynasty for information related to taxation as applied to the financial model as follows:

Peters, Mark, 2021: Letter dated October 18, 2021 that provides reliance; prepared for Stephen Hodgson, P.Eng.

This information is used in Sections 22 and 24 of the 2021 PEA.

4 PROPERTY DESCRIPTION AND LOCATION

4.1 Introduction

The Pebble Project is located in southwest Alaska, approximately 200 mi southwest of Anchorage, 17 mi northwest of the village of Iliamna, 100 mi northeast of Bristol Bay, and approximately 60 mi west of Cook Inlet.

The Project is centred, approximately, at latitude 59°53'54" N and longitude 155°17'44" W and is located on the United States Geological Survey (USGS) topographic maps Iliamna D6 and D7, in Townships 2–5 South, Ranges 33–38 West, Seward Meridian.

4.2 Mineral Tenure

Northern Dynasty holds indirectly through Pebble East Claims Corporation and Pebble West Claims Corporation, wholly-owned subsidiaries of the wholly-owned Pebble Partnership, a 100% interest in a contiguous block of 2,402 administratively active mining claims and leasehold locations covering approximately 417 mi^2 (which includes the Pebble deposit).

State mineral claims in Alaska are kept in good standing by performing annual assessment work or in lieu of assessment work by paying $100 per year per 40 acre (0.06 mi^2) mineral claim, and by paying annual escalating State rental fees each year. Assessment work is due annually by noon of September 1. However, credit for excess assessment work can be banked for a maximum of four years after work is performed and can be applied as necessary to continue to hold the claims in good standing. The Project claims have a variable amount of assessment work credit available that can be applied in this way. Annual assessment work obligations for the Project total US$667,700 and are due each year on September 1. Annual State rentals for 2021 are approximately US$1,375,910 and are payable no later than 90 days after the assessment work is due (approximately December 1).

The details of the administratively active mining claims and leasehold locations are provided in Table 4 1 (ADL refers to the Alaska Department of Lands).

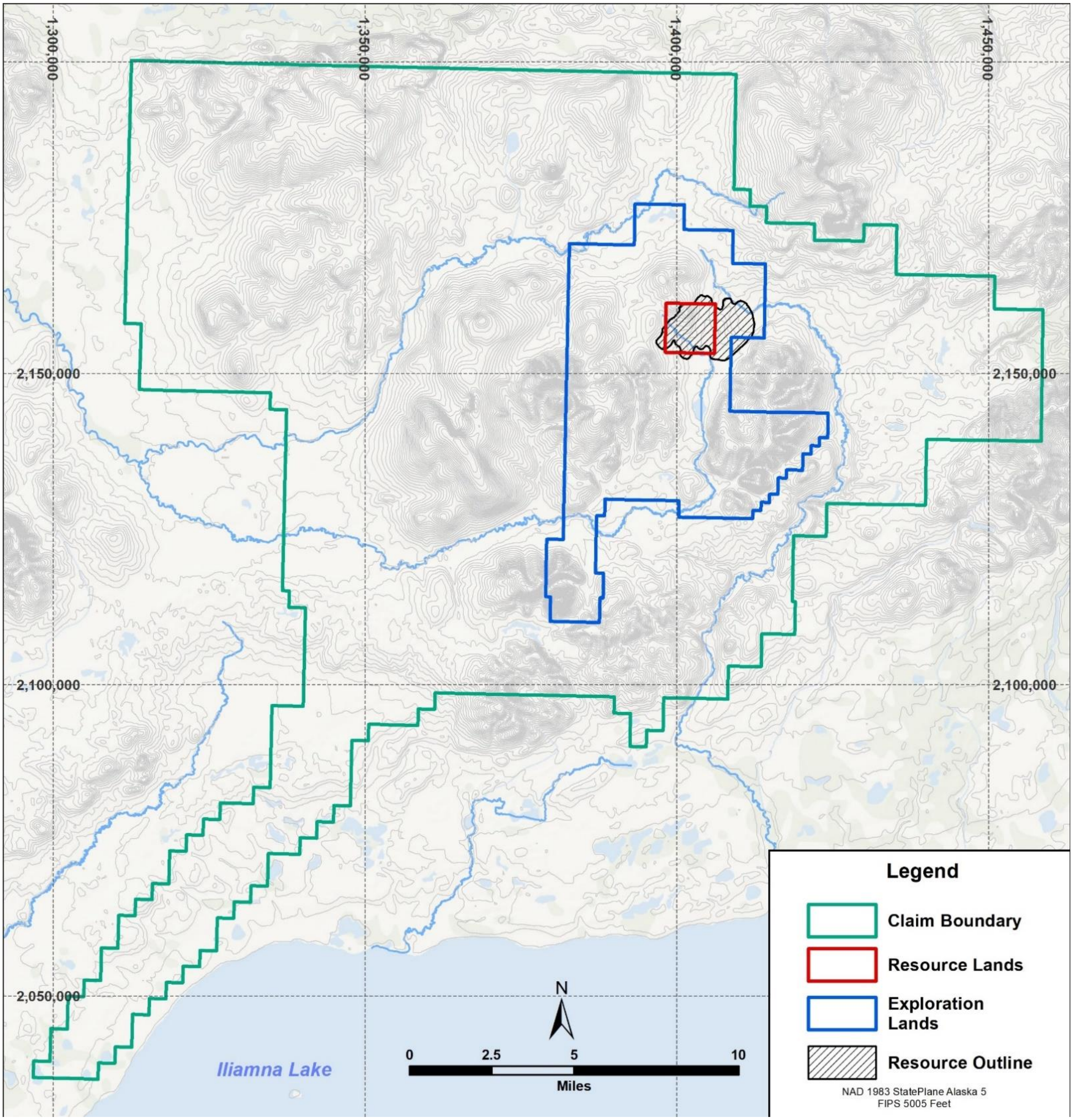
The claim boundaries have not been surveyed.

4.3 Royalties

Teck Resources Limited (Teck) holds a 4% pre-payback net profits interest (after debt service), followed by a 5% after-payback net profits interest in any mine production from the Exploration Lands, which are shown in Figure 4-1 and further described in Section 6 History.

In June 2020, the Pebble Partnership established the Pebble Performance Dividend LLP to distribute a 3% net profits royalty interest in the Pebble Project to adult residents of Bristol Bay villages that have subscribed as participants. The Pebble Performance Dividend will distribute a guaranteed minimum annual payment of US$3 million each year the Pebble mine operates, beginning at the outset of Project construction.

Figure 4-1: Mineral Claim Map with Exploration Lands and Resource Lands



Note: Figure prepared by Northern Dynasty, 2021.

Pebble East Claims Corp.		ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME
ADL #	CLAIM NAME	552987	KAK 57	553521	PEBA 95	553600	PEBF 13	638862	PEB 84
552871	SOUTH PEBBLE 113	552988	KAK 58	553522	PEBA 96	553601	PEBF 14	638863	PEB 85
552872	SOUTH PEBBLE 114	552989	KAK 59	553523	PEBA 97	553602	PEBF 15	638864	PEB 86
552873	SOUTH PEBBLE 115	552990	KAK 60	553524	PEBA 98	553603	PEBF 16	638865	PEB 87
552874	SOUTH PEBBLE 116	552991	KAK 61	553525	PEBA 99	553604	PEBF 17	638866	PEB 88
552875	SOUTH PEBBLE 117	552992	KAK 62	553526	PEBA 100	553605	PEBF 18	638867	PEB 89
552876	SOUTH PEBBLE 118	552993	KAK 63	553527	PEBA 101	553606	PEBF 19	638868	PEB 90
552877	SOUTH PEBBLE 119	552994	KAK 64	553528	PEBA 102	553607	PEBF 20	638869	PEB 91
552878	SOUTH PEBBLE 120	552995	KAK 65	553529	PEBA 103	553608	PEBF 21	638870	PEB 92
552879	SOUTH PEBBLE 121	552996	KAK 66	553530	PEBA 104	553609	PEBF 22	638871	PEB 93
552880	SOUTH PEBBLE 122	552997	KAK 67	553531	PEBA 105	553610	PEBF 23	638872	PEB 94
552881	SOUTH PEBBLE 123	552998	KAK 68	553532	PEBA 106	553611	PEBF 24	638873	PEB 95
552882	SOUTH PEBBLE 124	552999	KAK 69	553533	PEBA 107	553612	PEBF 25	638874	PEB 96
552883	SOUTH PEBBLE 125	553000	KAK 70	553534	PEBA 108	553613	PEBF 26	638875	PEB 97
552884	SOUTH PEBBLE 126	553001	KAK 71	553535	PEBA 109	553614	PEBF 27	638882	PEB 104
552885	SOUTH PEBBLE 127	553002	KAK 72	553536	PEBA 110	553615	SILL 6155	638883	PEB 105
552909	SOUTH PEBBLE 151	553003	KAK 73	553537	PEBA 111	553616	SILL 6156	638884	PEB 106
552911	SOUTH PEBBLE 153	553004	KAK 74	553538	PEBA 112	553617	SILL 6256	638885	PEB 107
552912	SOUTH PEBBLE 154	553005	KAK 75	553539	PEBB 1	638779	PEB 1	638886	PEB 108
552913	SOUTH PEBBLE 155	553006	KAK 76	553540	PEBB 2	638780	PEB 2	638887	PEB 109
552914	SOUTH PEBBLE 156	553007	KAK 77	553541	PEBB 3	638781	PEB 3	638888	PEB 110
552915	SOUTH PEBBLE 157	553008	KAK 78	553542	PEBB 4	638782	PEB 4	638889	PEB 111
552916	SOUTH PEBBLE 158	553009	KAK 79	553543	PEBB 5	638783	PEB 5	638890	PEB 112
552931	KAK 1	553010	KAK 80	553544	PEBB 6	638784	PEB 6	638891	PEB 113
552932	KAK 2	553011	KAK 81	553545	PEBB 7	638785	PEB 7	638892	PEB 114
552933	KAK 3	553012	KAK 82	553546	PEBB 8	638786	PEB 8	638893	PEB 115
552934	KAK 4	553013	KAK 83	553547	PEBB 9	638791	PEB 13	640061	PEB N-1
552935	KAK 5	553014	KAK 84	553548	PEBB 10	638792	PEB 14	640062	PEB N-2
552936	KAK 6	553015	KAK 85	553549	PEBB 11	638793	PEB 15	640063	PEB N-3
552937	KAK 7	553016	KAK 86	553550	PEBB 12	638794	PEB 16	640064	PEB N-4
552938	KAK 8	553017	KAK 87	553551	PEBB 13	638795	PEB 17	640065	PEB N-5
552939	KAK 9	553018	KAK 88	553552	PEBB 14	638796	PEB 18	640066	PEB N-6
552940	KAK 10	553019	KAK 89	553553	PEBB 15	638797	PEB 19	640067	PEB N-7
552941	KAK 11	553427	PEBA 1	553554	PEBB 16	638798	PEB 20	640068	PEB N-8
552942	KAK 12	553428	PEBA 2	553555	PEBB 17	638799	PEB 21	640069	PEB N-9
552943	KAK 13	553429	PEBA 3	553556	PEBB 18	638800	PEB 22	640070	PEB N-10
552944	KAK 14	553437	PEBA 11	553557	PEBB 19	638801	PEB 23	640071	PEB N-11
552945	KAK 15	553438	PEBA 12	553558	PEBB 20	638802	PEB 24	640072	PEB N-12
552946	KAK 16	553439	PEBA 13	553559	PEBB 21	638807	PEB 29	640073	PEB N-13
552947	KAK 17	553447	PEBA 21	553560	PEBB 22	638808	PEB 30	640074	PEB N-14
552948	KAK 18	553448	PEBA 22	553561	PEBB 23	638809	PEB 31	640075	PEB N-15
552949	KAK 19	553449	PEBA 23	553562	PEBB 24	638810	PEB 32	640076	PEB N-16
552950	KAK 20	553457	PEBA 31	553563	PEBB 25	638811	PEB 33	640077	PEB N-17
552951	KAK 21	553458	PEBA 32	553564	PEBB 26	638812	PEB 34	640078	PEB N-18
552952	KAK 22	553459	PEBA 33	553565	PEBB 27	638813	PEB 35	640079	PEB N-19
552953	KAK 23	553467	PEBA 41	553566	PEBB 28	638814	PEB 36	640080	PEB N-20
552954	KAK 24	553468	PEBA 42	553567	PEBB 29	638815	PEB 37	640081	PEB N-21
552955	KAK 25	553469	PEBA 43	553568	PEBB 30	638816	PEB 38	640082	PEB N-22
552956	KAK 26	553470	PEBA 44	553569	PEBB 31	638821	PEB 43	640083	PEB N-23
552957	KAK 27	553471	PEBA 45	553570	PEBB 32	638822	PEB 44	640084	PEB N-24
552958	KAK 28	553472	PEBA 46	553571	PEBB 33	638823	PEB 45	640085	PEB N-25
552959	KAK 29	553478	PEBA 52	553572	PEBB 34	638824	PEB 46	640086	PEB N-26
552960	KAK 30	553479	PEBA 53	553573	PEBB 35	638825	PEB 47	640087	PEB N-27
552961	KAK 31	553480	PEBA 54	553574	PEBB 36	638826	PEB 48	640088	PEB N-28
552962	KAK 32	553481	PEBA 55	553575	PEBB 37	638827	PEB 49	640089	PEB N-29
552963	KAK 33	553482	PEBA 56	553576	PEBB 38	638828	PEB 50	640090	PEB N-30
552964	KAK 34	553488	PEBA 62	553577	PEBB 39	638829	PEB 51	640091	PEB N-31
552965	KAK 35	553489	PEBA 63	553578	PEBE 1	638830	PEB 52	640092	PEB N-32
552966	KAK 36	553490	PEBA 64	553579	PEBE 2	638835	PEB 57	640093	PEB N-33
552967	KAK 37	553491	PEBA 65	553580	PEBE 3	638836	PEB 58	640094	PEB N-34
552968	KAK 38	553492	PEBA 66	553581	PEBE 4	638837	PEB 59	640095	PEB N-35
552969	KAK 39	553493	PEBA 67	553582	PEBE 5	638838	PEB 60	640096	PEB N-36
552970	KAK 40	553494	PEBA 68	553583	PEBE 6	638839	PEB 61	642027	SOUTH PEBBLE 71
552971	KAK 41	553500	PEBA 74	553584	PEBE 7	638840	PEB 62	642028	SOUTH PEBBLE 72
552972	KAK 42	553501	PEBA 75	553585	PEBE 8	638841	PEB 63	642029	SOUTH PEBBLE 73
552973	KAK 43	553502	PEBA 76	553586	PEBE 9	638842	PEB 64	642035	SOUTH PEBBLE 79
552974	KAK 44	553503	PEBA 77	553587	PEBE 10	638843	PEB 65	642036	SOUTH PEBBLE 80
552975	KAK 45	553504	PEBA 78	553588	PEBF 1	638844	PEB 66	642037	SOUTH PEBBLE 81
552976	KAK 46	553505	PEBA 79	553589	PEBF 2	638848	PEB 70	642038	SOUTH PEBBLE 82
552977	KAK 47	553506	PEBA 80	553590	PEBF 3	638849	PEB 71	642039	SOUTH PEBBLE 83
552978	KAK 48	553507	PEBA 81	553591	PEBF 4	638850	PEB 72	642040	SOUTH PEBBLE 84
552979	KAK 49	553508	PEBA 82	553592	PEBF 5	638851	PEB 73	642041	SOUTH PEBBLE 85
552980	KAK 50	553509	PEBA 83	553593	PEBF 6	638852	PEB 74	642042	SOUTH PEBBLE 86
552981	KAK 51	553510	PEBA 84	553594	PEBF 7	638853	PEB 75	642043	SOUTH PEBBLE 87
552982	KAK 52	553511	PEBA 85	553595	PEBF 8	638854	PEB 76	642044	SOUTH PEBBLE 88
552983	KAK 53	553517	PEBA 91	553596	PEBF 9	638855	PEB 77	642045	SOUTH PEBBLE 89
552984	KAK 54	553518	PEBA 92	553597	PEBF 10	638856	PEB 78	642046	SOUTH PEBBLE 90
552985	KAK 55	553519	PEBA 93	553598	PEBF 11	638857	PEB 79	642047	SOUTH PEBBLE 91
552986	KAK 56	553520	PEBA 94	553599	PEBF 12	638858	PEB 80	642048	SOUTH PEBBLE 92

ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME
642049	SOUTH PEBBLE 93	642393	PEB EB 56	643913	PEB SE 15	644221	PEB SE 58	644383	SP 292
642050	SOUTH PEBBLE 94	642394	PEB EB 57	643914	PEB SE 16	644222	PEB SE 59	644384	SP 293
642051	SOUTH PEBBLE 95	642395	PEB EB 58	643915	PEB SE 17	644223	PEB SE 60	644385	SP 294
642052	SOUTH PEBBLE 96	642396	PEB EB 59	643916	PEB SE 18	644224	PEB SE 61	644386	KAK 90
642053	SOUTH PEBBLE 97	642397	PEB EB 60	643917	PEB SE 19	644225	PEB SE A8	644387	KAK 91
642054	SOUTH PEBBLE 98	642398	PEB EB 61	643918	PEB SE 20	644226	PEB SE A9	644388	KAK 92
642055	SOUTH PEBBLE 99	642399	PEB EB 62	643919	PEB SE 21	644227	PEB SE A10	644389	KAK 93
642056	SOUTH PEBBLE 100	642400	PEB EB 63	643920	PEB SE 22	644228	PEB SE A11	644390	KAK 94
642057	SOUTH PEBBLE 101	642401	PEB EB 64	643921	PEB SE 23	644229	PEB SE A12	644391	KAK 95
642058	SOUTH PEBBLE 102	642402	PEB EB 65	643922	PEB SE 24	644230	PEB SE A13	644392	KAK 96
642059	SOUTH PEBBLE 103	642403	PEB EB 66	643923	PEB SE 25	644231	PEB EB 75	644393	KAK 97
642060	SOUTH PEBBLE 104	642404	PEB EB 67	643924	PEB SE 26	644232	PEB EB 76	644394	KAK 98
642061	SOUTH PEBBLE 105	642405	PEB EB 68	643925	PEB SE 27	644233	PEB EB 77	644395	KAK 99
642062	SOUTH PEBBLE 106	642406	PEB EB 69	643926	PEB SE 28	644234	PEB EB 78	644396	KAK 100
642063	SOUTH PEBBLE 107	642407	PEB EB 70	643927	PEB SE 29	644235	PEB EB 79	644397	KAK 101
642064	SOUTH PEBBLE 108	642408	PEB EB 71	643928	PEB SE 30	644236	PEB EB 80	644398	KAK 102
642065	SOUTH PEBBLE 109	642409	PEB EB 72	643929	PEB SE 31	644237	PEB EB 81	644399	KAK 103
642066	SOUTH PEBBLE 110	642410	PEB EB 73	643930	PEB SE 32	644238	PEB EB 82	644400	KAK 104
642067	SOUTH PEBBLE 111	642411	PEB EB 74	643931	PEB NW A1	644239	PEB EB 83	644401	KAK 105
642068	SOUTH PEBBLE 112	642412	PEB WB 1	643932	PEB NW A2	644240	PEB EB 84	644402	KAK 106
642334	PEB EBA 1	642413	PEB WB 2	643933	PEB NW A3	644241	PEB EB 85	644403	KAK 107
642335	PEB EBA 2	642414	PEB WB 3	643934	PEB NW A4	644242	PEB EB 86	644404	KAK 108
642336	PEB EBA 3	642415	PEB WB 4	643935	PEB NW 1	644243	PEB EB 87	644405	KAK 109
642337	PEB EBA 4	642416	PEB WB 5	643936	PEB NW 2	644244	PEB EB 88	644406	KAK 110
642338	PEB EB 1	642417	PEB WB 6	643937	PEB NW 3	644245	PEB EB 89	644407	KAK 111
642339	PEB EB 2	642418	PEB WB 7	643938	PEB NW 4	644246	PEB EB 90	644408	KAK 112
642340	PEB EB 3	642419	PEB WB 8	643939	PEB NW 5	644247	PEB EB 91	644409	KAK 113
642341	PEB EB 4	642420	PEB WB 9	643940	PEB NW 6	644248	PEB EB 92	644410	KAK 114
642342	PEB EB 5	642421	PEB WB 10	643941	PEB NW 7	644249	PEB EB 93	644411	KAK 115
642343	PEB EB 6	642422	PEB WB 11	643942	PEB NW 8	644250	PEB EB 94	644412	KAK 116
642344	PEB EB 7	642423	PEB WB 12	643943	PEB NW 9	644251	PEB EB 95	644413	KAK 117
642345	PEB EB 8	642424	PEB WB 13	643944	PEB NW 10	644252	PEB EB A5	644414	KAK 118
642346	PEB EB 9	642425	PEB WB 14	643945	PEB NW 11	644253	PEB EB A6	644415	KAK 119
642347	PEB EB 10	642426	PEB WB 15	643946	PEB NW 12	644254	PEB EB A7	644421	KAK 125
642348	PEB EB 11	642427	PEB WB 16	643947	PEB NW 13	644255	PEB EB A8	644422	KAK 126
642349	PEB EB 12	642428	PEB WB 17	643948	PEB NW 14	644256	PEB WB 40	644423	KAK 127
642350	PEB EB 13	642429	PEB WB 18	643949	PEB NW 15	644257	PEB WB 41	644424	KAK 128
642351	PEB EB 14	642430	PEB WB 19	643950	PEB NW 16	644258	PEB WB 42	644425	KAK 129
642352	PEB EB 15	642431	PEB WB 20	643951	PEB NW 17	644259	PEB WB 43	644426	KAK 130
642353	PEB EB 16	642432	PEB WB 21	643952	PEB NW 18	644260	PEB WB 44	644467	KAK 171
642354	PEB EB 17	642433	PEB WB 22	643953	PEB NW 19	644261	PEB WB 45	644468	KAK 172
642355	PEB EB 18	642434	PEB WB 23	643954	PEB NW 20	644262	PEB WB 46	644469	KAK 173
642356	PEB EB 19	642435	PEB WB 24	643955	PEB NW 21	644263	PEB WB 47	644470	KAK 174
642357	PEB EB 20	642436	PEB WB 25	643956	PEB NW 22	644264	PEB WB 48	644471	KAK 175
642358	PEB EB 21	642437	PEB WB 26	643957	PEB NW 23	644265	PEB WB 49	644472	KAK 176
642359	PEB EB 22	642438	PEB WB 27	643958	PEB NW 24	644266	PEB WB 50	644473	KAK 177
642360	PEB EB 23	642439	PEB WB 28	643959	PEB NW 25	644267	PEB WB 51	644474	KAK 178
642361	PEB EB 24	642440	PEB WB 29	643960	PEB NW 26	644268	PEB WB 52	644475	KAK 179
642362	PEB EB 25	642441	PEB WB 30	643961	PEB NW 27	644269	PEB WB 53	644476	KAK 180
642363	PEB EB 26	642442	PEB WB 31	643962	PEB NW 28	644270	PEB WB 54	644477	KAK 181
642364	PEB EB 27	642443	PEB WB 32	643963	PEB NW 29	644271	PEB WB 55	644478	KAK 182
642365	PEB EB 28	642444	PEB WB 33	643964	PEB NW 30	644272	PEB WB 56	644479	KAK 183
642366	PEB EB 29	642445	PEB WB 34	643965	PEB NW 31	644273	PEB WB 57	644480	KAK 184
642367	PEB EB 30	642446	PEB WB 35	643966	PEB NW 32	644274	PEB WB 58	644481	KAK 185
642368	PEB EB 31	642447	PEB WB 36	644196	PEB SE 33	644275	PEB WB 59	644482	KAK 186
642369	PEB EB 32	642448	PEB WB 37	644197	PEB SE 34	644276	PEB WB 60	644483	KAK 187
642370	PEB EB 33	642449	PEB WB 38	644198	PEB SE 35	644277	PEB WB 61	644881	KAK 188
642371	PEB EB 34	642450	PEB WB 39	644199	PEB SE 36	644278	PEB WB 62	644882	KAK 189
642372	PEB EB 35	643892	PEB SE A1	644200	PEB SE 37	644279	PEB WB 63	644883	KAK 190
642373	PEB EB 36	643893	PEB SE A2	644201	PEB SE 38	644304	SP 193	644884	KAK 191
642374	PEB EB 37	643894	PEB SE A3	644202	PEB SE 39	644305	SP 194	644885	KAK 192
642375	PEB EB 38	643895	PEB SE A4	644203	PEB SE 40	644306	SP 195	644886	KAK 193
642376	PEB EB 39	643896	PEB SE A5	644204	PEB SE 41	644307	SP 196	644887	KAK 194
642377	PEB EB 40	643897	PEB SE A6	644205	PEB SE 42	644308	SP 197	644888	KAK 195
642378	PEB EB 41	643898	PEB SE A7	644206	PEB SE 43	644309	SP 198	644889	KAK 196
642379	PEB EB 42	643899	PEB SE 1	644207	PEB SE 44	644310	SP 199	644890	KAK 197
642380	PEB EB 43	643900	PEB SE 2	644208	PEB SE 45	644311	SP 200	644891	KAK 198
642381	PEB EB 44	643901	PEB SE 3	644209	PEB SE 46	644316	SP 205	644892	KAK 199
642382	PEB EB 45	643902	PEB SE 4	644210	PEB SE 47	644317	SP 206	644893	KAK 200
642383	PEB EB 46	643903	PEB SE 5	644211	PEB SE 48	644371	SP 280	644894	KAK 201
642384	PEB EB 47	643904	PEB SE 6	644212	PEB SE 49	644374	SP 283	644895	KAK 202
642385	PEB EB 48	643905	PEB SE 7	644213	PEB SE 50	644375	SP 284	644896	KAK 203
642386	PEB EB 49	643906	PEB SE 8	644214	PEB SE 51	644376	SP 285	644897	KAK 204
642387	PEB EB 50	643907	PEB SE 9	644215	PEB SE 52	644377	SP 286	644898	KAK 205
642388	PEB EB 51	643908	PEB SE 10	644216	PEB SE 53	644378	SP 287	644899	KAK 206
642389	PEB EB 52	643909	PEB SE 11	644217	PEB SE 54	644379	SP 288	644900	KAK 207
642390	PEB EB 53	643910	PEB SE 12	644218	PEB SE 55	644380	SP 289	644901	KAK 208
642391	PEB EB 54	643911	PEB SE 13	644219	PEB SE 56	644381	SP 290	644902	KAK 209
642392	PEB EB 55	643912	PEB SE 14	644220	PEB SE 57	644382	SP 291	644903	KAK 210

ADL #	CLAIM NAME
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646605	PEBBLE BEACH 5943
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646617	PEB K 12
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648909	PEB WB 67
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663848	KAK 170A
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668743	KAS 3
668744	KAS 4
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668750	KAS 10
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669012	KAS 272
669013	KAS 273
669014	KAS 274

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669015	KAS 275
669038	KAS 298
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669043	KAS 303
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669129	KAS 394
669130	KAS 395
669135	KAS 400
669136	KAS 401
669137	KAS 402
669138	KAS 403

Pebble West Claims Corp.

ADL #	CLAIM NAME
516769	SILL 5951
516770	SILL 5952
516779	SILL 6051
516780	SILL 6052
516789	SILL 6151
516790	SILL 6152
516797	SILL 6247
516798	SILL 6248
516799	SILL 6249
516800	SILL 6250
516801	SILL 6251
516802	SILL 6252
516806	PEBBLE BEACH 5448
516807	PEBBLE BEACH 5449
516808	PEBBLE BEACH 5450
516809	PEBBLE BEACH 5451
516810	PEBBLE BEACH 5452
516811	PEBBLE BEACH 5453
516812	PEBBLE BEACH 5454
516813	PEBBLE BEACH 5548
516814	PEBBLE BEACH 5549
516815	PEBBLE BEACH 5550
516816	PEBBLE BEACH 5551
516817	PEBBLE BEACH 5552
516818	PEBBLE BEACH 5553
516819	PEBBLE BEACH 5554
516820	PEBBLE BEACH 5651
516821	PEBBLE BEACH 5652
516822	PEBBLE BEACH 5653
516823	PEBBLE BEACH 5654
516824	PEBBLE BEACH 5751

ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME
516825	PEBBLE BEACH 5752	516973	PEBBLE BEACH 4551	524776	PEBBLE BEACH 4053	524855	PEBBLE BEACH 6252	531423	PEBBLE BEACH 5146
516826	PEBBLE BEACH 5753	516974	PEBBLE BEACH 4552	524777	PEBBLE BEACH 4054	524856	PEBBLE BEACH 6253	531424	PEBBLE BEACH 5147
516827	PEBBLE BEACH 5754	516975	PEBBLE BEACH 4553	524778	PEBBLE BEACH 4055	524857	PEBBLE BEACH 6254	531425	PEBBLE BEACH 5244
516828	PEBBLE BEACH 5852	524511	SILL 5543	524779	PEBBLE BEACH 4148	524858	PEBBLE BEACH 6348	531426	PEBBLE BEACH 5245
516829	PEBBLE BEACH 5853	524512	SILL 5544	524780	PEBBLE BEACH 4149	524859	PEBBLE BEACH 6349	531427	PEBBLE BEACH 5246
516830	PEBBLE BEACH 5854	524515	SILL 5643	524781	PEBBLE BEACH 4153	524860	PEBBLE BEACH 6350	531428	PEBBLE BEACH 5247
516831	PEBBLE BEACH 5952	524516	SILL 5644	524782	PEBBLE BEACH 4154	524861	PEBBLE BEACH 6351	531429	PEBBLE BEACH 5344
516832	PEBBLE BEACH 5953	524519	SILL 5743	524783	PEBBLE BEACH 4155	524862	PEBBLE BEACH 6352	531430	PEBBLE BEACH 5345
516833	PEBBLE BEACH 5954	524520	SILL 5744	524784	PEBBLE BEACH 4248	524863	PEBBLE BEACH 6353	531431	PEBBLE BEACH 5346
516834	PEBBLE BEACH 6052	524523	SILL 5843	524785	PEBBLE BEACH 4249	524864	PEBBLE BEACH 6354	531432	PEBBLE BEACH 5347
516835	PEBBLE BEACH 6053	524524	SILL 5844	524786	PEBBLE BEACH 4255	525849	PEBBLE BEACH 6152	531433	PEBBLE BEACH 5444
516836	PEBBLE BEACH 6054	524527	SILL 5943	524787	PEBBLE BEACH 4348	531355	PEBBLE BEACH 3642	531434	PEBBLE BEACH 5445
516837	PEBBLE BEACH 6153	524528	SILL 5944	524788	PEBBLE BEACH 4349	531356	PEBBLE BEACH 3643	531435	PEBBLE BEACH 5446
516838	PEBBLE BEACH 6154	524531	SILL 6043	524789	PEBBLE BEACH 4355	531357	PEBBLE BEACH 3644	531436	PEBBLE BEACH 5447
516839	PEEBLE BEACH 4651	524532	SILL 6044	524790	PEBBLE BEACH 4448	531358	PEBBLE BEACH 3645	531437	PEBBLE BEACH 5544
516840	PEEBLE BEACH 4652	524535	SILL 6143	524791	PEBBLE BEACH 4449	531359	PEBBLE BEACH 3742	531438	PEBBLE BEACH 5545
516841	PEEBLE BEACH 4653	524536	SILL 6144	524792	PEBBLE BEACH 4450	531360	PEBBLE BEACH 3743	531439	PEBBLE BEACH 5546
516842	PEEBLE BEACH 4751	524539	SILL 6243	524793	PEBBLE BEACH 4454	531361	PEBBLE BEACH 3744	531440	PEBBLE BEACH 5547
516843	PEEBLE BEACH 4752	524540	SILL 6244	524794	PEBBLE BEACH 4455	531362	PEBBLE BEACH 3745	531441	PEBBLE BEACH 5644
516844	PEEBLE BEACH 4753	524541	SILL 6245	524795	PEBBLE BEACH 4548	531363	PEBBLE BEACH 3842	531442	PEBBLE BEACH 5645
516845	PEEBLE BEACH 4851	524542	SILL 6246	524796	PEBBLE BEACH 4549	531364	PEBBLE BEACH 3843	531443	PEBBLE BEACH 5646
516846	PEEBLE BEACH 4852	524543	SILL 6343	524797	PEBBLE BEACH 4550	531365	PEBBLE BEACH 3844	531444	PEBBLE BEACH 5647
516847	PEEBLE BEACH 4853	524544	SILL 6344	524798	PEBBLE BEACH 4554	531366	PEBBLE BEACH 3845	531445	PEBBLE BEACH 5744
516848	PEEBLE BEACH 4951	524550	SILL 6443	524799	PEBBLE BEACH 4555	531367	PEBBLE BEACH 3846	531446	PEBBLE BEACH 5745
516849	PEEBLE BEACH 4952	524551	SILL 6444	524800	PEBBLE BEACH 4648	531368	PEBBLE BEACH 3847	531447	PEBBLE BEACH 5746
516850	PEEBLE BEACH 4953	524557	SILL 6543	524801	PEBBLE BEACH 4649	531369	PEBBLE BEACH 3942	531448	PEBBLE BEACH 5747
516851	PEEBLE BEACH 5048	524558	SILL 6544	524802	PEBBLE BEACH 4650	531370	PEBBLE BEACH 3943	531449	PEBBLE BEACH 5844
516852	PEEBLE BEACH 5049	524568	SILL 6643	524803	PEBBLE BEACH 4654	531371	PEBBLE BEACH 3944	531450	PEBBLE BEACH 5845
516853	PEEBLE BEACH 5050	524569	SILL 6644	524804	PEBBLE BEACH 4655	531372	PEBBLE BEACH 3945	531451	PEBBLE BEACH 5846
516854	PEEBLE BEACH 5051	524579	SILL 6743	524805	PEBBLE BEACH 4748	531373	PEBBLE BEACH 3946	531452	PEBBLE BEACH 5847
516855	PEEBLE BEACH 5052	524580	SILL 6744	524806	PEBBLE BEACH 4749	531374	PEBBLE BEACH 3947	531453	PEBBLE BEACH 5944
516856	PEEBLE BEACH 5053	524595	SILL 6843	524807	PEBBLE BEACH 4750	531375	PEBBLE BEACH 4042	531454	PEBBLE BEACH 5945
516857	PEEBLE BEACH 5148	524596	SILL 6844	524808	PEBBLE BEACH 4754	531376	PEBBLE BEACH 4043	531455	PEBBLE BEACH 5946
516858	PEEBLE BEACH 5149	524611	SILL 6943	524809	PEBBLE BEACH 4755	531377	PEBBLE BEACH 4044	531456	PEBBLE BEACH 5947
516859	PEEBLE BEACH 5150	524612	SILL 6944	524810	PEBBLE BEACH 4848	531378	PEBBLE BEACH 4045	531457	PEBBLE BEACH 6044
516860	PEEBLE BEACH 5151	524630	SILL 7043	524811	PEBBLE BEACH 4849	531379	PEBBLE BEACH 4046	531458	PEBBLE BEACH 6045
516861	PEEBLE BEACH 5152	524631	SILL 7044	524812	PEBBLE BEACH 4850	531380	PEBBLE BEACH 4047	531459	PEBBLE BEACH 6046
516862	PEEBLE BEACH 5153	524649	SILL 7143	524813	PEBBLE BEACH 4854	531381	PEBBLE BEACH 4142	531460	PEBBLE BEACH 6047
516863	PEEBLE BEACH 5248	524650	SILL 7144	524814	PEBBLE BEACH 4855	531382	PEBBLE BEACH 4143	531461	PEBBLE BEACH 6144
516864	PEEBLE BEACH 5249	524668	SILL 7243	524815	PEBBLE BEACH 4948	531383	PEBBLE BEACH 4144	531462	PEBBLE BEACH 6145
516865	PEEBLE BEACH 5250	524669	SILL 7244	524816	PEBBLE BEACH 4949	531384	PEBBLE BEACH 4145	531463	PEBBLE BEACH 6146
516866	PEEBLE BEACH 5251	524684	SILL 7343	524817	PEBBLE BEACH 4950	531385	PEBBLE BEACH 4146	531464	PEBBLE BEACH 6147
516867	PEEBLE BEACH 5252	524685	SILL 7344	524818	PEBBLE BEACH 4954	531386	PEBBLE BEACH 4147	531648	PEBBLE BEACH 4545
516868	PEEBLE BEACH 5253	524698	SILL 7443	524819	PEBBLE BEACH 4955	531387	PEBBLE BEACH 4244	531649	PEBBLE BEACH 4546
516869	PEEBLE BEACH 5348	524699	SILL 7444	524820	PEBBLE BEACH 5054	531388	PEBBLE BEACH 4245	540399	PEBBLE BEACH 5555
516870	PEEBLE BEACH 5349	524712	SILL 7543	524821	PEBBLE BEACH 5055	531389	PEBBLE BEACH 4246	540400	PEBBLE BEACH 5655
516871	PEEBLE BEACH 5350	524713	SILL 7544	524822	PEBBLE BEACH 5154	531390	PEBBLE BEACH 4247	540401	PEBBLE BEACH 5755
516872	PEEBLE BEACH 5351	524714	SILL 7545	524823	PEBBLE BEACH 5155	531391	PEBBLE BEACH 4344	540402	PEBBLE BEACH 5855
516873	PEEBLE BEACH 5352	524715	SILL 7546	524824	PEBBLE BEACH 5254	531392	PEBBLE BEACH 4345	540403	PEBBLE BEACH 5955
516874	PEEBLE BEACH 5353	524716	SILL 7547	524825	PEBBLE BEACH 5255	531393	PEBBLE BEACH 4346	540404	PEBBLE BEACH 6055
516879	SILL 6351	524717	SILL 7548	524826	PEBBLE BEACH 5354	531394	PEBBLE BEACH 4347	540405	PEBBLE BEACH 6155
516880	SILL 6352	524748	PEBBLE BEACH 3452	524827	PEBBLE BEACH 5355	531395	PEBBLE BEACH 4444	540406	PEBBLE BEACH 6255
516888	SILL 6451	524749	PEBBLE BEACH 3453	524828	PEBBLE BEACH 5455	531396	PEBBLE BEACH 4445	540407	PEBBLE BEACH 6355
516889	SILL 6452	524750	PEBBLE BEACH 3454	524829	PEBBLE BEACH 5648	531397	PEBBLE BEACH 4446	540408	PEBBLE BEACH 6448
516948	PEBBLE BEACH 3850	524751	PEBBLE BEACH 3455	524830	PEBBLE BEACH 5649	531398	PEBBLE BEACH 4447	540409	PEBBLE BEACH 6449
516949	PEBBLE BEACH 3851	524752	PEBBLE BEACH 3552	524831	PEBBLE BEACH 5650	531399	PEBBLE BEACH 4544	540410	PEBBLE BEACH 6450
516950	PEBBLE BEACH 3852	524753	PEBBLE BEACH 3553	524832	PEBBLE BEACH 5748	531400	PEBBLE BEACH 4547	540411	PEBBLE BEACH 6451
516951	PEBBLE BEACH 3950	524754	PEBBLE BEACH 3554	524833	PEBBLE BEACH 5749	531401	PEBBLE BEACH 4644	540412	PEBBLE BEACH 6452
516952	PEBBLE BEACH 3951	524755	PEBBLE BEACH 3555	524834	PEBBLE BEACH 5750	531402	PEBBLE BEACH 4645	540413	PEBBLE BEACH 6453
516953	PEBBLE BEACH 3952	524756	PEBBLE BEACH 3652	524835	PEBBLE BEACH 5848	531403	PEBBLE BEACH 4646	540414	PEBBLE BEACH 6454
516954	PEBBLE BEACH 4050	524757	PEBBLE BEACH 3653	524836	PEBBLE BEACH 5849	531404	PEBBLE BEACH 4647	540415	PEBBLE BEACH 6455
516955	PEBBLE BEACH 4051	524758	PEBBLE BEACH 3654	524837	PEBBLE BEACH 5850	531405	PEBBLE BEACH 4744	540416	PEBBLE BEACH 6548
516956	PEBBLE BEACH 4052	524759	PEBBLE BEACH 3655	524838	PEBBLE BEACH 5851	531406	PEBBLE BEACH 4745	540417	PEBBLE BEACH 6549
516957	PEBBLE BEACH 4150	524760	PEBBLE BEACH 3752	524839	PEBBLE BEACH 5948	531407	PEBBLE BEACH 4746	540418	PEBBLE BEACH 6550
516958	PEBBLE BEACH 4151	524761	PEBBLE BEACH 3753	524840	PEBBLE BEACH 5949	531408	PEBBLE BEACH 4747	540419	PEBBLE BEACH 6551
516959	PEBBLE BEACH 4152	524762	PEBBLE BEACH 3754	524841	PEBBLE BEACH 5950	531409	PEBBLE BEACH 4844	540420	PEBBLE BEACH 6552
516960	PEBBLE BEACH 4250	524763	PEBBLE BEACH 3755	524842	PEBBLE BEACH 5951	531410	PEBBLE BEACH 4845	540421	PEBBLE BEACH 6553
516961	PEBBLE BEACH 4251	524764	PEBBLE BEACH 3848	524843	PEBBLE BEACH 6048	531411	PEBBLE BEACH 4846	540422	PEBBLE BEACH 6554
516962	PEBBLE BEACH 4252	524765	PEBBLE BEACH 3849	524844	PEBBLE BEACH 6049	531412	PEBBLE BEACH 4847	540423	PEBBLE BEACH 6555
516963	PEBBLE BEACH 4253	524766	PEBBLE BEACH 3853	524845	PEBBLE BEACH 6050	531413	PEBBLE BEACH 4944	540424	SILL 7643
516964	PEBBLE BEACH 4254	524767	PEBBLE BEACH 3854	524846	PEBBLE BEACH 6051	531414	PEBBLE BEACH 4945	540425	SILL 7644
516965	PEBBLE BEACH 4350	524768	PEBBLE BEACH 3855	524847	PEBBLE BEACH 6148	531415	PEBBLE BEACH 4946	540426	SILL 7645
516966	PEBBLE BEACH 4351	524769	PEBBLE BEACH 3948	524848	PEBBLE BEACH 6149	531416	PEBBLE BEACH 4947	540427	SILL 7646
516967	PEBBLE BEACH 4352	524770	PEBBLE BEACH 3949	524849	PEBBLE BEACH 6150	531417	PEBBLE BEACH 5044	540428	SILL 7647
516968	PEBBLE BEACH 4353	524771	PEBBLE BEACH 3953	524850	PEBBLE BEACH 6151	531418	PEBBLE BEACH 5045	540429	SILL 7648
516969	PEBBLE BEACH 4354	524772	PEBBLE BEACH 3954	524851	PEBBLE BEACH 6248	531419	PEBBLE BEACH 5046	540430	SILL 7743
516970	PEBBLE BEACH 4451	524773	PEBBLE BEACH 3955	524852	PEBBLE BEACH 6249	531420	PEBBLE BEACH 5047	540431	SILL 7744
516971	PEBBLE BEACH 4452	524774	PEBBLE BEACH 4048	524853	PEBBLE BEACH 6250	531421	PEBBLE BEACH 5144	540432	SILL 7745
516972	PEBBLE BEACH 4453	524775	PEBBLE BEACH 4049	524854	PEBBLE BEACH 6251	531422	PEBBLE BEACH 5145	540433	SILL 7746

ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME
540434	SILL 7747	542592	PEBBLE BEACH 5243	566568	PEBBLE BEACH 2737	566855	PEBBLE BEACH 3750	566966	PEBBLE BEACH 5539
540435	SILL 7748	542593	PEBBLE BEACH 5342	566569	PEBBLE BEACH 2738	566856	PEBBLE BEACH 3751	566967	PEBBLE BEACH 5540
540436	SILL 7843	542594	PEBBLE BEACH 5343	566570	PEBBLE BEACH 2739	566865	PEBBLE BEACH 3838	566968	PEBBLE BEACH 5541
540437	SILL 7844	542595	PEBBLE BEACH 5442	566571	PEBBLE BEACH 2740	566866	PEBBLE BEACH 3839	566969	PEBBLE BEACH 5638
540438	SILL 7845	542596	PEBBLE BEACH 5443	566572	PEBBLE BEACH 2741	566867	PEBBLE BEACH 3840	566970	PEBBLE BEACH 5639
540439	SILL 7846	542597	PEBBLE BEACH 5542	566607	PEBBLE BEACH 3138	566868	PEBBLE BEACH 3841	566971	PEBBLE BEACH 5640
540440	SILL 7847	542598	PEBBLE BEACH 5543	566608	PEBBLE BEACH 3139	566877	PEBBLE BEACH 3938	566972	PEBBLE BEACH 5641
540441	SILL 7848	542599	PEBBLE BEACH 5642	566609	PEBBLE BEACH 3140	566878	PEBBLE BEACH 3939	566973	PEBBLE BEACH 5738
540442	SILL 7943	542600	PEBBLE BEACH 5643	566610	PEBBLE BEACH 3141	566879	PEBBLE BEACH 3940	566974	PEBBLE BEACH 5739
540443	SILL 7944	542601	PEBBLE BEACH 5742	566637	PEBBLE BEACH 2938	566880	PEBBLE BEACH 3941	566975	PEBBLE BEACH 5740
540444	SILL 7945	542602	PEBBLE BEACH 5743	566638	PEBBLE BEACH 2939	566889	PEBBLE BEACH 4038	566976	PEBBLE BEACH 5741
540445	SILL 7946	542603	PEBBLE BEACH 5842	566639	PEBBLE BEACH 2940	566890	PEBBLE BEACH 4039	566977	PEBBLE BEACH 5838
540446	SILL 7947	542604	PEBBLE BEACH 5843	566640	PEBBLE BEACH 2941	566891	PEBBLE BEACH 4040	566978	PEBBLE BEACH 5839
540447	SILL 7948	552917	SOUTH PEBBLE 159	566655	PEBBLE BEACH 2836	566892	PEBBLE BEACH 4041	566979	PEBBLE BEACH 5840
540448	SILL 8043	552918	SOUTH PEBBLE 160	566656	PEBBLE BEACH 2837	566901	PEBBLE BEACH 4138	566980	PEBBLE BEACH 5841
540449	SILL 8044	552919	SOUTH PEBBLE 161	566657	PEBBLE BEACH 2838	566902	PEBBLE BEACH 4139	566981	PEBBLE BEACH 5938
540450	SILL 8045	552920	SOUTH PEBBLE 162	566658	PEBBLE BEACH 2839	566903	PEBBLE BEACH 4140	566982	PEBBLE BEACH 5939
540451	SILL 8046	552921	SOUTH PEBBLE 163	566659	PEBBLE BEACH 2840	566904	PEBBLE BEACH 4141	566983	PEBBLE BEACH 5940
540452	SILL 8047	552922	SOUTH PEBBLE 164	566660	PEBBLE BEACH 2841	566905	PEBBLE BEACH 4238	566984	PEBBLE BEACH 5941
540453	SILL 8048	552923	SOUTH PEBBLE 165	566697	PEBBLE BEACH 3238	566906	PEBBLE BEACH 4239	566985	PEBBLE BEACH 6038
540454	SILL 8143	552924	SOUTH PEBBLE 166	566698	PEBBLE BEACH 3239	566907	PEBBLE BEACH 4240	566986	PEBBLE BEACH 6039
540455	SILL 8144	552925	SOUTH PEBBLE 167	566699	PEBBLE BEACH 3240	566908	PEBBLE BEACH 4241	566987	PEBBLE BEACH 6040
540456	SILL 8145	552926	SOUTH PEBBLE 168	566700	PEBBLE BEACH 3241	566909	PEBBLE BEACH 4242	566988	PEBBLE BEACH 6041
540457	SILL 8146	552927	SOUTH PEBBLE 169	566701	PEBBLE BEACH 3242	566910	PEBBLE BEACH 4243	566989	PEBBLE BEACH 6042
540458	SILL 8147	552928	SOUTH PEBBLE 170	566737	PEBBLE BEACH 3038	566911	PEBBLE BEACH 4338	566990	PEBBLE BEACH 6043
540459	SILL 8148	552929	SOUTH PEBBLE 171	566738	PEBBLE BEACH 3039	566912	PEBBLE BEACH 4339	566991	PEBBLE BEACH 6138
540460	SILL 8243	552930	SOUTH PEBBLE 172	566739	PEBBLE BEACH 3040	566913	PEBBLE BEACH 4340	566992	PEBBLE BEACH 6139
540461	SILL 8244	566247	PEBBLE BEACH 1936	566740	PEBBLE BEACH 3041	566914	PEBBLE BEACH 4341	566993	PEBBLE BEACH 6140
540462	SILL 8245	566248	PEBBLE BEACH 1937	566751	PEBBLE BEACH 3252	566915	PEBBLE BEACH 4342	566994	PEBBLE BEACH 6141
540463	SILL 8246	566249	PEBBLE BEACH 1938	566752	PEBBLE BEACH 3253	566916	PEBBLE BEACH 4343	566995	PEBBLE BEACH 6142
540464	SILL 8247	566250	PEBBLE BEACH 1939	566753	PEBBLE BEACH 3254	566917	PEBBLE BEACH 4438	566996	PEBBLE BEACH 6143
540465	SILL 8248	566251	PEBBLE BEACH 1940	566754	PEBBLE BEACH 3255	566918	PEBBLE BEACH 4439	566997	PEBBLE BEACH 6238
540466	SILL 8343	566252	PEBBLE BEACH 1941	566767	PEBBLE BEACH 3338	566919	PEBBLE BEACH 4440	566998	PEBBLE BEACH 6239
540467	SILL 8344	566287	PEBBLE BEACH 2036	566768	PEBBLE BEACH 3339	566920	PEBBLE BEACH 4441	566999	PEBBLE BEACH 6240
540468	SILL 8443	566288	PEBBLE BEACH 2037	566769	PEBBLE BEACH 3340	566921	PEBBLE BEACH 4442	567000	PEBBLE BEACH 6241
540469	SILL 8444	566289	PEBBLE BEACH 2038	566770	PEBBLE BEACH 3341	566922	PEBBLE BEACH 4443	567001	PEBBLE BEACH 6242
540470	SILL 8543	566290	PEBBLE BEACH 2039	566771	PEBBLE BEACH 3342	566923	PEBBLE BEACH 4538	567002	PEBBLE BEACH 6243
540471	SILL 8544	566291	PEBBLE BEACH 2040	566781	PEBBLE BEACH 3352	566924	PEBBLE BEACH 4539	567003	PEBBLE BEACH 6244
540472	SILL 8643	566292	PEBBLE BEACH 2041	566782	PEBBLE BEACH 3353	566925	PEBBLE BEACH 4540	567004	PEBBLE BEACH 6245
540473	SILL 8644	566327	PEBBLE BEACH 2136	566783	PEBBLE BEACH 3354	566926	PEBBLE BEACH 4541	567005	PEBBLE BEACH 6246
541245	PB 113	566328	PEBBLE BEACH 2137	566784	PEBBLE BEACH 3355	566927	PEBBLE BEACH 4542	567006	PEBBLE BEACH 6247
541246	PB 114	566329	PEBBLE BEACH 2138	566793	PEBBLE BEACH 3438	566928	PEBBLE BEACH 4543	567007	PEBBLE BEACH 6338
541247	PB 115	566330	PEBBLE BEACH 2139	566794	PEBBLE BEACH 3439	566929	PEBBLE BEACH 4638	567008	PEBBLE BEACH 6339
541248	PB 116	566331	PEBBLE BEACH 2140	566795	PEBBLE BEACH 3440	566930	PEBBLE BEACH 4639	567009	PEBBLE BEACH 6340
541249	PB 117	566332	PEBBLE BEACH 2141	566796	PEBBLE BEACH 3441	566931	PEBBLE BEACH 4640	567010	PEBBLE BEACH 6341
541250	PB 118	566367	PEBBLE BEACH 2236	566797	PEBBLE BEACH 3446	566932	PEBBLE BEACH 4641	567011	PEBBLE BEACH 6342
541251	PB 119	566368	PEBBLE BEACH 2237	566798	PEBBLE BEACH 3447	566933	PEBBLE BEACH 4738	567012	PEBBLE BEACH 6343
541252	PB 120	566369	PEBBLE BEACH 2238	566799	PEBBLE BEACH 3448	566934	PEBBLE BEACH 4739	567013	PEBBLE BEACH 6344
542561	PEBBLE BEACH 4856	566370	PEBBLE BEACH 2239	566800	PEBBLE BEACH 3449	566935	PEBBLE BEACH 4740	567014	PEBBLE BEACH 6345
542562	PEBBLE BEACH 4956	566371	PEBBLE BEACH 2240	566801	PEBBLE BEACH 3450	566936	PEBBLE BEACH 4741	567015	PEBBLE BEACH 6346
542563	PEBBLE BEACH 5056	566372	PEBBLE BEACH 2241	566802	PEBBLE BEACH 3451	566937	PEBBLE BEACH 4838	567016	PEBBLE BEACH 6347
542564	PEBBLE BEACH 5156	566373	PEBBLE BEACH 2242	566811	PEBBLE BEACH 3538	566938	PEBBLE BEACH 4839	567017	PEBBLE BEACH 6438
542565	PEBBLE BEACH 5256	566407	PEBBLE BEACH 2336	566812	PEBBLE BEACH 3539	566939	PEBBLE BEACH 4840	567018	PEBBLE BEACH 6439
542566	PEBBLE BEACH 5356	566408	PEBBLE BEACH 2337	566813	PEBBLE BEACH 3540	566940	PEBBLE BEACH 4841	567019	PEBBLE BEACH 6440
542567	PEBBLE BEACH 5456	566409	PEBBLE BEACH 2338	566814	PEBBLE BEACH 3541	566941	PEBBLE BEACH 4938	567020	PEBBLE BEACH 6441
542568	PEBBLE BEACH 5556	566410	PEBBLE BEACH 2339	566815	PEBBLE BEACH 3546	566942	PEBBLE BEACH 4939	567021	PEBBLE BEACH 6442
542569	PEBBLE BEACH 5656	566411	PEBBLE BEACH 2340	566816	PEBBLE BEACH 3547	566943	PEBBLE BEACH 4940	567022	PEBBLE BEACH 6443
542570	PEBBLE BEACH 5756	566412	PEBBLE BEACH 2341	566817	PEBBLE BEACH 3548	566944	PEBBLE BEACH 4941	567023	PEBBLE BEACH 6444
542571	PEBBLE BEACH 5856	566413	PEBBLE BEACH 2342	566818	PEBBLE BEACH 3549	566945	PEBBLE BEACH 5038	567024	PEBBLE BEACH 6445
542572	PEBBLE BEACH 5956	566447	PEBBLE BEACH 2436	566819	PEBBLE BEACH 3550	566946	PEBBLE BEACH 5039	567025	PEBBLE BEACH 6446
542573	PEBBLE BEACH 6056	566448	PEBBLE BEACH 2437	566820	PEBBLE BEACH 3551	566947	PEBBLE BEACH 5040	567026	PEBBLE BEACH 6447
542574	PEBBLE BEACH 6156	566449	PEBBLE BEACH 2438	566829	PEBBLE BEACH 3638	566948	PEBBLE BEACH 5041	567035	PEBBLE BEACH 6546
542575	PEBBLE BEACH 6256	566450	PEBBLE BEACH 2439	566830	PEBBLE BEACH 3639	566949	PEBBLE BEACH 5138	567036	PEBBLE BEACH 6547
542576	PEBBLE BEACH 6356	566451	PEBBLE BEACH 2440	566831	PEBBLE BEACH 3640	566950	PEBBLE BEACH 5139	567045	PEBBLE BEACH 6646
542577	PEBBLE BEACH 6456	566452	PEBBLE BEACH 2441	566832	PEBBLE BEACH 3641	566951	PEBBLE BEACH 5140	567046	PEBBLE BEACH 6647
542578	PEBBLE BEACH 6556	566453	PEBBLE BEACH 2442	566833	PEBBLE BEACH 3646	566952	PEBBLE BEACH 5141	567047	PEBBLE BEACH 6648
542579	PEBBLE BEACH 4642	566487	PEBBLE BEACH 2536	566834	PEBBLE BEACH 3647	566953	PEBBLE BEACH 5238	567048	PEBBLE BEACH 6649
542580	PEBBLE BEACH 4643	566488	PEBBLE BEACH 2537	566835	PEBBLE BEACH 3648	566954	PEBBLE BEACH 5239	567049	PEBBLE BEACH 6650
542581	PEBBLE BEACH 4742	566489	PEBBLE BEACH 2538	566836	PEBBLE BEACH 3649	566955	PEBBLE BEACH 5240	567050	PEBBLE BEACH 6651
542582	PEBBLE BEACH 4743	566490	PEBBLE BEACH 2539	566837	PEBBLE BEACH 3650	566956	PEBBLE BEACH 5241	567051	PEBBLE BEACH 6652
542583	PEBBLE BEACH 4842	566491	PEBBLE BEACH 2540	566838	PEBBLE BEACH 3651	566957	PEBBLE BEACH 5338	567052	PEBBLE BEACH 6653
542584	PEBBLE BEACH 4843	566492	PEBBLE BEACH 2541	566847	PEBBLE BEACH 3738	566958	PEBBLE BEACH 5339	567053	PEBBLE BEACH 6654
542585	PEBBLE BEACH 4942	566527	PEBBLE BEACH 2636	566848	PEBBLE BEACH 3739	566959	PEBBLE BEACH 5340	567054	PEBBLE BEACH 6655
542586	PEBBLE BEACH 4943	566528	PEBBLE BEACH 2637	566849	PEBBLE BEACH 3740	566960	PEBBLE BEACH 5341	567055	PEBBLE BEACH 6656
542587	PEBBLE BEACH 5042	566529	PEBBLE BEACH 2638	566850	PEBBLE BEACH 3741	566961	PEBBLE BEACH 5438	567064	PEBBLE BEACH 6746
542588	PEBBLE BEACH 5043	566530	PEBBLE BEACH 2639	566851	PEBBLE BEACH 3746	566962	PEBBLE BEACH 5439	567065	PEBBLE BEACH 6747
542589	PEBBLE BEACH 5142	566531	PEBBLE BEACH 2640	566852	PEBBLE BEACH 3747	566963	PEBBLE BEACH 5440	567066	PEBBLE BEACH 6748
542590	PEBBLE BEACH 5143	566532	PEBBLE BEACH 2641	566853	PEBBLE BEACH 3748	566964	PEBBLE BEACH 5441	567067	PEBBLE BEACH 6749
542591	PEBBLE BEACH 5242	566567	PEBBLE BEACH 2736	566854	PEBBLE BEACH 3749	566965	PEBBLE BEACH 5538	567068	PEBBLE BEACH 6750

ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME	ADL #	CLAIM NAME
567069	PEBBLE BEACH 6751	567957	SILL 6353	642824	BC 336	642927	BC 439	643441	BC 1010
567083	PEBBLE BEACH 6846	567958	SILL 6354	642825	BC 337	642928	BC 440	644284	SP 173
567084	PEBBLE BEACH 6847	567959	SILL 6355	642826	BC 338	642929	BC 441	644285	SP 174
567085	PEBBLE BEACH 6848	567960	SILL 6356	642827	BC 339	642930	BC 442	644286	SP 175
567086	PEBBLE BEACH 6849	567961	SILL 6445	642832	BC 344	642931	BC 443	644287	SP 176
567087	PEBBLE BEACH 6850	567962	SILL 6446	642833	BC 345	642932	BC 444	644288	SP 177
567088	PEBBLE BEACH 6851	567963	SILL 6447	642834	BC 346	642933	BC 445	644289	SP 178
567102	PEBBLE BEACH 6946	567964	SILL 6448	642835	BC 347	642934	BC 446	644290	SP 179
567103	PEBBLE BEACH 6947	567965	SILL 6449	642836	BC 348	642935	BC 447	644291	SP 180
567104	PEBBLE BEACH 6948	567966	SILL 6450	642837	BC 349	642936	BC 448	644292	SP 181
567105	PEBBLE BEACH 6949	567967	SILL 6453	642838	BC 350	642937	BC 449	644293	SP 182
567106	PEBBLE BEACH 6950	567968	SILL 6454	642839	BC 351	642938	BC 450	644294	SP 183
567107	PEBBLE BEACH 6951	567969	SILL 6455	642840	BC 352	642939	BC 451	644295	SP 184
567841	SILL 5343	567970	SILL 6456	642841	BC 353	642944	BC 456	644296	SP 185
567842	SILL 5344	567971	SILL 6545	642842	BC 354	642945	BC 457	644297	SP 186
567843	SILL 5345	567972	SILL 6546	642843	BC 355	642946	BC 458	644298	SP 187
567844	SILL 5346	567973	SILL 6547	642848	BC 360	642947	BC 459	644299	SP 188
567845	SILL 5347	567974	SILL 6548	642849	BC 361	642948	BC 460	644300	SP 189
567855	SILL 5443	567975	SILL 6549	642850	BC 362	642949	BC 461	644301	SP 190
567856	SILL 5444	567976	SILL 6550	642851	BC 363	642950	BC 462	644302	SP 191
567857	SILL 5445	567977	SILL 6551	642852	BC 364	642951	BC 463	644303	SP 192
567858	SILL 5446	567978	SILL 6552	642853	BC 365	642952	BC 464	644312	SP 201
567859	SILL 5447	567979	SILL 6553	642854	BC 366	642953	BC 465	644313	SP 202
567860	SILL 5448	567980	SILL 6554	642855	BC 367	642954	BC 466	644314	SP 203
567869	SILL 5545	567981	SILL 6555	642856	BC 368	642955	BC 467	644315	SP 204
567870	SILL 5546	567982	SILL 6556	642857	BC 369	642956	BC 468	644318	SP 207
567871	SILL 5547	568175	SILL 8345	642858	BC 370	642957	BC 469	644319	SP 208
567872	SILL 5548	568176	SILL 8346	642859	BC 371	642958	BC 470	644320	SP 209
567873	SILL 5549	568177	SILL 8347	642860	BC 372	642959	BC 471	644321	SP 210
567881	SILL 5645	568178	SILL 8348	642861	BC 373	642960	BC 472	644322	SP 216
567882	SILL 5646	568255	SILL 8743	642862	BC 374	642964	BC 476	644323	SP 225
567883	SILL 5647	568256	SILL 8744	642867	BC 379	642965	BC 477	644324	SP 226
567884	SILL 5648	642753	BC 265	642868	BC 380	642966	BC 478	644325	SP 227
567885	SILL 5649	642754	BC 266	642869	BC 381	642967	BC 479	644326	SP 228
567886	SILL 5650	642755	BC 267	642870	BC 382	642968	BC 480	644327	SP 229
567893	SILL 5745	642756	BC 268	642871	BC 383	642969	BC 481	644328	SP 230
567894	SILL 5746	642757	BC 269	642872	BC 384	642970	BC 482	644329	SP 231
567895	SILL 5747	642758	BC 270	642873	BC 385	642971	BC 483	644330	SP 232
567896	SILL 5748	642759	BC 271	642874	BC 386	642972	BC 484	644331	SP 235
567897	SILL 5749	642764	BC 276	642875	BC 387	642973	BC 485	644332	SP 236
567898	SILL 5750	642765	BC 277	642876	BC 388	642974	BC 486	644333	SP 237
567905	SILL 5845	642766	BC 278	642877	BC 389	642975	BC 487	644334	SP 238
567906	SILL 5846	642767	BC 279	642878	BC 390	642976	BC 488	644335	SP 239
567907	SILL 5847	642768	BC 280	642879	BC 391	642977	BC 489	644336	SP 245
567908	SILL 5848	642769	BC 281	642880	BC 392	642978	BC 490	644733	SOUTH PEBBLE 234
567909	SILL 5849	642770	BC 282	642881	BC 393	642979	BC 491	644734	SOUTH PEBBLE 240
567910	SILL 5850	642775	BC 287	642886	BC 398	642980	BC 492	644735	SOUTH PEBBLE 241
567911	SILL 5851	642776	BC 288	642887	BC 399	642981	BC 493	644736	SOUTH PEBBLE 242
567917	SILL 5945	642777	BC 289	642888	BC 400	642982	BC 494	644737	SOUTH PEBBLE 243
567918	SILL 5946	642778	BC 290	642889	BC 401	642983	BC 495	644738	SOUTH PEBBLE 244
567919	SILL 5947	642779	BC 291	642890	BC 402	642987	BC 499	645612	SP 322
567920	SILL 5948	642780	BC 292	642891	BC 403	642988	BC 500	645613	SP 323
567921	SILL 5949	642781	BC 293	642892	BC 404	642989	BC 501	645614	SP 324
567922	SILL 5950	642786	BC 298	642893	BC 405	642990	BC 502	645615	SP 325
567923	SILL 5953	642787	BC 299	642894	BC 406	642991	BC 503	645616	SP 326
567927	SILL 6045	642788	BC 300	642895	BC 407	642992	BC 504	645617	SP 327
567928	SILL 6046	642789	BC 301	642896	BC 408	642993	BC 505	645618	SP 328
567929	SILL 6047	642790	BC 302	642897	BC 409	642994	BC 506	645619	SP 329
567930	SILL 6048	642791	BC 303	642898	BC 410	642995	BC 507	645620	SP 330
567931	SILL 6049	642792	BC 304	642899	BC 411	642996	BC 508	645621	SP 331
567932	SILL 6050	642797	BC 309	642900	BC 412	642997	BC 509	645622	SP 332
567933	SILL 6053	642798	BC 310	642905	BC 417	642998	BC 510	645623	SP 333
567937	SILL 6145	642799	BC 311	642906	BC 418	642999	BC 511	645624	SP 334
567938	SILL 6146	642800	BC 312	642907	BC 419	643000	BC 512	645625	SP 335
567939	SILL 6147	642801	BC 313	642908	BC 420	643001	BC 513	645626	SP 336
567940	SILL 6148	642802	BC 314	642909	BC 421	643002	BC 514	645627	SP 337
567941	SILL 6149	642803	BC 315	642910	BC 422	643003	BC 515	645628	SP 338
567942	SILL 6150	642808	BC 320	642911	BC 423	643004	BC 516	645629	SP 339
567943	SILL 6153	642809	BC 321	642912	BC 424	643005	BC 517	645630	SP 340
567944	SILL 6154	642810	BC 322	642913	BC 425	643006	BC 518	645631	SP 341
567947	SILL 6253	642811	BC 323	642914	BC 426	643432	BC 1001	645632	SP 342
567948	SILL 6254	642812	BC 324	642915	BC 427	643433	BC 1002	645633	SP 343
567949	SILL 6255	642813	BC 325	642916	BC 428	643434	BC 1003	645634	SP 344
567951	SILL 6345	642814	BC 326	642917	BC 429	643435	BC 1004	645635	SP 345
567952	SILL 6346	642819	BC 331	642918	BC 430	643436	BC 1005	645636	SP 346
567953	SILL 6347	642820	BC 332	642919	BC 431	643437	BC 1006	645637	SP 347
567954	SILL 6348	642821	BC 333	642924	BC 436	643438	BC 1007	645638	SP 348
567955	SILL 6349	642822	BC 334	642925	BC 437	643439	BC 1008	645639	SP 349
567956	SILL 6350	642823	BC 335	642926	BC 438	643440	BC 1009	645640	SP 350

ADL #	CLAIM NAME
645641	SP 351
645642	SP 352
645643	SP 353
645644	SP 354
645645	SP 355
645646	SP 356
645647	SP 357
645648	SP 358
645649	SP 359
645650	SP 360
645651	SP 361
645652	SP 362
645653	SP 363
645654	SP 364
645655	SP 365
645656	SP 366
645657	SP 367
645658	SP 368
645659	SP 369
645660	SP 370
645661	SP 371
645662	SP 372
649923	BC 1171
649924	BC 1172
649925	BC 1173
649926	BC 1174
649927	BC 1175
649928	BC 1176
649929	BC 1177
649930	BC 1178
649931	BC1179
649932	BC1180
649939	BC1187
649940	BC1188
649948	BC1196
649949	BC1197

Legend	
RESOURCE LANDS	516808
EXPLORATION LANDS	516769
ADL – Alaska Department of Lands	

4.4 Surface Rights

Northern Dynasty currently does not own any surface rights associated with the mineral claims that comprise the Pebble property. All lands are held by the State of Alaska, and surface rights may be acquired from the State government once areas required for mine development have been determined and permits awarded.

The access corridor is owned by a number of landowners, including the State of Alaska, Alaska Native Village Corporations, and private individuals. Pebble Partnership has completed access agreements with two Native Village Corporations and a private individual. Negotiations have advanced with other Native Village Corporations and individuals, but no agreements are in place. In June 2021, one of the Native Village Corporations announced they had signed an agreement whereby a fund has obtained an option to buy portions of their land to create a conservation easement. The fund must exercise its option by the end of 2022. If the fund closes this agreement with the Native Village Corporation, the Pebble Partnership would be required to identify an alternate route to the proposed marine terminal on Cook Inlet.

4.5 Environmental Liabilities

The Pebble Partnership currently maintains 581 monitoring wells that are periodically used to collect piezometric and water quality data across the project area. Materials and equipment used to support maintenance activities are stored at a small year-round field facility at the deposit site and two smaller satellite locations. The Pebble Partnership also operates a meteorological station and field acid rock drainage testing site to collect in situ weathering data. The environmental liabilities associated with the Pebble Project include removal of these small temporary structures and field equipment, closure of monitoring wells, and removal of piezometers. The State of Alaska holds a $2 million reclamation security associated with removal and reclamation of these liabilities.

4.6 Permits

Permits necessary for exploration drilling and other field programs associated with pre-development assessment of the Pebble Project are applied for as required each year. Additional information on permitting is provided in Section 20.6 Permitting Considerations. Of note in Section 20.6 is the Record of Decision (ROD) by USACE to deny Pebble Partnership's CWA 404 permit application. That denial is currently under appeal.

4.7 Comments on Section 4

On September 9, 2021, the EPA announced they planned to re-initiate the process of making a CWA Section 404(c) determination for the waters of Bristol Bay, which would set aside the 2019 withdrawal of that action that was based on a 2017 settlement agreement between the EPA and Pebble Partnership and supported by the results of the 2020 EIS. The 2019 withdrawal was contested by Project opponents and is currently subject to ongoing litigation. In that litigation, EPA has requested the court to remand the case to EPA, which would likely result in the reinstatement of the Proposed Determination. Pebble Partnership has filed an Opposition, asking the Court to impose a schedule requiring the EPA to issue a final appealable decision on the 2014 Proposed Determination under the Clean Water Act (CWA), whether that be to withdraw or finalize. The imposition of a schedule is necessary to ensure that EPA is not allowed to regulate by inaction.

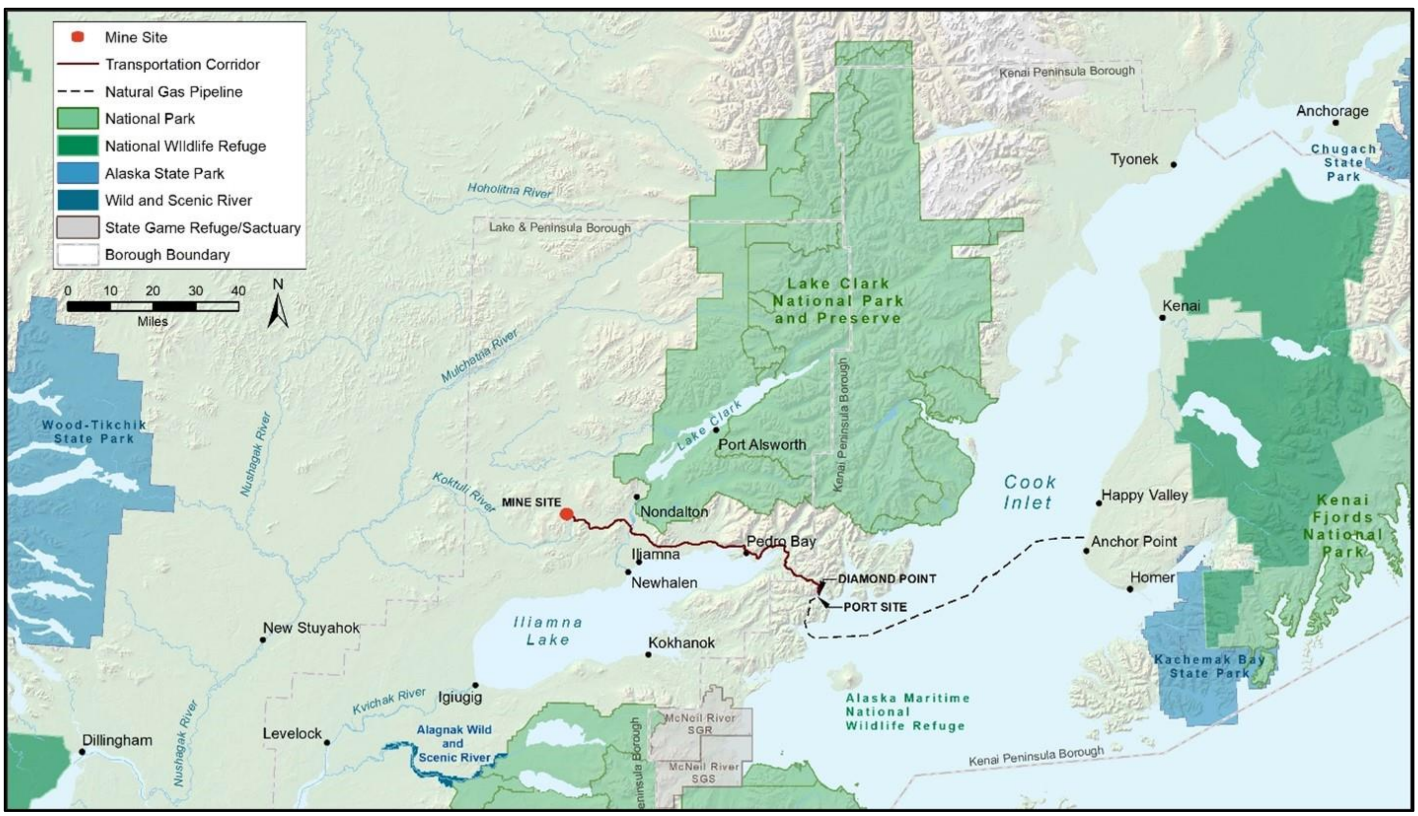
To the extent known to the QP, there are no other significant factors and risks that may affect access, title, or the right or ability to perform work on the Project that have not been discussed in this Report.

5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE, AND PHYSIOGRAPHY

5.1 Accessibility

The Pebble property is located in southwest Alaska (Figure 5-1), approximately 200 miles southwest of Anchorage, 65 miles west of Cook Inlet, and 16 miles northwest of the airport serving the villages of Iliamna and Newhalen. The map shows a proposed infrastructure corridor for the Project, as further described as the Least Environmentally Damaging Practicable Alternative (LEDPA) in the FEIS and in Section 18 of this Report.

Figure 5-1: Property Location and Access Map



Note: Prepared by Northern Dynasty, 2021.

Access to the Project is typically via air from the city of Anchorage to the airport serving the villages of Iliamna and Newhalen. With approximately 300,000 residents, Anchorage is the largest city in Alaska. It is situated at the northeastern end of Cook Inlet and is connected to the national road network via Interstate Highway 1 through Canada to the USA. Anchorage is serviced daily by numerous regularly scheduled flights to major airport hubs in the USA.

From Anchorage, there are regular flights to Iliamna through Iliamna Air Taxi and other operators. Charter flights may also be arranged from Anchorage. From Iliamna, current access to the Pebble Site is by helicopter.

5.2 Climate

The climate of the Project area is transitional; it is more continental in winter because of frozen water bodies and more maritime in summer because of the influence of the open water of Iliamna Lake and, to a lesser extent, the Bering Sea and Cook Inlet. Mean monthly temperatures in the deposit area range from about 11.4 °F in January to 50.8 °F in July (at the Pebble 1 meteorological station). The mean annual precipitation in the deposit area is estimated to be 54.6 inches (at the Pebble 1 meteorological station). About one-third of this precipitation falls as snow. The wettest months are August through October.

The climate is sufficiently moderate to allow a well-planned mineral exploration program could be conducted year-round (Rebagliati, C.M., and Haslinger, R.J., 2003) at Pebble, although the programs were typically restricted over the winter because of the shorter daylight and weather conditions. The Pebble Project will operate year-round, although transportation operations may experience short-term weather-related delays.

5.3 Infrastructure

There is a modern airfield at Iliamna, with two paved 4,920 ft airstrips, that services the communities of Iliamna and Newhalen. The runways are suitable for DC-6 and Hercules cargo aircraft and for commercial jet aircraft.

There are paved roads that connect the villages of Iliamna and Newhalen to the airport and to each other and a partly paved, partly gravel road that extends to a proposed Newhalen River crossing near Nondalton. The Pebble Site is currently not connected to any of these local communities by road; a road would be planned as part of the project design.

There is no access road that connects the communities nearest the Pebble Site to the coast on Cook Inlet. From the coast, at Williamsport on Iliamna Bay, there is an 18.6-mile State-maintained road that terminates at the east end of Iliamna Lake, where watercraft and transport barges may be used to access Iliamna. The route from Williamsport, over land to Pile Bay on Iliamna Lake, is currently used to transport bulk fuel, equipment and supplies to communities around the lake during the summer months.

Also, during summer, supplies have been barged up the Kvichak River, approximately 43.4 mi southwest of Iliamna, from Kvichak Bay on the North Pacific Ocean.

A small run-of-river hydroelectric installation on the nearby Tazamina River provides power for the three communities in the summer months. Supplemental power generation using diesel generators is required during winter months.

5.4 Local Resources

Iliamna and surrounding communities have a combined population of just over 400 people. As such, there is limited local commercial infrastructure except that which services seasonal sports fishing and hunting.

Section 18 discusses the availability of power, water, mining personnel, and planned locations for key infrastructure for the project that is envisaged in the 2021 PEA.

5.5 Physiography

The Pebble Site area is located in the Nushagak-Big River Hills physiographic region. The area consists of low, rolling hills separated by wide, shallow valleys. Elevations range from approximately 775 ft in the South Fork Koktuli (SFK) valley up to 2,760 ft on Kaskanak Mountain. Glacial and fluvial sediment of varying thickness covers most of the study area at elevations below approximately 1,400 ft, whereas the ridges and hills above 1,400 ft generally exhibit exposed bedrock or have thin veneers of surficial material. The hills tend to be moderately sloped with rounded tops. The valley bottoms are generally flat. No permafrost has been identified to date in the Project area.

6 HISTORY

6.1 Overview

Cominco Alaska, a division of Cominco Ltd., now Teck, began reconnaissance exploration in the Pebble region in the mid-1980s and in 1984 discovered the Sharp Mountain gold prospect near the southern margin of the current property. Gold was discovered in drusy quartz veins of probable Tertiary age near the peak of Sharp Mountain (anonymous Teck report, 1984). Grab samples of veins in talus ranged from 0.045 oz/ton Au to 9.32 oz/ton Au and 3.0 oz/ton Ag. No record of further work is available, but similar quartz veins were encountered in 2004 during surface mapping of the Project area conducted by Northern Dynasty. Most of these veins trend north-south and dip steeply.

Teck staked their first mineral claims on the Property during reconnaissance mapping and sampling programs in the Cone and Sharp Mountain areas in August and September 1984. In November 1987, Teck staked claims on the newly discovered Sill and Pebble prospects and added claims to these two areas in July 1988. Further staking by Teck took place in the Pebble deposit area in July 1989 and in the broader Pebble Site area in January and June through September 1991 (St. George et al, 1992). This staking, along with additional claims added in the 1990s, led to the formation of a large continuous claim group. Teck held these claims until the transactions in October 2001 when Northern Dynasty acquired its interest in the property.

In 1987, examination and sampling of several prominent limonitic and hematitic alteration zones yielded anomalous gold concentrations from the Sill prospect, which was recognized as a precious-metal, epithermal-vein occurrence, and from outcrops over and surrounding what later became the Pebble area, but which at that time was of uncertain affinity. These discoveries were followed by several years of exploration including soil sampling, geophysical surveys and core drilling.

Teck conducted geophysical surveys on the Pebble Site between 1988 and 1997. The surveys were dipole-dipole induced polarization (IP) surveys for a total of 122 line-km and were completed by Zonge Geosciences. This work defined a chargeability anomaly about 31.1 mi^2 in extent within Cretaceous age rocks which surround the eastern to southern margins of the Kaskanak batholith. The anomaly measures about 13 mi north-south and up to 6.3 mi east-west; the western margin of the anomaly overlaps the contact of the Kaskanak batholith, whereas to the east the anomaly is masked by Late Cretaceous to Eocene cover sequences. The broader anomaly was found to contain 11 distinct centres with stronger chargeability, many of which were later demonstrated to be coincident with extensive copper, gold and molybdenum soil geochemical anomalies. All known zones of mineralization of Cretaceous age on the Pebble property occur within the broad IP anomaly.

Core drilling was first conducted on the property during the 1988 exploration program which included 24 core drill holes at the Sill epithermal gold prospect, soil sampling, geological mapping, two core drill holes at the Pebble target and three holes totalling 893 ft on a target (later named the 25 Gold Zone by Northern Dynasty) located 3.7 mi south of the Pebble target.

Drilling at the Sill prospect intersected mineralization with gold grades that justified further exploration, but the initial Pebble drill holes yielded only modest encouragement (Table 6-1). In 1989, an expanded soil sampling program, the initial stages of the IP surveys described above and nine core drill holes were completed at the Pebble target, 15 core drill holes were completed at the Sill prospect, and three core drill holes were completed elsewhere on the property (Table 6-2). Although limited in scope, the IP survey at Pebble displayed response characteristics of a large porphyry copper system. Subsequent drilling by Teck intersected significant intervals of porphyry-style gold, copper and molybdenum mineralization, validating this interpretation.

Table 6-1: Teck Drilling on the Sill Prospect to the End of 1997

Year	No. of Drill Holes	Feet	Metres
1988	24	7,048	2,148
1989	15	3,398	1,036
Total	39	10,446	3,184

Table 6-2: Teck Drilling on the Pebble Deposit to the End of 1997

Year	No. of Drill Holes	Feet	Metres
1988	2	554	169
1989	9	3,131	954
1990	25	10,021	3,054
1991	48	28,129	8,574
1992	14	6,609	2,014
1997	20	14,696	4,479
Total	118	63,140	19,245

Exploration was accelerated when it became apparent that a significant porphyry copper-gold deposit had been discovered at Pebble. In 1990 and 1991, 25 and 48 core drill holes, respectively, were completed (Table 6-3). In 1991, baseline environmental and engineering studies were initiated and weather stations were established. A preliminary economic evaluation was undertaken by Teck in 1991 and was updated in 1992 on the basis of 14 new core drill holes. In 1993, an IP survey and a four-hole core drill program were completed at the target that was later named the 25 Gold Zone. In 1997, Teck completed an IP survey, geochemical sampling, geological mapping and 20 core drill holes within and near the Pebble deposit.

From 1988 to 1995, Teck undertook several soil geochemical surveys on the property and collected a total of 7,337 samples (Bouley et al., 1995).

Table 6-3: Total Teck Drilling on the Property to the End of 1997

Year	No. of Drill Holes	Feet	Metres
1988	26	7,602	2,317
1989	27	7,422	2,262
1990	25	10,021	3,054
1991	48	28,129	8,574
1992	14	6,609	2,014
1993	4	1,263	385
1997	20	14,696	4,479
Total	164	75,741	23,086

6.2 Historical

Teck drilled 125 core holes in the Pebble area between 1988 and 1997 for a total of 65,295.5 ft. These holes include 118 core holes drilled in what later became known as Pebble West and seven core holes drilled elsewhere on the property. Of the Pebble West holes, 94 were drilled vertically and 20 were inclined from −45° to −70° at various orientations. Teck also completed 39 core drill holes on the Sill prospect for a total of 10,445.5 ft in 1988 and 1989.

Sampling, sample preparation and analysis of the Teck drill holes is described in Section 11.

6.3 Ownership History

The following summary of historical property agreements is taken from Rebagliati et al (2010).

> *In October 2001, Northern Dynasty acquired, through its Alaskan subsidiary, a two-part Pebble Property purchase option previously secured by Hunter Dickinson Group Inc. (HDGI) from an Alaskan subsidiary of Teck Cominco Limited, now Teck Resources Limited (Teck). In particular, HDGI assigned this two-part option (the Teck Option) as 80% to Northern Dynasty while retaining 20% thereof. The first part of the Teck Option permitted Northern Dynasty to purchase (through its Alaskan subsidiary) 80% of the previously drilled portions of the Pebble Property on which the majority of the then known copper mineralization occurred (the "Resource Lands Option"). Northern Dynasty could exercise the Resource Lands Option through the payment of cash and shares aggregating US$10 million prior to November 30, 2004. The second part of the Teck Option permitted Northern Dynasty to earn a 50% interest in the exploration area outside of the Resource Lands (the "Exploration Lands Option"). Northern Dynasty could exercise the Explorations Lands Option by doing some 18,288 m (60,000 ft) of exploration drilling by November 30, 2004, which it completed on time. The HDGI assignment of the Teck Option also allowed Northern Dynasty to purchase the other 20% of the Teck Option retained by HDGI for its fair value.*
>
> *In November 2004, Northern Dynasty exercised the Resource Lands Option and acquired 80% of the Resource Lands. In February 2005, Teck elected to sell its residual 50% interest in the Exploration Lands to Northern Dynasty for US$4 million. Teck still retains a 4% pre-payback advance net profits royalty interest (after debt service) and 5% after-payback net profits interest royalty in any mine production from the Exploration Lands portion of the Pebble property.*

In June 2006, Northern Dynasty acquired, through its Alaska subsidiaries, the remaining HDGI 20% interest in the Resource Lands and Exploration Lands by acquiring HDGI from its shareholders and through its various subsidiaries had thereby acquired an aggregate 100% interest in the Pebble Property, subject only to the Teck net-profits royalties on the Exploration Lands. At that time, Northern Dynasty operated the Pebble Project through a general Alaskan partnership with one of its subsidiaries.

In July 2007, the Pebble Partnership was created and an indirectly wholly-owned subsidiary of Anglo American plc (Anglo American) subscribed for 50% of the Pebble Partnership's equity effective July 31, 2007. Over the next six years, Anglo American spent US$573 million on exploration, resource estimation, environmental data collection and technical studies, with a significant portion spent on engineering of possible mine development models, as well as related infrastructure, power and transportation systems prior to withdrawing from the project. In December 2013, Northern Dynasty exercised its right to acquire Anglo American's interest in the Pebble Partnership and now holds a 100% interest in the Pebble Partnership.

On June 29, 2010, Northern Dynasty entered into an agreement with Liberty Star Uranium and Metals Corp. and its subsidiary, Big Chunk Corp. (together Liberty Star), pursuant to which Liberty Star sold 23.8 mi^2 of claims (the 95 Purchased Claims) to a U.S. subsidiary of Northern Dynasty in consideration for both a $1 million cash payment and a secured convertible loan from Northern Dynasty in the amount of $3 million. The parties agreed, through various amendments to the original agreement, to increase the principal amount of the loan by $730,174. Northern Dynasty later agreed to accept transfer of 199 claims (the Settlement Claims) located north of the ground held 100% by the Pebble Partnership in settlement of the loan, and subsequently both the Purchased Claims and the Settlement Claims were transferred to a Northern Dynasty subsidiary and ultimately to Pebble West Claims Corporation, a subsidiary of the Pebble Partnership.

On January 31, 2012, the Pebble Partnership entered into a Limited Liability Company Agreement with Full Metal Minerals (USA) Inc. (FMMUSA), a wholly-owned subsidiary of Full Metal Minerals Corp., to form Kaskanak Copper LLC (the LLC). Under the agreement, the Pebble Partnership could earn a 60% interest in the LLC, which indirectly owned 100% of the Kaskanak claims, by incurring exploration expenditures of at least US$3 million and making annual payments of $50,000 to FMMUSA over a period ending on December 31, 2013. On May 8, 2013, the Pebble Partnership purchased FMMUSA's entire ownership interest in the LLC for a cash consideration of $750,000. As a result, the Pebble Partnership gained a 100% ownership interest in the LLC, the indirect owner of a 100% interest in a group of 464 claims located south and west of other ground held by the Pebble Partnership. In 2014, the LLC was merged into Pebble East Claims Corporation, a subsidiary of the Pebble Partnership, which now holds title to these claims.

On December 15, 2017 Northern Dynasty entered into a Framework Agreement with First Quantum Minerals Ltd. (First Quantum) that contemplated that an affiliate of First Quantum would subsequently execute an option agreement with Northern Dynasty with an option payment of US$150 million staged over four years. This option would entitle First Quantum to acquire the right to earn a 50% interest in the Pebble Partnership for US$1.35 billion. First Quantum made an early option payment of US$37.5 million to Northern Dynasty, applied solely for the purposes of progressing the permitting of the Pebble Project but withdrew from the Project in 2018.

6.4 Study History

The Pebble Project has been the subject of a number of studies, both published and internal, since Teck identified the deposit's potential. Northern Dynasty's initial Preliminary Assessment was published in 2004, prior to the discovery of the deeper, higher grade zone initially entitled Pebble East. The 2004 report evaluated an open pit to exploit the then-known resource. The Pebble East discovery led to extensive analysis of the means of mining that zone, which in turn led to the Northern Dynasty's second Preliminary Assessment in 2011. The 2011 report again evaluated the entire known resource, with three phases of open pit development. It also discussed the opportunity to mine the deeper, eastern portion of the resource by underground means. Additional internal analysis was conducted but most of that work went into hiatus with the departure of Anglo American from the Pebble Partnership in 2013.

In 2017, Northern Dynasty and Pebble Partnership developed a development plan to initiate the Federal permitting process under NEPA. That plan was submitted to USACE in December 2017 and its updated version is presented in the FEIS. The 2021 PEA discloses the results of the financial analysis of the plan contained in the FEIS. Additional details for the plan will be required if and when the Project proceeds through State permitting. The 2021 PEA also assesses future potential expansion scenarios for the Project, utilizing additional Mineral Resource and recognizing that any future development would require Federal and State permitting.

6.5 Historical Production

There has been no production from the Pebble Project.

7 GEOLOGICAL SETTING AND MINERALIZATION

7.1 Regional Geology

The tectonic and magmatic history of southwest Alaska is complex (Decker et al., 1994; Plafker and Berg, 1994). It includes formation of foreland sedimentary basins between tectonostratigraphic terranes, amalgamation of these terranes and their translation along crustal-scale strike-slip faults, and episodic magmatism and formation of related mineral occurrences. The overview presented here is based largely on Goldfarb et al. (2013) and its contained references.

The allochthonous Wrangellia superterrane comprises the amalgamated Wrangellia, Alexander and Peninsular oceanic arc terranes that approached North America from the southwest in the early Mesozoic. West-dipping subduction beneath the superterrane formed the Late Triassic to Early Jurassic Talkeetna oceanic arc, which is now preserved in the Peninsular terrane east of the Pebble deposit (Figure 7-1). Several foreland sedimentary basins dominated by Jurassic to Cretaceous flysch, including the Kahiltna basin that hosts the Pebble deposit (Kalbas et al., 2007), formed between Wrangellia and pericratonic terranes and previously-amalgamated allochthonous terranes of the Intermontane belt (Wallace et al., 1989; McClelland et al., 1992). Basin closure occurred as Wrangellia accreted to North America by the late Early Cretaceous (Detterman and Reed, 1980; Hampton et al., 2010). Between approximately 115 to 110 Ma and 97 to 90 Ma, the strata in the foreland basins were folded, complexly faulted and subjected to low-grade regional metamorphism (Bouley et al., 1995; Goldfarb et al., 2013). Intrusions at Pebble are undeformed (Goldfarb et al., 2013) and were probably emplaced during a period when at least local extension occurred across southwest Alaska in the mid-Cretaceous (e.g., Pavlis et al., 1993). The relative importance of extensional versus compressional structures to the formation of the Pebble deposit is not well constrained, although an important syn-hydrothermal transpressional fault occurs in the eastern part of the deposit.

Since the early Late Cretaceous, deformation in southwest Alaska has occurred mostly on major dextral strike-slip faults that broadly parallel to the continental margin (Figure 7-1). The major Denali Fault in central Alaska forms the contact between the Intermontane Belt and the collapsed flysch basins. Subparallel faults with less substantial displacement are located south of the Denali Fault, and the Pebble district is located between what are probably terminal strands of the dextral Lake Clark fault zone (Figure 7-1); Shah et al., 2009). The Lake Clark fault zone marks the poorly defined boundary between the Peninsular terrane to the southeast and the Kahiltna terrane, which hosts the Pebble deposit, to the northwest (Figure 7-1). Haeussler and Saltus (2005) propose 16.1 mi of dextral offset along the Lake Clark fault zone, most of which is interpreted to have occurred prior to approximately 38 to 36 million years ago (Ma). Recent field studies of geomorphology along the Lake Clark fault indicate that this structure has not experienced seismic activity for at least the last 10,000 years (Haeussler and Saltus, 2005, 2011; Koehler, 2010; Koehler and Reger, 2011). Other sub-parallel strike-slip faults also form terrane boundaries in the region, including the Mulchatna and Bruin Bay Faults (Figure 7-1). Goldfarb et al. (2013) propose that most or all movement on these smaller structures occurred during oroclinal bending in the Tertiary, after formation of the Pebble deposit.

The initiation of magmatism and metallogenesis in the Pebble district approximately coincides with the onset of dextral transpression during basin collapse (Goldfarb et al., 2013). Alkalic to subalkalic intrusions were emplaced between approximately 100 and 88 Ma (Bouley et al., 1995; Amato et al., 2007; Hart et al., 2010; Lang et al., 2013; Olson et al., 2017, 2020). Alaska-type ultramafic complexes were emplaced at Kemuk, which is enriched in platinum group elements (Iriondo et al., 2003; Foley et al., 1997), and a mineralogically-similar alkalic ultramafic body, albeit probably emplaced at shallow depths and without known enrichment in platinum group elements, occurs at Pebble (Bouley et al., 1995). Porphyry Cu-Mo±Au±Ag mineralization in the region is associated dominantly with subalkalic, felsic to intermediate intrusions formed between 97 and 90 Ma, and includes deposits at Pebble, Neacola (Reed and Lanphere, 1973; Young et al., 1997) and possibly the undated Iliamna prospect (Figure 7-2 A). Late Cretaceous intermediate to felsic intrusions are subalkalic and were emplaced between 75 and 60 Ma (e.g., Couture and Siddorn, 2007; Goldfarb et al., 2013). Porphyry Cu-Au±Mo and/or reduced intrusion-related gold mineralization associated with these rocks (Figure 7-2 A) formed at the Whistler deposit (Hames and Roberts, 2020), located about 93.2 mi northeast of Pebble, at Kijik River (Kreiner et al., 2020), the Bonanza Hills (Anderson et al., 2013) and Shotgun (Rombach and Newberry, 2001). Late Cretaceous to Eocene intrusions are common in the Kahiltna terrane and widespread, voluminous Eocene volcanic rocks cover much of the Kahiltna terrane and are associated with epithermal precious metal mineralization (Bundtzen and Miller, 1997). Igneous rocks of the mid-Cretaceous, Late Cretaceous, and Eocene magmatic suites are present within the Pebble district.

7.2 Project Geology

7.2.1 Kahiltna Flysch

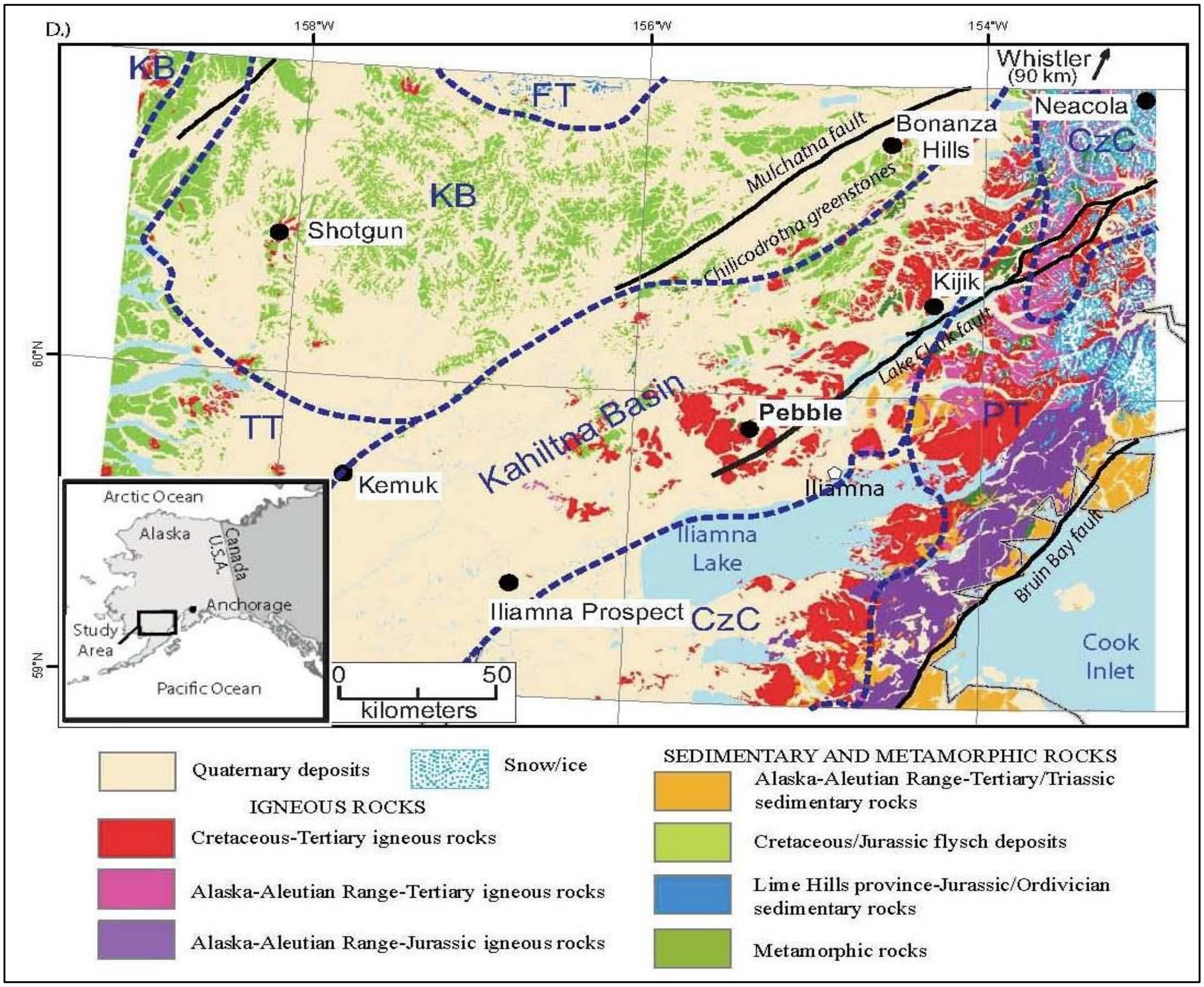
The oldest rock type in the Pebble district is the Kahiltna flysch, which comprises basinal turbidites, interbedded basalt flows and lesser breccias, and minor gabbroid intrusions. The Kahiltna flysch forms a northeast-trending belt about 250 mi. long, which has experienced multiple stages of igneous and hydrothermal activity (Figure 7-1; Goldfarb, 1997; Young et al., 1997). The flysch in the vicinity of Pebble is at least 99 to 96 million years old, based on the maximum age of cross-cutting intrusions. Sediments were predominately derived from intermediate igneous source rocks and consist of siltstone, mudstone, subordinate wacke and rare, thin, lensoidal beds of matrix-supported pebble conglomerate (Figure 7-1). Bedding ranges from laminar to thick and is commonly poorly defined. Bouma sequences (Bouley et al., 1995), graded beds and load casts demonstrate that the stratigraphy is right-way-up.

The flysch locally contains thick layers of basalt flows, lesser breccias and minor mafic volcaniclastic rocks located mostly in the southwest and northern parts of the district. Undated gabbros cut the flysch and volcanic rocks in several areas and are interpreted to be related either to the basaltic volcanic rocks within the flysch or to younger diorite sills.

7.2.2 Diorite and Granodiorite Sills

Diorite and granodiorite sills intruded the Kahiltna flysch (Figure 7-2 A) at approximately 96 Ma. These two rock types are interpreted to be approximately coeval, based on the similarity in their distribution and style of occurrence; they are only well documented within the Pebble deposit.

Figure 7-1: Location of the Pebble Deposit & Regional Geological Setting of Southwest Alaska



Note: Prepared by Lang et al. (2013) as modified slightly from Anderson et al., 2013. Dashed lines separate terranes: KB=Kuskokwim Basin; TT=Togiak Terrane; PT=Peninsular Terrane; FT=Farewell Terrane; CzC=Cenozoic cover. Filled circles are the locations of mineral deposits discussed in this text. Northern Dynasty claims cover only the Pebble deposit. Major dextral strike-slip faults are indicated by solid black lines.

Diorite sills are laterally extensive and range from less than 10 ft to greater than 300 ft in thickness. They are most common as stacked sheets in the western part of the Pebble deposit. The sills are medium grained and weakly porphyritic, with common plagioclase and hornblende and minor pyroxene set in a very fine-grained groundmass of plagioclase and hornblende (Figure 7-2B).

Three laterally continuous granodiorite sills occur within the Pebble deposit. They are up to 1,000 ft thick, with the thickest portions in the northeast part of the deposit. The sills range from fine to medium grained, with common plagioclase and hornblende as well as minor amounts of apatite, in a very fine-grained groundmass of potassium feldspar and quartz with minor to accessory magnetite, apatite and zircon (Figure 7-2 C).

7.2.3 Alkalic Intrusions and Associated Breccias

A complex suite of alkalic porphyry intrusions, which range from biotite pyroxenite, monzodiorite, monzonite to syenomonzonite, monzonite and monzodiorite in composition, and associated breccias, occur in the southwest quadrant of the Pebble deposit and extend several miles to the south (Schrader, 2001; Hart et al., 2010; Goldfarb et al., 2013). Isotopic dates on diorite and granodiorite sills, biotite pyroxenite and alkalic intrusions indicate that they are approximately coeval and were emplaced between 99 and 96 Ma (Schrader, 2001; Olson, 2015). Early intrusions are medium-grained, biotite monzonite porphyries (Figure 7-2 D) that commonly contain scattered potassium feldspar megacrysts up to a few centimetres in size. Later intrusions are fine-grained porphyritic biotite monzodiorite (Figure 7-2 E). All intrusive phases contain angular to subrounded xenoliths of flysch, diorite and, in the younger monzodiorite phase, xenoliths of older alkalic intrusions. Many of the intrusions grade laterally into breccias.

Breccias in the alkalic complex are complicated. Subordinate intrusion breccias have angular to subangular fragments in a cement of a relatively younger porphyritic biotite monzodiorite intrusion. Fragments of diorite sills, early alkalic biotite monzonite porphyry intrusions and flysch are most common xenoliths. In the common breccias, the matrices dominantly consist of a rock flour composed of subangular to subrounded fragments of these same rock types (Figure 7-2 F). Hydrothermal cement is absent, and fragments range from a few millimetres to tens of metres in size. Locally, intersections of diorite and granodiorite sills within the breccia bodies may correlate laterally with undisturbed sills. Due to the internal complexity of the alkalic rocks and breccias within the deposit, the complex is modeled as a single unit, loosely interpreted as a megabreccia.

7.2.4 Hornblende Granodiorite Intrusions

Granodiorite intrusions include the Kaskanak batholith and numerous smaller bodies, mostly within or proximal to zones of porphyry-style mineralization around the margins of the batholith. All isotopic dates on these rocks are approximately 90 Ma (Bouley et al., 1995; Lang et al., 2013). The Kaskanak batholith is dominantly a medium-grained hornblende granodiorite porphyry, with minor equigranular hornblende quartz monzonite. Granodiorite intrusions spatially associated with porphyry-style mineralization throughout the Pebble district are all mineralogically and texturally similar to the main phase of the Kaskanak batholith (Figure 7-2G). All of these intrusions are characterized by common hornblende, plagioclase and minor quartz and titanite, set in a fine-grained groundmass of quartz, plagioclase, potassium feldspar, apatite, zircon and magnetite. Megacrysts of potassium feldspar are up to 0.6 in in size, increase in both size and concentration with depth (from less than 2% to greater than 5%) and poikilitically enclose plagioclase and hornblende phenocrysts.

7.2.5 Volcanic Sedimentary cover Sequence

Cretaceous rock types 90 Ma or older are unconformably overlain by well-bedded sedimentary and volcanic rocks (Figure 7-2 H), informally called the cover sequence. The cover sequence is up to 2,200 ft thick over the eastern edge of the Pebble deposit, and basalt flows with lesser interbeds of clastic sedimentary rocks are up to at least 6,400 ft thick within the East Graben. The sequence occurs mostly on, and thickens toward, the east side of the district, and is widespread to the southwest, south and north of Pebble. Sedimentary rock types are facing right-way-up but have been tilted about 20º east in the deposit area, and include pebble to boulder conglomerate, wacke, siltstone and mudstone. Plant fossils are common in wacke, and coal-bearing seams up to approximately 1.5 ft thick have been intersected by drilling. Volcanic to sub-volcanic rocks include basalt flows and mafic dykes and sills. Volcaniclastic rocks are abundant and contain angular fragments ranging from basalt to rhyolite within a matrix of comminuted volcanic material. The cover sequence is cut by minor narrow, dykes and sills of felsic to intermediate composition. Lang et al., (2013) report that basalts in the East Graben are cut by 65 Ma hornblende monzonite porphyry intrusions, and Olson et al., (2017) assign sedimentary and volcanic rocks that overlie the eastern part of the deposit to the late Paleocene to Eocene Talarik Formation, which may correlate with the widespread Copper Lake Formation of Detterman and Reed (1980).

7.2.6 Hornblende Monzonite Porphyry Intrusions

Two porphyry intrusions of hornblende monzonite, up to 820 ft thick, cut basalts within the East Graben and have been dated at approximately 65 Ma (Lang et al., 2013). They are medium-grained and porphyritic, with common plagioclase and lesser hornblende set in a fine-grained groundmass of potassium feldspar, plagioclase and minor magnetite. These intrusions are not hydrothermally altered.

7.2.7 Eocene Volcanic Rocks and Intrusions

Volcanic and sub-volcanic intrusive rocks on the east side of the district are dated at approximately 46 to 48 Ma (Bouley et al., 1995; Lang et al., 2013). These rocks are mostly exposed on Koktuli Mountain east of the deposit and in the East Graben; reconnaissance drill intersections suggest they are also common in the southeast part of the district beneath glacial cover. Rock types include felsic dykes, brecciated rhyolite flows, fine-grained, equigranular to porphyritic biotite-bearing hornblende latite intrusions and coarse-grained hornblende monzonite porphyry.

7.2.8 Glacial Sediments

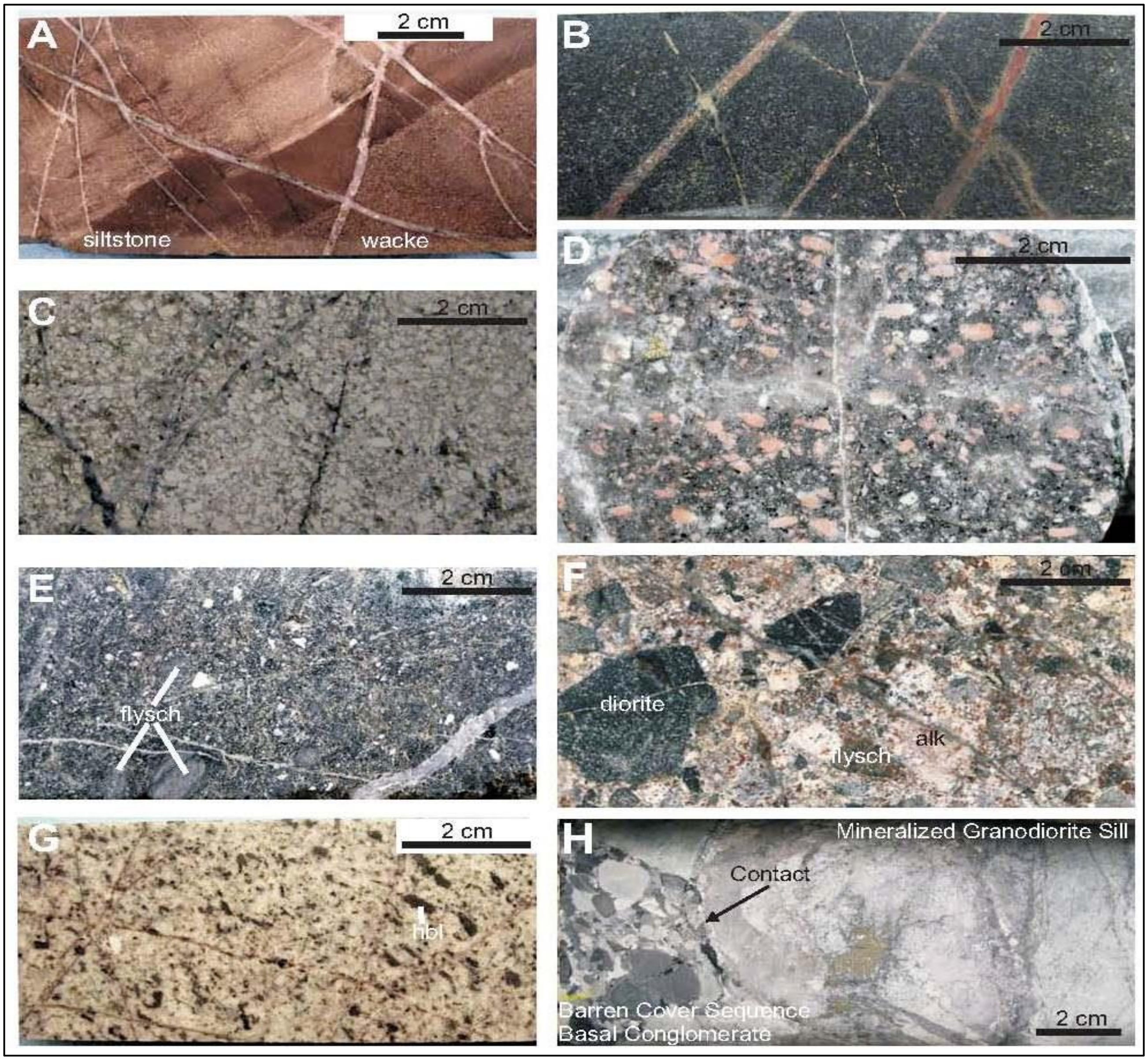
Unconsolidated glacial sediments of Pleistocene to recent age cover the valley floors and the flanks of the higher hills (Detterman and Reed, 1973; Hamilton and Klieforth, 2010). The sediments are typically less than 100 ft thick, but drill intersections range up to 525 ft in the wide valley in the southeast part of the district. Ice flow directions over the deposit were to the south-southwest, and the glaciers had retreated by approximately 11 ka (Detterman and Reed, 1973; Hamilton and Klieforth, 2010).

7.2.9 District Structure

The structural history of the district outside of the Pebble deposit is poorly understood due to a paucity of outcrop and marker horizons. The Kahiltna flysch exhibits shallow to moderate dips to the east, south and southeast, which may reflect doming around the margins of the Kaskanak batholith. Folds in the flysch are open, and most inter-limb angles are less than 20°. Folding and related deformation predate hydrothermal activity at Pebble (Bouley et al., 1995; Goldfarb et al., 2013).

Faults are abundant throughout the Pebble district. A metallogenically-significant northeast-trending, syn-hydrothermal brittle-ductile fault zone (BDF) is described later in this section. Most faults are brittle normal or normal-oblique structures that cut and displace all rock types in the district and, in many cases, have been inferred from discontinuities in airborne magnetic and electromagnetic data. The most prominent faults strike north-northeast and northwest, with fewer striking east. The most important of these faults bound the northeast-trending East Graben, which is believed to be a negative flower structure that down-drops high-grade mineralization on the east side of the Pebble deposit. Brittle faults cut Eocene rock types, but precursor structures may have been periodically active since the mid-Cretaceous (L. Rankin, pers. comm., 2011). There is no geological evidence to suggest that these faults have been recently active.

Figure 7-2: Rock Types in the Pebble District



Note: Prepared by Lang et al. 2013.

1. A: Kahiltna flysch with interbedded siltstone and wacke affected by biotite-rich potassic alteration.
2. B: Diorite sill cut by magnetite-rich veins with intense biotite-rich potassic alteration.
3. C: Granodiorite sill with crowded porphyritic texture and pervasive potassic alteration.
4. D: Biotite monzonite porphyry member of the alkalic suite.
5. E: Late biotite monzodiorite porphyry member of the alkalic suite with angular xenoliths of flysch.
6. F: Diatreme breccia from the alkalic suite with polylithic fragments in a matrix of rock flour.
7. G: Pebble East zone granodiorite porphyry pluton with relict hornblende phenocrysts selectively altered to biotite.
8. H: Sharp contact between mineralized granodiorite sill and overlying basal conglomerate of the cover sequence, top of the Pebble East zone.

7.3 Deposit Geology

The characteristics of the Pebble deposit are shown in plan view in Figure 7-3 and Figure 7-4, and in cross-section in Figure 7-5 to Figure 7-7. Geological interpretation of the Pebble deposit is based almost entirely on core drill intersections. Greater detail on the geology of the Pebble deposit is available in Lang et al. (2013), Olson (2015), and Olson et al. (2017, 2020).

7.3.1 Rock Types

The deposit is hosted by Kahiltna flysch, diorite and granodiorite sills, alkalic intrusions and breccias, granodiorite stocks, and granodiorite to granite dykes Figure 7-3and Figure 7-5. Within the deposit, the Kahiltna flysch is a well-bedded siltstone with less than 10% coarser-grained wacke interbeds; basalt and gabbro are absent. Bedding within the flysch typically dips less than 25º to the east. The flysch was intruded by diorite sills, granodiorite sills and rocks of the alkalic suite prior to hydrothermal activity. The diorite sills are found only in the western half of the deposit (Figure 7-5), whereas some granodiorite sills extend across the entire deposit. Intrusions and breccias of the alkalic suite occupy the southwest quadrant of the deposit (Figure 7-3).

The deposit is centered on a group of Kaskanak suite intrusions. Olson (2015) describes the sequence and composition of the intrusions within the Pebble deposit as: 1) earliest, voluminous equigranular granodiorite equivalent to the Kaskanak batholith; 2) transitionally porphyritic granodiorite stocks; 3) early-mineral granodiorite porphyry; 4) inter-mineral quartz granite porphyry; and 5) minor late-mineral high-silica quartz granite porphyry. Due to scale, the Kaskanak intrusions are simplified on Figure 7-3, and are shown as the larger Pebble East zone pluton and four smaller bodies in the Pebble West zone. The north contact of the Pebble East zone pluton is close to vertical, and its upper contact dips shallowly to the west; it remains undelineated to the south and has been dropped into the East Graben by the ZG1 normal fault to the east. Contacts of stocks in the Pebble West zone dip steeply to moderately outward. Drill intersections of equigranular granodiorite at depths more than ~3,300 ft below the deposit support the hypothesis that the observed porphyry dikes and stocks in the upper part of the deposit emanate and were derived from a deeper reservoir of granodiorite at depth that is part of the main mass of the Kaskanak batholith.

The Pebble East zone is entirely concealed by the east-thickening cover sequence. The contact between the flysch and the cover sequence ranges from sharp and undisturbed to structurally disrupted with slippage along the contact. The lower half of the sequence comprises a thick basal conglomerate with well-rounded cobbles and boulders of intrusive and volcanic rock types of unknown provenance, overlain by complex, interlayered, discontinuous lenses of pebble conglomerate, wacke, siltstone, and mudstone. The upper half of the sequence comprises volcanic and volcaniclastic rocks (Figure 7-5) dominated by basalt or andesite and intruded by minor felsic to intermediate sills and/or dykes.

The East Graben is filled by basalt flows and lesser sedimentary rocks that have an uncertain relationship to the cover sequence. The graben fill ranges from approximately 4,265 ft thick north of the ZE fault to a thickness of up to at least 6,400 ft to the south. Basalts in the lower half of the graben are cut by two ~65 Ma monzonite porphyry intrusions, which makes them older than the rocks that cover the Pebble East zone. The age of the upper part of the graben fill is unknown but similarities of the sedimentary layers to some rock types in the cover sequence suggests that they may be coeval.

Eocene rocks are rare within and proximal to the Pebble deposit. Where thus far encountered, they comprise narrow felsic dykes, a pink hornblende monzonite intrusion intersected at depth in the central part of the East Graben, and a rhyolite flow breccia at the top of the East Graben, south of the ZE fault.

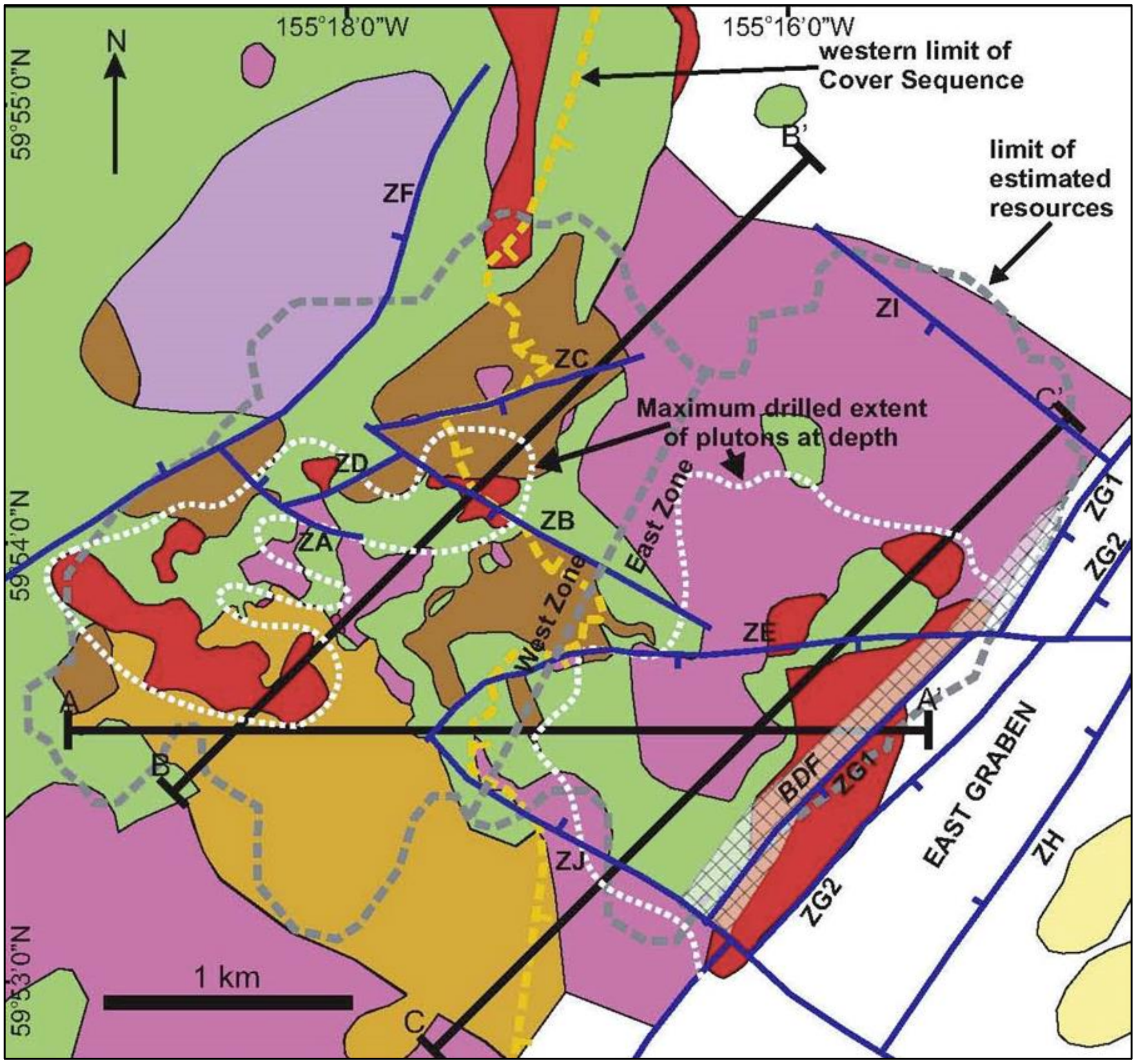
7.3.2 Structure

Within the western part of the Pebble deposit, the Kahiltna flysch occurs as an open, M-shaped anticline with axes that plunge shallowly to the east-southeast (Rebagliati and Payne, 2006). The folding predates intrusive activity at Pebble and diorite sills are commonly thicker where they exploited the hinges of the folds. Folding did not affect the cover sequence.

A BDF zone was identified on the east side of the Pebble deposit (Figure 7-3) where it manifests a zone of deformation defined by distributed cataclastic seams and healed breccias. It strikes north-northeast, extends at least 1.86 mi along strike, is up to 650 ft wide and is vertical to steeply west-dipping. The BDF is truncated on the east by the ZG1 fault (Figure 7-5) and does not affect the cover sequence. Displacement was dextral-oblique/reverse (S. Goodman, pers. comm., 2008), and correlation of alteration domains across the fault limits post-hydrothermal lateral displacement to less than 1,310 ft. The BDF was active before, during and after hydrothermal activity. Deformation is most intense in flysch north of the Pebble East zone pluton but is weaker within the intrusion, suggesting that the BDF was more active before or during emplacement of the stock. Syn-hydrothermal control on mineralization by the BDF is indicated by the much higher grades of copper and gold and higher vein density within the structural zone compared to adjacent, undeformed host rocks. The characteristics of deformation along the BDF, and its timing relative to hydrothermal activity at Pebble, support at least a local compressional to transpressional environment during the formation of the deposit. Local deformation of veins indicates some post-hydrothermal movement on the BDF.

Brittle faults within the Pebble deposit conform to the district-scale patterns described in Section 7.2.9 (Figure 7-3). The ZB, ZC and ZD faults occur in the Pebble West zone and exhibit normal offset of diorite and granodiorite sills of between 50 ft and 300 ft. Normal displacement on the ZJ and ZI faults is not well constrained. The ZA fault has about 100 ft of apparent reverse movement. A minimum of 820 ft of normal displacement occurred across the steeply west-dipping ZF fault, juxtaposing mineralized sodic-potassic alteration in the east against poorly mineralized, propylitic and quartz-sericite-pyrite alteration to the west. Scissors-style, south-side-down normal displacement on the ZE fault increases from around 100 ft on its western end to about 980 ft on the east side of the deposit. The ZG1 fault forms the western boundary of the East Graben and has a well-defined normal displacement of approximately 2,100 ft in the north and 2,900 ft in the south, based on offset of the contact between the deposit and the cover sequence (Figure 7-5). The ZG2 fault, which is parallel to the ZG1 fault, has between 880 ft and 1,800 ft of normal displacement. The ZH fault and possible parallel structures farther east mark the eastern margin of the East Graben but remain undelineated. Many of these brittle faults localized intermediate to mafic dykes and a date of 84 Ma for an andesite dyke by Schrader (2001) indicates that brittle faults were active at least from that time and likely continued at least until the Eocene (Olson, 2015).

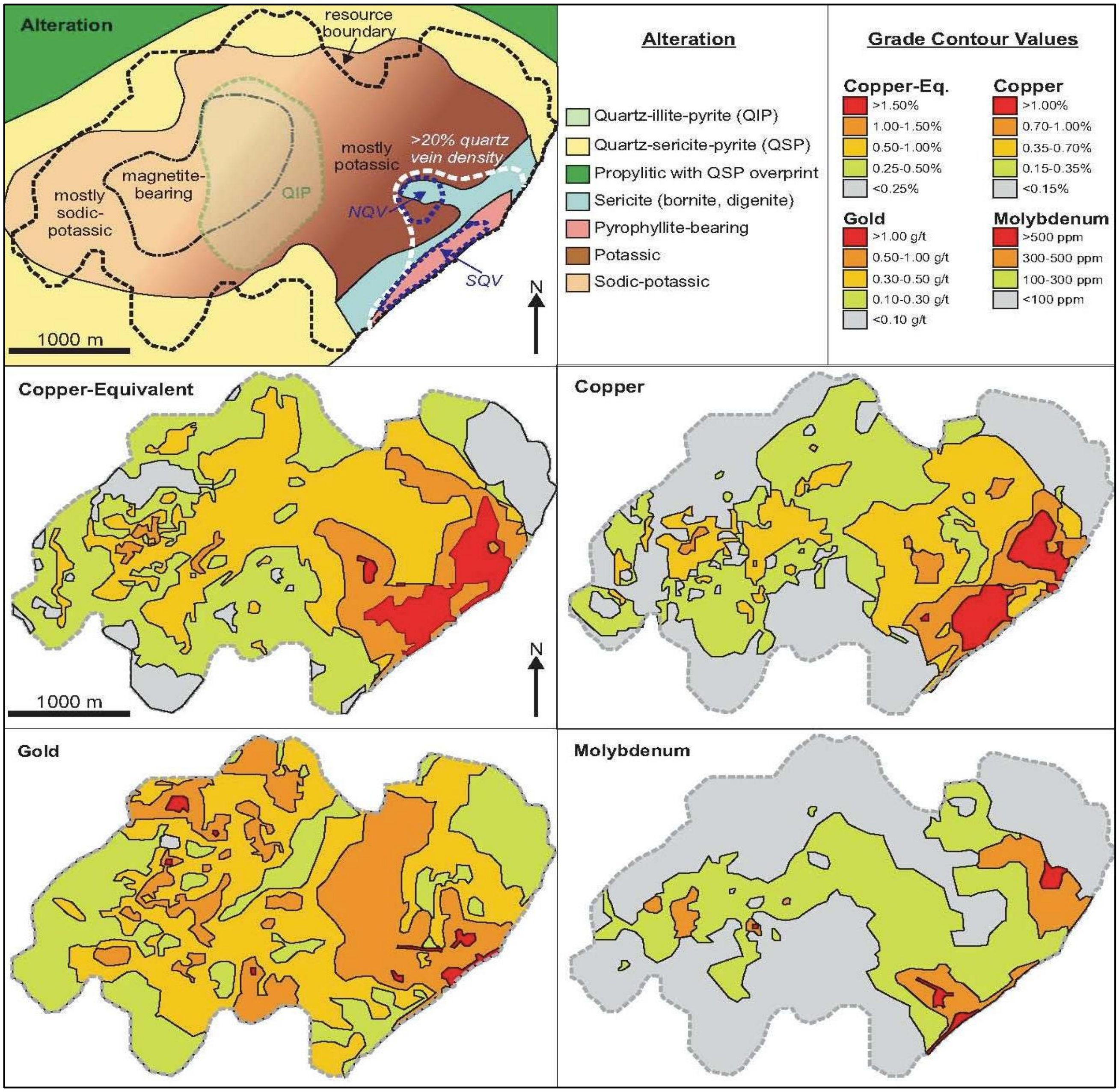
Figure 7-3: Geology of the Pebble Deposit Showing Section Locations



Note: Prepared by Lang et al. (2013).

1. The late Cretaceous cover sequence occurs to the east of the dark yellow line and has been removed for clarity.
2. Cross-sections A-A', B-B' and C-C' are shown in Figure 7-5, Figure 7-6 and Figure 7-7, respectively.
3. The brittle-ductile fault zone (BDF) is indicated by the cross-hatched pattern.
4. The dashed outline of the estimated resources at a 0.3% CuEq cut-off is used as a reference point for alteration and grade distribution in Figure 7-4.
5. White areas are either undrilled or rock types below cover sequence unknown.
6. See Figure 7-1 for geology legend.

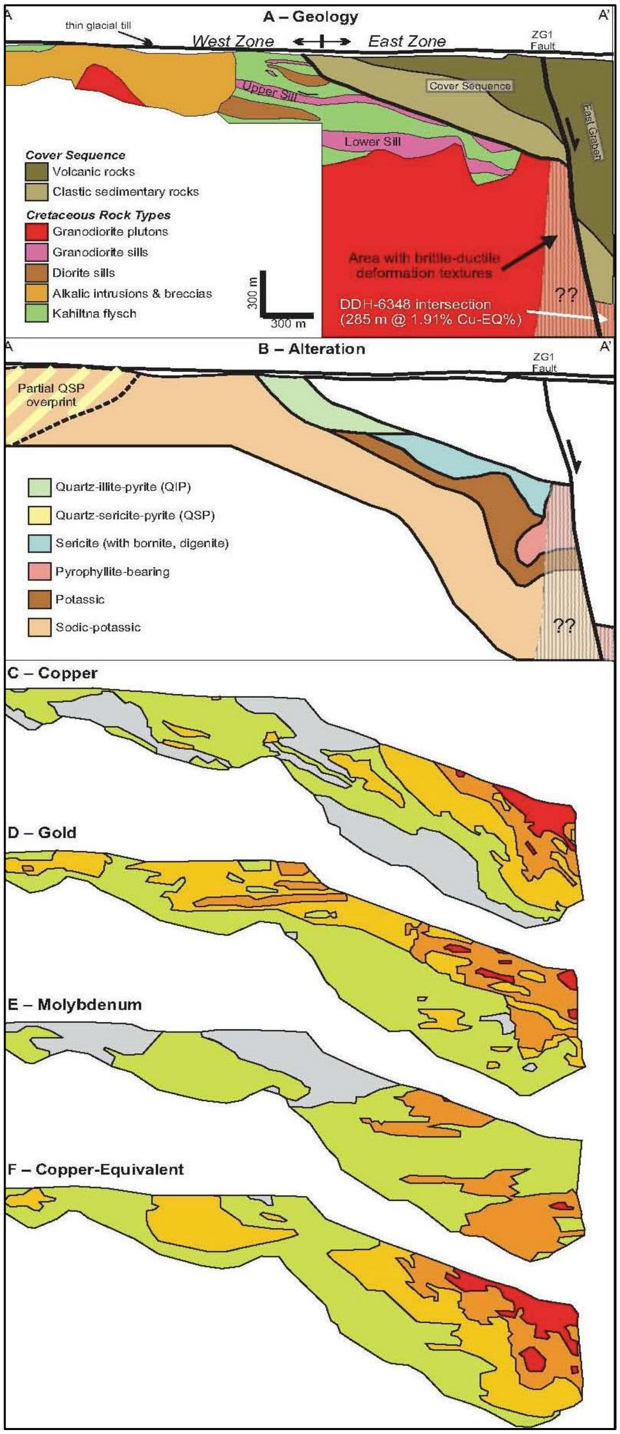
Figure 7-4: Plan View of Alteration and Metal Distribution in the Pebble Deposit



Note: Prepared by Lang et al. (2013).

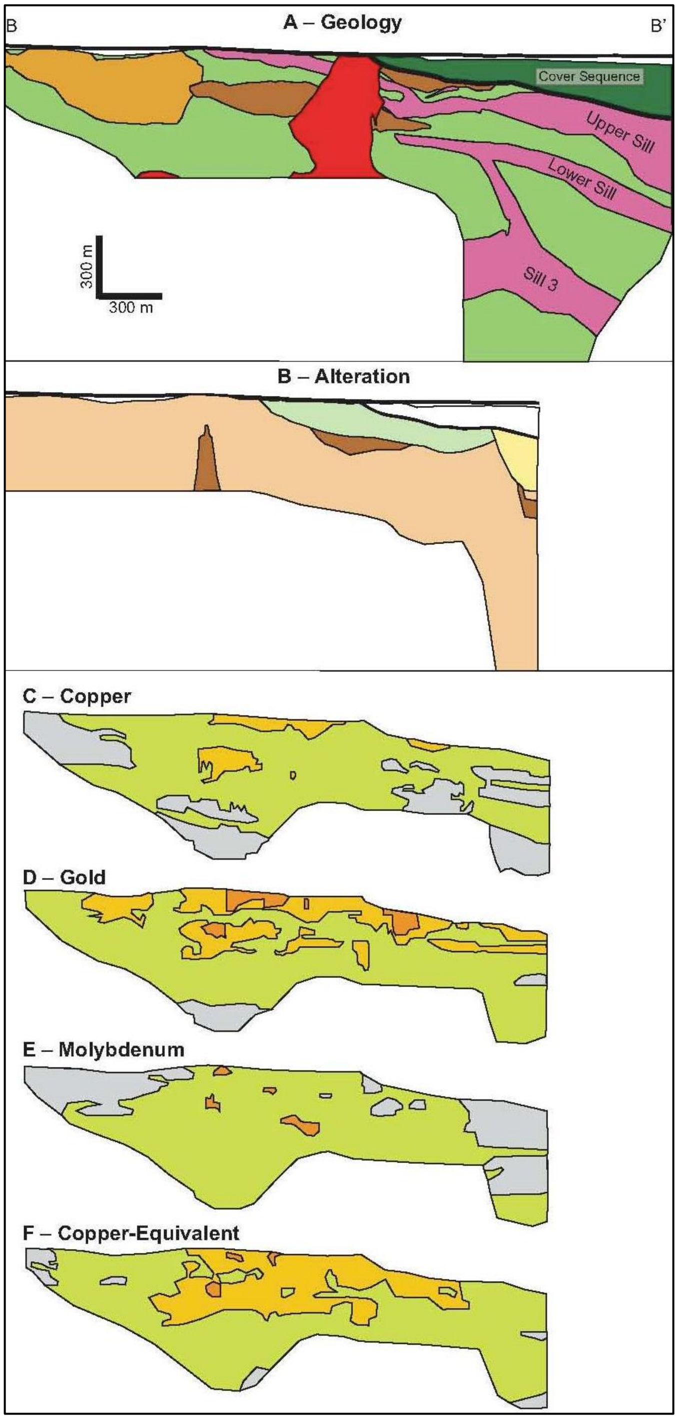
1. Grades are shown as they appear in a previously completed resource block model (Gaunt et al., 2010), at the contact between the deposit and the overlying cover sequence, which has been removed. These grades are not derived from the current resource estimate.
2. For geological reference, the resource outline matches that shown in Figure 7-3.
3. A simplified distribution of alteration types is shown on the map at upper left.
4. NQV and SQV are the northern and southern quartz vein domains (>50% quartz veins).

Figure 7-5: Geology, Alteration and Distribution of Metals on Section A-A'



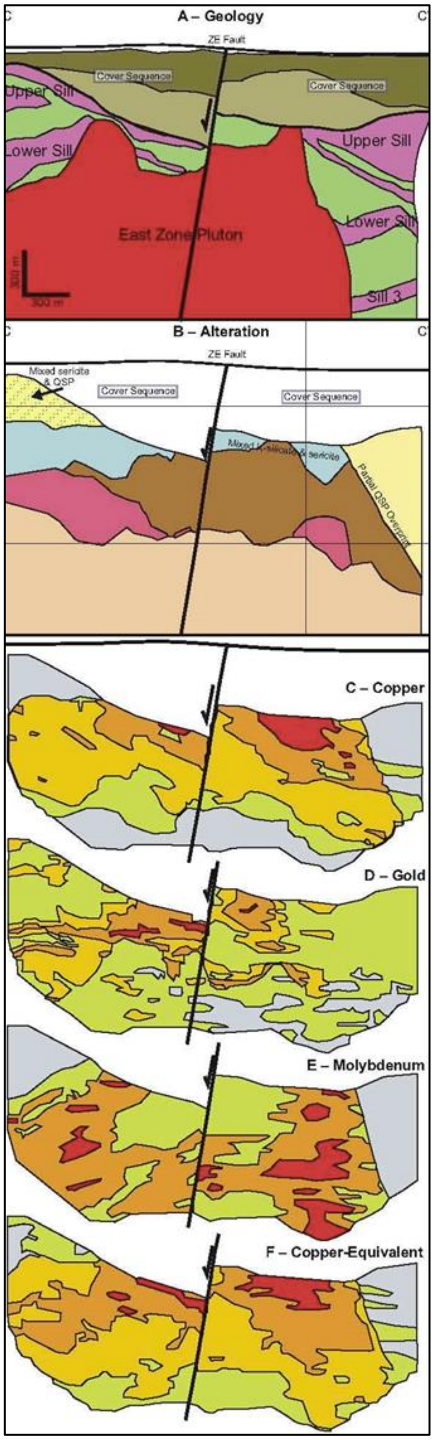
Note: Prepared by Lang et al. (2013).
Location of section is shown in Figure 7-3, and grade legends in Figure 7-4.

Figure 7-6: Geology, Alteration and Metal Distribution on Section B-B’



Note: Prepared by Lang et al. (2013).
Location of section is shown in Figure 7-3, and legend for grade ranges and alteration in Figure 7-4.

Figure 7-7: Geology, Alteration and Metal Distribution on Section C-C'



Note: Lang et al. (2013).
Location of section is shown in Figure 7-6, and legend for grade ranges and alteration in Figure 7-4.

7.3.3 Deposit Alteration Styles

Alteration styles are summarized below in the order of their interpreted relative ages.

7.3.3.1 Pre-hydrothermal Hornfels

Hornfels related to intrusion of the Kaskanak batholith pre-dates hydrothermal activity and is found in all Cretaceous rock types, except granodiorite plutons and dykes. The hornfels aureole to the batholith is narrow south of Pebble but extends well east of the batholith in the vicinity of the deposit, which suggests that the batholith underlies the deposit, a concept supported by magnetic data (Shah et al., 2009; Anderson et al., 2013). Hornfels-altered flysch is massive but highly susceptible to brittle fracture, although the narrow alteration envelopes around veins indicate that permeability between fractures was low. Hornfels in flysch outside the deposit comprises biotite, K-feldspar, albite, plagioclase and quartz with minor pyrite and other accessory minerals.

7.3.3.2 Hydrothermal Alteration

Numerous stages of hydrothermal alteration are present, including potassic (also sometimes called K- or potassium-silicate alteration), sodic-potassic, illite ± kaolinite, pyrophyllite and sericite advanced argillic, quartz-illite-pyrite, propylitic, and quartz-sericite-pyrite associations, as well as a variety of vein types. Sericite is defined herein as fine-grained, crystalline white mica, whereas illite is very fine-grained, non-crystalline white mica (Harraden et al., 2013). Advanced argillic alteration follows the naming convention of Meyer and Hemley (1967), although there are some differences noted in Pebble alteration. Most metals were introduced during early potassic and sodic-potassic alteration, with significant enhancement of grade in areas overprinted by younger advanced argillic alteration.

7.3.3.3 Early Potassic and Sodic-Potassic Alteration

Most copper-gold-molybdenum-silver-rhenium mineralization coincides with early potassic and sodic-potassic alteration. Potassic alteration occurs mostly in the upper part of the Pebble East zone, whereas sodic-potassic alteration occurs in the Pebble West zone and below potassic alteration in the Pebble East zone. Sodic-potassic alteration is distinguished from potassic primarily by the presence of albite and a higher concentration of carbonate minerals (Gregory and Lang, 2011, 2012; Gregory, 2017). Associated vein types are described below.

Potassic alteration occurs in all rock types and is most intense in flysch and granodiorite sills near the Pebble East zone pluton, within the Pebble East zone pluton and in small areas of the Pebble West zone (Gregory and Lang, 2009). It is weakest in the area between the Pebble East and Pebble West zone centers. The assemblage includes potassium feldspar, quartz and biotite with trace to minor ankerite or ferroan dolomite, apatite and rutile. Sulphides include disseminated chalcopyrite and pyrite with minor molybdenite and bornite (Gregory and Lang, 2009). The proportion of biotite to potassium feldspar correlates with the original Fe-Mg concentration of host rocks and, thus, is highest in flysch and diorite sills.

Intrusive rocks in the Pebble West zone are affected by early sodic-potassic alteration which comprises albite, biotite, potassium feldspar and quartz, accompanied by ankerite, ferroan dolomite, trace apatite, magnetite and, locally, siderite. The concentration of carbonate minerals increases with depth. Sulphides include pyrite and chalcopyrite that both generally decrease in concentration with depth. Sodic-potassic alteration of sedimentary rocks is mineralogically similar to that in the intrusions and is typically pervasive.

In the Pebble East zone, sodic-potassic alteration occurs below potassic alteration and is distinguished from similar alteration in the Pebble West zone by the presence of epidote and calcite and by lower metal grades. The potassic to sodic-potassic transition occurs over vertical distances of less than 330 ft. In the Pebble East zone pluton, cores and rims of zoned plagioclase phenocrysts are replaced by calcite-epidote and albite, respectively. Hornblende phenocrysts were replaced by biotite and then by chlorite. Hematitized igneous magnetite is also present. The igneous groundmass was replaced by fine-grained quartz, potassium feldspar, and variable albite. Mineralization is weak in this alteration and decreases with depth, and commonly comprises 2% pyrite and trace to minor chalcopyrite and molybdenite. This alteration is difficult to distinguish from peripheral propylitic alteration and its potential equivalence to well-mineralized sodic-potassic alteration in the Pebble West zone remains unclear.

Potassic alteration overprints sodic-potassic alteration but the two alteration types are interpreted to be coeval and therefore are treated as a single alteration event. The apparent relative timing is likely a consequence of telescoping and/or changing fluid chemistry during cooling. The paragenetic and spatial relationship between sodic-potassic alteration in the Pebble East and Pebble West zones and peripheral propylitic alteration is not established.

7.3.3.4 Vein Types Associated with Early Potassic and Sodic-Potassic Alteration

Four major quartz-sulphide vein types, comprising 80% of all veins in the deposit, are associated with early potassic and sodic-potassic alteration and are classified as types A, B, M and C. Each type includes varieties that broadly correlate with lateral and/or vertical position in the deposit. The naming conventions, while similar to common porphyry vein nomenclature, are not exact equivalents similarly named to vein types described from other deposits (e.g., Gustafson and Hunt, 1975; Clark, 1993; Gustafson and Quiroga, 1995). For clarity in the sections that follow, the term selvage is used to denote minerals lining the interior walls of a dilatant vein, whereas envelope refers to alteration in the host rock to a vein.

Total density of vein types A, B and C across most of the Pebble deposit is between 5 and 15 vol % (using the criteria of Haynes and Titley (1980) and excluding alteration envelopes). Lower concentrations occur near the margins of the deposit and at depth below the 0.3% CuEq resource boundary. Higher concentrations occur within or proximal to the Pebble East zone pluton and locally proximal to the smaller granodiorite plutons in the Pebble West zone. Vein density does not correlate consistently with rock type and, in most cases, patterns extend smoothly across lithological contacts. Measurements in oriented drill core do not reveal any significant or consistent preferred vein orientations.

On the east side of the Pebble East zone there are two domains characterized by 50 to 90% quartz veins. These two zones are surrounded by and gradational with a larger zone that contains greater than 20% quartz veins of either the A1 or B1 vein subtypes (see below). These zones of high vein density probably reflect repeated refracturing and dilation that accommodated repeated vein precipitation events. The first domain is located north of the ZE fault in a broadly cylindrical zone 330 to 1,640 ft wide and extending up to 1,970 ft below the cover sequence. Veins in this first zone are not deformed and controlling faults have not been identified. The second area forms a north-northeast-trending, nearly vertical, tabular zone that lies within the zone of brittle-ductile deformation. This second area is truncated to the east by the ZG1 fault, continues into the East Graben and is open below depths of 4,920 ft. Veins in this zone are commonly deformed, locally brecciated, and formed during syn-hydrothermal deformation along the BDF or a precursor structure.

7.3.3.4.1 Type A Veins

Type A veins are the oldest of the four types and include subtypes A1, A2 and A3. The A1 subtype is the most common and occurs mostly within the upper 2,300 ft of the Pebble East zone pluton. These veins are sinuous to anastomosing, discontinuous, and typically have diffuse contacts. They contain quartz, trace to minor potassium feldspar, less than 1 to 2% pyrite, lesser chalcopyrite, and rare molybdenite. Potassium feldspar alteration envelopes are commonly narrow, diffuse, and a few millimetres wide. They occur within zones of pervasive, weakly mineralized potassic alteration.

The A2 veins occur below approximately 3,300 ft in the Pebble East zone pluton and have characteristics transitional between quartz veins and pegmatites. They are characterized by potassium feldspar selvages and coarse-grained cores of euhedral to subhedral quartz. Coarse clots of biotite are locally present along with trace chalcopyrite, molybdenite and/or pyrite. The A2 veins are sinuous, discontinuous, irregular, have diffuse contacts and lack alteration envelopes.

A3 veins are transitional between vein types A1 and B1 and are most common below 2,500 ft in the Pebble East zone pluton. The A3 veins are typically anastomosing, sinuous to irregular and have diffuse contacts with prominent potassium feldspar envelopes. They contain quartz with trace to minor potassium feldspar and biotite, and locally contain up to 3% pyrite, minor chalcopyrite and rare molybdenite.

7.3.3.4.2 Type B Veins

Type B veins cut type A veins and include subtypes B1, B2 and B3. These are spatially coincident with potassic and sodic-potassic alteration, are the most widespread veins at Pebble and are most abundant within and proximal to the Pebble East zone pluton.

B1 veins are the most common subtype and are planar, continuous, have sharp contacts, and are typically 0.1 to 1.2 in wide. They are dominated by quartz with trace to minor biotite, potassium feldspar, apatite and/or rutile. The veins typically contain 2 to 5% of both pyrite and chalcopyrite with minor molybdenite and local bornite. Potassium feldspar (±biotite) alteration envelopes are ubiquitous, highly variable in width and contain disseminated chalcopyrite, pyrite and molybdenite.

B2 veins occur below 2,600 ft depth in the Pebble East zone and broadly coincide with sodic-potassic alteration. They contain quartz and minor K-feldspar and have narrow, weak potassium feldspar or biotite alteration envelopes. B2 veins transition upward into B1 veins and are distinguished from B1 veins by green chlorite pseudomorphs after coarse aggregates of locally preserved hydrothermal biotite and by minor calcite and epidote. The veins typically contain less than 2% pyrite, and minor chalcopyrite, and molybdenite.

B3 veins are most common in the north-central and south-central part of the Pebble East zone, and below 5,600 ft depth in the lower grade domain between the Pebble East and Pebble West zones. These veins are similar to B1 veins but contain molybdenite as the dominant sulphide and have only sporadic, weak, potassium feldspar alteration envelopes. B3 veins are planar and can be greater than 3.3 ft in width. B3 veins cut vein types A, B1, B2 and, locally, C veins; B3 veins are interpreted to represent a late substage of early alteration which locally introduced significant molybdenum to the Pebble deposit.

7.3.3.4.3 Type M Veins

Type M veins are associated with magnetite-bearing sodic-potassic alteration within and proximal to diorite sills in the Pebble West zone. Paragenetically, they formed between vein types B1 and C. They are planar to irregular and are typically 0.4 to 2 inches wide. These veins comprise mostly magnetite and quartz with lesser ankerite and potassium feldspar as well as greater than 10% chalcopyrite and pyrite with minor molybdenite. The M veins have narrow potassium feldspar alteration envelopes.

7.3.3.4.4 Type C Veins

Type C veins are the most abundant veins in the western half of the deposit. The C veins cut A and B veins (except possibly the B3 subtype) and are contemporaneous with or slightly younger than M veins. C veins at Pebble are defined according to their relative timing and do not resemble the C veins defined by Gustafson and Quiroga (1995). The veins contain mostly quartz, locally abundant ankerite or ferroan dolomite, minor to trace potassium feldspar, magnetite and biotite, and 10%

(locally up to 50%) sulphides. Sulphides include pyrite and chalcopyrite, variable molybdenite, trace arsenopyrite and rare bornite. The veins are planar, have sharp contacts, range from less than 0.4 in to approximately 2 in wide and commonly contain vugs along their central axis. Alteration envelopes are prominent with similar mineralogy to the veins and can be up to 10 times the width of the vein in the more permeable intrusive host rocks. Where the alteration envelopes to several C veins overlap, drill intersections up to approximately 15 ft in length can grade up to several percent copper.

7.3.3.5 Intermediate Illite ± Kaolinite Alteration

Illite ± kaolinite alteration is coincident with and overprints early potassic and sodic-potassic alteration. Alteration intensity is highest at moderate depths within the Pebble East zone pluton. In these rocks, illite replaces phenocrysts of plagioclase previously altered to potassium feldspar and locally replaces the potassically-altered igneous matrix. This alteration style is weakest in flysch in the Pebble West zone. Minor pyrite co-precipitated with illite but is likely a local reconstitution of older sulphides. Fracture or fault control is rarely apparent. Kaolinite accompanies illite in alteration of previously sodic-potassic altered areas where it replaces albite.

7.3.3.6 Late Advanced Argillic Alteration

Advanced argillic alteration occurs only in the East Zone, where it is associated with the highest grades of copper and gold in the deposit. Advanced argillic alteration occurs within and adjacent to the BDF. This alteration comprises a pyrophyllite-quartz-sericite-chalcopyrite-pyrite zone within the BDF that is bounded to the west by an upwardly-flaring envelope of sericite-quartz-pyrite-bornite-digenite-chalcopyrite alteration to the west (cf., Khashgerel et al., 2009). Advanced argillic alteration is truncated on the east by the ZG1 fault but deep intersections in hole 6348 demonstrate that this alteration and its associated high grade mineralization continues eastward into the graben. Both the sericite and the pyrophyllite alteration types replace potassic and sodic alteration. The sericite alteration is locally replaced by younger quartz-sericite-pyrite alteration.

Pyrophyllite alteration is accompanied by quartz, sericite, pyrite and chalcopyrite. Pyrite concentration is commonly greater than 5% and is much higher than in adjacent early potassic alteration. Pyrophyllite alteration is coincident with but overprints the southern zone of high quartz vein density; quartz-sulphide veins within this zone are commonly deformed. Veins associated with pyrophyllite alteration are irregular, narrow, contain pyrite ± chalcopyrite in massive to semi-massive concentrations, contain variable quartz, and lack visible alteration envelopes. Pyrophyllite alteration has not been identified in the northern zone of high quartz vein density.

Pervasive sericite alteration forms an upward-flaring envelope west of the pyrophyllite alteration. Sericite alteration occurs in the upper 1,000 ft of the deposit on the downthrown southern side of the ZE fault. This alteration is pervasive and dominated by white sericite that replaces feldspars previously affected by potassic and illite alteration. Pyrite concentration is intermediate between pyrophyllite alteration and early potassic alteration and decreases with depth. Sericite alteration is distinguished by high-sulphidation hypogene copper minerals represented by various combinations of bornite, covellite, digenite, tennantite-tetrahedrite, and locally trace enargite. These minerals commonly replace the rims of chalcopyrite and pyrite precipitated during early potassic alteration. Minor quartz-rich veins with pyrite are related to this alteration, are narrow and irregular, and locally have well-developed envelopes with quartz, sericite, pyrite and high sulphidation copper minerals.

7.3.3.7 Propylitic Alteration

Propylitic alteration extends at least 3 mi south of the deposit and to the limit of drilling 1.4 mi to the north. Weak propylitic alteration also occurs throughout the eastern half of the Kaskanak batholith. This alteration comprises chlorite, epidote, calcite, quartz, magnetite and pyrite, minor albite and hematite, and trace chalcopyrite. Sulphide concentration is less than 3% and is mostly pyrite.

Type H veins occur locally and at low vein density throughout propylitic alteration. They contain calcite, hematized magnetite, quartz, albite, epidote, pyrite and trace to minor chalcopyrite. H veins are planar, less than 0.4 in wide and have alteration envelopes similar in mineralogy and width to the veins.

Polymetallic type E veins occur locally south of the deposit, in areas of propylitic and quartz-sericite-pyrite alteration. Rarely, E veins cut sodic-potassic alteration in the Pebble West zone. The E veins are planar, can be up to two ft in width, have sharp contacts with host rocks and locally have weak sericite alteration envelopes. These veins contain various combinations of quartz, calcite, pyrite (locally arsenian), sericite, sphalerite, galena, minor chalcopyrite and trace arsenopyrite, tennantite-tetrahedrite, freibergite, argentite and native gold.

7.3.3.8 Quartz-Sericite-Pyrite and Quartz-Illite-Pyrite Alteration

The quartz-sericite-pyrite (QSP) alteration occurs closer to the centre of the deposit than does the propylitic alteration, but where these two alteration types overlap the QSP alteration is younger. QSP alteration, which is equivalent to classic phyllic alteration, is commonly texture-destructive and forms a halo around the deposit with inner and outer alteration fronts that dip steeply away from the core of the deposit. This halo extends at least 2.6 mi south of the deposit and 0.9 mi north; it is weakly developed west of the ZF fault where it partially overprints propylitic alteration. It occurs at depth in the north part of the East Graben but its full distribution east of the ZG1 fault is not established. In the Pebble East zone, the transition from potassic or advanced argillic alteration to intense, pervasive QSP alteration typically occurs over 50 to 60 ft. Weak QSP alteration occurs sporadically throughout the Pebble West zone with a more gradual outward transition than in the Pebble East zone.

The mineralogy of the QSP alteration type includes quartz, sericite, 8 to 20% pyrite, minor to trace ankerite, rutile and apatite, and rare pyrrhotite. Zones are cut by up to 10% pyrite-rich type D veins (Gustafson and Hunt, 1975) with variable amounts of quartz and trace rutile, chalcopyrite and ankerite. D veins are planar, have sharp contacts with host rocks and range from less than 1 in to 5 ft in width. Alteration envelopes are typically wider than the veins and form intense pervasive QSP alteration where they coalesce.

Quartz-illite-pyrite (QIP) alteration partially replaces potassic and/or sodic-potassic alteration in the upper, central part of the deposit. QIP alteration is interpreted as a zone of former weak to moderate, grade-destructive QSP alteration, located at the transition between sodic-potassic and potassic alteration, that was later overprinted by low-temperature illite alteration as the hydrothermal system waned. QIP alteration is texturally and mineralogically similar to QSP alteration, except that illite is the main phyllosilicate phase rather than sericite (Harraden et al., 2012). The pyrite concentration in QIP alteration is typically 5 to 10%, which occurs mostly in type D veins and their alteration envelopes. Domains between the QIP alteration envelopes preserve relict sodic-potassic alteration that host most of the copper mineralization that remains in this zone.

7.3.3.9 Post-Hydrothermal Alteration

The youngest alteration at Pebble is clay alteration, which is common within 50 ft of the contact between the cover sequence and underlying Cretaceous rocks. Young, brittle faults that cut the deposit, in particular the ZG1 fault, host or are closely associated with basalt dikes related to volcanic rocks in the cover sequence. The faults and dikes are surrounded by narrow alteration zones of epidote, calcite, chlorite, and pyrite. An extremely small proportion of mineralization in the deposit is affected by this alteration.

7.3.4 Mineralization Styles

Mineralization in the Pebble West zone is mostly hypogene, with a thin zone of mostly weak supergene overprint beneath a thin leached cap. Mineralization in the Pebble East zone is entirely hypogene with no preservation of leaching or paleo-supergene below the unconformity with the cover sequence.

7.3.4.1 Supergene Mineralization and Leached Cap

A thin leached cap occurs at the top of the Pebble West zone. Strong leaching is rarely more than 33 ft thick but is highly variable, and weak oxidation along fractures locally extends to depths of up to 500 ft along or near brittle faults. Hypogene pyrite is commonly preserved in the leached zone, and minor malachite, chrysocolla and native copper are present locally.

Supergene mineralization occurs only in the Pebble West zone where the cover sequence is absent. Similar to the overlying leached cap, the thickness of supergene mineralization is highly variable. It locally extends to a depth of 560 ft in strongly fractured zones, but on average is closer to 200 ft in average thickness and tapers toward the margins of the resource. In the supergene zone, pyrite is typically rimmed by chalcocite, covellite and minor bornite, and complete replacement of pyrite is rare (Gregory and Lang, 2009; Gregory et al., 2012). The transition to hypogene mineralization with depth is gradational over vertical intervals of up to approximately 100 ft. Supergene processes increased copper grade up to approximately 50% across narrow intervals but the upgrading is typically much less.

7.3.4.2 Hypogene Mineralization

Patterns of metal grades and ratios at Pebble correspond closely to alteration styles, with only weak or local relationships to host rock. The preserved deposit has a flat tabular geometry when the 20° post-hydrothermal tilt is removed. Copper and gold grades diminish below approximately 1,300 ft depth in the Pebble West zone but extend much deeper in the Pebble East zone, particularly within and proximal to the BDF. Laterally, grades decrease gradually toward the north and south margins of the deposit, where mineralization terminates over short distances due to the overprint by intense, grade-destructive QSP alteration. Moderate grades with the shortest vertical extent are observed in the middle of the deposit between the Pebble East and Pebble West zones. There is a general correspondence between copper and gold grades outside of the Pebble East zone pluton; within the Pebble East zone pluton, there is a closer correspondence between copper and molybdenum at low grades of gold, except where gold-rich advanced argillic alteration is present. On the west side of the deposit, mineralization extends to the normal/oblique ZF fault, but drilling has been too shallow to determine if the deposit continues to the west at depth. On the east side, the deposit was down-dropped by the ZG1 fault and continuation of high-grade mineralization into the East Graben has been confirmed by drilling. Molybdenum exhibits a more diffuse pattern, is open at depth and, in some areas, domains with strongly elevated grade corresponds with higher densities of molybdenite-rich type B3 veins.

Mineralization was primarily introduced during early potassic and sodic-potassic alteration. Copper is hosted primarily by chalcopyrite (Figure 7-8) that is locally accompanied by minor bornite (Figure 7-4) and trace tennantite-tetrahedrite. The pyrite to chalcopyrite ratio is typically close to one in potassic alteration in the Pebble East zone but is commonly much higher in the Pebble West zone where sulphide-rich type C and, locally, type D veins are present. Gold occurs primarily as electrum inclusions in chalcopyrite with minor amounts hosted by silicate alteration minerals and pyrite, and rarely as gold telluride inclusions in pyrite (Gregory et al., 2013). Diorite sills with magnetite-rich alteration and type M veins have relatively high gold concentrations. Molybdenite occurs in quartz veins and as intergrowths with disseminated chalcopyrite.

Incipient to weak illite ± kaolinite alteration had little effect on grade, whereas strong alteration reduced the grade of copper and gold but left molybdenum largely undisturbed. Gold liberated during illite ± kaolinite alteration was reconstituted as high-fineness inclusions (gold grains with less than 10 wt% Ag) in newly formed pyrite (Gregory and Lang 2009; Gregory et al., 2013). These patterns are consistent with the effects of illite alteration on grade in many porphyry deposits (e.g., Seedorf et al., 2005; Sillitoe, 2010).

Advanced argillic alteration zones have much higher grades of copper and gold but similar molybdenum compared to adjacent early potassic alteration. Pyrophyllite alteration precipitated high concentrations of pyrite and chalcopyrite and both minerals contain inclusions of high-fineness gold (Gregory et al., 2013). During sericite alteration, bornite, covellite, digenite and trace enargite or tennantite replaced chalcopyrite formed during early potassic alteration and also precipitated minor additional pyrite (Gregory and Lang, 2009). In general, gold occurs as high-fineness inclusions in later pyrite and high-sulphidation copper minerals, whereas electrum predominates in relict early chalcopyrite (Gregory et al., 2013).

The zone of high quartz vein density along the BDF is typically well-mineralized where it has been overprinted by pyrophyllite alteration. The northern zone of high quartz vein density has average to low grades of copper and gold except in small areas where higher grades reflect the presence of the sericite subtype of advanced argillic alteration.

The late QSP alteration is invariably destructive of both copper and molybdenum mineralization. Gold concentrations, however, remain consistent at 0.15 to 0.5 g/t, but locally exceed 1 g/t (Lang et al., 2008). The QIP alteration has a similar effect on copper, molybdenum and gold but is not completely pervasive, such that copper and molybdenum grades are reduced and some of the gold now occurs as high-fineness inclusions in pyrite formed by breakdown of older sulphides (Gregory et al., 2013).

Grade variation within the cores of the Pebble East and Pebble West zones shows a weak, local relationship to rock type. Higher than average copper and gold grades are spatially related to highly reactive, iron-rich diorite sills, a relationship common in porphyry deposits (e.g., Ray, Arizona; Phillips et al., 1974). On the margins of the deposit and in the lower grade area between the Pebble East and Pebble West Zones, relatively impermeable flysch affected by pre-hydrothermal hornfels has lower grades than adjacent, more permeable granodiorite sills.

7.3.4.3 Rhenium

The Pebble deposit is remarkable for its very large endowment in rhenium, for which a resource is estimated in Section 14 that compares favourably with the largest known global resources of rhenium (Sinclair et al., 2009). Rhenium is one of the lesser known metals and is one of the rarest elements on earth, with a crustal abundance of less than one part per billion (John et al., 2017). The United States, under Executive Order 13817, has caused rhenium to be placed on its list of critical minerals, stating that it “is essential to the economic and national security of the United States that has a supply chain vulnerable to disruption.” (US Department of the Interior news release, May 18, 2018). Rhenium typically does not form discrete minerals in nature, but because of its valence and atomic radius instead almost exclusively substitutes for molybdenum in the lattice of molybdenite (e.g., McCandless et al., 1993; Barton et al., 2019). Globally most rhenium is recovered from flue dust created during the roasting of molybdenite concentrates, most of which come from porphyry-style deposits like Pebble (John et al., 2017). Elevated concentrations of rhenium occur throughout the Pebble deposit and, as expected, the concentrations of rhenium and molybdenum are very closely correlated. Molybdenite concentrates produced during metallurgical testwork on the Pebble deposit, as described in Section 13, contain up to 960 ppm rhenium, which places Pebble in the upper echelon of porphyry deposits (e.g., McCandless et al., 1993; Barton et al., 2019). Detailed rhenium deportment studies have not yet been completed to determine if the concentration of rhenium in molybdenite varies spatially across the Pebble deposit or in paragenetically-distinct stages of molybdenite precipitation, e.g., molybdenite in late B3 veins compared to molybdenite in earlier potassic or sodic-potassic alteration. Visual inspection of the 3D distribution of molybdenum to rhenium ratios in assay results across the Pebble deposit, however, suggests a general consistency with limited variation.

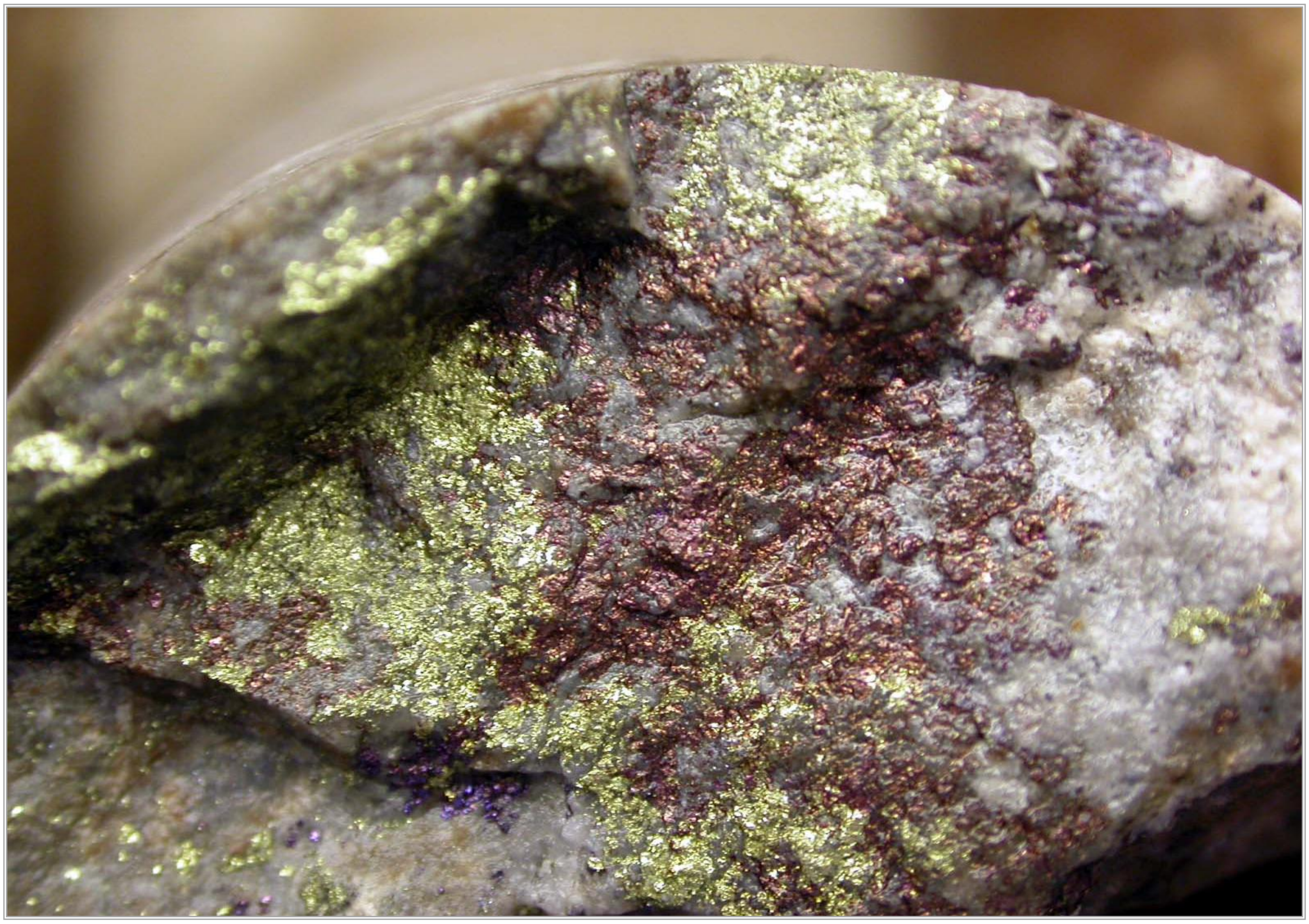
7.3.4.4 Palladium

The Pebble deposit also contains elevated concentrations of the platinum group metal palladium, which is also considered a critical mineral by the Department of the Interior. This places Pebble among a very small minority of porphyry deposits known to contain significant palladium concentrations (e.g., McFall et al., 2018; Hanley et al., 2020). The highest concentrations of palladium at Pebble occur in or proximal to areas affected by advanced argillic alteration, but elevated palladium also occurs in many other parts of the deposit including within the proposed open pit. The deportment of palladium remains essentially unstudied at Pebble. A single sample of pyrite from the pyrophyllite alteration zone was analyzed by in-situ laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and found to contain elevated palladium in undetermined form (Gregory et al. (2013). The deportment of palladium in porphyry deposits can be complex (e.g., Hanley et al., 2020) and a more detailed study of palladium deportment at Pebble is warranted to determine the degree to which this metal can be recovered to a chalcopyrite and/or pyrite concentrate.

Figure 7-8: Drill Core Photograph Showing Chalcopyrite Mineralization

Source: Northern Dynasty, 2006

Figure 7-9: Drill Core Photograph Showing Chalcopyrite and Bornite Mineralization



Source: Northern Dynasty

8 DEPOSIT TYPES

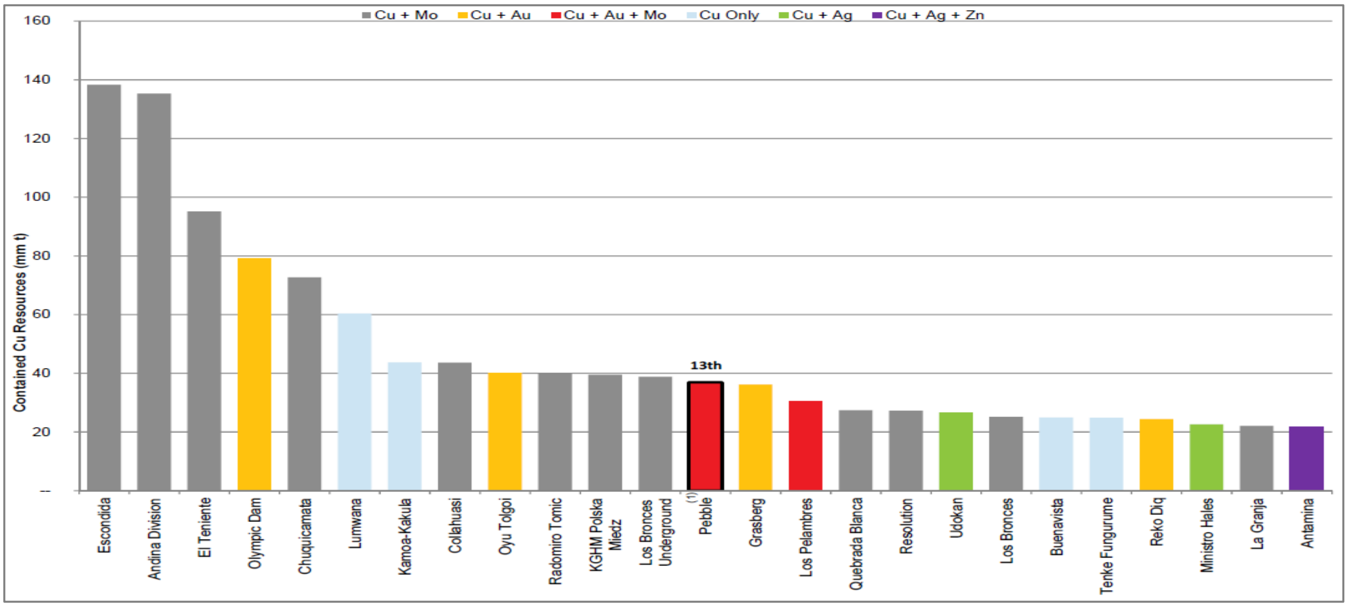
The Pebble deposit is classified as a porphyry copper-gold-molybdenum deposit. The principal features of porphyry copper deposits, as summarized recently by John et al. (2010), include:

- mineralization defined by copper and other minerals which occur as disseminations and in veins and breccias which are relatively evenly distributed throughout their host rocks;
- large tonnage amenable to bulk mining methods;
- low to moderate copper grades, typically between 0.3% and 2.0%;
- a genetic relationship to porphyritic intrusions of intermediate composition that typically formed in convergent-margin tectonic settings;
- a metal assemblage dominated by various combinations of copper, gold, molybdenum and silver, but commonly with other associated metals of low concentration; and
- a spatial association with other styles of intrusion-related mineralization, including skarns, polymetallic replacements and veins, distal disseminated gold-silver deposits, and intermediate to high-sulphidation epithermal deposits.

These characteristics correspond closely to the principal features of the Pebble deposit as described in Section 7. This Report focuses exclusively on the Pebble porphyry deposit; other deposits of intrusion-related skarn-, vein- and porphyry-style mineralization have been encountered elsewhere within the Pebble Project area but have not been the subject of detailed exploration or delineation.

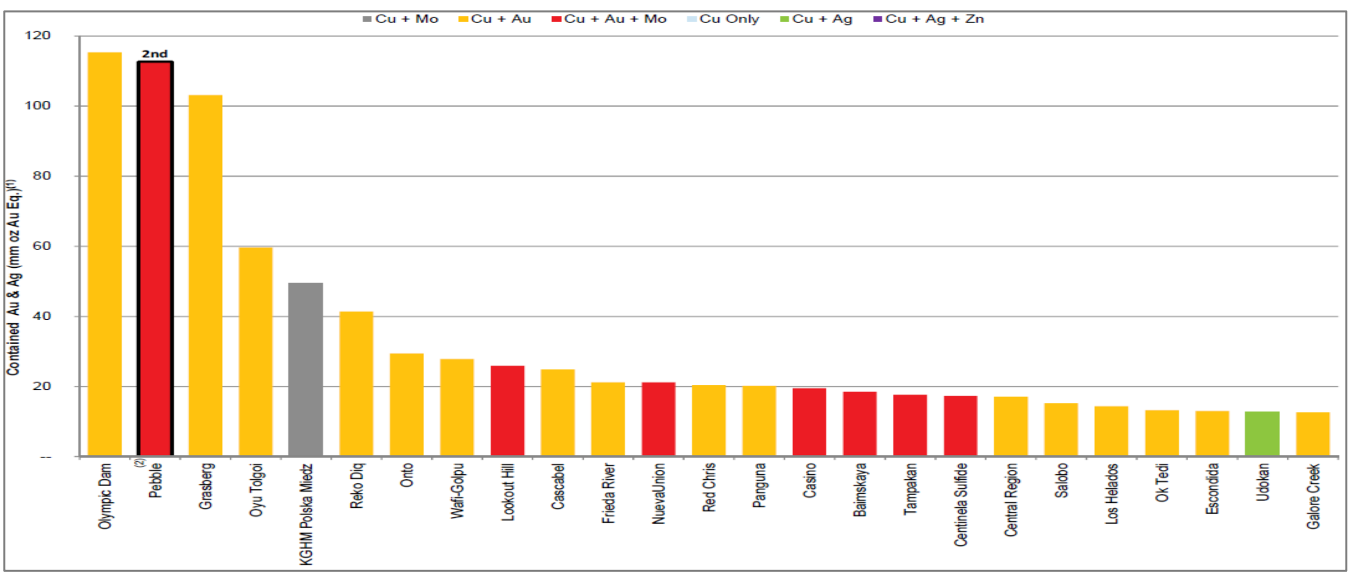
The Pebble deposit has many characteristics typical of porphyry deposits as a group, but it is unusual in terms of its size and the variety and scale of its contained metal. Pebble has one of the largest metal endowments of any gold-bearing porphyry deposit currently known. Comparison of the current Pebble Mineral Resource estimate to other major copper and precious metal deposits shows that it ranks at or near the top in terms of both contained copper (Figure 8-1) and contained precious metals (gold and silver; Figure 8-2). Pebble currently is both the largest known undeveloped copper resource and the largest known undeveloped gold resource in the world. Pebble also has a very large endowment in molybdenum and rhenium. The presence of palladium further highlights its unusual character. The bases for these estimations of metal endowment in the Pebble deposit are described in Section 14.

Figure 8-1: Pebble Deposit Rank by Contained Copper



Source: Company filings, Metals Economics Group; BMO Capital Markets, 2020
Note: Includes Inferred Resource.
1. At 0.30% Cu Eq. cut-off.

Figure 8-2: Pebble Deposit Rank by Contained Precious Metals



Source: Company filings, S&P Global Market Intelligence, street research; BMO Capital Markets, 2020
Note: Includes Inferred Resource.
1. Converted to Au Eq. at street consensus Au price of US$1,500/oz and Ag price of US$18.00/oz.
2. At 0.30% Cu Eq. cut-off.
3. Source: World Gold Council (https://www.gold.org/about-gold/facts-about-gold) says that about 187,000 tonnes of gold have been mined since the beginning of civilization. Pebble resource represents 3,340 t (10,776,800,344 tonnes x 0.31 g/t = 3,340 tonnes).

9 EXPLORATION

9.1 Overview

Geological, geochemical and geophysical surveys were conducted in the Pebble Project Site area from 2001 to 2007 by Northern Dynasty and since mid-2007 by the Pebble Partnership. The types of historical surveys and their results are summarized in the following sub-sections. More detailed descriptions of historical exploration programs and results may be found in Rebagliati and Haslinger (2003), Haslinger et al. (2004), Rebagliati and Payne (2006 and 2007), Rebagliati and Lang (2009) and Rebagliati et al. (2005, 2008, 2009 and 2010).

9.2 Geological Mapping

Between 2001 and 2006, the entire Pebble Project site area was mapped for rock type, structure and alteration at a scale of 1:10,000. This work provided an important geological framework for interpretation of other exploration data and drilling programs. A geological map of the Pebble deposit was also constructed but, due to a paucity of outcrop, was based solely on drill hole information. The content and interpretation of district and deposit scale geological maps have not changed materially from the information presented by Rebagliati et al. (2009 and 2010).

9.3 Geophysical Surveys

In 2001, dipole-dipole IP surveys totalling 19.3 line-mi were completed by Zonge Geosciences for Northern Dynasty, following up on and augmenting similar surveys completed by Teck.

During 2002, a ground magnetometer survey totalling 11.6 line-mi was completed at Pebble. The survey was conducted by MPX Geophysics Ltd., based in Richmond Hill, Ontario. The principal objective of this survey was to obtain a higher resolution map of magnetic patterns than was available from existing regional government magnetic maps. The focus of this work was the area surrounding mineralization in the 37 Skarn zone in the southern part of the Pebble district. A helicopter-based airborne magnetic survey was flown over the entire Pebble Project area in 2007. A total of 1,456.5 line-mi was flown at 656 ft line spacing, covering an area of 164.5 mi^2. The survey lines were flown at a mean terrain clearance of 196.8 ft along flight lines oriented 135° at a line spacing of 656 ft, with tie lines oriented 045° at a spacing of 1.24 mi Immediately over and surrounding the Pebble deposit, an area of 214.4 mi^2 was surveyed at a 1,328 ft line spacing for a total of 212.5 line-mi, without additional tie lines.

During 2007, a limited magnetotelluric survey was completed by GSY-USA Inc., the U.S. subsidiary of Geosystem SRL of Milan, Italy, under the supervision of Northern Dynasty geologists. The survey focused on the area of drilling in the Pebble East zone and comprised 196 stations on nine east-west lines and one north-south line, at a nominal station spacing of 656 ft. Interpretation, including 3D inversion, was completed by Mr. Donald Hinks of Rio Tinto Zinc.

In July 2009, Spectrem Air Limited, an Anglo American-affiliated company based in South Africa, completed an airborne electromagnetic, magnetic and radiometric survey over the Pebble area. A total of 2,386 line-mi was surveyed in two flight block configurations:

- A regional block covering an area of about 18.6 x 7.5 mi at a line spacing of 0.95 mi; and

- A more detailed block which covered the Pebble Project area using a line spacing of 820 ft.

The orientation of flight lines was 135° for both surveys, with additional tie-lines flown orthogonally. The objectives of this work included provision of geophysical constraints for structural and geological interpretation in areas with significant glacial cover.

Between the second half of 2009 and mid-2010, a total of 120.5 line-mi of IP chargeability and resistivity data were collected by Zonge Engineering and Research Organization Inc. (Zonge Engineering) for the Pebble Partnership. This survey was conducted in the southern and northern parts of the Project area and used a line spacing of about 0.5 mi. The objective of this survey was to extend the area of IP coverage completed prior to 2001 by Teck and during 2001 by Northern Dynasty.

During 2010, an airborne electromagnetic (EM) and magnetometer geophysical survey was completed on the Pebble Project totalling 4,009 line-mi. This survey was conducted by Geotech Ltd. of Aurora, Ontario.

The USGS collected gravity data from 136 stations distributed over an area of approximately 2,317 mi^2 during 2008 and 2009.

9.4 Geochemical Surveys

Between 2001 and 2003, Northern Dynasty collected 1,026 soil samples (Rebagliati and Lang, 2009). Typical sample spacing in the central part of the large geochemical grid was 100 ft to 250 ft along lines spaced 122 to 400 ft to 750 ft apart; samples were more widely spaced near the north, west and southwest margins of the grid.

These sampling programs outlined high-contrast, coincident anomalies in copper, gold, molybdenum and other metals in an area that measures at least 5.6 mi north-south by up to 2.5 mi east-west, with strong but smaller anomalies in several outlying zones. All soil geochemical anomalies lie within the IP chargeability anomaly described above. Three very limited surficial geochemical surveys were completed by the Pebble Partnership in 2010 and 2011; no significant geochemical anomalies were identified. A total of 126 samples, comprising 113 till and 13 soil samples, were collected on the KAS claims located in the southern end of the property; samples were on lines spaced approximately 8,000 ft apart with a sample spacing of approximately 1,300 ft. A total of 109 soil samples were collected from two small areas located approximately 11 mi to the west-northwest and 15 mi west of the Pebble deposit; samples were spaced approximately 330 ft apart on lines that were irregularly spaced to accommodate terrain features.

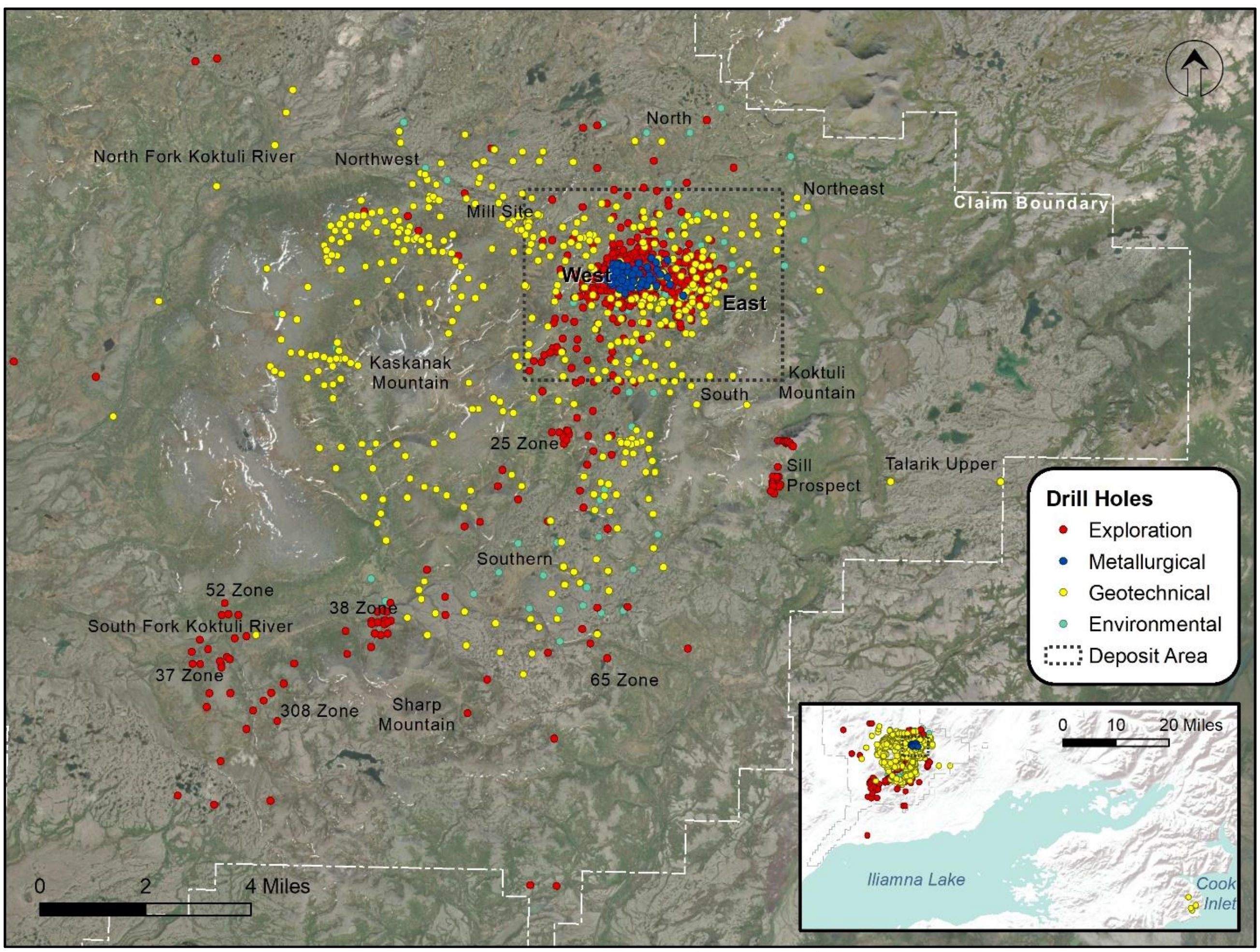
Additional surveys were completed between 2007 and 2012 by researchers from the USGS and the University of Alaska Anchorage. The types of surveys that were completed by these groups include: (1) hydrogeochemical surveys in several parts of the Pebble property which obtained multi-element inductively coupled plasma mass spectrometry (ICP-MS) data from samples of surface waters; (2) determination of copper isotope ratios in surface waters; (4) heavy indicator mineral analyses of glacial till; and (4) orientation surveys which utilized a variety of weak extraction geochemical techniques. The results of these surveys were largely consistent with the results obtained by earlier soil sampling programs.

10 DRILLING

10.1 Drill Hole Locations

Extensive drilling totaling 1,048,509.8 ft was completed in 1,389 holes on the Pebble Project. These drill campaigns took place during 19 of the 26 years between 1988 and 2013 and in 2018 and 2019. The most recent hole drilled on the Project was completed on October 13, 2019. The spatial distribution and type of holes drilled is illustrated in Figure 10-1. A detail of the drilling in the "Deposit Area" is shown in Figure 10-2.

Figure 10-1: Project Drill Hole Location Map



Note: Figure prepared by Northern Dynasty, 2021. Drilling completed by Teck (1988 to 1997) is summarized in Section 6.

All drill hole collars were surveyed using a differential global positioning system (DGPS) instrument. All holes were resurveyed in 2008 and 2009, with the exception of the Sill holes. A digital terrain model for the site was generated by photogrammetric methods in 2004. All post- Teck drill holes were surveyed downhole, typically using a single shot magnetic gravimetric tool. A total of 989 holes were drilled vertically (-90°) and 192 were inclined from -42° to -85° at various azimuths.

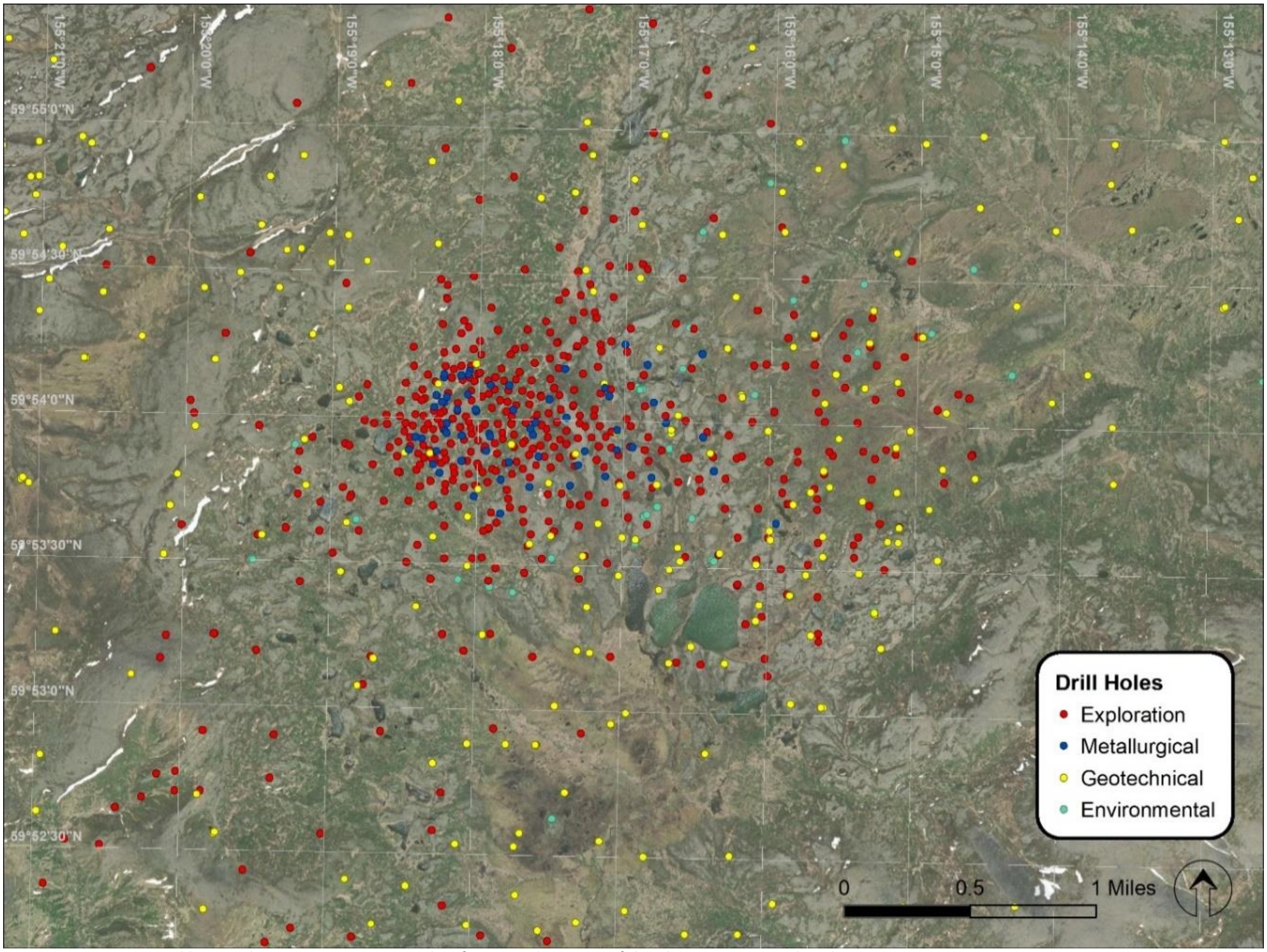
10.2 Summary of Drilling 2001 to 2019

The Pebble deposit was extensively drilled (Figure 10-2). Drilling statistics and a summary of drilling by various categories to the end of the 2013 exploration program are compiled in Table 10-1. This includes seven drill holes completed by FMMUSA, drilled by Peak Exploration (USA) Corp. in the area in 2008; these holes were drilled on claims that are now part of the Pebble Project area and have been added to the Pebble dataset.

Most of the footage on the Pebble Project was drilled using core drills. Only 18,716 ft was percussion-drilled from 229 rotary drill holes. Many of the cored holes were advanced through overburden, using a tricone bit with no core recovery. These overburden lengths are included in the core drilling total.

From early 2004 through 2013, all Pebble drill core was geotechnically logged on a drill run basis. Almost 70,000 measurements were made for a variety of geotechnical parameters on 737,000 ft of core drilling. Recovery is generally very good and averages 98.2% overall; two-thirds of all measured intervals have 100% core recovery. Detailed (domain-based) geotechnical logging and downhole surveys were also conducted between 2007 and 2012. Proper domain selection is the basis for rock mass classification and domain-based data is used extensively in open pit and underground mine design. In order to maximize the information from the 2007-2012 drill programs, several tools and techniques were added to a number of holes including: triple tube drilling, core orientation, acoustic televiewer probe and comprehensive point load testing complemented by laboratory UCS testing. Additionally, all Pebble drill core from the 2002 through 2013 and 2018 drill programs and the chip trays from the 2019 percussion program were photographed in a digital format.

Figure 10-2: Location of Drill Holes – Pebble Deposit Area



Note: Figure prepared by Northern Dynasty, 2021. This figure is the inset of the deposit-area outlined in Figure 10-1.

Table 10-1: Summary of Drilling to December 2019

	No. of Holes	Feet	Metres
By Operator			
Teck [1]	164	75,741.0	23,086
Northern Dynasty	578	495,069.5	150,897
Pebble Partnership [2]	640	472,249.3	143,942
FMMUSA	7	5,450.0	1,661
Total	1,389	1,048,509.8	319,586
By Type			
Core [1,5]	1,160	1,027,671.9	313,234
Percussion [6]	229	20,838.0	6,351
Total	1,389	1,048,509.8	319,586
By Year			
1988 [1]	26	7,601.5	2,317
1989 [1]	27	7,422.0	2,262
1990	25	10,021.0	3,054
1991	48	28,129.0	8,574
1992	14	6,609.0	2,014
1993	4	1,263.0	385
1997	20	14,695.5	4,479
2002	68	37,236.8	11,350
2003	67	71,226.6	21,710
2004	267	165,567.7	50,465
2005	114	81,978.5	24,987
2006 [3]	48	72,826.9	22,198
2007 [4]	92	167,666.9	51,105
2008 [5]	241	184,726.4	56,305
2009	33	34,947.5	10,652
2010	66	57,582.0	17,551
2011	85	50,767.7	15,474
2012	81	35,760.2	10,900
2013	29	6,190.0	1,887
2018	28	4,374.2	1,333
2019	6	1,917.4	584
Total	1,389	1,048,509.8	319,586
By Area			
East	149	450,047.3	137,174
West	447	349,128.7	106,414
Main [7]	83	9,629.8	2,935
NW	215	49,951.1	15,225
North	84	30,927.0	9,427
NE	15	1,495.0	456

	No. of Holes	Feet	Metres
South	117	48,387.8	14,749
25 Zone	8	4,047.0	1,234
37 Zone	7	4,252.0	1,296
38 Zone	20	14,221.5	4,335
52 Zone	5	2,534.0	772
308 Zone	1	879.0	268
Eastern	5	621.5	189
Southern	147	64,374.4	19,621
SW	39	6,658.8	2,030
Sill	39	10,445.5	3,184
Cook Inlet	8	909.5	277
Total	1,389	1,048,509.8	319,586

Notes:
1. Includes holes drilled on the Sill prospect.
2. Holes started by Northern Dynasty and finished by the Pebble Partnership are included as the Pebble Partnership.
3. Drill holes counted in the year in which they were completed.
4. Wedged holes are counted as a single hole including full length of all wedges drilled.
5. Includes FMMUSA drill holes; data acquired in 2010.
6. Percussion holes were drilled for engineering and environmental purposes. Shallow (<15 ft) auger holes not included.
7. Comprises holes drilled entirely in Tertiary cover rocks within the Pebble West and Pebble East areas.

Some numbers may not sum exactly due to rounding.

The drill hole database includes drill holes completed up until 2019; the drilling completed after 2012 is outside the area of the Mineral Resource estimate. Highlights of drilling completed by Northern Dynasty and the Pebble Partnership between 2001 and 2019 include:

- Northern Dynasty drilled 68 holes for a total of 37,237 ft during 2002. The objective of this work was to test the strongest IP chargeability and multi-element geochemical anomalies outside of the Pebble deposit, as known at that time, but within the larger and broader IP chargeability anomaly described above. This program discovered the 38 Zone porphyry copper-gold-molybdenum deposit, the 52 Zone porphyry copper occurrence, the 37 Zone gold-copper skarn deposit, the 25 Zone gold deposit, and several small occurrences in which gold values exceeded 3.0 g/t.

- In 2003, Northern Dynasty drilled 67 holes for a total of 71,227 ft, mainly within and adjacent to the Pebble West zone to determine continuity of mineralization and to identify and extend higher grade zones. Most holes were drilled to the 0 ft elevation above mean sea level and were 900 to 1,200 ft in length. Eight holes for a total of 5,804 ft were drilled outside the Pebble deposit to test for extensions and new mineralization at four other zones on the property, including the 38 Zone porphyry copper-gold-molybdenum deposit and the 37 Zone gold-copper skarn deposit.

- Drilling by Northern Dynasty in 2004 totalled 165,481 ft in 266 holes. Of this total, 131,211 ft were drilled in 147 exploration holes in the Pebble deposit; one exploration hole 879 ft in length was completed in the southern part of the property that discovered the 308 Zone porphyry copper-gold-molybdenum deposit. Additional drilling included 21,335 ft in 26 metallurgical holes in Pebble West zone, 9,127 ft in 54 geotechnical holes and 3,334 ft in 39 water monitoring holes, of which 33 holes for a total of 2,638 ft were percussion holes. During the 2004 drilling program, Northern Dynasty identified a significant new porphyry centre on the eastern side of the Pebble deposit (the Pebble East zone) beneath the cover sequence (as described in Section 7).

- In 2005, Northern Dynasty drilled 81,979 ft in 114 holes. Of these drill holes, 13 for a total of 12,198 ft were drilled mainly for engineering and metallurgical purposes in the Pebble West zone. Seventeen drill holes for a total of 60,696 ft were drilled in the Pebble East zone. The results confirmed the presence of the Pebble East zone and further demonstrated that it was of large size and contained higher grades of copper, gold and molybdenum than the Pebble West zone. The Pebble East zone remained completely open at the end of 2005. A further 13 holes for a total of 2,986 ft were cored for engineering purposes outside the Pebble deposit area. An additional 6,099 ft of drilling was completed in 71 non-core water monitoring wells.

- Drilling during 2006 focused on further expansion of the Pebble East zone. Drilling comprised 72,827 ft in 48 holes. Twenty of these holes were drilled in the Pebble East zone, including 17 exploration holes and three engineering holes for a total of 68,504 ft. The Pebble East zone again remained fully open at the conclusion of the 2006 drilling program. In addition, 2,710 ft were drilled in 14 engineering core holes and 1,612 ft were drilled in 14 monitoring well percussion holes elsewhere on the property.

- Drilling in 2007 continued to focus on the Pebble East zone. A total of 151,306 ft of delineation drilling in 34 holes extended Pebble East to the northeast, northwest, south and southeast; the zone nonetheless remained open in these directions, as well as to the east in the East Graben. Additional drilling included 10,167 ft in nine metallurgical holes in Pebble West, along with 4,367 ft in 26 engineering holes and 1,824 ft in 23 percussion holes for monitoring wells across the property.

- In 2008, 234 holes were drilled totalling 184,726 ft, the most extensive drilling on the Project in any year to date. A total of 136,266 ft of delineation and infill drilling, including six oriented holes, was completed in 31 holes in the Pebble East zone. This drilling further expanded the Pebble East zone. Fifteen metallurgical holes for a total of 14,511 ft were drilled in the Pebble West zone. Three 2,949 ft infill/geotechnical holes totalling 3,133 ft were drilled in the Pebble West zone. Geotechnical drilling elsewhere on the property included 103 core holes for a total of 18,806 ft. Hydrogeology and geotechnical drilling outside of the Pebble deposit accounted for 82 percussion holes for a total of 6,745 ft. In 2010, the Pebble Partnership acquired the data for seven holes totalling 5,450 ft drilled by FMMUSA in 2008. These drill holes are located on land that is now controlled by the Pebble Partnership and provided information on the regional geology.

- The Pebble Partnership drilled 34,948 ft in 33 core drill holes in 2009. Five delineation holes were completed for 6,076 ft around the margins of the Pebble West zone and 21 exploration holes for a total of 22,018 ft were drilled elsewhere on the property. In addition, seven geotechnical core holes were drilled for a total of 6,854 ft.

- In 2010, the Pebble Partnership drilled 57,582 ft in 66 core holes. Forty-eight exploration holes totalling 54,208 ft were drilled over a broad area of the property outside the Pebble deposit. An additional 3,374 ft were drilled in 18 geotechnical holes within the deposit area and to the west.

- In 2011, the Pebble Partnership drilled 50,768 ft in 85 core holes. Eleven holes were drilled in the deposit area totalling 33,978 ft. Of these, two holes were drilled in the Pebble East zone for metallurgical and hydrogeological purposes. The other nine holes in the deposit area were drilled for further delineation of the Pebble West zone and the area immediately to the south. These results indicated the potential for resource expansion to depth in the Pebble West zone. Six holes totalling 8,780 ft were also drilled outside the Pebble deposit area to the west and south. In addition, 8,010.2 ft was drilled in 68 geotechnical holes within and to the north, west and south of the deposit.

- The Pebble Partnership drilled 35,760 ft in 81 core holes in 2012. Eleven holes totalling 13,754 ft were drilled in the southern and western parts of the Pebble West zone. The results show potential for lateral resource expansion in this area and further delineation drilling is warranted. Six holes totalling 6,585 ft. were drilled to test exploration targets to the south on the Kaskanak claim block, to the northwest and south of Pebble, and on the KAS claim block further south. An additional 64 geotechnical and hydrogeological holes were drilled totalling 15,422 ft. Of this drilling, 41 holes were within the deposit area and 15 geotechnical holes were drilled at sites near the deposit, and eight geotechnical holes were completed near Cook Inlet.
- The Pebble Partnership drilled 6,190 ft in 29 core holes for geotechnical purposes in 2013 at sites west, south and southwest of the deposit area.
- The Pebble Partnership drilled 4,374.2 ft in 28 core holes for geotechnical purposes in 2018 to test tailings and water storage facilities in areas remote from the Pebble deposit.
- The Pebble Partnership drilled 1,917.4 ft in six percussion holes adjacent to the Pebble deposit to enable hydrological testing in 2019.
- No holes were drilled in 2014, 2015, 2016, 2017, 2020 or 2021.

A re-survey program of holes drilled at Pebble from 1988 to 2009 was conducted during the 2008 and 2009 field seasons. For consistency throughout the Project, the resurvey program referenced the control network established by R&M Consultants in the U.S. State Plane Coordinate System Alaska Zone 5 NAVD88 Geoid99. The resurvey information was applied to the drill collar coordinates in the database in late 2009.

In 2009 and 2013, the survey locations, hole lengths, naming conventions and numbering designations of the Pebble drill holes were reviewed. This exercise confirmed that several shallow, non-cored, overburden drill holes described in some engineering and environmental reports were essentially the near-surface pre-collars of existing bedrock core drill holes. As these pre-collar and bedrock holes have redundant traces, the geologic information was combined into a single trace in the same manner as the wedged holes. In addition, a number of very shallow (less than 15 ft), small diameter, water-monitoring auger holes were removed from the exploration drill hole database, as they did not provide any geological or geochemical information.

Drill core from the 2002 to 2013 and 2018 programs was boxed at the rig and transported daily by helicopter to the secure logging facility in the village of Iliamna, as were the chip trays from the 2019 percussion drill program.

10.2.1 Northern Dynasty 2002 – 2006 Drilling

The 2002 and 2003 holes were drilled for Northern Dynasty by Quest America Drilling Inc. (Quest) using NQ2 diameter (2 inches) core size.

Most of the 2004 drilling was also completed by Quest, with some footage drilled by Boart Longyear Company (Boart Longyear) and Midnight Sun Drilling Co. Ltd. Core diameters included NQ2, HQ (2.5 in) and PQ (3.3 in). Thirty-three rotary percussion water well, engineering and environmental holes were also completed. The 2004 drilling program included 26 larger diameter (PQ and HQ) holes for metallurgical testing. The average core recovery for all samples taken in 2004 was 97.6%.

Quest completed the 2005 drilling. Core diameters included NQ2, HQ and PQ core. The average core recovery for all 2005 core holes was 98.4%. In addition to the core drilling, a total of 6,100 ft was drilled in 71 rotary percussion holes by Foundex Pacific Inc. (Foundex) for water monitoring purposes.

The drilling contractors in 2006 were American Recon Inc. (American Recon) and Boart Longyear. Drill holes were NQ2 and HQ in diameter. A total of 13 shallow rotary percussion holes were also completed for environmental purposes by Foundex. Average core recovery in 2006 was 98.7%.

10.2.2 Northern Dynasty and Pebble Partnership 2007 Drilling

The drilling contractors used in 2007 were American Recon, Quest and Boart Longyear. Drill holes were NQ2 and HQ in diameter and were drilled for geological and metallurgical purposes. Additional drilling was completed by Foundex to establish monitoring wells, but core was not recovered from these holes. Several holes included wedges; in cases where the wedged hole successfully extended beyond the total depth of the parent hole, they were treated as extensions of their parent holes and overlapping information was ignored. The average core recovery for 2007 drill holes was 99.7%.

10.2.3 Pebble Partnership 2008 – 2014 Drilling

The drilling contractors used in 2008 were American Recon, Boart Longyear and Foundex. Drill holes were NQ, HQ and PQ in diameter, and were drilled for delineation, geotechnical and metallurgical purposes. The drilling contractor used for 2009 drilling was American Recon. Drill holes were NQ, HQ and PQ in diameter. Drilling contractors used for 2010 drilling were American Recon and Foundex. Drill holes were NQ and HQ in diameter. Drill contractors American Recon, Quest and Foundex completed 85 holes in 2011. The hole numbering sequences for 2011 are 11526 through 11542 for 17 district exploration holes and GH11-229 through GH11-296 for 68 geotechnical holes. Most of these holes were drilled vertically except for 11526, 11528, 11530, 11532, 11533 and 11539, which were inclined at -80°, and 11529, drilled at -75°. Among 68 geotechnical holes, 43 were sonic drilling. The average core recovery for the 2008 holes in 95.7%.

Drill contractors Quest and Foundex completed 81 holes in 2012. The hole numbering sequences are 12543 through 12562 for 20 exploration, delineation and hydrological holes, and GH12-297 through GH12-357S for 61 geotechnical holes. Most of 12-series holes were drilled with dips of -65° to -80°, and azimuths of 90° to 270° except for 12546, 12554, 12558, 12559, 12561 and 12562, which were drilled vertically. All GH-series holes were drilled vertically. Among 61 geotechnical holes, 31 were completed by sonic drilling. Of the 81 holes, 14 holes were drilled in the southern and western parts of the Pebble West zone; 6 holes were drilled in the broader claim area to test exploration targets to the south on the Kaskanak claim block to the northwest and south and the KAS claim block further south; and the 61 geotechnical and hydrogeological holes were drilled in the deposit area (45 holes), in Site A (8 holes) and in the area 50 mi to the southeast near Cook Inlet (8 holes).

Drill contractor Foundex completed vertical drilling in 37 holes at sites near the deposit in 2013. These holes numbered GH13-358 through GH13-383 were drilled PQ and HQ size for geotechnical and hydrogeological purposes.

In 2010, the Pebble Partnership acquired the data for seven holes with 414 samples drilled by FMMUSA in 2008. These drill holes are located near the Project on land that is now controlled by the Pebble Partnership and provided information on the regional geology. Seven NQ size vertical holes numbered PS08-01 to PS08-07 drilled by Peak Exploration (USA) Corp averaged 780 ft in length.

10.2.4 Pebble Partnership 2018 - 2019 Drilling

In 2018, 28 vertical geotechnical holes numbered GH18-387S to GH18-414S were drilled to by contractors Foundex and AES to test proposed tailings storage facility (TSF), quarry and water management facility locations.

Six reverse circulation (RC) percussion holes were drilled by T&J Enterprises for hydrogeological site investigation in 2019 in support of the ongoing EIS process. The work consisted of drilling vertically through overburden and bedrock, followed by the installation of pumping wells, monitoring wells, and grouted-in vibrating wire piezometers (VWPs).

10.3 Bulk Density Results

Bulk density measurements were collected from drill core samples, as described in Section 11.3.5. A summary of all bulk density results is provided in Table 10-2 and Table 10-3 shows a summary of bulk density drill holes used in the current Mineral Resource estimate.

Table 10-2: Summary of All Bulk Density (g/cm^3) Results

Age	No. of Measurements	Density Mean	Density Median
Quaternary	34	2.60	2.61
Tertiary	2,703	2.57	2.57
Cretaceous	8,671	2.66	2.64
All	11,775	2.63	2.62

Table 10-3: Summary of Bulk Density (g/cm^3) Results Used for Resource Estimation

Age	No. of Measurements	Density Mean	Density Median
Tertiary	3,026	2.56	2.57
Cretaceous	8,130	2.64	2.62
All	11,185	2.62	2.61

10.4 Conclusions

Samples from the 2002 through 2012 core drilling of Northern Dynasty provide 91% of the assays used in the Mineral Resource estimate. These drilling and sampling programs were carried out in a proficient manner consistent with industry standard practices at the time the programs were completed. Core recovery was typically very good and averaged over 98%; two-thirds of all measured intervals have 100% core recovery. No significant factors of drilling, sampling, or recovery that impact the accuracy and reliability of the results were observed.

The remaining 9% of assays used in the Mineral Resource estimate derive from historical 1988 to 1992 and 1997 Teck core drill programs. Northern Dynasty expended considerable effort to assess the veracity of the Teck drilling over several years. This included: re-survey of drill hole locations, review of remaining half core, extensive re-drilling of areas targeted by Teck, and plotting and comparison of Teck drill holes with nearby Northern Dynasty drill holes. No significant factors of the drilling, sampling or recovery of the Teck program that impact the accuracy and reliability of the results were observed.

QP Eric Titley considers the drill programs to be reasonable and adequate for the purposes of Mineral Resource estimation.

11 SAMPLE PREPARATION, ANALYSES, AND SECURITY

11.1 Sampling Method and Approach

The Pebble deposit has been explored by extensive core drilling, with 81,188 samples taken from drill core for assay analysis. Nearly all potentially-mineralized Cretaceous core drilled and recovered has been sampled by halving in 10 ft lengths. Similarly, all core recovered from the Late Cretaceous to Early Tertiary cover sequence (referred to as Tertiary here and in Section 13) has also been sampled, typically on 20 ft sample lengths, with some shorter sample intervals in areas of geologic interest. Unconsolidated overburden material, where it exists, is generally not recovered by core drilling and therefore not usually sampled.

Rock chips from the 229 rotary percussion holes were generally not sampled for assay analysis, as the holes were drilled for monitoring wells and environmental purposes. Only 35 samples were taken from the drill chips of 26 rotary percussion holes outside the Pebble deposit area, which were drilled for condemnation purposes.

For details of the main rock units in the Pebble deposit and mineralization, see Section 7.

Half cores remaining after sampling were replaced in the original core boxes and stored at Iliamna in a secure compound. Later geological, metallurgical and environmental sampling took place on a small portion of this remaining core. Crushed reject samples from the 2006 through 2013 and the 2018 analytical programs are stored in locked containers at Delta Junction, AK. Drill core assay pulps from the 1989 through 2013 and the 2018 programs are stored at a secure warehouse in Surrey, BC.

11.1.1 Teck 1988 – 1997 Sampling

Teck drill core was transported from the drill site by helicopter to a logging and sampling site in the village of Iliamna. The core from within the Pebble deposit was typically sampled on 10 ft intervals and most core from Cretaceous age units was sampled. Samples from the Sill and other areas were typically 5 ft in length, with shorter samples in areas of vein mineralization. Samples consisted of mechanically-split drill core. The samples were transported by air charter to Anchorage and by air freight to Vancouver, BC. All coarse rejects from 1988 through 1997, all pulps from 1988, and most from 1989 have been discarded. The remaining pulps were later shipped by Northern Dynasty to a secure warehouse at Surrey, BC, for long-term storage.

11.1.2 Northern Dynasty 2002 – 2006 Sampling

All drill core was sampled at a secure core logging facility in the village of Iliamna. NQ2 core samples, averaging 10 ft long, were collected by Northern Dynasty personnel by mechanically splitting the core in half lengthwise. In 2002 a total of 2,467 core samples were taken.

A total of 12,865 Cretaceous (syn-mineralization) samples averaging 10 ft long were taken in 2004; 10,893 samples were mechanically split half-core samples and 1,972 samples were of the metallurgical type. The metallurgical samples were taken by sawing an off-centre slice representing 20% of the core volume, which was submitted for assay analysis. The remaining 80% was used for metallurgical purposes. No intact drill core remains after this type of metallurgical sampling, only assay reject and pulp samples. In addition, 904 Tertiary (post-mineralization) samples averaging 15 ft long were taken for trace element analysis. Tertiary samples were collected by mechanically splitting the core in half lengthwise. A total of

4,378 Cretaceous samples and 1,435 Tertiary samples were collected in 2005. Of the Cretaceous samples, 3,541 were taken by sawing the core in half lengthwise. The remaining 837 Cretaceous samples were from metallurgical holes that were split using the 20% off-centre saw method. Tertiary samples were also sampled using this method. Cretaceous samples averaged 10 ft long and Tertiary samples averaged 20 ft long. No samples were collected or analyzed from the 71 rotary percussion holes drilled in 2005.

In 2006, the 2,759 Cretaceous samples collected averaged 10 ft in length and the 1,847 Tertiary samples averaged 20 ft in length. The Cretaceous samples were collected by sawing the core in half lengthwise, and the Tertiary samples were collected by the 20% off-centre saw method described for the 2004 metallurgical holes.

11.1.3 Northern Dynasty and Pebble Partnership 2007 Sampling

A total of 12,664 samples were taken from the 72 drill holes in 2007. The 9,485 Cretaceous samples averaged 10 ft long, and the 3,179 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise, and the Tertiary samples were collected by the 20% off-centre saw method.

11.1.4 Pebble Partnership 2008 -2014 Sampling

A total of 12,701 samples were taken in 2008 by the Pebble Partnership. The 9,312 Cretaceous samples averaged 10 ft long and the 3,389 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise. The Tertiary samples and assay samples from metallurgical holes were collected using the 20% off-centre saw method described for the 2004 metallurgical holes. The remaining 80% of the core from the Cretaceous portions of the metallurgical holes were used for metallurgical testing. A total of 2,835 mainstream samples were collected in 2009. The 2,555 Cretaceous samples averaged 10 ft long and the 280 Tertiary samples averaged 20 ft long. The Cretaceous samples were collected by sawing the core in half lengthwise. Tertiary samples were collected using the 20% off-centre saw method.

A total of 4,714 mainstream samples were taken in 2010. The 4,463 Cretaceous samples and the 251 Tertiary samples averaged 10 ft long. All samples were taken by sawing the core in half lengthwise.

A total of 4,281 mainstream samples were taken in 2011. The 3,674 Cretaceous samples averaged 10 ft in length and the 607 Tertiary samples averaged 20 ft in length. Cretaceous samples were taken by sawing the core in half lengthwise. Tertiary samples were taken by the 20% off-centre saw-cut method described above.

A total of 2,681 core samples (2,537 Cretaceous samples and the 144 Tertiary samples) were taken in 2012. The Cretaceous samples averaged 10 ft in length and were taken by sawing the core in half lengthwise. Tertiary samples averaged 20 ft in length and were taken by the 20% off-centre cut method.

A total of 523 samples were taken in 2013: 1 from Quaternary, 124 from Tertiary and 398 from Cretaceous strata. The Cretaceous and Quaternary samples average 10 ft in length and were taken by sawing the core in half lengthwise. The Tertiary samples average 15 ft in length and were taken by the 20% off-centre cut method.

In 2018, 329 samples averaging 10 ft in length were taken by sawing the core in half lengthwise.

The six RC holes drilled in 2019 were not sampled for assay.

The large 1.7 to 2.2 lb Cretaceous rock assay pulps and the 0.5 lb Tertiary waste rock pulps from these years are stored in a secure warehouse at Surrey, BC.

Essentially, all potentially mineralized Cretaceous rock recovered by drilling on the Pebble Project is subject to sample preparation and assay analysis for copper, gold, molybdenum and several other elements. Similarly, all Late Cretaceous to

Early Tertiary cover sequence (Tertiary) rock cored and recovered during the drill program is also subject to sample preparation and geochemical analysis by multi-element methods. Since 2007, all sampling at Pebble has been undertaken by employees or contractors under the supervision of a QP. QP Titley believes these processes are acceptable for use in geological and resource estimation for the Pebble deposit.

11.2 Sample Preparation

11.2.1 Teck 1988 – 1997 Sample Preparation

Teck drill core samples collected prior to the 1997 program were prepared by ALS Minerals (ALS Vancouver) Laboratories in North Vancouver, BC (formerly Chemex Labs Inc.). The core samples were processed by drying, weighing, crushing to 70% passing 10 mesh and then splitting to a 250 g sub-sample and a coarse reject; the 250 g sub-sample was pulverized to 85% passing 200 mesh. During the 1997 program, drill core samples were prepared by ALS Laboratories in Anchorage using similar methods.

11.2.2 Northern Dynasty 2002 Sample Preparation

In 2002, the samples were prepared at the ALS Fairbanks sample preparation laboratory (ALS Fairbanks). ALS was certified under an International Organization for Standardization (ISO) 9001 accreditation in 1999 and has been ISO/IEC 17025 certified since 2009. The sample bags were verified against the numbers listed on the shipment notice. In 2002, the entire sample of half-core was dried, weighed and crushed to 70% passing 10 mesh (2 mm), then a 250 g split was taken and pulverized to 85% passing 200 mesh (75 µm). The pulp was split, and approximately 125 g were shipped by commercial airfreight for analysis at the ALS Vancouver. The remaining pulps were shipped to a secure warehouse at Surrey, BC for long-term storage. The coarse rejects were held for several months at ALS Fairbanks until QA/QC measures were completed and were then discarded.

11.2.3 Northern Dynasty 2003 Sample Preparation

The 2003 samples were prepared at the SGS Mineral Services (SGS) sample preparation laboratory in Fairbanks (SGS Fairbanks). After verification of the sample bag numbers against the shipment notice, the entire sample of half-core was dried, weighed and crushed to 75% passing 10 mesh (2 mm). A 400 g split was taken and pulverized to 95% passing 200 mesh (75 µm), and pulps were shipped by commercial airfreight to the SGS laboratories in either Toronto, ON, or Rouyn, QC. The assay pulps were returned for storage at the Surrey warehouse. Coarse rejects were held for several months at SGS Fairbanks until all QA/QC measures were completed and were then discarded.

11.2.4 Northern Dynasty and Pebble Partnership 2004-2013 and 2018 Sample Preparation

For the 2004 through 2013 and 2018 drill programs, ALS Fairbanks performed the sample preparation work. The laboratory received the half-core Cretaceous samples and the off-centre saw splits from the Tertiary samples and metallurgical holes, verified the sample numbers against the sample shipment notice and performed the sample drying, weighing, crushing and splitting. ALS Vancouver pulverized the samples from 2004 through 2006 (as described for 2002 samples), and ALS Fairbanks pulverized the samples from 2007 through 2013 and 2018. Assay pulps were returned for long-term storage at the Surrey warehouse. Crushed reject samples from the 2006 through 2013 and 2018 analytical programs are stored in locked containers at Delta Junction, AK. No samples were taken from the 2019 percussion drill program.

11.3 Sample Analysis

11.3.1 Teck 1988 – 1997 Sample Analysis

Teck analyzed a total of 6,987 core samples from 164 drill holes, including 676 samples analyzed from 39 drill holes on the Sill prospect. Samples from the 1988, 1989 and 1997 programs were analyzed by Cominco Exploration and Research Laboratory (CERL), a subsidiary of Teck in Vancouver, BC. Samples from the 1990 - 1993 programs of Teck were analyzed by the independent laboratory ALS Vancouver. Of the Teck samples outside the Sill zone, 69% were analyzed by ALS Vancouver.

Teck systematically assayed the Cretaceous rock intersections for gold from all drill holes completed on the property from 1988 through 1997. Prior to 1990, gold was determined by aqua regia (AR) decomposition solvent extraction of a 5 g sample with an AAS finish, and by lead collection fire assay (FA) with atomic absorption spectroscopy (AAS), or gravimetric finish on higher grade samples. After 1989, gold was determined by lead collection FA-AAS only, and overall, gold was determined by FA-AAS on over 90% of the Pebble deposit samples analyzed during the Teck era.

Copper analysis was added when the Pebble porphyry discovery hole was drilled in 1989, and single element copper analysis by AR digestion AAS finish continued for all Cretaceous intersections in 1989. Selective single element molybdenum assays by HNO3-HCl04 decomposition AAS finish and single element silver analysis by AR digestion AAS were added to some holes in 1989. In 1990, Teck added multi-element analysis by inductively coupled plasma atomic emission spectroscopy (ICP-AES) finish to the analytical protocol, which included the determination of copper, molybdenum, silver and 29 additional elements. In 1991 and 1992, some sections of core were analyzed using multi-element methods and some were analyzed using single element copper analysis. Only four holes were drilled by Teck in 1993, on targets well south of the Pebble deposit, and these were only assayed for gold and copper. No drilling was completed from 1994 to 1996.

During the 1997 program, drill core samples prepared by ALS Anchorage were submitted to CERL for copper analysis by AR digestion with ICP-AES finish. Gold was analyzed by FA on a one assay-ton sample with AAS finish. Trace elements were analyzed by AR digestion with an ICP-AES finish. One blind standard was inserted for every 20 samples analyzed. One duplicate sample was taken for every 10 samples analyzed.

11.3.2 Northern Dynasty 2002 Sample Analysis

Analytical work for the 2002 drilling program was completed by ALS Vancouver, an ISO 9002 certified laboratory. All samples were analyzed for copper, silver, molybdenum and additional elements by multi-element analysis and for gold by fire assay.

Multi-element analysis for 34 elements, including copper, silver and molybdenum, was by AR digestion of a 0.5 g sample with an ICP-AES finish (ALS code ME-ICP41 shown in Table 11-1).

Table 11-1: ALS Aqua Regia Digestion Multi-Element Analytical Method ME-ICP41

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.2	100
Aluminum	Al	%	0.01	15
Arsenic	As	ppm	2	10,000
Boron	B	ppm	10	10,000
Barium	Ba	ppm	10	10,000
Beryllium	Be	ppm	0.5	100
Bismuth	Bi	ppm	2	10,000
Calcium	Ca	%	0.01	15
Cadmium	Cd	ppm	0.5	500
Cobalt	Co	ppm	1	10,000
Chromium	Cr	ppm	1	10,000
Copper	Cu	ppm	1	10,000
Iron	Fe	%	0.01	15
Gallium	Ga	ppm	10	10,000
Mercury	Hg	ppm	1	10,000
Potassium	K	%	0.01	10
Lanthanum	La	ppm	10	10,000

Element	Symbol	Units	Lower Limit	Upper Limit
Magnesium	Mg	%	0.01	15
Manganese	Mn	ppm	5	10,000
Molybdenum	Mo	ppm	1	10,000
Sodium	Na	%	0.01	10%
Nickel	Ni	ppm	1	10,000
Phosphorus	P	ppm	10	10,000
Lead	Pb	ppm	2	10,000
Sulfur	S	%	0.01	10
Antimony	Sb	ppm	2	10,000
Scandium	Sc	ppm	1	10,000
Strontium	Sr	ppm	1	10,000
Titanium	Ti	%	0.01	10
Thallium	Tl	ppm	10	10,000
Uranium	U	ppm	10	10,000
Vanadium	V	ppm	1	10,000
Tungsten	W	ppm	10	10,000
Zinc	Zn	ppm	2	10,000

A total of 1,715 samples from 26 drill holes exhibiting porphyry-style copper-gold mineralization were assayed for copper by AR digestion with an AAS finish to the ppm level (ALS code Cu-AA46 shown in Table 11-2). Five copper assays greater than 10,000 ppm in hole 2037 were also assayed by this method. A further 271 samples from 5 drill holes were assayed for copper by four-acid (HNO_3-$HClO_4$-HF-HCl) digestion AAS (ALS code Cu-AA61 in Table 11-2) and 62 samples from drill hole 2034 were assayed for molybdenum by four-acid digestion with an AAS finish (ALS code Mo-AA61 shown in Table 11-2). Two samples with Pb and Zn concentrations >10,000 ppm by method ME-ICP41 were reanalyzed by four-acid digestion AAS (ALS codes Pb-AA46 and Zn-AA46 respectively, these methods are also shown in Table 11-2).

Table 11-2: ALS Additional Analytical Procedures

Element	Symbol	Method Code	Digestion	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Copper	Cu	Cu-AA46	Aqua regia	AAS	0.4	%	0.01	50
Lead	Pb	Pb-AA46	Aqua regia	AAS	0.4	%	0.01	50
Zinc	Zn	Zn-AA46	Aqua regia	AAS	0.4	%	0.01	50
Copper	Cu	Cu-AA61	Four-acid	AAS	0.4	ppm	1	10,000
Copper	Cu	Cu-AA62	Four-acid	AAS	0.4	%	0.01	50
Copper	Cu	Cu-OG62	Four-acid	ICP-AES	0.4	%	0.01	40

Gold concentrations were determined by 30 g FA fusion with lead as a collector and an AAS finish (ALS code Au-AA23 in Table 11-3). Four samples that returned gold results greater than 10,000 ppb (10 g/t), were re-analyzed by one assay-ton

FA fusion with a gravimetric finish (ALS code Au-GRAV21 in Table 11 3). Seven samples from drill hole 2013 were analyzed for gold, platinum, and palladium by 30 g FA fusion with ICP finish (ALS code PGM-ICP23 in Table 11-3). In 2007, and additional 459 samples from 11 other 2002 holes were analyzed by this method.

Table 11-3: ALS Precious Metal Fire Assay Analytical Methods

Element	Symbol	Method Code	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Gold	Au	Au-AA23	AAS	30	ppm	0.005	10
Gold	Au	Au-GRA21	Gravimetric	30	ppm	0.05	1,000
Gold	Au	PGM-ICP23	ICP-AES	30	ppm	0.001	10
Platinum	Pt	PGM-ICP23	ICP-AES	30	ppm	0.005	10
Palladium	Pd	PGM-ICP23	ICP-AES	30	ppm	0.001	10

11.3.3 Northern Dynasty 2003 Sample Analysis

Analytical work for the 2003 drilling program was completed by SGS Canada Inc. of Toronto, ON, an ISO 9002 registered, ISO 17025 accredited laboratory. All samples were assayed for copper by a total digestion ICP-AES method and for gold by FA. An AR digestion multi-element geochemical package was used for 33 additional elements including copper, silver, and molybdenum.

Copper assays were completed at SGS Toronto. Samples were fused with sodium peroxide, digested in dilute nitric acid and the solution analyzed by ICP-AES, with results in percent on SGS method ICAY50 as detailed in Table 11-4.

Table 11-4: SGS Copper Analytical Method ICAY50

Element	Symbol	Digestion	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Copper	Cu	Sodium Peroxide Fusion	ICP-AES	0.2	%	0.01	10

Gold analyses were completed at SGS Rouyn, QC, by one assay-ton (30 g) lead-collection FA fusion with AAS finish, with results reported in ppb. Ten samples that returned gold results greater than 2,000 ppb (2 g/t) were re-analyzed by 30 g FA fusion with a gravimetric finish, with results reported in g/t. The SGS analytical methods for gold are listed in Table 11-5.

Table 11-5: SGS Gold Fire Assay Analytical Methods

Element	Symbol	Method Code	Instrument	Sample Mass (g)	Units	Lower Limit	Upper Limit
Gold	Au	FA305	AAS	30	ppb	5	2,000
Gold	Au	FA30G	Gravimetric	30	g/t	0.03	1,000

All samples were subject to multi-element analysis for 33 elements including copper, molybdenum, and sulphur by AR digestion with an ICP-AES finish at SGS Toronto by SGS method ICP70. The elements reported, units and detection limits are listed in Table 11-6.

Table 11-6: SGS Aqua Regia Digestion Multi-Element Analytical Method ICP70

Element	Symbol	Units	Lower Limit	Upper Limit	Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.2	10	Molybdenum	Mo	ppm	1	10,000
Aluminum	Al	%	0.01	15	Sodium	Na	%	0.01	15
Arsenic	As	ppm	3	10,000	Nickel	Ni	ppm	1	10,000
Barium	Ba	ppm	1	10,000	Phosphorus	P	%	0.01	1
Beryllium	Be	ppm	0.5	2,500	Lead	Pb	ppm	2	10,000
Bismuth	Bi	ppm	5	10,000	Sulphur	S	%	0.01	10
Calcium	Ca	%	0.01	15	Antimony	Sb	ppm	5	10,000
Cadmium	Cd	ppm	1	10,000	Scandium	Sc	ppm	0.5	10,000
Cobalt	Co	ppm	1	10,000	Tin	Sn	ppm	10	10,000
Chromium	Cr	ppm	1	10,000	Strontium	Sr	ppm	0.5	5,000
Copper	Cu	ppm	0.5	10,000	Titanium	Ti	%	0.01	15
Iron	Fe	%	0.01	15	Vanadium	V	ppm	2	10,000
Potassium	K	%	0.01	15	Tungsten	W	ppm	10	10,000
Lanthanum	La	ppm	0.5	10,000	Yttrium	Y	ppm	0.5	10,000
Lithium	Li	ppm	1	10,000	Zinc	Zn	ppm	0.5	10,000
Magnesium	Mg	%	0.01	15	Zirconium	Zr	ppm	0.5	10,000
Manganese	Mn	ppm	2	10,000					

In addition, 30 samples were analyzed for whole-rock geochemical analysis by lithium metaborate fusion with an x-ray fluorescence (XRF) finish. All duplicates were analyzed at ALS Vancouver.

11.3.4 Northern Dynasty and Pebble Partnership 2004-2013 and 2018 Sample Analysis

Analytical work from 2004 to 2013 and 2018 was completed by ALS Vancouver. ALS Vancouver has been ISO/IEC 17025 accredited since 2005. Total copper and molybdenum concentrations were determined by an intermediate-grade multi-element analytical method. A four-acid digestion was followed by ICP-AES finish (ALS code ME-ICP61a). This multi-element method was also used to determine 31 additional elements including sulphur. The elements reported, units and detection limits are listed in Table 11-7.

Table 11-7: ALS Four Acid Digestion Multi-Element Analytical Method ME-ICP61a

Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	1	200
Aluminum	Al	%	0.05	50
Arsenic	As	ppm	50	100,000
Barium	Ba	ppm	50	50,000
Beryllium	Be	ppm	10	10,000
Bismuth	Bi	ppm	20	500,00
Calcium	Ca	%	0.05	50
Cadmium	Cd	ppm	10	10,000
Cobalt	Co	ppm	10	50,000
Chromium	Cr	ppm	10	100,000
Copper	Cu	ppm	10	100,000
Iron	Fe	%	0.05	50
Gallium	Ga	ppm	50	50,000
Potassium	K	%	0.1	30
Lanthanum	La	ppm	50	50,000
Magnesium	Mg	%	0.05	50
Manganese	Mn	ppm	10	100,000

Element	Symbol	Units	Lower Limit	Upper Limit
Molybdenum	Mo	ppm	10	50,000
Sodium	Na	%	0.05	30
Nickel	Ni	ppm	10	100,000
Phosphorus	P	ppm	50	100,000
Lead	Pb	ppm	20	100,000
Sulphur	S	%	0.05	10
Antimony	Sb	ppm	50	50,000
Scandium	Sc	ppm	50	50,000
Strontium	Sr	ppm	10	100,000
Thorium	Th	ppm	50	50,000
Titanium	Ti	%	0.05	30
Thallium	Tl	ppm	50	50,000
Uranium	U	ppm	50	50,000
Vanadium	V	ppm	10	100,000
Tungsten	W	ppm	50	50,000
Zinc	Zn	ppm	20	100,000

In 2004 and 2005, approximately one sample in 10 was also analyzed for copper by a high-grade, four-acid digestion method with AAS finish (ALS code Cu-AA62). Details on this and other copper check assay and overlimit methods employed are in Table 11-2.

Gold content was determined by 30 g lead collection FA fusion with AAS finish (ALS code Au-AA23). A total of 14 samples from this period returned gold values greater than 10 ppm; they were re-analyzed by 30 g FA fusion with a gravimetric finish (ALS code Au-GRA21), with results reported in ppm. From drill hole number 7371 onward, gold, platinum and palladium concentrations were determined by 30 g FA fusion with ICP-AES finish (ALS code PGM-ICP23). In 2002, 464 samples from 12 holes in the 25 Zone, 37 Zone and nearby were also analyzed by method PGM-ICP23. Table 11-3 provides further details on the sample size and detection limits of the ALS precious metal fire assay methods used. A single silver value >200 ppm was re-analyzed by AR digestion AAS (Method Ag-AA62 on Table 11-2). Beginning in 2004 for Tertiary rocks and 2007 for Cretaceous rocks, samples were analyzed for 48 elements including copper, silver, molybdenum, and rhenium by four-acid digestion followed by ICP-AES and inductively coupled plasma–mass spectroscopy finish (ICP-MS). Information on this method (ALS code ME-MS61) is listed in Table 11-8.

Table 11-8: ALS Four Acid Digestion Multi-Element Analytical Method ME-MS61

Element	Symbol	Unit	Lower Limit	Upper Limit	Element	Symbol	Units	Lower Limit	Upper Limit
Silver	Ag	ppm	0.01	100	Sodium	Na	%	0.01	10
Aluminum	Al	%	0.01	50	Niobium	Nb	ppm	0.1	500
Arsenic	As	ppm	0.2	10,000	Nickel	Ni	ppm	0.2	10,000
Barium	Ba	ppm	10	10,000	Phosphorous	P	ppm	10	10,000
Beryllium	Be	ppm	0.05	1,000	Lead	Pb	ppm	0.5	10,000
Bismuth	Bi	ppm	0.01	10,000	Rubidium	Rb	ppm	0.1	500
Calcium	Ca	%	0.01	50	Rhenium	Re	ppm	0.002	50
Cadmium	Cd	ppm	0.02	500	Sulphur	S	%	0.01	10
Cerium	Ce	ppm	0.01	500	Antimony	Sb	ppm	0.05	1,000
Cobalt	Co	ppm	0.1	10,000	Scandium	Sc	ppm	0.1	250
Chromium	Cr	ppm	1	10,000	Selenium	Se	ppm	1	1,000
Cesium	Cs	ppm	0.05	500	Tin	Sn	ppm	0.2	500
Copper	Cu	ppm	0.2	10,000	Strontium	Sr	ppm	0.2	10,000
Iron	Fe	%	0.01	50	Tantalum	Ta	ppm	0.05	100
Gallium	Ga	ppm	0.05	500	Tellurium	Te	ppm	0.05	500
Germanium	Ge	ppm	0.05	500	Thorium	Th	ppm	0.01	500
Hafnium	Hf	ppm	0.1	500	Titanium	Ti	%	0.005	10
Indium	In	ppm	0.005	500	Thallium	Tl	ppm	0.02	500
Potassium	K	%	0.01	10	Uranium	U	ppm	0.1	500
Lanthanum	La	ppm	0.5	500	Vanadium	V	ppm	1	10,000
Lithium	Li	ppm	0.2	500	Tungsten	W	ppm	0.1	10,000
Magnesium	Mg	%	0.01	50	Yttrium	Y	ppm	0.1	500
Manganese	Mn	ppm	5	100,000	Zinc	Zn	ppm	2	10,000
Molybdenum	Mo	ppm	0.05	10,000	Zirconium	Zr	ppm	0.5	500

As adjuncts to ALS methods ME-ICP61 and ME-MS61, mercury was determined by AR digestion with cold vapour AAS finish (ALS method Hg-CV41) and AR digestion ICP-MS (ALS method Hg-MS42) on samples where method ME-ICP61a is not performed. Table 11-9 provides further details on these methods.

Table 11-9: ALS Mercury Aqua Regia Digestion Analytical Methods

Element	Symbol	Method Code	Sample Mass (g)	Units	Lower Limit	Upper Limit
Mercury	Hg	Hg-CV41	0.5	ppm	0.01	100
Mercury	Hg	Hg-MS42	0.5	ppm	0.005	100

A total of 13,371 samples were subject to sequential copper speciation analyses that included: oxide copper analysis by citric acid leach AAS finish; non-sulphide copper analysis by 5% sulphuric acid leach AAS finish and cyanide leachable copper on the sample residue of the sulphuric acid leach by cyanide leach AAS finish (ALS codes Cu-AA04, Cu-AA05 and Cu-AA17). These methods and the database codes associated with them are outlined in Table 11-10.

Table 11-10: ALS Copper Speciation Analytical Methods

Database Code	Method Code	Leach	Sample Mass (g)	Units	Lower Limit	Upper Limit
CuOx	Cu-AA04	Citric acid	0.25	%	0.01	10
CuS	Cu-AA05	5% Sulphuric acid	0.5	%	0.01	10
CuCN	Cu-AA17	Cyanide	2	%	0.01	10

A total of 222 samples from a drill hole in Pebble East were analyzed for precious metals (ALS code Au-SCR21 modified to include platinum and palladium). A 1,000 g pulp sample was screened at 100 µm (Tyler 150 mesh) and the entire plus fraction was weighed and analyzed by FA ICP finish and two 30 g minus fractions.

All duplicates since 2004 have been analyzed at Acme Analytical Laboratories (Acme), now Bureau Veritas Commodities Canada Ltd. (BVCCL) in Vancouver, BC, using similar methods to those at ALS. Acme (BVCCL) code MA270, a four-acid digestion with ICP-AES finish, was used to determine total concentrations for copper, molybdenum and 38 additional elements. Table 11-11 lists the elements analyzed and the detection limits of this method.

Table 11-11: BVCCL Four Acid Digestion Multi-Element Analytical Method MA270

Element	Symbol	Units	Lower Limit	Element	Symbol	Units	Lower Limit
Silver	Ag	ppm	0.5	Sodium	Na	%	0.01
Aluminum	Al	%	0.01	Niobium	Nb	ppm	0.5
Arsenic	As	ppm	5	Nickel	Ni	ppm	0.5
Barium	Ba	ppm	5	Phosphorus	P	%	0.01
Beryllium	Be	ppm	5	Lead	Pb	ppm	0.5
Bismuth	Bi	ppm	0.5	Rubidium	Rb	ppm	0.5
Calcium	Ca	%	0.01	Sulphur	S	%	0.05
Cadmium	Cd	ppm	0.5	Antimony	Sb	ppm	0.5
Cerium	Ce	ppm	5	Scandium	Sc	ppm	1
Cobalt	Co	ppm	1	Tin	Sn	ppm	0.5
Chromium	Cr	ppm	1	Strontium	Sr	ppm	5
Copper	Cu	ppm	0.5	Tantalum	Ta	ppm	0.5
Iron	Fe	%	0.01	Thorium	Th	ppm	0.5
Hafnium	Hf	ppm	0.5	Titanium	Ti	%	0.001
Potassium	K	%	0.01	Uranium	U	ppm	0.5
Lanthanum	La	ppm	0.5	Vanadium	V	ppm	10
Lithium	Li	ppm	0.5	Tungsten	W	ppm	0.5
Magnesium	Mg	%	0.01	Yttrium	Y	ppm	0.5
Manganese	Mn	ppm	5	Zinc	Zn	ppm	5
Molybdenum	Mo	ppm	0.5	Zirconium	Zr	ppm	0.5

Check assays for gold were determined by Acme (BVCCL) code FA330, a 30 g FA fusion with ICP-AES finish. Table 11-12lists the details for this method.

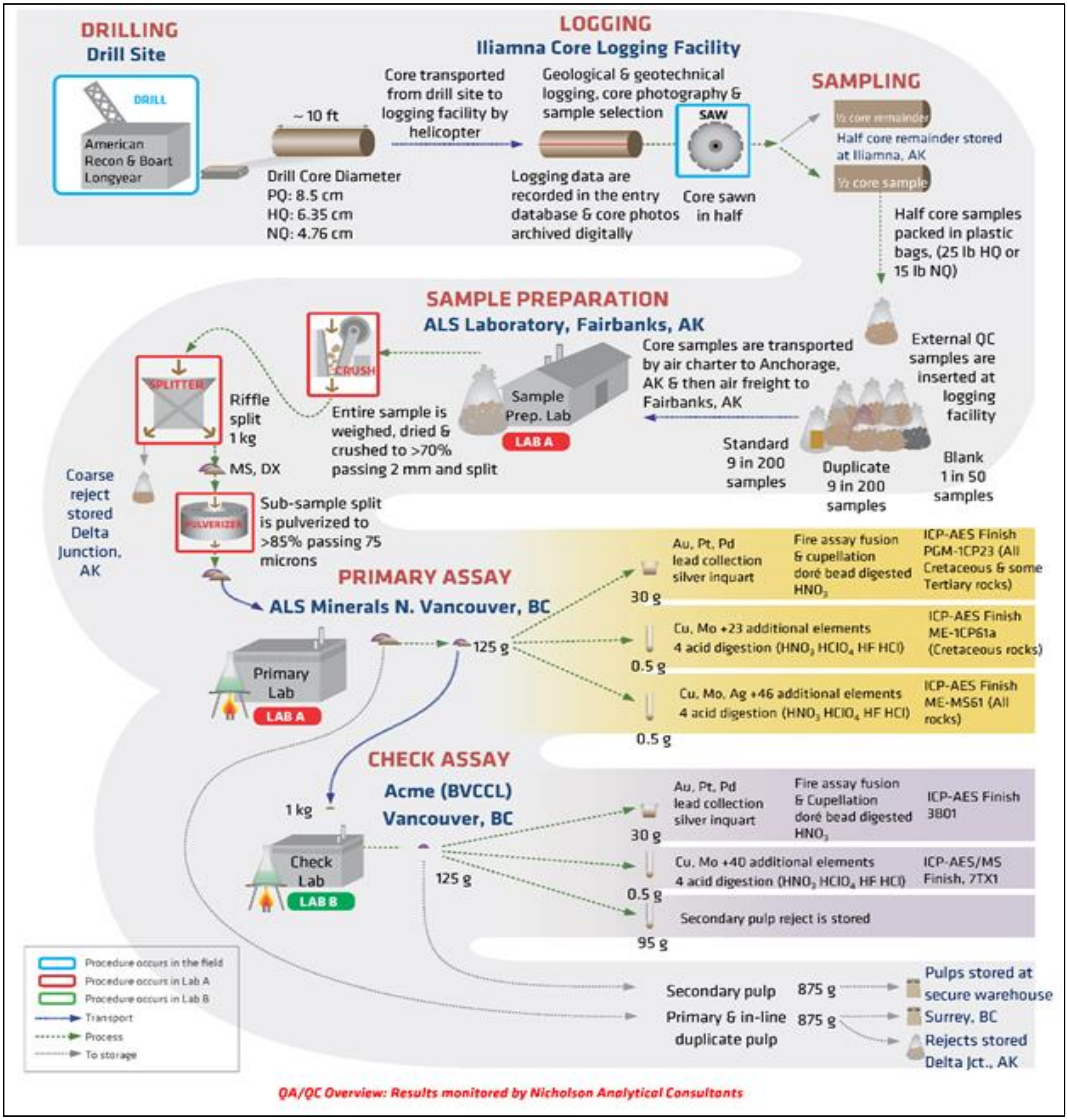
Table 11-12: BVCCL Precious Metal Fire Assay Analytical Method

Element	Symbol	Method Code	Instrument	Units	Sample Mass (g)	Lower Limit
Gold	Au	FA330	ICP-AES	ppb	30	2

In 2010, 115 till samples were also analyzed at BVCCL. The samples were dried and sieved to 230 mesh (63 µm), and a 15 g sub-sample was digested in AR and analyzed by ICP-MS (BVCCL code 1F05).

Figure 11-1 illustrates the sampling and analytical flowchart for the 2010 through 2013 drill programs.

Figure 11-1: Pebble Project 2010 to 2013 Drill Core Sampling and Analytical Flow Chart



Note: Modified after Gaunt et al., (2014).

11.3.5 Bulk Density Determinations

Density measurements were made at 100 ft intervals within continuous rock units, and at least once in each rock unit less than 100 ft wide. Rocks chosen for analysis were typical of the surrounding rock. Where the sample interval occurred in a section of missing core, or poorly-consolidated material unsuitable for measurement, the nearest intact piece of core was measured instead.

Core samples free of visible moisture were selected; they ranged from 3 to 12 in long, and averaged 11.8 in. The samples were dried, weighed in air on a digital scale (capacity 4.4 lb.) and the mass in air (MA) recorded to the nearest 0.1 g. The sample was suspended in water below the scale and its weight in water (Mw) entered. Calculation of the density was conducted using the following formula:

$$\text{Density} = MA / (MA - Mw)$$

Core-sized pieces of aluminum were used as density standards at site starting in 2008. A total of 9,951 density measurements of Tertiary and Cretaceous rocks were taken using a water immersion method on whole and half drill core samples at the Iliamna core logging facility.

11.4 Quality Control/Quality Assurance

QP Titley reviewed the data verification procedures followed by Northern Dynasty and the Pebble Partnership and by third parties on behalf of those entities, and believes these procedures are consistent with industry best practices and acceptable for use in geological and resource estimation.

11.4.1 Quality Assurance and Quality Control

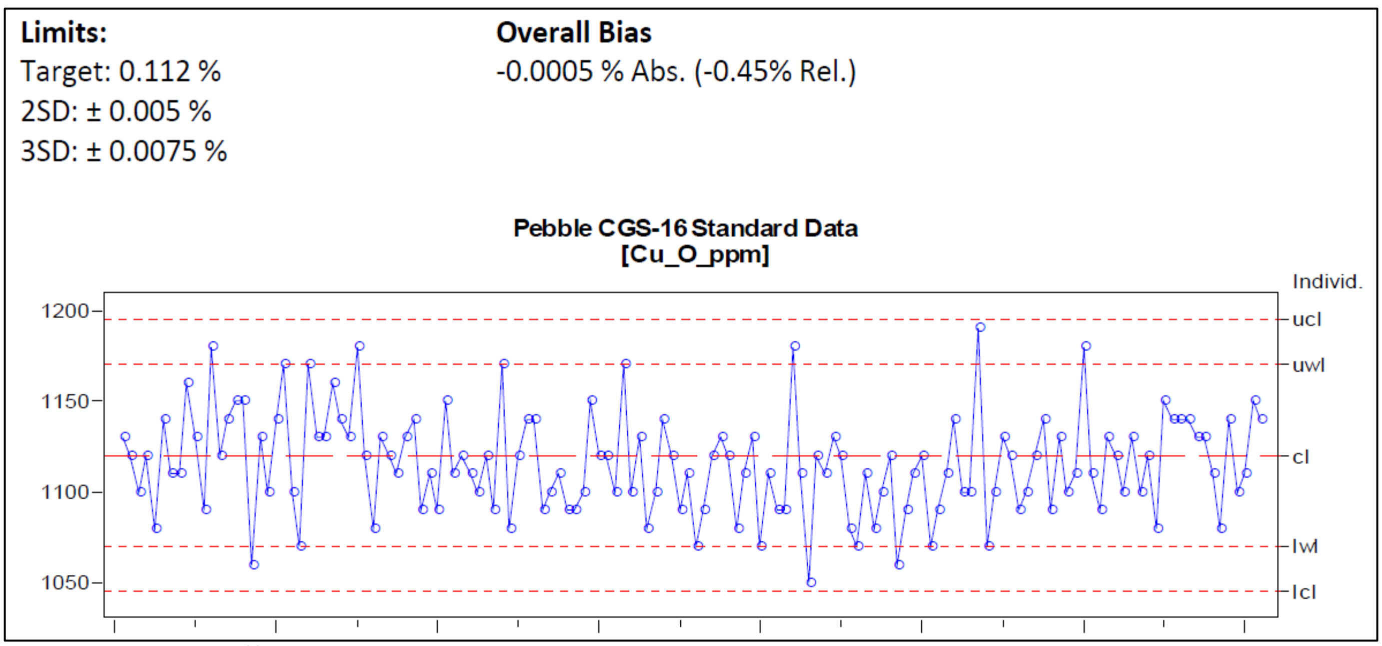
Northern Dynasty maintained an effective QA/QC program consistent with industry best practices, which was continued from 2007 to 2013 under the Pebble Partnership. This program is in addition to the QA/QC procedures used internally by the analytical laboratories. The QA/QC program was independently reviewed by Analytical Laboratory Consultants Ltd (ALC, 2004 to 2007) and Nicholson Analytical Consulting (NAC, 2008 to 2012). The analytical consultants provided ongoing monitoring, including facility inspection and timely reporting of the performance of standards, blanks and duplicates in the sampling and analytical program. The results of this program indicate that analytical results are of a high quality, suitable for use in detailed modelling and resource evaluation studies.

Table 11-13 describes the QA/QC sample types used in the program. The performance of the copper-gold standard CGS-16 is illustrated in Figure 11-2and Figure 11-3. A comparison of the matched-pair duplicate assay results of ALS and Acme (BVCCL) for 2004 through 2010 is provided in Figure 11-4 and Figure 11-5.

Table 11-13: QA/QC Sample Types Used

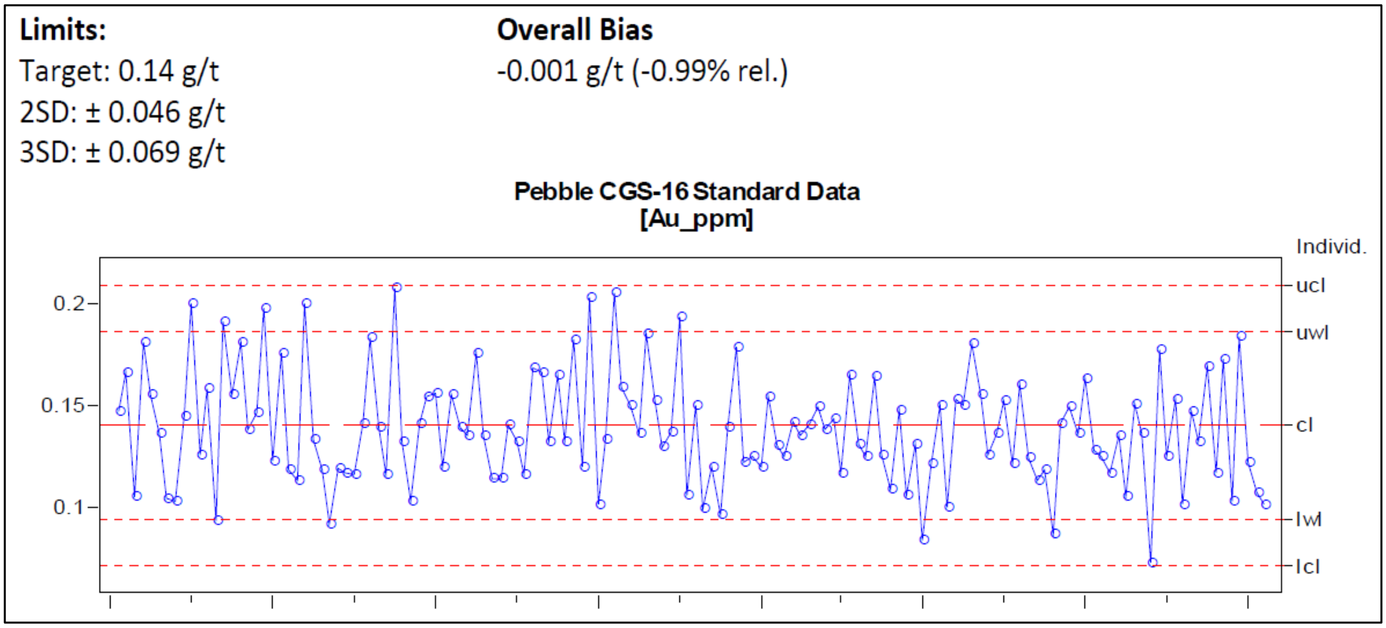
QC Code	Sample Type	Description	Percent of Total
MS	Regular Mainstream	• Regular samples submitted for preparation and analysis at the primary laboratory.	89%
ST	Standard (Certified Reference Material)	• Mineralized material in pulverized form with a known concentration and distribution of element(s) of interest. • Randomly inserted using pre-numbered sample tags.	4.5% or 9 in 200
DP	Duplicate or Replicate	• An additional split taken from the remaining pulp reject, coarse reject, ¼ core or ½ core remainder. • Random selection using pre-numbered sample tags.	4.5% or 9 in 200
SD	Standard Duplicate	• Standard reference sample submitted with duplicates and replicates to the check laboratory.	<1%
BL	Blank	• Sample containing negligible or background amounts of elements of interest, to test for contamination.	2% 1 in 50

Figure 11-2: Performance of the Copper Standard CGS-16 in 2008



Note: Figure prepared by NAC, Oct. 19, 2009.

Figure 11-3: Performance of the Gold Standard CGS-16 in 2008



Note: Figure prepared by NAC, Oct. 19, 2009.

11.4.2 Standards

Standard reference materials (standards) were inserted into the Cretaceous sample stream (approximately 9 samples for every 200 samples) after sample preparation as anonymous (blind), consecutively numbered pulps. These standards are in addition to internal standards routinely analyzed by the analytical laboratories. Standards were inserted in the field by the use of sample tags, on which the "ST" designation for "Standard" was pre-marked. For the Tertiary waste rock analytical program, coarse blanks were inserted at the sample tags positions marked as ST until late 2008 and, since then a commercial pulp blank has been used.

Standard performance was monitored by charting the analytical results over time against the concentration of the control elements. The results are compared with the expected value and range, as determined by round-robin analysis. A total of 32 different standard reference materials were used to monitor the assay results from 1997 through 2018 and 2020 rhenium analysis programs. Copper and gold standards were inserted during the 1997 through 2020 programs. Molybdenum standards were added in September 2008.

In December 2007, several tons of coarse reject samples from Pebble East and Pebble West were pulled from storage and shipped to Ore Research & Exploration Pty Ltd in Victoria, Australia, for the production of ten matrix-matched certified reference materials. These standards (PLP-1 through PLP-10) became available in late 2009 and have been used to monitor the Pebble analytical results since that time. Nine of the standards from mineralized Cretaceous rocks are certified for copper, gold, silver, molybdenum, and arsenic. One low- grade standard (PLP-2) is from Tertiary rock and is certified for copper, silver, molybdenum, arsenic, and mercury.

A standard determination outside the control limits indicates a control failure. The control limits used are as follows:

- warning limits: ±2 standard deviations; and,

- control limits: ±3 standard deviations.

When a control failure occurred, the laboratory was notified and the affected range of samples re-analyzed. By the end of the program, no sample intervals had outstanding QA/QC issues. The standard monitoring program provides a good indication of the overall accuracy of the analytical results.

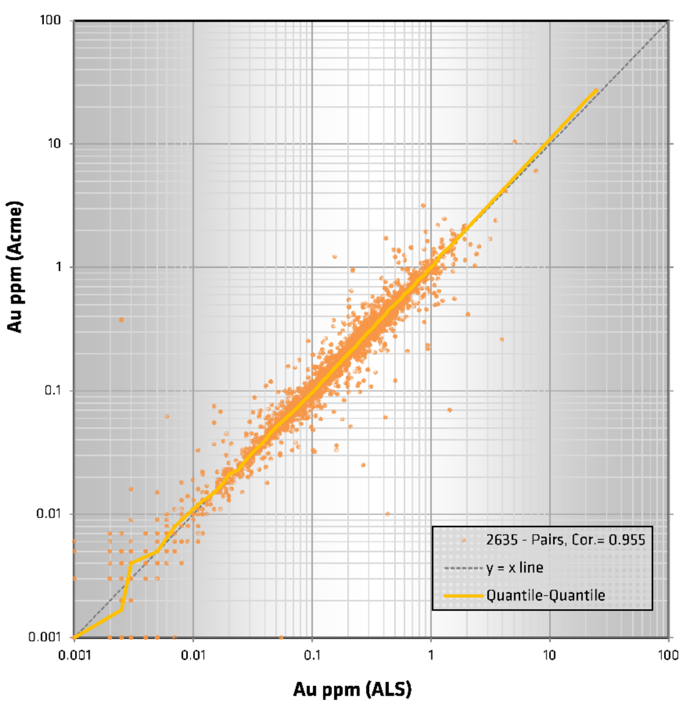
11.4.3 Duplicates

Random duplicate samples were selected and tagged in the field by the use of sample tags on which the “DP” designation for “duplicate” was pre-marked. From 2004 onward, samples to be duplicated were split by ALS Fairbanks and submitted to Acme (BVCCL) in Vancouver for pulverization.

The original samples were assayed by ALS of North Vancouver and the corresponding duplicate samples were assayed by BVCCL. The approximately 2,000 coarse reject, inter-laboratory duplicate assay results from 2004 to 2010 match well; the correlation coefficients are 0.96 for gold, 0.98 for copper and 0.98 for molybdenum. In 2011 and 2013, the duplicate analyses rate of 9 in 200 samples was continued and the number of duplicate samples analyzed was doubled. The protocol was modified so that after every 20th mainstream sample analyzed within the regular sample stream an in-line, intra-laboratory coarse reject duplicate (a “prep-rep” duplicate) was analyzed. In addition to this, the original pulp of this sample was sent to BVCCL for inter-laboratory check assaying when final QA/QC on the original samples was completed.

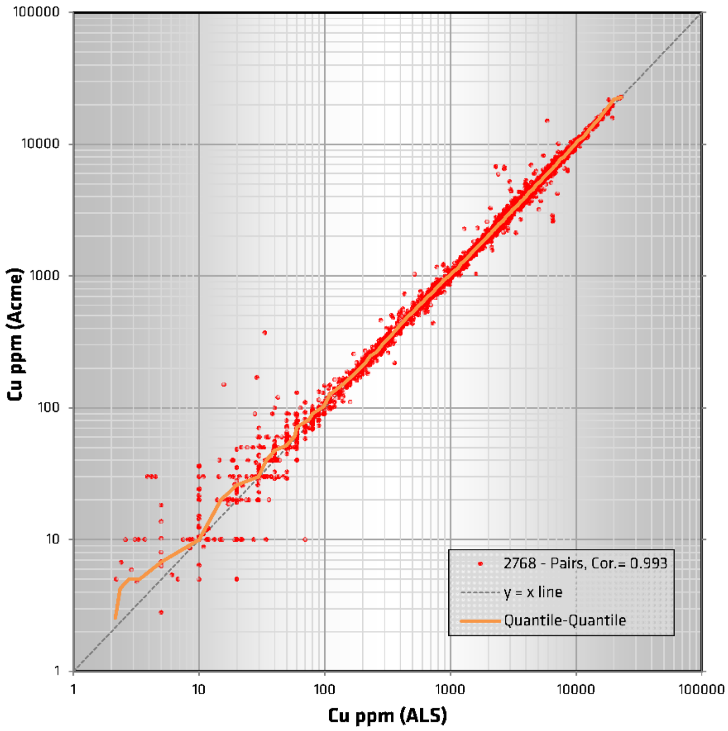
Figure 11-4 and Figure 11-5 provide a comparison of the matched-pair duplicate assay results of ALS Vancouver and BVCCL for 2004 through 2010.

Figure 11-4: Comparison of Gold Duplicate Assay Results for 2004 to 2010



Source: Ghaffari et al., (2011).

Figure 11-5: Comparison of Copper Duplicate Assay Results for 2004 to 2010



Source: Ghaffari et al., (2011).

11.4.4 Blanks

A total of 1,362 field blanks have been inserted since 2004 to test for contamination. This is in addition to the analytical blanks routinely inserted with the samples by the assay laboratories as a part of their internal quality control procedures. In 2004, coarse landscape dolomite was inserted as a blank material. This material was replaced by gravel landscape material between 2005 and late 2008. In late 2008, the gravel blank was replaced by a quarried grey granitic landscape rock. This material has a lithological matrix similar to the Pebble Cretaceous host rocks.

About 1 lb of the blank was placed in a sample bag, given a sequential sample number in the sequence and randomly inserted one to six times per drill hole after the regular core samples were split at Iliamna. These blank samples were processed in sample number order along with the regular samples.

Of the blanks inserted, 444 were included in the Tertiary waste rock sample program in the position marked for the standard. In late 2008, a commercial precious metals pulp blank was inserted with the Tertiary waste rock samples. In late 2009, the use of matrix-matched low grade Tertiary standard PLP-2 was initiated.

The majority of assay results for the blanks report at or below the detection limit. The maximum values reported in the current results are gold (0.028 g/t) and copper (0.057%). No significant contamination occurred during sample preparation, with a few minor exceptions, possibly due to cross-sample mixing errors during crushing.

11.4.5 QA/QC on Other Elements

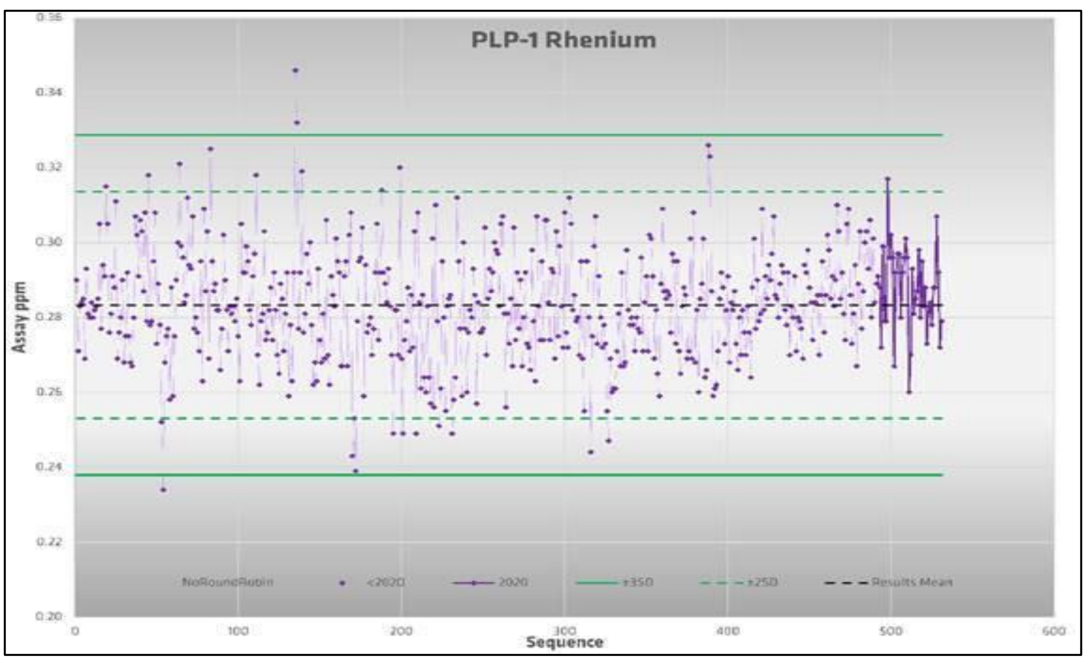
The four-acid digestion ICP-AES 33 multi-element analytical method employed from 2004 through 2013 (ALS method ME-ICP61) is optimized for copper and molybdenum analysis. The copper and molybdenum assays were monitored by internal laboratory and external standards.

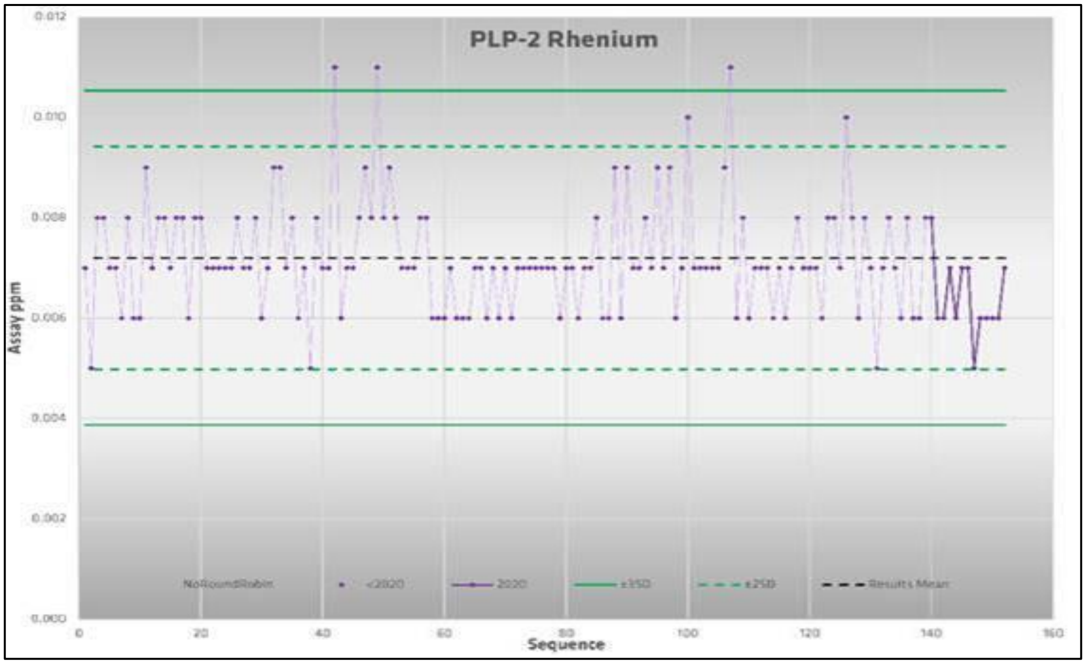
Parallel to this method (as described in Section 11), an ICP-MS 48 multi-element method (ALS Method ME-MS61) was also used to determine the same 25 elements above and 23 additional elements. The ICP-MS method gives lower detection limits for most of the elements.

11.4.6 Rhenium Study

In July 2020, the original assay pulps from 938 sample intervals cored in years 1991, 2003, 2004 and 2005 Pebble deposit drilling were retrieved from a company warehouse for a study on the relationship between rhenium and molybdenum concentrations. The selected samples were originally analyzed for copper, molybdenum and other elements, but had not been analyzed for rhenium. Samples were submitted to ALS Vancouver for multi-element analysis by four acid digestion ICP-MS finish (ALS method ME-MS61), along with 52 Pebble project-based standards, 17 nominal blanks and 48 duplicates. In addition to rhenium and molybdenum, the concentrations of copper, silver and 44 other elements were also determined in this study. The performance of standard PLP-1 for rhenium is illustrated in Figure 11-6. The pre-2020 results and year 2020 results from ALS are highlighted by lighter and darker shaded lines, respectively. The performance of the nominal (low element concentration) blank PLP-2 for rhenium is similarly presented in Figure 11-7. As the control samples used had not originally been subject to round-robin analysis for rhenium, results of several hundred analyses at ALS Vancouver were used to establish reasonable concentration levels for them. These levels were corroborated with results obtained by other analytical laboratories using similar analytical methods.

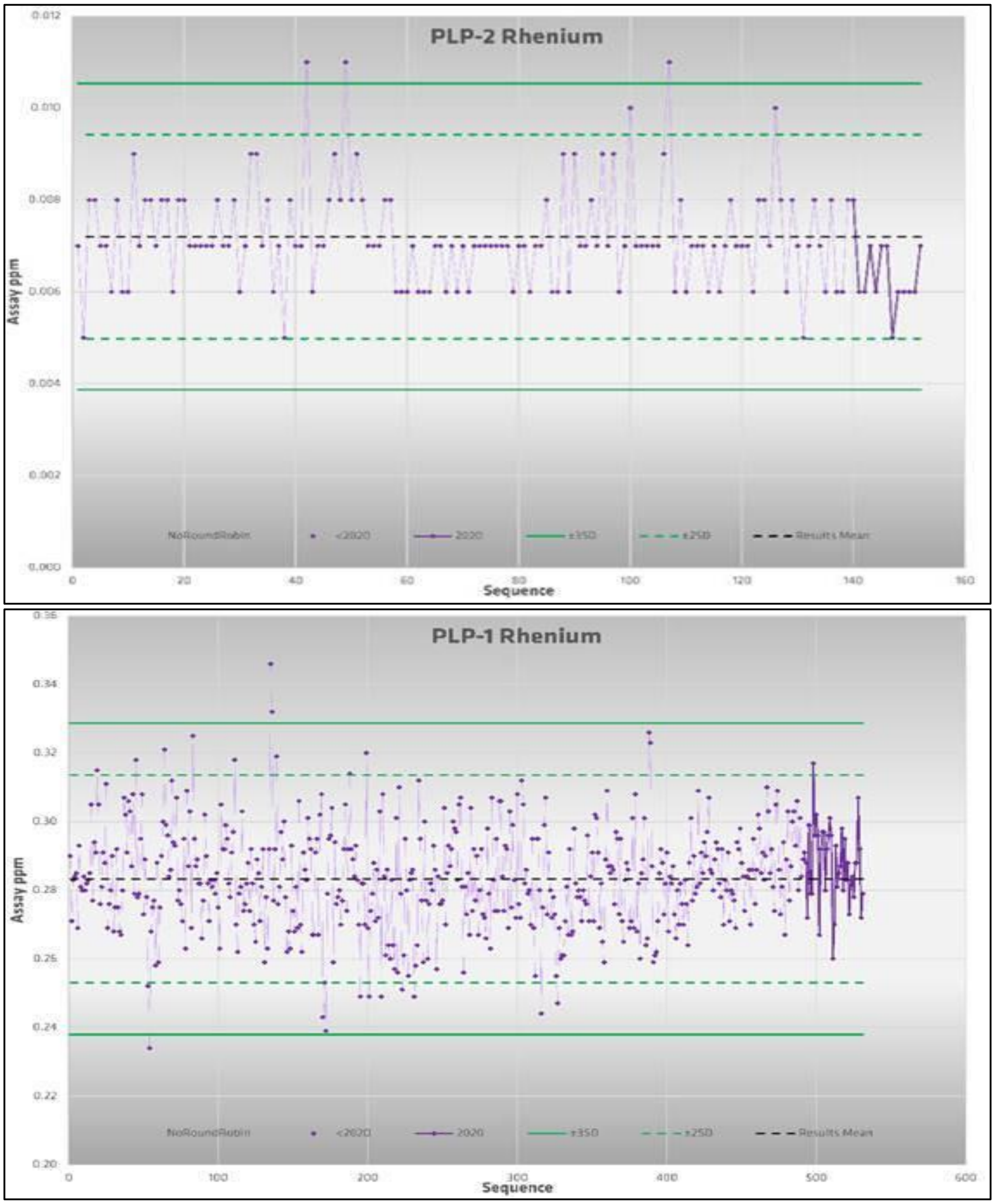
Figure 11-6: Performance of Standard PLP-1 for Rhenium





Source: Gaunt et al., (2020).

Figure 11-7: Performance of Control Sample PLP-2 for Rhenium

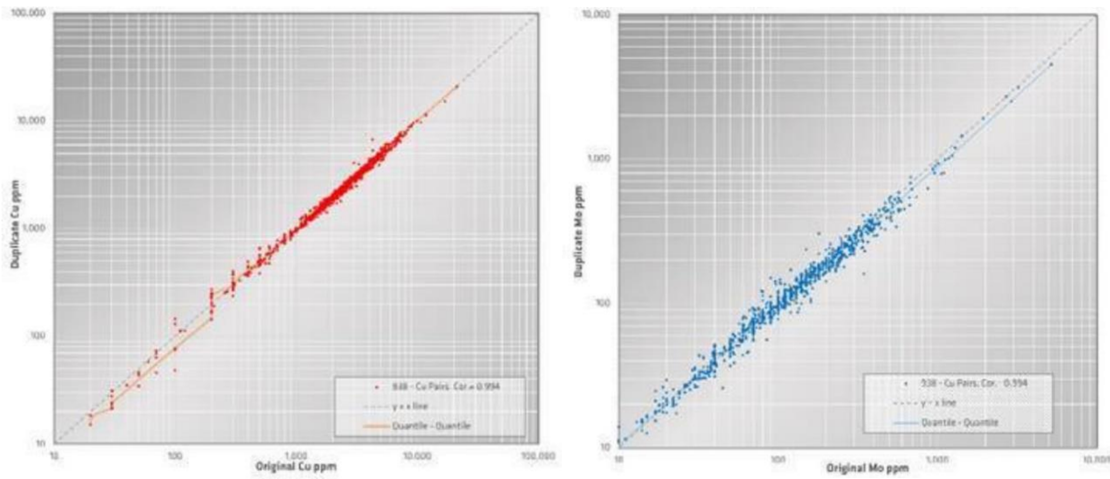


Source: Gaunt et al., (2020).

Based on the results of this study, the QP Titley is of the opinion that the rhenium results obtained are suitable for use in the development of a regression equation to enable resource estimation of this element.

As part of the 2020 rhenium study, additional elements including copper and molybdenum were analyzed by the multi-element method employed. The copper and molybdenum results obtained in 2020 were compared with the original assay results. These comparisons are presented in Figure 11-8 as scatterplots in log format of the original results versus the new results. A reasonable level of correspondence in concentrations of the matched pairs was obtained for each element

Figure 11-8: Scatterplots in Log Format of Original vs 2020 Re-analysis for Copper and Molybdenum



Source: Gaunt et al., (2020).

In the opinion of the QP Titley, the reanalysis of these samples for copper and molybdenum lends further credence to the veracity of the assay results for these elements and the appropriateness of their use in this Report.

11.5 Bulk Density Validation

The bulk density data were reviewed prior to the resource estimate. The following types of errors were noted: entry errors, standards labelled as regular samples, incorrectly calculated density values based on the mass in air and mass in water values entered and extremely high or low-density values without appropriate explanation. These errors were investigated and corrected prior to including the data for resource estimation.

Two other possible sources of error in the measurements were identified: the presence of moisture in the mass in air measurement for some samples, and the presence of porosity and permeability of the bulk rock mass not determinable by the method. The former will result in measurements that are somewhat overstated, and the latter in measurements that are understated in terms of the dry in situ bulk density.

11.6 Survey Validation

In 1988, Teck established a survey control network including the Pebble Beach base monument in the deposit area using U.S. State Plane Coordinate System Alaska Zone 5. This monument was tied to the NGS State Monuments Koktuli, PIG and RAP at Iliamna and formed the base for subsequent drill collar surveys. In 2004, air photo panels and a control network were established using NAD 83 US State Plane Coordinate System Alaska Zone 5 with elevations corrected to NAVD88 based on Geoid99.

In 2005, differences between the elevations of surveyed drill collars in the deposit area and the digital elevation model (DEM) topography were observed. In early 2008, a re-survey program was initiated to investigate and resolve these discrepancies. A consistent error was identified in the collar coordinates from some years, and questions arose as to whether drill collars had been surveyed to the top of the drill casing or to ground level. In September 2008, two new control points - Pebble 1 and Pebble 2 - were established by R&M Consultants Inc. of Anchorage in the deposit area; they tied these two points and the Pebble Beach monument into the 2004 control network and an x, y, z linear coordinate correction was applied to resolve previously observed drill hole elevation discrepancies.

Subsequently, during the 2008 and 2009 field seasons, all holes drilled at the Pebble Project since inception in 1988 were re-surveyed using a real time kinematic (RTK) GPS, referencing the coordinates of the Pebble Beach monument as established by the 2008 re-survey to gain a complete set of consistently acquired collar survey data. The majority of the drill holes were marked with a wooden post and an aluminum tag. In cases where the post was missing, the original coordinates were used to find evidence of the drill hole. Any hole missing a drill post was re-marked, and this was noted in the database. The resurveys were taken to the top of tundra over the centre of the drill hole. Where a drill hole could not be located, the resurveyed coordinate was taken at the original drill collar coordinates and the elevation re-established in the new system.

All post Teck holes were down-hole surveyed by single shot magnetic methods. In 2008, several angle holes were also surveyed by a non-magnetic gyroscopic tool.

11.7 Data Environment

All drill logs collected on the Pebble Project were compiled in a SQL Server database. Drill hole logs were entered into notebook computers running a digital data entry module for the Pebble Project at the core shack in Iliamna prior to 2018. During the pre-2018 drilling programs, the core logging computers were synchronized on a daily basis with the site master database on the file server in the Iliamna geology office. In 2018 and 2019, data entry was to a cloud-based server. Core photographs are also transferred to the file server in the Iliamna geology office on a daily basis. In the geology office, the logs were reviewed and validated, and initial corrections made.

Prior to 2018, site data were transmitted on a weekly basis to the Vancouver office, where the logging data were imported into the Project master database and merged with digital assay results provided by the analytical laboratories. After importing, a further printing, validation and verification step followed. In 2018 and 2019, a cloud-based application was used. Any errors noted are submitted to the Iliamna office for correction. If analytical re-runs are required, the relevant laboratories are notified and corrections are made to the corresponding results within the project master database. Parallel to this, an independent QA/QC consultant compiled the sample log data from the site with assay data received directly from the laboratories for the 2004 through 2012 programs as part of an ongoing monitoring process. Compiled data are exported to the site database, to resource estimators, and to other users as required.

11.7.1 Error Detection Processes

Error detection within the data entry modules is used in the core shack and the Iliamna geology office as part of the data verification process. This process standardizes and documents the data entry, restricts data which can be entered and processed, and enables corrections to be made at an early stage. Users are prompted to make selections from ‘pick-lists’, when appropriate, and other entries are restricted to reasonable ranges of input. In other instances, information must be entered and certain steps completed prior to advancing to the next step. After the logs have been entered, they are reviewed and validated by the logger and printed.

Site data were transmitted to the Pebble database compilation group on a regular basis. The compiled data from the header, survey, assay, geology and geotechnical tables were validated for missing, overlapping or duplicated intervals or sample numbers, and for matching drill hole lengths in each table. Drill hole collars and traces were viewed on plan view and in section by a geologist as a visual check on the validity of the collar and survey information.

As the analytical data returned from the laboratory, they were merged with the site sampling data, and the gold, copper, silver and molybdenum values of the regular samples and QA/QC samples reviewed. Particular attention was paid to standards that failed QA/QC; they were targeted for immediate review and re-runs were requested from the analytical laboratory if necessary.

11.7.2 Analysis Hierarchies

The first valid QA/QC-passed analytical result received from the primary laboratory has the highest priority in the analytical hierarchy. If the same analytical method is used more than once, no averaging is done. If different analytical methods are employed on the same sample, the most appropriate combination of digestion and analytical method is selected and used.

For gold analysis, FA determined by gravimetric finish supersedes results by AAS or ICP finish, particularly where the AAS or ICP results are designated as over limits. For copper analysis done on Cretaceous rocks after 2004, ALS intermediate grade multi-element analytical method (ALS method ME-ICP61) supersedes copper by low grade multi-element method (ALS method ME-MS61).

In the case of all other elements, including molybdenum, silver and sulphur analyses from 2007 through 2013, the multi-element method (ALS method ME-MS61) supersedes the intermediate grade multi-element method (ALS method ME-ICP61), unless the low-grade method results are greater than the upper detection limit. In that case, the intermediate grade method result prevails. All rhenium results are by ALS method ME-MS61. Infrequent extremely high results for copper, molybdenum, silver, lead or zinc were reanalyzed by single element over limit analytical methods that supersede the original result.

11.7.3 Wedges

Some long holes, particularly in Pebble East, were intentionally wedged. This was undertaken when drilling conditions in the parent hole deteriorated to such an extent that continuation to target depth was impractical. For consistency of sample support for geological and resource modelling, mother hole/wedge hole combinations are represented by singular linear traces in the database. In treating the wedged portion of a hole that successfully extends beyond its parent hole, the following approach was used. The wedged portion of the hole was treated as a continuation of the mother hole from the point where the wedge starts. The information from the mother hole and the wedge was blended onto a string that follows the mother hole to the wedge point, and then follows the wedge (and the wedge surveys) to the end of the hole. The 'best available' information from the two hole strings was combined to produce one linear drill hole trace.

11.8 Verification of Drilling Data

The 1997 and prior Teck data were validated by Northern Dynasty in 2003 using:

- the digital data and printed information obtained from Teck;
- digital assay results obtained directly from ALS and Cominco Exploration Research laboratories, where available; and
- selected re-analysis of original assay pulps obtained from Teck.

Most of the pre-2002 data in the current database is derived from a digital compilation created by Teck in 1999. Twenty-eight gold results from 1988 and 1989 holes, which existed only on hand-written drill logs, were added to the database. A complete set of original information, including original drill logs, does not exist for all historical holes, particularly for those drilled in the Sill zone in 1988 and 1989. Assay data for the 1988 and 1989 holes drilled in Pebble West and 25 zone is from a combination of CERL assay certificates, the Teck digital compilation file and the original drill logs. The data compiled by Teck appears to be of good quality and matches the digital analytical data received directly from the CERL and ALS laboratories, with few exceptions. Most differences appear to be due to separately reported over-limits and re-runs. The small number of errors identified in the Teck data, including mismatched assay data, conversion errors, unapplied over-limits and typographical errors were corrected.

The 2002 analytical data were also verified and validated. A few errors were identified and corrected. When the 2003 digital data were verified against the assay certificates, some differences with the printed certificates were identified. In 2003, the analytical results were provided by SGS in a digital format that included SGS internal standards, duplicates and blanks. These digital results differed from the values on the corresponding printed certificates in two ways: digits in excess of three significant figures were recorded, and results were not trimmed to the upper detection limit value. As a result, sixteen 2003 gold assays over 2,000 ppb had incorrect values assigned to them in the database. This was corrected by applying the correct FA over-limit re-run result to these samples in the database. No over-limits existed in the 2003 copper results so there were no errors with this element. The lone over-limit molybdenum value was left untrimmed because this result was substantiated by an ALS check assay. Results from 2003 for elements other than gold, copper and molybdenum were left untrimmed in the database.

Norwest Corporation reported on additional data verification done in conjunction with the resource estimate in a technical report dated the February 20, 2004. "Norwest received, from Northern Dynasty, the initial Pebble drill hole database in the form of an assay, collar, downhole survey and geology file. An audit was undertaken of 5% of the data within these files. Digital files were compared to original assay certificates and survey records. It was determined that the downhole survey file had an unacceptable number of errors. The assay file had an error rate of approximately 1.2%. This was considered acceptable for this level of study." These errors were investigated and subsequently corrected by Northern Dynasty.

The ongoing error-trapping and verification process for drill hole data collected from 2004 to 2019 is described in Section 11.1.4. Typically, validation and verification work was completed within a few months of completion of a drill hole, although some QA/QC issues took longer to resolve. Work at the Iliamna office consisted mostly of validating the site data entry and resolving errors that were identified. Additional validation and verification work was performed in the Vancouver office. This consisted of checking the site data tables for missing, overlapping, unacceptable and mismatching entries, and reviewing the analytical QA/QC results. During verification of the data, a low number of errors were found. Erroneously labelled standards in the sample log were the main source of error. Digital values not matching the analytical certificates were the next area of concern. In this case, the digital data were usually correct, as the certificates had been superseded by new results from QA/QC re-runs.

In addition to typical database validation procedures, the copper, gold and molybdenum data included in Northern Dynasty news releases prior to 2009 were manually verified against the results on the ALS analytical certificates.

A significant amount of due diligence and analytical QA/QC for copper, gold and molybdenum has been completed on the samples that were used in the current Mineral Resource estimate. This verification and validation work performed on the digital database provides confidence that it is of good quality and acceptable for use in geological modelling, mineral estimation and preliminary mine planning.

12 DATA VERIFICATION

QP Robin Kalanchey was involved in multiple aspects of the 2021 PEA, and worked directly with engineers, designers, estimators and analysts in the development of the process facility and infrastructure engineering, cost estimates and the financial evaluation for the Proposed Project and potential expansion scenarios. In his QP capacity, Mr. Kalanchey reviewed the relevant mineral processing and metallurgical test reports, as completed by others, the engineering design documentation, as well as consolidated capital and operating cost estimates, and the corresponding economic models. QP Kalanchey has validated the data used as the basis of the engineering design, cost estimates and inputs to the economic models against Ausenco's internal standards and industry benchmarks, available metallurgical testwork reports for the Pebble deposit, and preferred practices for base metal deposits.

QP Kalanchey has not visited the Pebble site but has relied on the information provided in site visit reports as produced by Mr. Paul Staples, P.Eng, of Ausenco, who visited the site previously and during such visit observed the mine site, the port site and the data collection activities taking place at the time of the visit.

QP Kalanchey is of the opinion, given his involvement in the Project and his interactions with the design and project teams, that the data used as the basis of the engineering designs, cost estimates and financial evaluations, as presented herein, are appropriate and adequate for the purposes of this 2021 PEA.

QP Hassan Ghaffari was involved in the metallurgical testwork review, metal recovery projections, and processing design since 2012 when Tetra Tech was retained by Northern Dynasty to conduct an internal engineering study for the Pebble Project. He also supervised Ting Lu, P.Eng during the preparation of Section 13, Mineral Processing and Metallurgical Testing, of the 2014, 2018 and 2020 Technical Reports for Northern Dynasty.

In his QP capacity, QP Ghaffari reviewed the relevant mineral processing and metallurgical test reports that were completed by reputational commercial laboratories and leading processing equipment manufacturers. QP Ghaffari has conducted due diligence by reviewing the background, procedures and results of the testing programs. He also analyzed original test data and communication documents to verify the test results for metal recovery projections. All aspects of these programs were deemed to be of suitable standard.

In the months immediately prior to the completion of this Report, QP Ghaffari extensively reviewed all aspects of the test results regarding rhenium distributions and recovery methods, as well as projected rhenium recovery based on the results of the conventional flotation tests.

In QP Ghaffari's opinion, the verification work conducted for the testwork review and metal projections is adequate for the purposes used in this Report.

QP Sabry Abdel Hafez was involved in the pit optimizations, pit designs, mine plan and mine costing since 2012 when Tetra Tech was retained by Northern Dynasty to conduct an internal engineering study for the Pebble Project.

In his QP's capacity, QP Abdel Hafez has reviewed the relevant pit optimization and mine costing data. There have been no limitations placed on the ability of QP Abdel Hafez to verify the data used. In the QP's opinion the data are adequate for the purposes used in this technical report.

QP Les Galbraith has been involved with Pebble Project waste and water management studies, including site investigation programs at the locations of the TSFs and the water management ponds since 2004. He has visited the site many times, with the last visit being in June 2013. Site geotechnical data, including geophysical surveys calibrated with drillhole data, were reviewed and are considered to be adequate to support this technical report.

QP David Gaunt was involved in the due diligence program and conducted the original modelling of the deposit prior to its acquisition by Northern Dynasty in 2001. He has been directly involved in resource estimation of the deposit continuously since that time. In this capacity he has worked directly with site personnel including QA/QC supervisors, project geologists, engineering personnel, data loggers, and other management personnel. QP David Gaunt either prepared or supervised all resource estimates completed on the project from 2003 through to 2018 and has extensive knowledge of this work. QP Gaunt has conducted numerous site visits to review aspects of the program such as drilling, sample procedures, geological interpretation, and QA/QC status. The most recent visit to site was conducted in 2010. All aspects of the project pertinent to resource estimation were deemed to be of suitable standard.

In the months immediately prior to the completion of this Report, QP Gaunt extensively reviewed all aspects of the resource estimate including analytical QA/QC, statistical performance, domaining, variography and rhenium estimation parameters. Analytical data and estimation procedures developed were deemed to be appropriate for estimation of rhenium.

Subsequent verification analyses on estimated grades lends credence to their accuracy, spatial distribution and correspondence with informing drill data.

QP James Lang has been directly involved in the acquisition of geological, exploration, drilling, and other related types of data on the Pebble Project since 2003. He has been physically on the Project site every year through 2019 for a total of over 650 days. Prior to 2007, QP Lang undertook a variety of specialized geological studies of both the Pebble deposit and the surrounding environs for Northern Dynasty, including examination of outcrops, extensive examination, review, and sampling of diamond drill core, review and reconciliation of drill logs, review of geochemical results in respect of geological controls, the acquisition of geotechnical data from drill core, and other similar activities, and he also participated in QA/QC oversight of many types of geological data acquisition. From 2007-2010, QP Lang was on-site Chief Geologist for the Project on behalf of Northern Dynasty and the Pebble Partnership, supervising the geology team and their activities, including QA/QC oversight of their data collection methods, supervision of geometallurgical and metal deportment studies, modeling in support of deposit delineation and exploration, and characterization of the physical and mineralogical properties of the deposit. He also served as geological liaison to the metallurgical and geotechnical engineering and environmental disciplines. QP Lang was a member of the Geology and Exploration Technical Committee of the Pebble Partnership from 2007-2013, the duties of which included review of data collection methods, review of the results of drilling, and geochemical and geophysical surveys, and the planning of all exploration and geology activities on the Project. Since 2013, QP Lang has remained responsible for the limited geological activities that have occurred on the Project and the curation of geological data.

Verification of the geological data presented in this Report was achieved by two primary means. Firstly, by the direct participation of QP Lang in the acquisition of much of the data used in this Report, and secondly by his historical and ongoing custodianship of the geological data and its review in the context of newly-acquired analytical data presented and regional context provided by third-party studies referenced in this Report. As mentioned above, QP Lang also conducted site visits to observe and oversee collection of the data. During the period from 2003 until present, there have been no limitations placed on the ability of QP Lang to verify the data used herein, and there have been no material failures in the verification of said data. QP Lang deems these data to be appropriate to and adequate for the purposes of this Report.

QP Eric Titley was involved in the due diligence program on exploration conducted by Teck that ultimately resulted in the acquisition of the Pebble Project by Northern Dynasty in 2001. He has been directly involved in the exploration, drilling, sampling, analytical, QA/QC and data management programs of the Pebble Project on behalf of Northern Dynasty and Pebble Partnership continuously since then. Northern Dynasty and Pebble Partnership systematically validated and verified results from its exploration programs on the Pebble Project as they progressed between May 2002 and October 2019. QP

Titley worked closely with the independent analytical consultants and supervised the analytical, QA/QC and data management aspects of these programs on behalf of Northern Dynasty and Pebble Partnership and has extensive knowledge of this work. QP Titley conducted site visits, most recently in September 2011, to review the ongoing drilling, sampling, and analytical QA/QC operations. All aspects of these programs were deemed to be of a suitable standard.

In the months immediately prior to completion of this Report, QP Titley extensively reviewed and re-assessed the drill hole database used in the current resource estimate. This involved detailed comparison of the resource database with original source records that support it, including a number of original laboratory assay certificates. A high level of concordance between the resource database and the original source records was indicated by this study. In addition, over 900 original assay sample pulps from the 1991 through 2005 drill programs within the current resource area were retrieved and submitted for multi-element analysis. Re-analysis results included copper, silver, molybdenum and rhenium. The new copper, molybdenum and silver analyses compare with the original assays to an acceptable level. The newly-acquired rhenium analyses were used to upgrade the data support for this element in the resource database.

The verification work conducted lends credence to the veracity of the resource database. In QP Titley's opinion the data is adequate for the purposes used in mineral resource estimation.

13QP Stephen Hodgson has served many years in engineering leadership positions for the Pebble Project, including studies of the Project in 1991 and 1992 for a previous owner. He joined Northern Dynasty as Vice President Engineering in 2005 and has been engaged in the Project since that time, managing engineering studies. With the creation of the Pebble Partnership in 2007, he was Director of Engineering until 2011. Between 2011 and 2013, he served as a member of the Project's Steering Committee and resumed the engineering leadership role in 2013. In 2017, he was named Senior Vice President Engineering and Project Director for the Pebble Partnership with responsibility for the technical aspects of the Project, including oversight of the development of the Project Description.

QP Hodgson has visited the Pebble site many times, the most recent occasion in October 2019, to observe and oversee the collection of engineering and other data for Project design for the environmental assessment process. He has interacted continuously with the geological team during his tenure with Northern Dynasty and Pebble Partnership, including collaborating in the development of enclosing pits to define resources. QP Hodgson has reviewed all sections of this Report and discussed the information presented by each of the QPs.

QP Hodgson's opinion is, given his tenure on and in-depth knowledge of the Pebble Project and his interaction with the geological, resource, and metallurgical teams, these data are appropriate and adequate for the purposes of this technical report.

13 MINERAL PROCESSING AND METALLURGICAL TESTING

This section summarizes the relevant results from all metallurgical testwork programs for the Pebble Project that was initiated by Northern Dynasty in 2003 and continued under the direction of Northern Dynasty until 2008. From 2008 to 2013, metallurgical testwork progressed under the direction of the Pebble Partnership. During the same period, geometallurgy studies were conducted by the Pebble Partnership and continued until 2014. This section includes testwork review with a focus on tests completed from 2011 to 2014, geometallurgical studies, and an updated metal recovery projection.

13.1 Test Programs Summary

Metallurgical testwork between 2005 and 2014 can be divided into three stages. The first stage testwork was conducted from 2003 to 2005 to understand the metallurgical response of the mineralized materials and to develop a baseline process flowsheet. The objectives of the second stage testwork, conducted between 2006 and 2010, were to optimize the baseline flowsheet on variability samples and to investigate appropriate processing methods to improve metal recoveries. The third stage testwork from 2011 to 2014 was focused on metallurgical verification tests on samples representing each metallurgical domain at the property in batch, pilot, and locked cycle tests. Additional testwork conducted during the third stage included evaluations of the performance of a secondary gold recovery plant and pressure oxidation of molybdenum concentrates to recover molybdenum and rhenium, and the subsequent metal extractions.

13.1.1 2003 to 2005 Testwork

The first stage metallurgical testwork was performed by different laboratories. The testwork conducted by Vancouver-based Process Research Associates Ltd (PRA) was preliminary in nature and was followed by testwork completed by G&T Metallurgical Services Ltd. (G&T) in Kamloops, BC. Based on their test results, a comprehensive metallurgy test program was carried out at the SGS Lakefield laboratories located in Lakefield, ON (SGS Lakefield). The basic flowsheet from PRA was optimized by testing on primary grind size, regrind size, flotation and gold leaching. In addition, comminution data were obtained from samples covering the bulk of the lithology and alteration combinations in the mineral resource. A few miscellaneous tests were also performed including settling and filtration and concentrates properties. The SGS Lakefield test results demonstrated that marketable concentrate over 26% copper could be obtained, and production of molybdenum as a separate concentrate and doré by leaching were viable. All these laboratory facilities are well recognised in the mining industry.

13.1.2 2006 to 2010 Testwork

The second stage metallurgical testwork, conducted between 2006 and 2010, covered comminution, gravity separation, flotation, leaching, settling tests and other miscellaneous testwork as listed in Table 13-1. The main purpose of the testwork was to optimize the process flowsheet to incorporate supergene mineralization from the western portion of the Pebble deposit, and to explore the performance variability of composite samples from Pebble West zone and Pebble East zone mineralization.

Table 13-1: Testwork Programs and Reports 2006 to 2010

Test Program	Laboratory	Report Date
Metal Recoveries Related Programs: Comminution/Flotation/Leaching Tests		
Screen Analysis Data on Rod Mill Feed	Phillips Enterprises, LLC	Apr 17, 2008
Rod Mill Grindability Test Data	Phillips Enterprises, LLC	Apr 18, 2008
Screen Analysis Data on Rod Mill Product	Phillips Enterprises, LLC	May 13, 2008
Bond Abrasion Test Data	Phillips Enterprises, LLC	Apr 22, 2008
Ball Mill Grindability Test Data	Phillips Enterprises, LLC	Jun 6, 2008
Screen Analysis Data on Ball Mill Feed	Phillips Enterprises, LLC	Jun 10, 2008
Screen Analysis Data on Ball Mil Product	Phillips Enterprises, LLC	Jun 24, 2008
Mail to the Pebble Partnership c/o Mr. Alex Doll, Final Report of Comminution QA/QC Testing	Phillips Enterprises, LLC	Jul 18, 2008
Technical Memorandum to Steve Moult of Pebble Partnership, Grinding Throughput Calculation Procedure for Mine Production Schedules	DJB Consultants Inc (DJB)	Sep 30, 2008
E-Mail Transmission, Compare JK SimMet SABC-A and SABC-B Throughput Prediction to Morrell Total Power Calculation for Selected 2010 SMC Samples; Also, Morrell HPGR Predictions	Contract Support Services	Jan 21, 2010
E-Mail Transmission, Final Report, Pebble LOM Simulations, Years 1 to 13: SABC-A vs. SABC-B Circuit Options	Contract Support Services	Apr 7, 2010
E-Mail Transmission, Final Report, Pebble LOM Simulations, Years 1 to 25: SABC-A vs. SABC-B Circuit Options	Contract Support Services	Apr 29, 2010
E-Mail Transmission, Summary of Results, Pebble LOM Simulations: Years 1–45: SABC-A Revision B, Correct Year 8 Throughput	Contract Support Services	Dec 30, 2010
E-Mail Transmission, Summary of Results, Pebble LOM Simulations, Years 1–45: SABC-B Circuit Option, Comparison with SABC-A	Contract Support Services	Dec 30, 2010
An Investigation into the Recovery of Copper, Gold, and Molybdenum by Laboratory Flotation from Pebble Samples. Project 10926-008 Report #1	SGS Lakefield	Jul 6, 2006
An Investigation into Copper, Gold, and Molybdenum Recovery from Pebble East Phase I Composites. Project 11486-003 Report #1	SGS Lakefield	Jun 30, 2009
An Investigation into Bulk Flotation of Pebble East and West Composites, Project 11486-003 Report #2	SGS Lakefield	Jun 26, 2009
An Investigation into Aging of Pebble East Phase I Samples. Project 11486-003 Report #3	SGS Lakefield	Jun 30, 2009
Tank Cell e500 Mechanical Testwork	Outotec	Mar 11, 2010
Copper Sulphide Jar Mill Testing Test Plant Report #20002007	Metso	Apr 12, 2010
An Investigation into the Recovery of Copper, Gold, and Moly from Pebble East and West zones. Project 12072-002 Report #2	SGS Lakefield	Dec 21, 2009, Jan 24, 2010

Test Program	Laboratory	Report Date
Determination of GRG Content Final Report Revised # T1144	COREM	May 27, 2010
Gravity Modelling Report Project # KRTS 20587	Knelson Research & Technology Centre	Aug 17, 2010
Settling Tests		
Summary of High Rate Thickening Test Results Tailings Samples	Outotec	Apr 2, 2010
Outotec Thickener Interpretation and Recommendations for Test Data Report TH-0493	Outotec	Apr 9, 2010
Thickener Test Data Report # TH-0493	Outotec	Apr 9, 2010
Thickener Test Data Report # TH-0493_R1	Outotec	Apr 16, 2010
Thickener Test Data Report # TH-0497	Outotec	Jun 2, 2010
Outotec Thickener Interpretation and Recommendations for Test Data Report TH-0497	Outotec	Jun 17, 2010
Filtration Tests		
Test Report 12875T1 Pebble Partnership	Larox	Mar 8, 2010, Apr 7, 2010
Rheology Tests		
Report of Investigation into The Response of the Pebble Project Rougher Tailings to Sedimentation and Rheology Testing	FL Smith	Mar 2010

The major observations from the second testwork campaign are summarized as follows:

- Bulk flotation testwork was intended to optimize the flowsheet to treat the supergene and transition zones in Pebble West. Most samples achieved the 26% copper concentrate target, in the variability tests and the locked cycle tests.
- Copper-molybdenum locked cycle separation tests demonstrated more than 99% of the copper contained in the circuit feed was recovered to copper concentrate and 92.6 to 98.4% of the molybdenum was recovered to molybdenum concentrate.
- The molybdenum concentrate, obtained from the last cleaner stage of the open circuit tests, was found to contain significant rhenium, with grades ranging up to 960 g/t, and the copper content observed was between 1.8% and 5.9%.
- Gravity recoverable gold (GRG) was determined to optimize gravity gold recovery. The obtained recovery was similar to previous testwork.
- Pyrite flotation was conducted with pyrite concentrate subjected to gold leaching tests. The average gold extraction was 55% by leaching for 48 hours.
- Other metallurgical testwork conducted in this period included tailings thickening, regrinding jar tests, and copper concentrate thickening and filtration.

13.1.3 2011 to 2014 Testwork

The Pebble Partnership continued metallurgical testwork during 2011 and 2014. The major goals of the 2011 and 2014 testwork program were as follows:

- Complete QEMSCAN® analysis of the variability sample inventory to support geometallurgical studies.
- Conduct additional flotation variability tests to ensure samples of each metallurgical domain type are represented.
- Conduct continuous flotation testwork to generate product for downstream testwork.
- Conduct testwork related with the design of the secondary recovery gold plant.
- Perform an initial program to test a molybdenum autoclave process (MAP) on Pebble concentrates for molybdenum and rhenium recovery.

Table 13-2: Subsequent Testwork Programs and Reports, 2011 to 2014

Test Program	Laboratory	Report Date
Metal Recoveries – Comminution/Flotation/Leaching		
An Investigation into Ultrafine Grinding of Pilot Plant Concentrates from the Pebble Deposit	SGS Lakefield	Feb 9, 2011
An Investigation into the Grindability Characteristics of a Single Sample W-214-215 from the Pebble West zone	SGS Lakefield	Apr 6, 2011
Continuous Flotation of Five Composites from the Pebble Deposit	SGS Lakefield	Jun 21, 2011
Copper Molybdenum Separation Testing on a Pebble Bulk Concentrate	G&T Metallurgical Services Ltd.	Sep 22, 2011
An Investigation into the Recovery of Copper, Gold, and Molybdenum from the Pebble Deposit; Incomplete; Progress Report, Project 12072-003 and -007	SGS Lakefield	Jan 24, 2012
Concentrate Quality		
An Investigation by High Definition Mineralogy into the Mineralogy Characteristics of Five Concentrate Samples from Five Different Composites	SGS Lakefield	Mar 23, 2011
An Investigation into a Deportment Study of Gold in Eight Samples from the Pebble Gold zone	SGS Lakefield	Jun 17, 2011
An Investigation by High Definition Mineralogy into the Mineralogy Characteristics of Eight Products of Three Pilot Plant Samples	SGS Lakefield	Jun 23, 2011
Filtration		
Filtration Test Report	Outotec	Jun 17, 2011
Rheology Tests		
Grinding Transfer Stream Rheology Testwork Report, Report # PBL-5172 R02 Rev 0 & Rev 1	Paterson & Cooke	Sep 2011, Oct 2011
Bulk Tailings Rheology Testwork Report. Report # 4303207-25-RP-002	Paterson & Cooke	Nov 2011
An Investigation into the Recovery of Copper, Gold, and Molybdenum from the Pebble Deposit; Incomplete; Final Report, Project 12072-003 and -007	SGS Lakefield	Sep 24, 2014

Results are discussed on the following subsections.

13.2 Comminution Tests

13.2.1 Bond Grindability Tests

The Bond rod mill work index (RWi) and Bond ball mill work index (BWi) are listed in Table 13-3 and, Table 13-4, respectively.

Table 13-3: Pebble West Rod Mill Data Comparison, SGS January 2012**

	RWi (kWh/t)			
Core Year	2004	2005, 2006	2008	2011
Composites	-	W1 to W177	W178 to W394	W395 to W445
Year Tested	2005	2008, 2010, 2011	2009, 2010, 2011	2011
Results Available	295	47	19	3
Average	15.6	14.4	13.0	15.3
Minimum*	9.7	10.1	11.0	11.6
Median	15.3	14.0	12.8	12.6
Maximum*	24.3	20.4	19.5	21.7

Notes: * Minimum and maximum refer to softest and hardest values for the grindability test.
** Drilled samples are from the Pebble West zone at a grind particle size of 1.4 mm or 14 mesh.

Table 13-4: Pebble West Ball Mill Data Comparison, SGS January 2012**

	BWi (kWh/t)			
Core Year	2004	2005, 2006	2008	2011
Composites	-	W1 to W177	W178 to W394	W395 to W445
Year Tested	2005	2008, 2010, 2011	2009, 2010, 2011	2011
Results Available	295	57	72	2
Average	14.2	14.0	13.4	11.7
Minimum*	7.7	8.4	8.0	11.4
Median	14.0	13.7	12.7	11.7
Maximum*	22.1	21.7	20.4	12.1

Notes:
1. Minimum and maximum refer to softest and hardest values for the grindability test.
2. Drilled samples are from the Pebble West zone, at a grind particle size of 0.147 mm or 100 mesh for the 2005 tests, and 0.204 mm/65 mesh for the remaining tests.

13.2.2 Bond Low Energy Impact Tests

Comminution testwork was carried out on samples collected between 2004 and 2010 summarized in Table 13-5 through Table 13-8. The testwork completed is considered to be representative of the deposit.

Table 13-5 shows the Bond low-energy impact test results on Pebble West zone samples. The tests were completed by Philips Enterprises, LLC under the supervision of SGS Lakefield.

Table 13-5: Bond Low-Energy Impact Test Results, SGS January 2012

	CWi (kWh/t)			Rock Density
	Average	Minimum	Maximum	g/cm^3
Average*	9.9	5.3	17.8	2.52
Minimum	3.7	1.6	8.1	2.38
Median	10.0	5.3	17.7	2.54
Maximum	15.6	10.5	33.9	2.68

13.2.3 SMC Tests

The SAG Mill Comminution (SMC) test is to provide impact breakage parameters in a cost-effective means when a full drop weight test JK drop-weight test is not available due to the limited sample quantities. Additional SMC tests were conducted on Pebble West and Pebble East drill core samples in 2012. The major test results including the direct measurements of sample densities, JK drop-weight test index (DWi), the calculated JK drop weight test rock breakage parameters A x b, and the t_{10} values are summarized in Table 13-6for Pebble West zone and Table 13-7 for Pebble East samples. The tested samples represent the relevant rock types for the west and east zones of the project. Test results since 2004 are also presented.

Table 13-6: Major SMC Data Comparison on Pebble West Samples-SGS Test Report Sept. 2014

	DWi kWh/m³			A x b				t_{10}@1kWh/t			Density (g/cm^3)			
Core Years	2005, 2006	2008	2011	2004	2005, 2006	2008	2011	2005, 2006	2008	2011	2004	2005, 2006	2008	2011
Comp	W1 to W177	W178 to W394	W395 to W445	-	W1 to W177	W178 to W394	W395 to W445	W1 to W177	W178 to W394	W395 to W445	-	W1 to W177	W178 to W394	W395 to W445
Years Tested	2008, 2010, 2011	2009, 2010, 2011	2011	2005	2008, 2010, 2011	2009, 2010, 2011	2011	2008, 2010, 2011	2009, 2010, 2011	2011	2005	2008, 2010, 2011	2009, 2010, 2011	2011
Results Available	53	64	15	47	53	64	15	53	64	15	47	53	64	15
Average	6.46	6.12	6.94	45.7	44.0	50.1	43.6	31.8	34.8	31.3	2.59	2.60	2.60	2.62
Minimum*	2.74	1.79	2.61	98.3	89.4	135.2	98.9	46.5	62.3	48.1	2.49	2.43	2.38	2.44
Median	5.93	5.78	7.47	43.1	43.2	45.6	35.9	31.7	33.6	29.7	2.59	2.62	2.59	2.64
Maximum*	11.5	10.9	11.1	26.0	24.0	26.1	24.5	21.3	22.8	21.5	2.89	2.76	2.90	2.74

Notes: * Minimum and maximum refer to softest and hardest values for the grindability test.

Table 13-7: Major SMC Data Comparison on Pebble East Samples

	DWi kWh/m³			A x b			t_{10}@1kWh/t			Density (g/cm³)		
Phase	I	II	III	I	II	III	I	II	III	I	II	III
Results Available	134	182	44	134	182	44	134	182	44	134	182	44
Average	4.93	6.16	3.88	57.9	45.7	75.3	40.1	33.1	46.2	2.61	2.59	2.59
Minimum*	1.69	2.59	1.61	150	98.3	158.8	68.8	51.2	70.6	2.50	2.49	2.53
Median	4.85	6.04	3.79	54.3	43.1	68.1	39.5	32.3	45.0	2.61	2.59	2.58
Maximum*	8.81	10.3	6.3	30.0	26.0	41.5	25.9	22.7	31.6	2.87	2.89	2.69

Notes: Source SGS Summary Report, 2014.
* Minimum and maximum refer to softest and hardest values for the grindability test.

13.2.4 MacPherson Autogenous Grindability Tests

Two variable samples from the Pebble West zone were blended to represent the global average for this zone and sent to SGS Lakefield for MacPherson autogenous grindability tests. The test results are shown in Table 13-8. The composite sample was categorized as medium with respect to the throughput rate, the specific energy input, and the final grind. The composite sample is near the median of the Pebble West distribution for A x b, DWi and BWi.

Table 13-8: MacPherson Autogenous Grindability Test Results, SGS January 2012

Sample	Feed Rate (kg/h)	F_{80} (µm)	P_{80} (µm)	Gross Work Index (kWh/t)	Correlated Work Index (kWh/t)	Gross Energy Input (kWh/t)	Hardness Percentile
W214/215	12.4	22,176	331	13.6	12.6	6.5	31

13.3 Flotation Concentration Tests

Focusing on the on-site production of three final products, namely copper concentrate, molybdenum concentrate and gold gravity concentrate, flotation tests conducted on Pebble materials since 2011 primarily consisted of:

- bulk flotation to produce a copper-molybdenum flotation concentrate with associated gold and rhenium;
- molybdenum flotation to produce the final copper concentrate and molybdenum concentrate; and
- pyrite flotation with the concentrate being subjected to cyanide leaching; Other separation techniques were also tested at a preliminary level to optimize metal recoveries and concentrate grades, including:
- GRG tests (Section 13.4);

- sulphidization, acidification, recycling, and thickening (SART) process tests to recover copper from leaching circuit residue. SART test results are not included due to removing cyanide applications in the process design; and
- pressure oxidation tests conducted on molybdenum flotation concentrates to recover molybdenum and rhenium (Section 13.5).

13.3.1 Recovery of Bulk Flotation Concentrate

13.3.1.1 Flotation Kinetics and Preliminary Optimization

In 2011 and 2012 test programs, SGS Lakefield investigated flotation kinetic properties. Both rougher flotation and first cleaner flotation were tested on various samples, with pH value, reagent type/dosage/addition points and pulp density factors varied in order to determine optimized conditions for subsequent batch cleaner and locked-cycle tests.

The 2011 program focused on bulk rougher kinetics tests on composite samples representing supergene and hypogene rock types. The 2012 program included rougher flotation kinetics on the individual variability sample W182, representing supergene, and four domain composite samples, namely K-silicate, supergene, sodic potassic and illite-pyrite. Additional first cleaner kinetics was also investigated on the four domain samples.

The observations from the two programs are summarized as follows:

- Rougher pH level (SGS Lakefield, 2011)
  - By increasing pH values of the rougher flotation stage to about 8.5, metal recoveries to rougher concentrate can be significantly increased.
  - This was attributed to the low average natural pH value of the four sample types (i.e., 5.8, 5.7, 7.2 and 6.2).
- Rougher reagent dosage and addition points (SGS Lakefield, 2011)
  - A rougher flotation collector comparison was made between using only potassium ethyl xanthate (PEX) as the collector versus PEX with the promoter (AERO 3894) added. It was observed that metal recoveries increased for supergene with the addition of AERO 3894; however, metal recovery increases were not demonstrated for other samples.
  - Collector dosages for PEX and AERO 3894 were tested at 27.5 g/t and 45 g/t, respectively. The results indicated that adding 27.5 g/t PEX was sufficient for the first two rougher stages. The optimized retention time is about 12 minutes for the rougher stage.
- Rougher sulphidization (SGS Lakefield, 2012)
  - Tests on sample W182 were performed to investigate the effect in the rougher stage of using sodium hydrosulphide (NaHS) to achieve a target of a reduction potential (-140 mV measured with silver/silver cleaner) electrode. There were no observed effects on metal recoveries to the rougher concentrate.
- Rougher pulp density (SGS Lakefield, 2011-2012)
  - Tests on one composite sample indicated that reducing pulp density from 30 to 25% improved gold and molybdenum recovery significantly, while copper recovery was unaffected.

- Flotation rate (SGS Lakefield, 2011-2012)
    - The supergene sample was found to be the slowest to recover copper, gold and molybdenum in the rougher flotation stage and the K-silicate sample the fastest. The indicated retention time for rougher flotation is approximately 12 minutes. At the first cleaner stage, all samples presented similar flotation rates in terms of copper recovery, with the molybdenum recovery rate being the slowest. The retention time indicated by the tests for first cleaner flotation is six minutes.

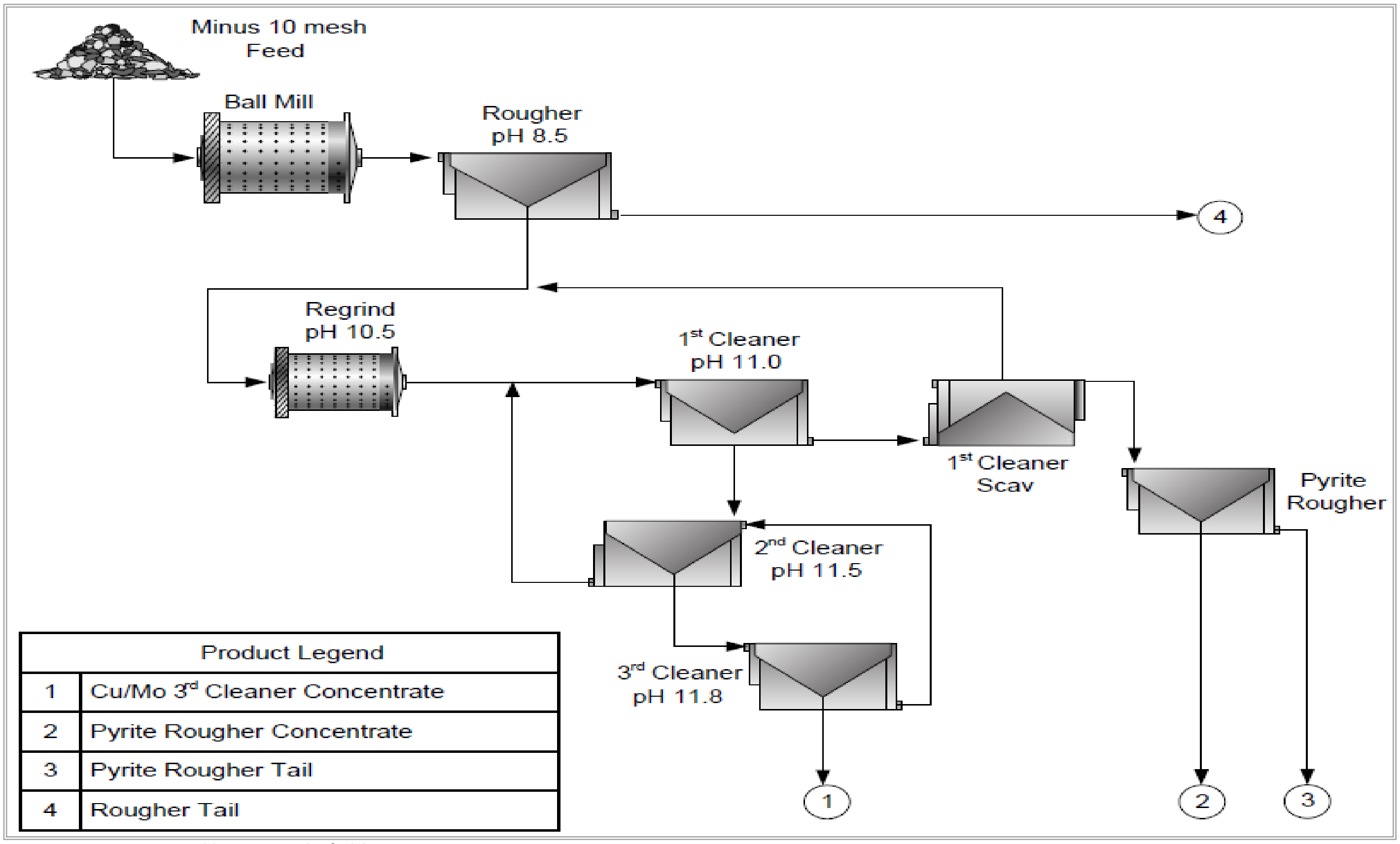
13.3.1.2 Flotation Tests on Variability Samples

SGS Lakefield conducted significant flotation testwork since mid-2009 on both the Pebble West and Pebble East zones. The baseline flowsheet is shown in Figure 13-1. The target pH value for the rougher flotation stage was set at 8.5, and the P_{80} feed particle size was about 200 µm. The regrind size, reagent dosage and types and pH levels in the cleaner flotation stage were varied across the testwork in order to determine the optimal copper grade of the bulk concentrate.

SGS Lakefield conducted batch cleaner tests on 146 variability samples from the Pebble West and Pebble East zones. The variability samples represented the flotation geometallurgical domains as described in Section 13.9.2 and should be considered representative of the mineralized material. Five of the variable batch cleaner tests were performed on the low copper grade samples. At an average feed grade of 0.16% copper, a bulk concentrate containing about 29.3% copper can be recovered at a 68.1% recovery. This indicates that a saleable concentrate can be produced from low-grade mineralized material.

SGS Lakefield also performed locked-cycle tests on 107 variability samples from the Pebble West and Pebble East zones, the results of which are summarized in Table 13-9. The average metal recoveries were higher than with the batch tests, while the metal grades of the concentrates were slightly lower. Three duplicate locked-cycle tests were performed, with results in a similar range to those obtained from the variable locked-cycle tests.

Figure 13-1: Basic Testwork Flowsheet



Note: Figure prepared by SGS Lakefield, 2011

Table 13-9: Summary of Locked-Cycle Test Variability Test Results

Domain	Feed Properties						3rd Cl Average Grade			3rd Cl Average Rec		
	Py	Cpy	Py:Cpy	Cu	Au	Mo	Cu	Au	Mo	Cu	Au	Mo
	%	%		%	gpt	%	%	gpt	%	%	%	%
Supergene Illite Pyrite	6.8	0.8	7.0	0.33	0.4	0.011	24.1	37.7	0.8	64.3	36.0	61.0
Supergene Sodic Potassic	3.3	1.0	4.0	0.48	0.42	0.016	30.7	19.6	0.8	75.4	53.8	54.7
Hypogene Illite Pyrite	6.4	1.0	6.3	0.36	0.43	0.015	27.2	18.3	1.1	83.8	44.2	77.3
Hypogene Sodic Potassic	3.7	1.0	4.8	0.35	0.38	0.024	27.5	19.5	1.8	84.6	55.6	79.8
Hypogene K-Silicate	3.1	2.3	1.9	0.63	0.62	0.024	27.6	21.4	1.2	90.8	59.6	88.4
Hypogene Sericite	8.3	1.9	6.1	0.66	0.36	0.031	25.1	7.6	1.3	82.5	41.9	82.0
Hypogene Quartz-sericite-pyrite	11.8	2.2	6.9	0.58	0.33	0.036	25.7	5.7	1.6	86.0	33.0	85.6
Hypogene Quartz Pyrophyllite	18.1	5.0	3.7	1.51	0.83	0.027	30.5	11	0.5	93.6	60.9	84.5

Definitions: cleaner (Cl), pyrite (Py), chalcopyrite (Cpy), pyrite to chalcopyrite ratio (Py:Cpy), Recovery (Rec)

Samples from 10 locked cycle tests were submitted for rhenium and silver assays to complete a mass balance. The recoveries of rhenium and silver to the 3rd cleaner concentrate was calculated as 73.4% and 62.7%, respectively, as shown in Table 13-10. A linear relationship between the recovery of molybdenum and rhenium can be observed on the ten sets of data. This can be attributed to the rhenium occurrence as a solid substitution for molybdenite atoms on the molybdenite lattice structure (SME, 2018).

Table 13-10: Locked-Cycle Test Results on Pebble Variability Samples, SGS Lakefield, 2014

Test #/Composite	Cu/Mo Concentrate Grade, %, g/t					Cu/Mo Concentrate Recovery %				
	Cu	Au	Mo	Ag	Re	Cu	Au	Mo	Ag	Re
LCT1/W182	28.8	12.3	0.38	69	9.7	67.2	41.4	43.8	29.6	42.0
LCT4/W265	30.5	33.9	0.67	76	10.0	82.2	68.6	68.6	48.9	58.5
LCT7/W223	27.3	21.7	0.7	60	18.4	72.7	67.8	74.7	62.9	76.3
LCT41/W181	31.9	24.6	0.31	90	6.0	73.0	56.5	51.5	62.9	45.9
LCT62/V101	31.2	11.4	0.45	74	5.3	93.0	64.9	82.2	80.8	83.2
LCT63/V102	29.5	10.6	0.51	81	8.2	94.2	56.9	86.7	81.4	87.8
LCT64/V130	24.2	18.0	1.80	104	32.8	89.3	61.1	96.4	74.7	96.3
LCT66/V222	24.8	3.8	2.07	82	33.1	83.9	29.1	89.9	73.0	91.0
LCT69/V263	24.3	6.0	1.40	65	26.3	84.2	35.7	67.0	63.1	71.0
LCT89/W312	18.0	11.6	1.05	99	22.1	56.2	37.7	77.5	49.6	82.4

13.3.1.3 Flotation Tests Optimization

SGS Lakefield made a few attempts to improve the copper grade in the obtained bulk concentrate for samples with high clay and/or pyrite/chalcopyrite content. SGS Lakefield observed that:

- adding sodium silicate did not appear to have a beneficial impact on the selectivity of metal recovered to rougher flotation concentrate;
- reducing pulp density from 35% to 28% solids improved metal recoveries, especially with molybdenum;
- for samples high in pyrite, adding dextrin helped to achieve the desired 26% copper of bulk concentrate copper/gold/molybdenum; however, it was also noted that extra fuel oil will be required when adding dextrin. SGS Lakefield also recommended considering a ratio of sulphur to copper of greater than 10 to identify if dextrin addition is required;
- the effects of regrind size, and pulp temperature were further investigated in batch cleaner flotation tests and in the locked-cycle tests. The testwork was performed by SGS Lakefield in both 2011 and 2012, resulting in the following major conclusions: the investigated regrind size P_{80} of 15 to 58 µm had little impact on copper recovery or grades, while a finer regrind size benefitted both gold and molybdenum recovery; and

- there was no observed impact from changing the pulp temperature from 5°C to 25°C on flotation recoveries.

SGS Lakefield also compared two other frothers (HP700 and W22 C) with the primary frother, methyl isobutyl carbinol (MIBC). SGS Lakefield found that the HP700 froth bed was less stable than that of the MIBC; W22 C showed better molybdenum recovery, and a lower dosage produced similar metal recoveries. SGS Lakefield also compared the lower cost collector sodium ethyl xanthate (SEX) with PEX and concluded that interchanging SEX and PEX had no effect on metal recoveries.

13.3.1.4 Flotation Tests on Bulk Composites

As part of SGS Lakefield's 2011 test program, bulk flotation tests on a locked-cycle scale were conducted on illite-pyrite, carbonate and supergene composites. The purpose of this testwork was to produce large quantities of products that could be used for vendor testwork. It should be noted that the carbonate composite sample was an early geometallurgical domain type classification and was redefined as sodic potassic in later geometallurgical studies. The locked-cycle test results are shown in Table 13-11. SGS Lakefield observed that the illite-pyrite composite did not reach the target copper grade of 26%. SGS suspected this may be caused by a low head grade and the presence of high levels of pyrite and clay minerals.

Table 13-11: Locked-Cycle Test Results of Bulk Samples, SGS Lakefield, 2012

Composite	Regrind Size P_{80} µm	Cu/Mo Concentrate Grade				Cu/Mo Concentrate Recovery %		
		%	Au g/t	Au oz/ton	Mo %	Cu	Au	Mo
Illite-Pyrite	28	10.4	11.2	0.327	0.20	77.0	40.3	34.9
Carbonate	37	28.4	10.7	0.312	1.25	79.4	43.5	59.8
Supergene	38	27.1	16.0	0.467	1.64	70.6	47.3	70.0

13.3.1.5 Continuous Flotation Tests on Composites

A continuous flotation plant was utilized on five composite samples from the Pebble deposit to generate additional quantities of sample for vendor testwork. The five composites ranged in head grade from 0.28 to 0.57% Cu, from 0.30 to 0.46 g/t Au, and from 0.010 to 0.028% Mo. The main purpose of this continuous flotation testwork was to generate product for downstream testwork and to evaluate the implementation of a gravity circuit on a portion of the feed to the regrind mill. A continuous flotation plant was utilized on five composite samples from the Pebble deposit to generate additional quantities of sample for vendor testwork. The five composites ranged in head grade from 0.28 to 0.57% Cu, from 0.30 to 0.46 g/t Au, and from 0.010 to 0.028% Mo.

The pilot plant was completed over a series of day shifts and continuous runs. Overall, 28 runs were completed: 17 on the commissioning composite representing first years of operation, 3 on the sodic potassic, 2 on the K-silicate, 3 on the supergene, and 3 on the illite pyrite composites. The additional water generated by incorporation of the Knelson concentrator (gravity circuit) was managed by using a thickener to treat the gravity tailings stream. Any further continuous testwork would ideally be completed on a higher feed rate and a sufficient amount of operation time reserved for reagent optimization.

The continuous flotation results for the K-Silicate composite were close to the locked cycle test results, with the exception that molybdenum recoveries were slightly lower. The continuous flotation copper recovery for the supergene composite was higher compared to the locked cycle test result. For the remaining three composites, copper and gold recoveries were

7% lower, on average. Except for the supergene composite, molybdenum losses to the rougher tail were almost twice as high as in the locked cycle test. Final concentrate molybdenum recoveries were almost half the LCT recoveries. The molybdenum recovery to the final concentrate would likely improve with longer retention times in the 2nd and 3rd cleaning stages.

One of the main purposes of the pilot plant was to determine the amount of gold that could be recovered by adding a Knelson concentrator in the regrind circuit. The Knelson concentrator treated a 33% bleed stream from the regrind cyclone underflow. The average gold recovery to the Knelson concentrate ranged from 2.6% for the Supergene composite to 7.5% for the K-silicate composite. A comparison of metallurgical performance with and without the Knelson concentrator indicated similar overall gold recoveries to a 26% copper concentrate.

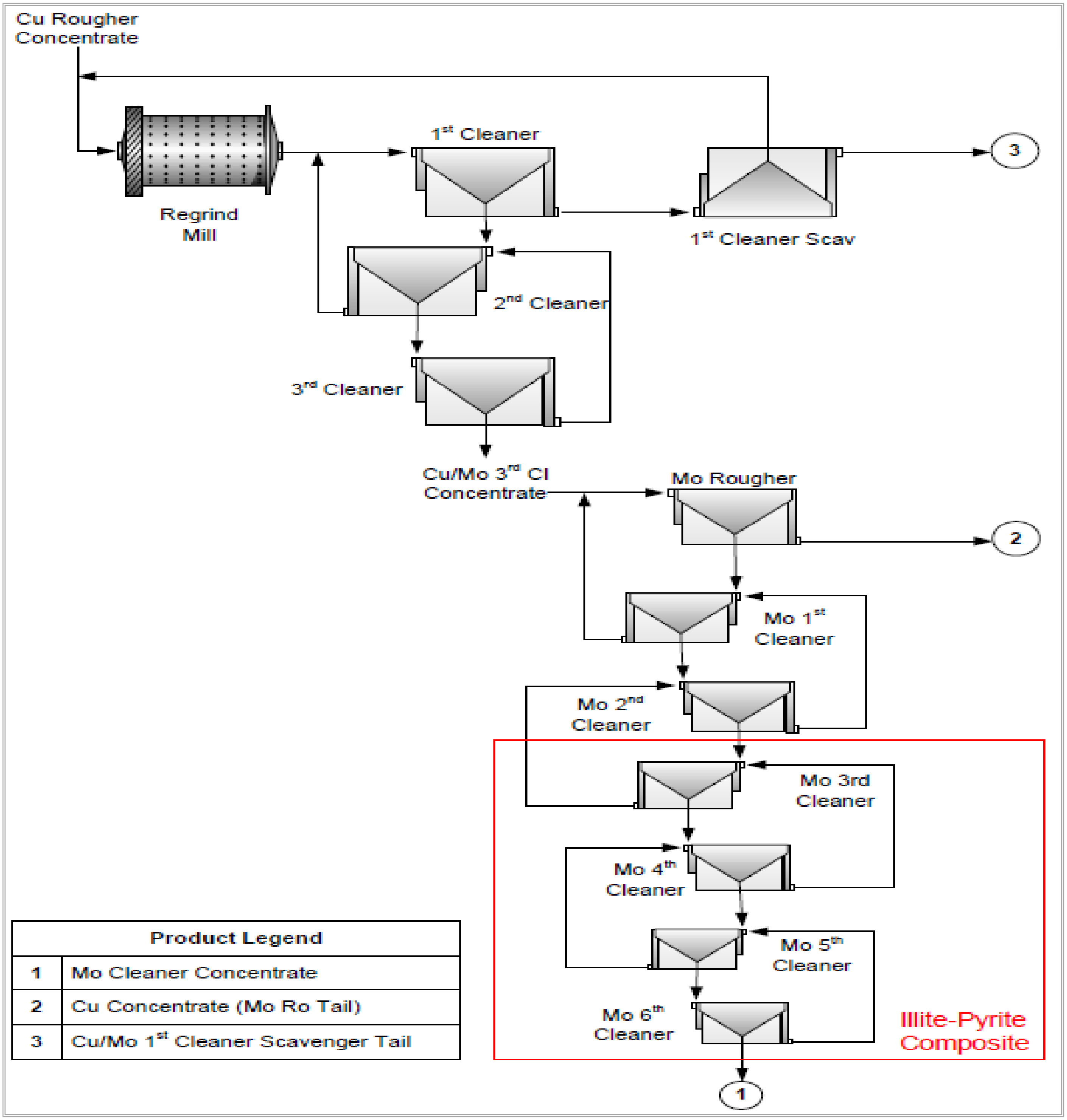
13.3.2 Separation of Molybdenum and Copper

Separation of molybdenum from copper in the bulk flotation concentrate was tested by SGS Lakefield in the 2011 and 2012 programs. In addition, G&T also performed separation tests on one sample in 2011.

13.3.2.1 SGS Lakefield Separation Work, 2011 and 2012

Preliminary separation tests for molybdenum and copper were performed on three composite samples, including illite-pyrite, carbonate and supergene (SGS Lakefield, 2011). The locked-cycle tests in the 2011 program employed a basic flowsheet, as shown in Figure 13-2. The cycle numbers were varied in order to achieve the target grade of a final molybdenum concentrate.

Figure 13-2: Basic Testwork Flowsheet



Note: Figure prepared by SGS Lakefield, 2011.

The 2011 program results outlined in Table 13-12 show that only the carbonate composite achieved a molybdenum grade of 50%, while the other two composite samples were unable to produce a marketable molybdenum product. Increasing the locked cycles from 3 to 6 for the illite-pyrite composite produced only a marginal increase in molybdenum grade.

As part of the 2012 testing program, further tests to improve the molybdenum separation were conducted on four domain samples. The commissioning sample, which represented the sodic potassic domain, was used to optimize the flotation conditions required for copper-molybdenum separation. A series of open cycle and kinetic tests were conducted to establish the conditions for the commissioning composite locked cycle test. Results of the locked cycle tests are provided also in Table 13-12.

Locked cycle test results for the latter three composites were found to be below expectations. It should be noted that the locked cycle tests conducted on the illite pyrite, sodic potassic and supergene composites were carried out without the open cycle tests to confirm conditions (due to their smaller mass compared to the commissioning composite), and by a different flotation operator than previous. Molybdenum head grades of the bulk cleaner concentrates from the three problematic domain samples were also below typical values achieved in locked cycle tests which may have contributed to the poor results. Further investigation confirmed that major molybdenum loss occurred in the rougher circuit.

Addition of the flotation reagent sodium hydrosulfide (NaHS) in the rougher stage was found to be too high, resulting in unacceptable molybdenum depression. Adding a scavenger stage to the rougher flotation resulted in significant improvements in molybdenum recovery of approximately 15% for the sodic potassic composite, and over 30% for the illite pyrite composite. The scavenger tests were not conducted for the supergene composite due to lack of sample.

Table 13-12: Locked-Cycle Test Results of Molybdenum Flotation

Composite	Regrind Size P_{80} µm	Mo Concentrate						Cu Concentrate					
		Grade			Recovery %			Grade			Recovery %		
		Cu %	Au g/t	Mo %	Cu	Au	Mo	Cu %	Au g/t	Mo%	Cu	Au	Mo
SGS 2011													
Illite-Pyrite	28	5.93	15.4	11.6	0.7	0.9	32.3	10.5	11.1	0.015	76.3	39.4	2.6
Carbonate	37	1.81	3.96	49.7	0.1	0.4	55.5	29.0	10.9	0.091	79.3	43.1	4.2
Supergene	38	3.46	3.84	38.7	0.4	0.5	68.9	28.1	16.5	0.027	70.2	46.8	1.1
SGS 2012													
Commissio n	-	1.86	2.12	48.2	0.2	0.3	92.7	21.8	11.2	0.068	99.8	99.7	7.3
Sodic Potassic	-	3.01	N/A	41.1	0.1	N/A	83.6	23.3	N/A	0.074	99.9	N/A	16.4
Illite-Pyrite	-	3.19	N/A	43.5	0.02	N/A	79.8	23.8	N/A	0.14	99.8	N/A	20.2
Supergene	-	2.42	N/A	43.8	0.1	N/A	86.9	29.8	N/A	0.078	99.9	N/A	13.1

Note: Prepared by SGS Lakefield, 2011-2012.

13.3.2.2 G&T Separation Work

G&T tested molybdenum recovery from bulk flotation concentrate, using one sample of copper-molybdenum bulk concentrate (G&T 2011). The head analysis indicated that the bulk concentrate had high levels of pyrite (about 13.2%) and galena (about 0.5%). Due to the limited sample size, only two batch cleaner tests were performed on the bulk concentrate sample. A regrind stage was used in Test 1, while no regrinding was performed in Test 2. The test results are summarized in Table 13-13.

Test 1 and Test 2 results were 50.6% and 47.6% for molybdenum grades in the final molybdenum concentrates, and recoveries were 76.2% and 74.7% molybdenum, respectively. G&T recommended further testing be considered, including locked-cycle tests and other potential reagent schedules.

Table 13-13: Molybdenum Recovery

	Regrind Size P_{80} µm	Grade				Recovery %		
		Cu %	Au		Mo%	Cu	Au	Mo
			g/t	oz/ton				
Test 1	33	-	-	-	-	-	-	-
Molybdenum Concentrate	-	1.45	2.36	0.0689	50.6	0.1	0.2	76.2
Molybdenum 3rd Cl Tail	-	12.9	18.9	0.552	12.1	0.1	0.2	3.0
Molybdenum 2nd Cl Tail	-	24.2	35.4	1.034	3.89	1.2	3.1	6.9
Molybdenum 1st Cl Tail	-	24.3	27.7	0.809	1.47	5.3	10.4	11.3
Molybdenum Ro Tail	-	26.3	14.2	0.415	0.02	93.3	86.2	2.6
Test 2	49	-	-	-	-	-	-	-
Molybdenum Concentrate	-	2.74	3.92	0.114	47.6	0.1	0.3	74.7
Molybdenum 3rd Cl Tail	-	14.8	21.2	0.619	8.18	0.1	0.2	1.4
Molybdenum 2nd Cl Tail	-	21.3	38.4	1.12	5.51	0.5	1.5	4.3
Molybdenum 1st Cl Tail	-	27.9	28.4	0.829	0.80	3.6	6.5	3.6
Molybdenum Ro Tail	-	26.0	13.9	0.406	0.12	95.8	91.5	16.0

Source: G&T, 2011

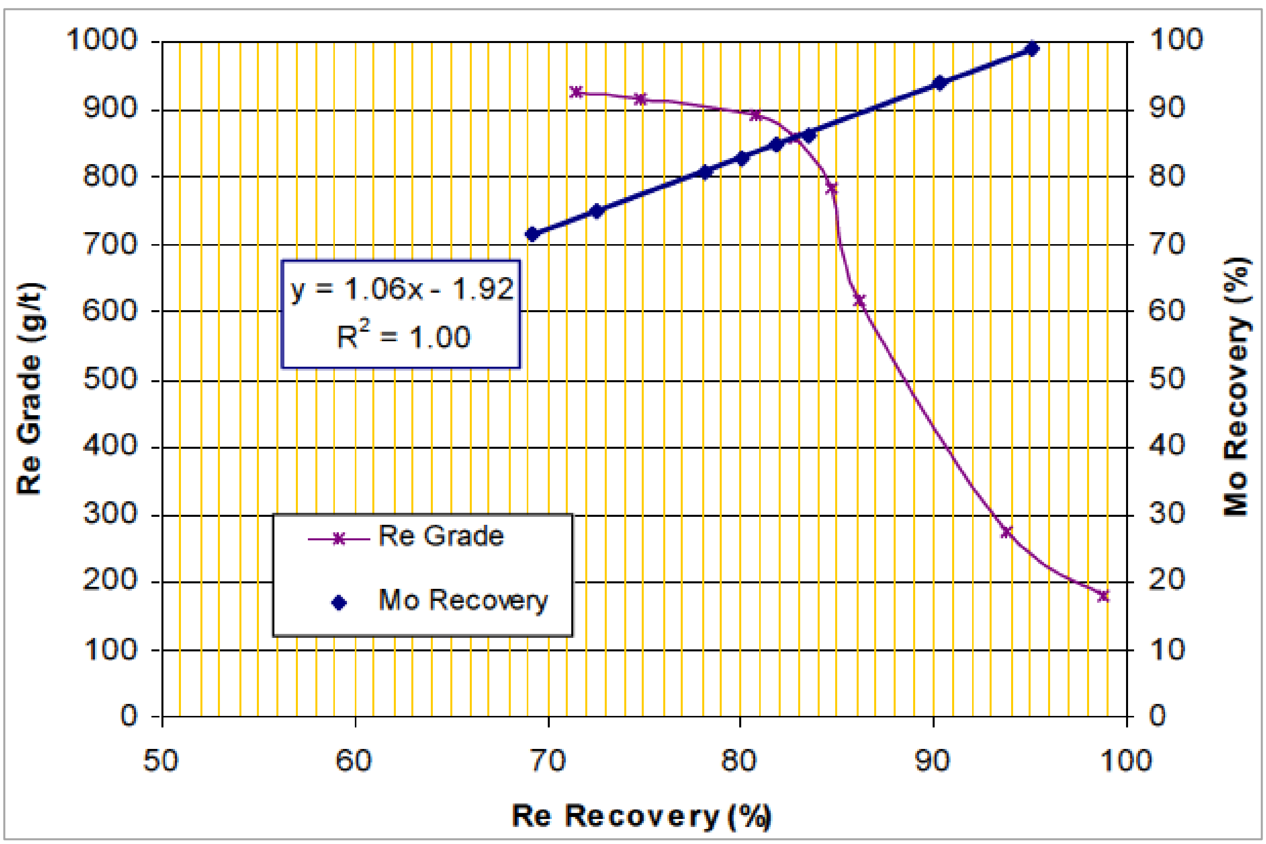
13.3.3 Rhenium Recovery into Molybdenum Concentrate

Rhenium was shown to report to the molybdenum concentrate in molybdenum flotation process. A rhenium mass balance was reported by SGS Lakefield in 2012 with the test results of an open circuit batch molybdenum cleaner flotation test (Mo-F13), as shown in Table 13-14. Figure 13-3 presents the rhenium recovery and grade data. Rhenium grade of over 900 g/t was observed in the 5th and 6th cleaner molybdenum concentrates. A linear relationship is also noticed between molybdenum recovery and rhenium recovery.

Table 13-14: Molybdenum Open Cycle Cleaner Flotation Test Results (Mo-F13, SGS Lakefield, 2012)

Products	Weight		Assays				Distributions			
	g	%	Cu %	Mo %	Au g/t	Re g/t	Cu %	Mo %	Au %	Re %
Mo 6th Cl Conc	42.9	1.21	1.59	49.0	1.75	926	0.1	69.2	0.2	71.4
Mo 6th Cl Tail	2.5	0.07	3.69	40.8	2.17	759	0	3.4	0	3.4
Mo 5th Cl Tail	5.1	0.14	5.76	33.9	3.79	651	0	5.7	0.1	6
Mo 4th Cl Tail	3.2	0.09	11	18.1	7.82	341	0	1.9	0.1	2
Mo 3rd Cl Tail	6.5	0.18	18.6	8.29	14.3	163	0.2	1.8	0.2	1.9
Mo 2nd Cl Tail	17.4	0.49	30.1	2.85	17.6	47.6	0.7	1.6	0.8	1.5
Mo 1st Cl Scav Conc	7.9	0.22	14.7	18.6	12.9	364	0.2	4.8	0.3	5.2
Mo 1st Cl Scav Tail	104.3	2.94	25	0.58	15.2	13.1	3.6	2	4.2	2.5
Rougher Sc Conc	116.9	3.3	23.8	1.24	13.3	24	3.9	4.8	4.2	5
Rougher Scav Tail	3235.5	91.3	20.2	0.046	10.4	<0.2	91.2	4.9	89.9	1.2
Head (calc.)	3542.2	100	20.2	0.86	10.6	15.7	100	100	100	100

Figure 13-3: Rhenium Grade and Recovery Relationship



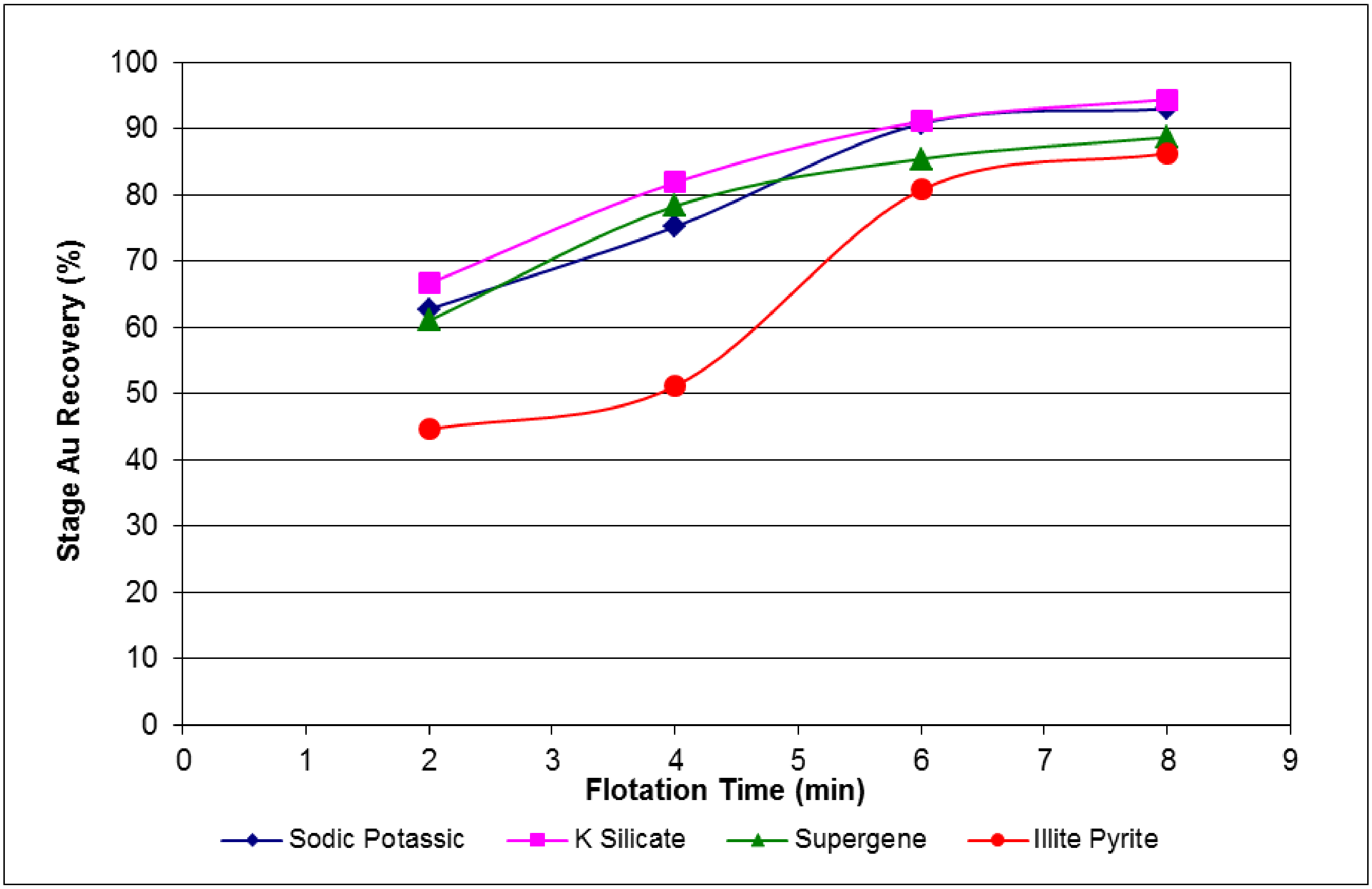
Note: Figure prepared by SGS Lakefield, 2012.

13.3.4 Pyrite Flotation

The purpose of a pyrite flotation is to concentrate gold-bearing sulphide minerals prior to a subsequent leach process to recover additional precious metals.

A pyrite flotation step was included as part of the locked cycle variability tests. The pyrite flotation stage gold recoveries from the initial samples were found to be highly variable in a four-minute laboratory flotation process. In order to optimize the pyrite flotation metallurgy, SGS Lakefield performed a series of kinetics tests on the first scavenger tailings samples generated from four domain composite samples. Results of the tests are summarized in Figure 13-4 which shows the optimum laboratory flotation time occurs at approximately eight minutes.

Figure 13-4: Pyrite Flotation Kinetics Test Results



Note: Figure prepared by SGS Lakefield, 2012

13.4 Gold Recovery Tests

Both gravity concentration and cyanide leaching methods were investigated as part of metallurgical test program to recover gold from the mineralized samples.

13.4.1 Gravity Recoverable Gold Tests

Three composite samples, representing illite-pyrite, carbonate and supergene mineralization types, were tested for GRG potential in COREM's facility (COREM, 2010). GRG tests were carried out on the variable samples reground to a target particle size P_{80} of 25 µm. Using a modified GRG test, the supergene sample had the highest GRG content of 33%, followed by illite-pyrite with 29% GRG and carbonate at 23%.

In 2011, four composite samples from the continuous testwork program were tested for gravity recoverable gold. K-silicate sample had the highest GRG potential at 49%, followed by sodic potassic (41%), supergene (33%), commissioning (26%), and illite pyrite (25%).

13.4.2 Gold Recovered from Leaching

Cyanide leaching testwork was carried out on the pyrite concentrates of various samples. Initial tests indicated that gold recovery can be significantly increased by an average of 15% when the pyrite concentrate particle size was reduced to a P_{80} of approximately 10 µm (SGS Lakefield, 2011).

The pyrite concentrate regrind test was conducted showed the average power consumption as 48.7 kWh/t at a target P_{80} of 10 µm, and the average media consumption was 22.2 g/kWh.

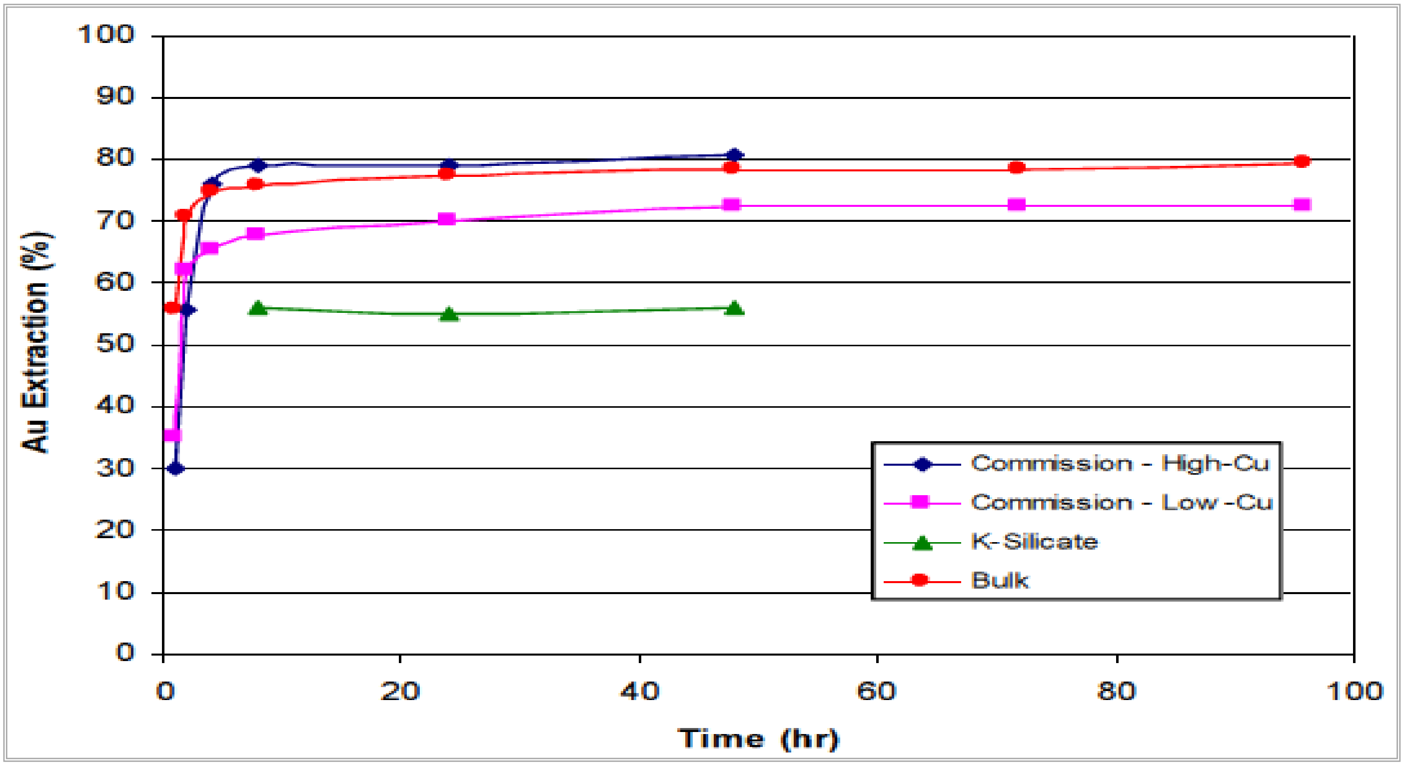
Further cyanide leaching tests were carried out on the reground pyrite concentrate on variable samples (SGS 2012). The optimized leaching test conditions that gave the best gold, copper and silver extraction rates are summarized below:

- pre-oxidation with oxygen addition to 20 ppm before leaching;
- leaching pulp density of 33% solids;
- leaching pH 10.5 to 11.0; and
- cyanide concentration of 2 g/L.

Variable sample cyanide leaching tests were performed under the optimized condition. The average extraction rates were 72.9% for gold, 72.8% for silver and 75.5% for copper with a 48-hour leaching period.

Bulk leaching test CN-51 was conducted under the same conditions with varied composite samples. The leaching kinetic properties are shown in Figure 13-5.

Figure 13-5: Bulk Cyanidation Silver Extraction Kinetics



Note: Figure prepared by SGS Lakefield, 2012.

Carbon adsorption tests were carried out on commission composite samples as well as K-silicate composite samples. The observations are summarized as follows:

- Most leaching can be completed after about 12 hours, but some concentrates benefited from a longer leach time of 24 to 48 hours; and,
- The copper loading rate on carbon was higher than with gold or silver, approximately 20 lb/ton from solution containing 4 to 4.5 g/L copper, approximately 8 lb/ton from a 1.5 to 2.5 g/L copper solution.

Leaching circuit simulations were performed by SGS, as described in their 2012 report. The simulations were based on 3,300 US GPM slurry feed of low-copper commissioning composite samples, high-copper commissioning samples, and K-silicate composite samples. From the simulation results, it was noticed that:

- A total of 24 hours should be allowed for leaching and carbon adsorption;
- At least 6 to 10 hours of leaching is required before the first carbon adsorption for optimum carbon adsorption; this results in a hybrid leaching plant of carbon-in-pulp (CIP) + CIL arrangement;
- A minimum of six adsorption tanks are required due to the slow carbon adsorption kinetics of gold and silver. Additional tanks will be required if targeting less than 0.01 ppm gold in barren solution;

- The carbon adsorption tanks will require a relatively high carbon inventory of about 38.5 ton per stage; and,
- The efficiency of the gold stripping plant should be maintained at over 95% to prevent gold loss when recycling back to the leaching circuit.

13.5 SART Process (Sulphidization, Acidification, Recycling, Thickening)

SGS tested SART potential to recover the dissolved copper in the leaching circuit. SART lab tests were performed on both high- and low-copper pyrite concentrates. For the high-copper sample, the lowest copper concentration in the final solution was lower than 10 ppm from the original 3,130 ppm. With the low-copper sample, the concentration of copper dropped from 1,810 ppm to about 3 ppm. The test conditions for the two optimized results within this test range were:

- The addition of sulphuric acid (H_2SO_4) to reach a pH value of 4.0; and,
- The addition of the reagent NaHS at 130% of the stoichiometric ratio.

13.6 Cyanide Destruction

SGS tested cyanide destruction with the Inco sulphur dioxide (SO_2/air) destruction process on various composite samples. It was observed that, when the sample had a high concentration of weak acid dissociable cyanide (CNWAD) of 1,680 mg/L, a long retention time of six hours was required to achieve a CNWAD of 1.0 mg/L in the treated solution. However, when the CNWAD concentration in the feed sample was reduced to 400 ppm, the required retention time fell to about two hours to achieve a CNWAD of less than 0.1 mg/L in the treated solution.

13.7 Auxiliary Tests

13.7.1 Concentrate Filtration

Outotec tested the filtration rates and cake moisture on a copper concentrate sample (Outotec, 2011). Three tests with varied pumping times were performed at Outotec's laboratory. With a feed solids density of 58 to 60% by weight, the cake moisture for all three tests was less than 9%. The measured filtration rate was between 569 and 663 kg/m^2/h.

13.8 Quality of Concentrates

The results of the detailed assays obtained on all the variability locked cycle test copper/molybdenum 3rd cleaner concentrates were completed and reported in the 2014 SGS Lakefield report. Table 13-15 shows the major elements distributions. The median concentrations of the potentially payable elements in the final copper/molybdenum concentrates are 27.5% Cu, 15.5 g/t Au, 1.07% Mo, 20.2 g/t Re and 71 g/t Ag.

Table 13-15: LCT Cu-Mo Concentrate Major Elements Analysis Results – SGS Lakefield, 2014

Variability Samples	Cu %	Au g/t	Mo %	S %	Fe %	Re g/t	Ag g/t
Average	27.1	16.9	1.26	34.6	29.9	23.7	75
Min	17.6	1.2	0.07	23.5	23.5	1.3	20
Median	27.5	15.5	1.07	34.4	29.9	20.2	71
Max	39.0	52.7	4.82	40.7	34.5	122.0	151

Note: Prepared by Lakefield, 2014.

The detailed elemental analysis was also completed on the copper-molybdenum concentrate samples of the variability locked cycle tests as reported in the 2014 SGS Lakefield report. The results indicate that the Pebble bulk concentrate will not be problematic in terms of deleterious elements. The assays showed that more than 90% of the 103 variability samples were below the penalty triggers for mercury, antimony, arsenic, and zinc, with the exception of 10 samples from illite pyrite and sodic potassic zones.

The elemental analysis of copper concentrates and molybdenum concentrates from the copper/molybdenum separation testwork are listed in Table 13-6 and Table 13-17. The reported rhenium grade in the LCT molybdenum concentrate ranged from 791 to 832 g/t Re.

Table 13-16: LCT Cu Concentrate Major Elements Analysis Results – SGS Lakefield, 2014

	Cu %	Au g/t	Mo %	S%	Fe %	Re g/t	Ag g/t
Illite Pyrite	23.0	10.2	0.026	36.1	31.8	0.4	91
Supergene	29.3	11.4	0.065	33.0	28.9	1.5	104
Sodic Potassic	24.0	8.54	0.011	36.2	33.1	<0.2	37
K-Silicate	24.0	8.41	0.021	36.6	32.9	0.3	39
Commission	21.2	10.6	0.032	35.0	32.1	0.5	80

Table 13-17: LCT Mo Concentrate Major Elements Analysis Results – SGS 2014

	Cu %	Au g/t	Mo %	S%	Fe %	Re g/t	Ag g/t
Illite Pyrite	3.94	3.42	42.6	38.5	5.33	791	31.6
Supergene	2.45	3.87	43.7	34.0	3.84	832	23.2
Sodic Potassic	3.71	3.60	43.0	34.9	5.31	830	22.9
K-Silicate	2.53	1.34	50.9	36.7	3.34	n/a	11.1
Commission	1.94	2.12	47.8	35.9	3.37	812	<40

13.9 Geometallurgy

13.9.1 Introduction

Geometallurgical studies were initiated by the Pebble Partnership in 2008 and continued through 2012. The principal objective of this work was to quantify significant differences in metal deportment, meaning the mineralogical association of a given metal that may result in variations in metal recoveries during mineral processing.

Characterization of the respective geometallurgical domains within the deposit was based on the acquisition of detailed mineralogical data determined using QEMSCAN® mineral mapping technology. QEMSCAN® was used to form the basis for definition of the geometallurgical domains as follows:

- to determine the mineralogy of samples;
- to classify them by alteration assemblage;
- to assess variations in copper mineral speciation; and
- to locate gold inclusions down to 1 µm in diameter and characterize their size, shape, composition and host mineralogy.

The results of the geometallurgical studies indicate that the deposit comprises numerous geometallurgical domains. These domains are defined by distinct, internally consistent copper and gold deportment characteristics that correspond spatially with changes in silicate alteration mineralogy. Overall metal deportment reflects characteristics developed during both the initial stage of metal introduction that occurred during specific stages of alteration and subsequent redistribution by overprinting alteration types.

Chalcopyrite is the dominant copper mineral in most of the deposit. Bornite is a greatly subordinate component that is most abundant in advanced argillic alteration. Supergene mineralization, in the form of chalcocite and lesser bornite and covellite, forms rims on and partially replaces hypogene chalcopyrite in the near surface portion of the western half of the deposit, where mineralization was exposed subsequent to glaciation (there is no evidence for paleo-supergene effects in the eastern part of the deposit that is located beneath the post-hypogene rocks of the cover sequence). Hypogene pyrite is present in much of the supergene zone where it typically has been partially replaced by the supergene copper minerals. Molybdenum deportment does not vary appreciably across the deposit, and this metal occurs exclusively in the mineral molybdenite. The deportment of silver and palladium has not been studied in detail. Rhenium occurs as a substitution for molybdenum in the matrix of molybdenite, but the potential for spatial and temporal variations in the degree of substitution has not been studied.

Gold has a more variable deportment across the deposit than the other primary metals of economic interest, and this behaviour can be related directly to variations in predicted gold recoveries to different metallurgical products, as determined by metallurgical testwork. Gold occurs mostly as inclusions in chalcopyrite, pyrite, and to a much lesser extent, in silicate alteration minerals. The proportion of gold hosted by chalcopyrite, pyrite, and the silicate alteration minerals varies significantly between volumetric domains that were affected by different types or combinations of hydrothermal alteration (Gregory et al., 2013). The consequence of these differences in gold deportment is that different alteration domains exhibit different degrees of recovery to different processing materials, such as copper concentrates versus pyrite concentrates versus silicate tailings. It is this knowledge of the relationship between hydrothermal alteration, as defined in a three-dimensional alteration model for the Pebble deposit, and the specific deportment of gold micro-inclusions that allows the spatial variations in gold recovery across the deposit to be modelled.

13.9.2 Description of Geometallurgical Domains

Hypogene mineralization in the Pebble deposit has been divided into seven geometallurgical domains, the boundaries of which correspond to the distribution of specific alteration types and their combination within the three-dimensional alteration model. The most volumetrically significant geometallurgical domains are the potassic (in some places referred to as K-silicate or potassium silicate) and sodic-potassic domains, whereas the illite-pyrite, QSP, quartz-pyrophyllite, sericite, and 8431M (see Section 13.9.2.7 for definition of this domain) domains are smaller. Two additional domains occur in the western part of the Pebble deposit where the sodic-potassic and illite-pyrite domains are overprinted by supergene alteration. These domains are being used to constrain the geometallurgical parameters in the resource block model. Specific metallurgical recoveries have been applied to each geometallurgical domain (see Section 13.10).

13.9.2.1 Potassic Domain

The potassic domain is concentrated near the top of the main granodiorite pluton and its immediate host rocks in the eastern part of the deposit. Material in this domain is dominated by K-feldspar, quartz, and minor biotite, and has been variably overprinted by illite. The copper sulphide minerals are dominated by chalcopyrite, accompanied by a subequal concentration of pyrite and, more rarely, traces of sphalerite. Gold occurs dominantly as inclusions in chalcopyrite. This material type is volumetrically most important in the Pebble East zone and is predicted to have the best metallurgical response due to low clay and pyrite concentrations and a close association of gold with chalcopyrite.

13.9.2.2 Sodic-Potassic Domain

Material in the sodic-potassic domain is dominated by K-feldspar, quartz, albite and biotite, accompanied by low concentrations of subequal illite and kaolinite. Chalcopyrite is the main copper sulphide mineral and the ratio of pyrite to chalcopyrite is moderate and a bit higher than in the potassic domain. The carbonates siderite and ferroan dolomite are also commonly present. Gold occurs as inclusions in both chalcopyrite and pyrite. It is the dominant geometallurgical domain in the western part of the deposit and extends to depth to the east, below the potassic domain. Supergene mineralization is present in the uppermost part of this domain in the western part of the deposit.

13.9.2.3 Illite-Pyrite Domain

The mineralogical characteristics of the illite-pyrite domain reflect successive, partial overprints of quartz-sericite-pyrite and later illite alteration on an early stage of well-mineralized sodic-potassic and/or potassic alteration. Illite-pyrite material is dominated by K-feldspar, quartz, illite and biotite. The illite-pyrite domain has a high concentration of pyrite and a high ratio of pyrite to chalcopyrite. This assemblage occurs in the shallow part of the eastern portion of the Pebble West zone and also extends to the east where it replaces potassic alteration below the cover sequence. Supergene mineralization affects the upper part of the illite-pyrite domain in the western part of the deposit that is not concealed by the younger cover sequence. Gold deports as inclusions both within early chalcopyrite that is part of the early sodic-potassic and potassic alteration, and to a greater extent in pyrite that formed during the later alteration overprints. The high clay and pyrite concentrations are expected to lead to processing challenges that could include the increase of reagent consumptions and/or the decrease of a flotation selectivity between copper minerals and pyrite. Additionally, the gold-pyrite association will result in a lower gold recovery to the final copper flotation concentrate compared to the sodic-potassic and potassic geometallurgical domains.

13.9.2.4 Quartz-Sericite-Pyrite Domain

The QSP domain occurs on the north and south margins of the alteration model. This alteration is a late-stage overprint around the margins of the deposit and is strongly grade destructive for copper, molybdenum, and gold that originally formed during earlier alteration types. This material is dominated by quartz and sericite, has a very high pyrite concentration, and contains very little chalcopyrite. As a consequence, both grade and recovery of this domain are very low and it would form a part of the normal processing stream.

13.9.2.5 Quartz-Pyrophyllite Domain

The quartz-pyrophyllite domain is coincident with the distribution of quartz pyrophyllite alteration. It occurs in the easternmost part of the deposit where it has typically overprinted an older zone of potassic alteration with a very high concentration of quartz veins. This material is composed mostly of quartz, sericite, and pyrophyllite. -pyrophyllite assemblage. This domain has high concentrations of both pyrite (average 9.7 wt%) and chalcopyrite (average 3.8 wt%), along with very low concentrations of bornite. Gold mostly occurs as inclusions in chalcopyrite, with lesser amounts in pyrite and silicate alteration minerals. This is the highest-grade material in the deposit and has favourable gold deportment, but also has higher clay and pyrite concentrations.

13.9.2.6 Sericite Domain

The high-grade sericite domain is different to the very low-grade quartz-sericite-pyrite domain. The sericite domain is characterized by quartz, sericite, minor pyrophyllite, and variable concentrations of K-feldspar. This material occurs in two areas within the Pebble East zone. The main and most intense volume of sericite domain occurs south of the ZE fault and forms an envelope to the western side of the quartz-pyrophyllite domain. A second, much weaker and smaller area of sericite domains occurs in the Pebble East zone, just north of the ZE fault. The copper minerals are dominated by chalcopyrite accompanied by trace to minor bornite, digenite and covellite, traces of the arsenic-bearing sulphosalts enargite and tennantite, and trace sphalerite. The pyrite concentration is high but the pyrite to chalcopyrite ratio is moderate due to high copper grade. Gold inclusions occur in both chalcopyrite and pyrite, and to a much lesser extent in bornite and digenite. The domain has high concentrations of both clay and pyrite and variable gold deportment; this may have implications for mineral processing, but the high-tenor copper sulphides may yield a higher concentrate grade.

13.9.2.7 8431M Domain

The 8431M domain is a variant on the potassic domain. It occurs as a small volume of rock in the vicinity of drill holes 8431M and 11527 in the western part of the deposit and is surrounded by the sodic-potassic domain. The material contains abundant biotite and K-feldspar, lesser quartz and illite, and also contains a relatively higher concentration of magnetite similar to that found in altered diorite sills. The copper minerals are dominated by chalcopyrite and the concentration of pyrite is relatively low, yielding a lower-than-average pyrite to chalcopyrite ratio. The concentration of molybdenite is also very high. Metallurgical tests from hole 8431M have the highest gold recoveries in the western part of the deposit. This is unusual because most of the gold occurs as inclusions in pyrite, but it is believed that the larger grain size of the gold inclusions results in liberation and therefore higher than expected recovery. Because the 8431M geometallurgical domain is so small, it has been included with the surrounding sodic-potassic geometallurgical domain for modeling purposes.

13.9.2.8 Supergene Domains

A thin, irregular zone of supergene mineralization of variable thickness extends across the near-surface part of much of the western part of the deposit. The zone is characterized by weak enrichment of copper that manifests partial replacement of hypogene chalcopyrite and rimming of hypogene pyrite by supergene chalcocite and lesser bornite and covellite. Geometallurgically, supergene mineralization is defined as all material with cyanide soluble copper above 20%. Supergene effects overprint the near surface parts of the sodic-potassic and illite-pyrite domains in the western part of the deposit and require consideration as two additional geometallurgical domains.

13.10 Metal Recovery Projection

Metal recovery projections of copper, gold, silver and molybdenum were completed in 2014 based on the review of 111 variability locked cycle test results on 103 samples. The projections were updated in 2018 to reflect the changes of the proposed processing methods for Pebble deposit, including the exclusion of a cyanide leach process and the implementation of a finer primary grind particle size to improve metal recoveries. The 2018 projections remain the same in this technical report, while a high-level recovery estimate of rhenium has been completed and is included.

13.10.1 Metal Projections of Copper, Gold Silver and Molybdenum – 2014/2018, Tetra Tech

In 2014, a metal recovery projection was completed based on the variability locked-cycle flotation tests, variability cyanidation tests, and cyanide recovery (SART) tests on two commissioning samples. The overall metal recoveries of copper, gold, and silver consist of two parts with the majority via flotation concentration and a small portion from the gold plant, i.e., the cyanide leaching and SART processes. In 2018, as secondary gold recovery using cyanide was excluded from the proposed processing methods, the 2014 metal recovery projections were adjusted accordingly.

13.10.1.1 Metal Recovery Projection Basis - 2014-2018, Tetra Tech

The adjusted analysis made to predict metal recoveries can be summarized as follows, starting from the changes made in the analysis followed by the original analysis basis that is still applicable.

13.10.1.1.1 Adjusted Analysis Basis

The following considerations were made in adjusting the metal recoveries:

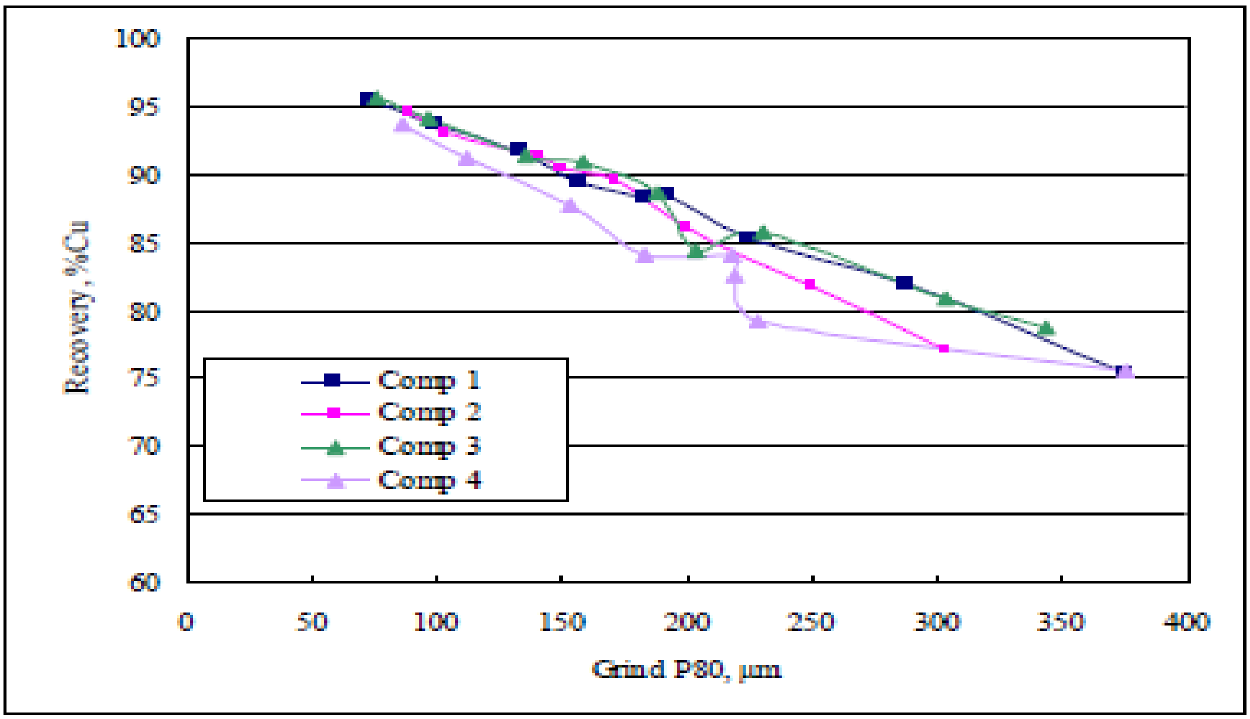
- reducing the primary grind size P_{80} from about 200 µm to 125 µm with corresponding improved metal recoveries;
- adjusting the copper recovery by applying an average recovery increase of 0.5% per 10 µm reduction of primary grind size; and
- applying a similar same recovery change factor for gold, silver, and molybdenum.
- a review of the 103 available samples, eight were excluded from the analysis – 5 of 8 because they were below the 0.20% Cu cut-off grade, and 3 of 8 because they were contaminated by drilling fluid;
- the remaining 95 samples were used to determine copper, gold and molybdenum recoveries;
- silver recovery was based on a dataset of 10 samples due to incomplete silver assay data for the testwork;
- locked cycle test recovery distributions were reviewed for each geometallurgical domain type to determine if domains could be grouped into similar recovery domains;
- the outcome of this analysis established seven recovery domains for copper, six for gold, and seven for molybdenum;
- recoveries were determined using the median value of each dataset;
- copper-molybdenum separation efficiency was assumed to be 92.7% molybdenum recovery to the molybdenum concentrate; and

- gold recovery included an incremental 1.0% for the gravity circuit.

13.10.1.2 Effects of Primary Grind Size on Metal Recoveries

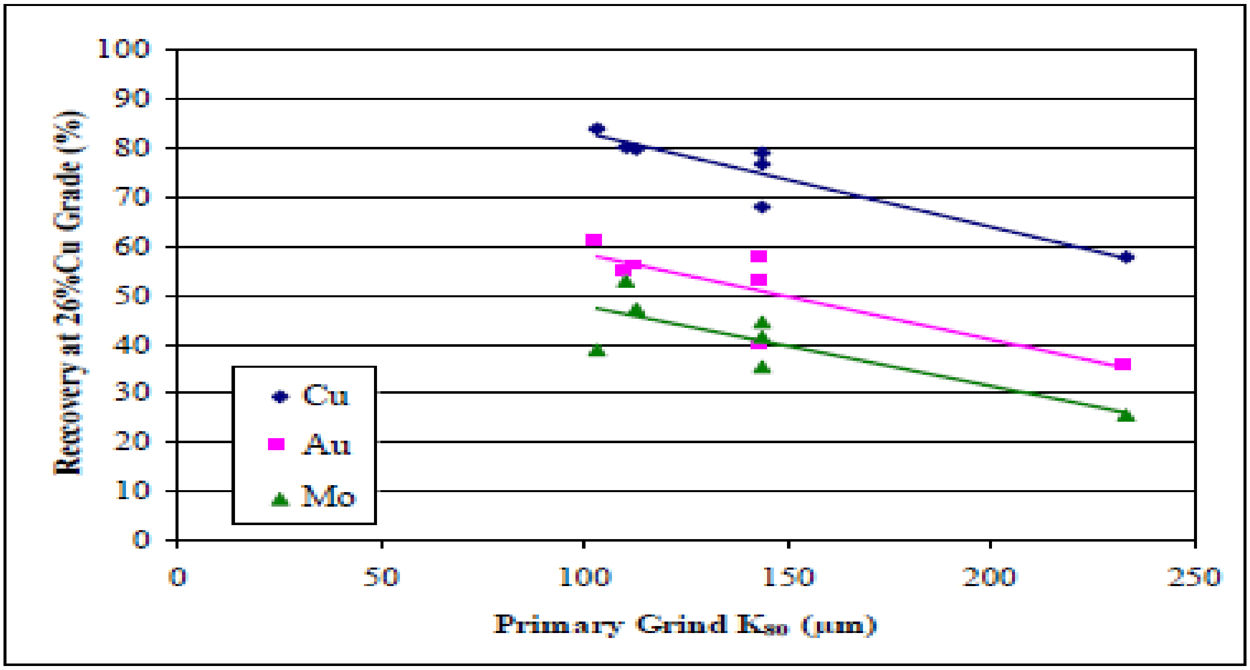
Four testwork programs were conducted in 2005 and 2006 by SGS Lakefield to investigate the impacts of the primary grind size on metal recoveries with different composite samples in rougher flotation, batch cleaner flotation and locked-cycle flotation tests. A general observation was made that higher metal recoveries can be obtained with a finer primary grinding size, with just a few exceptions that mainly resulted from the inconsistent test conditions. The primary size effect testing results are plotted and connected with trendline by SGS Lakefield as presented in Figure 13-6 to Figure 13-7.

Figure 13-6: The Effect of Primary Grind Fineness of Copper Recovery to Rougher Concentrate



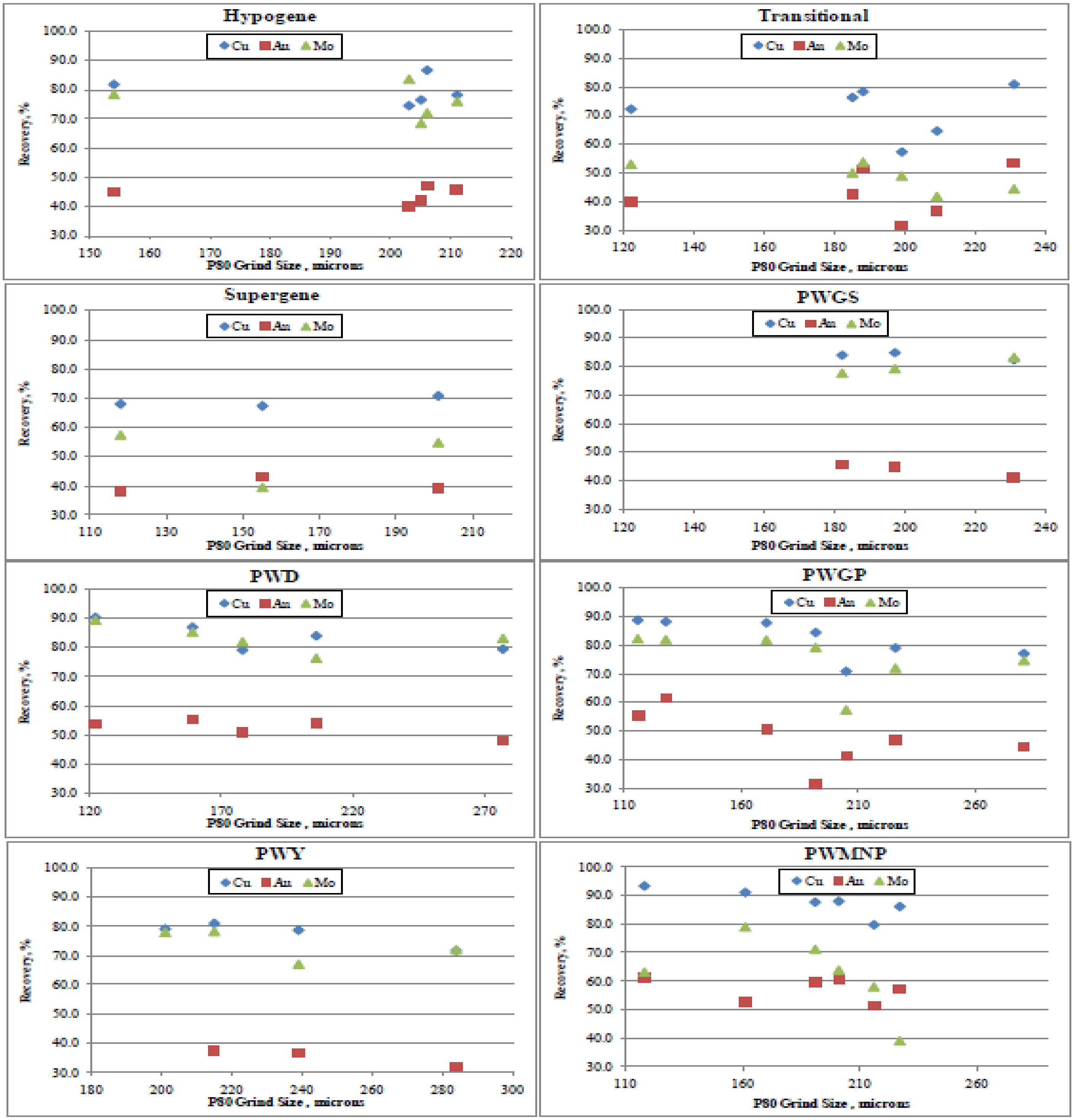
Note: Prepared by SGS Lakefield, 2006

Figure 13-7: Effect of Primary Grind Size on Cu, Au and Mo Recovery to Batch Copper Concentrate



Source: SGS Lakefield, 2006

Figure 13-8: Cu, Au and Mo Recovery into a 26% Batch Cu Concentrate



Source: SGS Lakefield, 2006

The observed linear relationship between the primary grind size and metal recovery change was mathematically summarized by SGS Lakefield, in 2005 and 2006, as follows:

"Linear trendlines that were fitted to the data sets suggested that in only 4 cases the metal recovery improved with coarser grinds compared with 20 cases that produced inferior recoveries at a coarse grind. Metal losses of Cu, Au, and Mo typically ranged between 0.5% to 1.0% per 10 microns increase in grind size".

Similar observations were obtained from the batch cleaner and locked cycle flotation tests as shown in Table 13-18 to Table 13-19. It can be noted that the metal recovery increase in the locked cycle flotation tests is lower as compared with the batch cleaner flotation tests. The average metal increase per 10 µm reduction of primary grind size from the locked cycle tests are 0.48% for copper, 0.15% for gold, and 0.34% for molybdenum.

Table 13-18: Summary of Batch Recovery Change per 10 µm Primary Grind Size Reduction

Composite	Product	Change per 10 µm Size Reduction (% Recovery)		
		Cu	Au	Mo
2005G	Ro+Scav Concentrate	0.62	0.24	0.53
2005Y	Ro+Scav Concentrate	0.70	0.37	0.53
2006G	Ro+Scav Concentrate	0.28	0.23	0.24
2006Y	Ro+Scav Concentrate	0.50	0.22	0.40
2005G	Cu/Mo Concentrate	0.62	NA	0.44
2005Y	Cu/Mo Concentrate	0.86	NA	0.59
2006G	Cu/Mo Concentrate	0.33	NA	0.51
2006Y	Cu/Mo Concentrate	0.49	NA	0.44

Table 13-19: Change in Metal Recovery for 101µm Primary Grind Size Reduction, P_{80} 150µm to 300 µm

Composite	Product	Cu %	Au %	Mo %
PBA	Cu/Mo Concentrate	0.38	-0.46	0.59
PBB	Cu/Mo Concentrate	0.57	0.15	1.46
PBC	Cu/Mo Concentrate	0.54	0.68	0.31
PBD	Cu/Mo Concentrate	0.45	-0.43	0.58
PBE	Cu/Mo Concentrate	0.34	0.01	-0.1
PBF	Cu/Mo Concentrate	0.54	0.38	0.57
PBA	Ro+Scav Concentrate	0.84	-1.05	0.84
PBB	Ro+Scav Concentrate	0.29	0.50	1.61
PBC	Ro+Scav Concentrate	0.41	0.34	-0.01
PBD	Ro+Scav Concentrate	0.40	0.01	0.72
PBE	Ro+Scav Concentrate	0.79	0.31	0.70
PBF	Ro+Scav Concentrate	0.51	0.46	0.64

13.10.2 Metal Recovery Projection Results

The adjusted metal recoveries are presented in Table 13-20, excluding any incremental recovery of gold, silver and copper realized from the leaching circuit and SART process. The flotation recoveries are adjusted based on the previous projection but at a primary grind P_{80} of 135 µm.

Table 13-20: Projected Metallurgical Recoveries Tetra Tech, 2021

Domain	Flotation Recovery %				
	Cu Con, 26% Cu			Mo Con, 50% Mo	
	Cu	Au	Ag	Mo	Re
Supergene:					
Sodic Potassic	74.7	60.4	64.1	51.2	70.8
Illite Pyrite	68.1	43.9	64.1	62.6	70.8
Hypogene:					
Illite Pyrite	91.0	46.2	67.5	77.1	70.8
Sodic Potassic	91.0	63.8	67.7	80.9	70.8
Potassic	93.0	63.1	66.0	84.8	70.8
Quartz Pyrophyllite	95.0	65.5	64.6	80.7	70.8
Sericite	91.0	41.3	67.5	77.1	70.8
Quartz Sericite Pyrite	90.5	33.3	67.5	86.8	70.8
LOM Average	87	60	67	75	71

Note: An additional 1% Au recovery to the gravity concentrate is expected.

The metallurgical testwork from 2011 to 2013 on the Pebble deposit indicates that significant rhenium can be recovered to the bulk copper-molybdenum flotation concentrate and further concentrated into the final molybdenum flotation concentrate. The overall rhenium recovery is determined by the rhenium recovery to the bulk copper-molybdenum concentrate and the separation efficiency of the rhenium into the molybdenum concentrate in the subsequent copper-molybdenum separation stages. The estimated rhenium recovery is about 70.8% on average for all the domains based on the following considerations:

- The available rhenium distributions to the bulk copper/molybdenum concentrates are based on the 10 of the 111 LCT tests on variability samples. The average recovery was calculated as 73.4% representing five of the eight geometallurgical domains.

- The application of a similar separation efficiency of molybdenum as of 92.7% in the copper-molybdenum separation to estimate the rhenium stage recovery, considering the significant linear relationship between the molybdenum and rhenium bulk and circuit recovery test data.
- The adjustment of the overall rhenium recovery by applying a similar factor for an average recovery increase of 0.5% per 10 µm reduction of primary grind size.

14 MINERAL RESOURCE ESTIMATES

14.1 Summary

The Pebble Mineral Resource estimate presented in this section is unchanged from the resource estimate disclosed in 2020 (Gaunt et al, 2020). No core drilling has taken place in the vicinity of the Mineral Resource area since 2013, nor have any additional analyses have been obtained since that time for copper, gold, molybdenum, or silver.

The current estimate is based on all core holes in the vicinity of the block model extents, completed to the end of 2013. Wireframe domains for the estimated metals, as well as bulk density, were interpreted using geological, structural and alteration data. Descriptive statistics, unique search strategies and geostatistical parameters for block interpolation and resource classification were then developed for each of the modeled domains.

The Pebble Mineral Resource estimate is presented in Table 14-1.

Tonnes were rounded to the nearest million. The highlighted 0.3% CuEq cut off is appropriate for a large scale, open pit deposit of this type in Alaska. Of the total Mineral Resource, the Measured category represents approximately 5%, the Indicated category represents 54%, and the Inferred category represents approximately 41%.

Table 14-1: Pebble Deposit Mineral Resource Estimate August 2020

MEASURED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.64	531,000,000	0.33	0.35	177	1.7	0.31	3.87	5.96	0.21	28.4	167,000
0.2	0.64	530,000,000	0.33	0.35	177	1.7	0.32	3.87	5.96	0.21	28.4	167,000
0.3	**0.65**	**527,000,000**	**0.33**	**0.35**	**178**	**1.7**	**0.32**	**3.83**	**5.93**	**0.21**	**28.1**	**167,000**
0.4	0.66	508,000,000	0.34	0.36	180	1.7	0.32	3.81	5.88	0.20	27.4	163,000
0.6	0.77	279,000,000	0.40	0.42	203	1.8	0.36	2.46	3.77	0.12	16.5	100,000
1.0	1.16	28,000,000	0.62	0.62	302	2.3	0.52	0.38	0.56	0.02	2.0	14,000

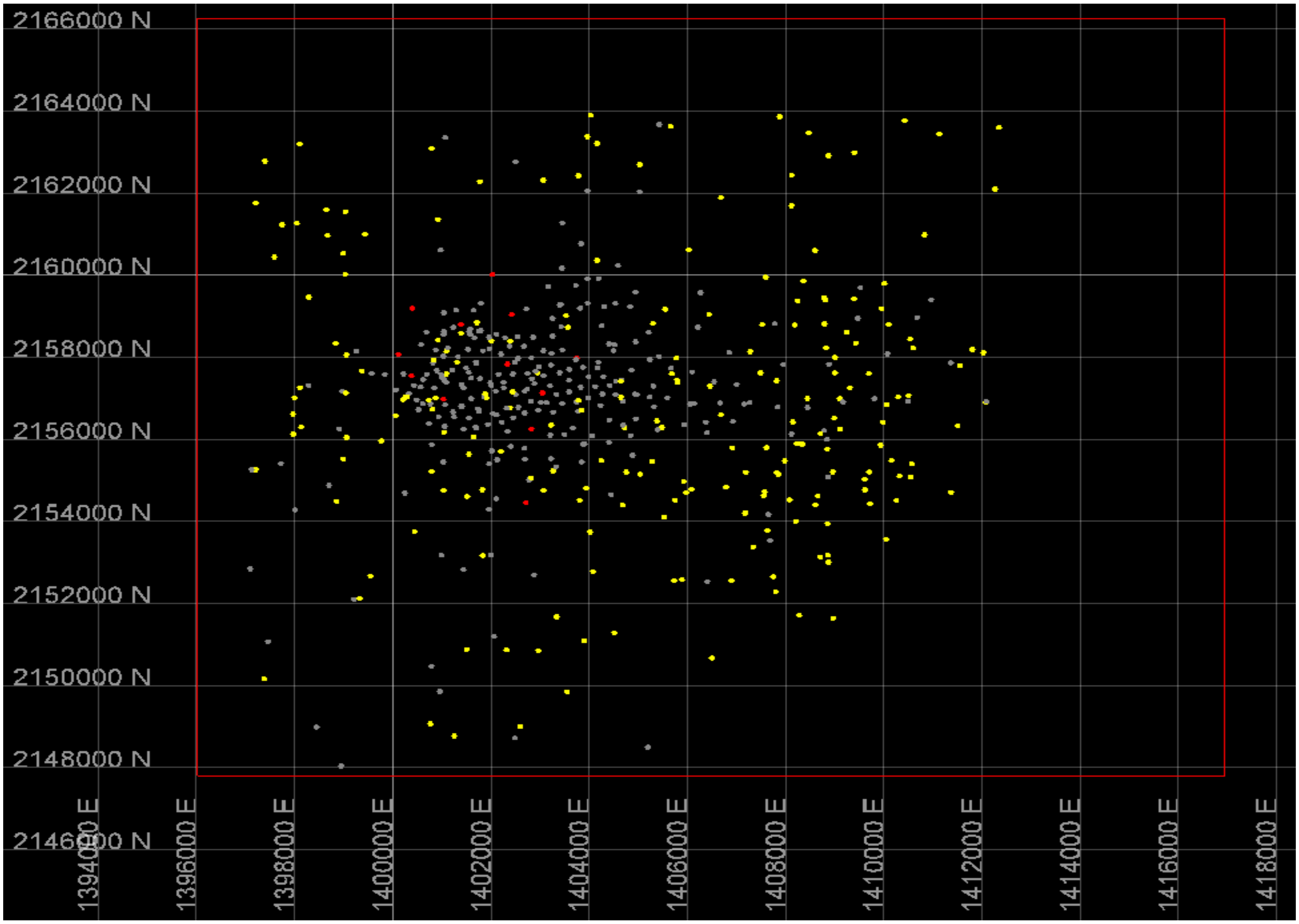
INDICATED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.73	6,409,000,000	0.39	0.32	233	1.6	0.39	54.38	66.56	3.29	328.5	2,500,000
0.2	0.73	6,305,000,000	0.39	0.33	236	1.6	0.40	54.20	66.08	3.28	326.0	2,497,000
0.3	**0.77**	**5,929,000,000**	**0.41**	**0.34**	**246**	**1.7**	**0.41**	**53.58**	**64.81**	**3.21**	**316.4**	**2,443,000**
0.4	0.82	5,185,000,000	0.45	0.35	261	1.8	0.44	51.42	58.35	2.98	291.7	2,271,000
0.6	0.99	3,455,000,000	0.55	0.41	299	2.0	0.51	41.88	45.54	2.27	221.1	1,748,000
1.0	1.29	1,412,000,000	0.77	0.51	343	2.4	0.60	23.96	23.15	1.07	109.9	853,000

MEASURED+INDICATED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.72	6,941,000,000	0.38	0.33	228	1.6	0.39	58.29	72.53	3.49	357.1	2,672,000
0.2	0.73	6,835,000,000	0.39	0.33	231	1.6	0.39	58.15	72.08	3.49	354.5	2,666,000
0.3	**0.76**	**6,456,000,000**	**0.40**	**0.34**	**240**	**1.7**	**0.41**	**56.92**	**70.57**	**3.42**	**344.6**	**2,615,000**
0.4	0.81	5,693,000,000	0.44	0.35	253	1.8	0.43	55.21	64.06	3.18	320.3	2,431,000
0.6	0.97	3,734,000,000	0.54	0.41	291	2.0	0.50	44.44	49.22	2.40	237.7	1,848,000
1.0	1.29	1,440,000,000	0.76	0.51	342	2.4	0.60	24.12	23.61	1.08	112.0	867,000

INFERRED			METAL GRADES					CONTAINED METAL				
Cutoff CuEq (%)	CuEq (%)	Tonnage	Cu (%)	Au (g/t)	Mo (ppm)	Ag (g/t)	Re (ppm)	Cu (Blbs)	Au (Moz)	Mo (Blbs)	Ag (Moz)	Re (Kg)
0.1	0.45	6,435,000,000	0.20	0.23	174	1.1	0.28	28.22	47.38	2.47	232.1	1,789,000
0.2	0.48	5,819,000,000	0.22	0.24	190	1.1	0.30	27.57	44.34	2.44	212.2	1,763,000
0.3	**0.55**	**4,454,000,000**	**0.25**	**0.25**	**226**	**1.2**	**0.36**	**24.54**	**35.80**	**2.22**	**170.4**	**1,603,000**
0.4	0.68	2,646,000,000	0.33	0.30	269	1.4	0.44	19.24	25.52	1.57	119.1	1,154,000
0.6	0.89	1,314,000,000	0.48	0.37	292	1.8	0.51	13.90	15.63	0.85	75.6	673,000
1.0	1.20	361,000,000	0.68	0.45	377	2.3	0.69	5.41	5.22	0.30	26.3	251,000

- David Gaunt, P. Geo, a qualified person who is not independent of Northern Dynasty is responsible for the estimate.
- Copper equivalent (CuEq) calculations use the following metal prices: US$1.85 /lb for Cu, US$902 /oz for Au and US$12.50 /lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).
- Contained metal calculations are based on 100% recoveries.
- The base case Mineral Resource estimate (bolded) is reported above a 0.30% CuEq cut-off.
- The Mineral Resource estimate is constrained by a conceptual pit shell that was developed using a Lerchs-Grossmann algorithm and is based in the following parameters: 42 degree pit slope; metal prices and recoveries for gold of US$1,540.00/oz and 61% Au, for copper of US$3.63/lb and 91% Cu, for silver of US$20.00/oz and 67% Ag and for molybdenum of US$12.36/lb and 81% Mo, respectively; a mining cost of US$1.01/ton with a US$0.03/ton/bench increment and other costs (including processing, G&A and transport) of US$6.74/ton.
- The terms "Measured Resources", "Indicated Resources" and “Inferred Resources” are recognized and required by Canadian regulations under 43-101. The SEC has adopted amendments to its disclosure rules to modernize the mineral property disclosure required for issuers whose securities are registered with the SEC under the US Securities Exchange Act of 1934, effective February 25, 2019, that adopt definitions of the terms and categories of resources which are "substantially similar" to the corresponding terms under Canadian Regulations in 43-101. Accordingly, there is no assurance any mineral resources that we may report as Measured Resources, Indicated Resources and Inferred Resources under 43-101 would be the same had we prepared the resource estimates under the standards adopted under the SEC Modernization Rules. Investors are cautioned not to assume that all or any part of mineral deposits in these categories will ever be converted into Mineral Reserves or be legally or economically mineable. In addition, Inferred Resources have a great amount of uncertainty as to their economic and legal feasibility. Under Canadian rules, estimates of Inferred Resources may not form the basis of feasibility or pre-feasibility studies, or economic studies except for a Preliminary Economic Assessment as defined under 43-101.
- Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
- The Mineral Resource estimates contained herein have not been adjusted for any risk that the required environmental permits may not be obtained for the Pebble Project. The risk associated with the ability of the Pebble Project to obtain required environmental permits is a risk to the reasonable prospects for eventual economic extraction of the mineralization and the classification of the estimate as a Mineral Resource.

Figure 14-1: Block Model (red line); Drill Hole Collars and Re-analyses: Lacking (grey), Existing (yellow), 2020 Pulps (red)



Note: Prepared by NDM, 2020

14.2 Geological Interpretation for Estimation

The Pebble deposit extends for a strike length of approximately 13,000 ft, a width of 7,700 ft, and to a depth of at least 5,810 ft. Metal distribution within the Pebble deposit is affected by lithology, alteration, weathering and structure such that the distribution cannot be constrained on the basis of a single attribute. Further, the distribution of each of the metals differs in accordance with the differing response of those metals to the thermal and chemical environments prevailing at the time of deposition. Therefore, for the purpose of resource estimation domains were developed for each of the five metals.

These domains are defined by deposit orientation, geology alteration and grade. Three boundaries are common to all metals: 1) the north-south divide that separates the deposit into east and west portions and marks a change in the dip of the stratigraphy from flat lying to gently east dipping, 2) the east-trending fault (ZE Fault) that divides the eastern portion of the deposit into two zones, and 3) the north-northeast trending ZG Fault which constrains the deposit to the east. The shape and location of the domain boundary differs among the metals but in general is gently east-dipping and separates an upper higher-grade zone (copper, gold and silver) from a lower grade zone; this lower-grade zone underlies both western and eastern parts of the deposit. East of the east-west divide the higher-grade zone is divided into a north and a south domain by the ZE Fault. In the case of molybdenum, in contrast to the other metals, the upper, western zone is lower- grade and the underlying zone is higher grade. The domaining developed for molybdenum was used for rhenium estimation given the very high statistical and spatial correlation between these two metals.

There are two additional domains for copper: leached and supergene; both are located in the near-surface western portion of the deposit and both have been interpreted based on copper speciation data. Copper grade distribution is further constrained by two lower-grade domains that overlie portions of the east and west halves of the deposit. The gold domains also contain a very small low-grade domain immediately above the western higher-grade domain.

The bulk density domains are described in Section 14.6.

The domains are tabulated in Table 14-2.

As a general statement domain code 40 will identify lower-grade portions of the deposit, domain code 41 will identify upper, higher-grade portions in the western half of the deposit, whereas domain codes 42 and 43 will identify the northern and southern quadrants respectively in the eastern half of the deposit.

Table 14-2: Pebble Deposit Metal Domains

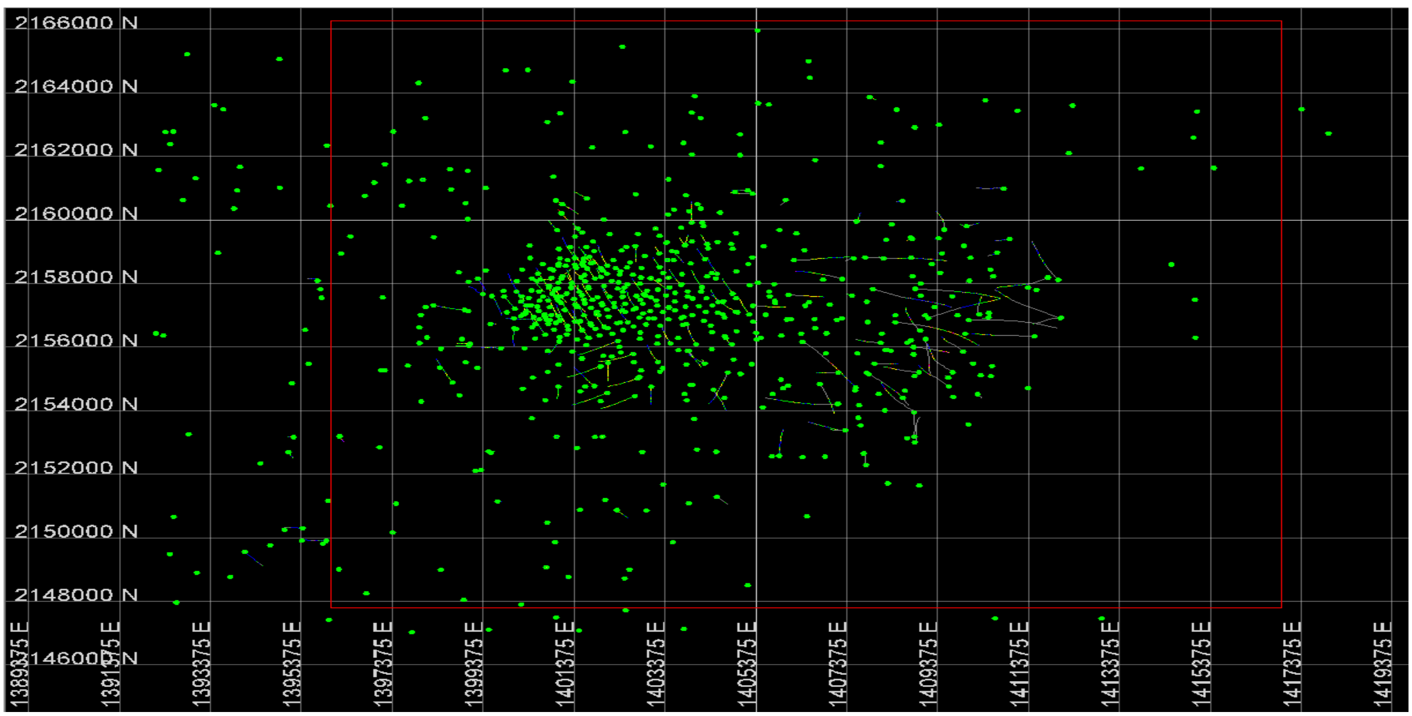
Domain	Code	Description
Ag low grade	40	Hypogene at depth
Ag moderate grade	41	West part near surface
Ag Northeast	42	East part, north of ZE fault
Ag Southeast	43	East part, south of ZE fault
Au low grade	40	Hypogene at depth
Au moderate grade	41	West part near surface
Au Northeast	42	East part north of ZE fault
Au Southeast	43	East part south of ZE fault
Cu Leach	1	Cu/leach
Cu Supergene	2	Cu/supergene
Cu low grade	40	Hypogene at depth
Cu moderate grade	41	Hypogene West near surface
Cu Hypogene Northeast	42	East part north of ZE fault

Domain	Code	Description
Cu Hypogene Southeast	43	East part south of ZE fault
Mo/Re low grade	40	Above 70 ppm cap
Mo/Re high grade	41	Below 70 ppm cap west
Mo/Re high grade Northeast	42	Above 70 ppm cap, east part north of ZE fault
Mo/Re high grade Southeast	43	Above 70 ppm cap, east part south of ZE fault

Separate variables were set up in the block model for each of the metals, each metal domain and for bulk density (noted as SG0 to SG3 and SG10 in Section 14.6). This approach allowed for the application of a unique suite of search strategies and kriging parameters to each metal domain based on that domain's geostatistical characteristics.

The distribution of drill holes relative to the extent of the block model is shown in Figure 14-2.

Figure 14-2: Pebble Deposit Plan View of Drill Holes and Block Model Extent (red rectangle)



Note: Prepared by NDM, 2020

14.3 Inclusion of Rhenium in the Project Database

The rhenium drill data used in that metals estimation has in part been generated by regression using the correlation with molybdenum. Table 14-3 shows the correlation coefficients between rhenium and each of 21 possible predictors in the

Pebble analytical database. The only strong correlation is with molybdenum at +0.87. The correlations between rhenium and other elements are weak and non-existent.

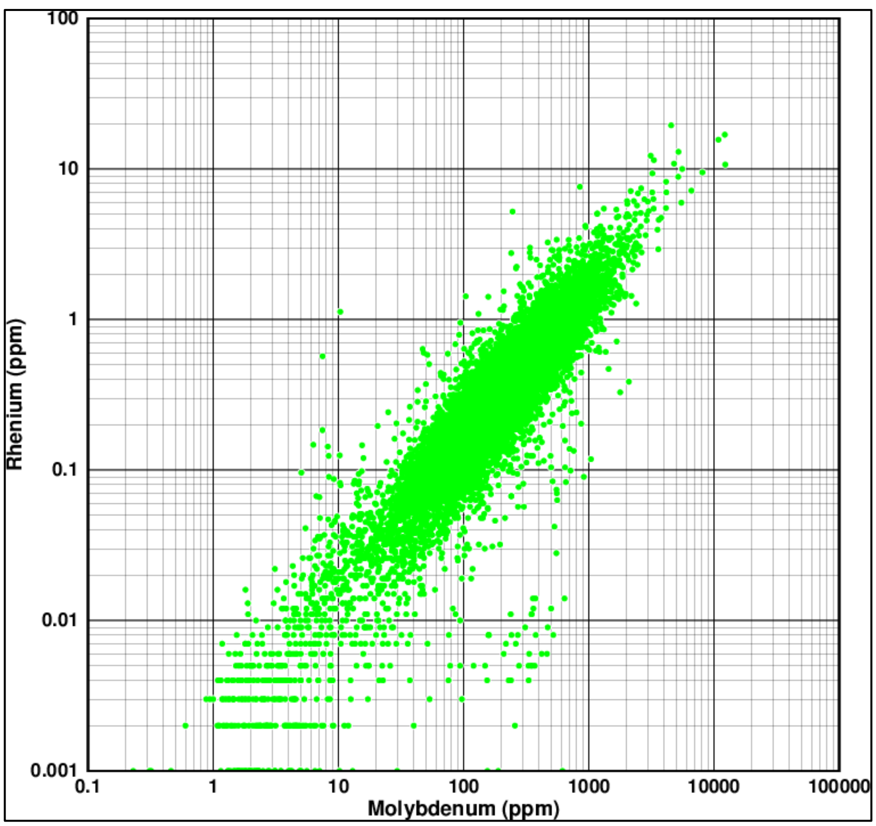
Table 14-3: Correlation coefficients between rhenium and other elements

Ag	Al	As	Ba	Ca	Cd	Co
+0.02	+0.02	+0.02	0.00	−0.09	−0.02	−0.07
Cr	**Cu**	**Fe**	**K**	**Mg**	**Mn**	**Mo**
−0.04	+0.16	−0.14	0.00	−0.12	−0.13	+0.87
Na	**Ni**	**Pb**	**Sb**	**Sr**	**V**	**Zn**
−0.08	−0.07	−0.01	−0.02	0.00	−0.10	0.00

Figure 14-3shows a scatterplot of rhenium versus molybdenum on a log-log scale. The linear relationship between the logarithms of the two elements results in the regression equation having the following form when expressed in terms of the raw, untransformed variables (with both measured in units of parts-per-million):

$$Re = 0.002269 \cdot Mo^{0.951}$$

Figure 14-3: Rhenium Versus Molybdenum



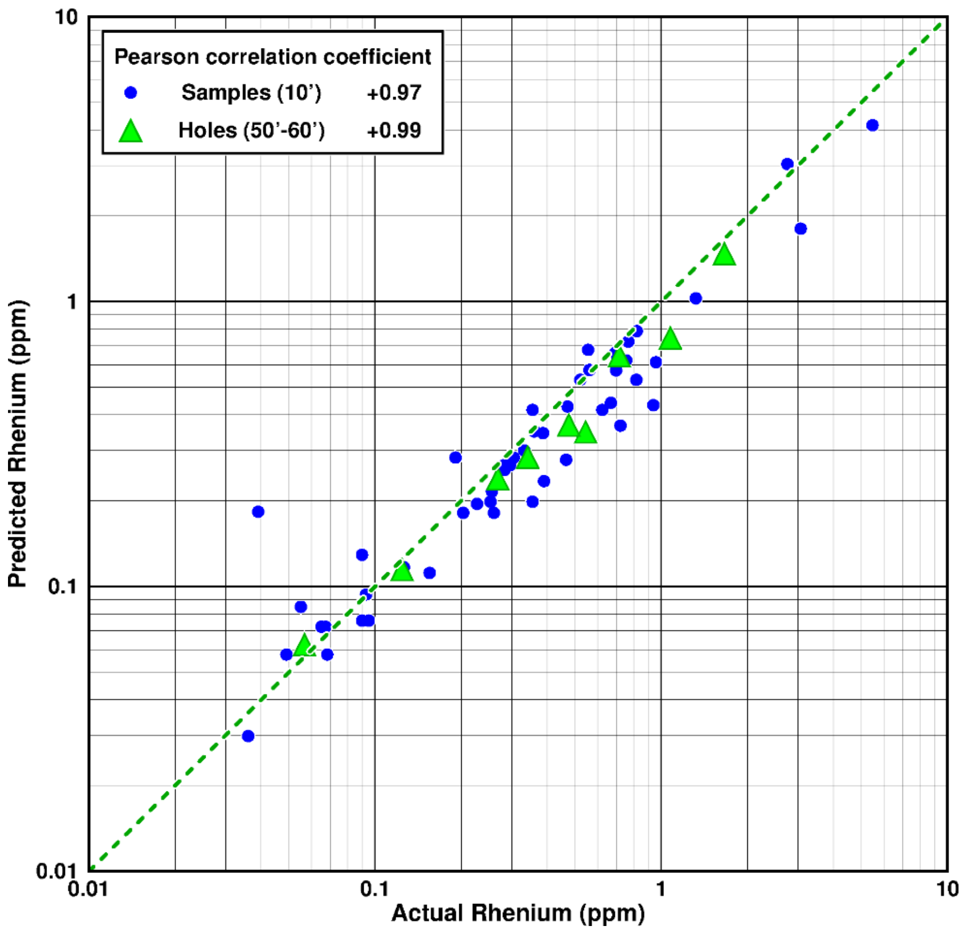
Note: Prepared by NDM, 2020

14.4 Regression Validation

Subsequent to the development of the regression formula, rhenium assays for 50 withheld samples were provided so that the reliability of the prediction could be assessed using data that had not played any role in the development of the regression equation (Srivastava, 2020).

Figure 14-4 shows the rhenium grades predicted by the regression equation versus the rhenium assays reported by the laboratory.

Figure 14-4: Rhenium predictions versus actual rhenium assays for withheld validation samples



Note: Prepared by NDM, 2020

The blue dots in Figure 14-4 are the 50 withheld validation sample assays from the initial data base. For these 50 samples, there is a small bias, with the predicted rhenium values being slightly conservative at about 15% lower than the actual assays. The correlation between the actual assays and the predictions is an excellent +0.97.

Predictions for small volumes are more uncertain than predictions made for larger volumes such as the 75 x 75 x 50 ft blocks used in the resource block model. In order to test the reliability of the rhenium predictions for larger volumes withheld analyses were also combined into 50 ft to 60 ft lengths which is the approximate height of resource blocks. The correlation coefficient is +0.99 at the scale closer to the size of resource blocks confirming the following regression equation produces excellent predictions of rhenium at the scale of the sample interval and even better predictions at the scale of the resource blocks: hat the following regression equation at:

$$Re = 0.002269 \cdot Mo^{0.951}$$

The regression equation was used to populate missing rhenium analyses into the drill database and these values along with the existing rhenium results were used to estimate rhenium into the Pebble block model.

14.5 Exploratory Data Analysis

14.5.1 Assays

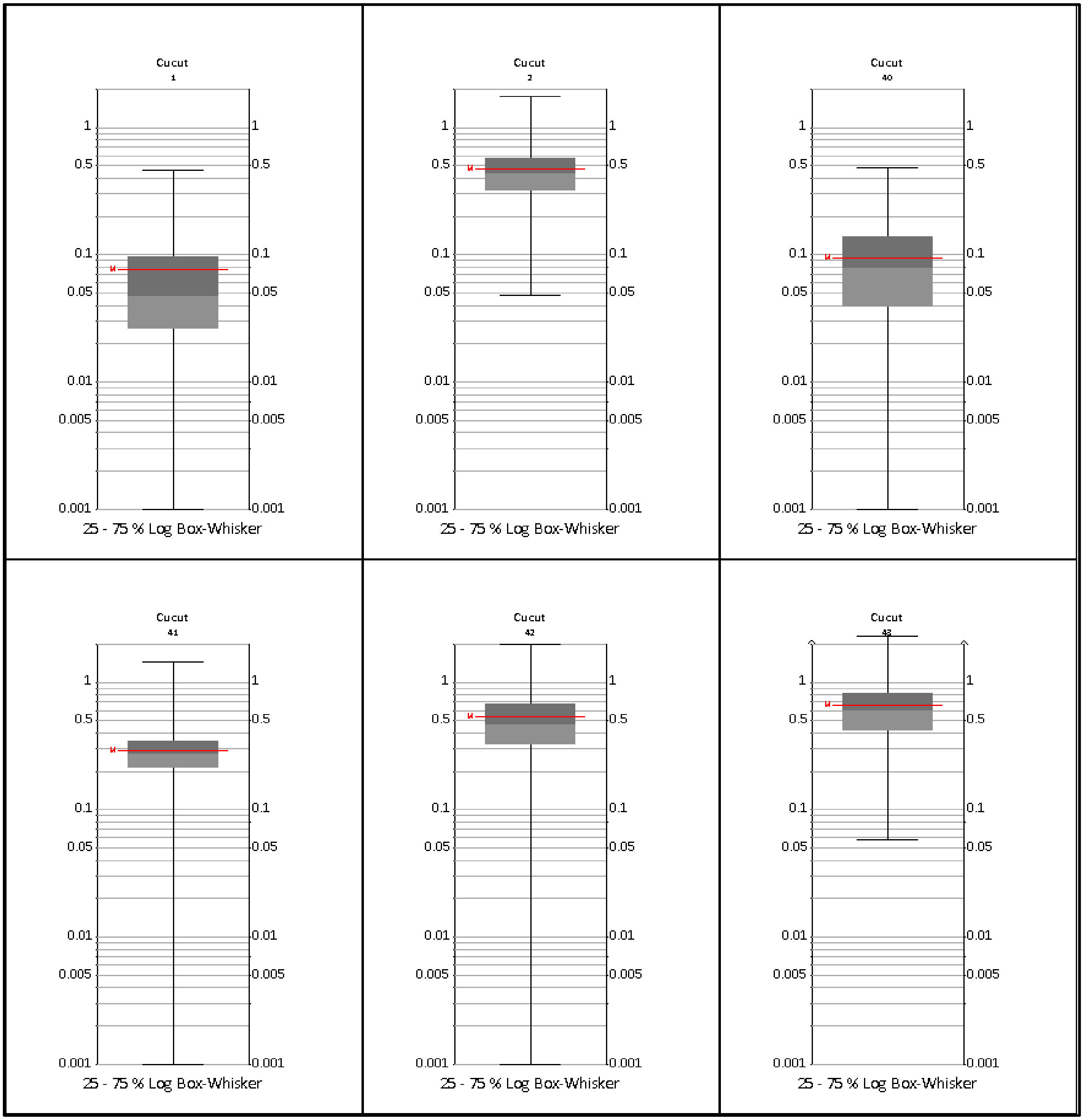
Global descriptive statistics for all non-zero copper, gold, silver, molybdenum, and rhenium assays are presented in Table 14-4.

Table 14-4: Pebble Deposit Assay Database Descriptive Global Statistics

Statistic (Non-zero)	Length (ft)	Ag (ppm)	Au (g/t)	Cu (%)	Mo (ppm)	Re (ppm)
Mean	9.97	1.57	0.32	0.33	191.3	0.33
Median	10.00	1.00	0.23	0.26	130	0.22
Standard Deviation	1.86	5.02	1.50	0.31	298.26	0.49
Coefficient of Variation	0.19	3.20	4.63	0.94	1.56	1.49
Kurtosis	23.31	30,529	41,613	28.36	2,455	1,285
Skewness	2.1	155.3	189.9	2.9	29.00	20.26
Minimum	0.001	0.1	0.001	0.001	0.20	0.001
Maximum	55	1030	334.8	9.29	32,200	43.93
Count	59,105	58,876	59,114	58,912	59,114	58,093

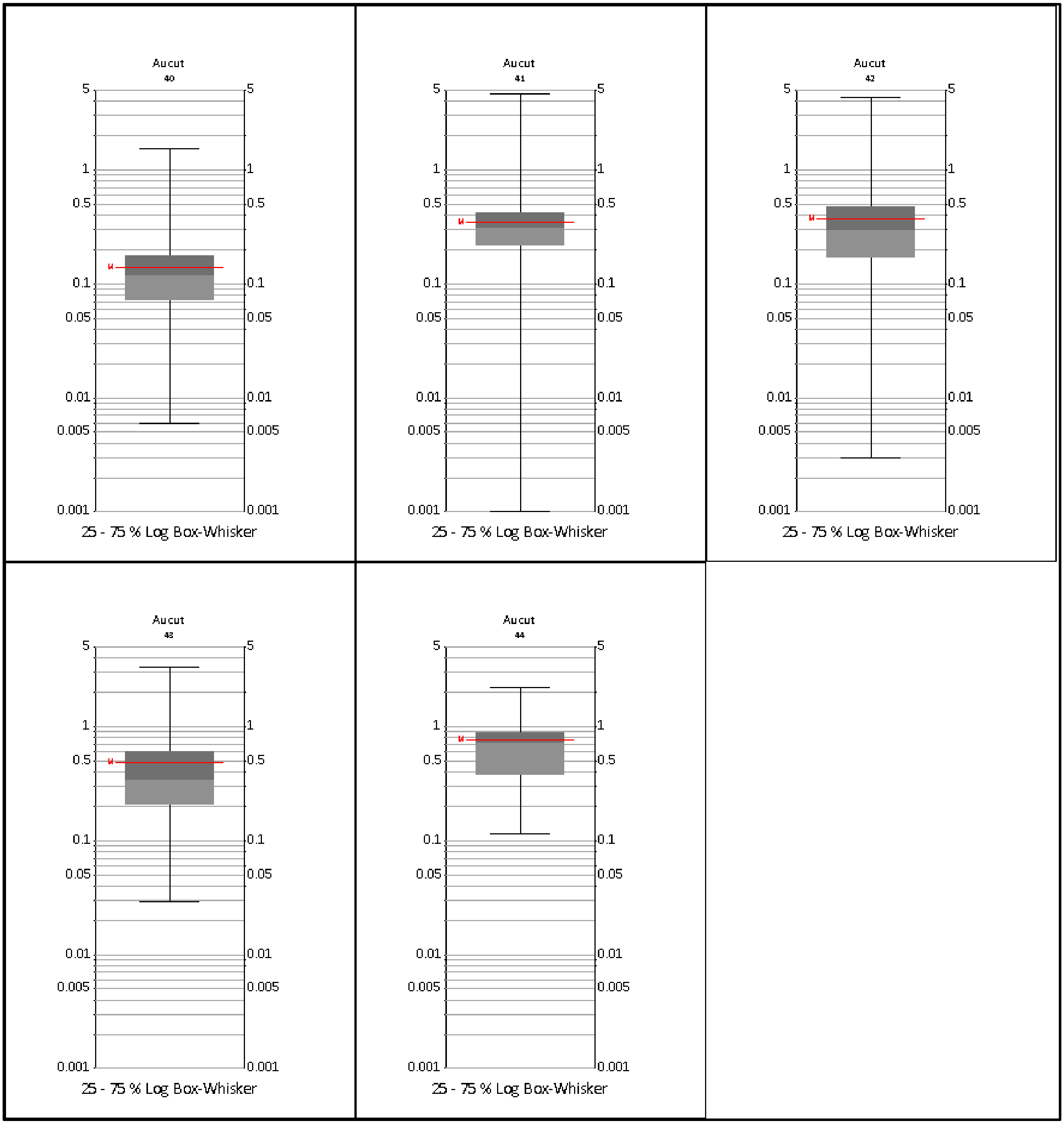
Descriptive statistics were generated for each of the metal domains and these are summarized graphically as box-and-whisker plots in Figure 14-5 to Figure 14-9.

Figure 14-5: Pebble Deposit Copper Assay Domain Box-and-Whisker Plots



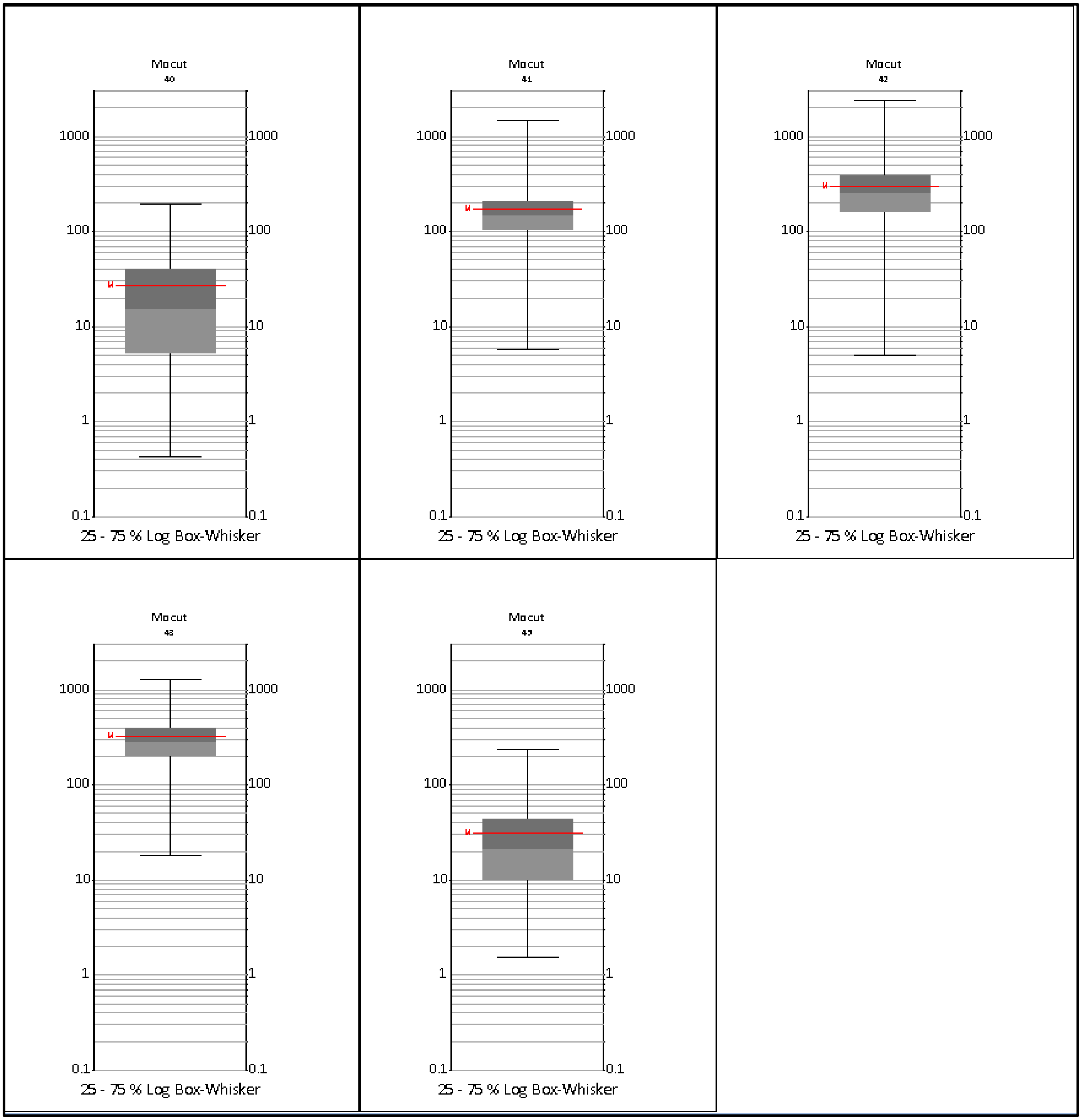
Note: M = arithmetic mean; Note: Prepared by NDM, 2020

Figure 14-6: Pebble Deposit Gold Assay Domain Box-and-Whisker Plots



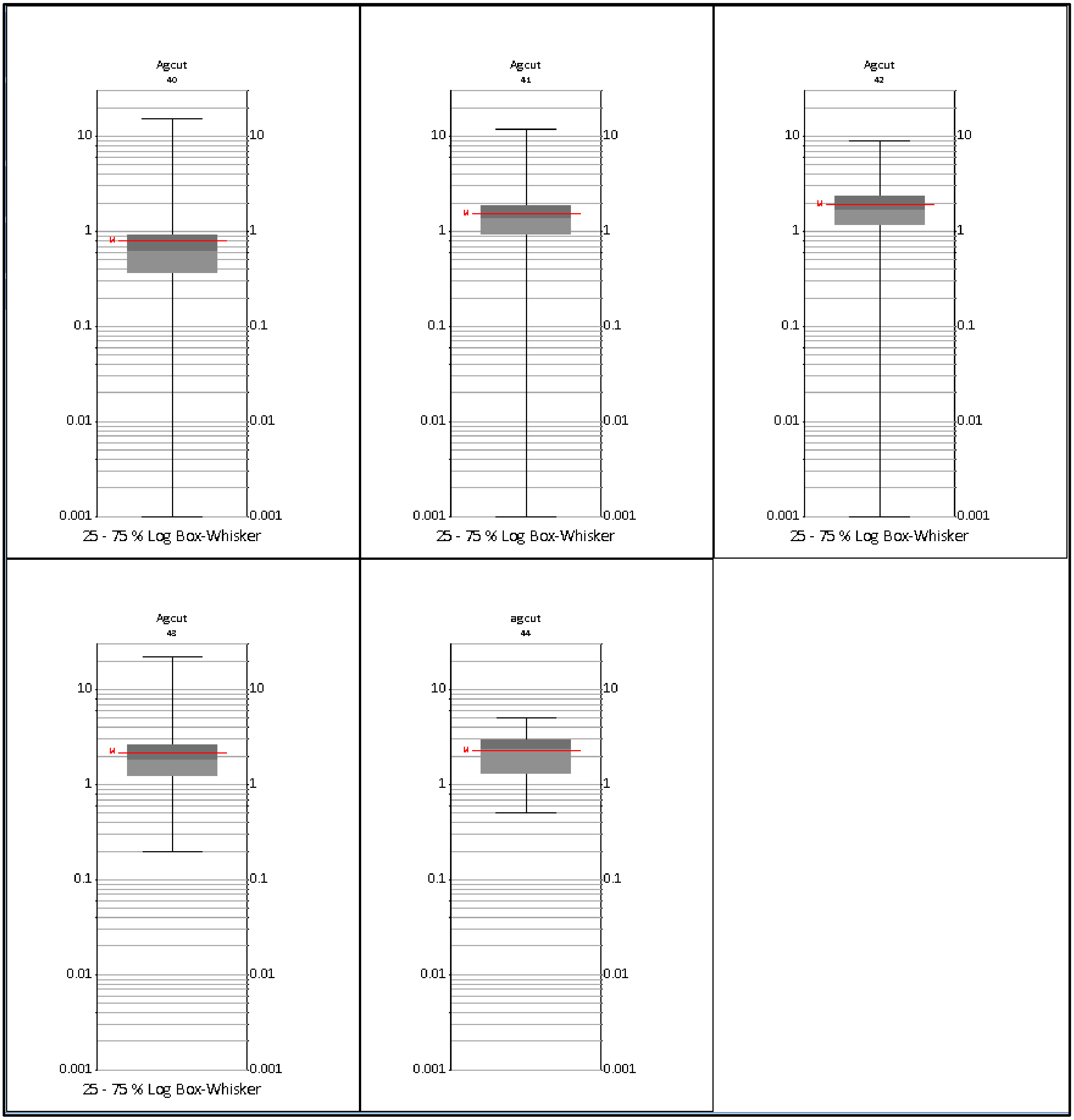
Note: M = arithmetic mean; Note: Prepared by NDM, 2020

Figure 14-7: Pebble Deposit Molybdenum Assay Box-and-Whisker Plots



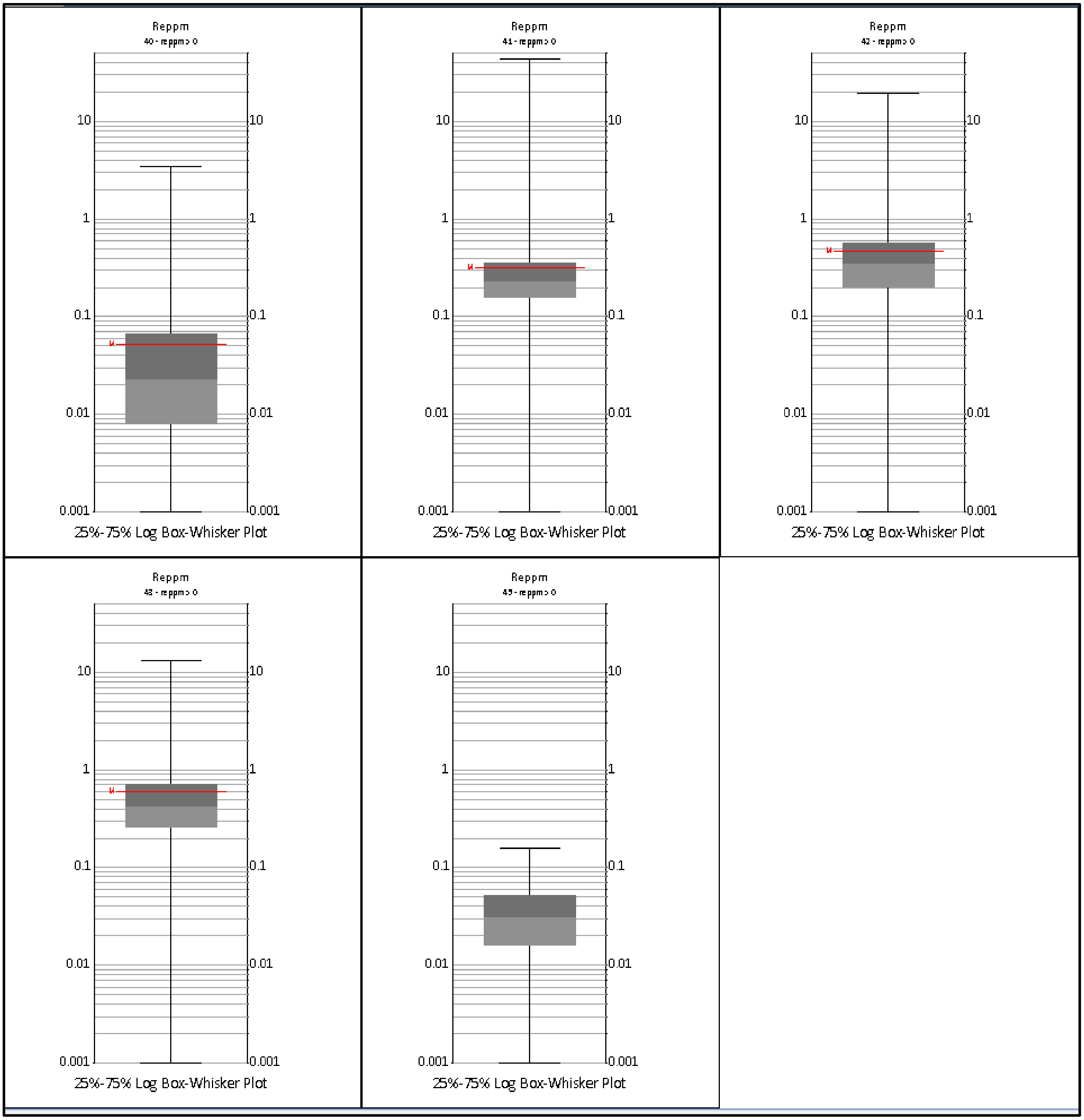
Note: M = arithmetic mean, Note: Prepared by NDM, 2020

Figure 14-8: Pebble Deposit Silver Assay Box-and-Whisker Plots



Note: M = arithmetic mean; Note: Prepared by NDM, 2020

Figure 14-9: Pebble Deposit Rhenium Assay Box-and-Whisker Plots



Note: M = arithmetic mean; Note: Prepared by NDM, 2020

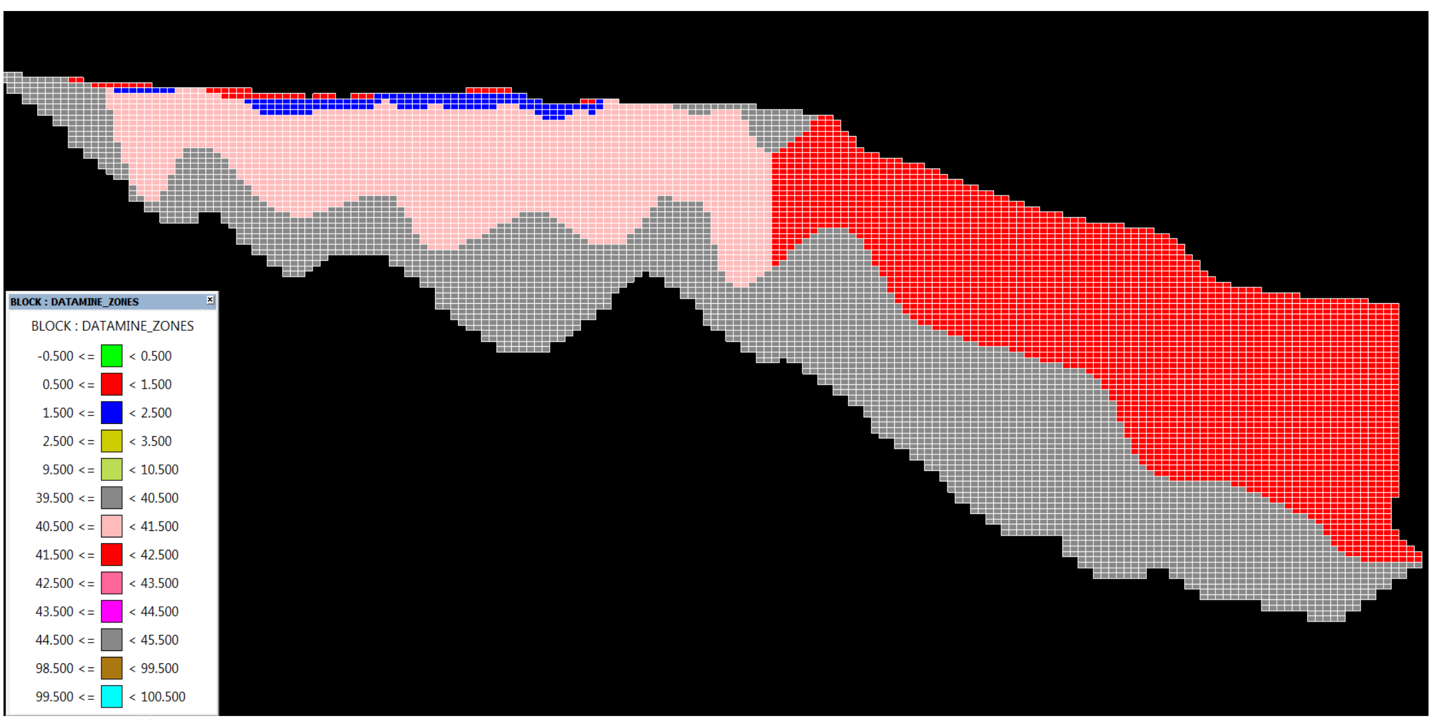
As described in Section 14.2, there are four basic domains for copper, gold, molybdenum, silver and rhenium, plus additional leach and supergene domains for copper. A north-south soft boundary separates the flat-lying western portion of the deposit from the gently east-dipping eastern portion of the deposit and it is for this reason that the deposit is broadly divided into east and west halves. The eastern portion of the deposit is divided into northern and southern quadrants by an east-west fault (the ZE fault) which is always treated as a hard boundary between these two zones.

For copper, gold, and silver the western half of the deposit has a flat-lying, near surface high-grade domain (41) which is underlain by a low-grade domain (40). As indicated on the box-and-whisker plots (Figure 14-5, Figure 14-6, Figure 14-8) there is a marked difference in mean grades for these zones and, as such, these domains are separated by a planar, gently east-dipping hard boundary that extends into the eastern portion of the deposit beneath the northeast and southeast hypogene domains.

For molybdenum and rhenium, the west half of the deposit has a thin, flat-lying near-surface low-grade domain (40) that is underlain by a higher-grade domain (41) as shown by the grades in the box-and-whisker plots (Figure 14-7 and Figure 14-9). These domains are separated by a planar, flat-lying hard boundary that extends into the eastern portion of the deposit into the upper reaches of the northeast and southeast hypogene domains.

The box-and-whisker plots also indicate that the fault-bounded domains (42, 43) have similar average grades for all metals; however, their separation into domains by a hard boundary is required due the displacement along the ZE fault plane. The copper leach zone is also clearly distinguishable although the supergene zone is not markedly different from the other high-grade domains. Five of the six domains are shown in Figure 14-10. This east-west section is located north of the east west trending ZE fault so zone 43 is not visible. The east-west divide is clearly visible between zones 41 in the west and 42 in the east.

Figure 14-10: Pebble Deposit Copper Grade Domains



Note: Prepared by NDM, 2020

14.5.2 Capping

The determination of appropriate capping levels is subjective but is commonly established by reference to cumulative frequency plots of the metal assays. Prominent breaks in the plot line, particularly at the upper end, infer a sub-population of values separate from the main population. The break in the trend defines the capping value and all assays above that point are reduced to the capping value.

Capping values applied to the Pebble assays were determined for each domain and are shown in Table 14-5.

Table 14-5: Pebble Deposit Capping Values

Code	Explanation	Units	Cap
40	Ag - Hypogene at depth	g/t	35
41	Ag - Hypogene West near surface	g/t	19
42	Ag - North of ZE fault	g/t	13
43	Ag - South of ZE fault	g/t	70
40	Au - Hypogene at depth	g/t	2.8
41	Au - Hypogene West near surface	g/t	7.0
42	Au - North of ZE fault	g/t	7.7
43	Au - South of ZE fault	g/t	4.3
1	Cu - Leach	%	0.25
2	Cu - Supergene	%	2.2
40	Cu - Hypogene at depth	%	0.8
41	Cu - Hypogene West near surface	%	2.0
42	Cu - North of ZE fault	%	2.4
43	Cu - South of ZE fault	%	2.4
40	Mo - Below 70 ppm cap	ppm	300
41	Mo - Above 70 ppm cap west	ppm	2100
42	Mo - Above 7 0ppm cap, north of ZE fault	ppm	2800
43	Mo - Above 70 ppm cap, south of ZE fault	ppm	2800
40	Re - Below 70 ppm cap	ppm	0.7
41	Re - Above 70 ppm cap west	ppm	3.0
42	Re - Above 70ppm cap, north of ZE fault	ppm	3.9
43	Re - Above 70 ppm cap, south of ZE fault	ppm	5.8

14.5.3 Composites

Samples were composited to 50 ft lengths to match the anticipated bench height during mining. Although the compositing is not intended to ensure the composite intervals will coincide with the benches, the composite length results in grades that match the resolution of those that can be expected from bench-scale sampling. The number of composites and their mean values are given in Table 14-6.

Table 14-6: Pebble Deposit Composite Mean Values

Metal	Composites	Mean
Ag (g/t)	16,210	1.17
Au (g/t)	12,254	0.31
Cu (%)	16,184	0.24
Mo (ppm)	16,170	140
Re (ppm)	11.914	0.32
Bulk Density (g/cm^3)	9,830	2.62

14.6 Bulk Density

The database contains values for 9,830 bulk density measurements. These measurements were made on 0.1 m samples of drill core selected from locations throughout the Pebble deposit so as to reasonably reflect deposit-wide variations in rock mass. These values were not composited because they are spatially isolated and not appropriate for compositing; hence were employed directly in the interpolation process. Five separate bulk density domains were identified:

- pyrite cap within the western portion of the deposit (SGZ1);
- pyrite cap within the eastern portion of the deposit (SGZ2);
- cretaceous hanging wall (SGZ3);
- tertiary unmineralized rock east of the ZG1 Fault (SGZ10); and
- tertiary unmineralized rock west of the ZG1 Fault (SGZ11).

Bulk density measurements within these domains were interpolated into the block model using ordinary kriging (OK) and then used to estimate tonnages.

14.7 Spatial Analysis

Variography was completed on composited drill results on a per metal, per domain basis. The Pebble variography and search ellipse parameters are presented in Table 14-7 and Table 14-8, respectively.

Table 14-7: Pebble Deposit Variogram Parameters

Domain	Variogram Weights			S1 Axis Range (ft)			S2 Axis Range (ft)		
	S0	S1	S2	Major	Semi-major	Minor	Major	Semi-major	Minor
Ag40	0.52	0.41	0.00	750	475	1,500	0	0	0
Ag41	0.30	0.33	0.00	450	360	475	0	0	0
Ag42	0.08	0.34	0.26	600	600	600	700	2,250	1,500
Ag43	0.13	0.49	0.00	1,300	800	1,200	0	0	0
Au40	0.46	0.54	0.00	700	700	350	0	0	0
Au41	0.16	0.26	0.29	250	250	200	1,200	850	800
Au42	0.43	0.57	0.00	1,100	1,500	800	0	0	0
Au43	0.20	0.70	0.00	900	600	450	0	0	0
Cu1	0.31	0.48	0.21	700	700	350	700	700	350
Cu2	0.40	0.60	0.00	900	520	520	0	0	0
Cu40	0.15	0.60	0.00	1,400	1,300	550	0	0	0
Cu41	0.11	0.25	0.30	450	700	450	4,000	1,300	1,300
Cu42	0.13	0.12	0.30	370	500	700	1,400	1,100	700
Cu43	0.12	0.49	0.00	1,500	1,300	500	0	0	0
Mo40	0.28	0.72	0.00	900	200	450	0	0	0
Mo41	0.19	0.16	0.30	600	1,000	500	1,700	1,000	1,600
Mo42	0.38	0.19	0.35	1,200	1,200	1,200	1,200	1,200	1,200
Mo43	0.47	0.23	0.30	1,300	1,900	900	1,900	2,000	1,000
Re40	0.20	0.07	0.73	150	150	120	1500	900	700
Re41	0.27	0.31	0.42	160	260	325	900	700	575
Re42	0.29	0.20	0.51	400	400	400	1200	1200	1100
Re43	0.38	0.05	0.57	300	300	300	1700	1700	850
SG0	0.44	0.56	0.00	1,350	1,350	800	0	0	0
SG10	0.34	0.41	0.00	1,350	850	950	0	0	0
SG1	0.46	0.54	0.00	640	485	450	0	0	0
SG2	0.37	0.63	0.00	1,700	1,280	500	0	0	0
SG3	0.42	0.40	0.00	1,825	1,610	900	0	0	0

Table 14-8: Pebble Deposit Search Ellipse Parameters

Domain	Ellipse Orientation (°)			Ellipse Dimensions (ft)		
	Bearing	Plunge	Dip	Major	Semi-major	Minor
Ag40	120.0	0.0	60.0	565	355	1,125
Ag41	180.0	0.0	0.0	340	270	355
Ag42	130.0	0.0	-60.0	525	1,690	1,125
Ag43	20.0	40.0	0.0	975	600	900
Au40	0.0	-0.5	0.0	510	510	260
Au41	70.0	0.0	-0.5	800	600	560
Au42	290.0	20.0	0.0	825	1,110	600
Au43	79.0	-17.0	-10.0	715	460	350
Cu1	40.0	0.0	0.0	550	530	270
Cu2	30.0	0.0	-0.5	675	390	400
Cu40	72.0	-30.0	-28.0	1,100	1,020	425
Cu41	53.0	-20.0	-79.0	2,900	950	950
Cu42	290.0	40.0	-0.5	1,023	830	540
Cu43	310.0	58.0	-17.0	1,180	1,030	400
Mo40	160.0	0.0	90.0	720	155	350
Mo41	180.0	0.0	-90.0	1,200	800	1,200
Mo42	130.0	0.5	-90.0	900	890	900
Mo43	143.0	-68.0	-26.0	1,230	1,430	710
Re40	79.0	-7.0	-19	1500	900	700
Re41	340	0	0	900	700	575
Re42	324	29	-78	1200	1200	1100
Re43	60	0	-80	1700	1700	850
SG0	30.0	0.0	0.0	1,000	1,000	600
SG10	40.0	0.0	-90.0	1,050	450	550
SG1	88.0	6.0	40.0	450	350	325
SG2	117.0	-34.0	22.0	1,300	1,000	370
SG3	80.0	0.0	0.0	1,300	1,200	660

14.8 Resource Block Model

The block model parameters are set out in Table 14-9.

Table 14-9: Pebble Deposit 2020 Block Model Parameters

Origin*	Coordinates	Dimensions	Number	Size (ft)	Rotation (°)
X	1396025	Columns	279	75	0
Y	2147800	Rows	246	75	-
Z	-5500	Levels	150	50	-

14.9 Interpolation Plan

Grade interpolation using OK was carried out in three passes: the search ellipse used for the first pass had axes that measured 95% of the variogram range (those shown in Table 14 7), the second pass used search ellipse axes equal to 150% of the range and the third pass used search ellipse dimensions equal to 300% of the range.

The first and second passes were limited to a minimum of eight and a maximum of 24 composites, with a maximum of three composites from any one drill hole. For the third pass the minimum number of composites was set to five.

Domain boundaries were 'hard' (interpolation using composites only from within a given domain) with the exception of the east-west divide. The domain restrictions are set out in Table 14-10.

Table 14-10: Pebble Deposit Domain Interpolation Data Sources

Domain Estimated	Domains Sourced
Ag40	Ag zone 40
Ag41	Ag zone 41, 42, 43
Ag42	Ag zone 42, 41
Ag43	Ag zone 43, 41
Au40	Ag zone 40
Au41	Au zone 41, 42, 43
Au42	Au zone 42, 41
Au43	Au zone 43, 41
Cu1	Cu zone 1
Cu2	Cu zone 2
Cu40	Cu zone 40
Cu41	Cu zone 41, 42, 43
Cu42	Cu zone 42, 41
Cu43	Cu zone 43, 41
Mo40	Mo zone 40
Mo41	Mo zone 41, 42, 43
Mo42	Mo zone 42, 41
Mo43	Mo zone 43, 41
Re40	Mo zone 40
Re41	Mo zone 41, 42, 43
Re42	Mo zone 42, 41
Re43	Mo zone 43, 41

14.10 Reasonable Prospects of Economic Extraction

The resource estimate is constrained by a conceptual pit that was developed using a Lerchs-Grossmann algorithm and is based on the parameters set out in Table 14-11.

Table 14-11: Pebble Deposit Conceptual Pit Parameters

Parameter		Units	Cost ($)	Value
Metal Price	Gold	$/oz	-	1,540.00
	Copper	$/lb	-	3.63
	Molybdenum	$/lb	-	12.36
	Silver	$/oz		20.00
Metal Recovery	Copper	%	-	91
	Gold	%	-	61
	Molybdenum	%	-	81
	Silver	%	-	67
Operating Cost	Mining (mineralized material or waste)	$/ton mined	1.01	-
	Added haul lift from depth	$/ton/bench	0.03	-
	Process			
	-Process cost adjusted by total crushing energy	$/ton milled	4.40	-
	-Transportation	$/ton milled	0.46	-
	-Environmental	$/ton milled	0.70	-
	-G&A	$/ton milled	1.18	-
Block Model	Current block model	ft	-	75 x 75 x 50
Density	Mineralized material and waste rock	-	-	Block model
Pit Slope Angles	-	degrees	-	42

14.11 Mineral Resource Classification

Mineral Resources are classified as Measured, Indicated and Inferred. For a block to qualify as Measured, the average distance to the nearest three drill holes must be 250 ft or less of the block centroid. For a block to qualify as Indicated, the average distance from the block centroid to the nearest three holes must be 500 ft or less. For a block to qualify as Inferred it will generally be within 600 ft laterally and 300 ft vertically of a single drill hole. Blocks were plotted according to the above criteria and then individual 3D solids were created encompassing the block extents while eliminating outliers. These solids were then used to assign the final block classification.

14.12 Copper Equivalency

The Mineral Resource estimate was tabulated on the basis of CuEq; gold and molybdenum are converted to equivalent copper grade and those equivalencies are added to the copper grade. Neither silver nor rhenium grades were estimated prior to 2014 and 2020 respectively; therefore, to permit a direct comparison between previous resource estimates, the minor economic contribution of these metals was not included in the current CuEq calculation. To further maintain the comparison between the previous and current estimates, the CuEq formula is predicated upon the metal prices and metal recoveries used in the 2011 estimate. This does not affect the actual metal grades reported, only their equivalent copper grades when calculating the copper equivalent value.

Metallurgical testing determined that metal recoveries in the eastern portion of the deposit (west of State plane easting 1405600) can be expected to be higher than those for the western portion of the deposit. Therefore, separate equivalency estimates were made for the western and eastern portions of the deposit. The formulae used for the conversion are given as follows:

CuEq General Equation =	Cu% + ((Au g/t * (Au recovery / Cu recovery) * (Au $ per gram / Cu $ per %)) + ((Mo % *(Mo recovery / Cu recovery) * ((Mo $ per %) / Cu $ per %))
CuEq (Pebble West) =	Cu% + ((Au g/t * (0.696/0.85) * (29.00/40.75)) + ((Mo % * (0.778/0.85) * (275.58/40.79))
CuEq (Pebble East) =	Cu% + ((Au g/t * (0.768/0.893) * (29.00/40.79)) + ((Mo % * (0.837/0.893) * (275.58/40.79))

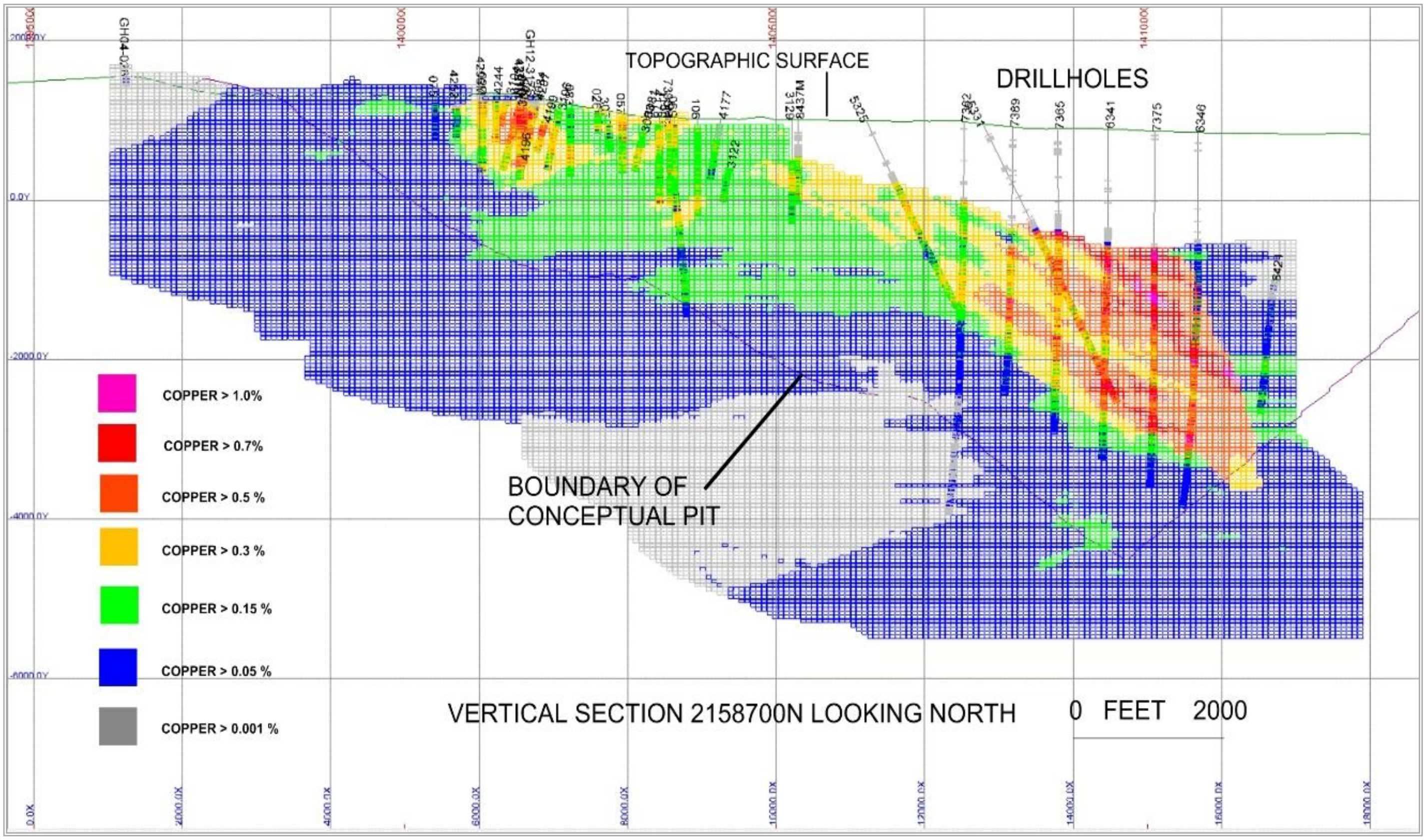
Where:

- Pebble West Au recovery = 69.6%;
- Pebble East Au recovery = 76.8%;
- Pebble West Cu recovery = 85%;
- Pebble East Cu recovery = 89.3%;
- Pebble West Mo recovery = 77.8%;
- Pebble East Mo recovery = 83.7%;
- Cu price = $1.85/lb;
- Au price = $902/oz;
- Mo price = $12.50/lb;
- all metal prices are based on the estimate in the 2011 PEA;
- g/oz = 31.10348; and,
- lb/% = 22.046.

14.13 Block Model Validation

The block model was inspected visually for correspondence between composite grades and block grades. This inspection was carried out on vertical sections at 100-foot intervals both east-west and north-south. There is close agreement between composite and block grades. By way of example, Figure 14-11shows the correlation between block and composite copper grades for vertical section 2158700 N.

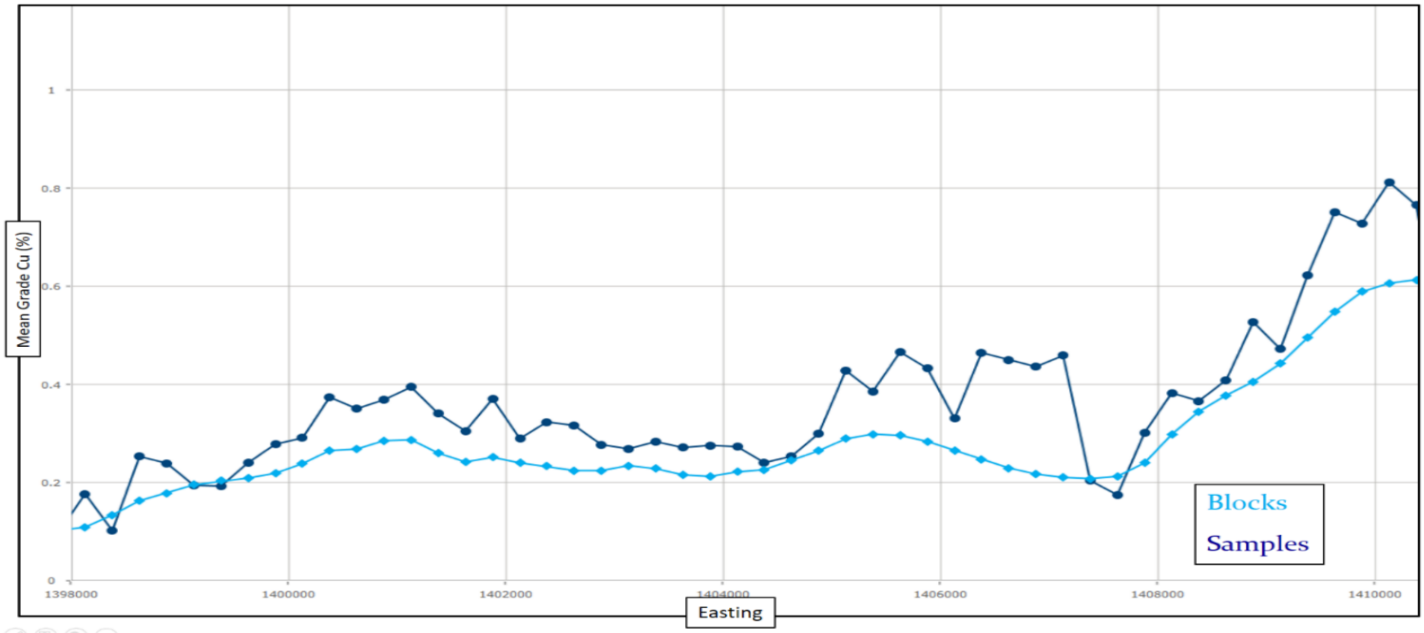
Figure 14-11: Pebble Deposit Vertical Section Showing Block and Composite Copper Grades; Section Line 2158700N



Note: Prepared by NDM, 2020

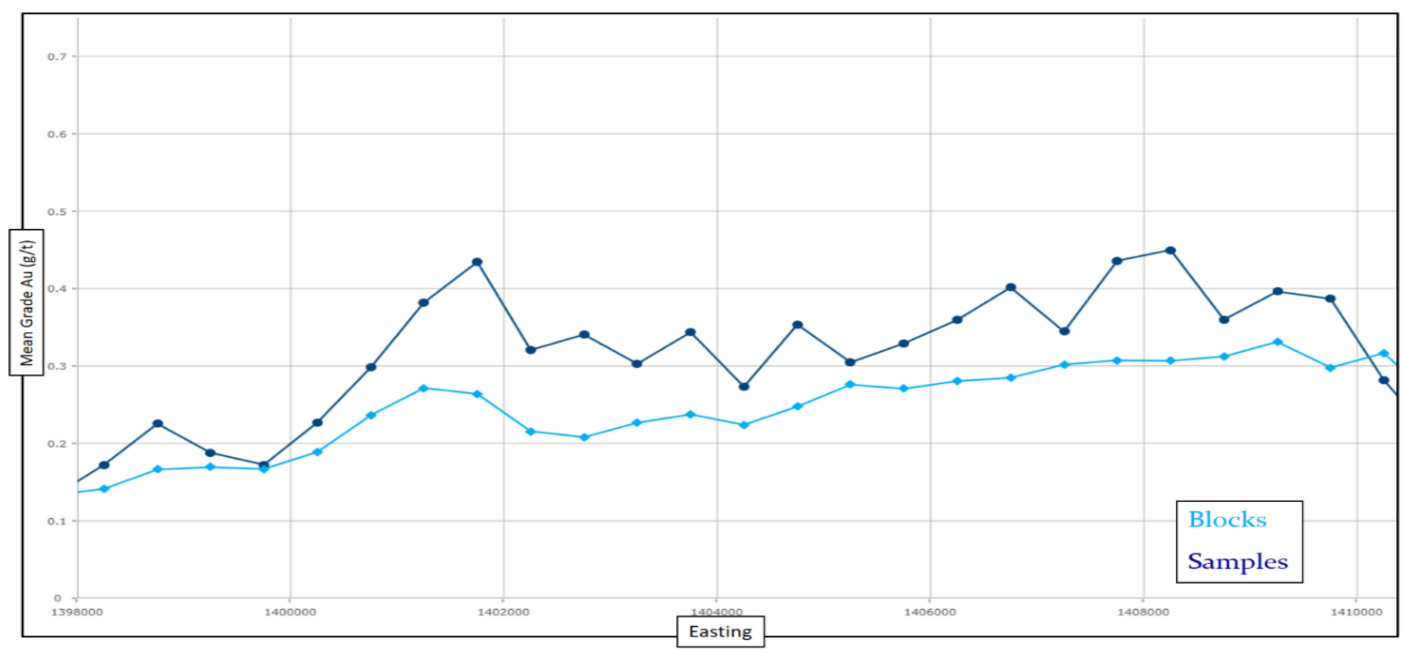
The second type of validation consisted of swath plot analysis in which the variation in metal grade for both estimated blocks and informing samples is compared along a nominated section. The comparison for copper, gold, molybdenum and rhenium presented in Figure 14-12 to Figure 14-15 shows that there is reasonable agreement between the metal grades and the informing samples.

Figure 14-12: Copper Swath Plot at 2157000N



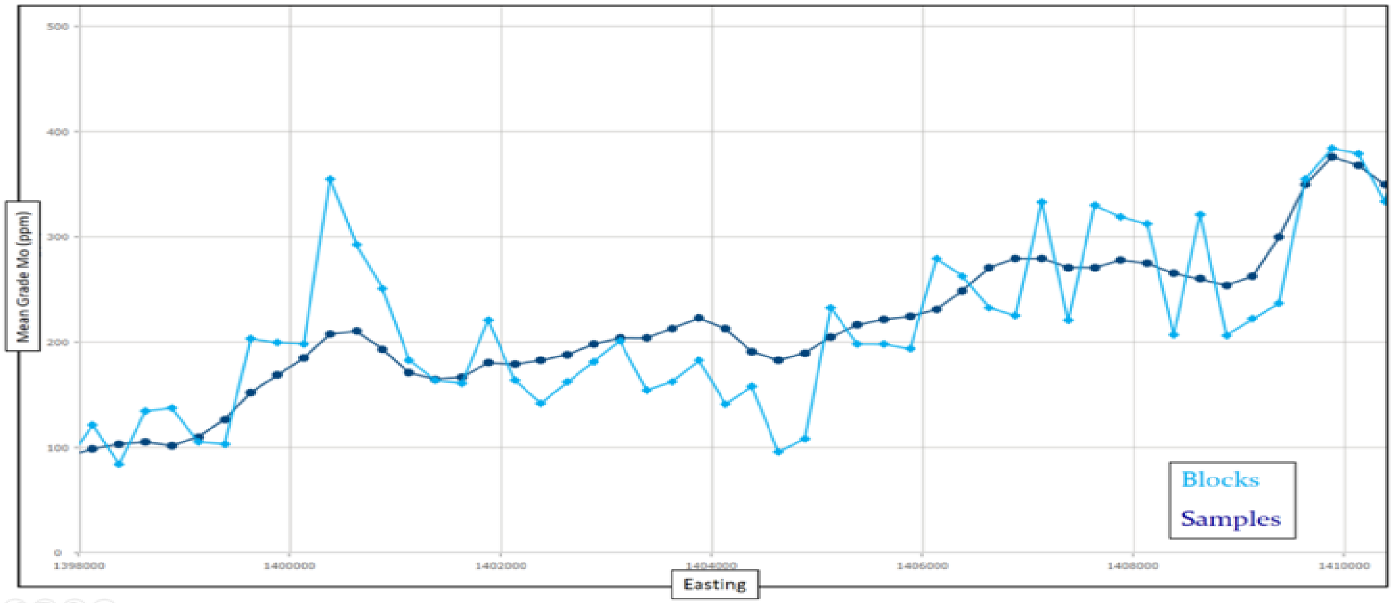
Note: Prepared by NDM, 2020

Figure 14-13: Gold Swath Plot at 2157000N



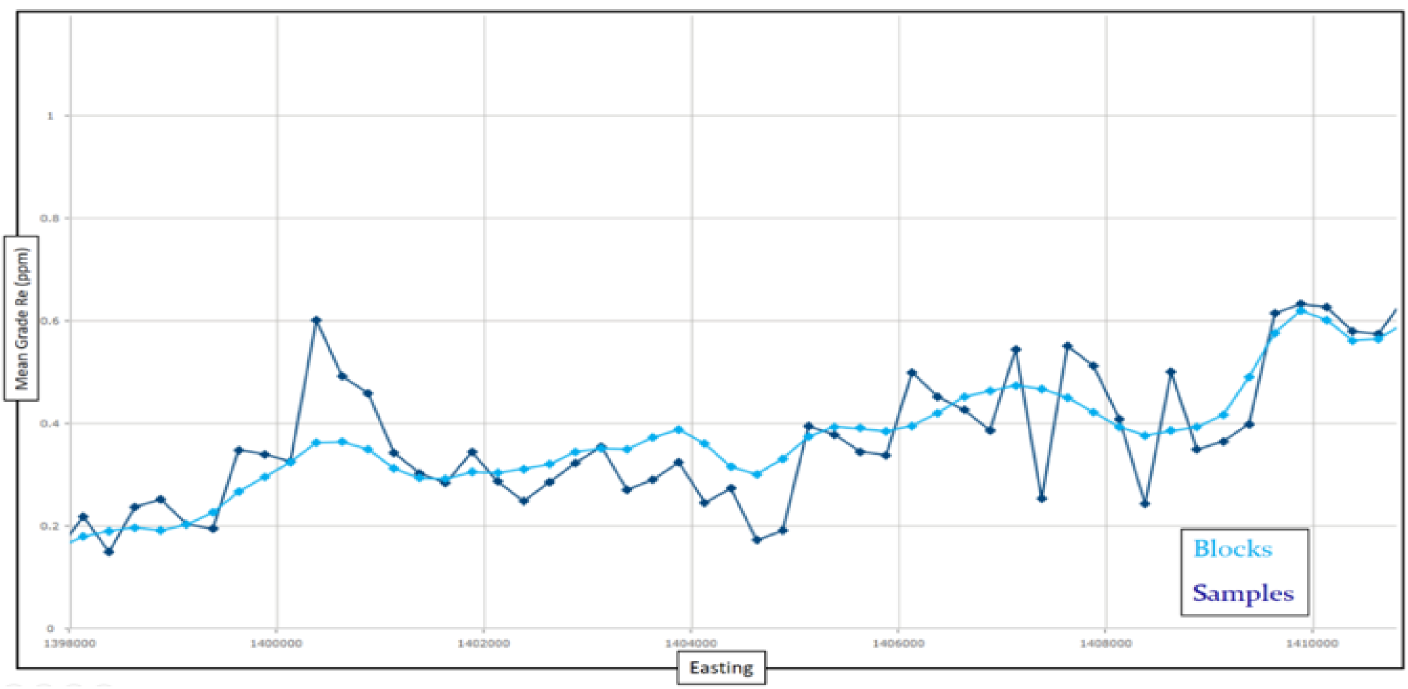
Note: Prepared by NDM, 2020

Figure 14-14: Molybdenum Swath Plot at 2157000N



Note: Prepared by NDM, 2020

Figure 14-15: Rhenium Swath Plot at 2157000N



Note: Prepared by NDM, 2020

14.14 Factors That May Affect the Mineral Resource Estimates

The Mineral Resource estimates may ultimately be affected by a broad range of environmental, permitting, legal, title, socio-economic, marketing and political factors pertaining to the specific characteristics of the Pebble deposit (including its scale, location, orientation and polymetallic nature) as well as its setting (from a natural, social, jurisdictional and political perspective).

Factors that may affect the Mineral Resource estimate include:

- changes to the geological, geotechnical and geometallurgical models as a result of additional drilling or new studies;
- the discovery of extensions to known mineralization as a result of additional drilling;
- changes to the Re:Mo correlation coefficients and resultant regression equation due to additional drilling;
- changes to commodity prices resulting in changes to the test for reasonable prospects for eventual economic extraction; and
- changes to the metallurgical recoveries resulting in changes to the test for reasonable prospects for eventual economic extraction.

The Mineral Resource estimates contained have not been adjusted for any risk that the required environmental permits may not be obtained for the Project. The risk associated with the ability of the Project to obtain required environmental permits is a risk to the reasonable prospects for eventual economic extraction of the mineralisation and the classification of the estimate as a Mineral Resource.

15 MINERAL RESERVE ESTIMATES

This section is not relevant to this report.

16 MINING METHODS

16.1 Introduction

The 2021 PEA is preliminary in nature and includes inferred Mineral Resources that are considered too speculative to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results will be realized. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

16.2 Mine Plan Inputs

16.2.1 Block Model

The mining team was provided with a 75 x 75 x 50 ft block model.

16.2.2 Pit Slope Angle

Pit slope angles are based on work completed by SRK in 2012 (SRK, 2012) report and outlined in Section 16.3.

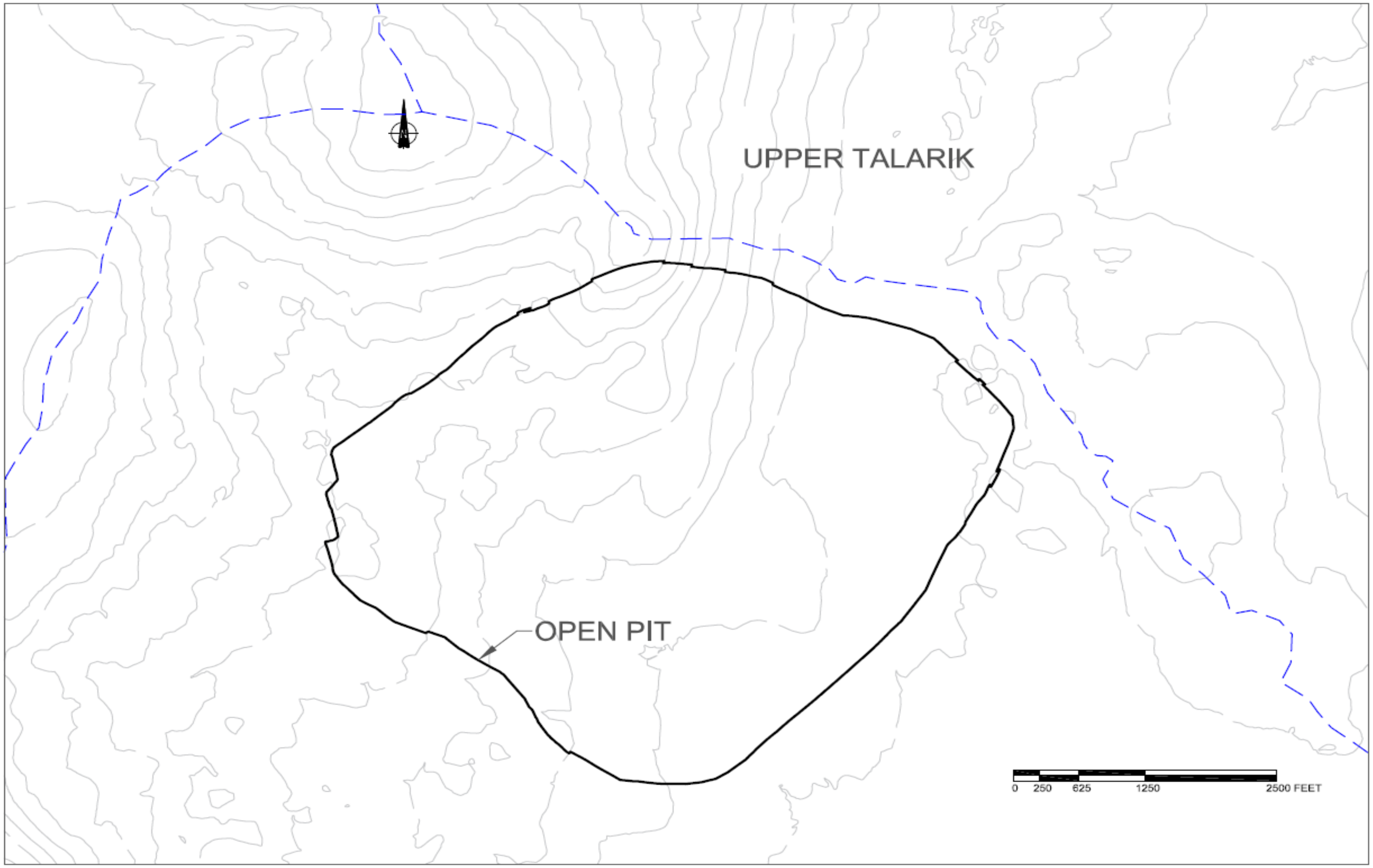
16.2.3 Surface Topography

Northern Dynasty provided digital topographical drawings, as shown in Figure 16-1, which also shows the Upper Talarik limits and proposed open pit outlines.

16.2.4 Pit Optimization Parameters

The conceptual economic, technical and operational parameters used for open pit and mining schedule optimizations are provided in Table 16-1.

Figure 16-1: Proposed Open Pit



Note: Prepared by Tetra Tech Canada Inc., 2021

Table 16-1: Pit Optimization Parameters

Item		Units	Value
Mill Production Rate		ton/d	180,000
Metal Price	Gold	US$/oz	1,600
	Copper	US$/lb	3.00
	Molybdenum	US$/lb	9.00
	Silver	US$/oz	18.00
Metal Recovery	Copper	%	Variable
	Gold	%	Variable
	Molybdenum	%	Variable
	Silver	%	Variable
Concentrates	Copper Concentrate Grade	% Cu	26.0
	Moisture Content – Cu Concentrate	%	8.0
	Gold in Cu Concentrate	g/ton	Variable
	Silver in Cu Concentrate	g/ton	Variable
	Molybdenum Concentrate Grade	% Mo	50.0
	Moisture Content – Mo Concentrate	%	8.0
Transportation	Cu Concentrate		
	-Pumping from Mine Site to Marine Terminal	$/wet ton	5.72
	-Ocean transportation costs	$/wmt	45.35
	-Doré	$/oz	1.00
	Mo Concentrate		
	-Trucking from Mine Site to Marine Terminal	$/wet ton	0.00 (Using returning traffic)
	-Ocean Transportation Costs	$/wet ton	75.28
Metal Payable	Copper in Cu Concentrate	%	96.15
	Gold in Cu Concentrate	%	97.00
	Silver in Cu Concentrate	%	90.00
	Gold in Doré	%	99.85
	Silver in Doré	%	99.50
	Mo in Mo Concentrate	%	98.50
Marketing	Concentration Losses	%	0.15
	Insurance	% of value	0.10
	Representation	US$/wet ton of concentrate	2.27
Treatment, Smelting and Refining Terms	Treatment of Cu Concentrate	US$/dry ton of concentrate	77.11
	Refining of Cu in Cu Concentrate	US$/payable lb	0.085
	Refining of Au in Cu Concentrate	US$/payable oz	7.00
	Refining of Ag in Cu Concentrate	US$/payable oz	0.50
	Refining of Au/Ag Doré	US$/payable oz	1.00

Item		Units	Value
	Roasting of Mo in Mo Concentrate	US$/payable lb	3.00
Operating Cost	Mining (Ore or Waste) at 950 ft elevation	US$/ton mined	1.01
	Added Mining Cost by Depth	US$/ton mined/bench	0.03
	Process Cost Adjusted by Crushing Energy	US$/ton milled	Variable
	Site facilities	US$/ton milled	0.59
	Environmental	US$/ton milled	0.56
	Road maintenance	US$/ton milled	0.02
	Port & logistics	US$/ton milled	0.68
	Tailings	US$/ton milled	0.02
	Water Treatment	US$/ton milled	0.64
	G&A	US$/ton milled	0.61
Block Model	Block Dimension	ft x ft x ft	75 x 75 x 50
	Specific Gravity	-	Variable
Mining Dilution		%	0.50
Mining Recovery		%	99.00
Pit Slope Inputs			See Section 16.3

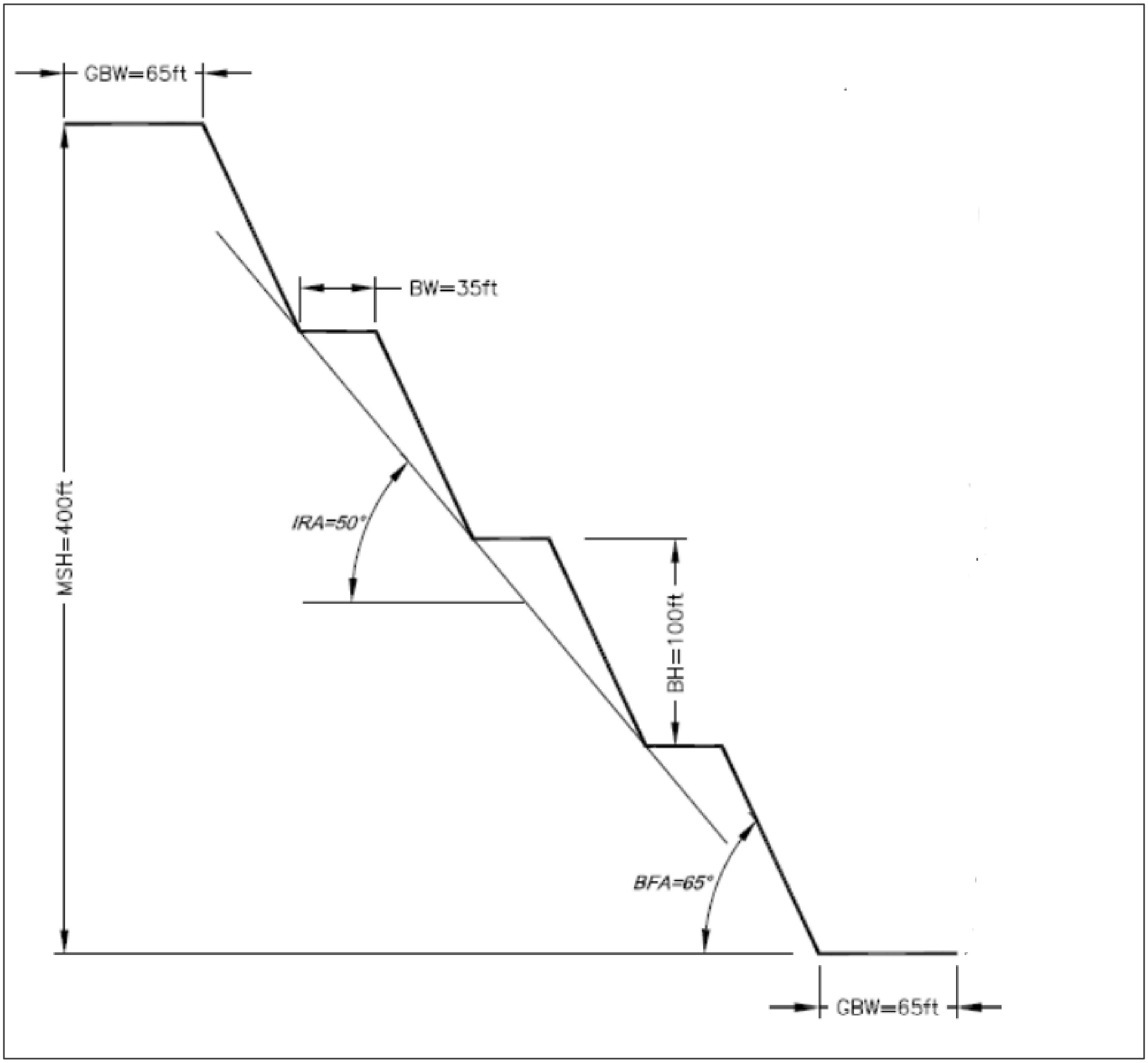
16.3 Mine Design

Slope design recommendations are provided in SRK (2012) and summarized as follows:

- Maximum stack height (MSH) = 400 ft;
- At a minimum, a geotechnical berm of 65 ft should be used separate the various stacks;
- Inter-ramp angle (IRA) = variable, depending on kinematics and rock mass stability, ranging from 40º to 55°;
- Bench face angle (BFA) = variable, kinematically controlled, expected break-back angles in the range of 75º to 55°;
- Bench height (BH) = double-benching (100 ft) in all sectors, with the exception of the YGs-Weak rocks which should be single-benched (50 ft). Fault-zones are considered 'weak' and need to be single-benched at a rate of one below and three above, and should be further investigated and applied at the feasibility level; and
- Bench width (BW) = is scaled according to the rock mass condition, typically in the range of 30 to 50 ft) for the 25-year pit.

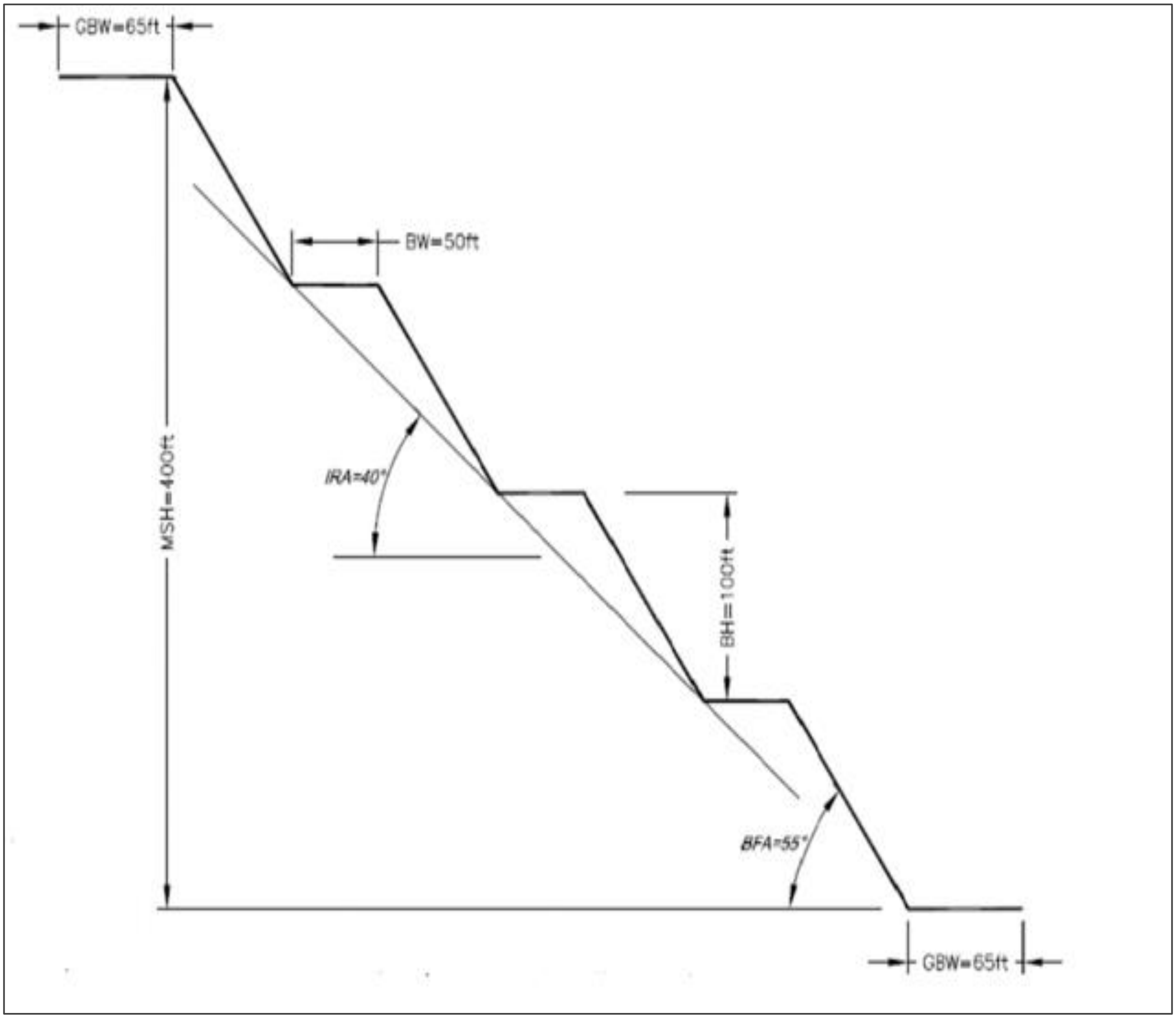
Recommended slope designs are shown in Figure 16-2 and Figure 16-3.

Figure 16-2: Pit Wall Slope for Cretaceous North West Sector



Note: Prepared by SRK, 2012.

Figure 16-3: Pit Wall Slope for Cretaceous North Sector



Note: Prepared by SRK, 2012

16.3.1 Minimum Working Area

Benches were designed to accommodate 80 yd^3 electric cable shovels and 400-ton haulage trucks. In narrow areas and at the pit bottom, where mining widths are reduced, Tetra Tech recommends the use of a 53 yd^3 wheel loader.

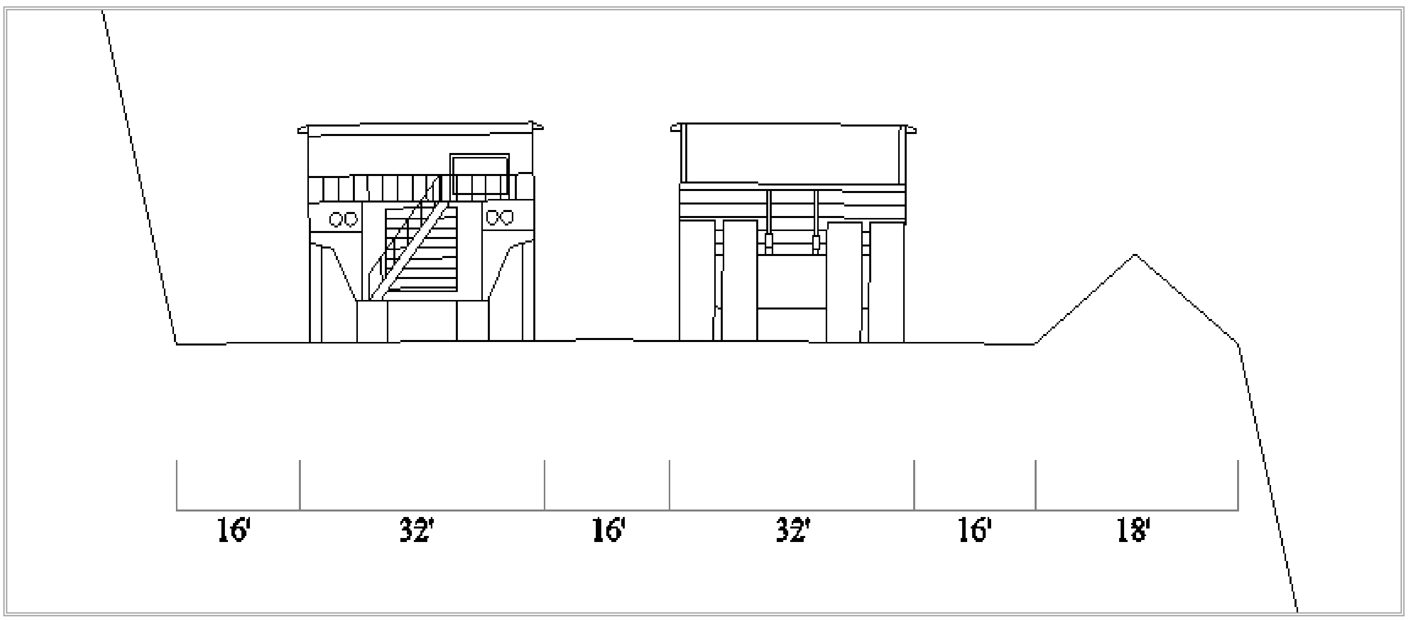
16.3.1.1 Haul Road

Main haul roads for the Pebble Project were designed to accommodate 400-ton haulage trucks with two-way traffic. Haul road design details are provided in Table 16-2 and Figure 16-4. Ramps were designed with a maximum grade of 10%.

Table 16-2: Haul Road Width

Traffic	Two-way (ft)
Running Surface	112.0
Safety Berm	18.0
Total	130.0

Figure 16-4: Two-way Haul Road



Note: Prepared by Tetra Tech Canada Inc., 2021

16.3.2 Pit Hydrology/Dewatering

An allowance has been included in the mining operating cost to account for pit dewatering costs.

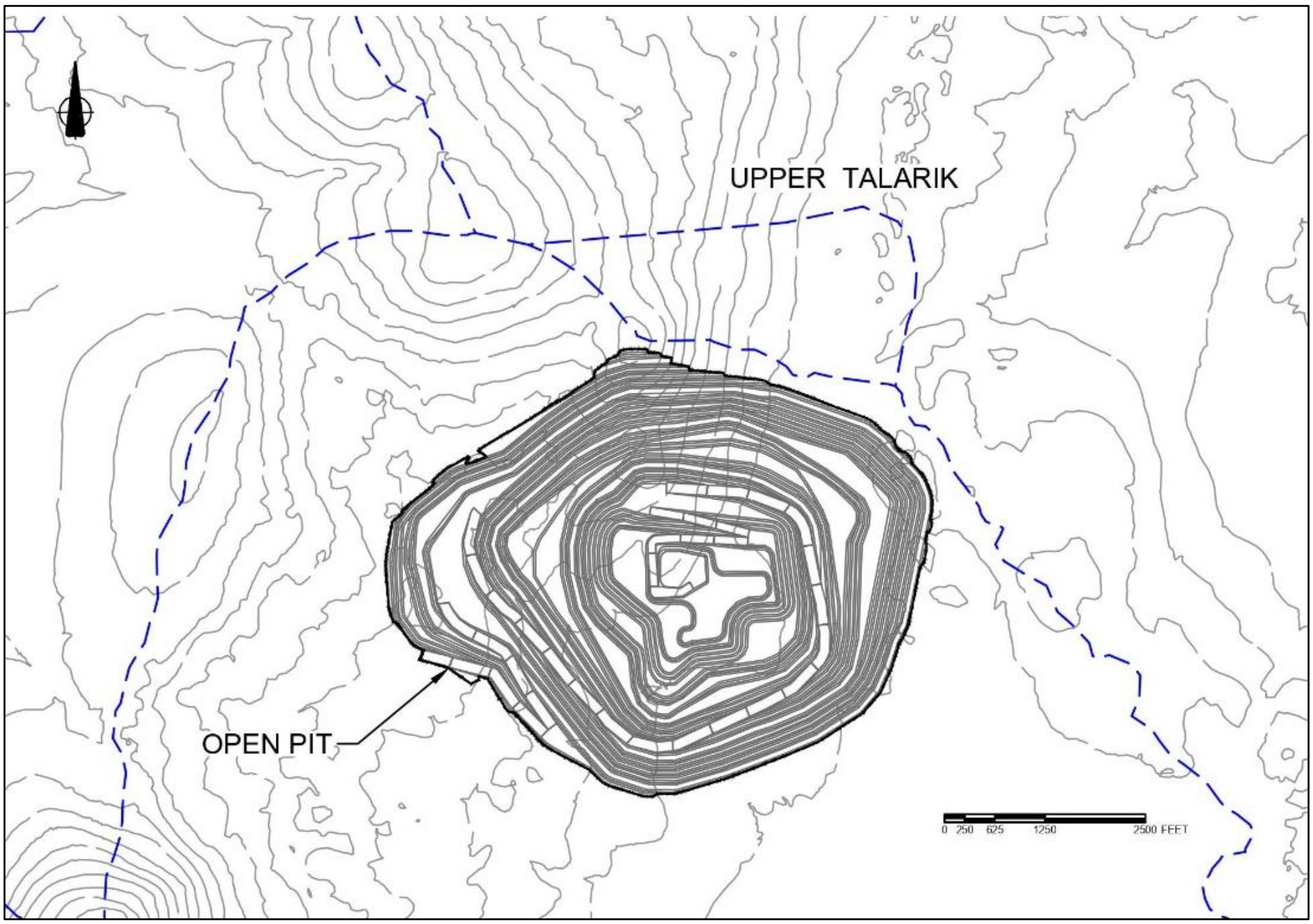
16.3.3 Pit Design Results

The final pit includes 1,291 million tons of Mineral Resources with a LOM strip ratio of 0.12. A material summary from the final pit is provided in Table 16-3 and the final pit is shown in Figure 16-5.

Table 16-3: **Open Pit Design Results**

Material	Mass (Mton)	Cu (%)	Au (oz/ton)	Mo (ppm)	Ag (oz/ton)	Re (ppm)
Mineralized Material	1,291	0.29	0.01	154	0.04	0.28
Overburden	60	-	-	-	-	-
Waste rock	93	-	-	-	-	-

Figure 16-5: **Final Open Pit**



Note: Prepared by Tetra Tech Canada Inc., 2021

16.4 Mine Plan

The open pit mine for the Proposed Project would be a conventional drill, blast, truck, and shovel operation with an average mining rate of approximately 70 million tons per year and an overall stripping ratio of 0.12 ton of waste per ton of mineralized material.

The open pit would be developed in stages, with each stage expanding the area and deepening the previous stage. The final dimensions of the open pit would be approximately 6,800 ft long and 5,600 ft wide, with the depth to 1,950 ft.

Mining would occur in two phases – preproduction and production.

The mine operation would commence during the last year of the preproduction phase and extend for 20 years during the production phase.

The preproduction phase would consist of dewatering the pit area and mining of non-economic materials overlying the mineralized material from the initial stage of the open pit. Dewatering would begin approximately one year before the start of preproduction mining. Approximately 33 million tons of material would be mined during this phase (Table 16-4).

Table 16-4: Mined Material – Preproduction Phase

Material Type	Quantity
Overburden	22 million tons
Waste rock	11 million tons

The production phase encompasses the period during which economic-grade mineralized material would be fed to the process plant to produce concentrates for shipment and sale. The production phase is planned to last for 20 years. Mineralized material would be mined and be fed through the process plant at a rate of 180,000 tons/day. The open pit would be mined in a sequence of increasingly larger and deeper stages. Approximately 1.4 billion tons of material are planned to be mined during the production phase (Table 16-5).

Table 16-5: Mined Material – Production Phase

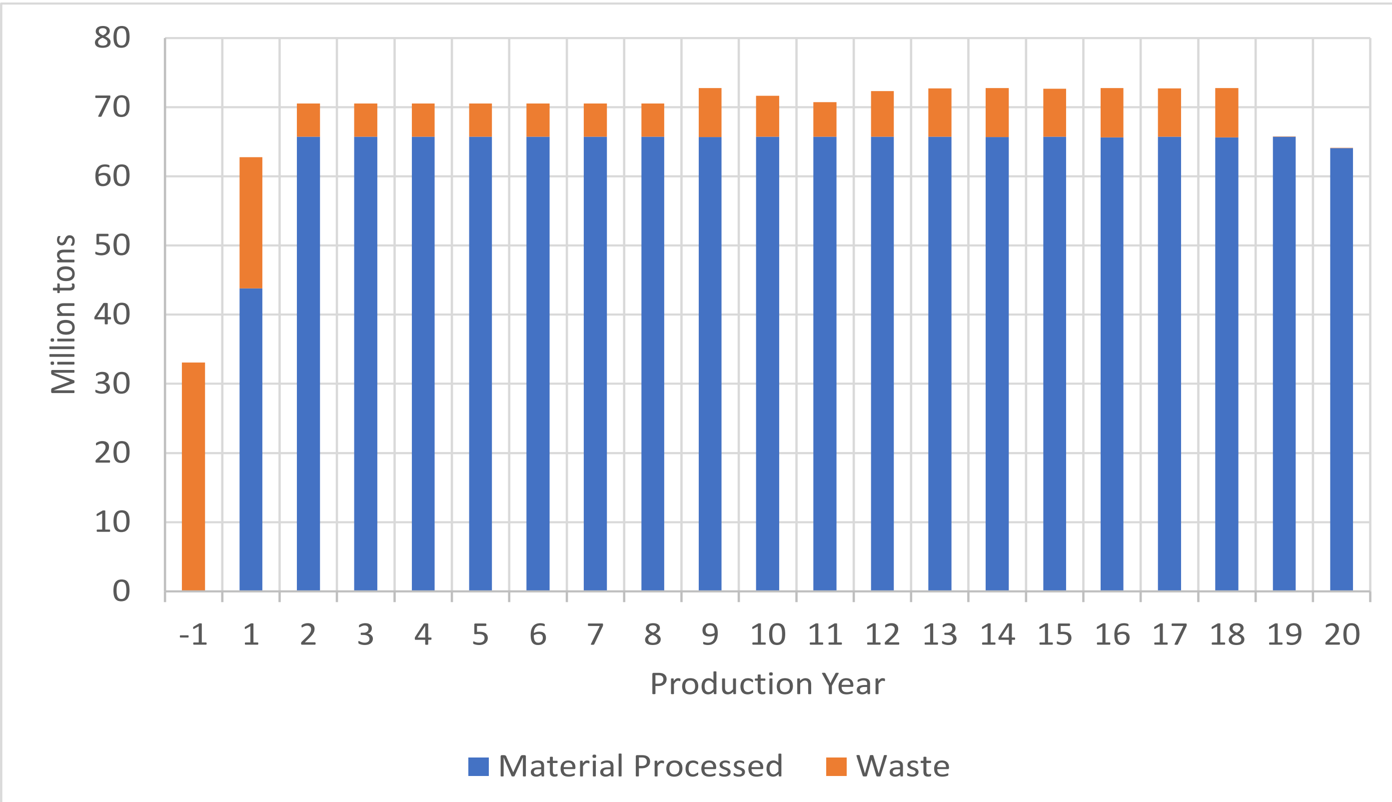
Material Type	Quantity
Overburden	38 million tons
Mineralized material process plant feed	1,291 million tons
Waste rock	82 million tons

A detailed annual production forecast is shown in Table 16-6 and Figure 16-6. The mining forecast was generated using five pushbacks and was based on a maximum processing capacity of 180,000 tons per day. Based on the selected ultimate pit, final pit design and the generated production schedule, the Pebble Project's total LOM is 21 years, including 1 year of preproduction stripping followed by 20 years of production. Over the 21-year LOM, the pit would produce 1,291 million tons of mineralized material and 153 million tons of overburden and waste rock. The LOM stripping ratio (defined as waste material mined, in tons, divided by mineralized material mined, in tons) is 0.12:1.

Table 16-6: Production Forecast

Year	Total Material Mined Mtons	Plant Feed Mtons	Waste Mtons	Strip Ratio	Copper %	Gold oz/ton	Molybdenum ppm	Silver oz/ton	Rhenium ppm
-1	33.07	-	33.07						
1	62.75	43.81	18.93	0.43	0.35	0.01	168	0.04	0.29
2	70.55	65.72	4.83	0.07	0.38	0.01	197	0.04	0.35
3	70.55	65.72	4.83	0.07	0.33	0.01	235	0.04	0.42
4	70.55	65.72	4.83	0.07	0.31	0.01	147	0.04	0.26
5	70.53	65.72	4.81	0.07	0.29	0.01	132	0.05	0.23
6	70.52	65.72	4.80	0.07	0.28	0.01	192	0.04	0.34
7	70.55	65.72	4.83	0.07	0.33	0.01	165	0.05	0.30
8	70.54	65.72	4.82	0.07	0.32	0.01	180	0.04	0.34
9	72.75	65.70	7.06	0.11	0.27	0.01	100	0.04	0.19
10	71.66	65.72	5.94	0.09	0.29	0.01	126	0.04	0.23
11	70.72	65.72	5.00	0.08	0.27	0.01	144	0.04	0.26
12	72.32	65.72	6.61	0.10	0.29	0.01	154	0.04	0.28
13	72.74	65.72	7.02	0.11	0.31	0.01	169	0.04	0.30
14	72.75	65.70	7.05	0.11	0.33	0.01	159	0.05	0.29
15	72.69	65.72	6.97	0.11	0.22	0.01	89	0.05	0.16
16	72.75	65.65	7.10	0.11	0.25	0.01	127	0.04	0.23
17	72.73	65.72	7.01	0.11	0.25	0.01	166	0.04	0.30
18	72.75	65.62	7.13	0.11	0.19	0.01	74	0.04	0.13
19	65.72	65.72	0.00	0.00	0.25	0.01	182	0.04	0.32
20	64.06	64.06	0.00	0.00	0.20	0.00	184	0.03	0.32
Total / Average	1,443.23	1,290.60	152.63	0.12	0.29	0.01	154	0.04	0.28

Figure 16-6: Production Forecast



Note: Prepared by Tetra Tech Canada Inc., 2021

16.5 Blasting

Open pit blasting would be conducted using either emulsion blasting agents manufactured on site or, in dry conditions, a blend of ammonium nitrate and fuel oil (ANFO). The preference would be to use the emulsion blasting agent because of its higher density and superior water resistance. Initial operations during the preproduction phase may use pre-packed emulsion blasting agents or a mobile bulk emulsion manufacturing plant until the permanent explosives plant is completed.

Ammonium nitrate prill would be shipped to the site in containers and stored separately as a safety precaution. All explosive magazines would be constructed and operated to meet mine safety and health regulations. The ammonium nitrate prill would be converted to solution in the explosives plant and transported to the blasting site in a mobile mixing unit. There it would be mixed with diesel fuel and emulsifying agents as it is discharged into the blast holes. The emulsion would become a blasting agent only once it is sensitized using the sensitizing agent while in the drill hole.

Based on knowledge of the rock types in the Pebble deposit, blasting would require an average powder factor of approximately 0.5 pounds per ton of rock. Blasting events during the preproduction phase would occur approximately once per day. The frequency would increase during the production phase, with events occurring as often as twice per day.

16.6 Mine Waste Rock Management

Waste rock material with a mineral content below an economically recoverable level that is removed from the open pit, exposing the higher-grade production material. Waste rock would be segregated by its potential to generate acid. NPAG and non-metal leaching (ML) waste rock may be used for embankment construction. PAG and ML waste rock would be stored in the pyritic TSF until mine closure, when it would be back hauled into the open pit.

Quantities of waste material mined are outlined in Table 16-7. During the preproduction phase, approximately 33 million tons of non-mineralized and mineralized material would be removed from the open pit. Non-mineralized waste and overburden would be stockpiled or used in construction, mineralized waste would be stockpiled and relocated to the pyritic TSF once complete, or if grades are sufficient, stockpiled for milling once the mill is complete. Material would be stockpiled within the pit footprint, or in designated stockpiles as appropriate.

Overburden is the unconsolidated material lying at the surface. At the Pebble deposit, the overburden depth ranges from 0 to 140 ft. Overburden removal would commence during the preproduction phase and would recur periodically during the production phase at the start of each pit stage. The overburden would be segregated and stockpiled in a dedicated location southwest of the open pit. A berm built of non-mineralized rock would surround the overburden to contain the material and increase stability. Overburden materials deemed suitable would be used for construction. Fine- and coarse-grained soils suitable for plant growth would be stockpiled for later use as growth medium during reclamation. Growth medium stockpiles would be stored at various locations around the mine site and stabilized to minimize erosion potential. Details on how the PAG material would be reclaimed are provided in Section 18.

Table 16-7: Overburden and Waste Rock mined over the LOM

Material	Preproduction	Production	Total
Overburden, million tons	22	38	60
Waste rock, million tons	11	82	93
Total, million tons	**33**	**110**	**153**

16.7 Mining Equipment

16.7.1 Mine Equipment Fleet

The Project production fleet would use the most efficient mining equipment available to minimize fuel consumption per ton of rock moved. Most mining equipment would be diesel-powered. This production fleet would be supported by a fleet of smaller equipment for overburden removal and other specific tasks for which the larger units are not well-suited. Equipment requirements would increase over the life of the mine to reflect increased production volumes and longer cycle times for haul trucks as the pit is lowered. All fleet equipment would be routinely maintained to ensure optimal performance and minimize the potential for spills and failures. Mobile equipment (haulage trucks and wheel loaders) would be serviced in the truck shop; track-bound equipment (shovels, excavators, drills, and dozers) would be serviced in the field under appropriate spill prevention protocols. Track-mounted electric shovels would be the primary equipment unit used to load blasted rock into haulage trucks. Each electric shovel is capable of mining at a sustained rate of approximately 30 million tons per year.

Wheel loaders are highly mobile, can be rapidly deployed to specific mining conditions, and are highly flexible in their application.

Diesel off-highway haulage trucks would be used to transport the fragmented mineralized material to the crusher.

Track-mounted drill rigs are used to drill blast holes into the waste rock and mineralized material prior to blasting. Hole diameters would vary between 6 and 12 in. Drill rigs may be either electrically powered, as is the case for the larger units, or diesel powered.

This equipment would be supported by a large fleet of ancillary equipment, including track and wheel dozers for surface preparation, graders for construction and road maintenance, water trucks for dust suppression, maintenance equipment, and light vehicles for personnel transport. Other equipment, such as lighting plants, would be used to improve operational safety and efficiency.

The equipment selection, sizing, and fleet requirements were based on anticipated site operating conditions, haulage profiles, cycle times and overall equipment utilization. Large mining equipment have been selected to match the production schedule. In determining the number of units for the major equipment such as drills, shovels and trucks annual operating hours have been calculated and compared to the available hours for the equipment. Mine support equipment such as track dozers, motor graders, water trucks and snow and sanding trucks have been matched with major mining equipment. Equipment additions and replacements have been determined for each piece of major and support equipment.

16.7.2 Operating Hours

Mining is assumed to operate 365 days per year, with 2 shifts per day and 12 hours per shift. As shown in Table 16-8, the expected delays per shift are 177 minutes.

Table 16-8: Operational Delays per Shift

Delay	Time (min)
Weather	24
Breaks	60
Shift Change	30
Blasting	30
Communication	2
Training	1
Fuel, Equipment Moves, Other	30
Total	177

16.7.3 Primary Equipment

Loading would be performed using the 80 yd^3 cable shovels and hauling would be performed using the 400-ton haulage trucks.

Blasthole drilling would be performed using 12.25 in. electric rotary drills as primary drilling equipment, and smaller 6.5 in. rigs would be used for wall control. Blasting would be performed using ANFO and emulsion with mix proportions of 0.85 and 0.15, respectively.

The primary equipment requirements for the LOM are summarized in Table 16-9..

Table 16-9: Primary Equipment Requirements

Year	Electric Drills 12.25"	Electric Cable Shovels 80 yd^3	Wheel Loader 53 yd^3	Haulage Trucks 400 ton
-1	1	1	1	5
1	2	2	1	9
2	3	2	1	10
3	3	2	1	11
4	3	2	1	11
5	3	2	1	11
6	3	2	1	12
7	3	2	1	13
8	3	2	1	14
9	3	2	1	14
10	3	2	1	14
11	3	2	1	14
12	3	2	1	14
13	3	2	1	15
14	3	2	1	16
15	3	2	1	16
16	3	2	1	16
17	3	2	1	16
18	3	2	1	16
19	2	2	1	16
20	2	2	1	16

16.7.4 Support and Ancillary Equipment

The selection of support equipment takes into account the size and type of the main fleet for loading and hauling, the geometry and size of the pit and the number of roads and WDs that would operate at the same time. It reflects experience at operations of similar size and also considers the specific characteristics of the Pebble Project.

The support equipment requirements and the mine ancillary equipment fleet requirements for the LOM are summarized in Table 16-10 and Table 16-11, respectively.

Table 16-10: Support Equipment Requirements

Equipment	Maximum Fleet Size
Track Dozer 850 hp	3
Wheel Dozer 684 hp	2
Grader 24 ft	2
Water Truck 52,000 gal	2
Wall Control Drill (6.5")	1
Blasthole Stemmer	2

Table 16-11: Ancillary Equipment Requirements

Equipment	Maximum Fleet Size
Vibratory Compactor	1
Integrated Tool Carrier	1
Excavator	1
Motivator	1
Flatbed Truck	1
Fuel/Lube Truck	2
Mechanics Service Truck	2
Welder Truck	2
Tire Service Truck	2
Snow/Sand Truck	2
Pickup Truck	10
Mobile Crane	2
Rough Terrain Forklift	2
Shop Forklift	2
Light Plant	8
Dispatch System	1
Mobile Radios	100
Cable Reeler	1

16.8 Mining Labour

Salaried and hourly labour requirements for the mine were determined for each labour category. The machine operator and maintenance labour complement reflects employees on payroll (as opposed to on-site) and aligns with a two-week-on/one-week-off shift schedule. Each shift would be 12 hours long.

The average ratio of maintenance labour complement to operator labour complement was estimated at 0.63:1. The maintenance labour estimate is based on historical ratios between equipment operators and maintenance mechanics and electricians. All other labour and staff numbers were estimated from experience with existing mines and anticipated operating conditions for the Project.

A benefit package of 40% was applied to both salaried staff and the hourly labour base rates. The labour burden consists of vacation, statutory holidays, medical and health insurance, employment insurance, long-term disability insurance, overtime, shift differential and other factors.

Table 16-12 shows the maximum salaried staff requirements during the LOM. The hourly mining operator and maintenance labour on payroll is shown in Table 16-13.

Table 16-12: LOM Maximum Number of Employees

Position	Maximum Number of Employees
Mine Management	1
Technical Services Staff	21
Operations Staff	12
Maintenance Staff	9
Total	43

Table 16-13: Operator and Maintenance Staff on Payroll

Year	Operators	Maintenance	Total
-1	62	58	120
1	82	68	150
2	88	71	159
3	90	72	162
4	89	72	161
5	91	72	163
6	95	74	169
7	96	75	171
8	101	77	178
9	90	72	162
10	93	73	166
11	95	74	169
12	100	77	177
13	105	79	184
14	107	80	187
15	95	74	169
16	97	75	172
17	102	78	180
18	98	76	174
19	102	78	180
20	108	80	188

17 RECOVERY METHODS

17.1 Summary

The processing plant is designed with a feed rate of 180,000t tons per day. The feed material would be processed to produce two principal products, a copper-gold flotation concentrate and a molybdenum flotation concentrate, as well as a tertiary gravity gold concentrate through the following unit processes:

- primary crushing;
- grinding with SAG and ball mills;
- bulk copper-gold-molybdenum flotation;
- gravity concentration in the regrind circuit of the bulk rougher concentrate, and
- molybdenum flotation to separate a copper-gold flotation concentrate and a molybdenum flotation concentrate.

Figure 17-1 shows a simplified process flowsheet of the entire process route.

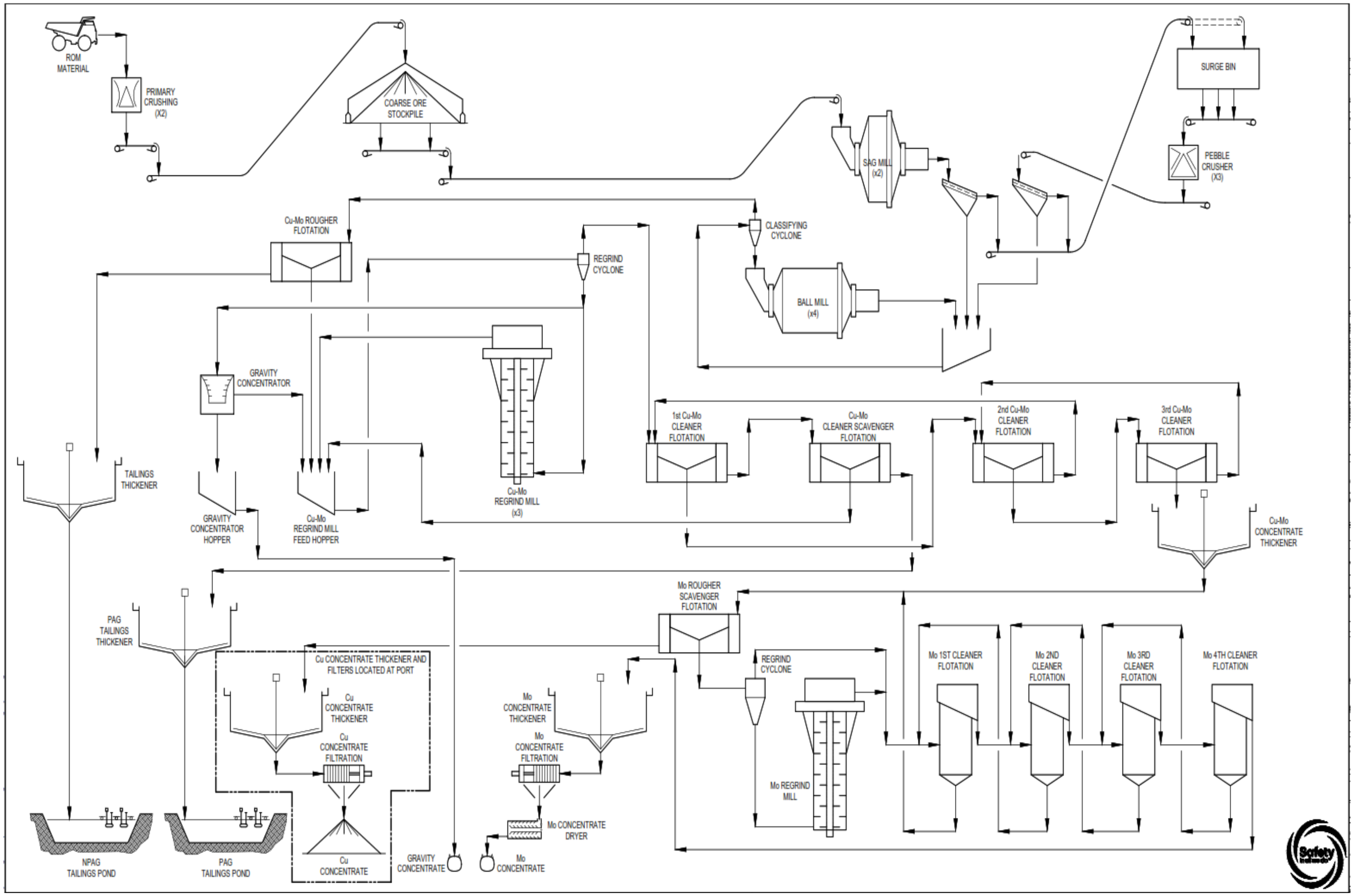
Run-of-mine material would be delivered to one of two primary gyratory crushers to reduce the material to a nominal particle size P_{80} of 145 mm. The crushed material from both crushers would be delivered via a single overland conveyor to a covered stockpile.

Coarse material would be reclaimed from the stockpile onto two SAG mill feed conveyors and into the SAG/ball milling/pebble crushing (SABC) circuit. The SAG mills would grind the mill feed material and would discharge the slurry onto the associated SAG mill discharge screen where the oversize pebbles would be conveyed to the pebble crushing building. Crushed pebbles would be sent to the pebble crushing screen. SAG mill discharge screen and pebble crushing screen undersize would be pumped with the ball mill discharge to cyclones that would produce an overflow fraction P_{80} of 135 µm for the downstream flotation processes.

Bulk rougher scavenger flotation would be carried out through two trains of eight 630 m^3 flotation cells. The bulk (copper-gold-molybdenum) concentrate would then be reground to a P_{80} of 25 µm prior to cleaner flotation. Cyclone underflow from the regrind circuit would be treated with a gravity concentrator to produce a gravity gold concentrate that would be pumped to geotextile dewatering bags for dewatering.

Regrind cyclone overflow would be treated by three stages of cleaner flotation with the final bulk concentrate to be thickened prior to molybdenum separation. The molybdenum rougher product would be reground with a high intensity grinding (HIG) mill producing a P_{80} of 25 µm product. By selective molybdenum flotation and four stages of cleaning, final molybdenum and copper-gold concentrates would be produced. Molybdenum concentrate would be thickened, filtered, dried and containerized at mine site for shipment. Copper-gold concentrate would be pumped to the port via a concentrate pipeline, where it would be thickened and filtered prior to bulk loading into barges for transhipment.

Figure 17-1: Simplified Process Flowsheet



Note: Prepared by Ausenco, 2021.

17.2 Major Process Design Criteria

The process design criteria are summarized in Table 17-1.

Table 17-1: Major Process Design Criteria

Criteria	Units	Value
Daily Process Rate	tons/d	180,000
Operating Days per Year	d/y	365
Life of Mine (LOM)	y	20
Feed Grades		
Copper	% Cu	0.46
Gold	g/t Au	0.47
Molybdenum	% Mo	0.03
Concentrate Grades		
Copper concentrate grade	%Cu	26
	g/t Au	16
Molybdenum concentrate grade	%Mo	50
Gravity gold concentrate grade	g/t Au	44
Comminution Characteristics		
JK A x b	-	46.0
Bond ball mill work index, BWi	kWh/t	13.0
Bond abrasion index Ai, average	g	0.297
Primary Crushing		
Availability	%	75
Primary crushing rate	tons/h	10,000
Circuit arrangement		gyratory
Primary crushing product particle size, P_{80}	mm	145
Grinding		
Availability	%	92
Grinding process rate	tons/h	8,152
Circuit arrangement		SABC
Primary grind product size, P_{80}	µm	135
Flotation/Regrind/Gravity		
Availability	%	92
Flotation circuit feed rate	tons/h	8,152
Cu-Mo bulk flotation circuit arrangement		rougher/regrind/3-stage cleaner
Cu-Mo bulk rougher concentrate regrind size, P_{80}	µm	25
Proportion of cyclone underflow to gravity (by weight)	%	35
Mo flotation circuit arrangement		rougher/regrind/4-stage cleaner

Criteria	Units	Value
Mo rougher concentrate regrind size, P_{80}	µm	25
Concentrate dewatering		
Cu concentrate filter cake moisture content	%	8.5
Gravity concentrate moisture	%	15
Molybdenum concentrate dryer product moisture	%	5

* The PDC was developed in metric units and then converted into US units in the process description write-up.

17.3 Process Plant Description

17.3.1 Primary Crushing

Mineralized material would be delivered by haulage trucks to each of the two 60 ft x 110 ft fixed primary gyratory crushers. The crushers would be set to produce a product P_{80} of 145 mm. Located underneath each primary crusher would be the crusher discharge vault and an apron feeder that would control the rate of discharge onto the sacrificial conveyor belt below.

The crushing plant is designed for an operating availability of 75%. Each crusher would have a typical operating range of 5,000-6,000 tons/h depending on the ROM material size distribution. Each crusher would discharge onto a common main overland conveyor via a respective transfer conveyor. Each primary crushing station would be equipped with a rock breaker, dust control equipment and sumps for surface run-off collection.

The major primary crushing equipment is as follows:

- two 60 ft x 110 ft primary gyratory crushers; each fitted with a 1,500 kW drive; and
- discharge vault apron feeders and sacrificial belt conveyors.

17.3.2 Stockpile

Primary crusher product would be conveyed by the overland conveyor to the stockpile located adjacent to the grinding and flotation building. The covered stockpile would have a live capacity of 90,000 tons or 12 hours of mill operating time.

Under normal operation mill feed material would be reclaimed by two lines of three apron feeders onto two reclaim conveyor belts to the two grinding lines.

17.3.3 Primary Grinding

Two identical trains of SAG mill, followed by a conventional ball mill and pebble crusher (collectively SABC circuit) would receive reclaimed mill feed material from the coarse ore stockpile (COS). (Note that the term ore in this context refers only to mineralized feed material but is labelled as ore to conform with industry convention for naming of the stockpile; no economic surety is implied.) Each train would have an average throughput of 90,000 short tons per day. The equipment for the two primary grinding lines would comprise:

- two 42 ft diameter x 27 ft effective grinding length (EGL) SAG mills each with 30 MW gearless drive;

- screens, conveyors and feeders;
- one pebble crusher surge bin; and
- three 933 kW pebble crushers.

The reclaimed material would be fed to each SAG mill feed chute at which point process water and lime would also be added. An automatic ball charging system would deliver SAG mill balls when required. Each SAG mill would discharge onto a pair of SAG mill discharge screens. For each SAG mill, the screen undersize would gravitate to the cyclone feed pump-box, while the screen oversize pebbles would be conveyed to a common pebble crushing plant equipped with a trio of crushers. Crushed pebbles would be conveyed to a surge-bin from where they would be split to one screen for each SAG mill. Similar to the SAG discharge screens, the crushed pebble screen undersize would discharge into the cyclone feed pump-box, while the screen oversize would return to the pebble crushers with the SAG screen oversize.

17.3.4 Secondary Grinding

Each SAG mill would feed a pair of ball mills via dedicated cyclone packs. Each pair of mills would share a common cyclone feed pump-box, which would split the slurry to one cyclone feed pump for each cyclone pack. The ball milling circuits would be designed to operate with a 300% circulating load. The major process equipment in the secondary grinding circuit comprises:

- four 26 ft diameter x 40 ft long (EGL) ball mills, each driven by a 16 MW twin pinion drive; and
- pumps and hydrocyclone clusters for each ball mill.

Process water and lime would be added to each grinding circuit cyclone feed pump-box to maintain cyclone feed density and cyclone overflow pH. The hydrocyclone underflow would gravitate to each ball mill feed chute where additional water would be added to maintain a ball mill solids density of 75%. The overflow from the quartet of hydrocyclone clusters would be transferred to the flotation feed conditioning tank using a common launder. The conditioning tank would also act as a distributor for the pair of eight-cell rougher-scavenger flotation tank cell lines as shown in Figure 17-1. The grinding circuit product would have a P_{80} of 135 µm.

17.3.5 Bulk Rougher Flotation

The flow from the conditioning tank would be split between the two parallel banks of bulk rougher flotation cells. Each bank would consist of eight 824 yd^3 tank cells, totalling sixteen cells in all. The reagents that would be added include lime, fuel oil emulsion (molybdenum collector), sodium xanthate (SEX) and methyl isobutyl carbinol (MIBC). The copper-gold/molybdenum concentrate collected in the bulk roughing cells would be delivered to a set of HIG regrind mills. The tailings from each bank would gravitate to the twin tailings thickeners for dewatering prior to being pumped to the bulk TSF.

17.3.6 Bulk Concentrate Re-grind

The bulk rougher concentrate would flow to the bulk regrind mill pump-box which would deliver slurry to the regrind hydrocyclone cluster. The regrind mills would grind the bulk rougher concentrate to a P_{80} of 25 µm.

The overflow from the hydrocyclone cluster would flow by gravity to the bulk cleaner circuit, while the underflow of the hydrocyclones would flow to the regrind mill feed distributor. Approximately 35% of the underflow would be directed to three gravity concentrators for pyrite/gold recovery, with the non-pyrite portion returning to the cyclone feed pump box. The balance of the underflow would be directed to the HIG mills for regrinding. Gravity concentrate would be pumped to geotextile dewatering bags in a dewatering area. All the effluent that would be released from the geotextile bags in the dewatering process would be collected and reused.

The major equipment would consist of the following items:

- three 5,000 kW HIG mills;
- pumpbox and hydrocyclone cluster; and
- three centrifugal gravity concentrators.

17.3.7 Bulk Concentrate Cleaner Flotation

The reground rougher concentrate would be further upgraded in a three-stage cleaner flotation circuit. The 1st cleaner flotation would be followed by cleaner-scavenger flotation. The first cleaner concentrate would advance to the 2nd cleaner stage, whilst the cleaner scavenger concentrate would return to the bulk regrind pumpbox. Cleaner scavenger tailings would report to the potentially acid generating (PAG) thickener for thickening prior to pumping to the pyritic TSF.

Concentrate from the 2nd cleaner would feed the 3rd cleaner flotation stage, whilst the 2nd cleaner tailings would be returned to the 1st cleaner. The 3rd cleaner concentrate would report to the bulk thickener, whilst 3rd cleaner tailings would be returned to the 2nd cleaner.

The same reagents used in the rougher flotation circuit would be applied in the cleaner circuit, with the addition of carboxymethyl cellulose (CMC).

17.3.8 Molybdenum Flotation

Bulk copper-molybdenum concentrate thickener underflow would report to a molybdenum flotation circuit to separate the bulk concentrate into a copper/gold concentrate and a molybdenum concentrate. To allow selective flotation of the molybdenite, copper/gold bearing minerals would be depressed through the addition of dilute sodium hydrosulphide (NaHS). The circuit would involve rougher flotation in tank cells followed by open-circuit regrinding in a small HIG mill to a nominal product P_{80} of 25 µm. Regrind cyclone overflow would be refloated in a 4-stage column cleaning process. The concentrate of each column would feed the next stage column, while each column tail would return to the previous stage. The 4^{th} cleaner column concentrate would report to the molybdenum concentrate thickener, while the 1^{st} cleaner column tailing would return to the molybdenum rougher flotation stage. The rougher flotation tailing (final copper concentrate) would be pumped to the copper concentrate thickening and filtration plant located at the port facility. To minimize consumption of NaHS, all molybdenum flotation cells would use nitrogen instead of air. Other flotation reagents used in the molybdenum flotation circuit would include fuel oil emulsion and MIBC.

The major equipment would consist of the following items:

- one 130 kW HIG mill; and
- one copper-molybdenum concentrate thickener of 108 ft diameter.

17.3.9 Concentrate Dewatering and Filtration

The copper-gold concentrate would be pumped via pipeline to the marine terminal, where it would be thickened to 65% solids by weight in a high-rate thickener. Thickener underflow would feed a pair of copper concentrate pressure filters at port facility. The filtered concentrate at maximum 8.5% moisture would be conveyed and discharged into a concentrate storage shed and subsequently into barges for transhipment. The thickener overflow and filtrate would be combined and pumped back to the main process plant via return pipeline and would be used as part of the plant process water.

The molybdenum concentrate would be thickened in a high-rate thickener to 55% solids by weight at the plant site. The thickener underflow would feed the molybdenum concentrate filter press, where the moisture content would be reduced to 12%. The filtered concentrate would be further dewatered by a dryer to 5% moisture before being bagged, containerized and shipped to smelters.

The major equipment would consist of the following items:

- copper concentrate thickener sized 108 ft diameter (at marine terminal);
- two copper concentrate filters with a cloth size of 6 ft width x 489 ft length (at marine terminal);
- molybdenum concentrate thickener sized 16 ft diameter (plant site); and
- one molybdenum concentrate filter with a cloth size of 3 ft width x 72 ft length (plant site),

17.3.10 Tailings Management and Process Water Supply System

Two types of tailings would be generated by the recovery process, namely the bulk tailings, and the pyritic tailings. Each tailings stream would be thickened and pumped to separate TSFs. The diameters of the tailing's thickeners are 325 ft and 207 ft for the bulk and pyritic tailings, respectively.

The overflow streams from each thickener would be pumped to the process water tank. Supernatant water in the bulk TSF and pyritic TSF would be reclaimed to the main water management pond. The bulk of this water would be pumped to the process water tank and any additional water volumes would be treated and discharged.

17.3.11 Reagents Handling and Storage

The reagents used within the process plant would include:

- SEX;
- fuel oil;
- MIBC;
- quicklime;
- sodium hydrosulphide;
- CMC;

- polymer (thickener aid);
- antiscalant;
- dispersant (sodium silicate); and
- liquid Nitrogen.

All reagent solutions would be prepared in a bermed containment area in a separate reagent preparation and storage facility. The reagent storage tanks would be equipped with level indicators and instrumentation to ensure that spills do not occur during preparation or operation. Appropriate ventilation, fire and safety protections would be provided at the facilities.

The liquid reagents (including fuel oil emulsion, CMC, MIBC and antiscalant) would be added in undiluted form to various process circuits via individual metering pumps. The solid reagents, including SEX and NaHS, would be mixed with fresh water to 10% and 25% solution strengths, respectively, in separate mixing tanks and stored in holding tanks before being added into the process circuits at various points using metering pumps. Quicklime would be slaked on site from bulk pebble quicklime, diluted to a 20% strength milk of lime and distributed to various addition points from a circulating loop.

Flocculant and dispersant would be dissolved, diluted to the appropriate strength, and added to various thickener feeds using metering pumps.

Liquid nitrogen would be used in the molybdenum flotation circuit to help maintain a reducing environment for copper sulphide depression.

17.3.12 Assay and Metallurgical Laboratories

The assay laboratory would be equipped with the necessary analytical instruments to provide routine assays for the mine, process and environmental departments.

The metallurgical laboratory would be set-up with all equipment and instruments required for routine test-work in support of plant optimisation.

17.3.12.1 Power Supply

A natural gas-fired combined cycle gas turbine plant would supply 270 MW of power to the mill site. Power at the marine terminal would be provided by three 2 MW natural gas fired reciprocating engine-based power generators. Power supply is discussed in detail on Section 18.7.1 Fresh Water Supply

Fresh water would be supplied from the water treatment plant for the following applications:

- fire water for emergency use;
- cooling water for mill motors and mill lubrication systems;
- reagent preparation;
- gland seal water; and

- gravity circuit.

The fire protection system would be designed to provide a water flow of 2,000 US GPM at 100 psi for two hours. Water to be used for gland water or for reagent preparation would undergo filtration and would be stored in a separate tank.

17.3.13 Air Supply

Air systems for the milling operation would be as follows:

- a high pressure air compressor would be located at each of the two primary crushing areas to provide air for dust collection systems;
- high pressure air for various plant services would be supplied by three dedicated air compressors;
- high pressure air for filter pressing and drying of copper-gold and molybdenum concentrates would be supplied by dedicated air compressors;
- low pressure air for flotation cells would be supplied by blowers; and.
- instrument air would be dried and stored for use at the main process plant site.

17.4 Process Control Philosophy

The process plant site process control systems would be based upon a distributed control system with PC-based operator interface stations. These stations would be staffed 24 hours per day and are located in the following four control rooms:

- main process plant grinding and flotation control room;
- primary crusher #1 control room;
- primary crusher #2 control room; and
- copper concentrate filtration plant (located at marine terminal).

Note that monitoring of the copper concentrate and return water pipelines would be done from both the copper concentrate filtration plant control room and the main process plant grinding and flotation control room.

Process control would be enhanced by the installation of an automatic sampling system. The system would collect samples from various streams for online analysis and daily metallurgical accounting.

For the protection of operating staff, a monitor and alarm system would monitor the level of hydrogen sulphide in and around the molybdenum flotation circuit.

18 PROJECT INFRASTRUCTURE

18.1 Introduction

The Pebble Project is located in an area of Alaska with minimal development and would require construction of infrastructure at the mine site as well as power generation and transportation facilities.

The mine site infrastructure would include truck shop, maintenance facilities, offices, service roads, utilities and worker accommodations. Figure 18-1 provides an overview of mine site infrastructure for the Pebble Project, including tailings and water management facilities.

Natural gas-fired power plants would be constructed at both the mine and the marine terminal. The natural gas for power generation would be delivered by a pipeline extending across Cook Inlet to the marine terminal and then on to the mine site along the roadway corridor.

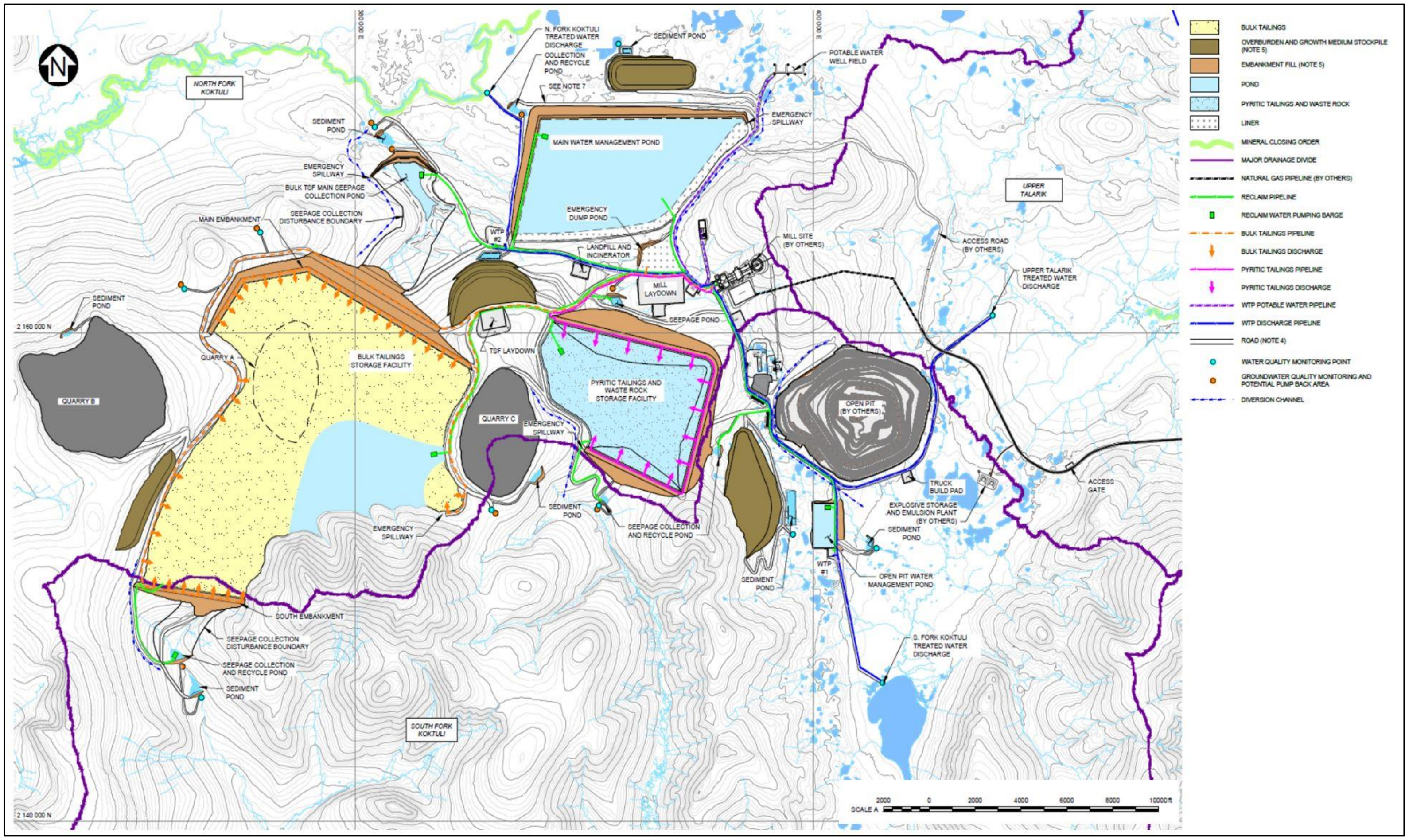
The transportation infrastructure would consist of a marine terminal facility located north of Diamond Point and a permanent access road, as well as a copper concentrate slurry pipeline system following the roadway from the mine site to the terminal.

The marine terminal facility would include marine infrastructure capable of handling barges for concentrate bulk transhipment as well as large ocean barges (400 x 100 ft) for transport of construction materials and operating supplies by container. Barge access from Cook Inlet to the marine terminal site would include a dredged channel and turning basin in front of the dock structures with a minimum 15 ft draft limit. Separate onshore facilities would include concentrate filtration and storage, power generation, maintenance facilities, offices and worker accommodations.

An all-weather 82-mile gravel road would connect the marine terminal facility with the mine site. It would follow a route along the north end of Iliamna Lake and would be designed to facilitate the transport of modules during construction and to enable access for truck haulage of equipment and supplies from the terminal facilities to the mine site during operation.

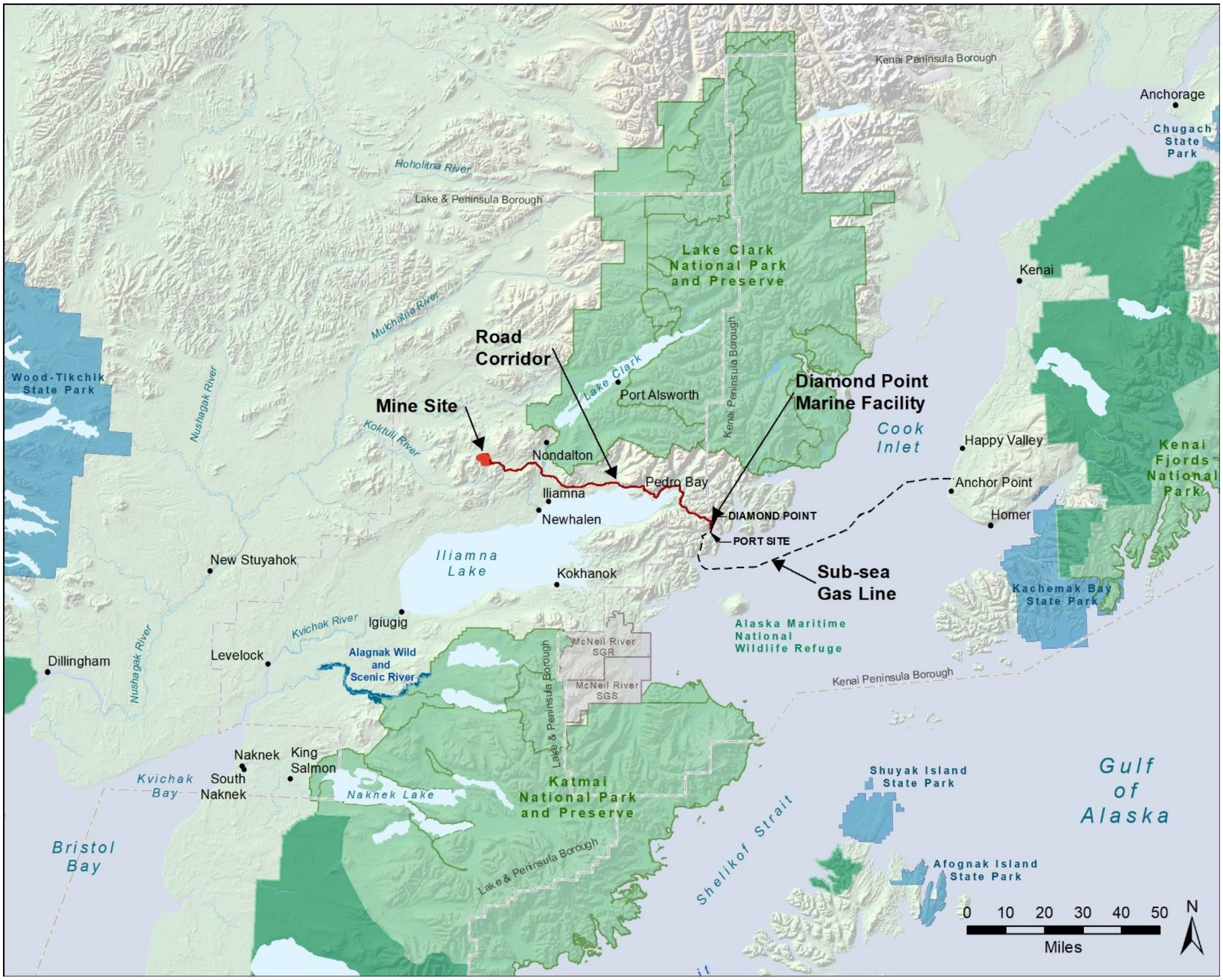
The transportation corridor would also include a buried natural gas pipeline extending from the terminal site to the mine to supply the natural gas-fired generating plant at the mine site. This same trench would be used to locate the fiber optic cable installed with the natural gas pipeline, the copper concentrate slurry pipeline, and the return water line running between the marine facility and the mine site. Figure 18-2 illustrates the general plan of the proposed infrastructure for the Pebble Project.

Figure 18-1: Mine Site Infrastructure



Note: Prepared by KP, 2020

Figure 18-2: Proposed Infrastructure



Note: Prepared by NDM, 2021.

18.2 Access and Site Roads

There is currently no road infrastructure connecting the planned marine terminal site to the mine site. The proposed road infrastructure is classified into four categories:

- The main access road from the marine terminal site to the mine site would be used to supply equipment and materials to the mine site from the marine facilities. The vehicle types to use these roads would be low-beds, B-trains, semi-trailer combinations and light/medium duty trucks. The main access road intersects the existing road north of the villages of Newhalen and Iliamna. This road would connect the mine site to those communities and to the Iliamna airport, for crew and air freight transport.

- The main access road would replace most of the existing State road from Williamsport to Pile Bay. The section being replaced extends from near Williamsport to just north of the Iliamna River.
- Haul roads would be located at the mine site and would connect the infrastructure network such as the open pit, process plant and TSFs. These roads would be used by large haul vehicles for hauling mineralized material or waste material.
- Service roads would provide on-site access to mine infrastructure: the emulsion plant, explosives magazine, WTPs and conveyor systems. The vehicles anticipated to use these roads would be light/medium-duty trucks and service vehicles.

18.2.1 Main Access Road

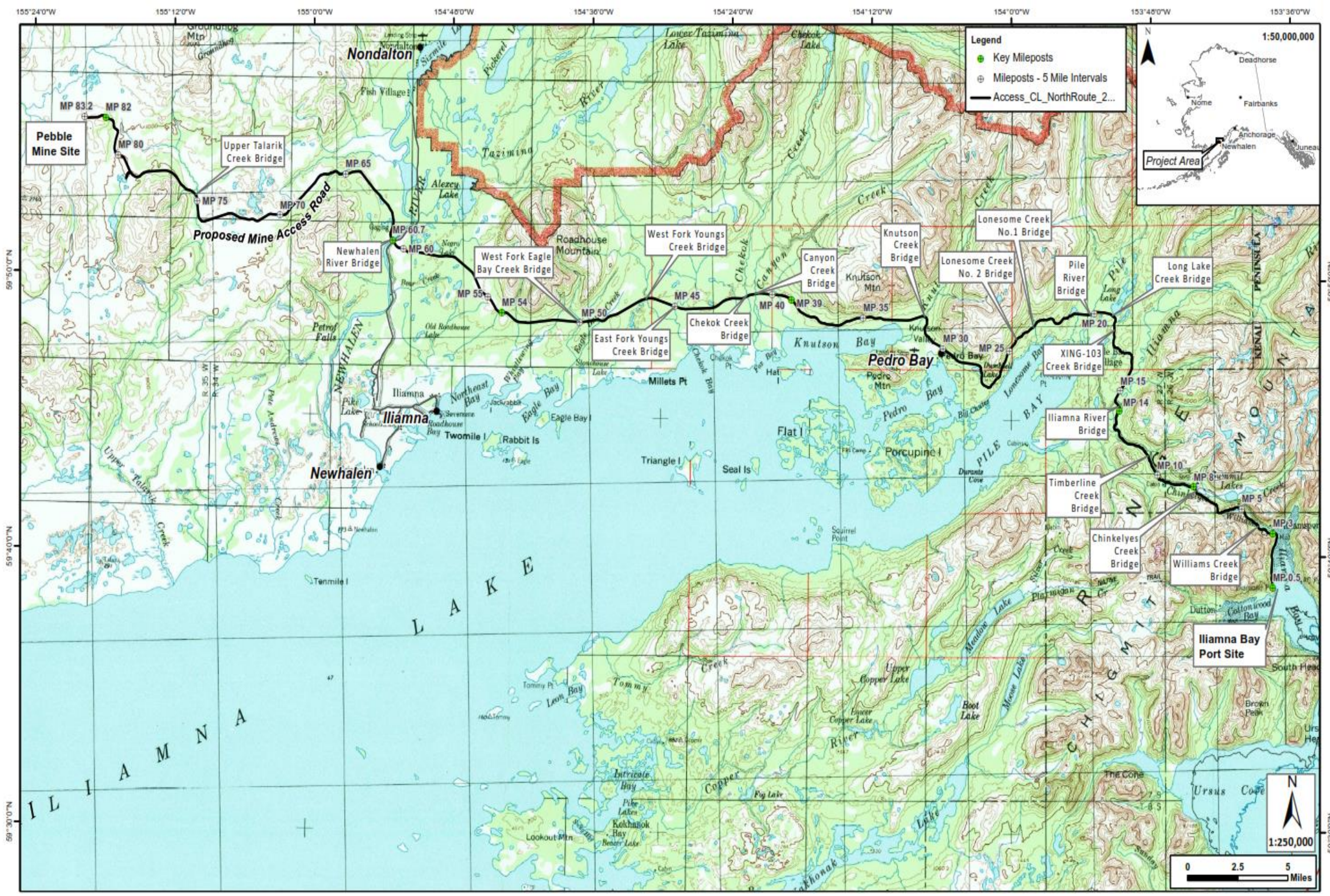
The proposed Pebble Mine access road alignment would be 82 mi long and traverse from the Diamond Point marine terminal site on Iliamna Bay, milepost (MP) 0.5, to the mine site (MP 82). Due to the evolution of the marine terminal site location, the current alignment begins at MP 0.5. The alignment interval from the marine terminal site to Williamsport (MP 3) is considered the coastal portion of the mine access road route. This section is along the west side of Iliamna Bay at the toe of the mountain slopes and partially within the intertidal zone. Mass rock excavation would be required, as would placement of rock fill with associated armor rock protection in the intertidal zone. At the head of Iliamna Bay and near Williamsport, the route turns northwesterly and climbs over Iliamna Bay Pass, through the Chigmit Mountains, and descends into the Chinkelyes Creek drainage (MP 8). A snowpack of 4-10 ft depth is typical for this area and avalanche hazards are recognized. Elevation of the road profile varies from sea level to 900 ft amsl. After crossing Chinkelyes Creek (MP 8), the route continues northwest as it roughly parallels Chinkelyes Creek to the crossing of Iliamna River (MP 14).

The existing Williamsport–Pile Bay Road is owned and maintained by the State of Alaska and would be used for construction access. Sections of the existing road would be upgraded and incorporated into the mine access alignment.

From the Iliamna River crossing to a point on the west side of Knutson Mountain (MP 39) the alignment continues westward, roughly paralleling the north shore of Iliamna Lake. The road route along this section is confined to lower elevations due the steep, mountainous terrain that rises rapidly from 100 ft amsl along the lake shore to elevations of 3,000 to 4,000 ft amsl. Avalanche hazards exist in isolated locations along the alignment. Between Iliamna River and Knutson Mountain the terrain is rugged and variable, with the ground conditions that are fair for road development. The terrain west of Knutson Mountain to Roadhouse Mountain (MP 54) is favorable to excellent for road construction and consists of outwash plains, ancient beach deposits and alluvial fan deposits.

The overall conditions for the remainder of the route from Roadhouse Mountain to the planned mine site (MP 82) are typically excellent for road construction. This section traverses gently rolling, open terrain that is commonly subject to windy conditions. Snow drifting would be a significant factor, which may be mitigated through use of snow fences, proper snow removal techniques and appropriate road profile and cross-section. As the access route wraps around Roadhouse Mountain it would cross tundra upland terrain to the Newhalen River crossing. After crossing the Newhalen River (MP 60.7) the route climbs out of a minor tributary valley of the Newhalen River and continues along upland terrain to the mine site. Figure 18-3 shows an overview map of the proposed road alignment.

Figure 18-3: Overview of Road Alignment from Diamond Point to Mine Site



Note: Prepared by Recon, 2021.

The design of the Pebble Mine access road was predominantly dictated by the sizes and weights of vehicles and loads to be transported over the road, the majority of which would be conventional highway tractors and trailers. However, the principal controlling factor for much of the road design is the transport of large and heavy modules for mine construction.

The Pebble Mine access road would have a 30 ft clear travel surface, maximum grades of 8% with 6% preferred, and 700 ft typical minimum for horizontal curves with select curves being widened for module transport. The vertical curves would meet the requirements for modular carrier vertical articulation. Cut or fill slopes would vary from 0.5:1 to 2:1 depending on rock and soil type. Road embankments would vary from 3.5 to 25 ft thick, depending on quality of subgrade and if located in an intertidal zone. The surface course would be 2 in. minus crushed rock and 12 in. in depth. Armor rock would be used as appropriate in the intertidal zones.

The proposed road alignment traverses highly varied terrain types, thus, there would be several different construction methods employed throughout the project. In general, the western three-quarters of the road would be built by conventional cut/fill techniques using any suitable native subgrade material for development of the road prism. Typically, a subbase and final surfacing layer would be applied consisting of a crushed and/or screened material suitable for structural fill and surface maintenance and wear-course. At intervals not appropriate for cut/fill construction, an elevated fill section would be employed, particularly where snow drifting, or poor soils, are a concern. The mountainous sections would include significant rock excavation with an equipment fleet suitable for the terrain and volumes of rock to be excavated and placed. The coastal section involves a massive fill in the intertidal zone, including selective placement of large armor rock. Heavy equipment specific to this task would be employed. Although there are high volume exaction and fills, there are no apparent extreme conditions which would necessitate tunneling or unusual stabilization efforts.

The access road would include 17 bridges, eight of which would be single-span, two-lane bridges that range in length from approximately 40 to 90 ft. There would be one multi-span, 550 ft, two-lane bridge across the Newhalen River and eight other multi-span, two-lane bridges that range in length from approximately 125 to 245 ft. Road culverts at stream crossings are divided into categories based on whether the streams are fish-bearing. Culverts at streams without fish would be designed and sized for drainage only, in accordance with Alaska Department of Transport & Public Facilities (ADOT&PF) standards. Culverts at streams with fish would be designed and sized for fish passage in accordance with U.S. Fish and Wildlife Service standards.

The natural gas pipeline, concentrate pipeline, water return pipeline, and fiber optic cable would be buried in a corridor adjacent to the access road. For bridged river crossings, the pipelines and fiber optic cable would be attached to the bridge structures.

Stream crossings requiring bridge construction would typically incorporate use of temporary bridges for construction access. Early mine site access would include a use of a ferry for crossing of the Newhalen River. Temporary infrastructure related to ferry operations would include short access roads and landing area pads.

18.2.2 Haul Roads

The Project requires a network of haul roads to connect the mine infrastructure such as the open pit, WSFs, mill plant site and TSFs. The haul road network was designed to separate haul traffic from access traffic.

The anticipated haulage trucks would have up to 400-ton payloads and an operating width of 32 ft. The haul roads would be 110 ft wide to allow for two-way traffic. For improved safety, fills greater than 10 ft high would be constructed with earth berms or concrete barriers. The haul roads would also be used by service vehicles accessing certain mine site infrastructure, such as the truck shop and process plant.

18.2.3 Service Roads

Approximately three miles of service roads would be constructed to provide service vehicles (i.e., light/medium-duty trucks and service vehicles) with access to mine infrastructure such as the emulsion plant, explosives magazine, TSFs and WTPs.

18.3 Tailings Storage Facilities

18.3.1 Introduction

Waste and water management at the Project would be an integrated system designed to safely contain these materials, to facilitate water treatment and discharge, and to provide adequate process water to support the operations. The system is planned to begin operation prior to start up and to continue operations through closure and post closure. The system would manage:

- bulk tailings;
- pyritic tailings;
- PAG waste rock;
- process water;
- non-contact water for direct discharge; and
- contact water to be treated and discharged to the environment.

The design of these facilities incorporates a significant climate record, extensive site investigation, and a number of features intended to ensure safe operation.

18.3.2 Tailings Overview

The bulk NAG and pyritic PAG tailings would be stored in separate TSFs constructed primarily within the North Fork Koktuli (NFK) Watershed (Figure 18-1). The principal objective of the design and operation of the TSFs is to provide secure containment for all tailings solids and PAG waste rock. Decant water from the tailings as they settle and precipitation falling onto or draining into the TSFs would be contained prior to transfer to the main water management pond (WMP). The design and operation of the TSFs are integrated with the overall water management objectives for the entire mine development, in that surface contact runoff from disturbed catchment areas is controlled, collected and either contained on site for use in the milling process, or treated and discharged to the environment. An additional requirement for the design and operation of the TSF is to allow for effective reclamation of the tailings impoundment and associated disturbed areas so that post closure land use objectives can be met at the end of mine operations. The bulk TSF would be closed and reclaimed at the end of operations. The pyritic tailings and the PAG waste rock would be re-located to the pit at the end of mining and the pyritic TSF decommissioned and reclaimed.

18.3.3 Site Selection

A multi-year, multi-disciplinary evaluation was completed to select the preferred TSF locations that meet all engineering and environmental goals while allowing for cost-effective integration into the site waste and water management plans. More than 35 tailings disposal options were evaluated against a range of siting criteria during this evaluation, including:

- minimizing potential impacts to environmental resources;
- providing adequate storage capacity. The sites would accommodate the total volume of tailings and PAG waste rock for the 20-year life of the Project;
- proximity to the process plant and the open pit. The sites are near the process plant and the open pit which reduces power consumption, hauling distance, and the overall project footprint; and
- facilitating closure. Segregating the pyritic tailings and PAG waste in a separate TSF facilitates placement of these materials in the pit at the end of the mine life, thus eliminating the pyritic TSF from the long-term closure plan.

18.3.4 Design Criteria

The TSFs would be designed to meet or exceed the standards of the current 2005 Guidelines for Cooperation with the Alaska Dam Safety Program (ADSP) and the draft 2017 version, as prepared by Alaska Department of Natural Resources (ADNR). The TSFs would be designed to the standards of a Class I hazard potential dam (the highest classification).

The TSF design criteria include:

- Providing storage for the 20-year mine life proposed project case resource - approximately 1.3 billion tons of tailings plus 93 million tons of PAG waste rock:
  - The bulk TSF would store approximately 1.1 billion tons;
  - The pyritic TSF would store approximately 157 million tons plus 93 million tons of PAG waste rock;
- The mill throughout is planned at 180,000 tons/d;
  - The bulk tailings output is approximately 155,000 tons/d;
  - The pyritic tailings output is approximately 25,000 tons/d;
- Providing storage for full containment of the probable maximum flood (PMF) event plus a freeboard allowance;
- Founding the TSF embankments on bedrock, with the overburden materials within the embankment footprints removed prior to construction;
- Designing the TSFs to safely withstand the earthquake loading conditions from the maximum credible earthquake;
- Thickened tailings disposal in the bulk and pyritic TSFs;
- A permeable bulk TSF main embankment to promote a depressed phreatic surface in the embankment and in the tailings mass in proximity to the embankment;

- A fully-lined pyritic TSF to maintain the pyritic tails and PAG waste in a sub-aqueous state to prevent oxidation;
- Limiting the volume of stored water within the bulk TSF under normal operating conditions and keeping the operating pond away from the dam face, with TSF reclaim water transferred to the main WMP;
- The inclusion of basin underdrains to provide preferred drainage paths for seepage flows;
- Providing seepage collection systems downstream of the TSF structures to minimize adverse downstream water quality impacts;
- The consideration of long-term-term closure at all stages of the TSF design process:
  - The bulk TSF main embankment seepage collection pond (SCP) collects seepage and runoff and transfers it to the main WMP;
  - The bulk TSF south embankment and the pyritic TSF seepage collection ponds collect seepage and runoff and transfers it to back into the TSFs;
- The inclusion of monitoring instrumentation for all aspects of the facility during operations and after closure; and
- Flattening of the downstream slopes to achieve a minimum factor of safety under static loading conditions of 1.8.

18.3.5 Tailings Storage Facility Design

The TSF embankments would be zoned, earthfill/rockfill embankments constructed using select overburden and rockfill obtained from open pit stripping or local quarries. The starter embankments for both facilities would be constructed as part of the initial site construction works and would provide storage capacity for two years of operations. The TSF embankments would be expanded in stages throughout the mine life with each stage providing the required capacity for the period until the next stage of construction is completed. The bulk and pyritic TSF designs are summarized below.

18.3.5.1 Seismicity Analyses

Site-specific peak ground accelerations were determined for the mine site using the seismic database of the USGS probabilistic seismic hazard program for Alaska[21]. The deterministic seismic hazard analysis considered all known seismic sources and fault systems in the region of southern Alaska and applying a maximum earthquake magnitude to each potential source. The maximum design earthquake (MDE) events which were considered were:

- M9.2 interface subduction earthquake associated with the Alaska-Aleutian Megathrust, peak ground acceleration = 0.16 g;
- M8.0 deep intraslab (in-slab) subduction earthquake, peak ground acceleration = 0.61 g;
- M7.5 shallow crustal earthquake on the mapped Lake Clark fault, peak ground acceleration = 0.32 g; and
- M6.5 maximum background earthquake (shallow crustal event assumed to occur directly beneath potential mine site facilities), peak ground acceleration = 0.56 g.

[21] https://earthquake.usgs.gov/hazards/hazmaps/ak/index.php#2007; Wesson et al, 2007

Differences in ground motion characteristics for each of these MDEs were modeled to determine estimates of deformation in the downstream direction, with the analysis estimates of minimal deformation (<0.08 ft) of the bulk TSF Main Embankment.

18.3.5.2 Bulk TSF

The bulk TSF would store approximately 1.1 billion tons of bulk tailings. The TSF would consist of a main (north) embankment and a south embankment.

Initial construction of the earthfill/rockfill bulk TSF main embankment would include a cofferdam located upstream of the main starter embankment. The embankment foundation would be prepared by removing overburden materials prior to placement of embankment fill materials. The starter embankment would be constructed to a height of approximately 265 ft (elevation 1,450 ft above sea level) and would provide the storage capacity for approximately two years of bulk tailings production. The main embankment would be progressively raised during operations using the centerline construction method. The main embankment does not include a low permeability zone and would operate as a permeable structure to facilitate in the drainage of the tailings mass adjacent to the dam. The main embankment would include a sequence of engineered filter zones to provide the necessary filter requirements between adjacent fill materials and to control drainage and the phreatic surface. The overall downstream embankment slopes would be maintained at approximately 2.6H:1V (horizontal:vertical). The TSF basin would include an underdrain system constructed at various locations to provide preferred drainage paths for seepage flows.

The south embankment would be constructed in year three of operations and would be progressively constructed using the downstream construction method to facilitate the installation of a synthetic liner on the upstream face. The upstream face would be constructed at 3H:1V, and the downstream slope would be constructed at 2H:1V. Overburden materials would be removed below the embankment footprint. The earthfill/rockfill embankment would include engineered filter zones and a grout curtain to reduce seepage below the embankment. Tailings would be discharged from around the perimeter of the TSF to maintain the large tailings beaches and to promote surface drainage towards the east, away from the embankments, and towards the location of the closure spillway.

The bulk tailings would be discharged via spigots spaced at regular intervals along the interior perimeter of the bulk tailings cell, promoting beach development and allowing the supernatant pond to be maintained away from the main embankment. The bulk TSF would include a reclaim pumping system to manage the supernatant pond and limit the volume of water stored within the facility.

The final crest elevation for the bulk TSF embankments is approximately 1,730 ft above sea level. Embankment heights, as measured from lowest downstream slope elevation, would be 545 ft (main) and 300 ft (south).

18.3.5.3 Pyritic TSF

The pyritic TSF would store approximately 157 million tons of pyritic tailings and 93 million tons of PAG waste rock. The PAG waste rock would be placed around the perimeter of the basin with the pyritic tailings being discharged into the center of the facility at sub-aqueous discharge points with the level maintained just below the upper bench level for the PAG waste being stored. This placement methodology would result in PAG materials being exposed for less than two years before inundation with tailings and the water cover. The pyritic TSF would maintain a full water cover throughout operations to minimize the potential for oxidation of the pyritic tailings. The operating level of the supernatant pond would be managed via a floating reclaim system.

The pyritic TSF design would include a fully-lined basin with an underdrain system installed below the liner. The pyritic TSF would include three embankments, the north, south, and east, which would be progressively constructed using the downstream method. Upstream slopes would be 3H:1V to facilitate liner installation and the downstream slopes would be maintained at 2.6H:1V. The final crest elevation would be 1,620 ft above sea level. The final north embankment height would be 335 ft, the south embankment height would be 215 ft, and the east embankment height would be 225 ft.

18.3.5.4 TSF Closure

Closure of the bulk TSF would include a spillway located at the east side of the facility with the flows directed towards the north. Late in the operating phase, tailings discharge into the bulk TSF would be managed to allow for surface drainage toward the closure spillway to the maximum extent practical. As milling operations cease, free water would be pumped from the surface of the bulk tailings, and the tailings would be allowed to consolidate until the surface is suitable for equipment traffic on the surface. The tailings surface would then be re-graded as needed to facilitate drainage towards the closure spillway. A capillary break and growth medium would be placed over the surface of the tails prior to seeding for revegetation. Growth medium would also be placed on the bulk TSF embankments prior to seeding for revegetation.

Seepage water from the bulk TSF embankment seepage collection systems would be collected and directed to the main water management pond, or the pit lake throughout closure.

The pyritic tailings and PAG waste rock stored within the pyritic TSF would be transferred to the open pit during closure. The TSF embankments would be breached and contoured to prior to reclamation, which would include placement of growth medium and reseeding.

18.4 Water Management

18.4.1 Water Management Systems

The water management strategy for the Project uses water from within the Project area to the maximum practical extent. Contact water (mine drainage and process water) from the mine site would be collected and managed using various water management facilities. Mine drainage is defined as groundwater or surface runoff that has come into direct contact with mining infrastructure and requires treatment at the water treatment plants to meet discharge water quality standards prior to discharge to the environment. The primary water management systems and components include:

- diversion channels;
- sediment ponds;
- seepage collection and recycle ponds;
- main water management pond;
- open pit water management pond;
- bulk and pyritic TSF reclaim systems; and
- water treatment plants.

18.4.1.1 Diversion Channels

Diversion channels would direct non-contact water around the Project's infrastructure, where possible, and directly discharge it to the downstream environment. This would reduce the amount of water collected within the mine site footprint for both operations and closure.

18.4.1.2 Sediment Ponds

Stormwater runoff from the overburden stockpiles, the growth medium stockpiles, and the quarries would be collected and treated locally at sediment ponds prior to release to the environment.

18.4.1.3 Seepage Collection and Recycle Ponds

Seepage collection and recycle ponds would be constructed downstream of the TSFs to collect and recycle seepage from the facilities. These include seepage recycle ponds would include grout curtains and low-permeability core zones, and downstream monitoring wells. Embankment runoff and TSF seepage collecting in the downstream seepage collection ponds would ultimately be transferred to the main WMP to be used in mining operations or treated for discharge.

18.4.1.4 Main Water Management Pond

The main WMP would be the primary water management structure at the mine site. It would be a fully-lined facility and constructed using quarried rockfill materials founded on bedrock. The main WMP embankment design is approximately 190 ft high with an overall downstream slope of approximately 2H:1V and an upstream slope of 3H:1V to accommodate the liner. It would be constructed to its final height during the initial construction period. In addition to the geomembrane liner the embankment would include a filter/transition zone. The basin and upstream embankment face would include a layer of materials above the liner to provide ice protection during freezing conditions. The operating capacity of the main WMP was sized to manage surplus water from the mine site and to supply water to the mining process over the full range of historic climate conditions.

18.4.1.5 Open Pit Water Management Pond

Groundwater and surface runoff collected in the open pit and from the surrounding area during operations would be directed to the open pit water management pond, prior to being treated at WTP #1. The open pit water management pond would be constructed using cut-and-fill methods and would be fully lined. The maximum height of the pond would be approximately 100 ft tall.

18.4.1.6 Bulk and Pyritic TSF Reclaim Systems

The bulk TSF would be operated with a minimum supernatant pond and the pyritic TSF would be operated with a minimum depth of approximately 5 ft in the supernatant pond to minimize the potential for oxidation of the pyritic tailings and waste rock. This would be achieved by pumping excess water to the main WMP to minimize the volume of water stored within these facilities.

18.4.1.7 Water Treatment Plants

Contact water would be treated using water treatment plants and then would be released to the environment. WTP#1, which would be located near the open pit, and WTP#2, to be located near the main WMP, would be operational during the operations period, while WTP#3, located near the open pit, would be operational during the closure period and for the long-term. WTP#1 would be decommissioned at the end of operations; WTP#2 would be decommissioned at the end of closure phase 1; and WTP#3 would be operational from closure phase 1, during phase 3, and during post closure. The detailed description of these facilities is presented on Section 18.4.

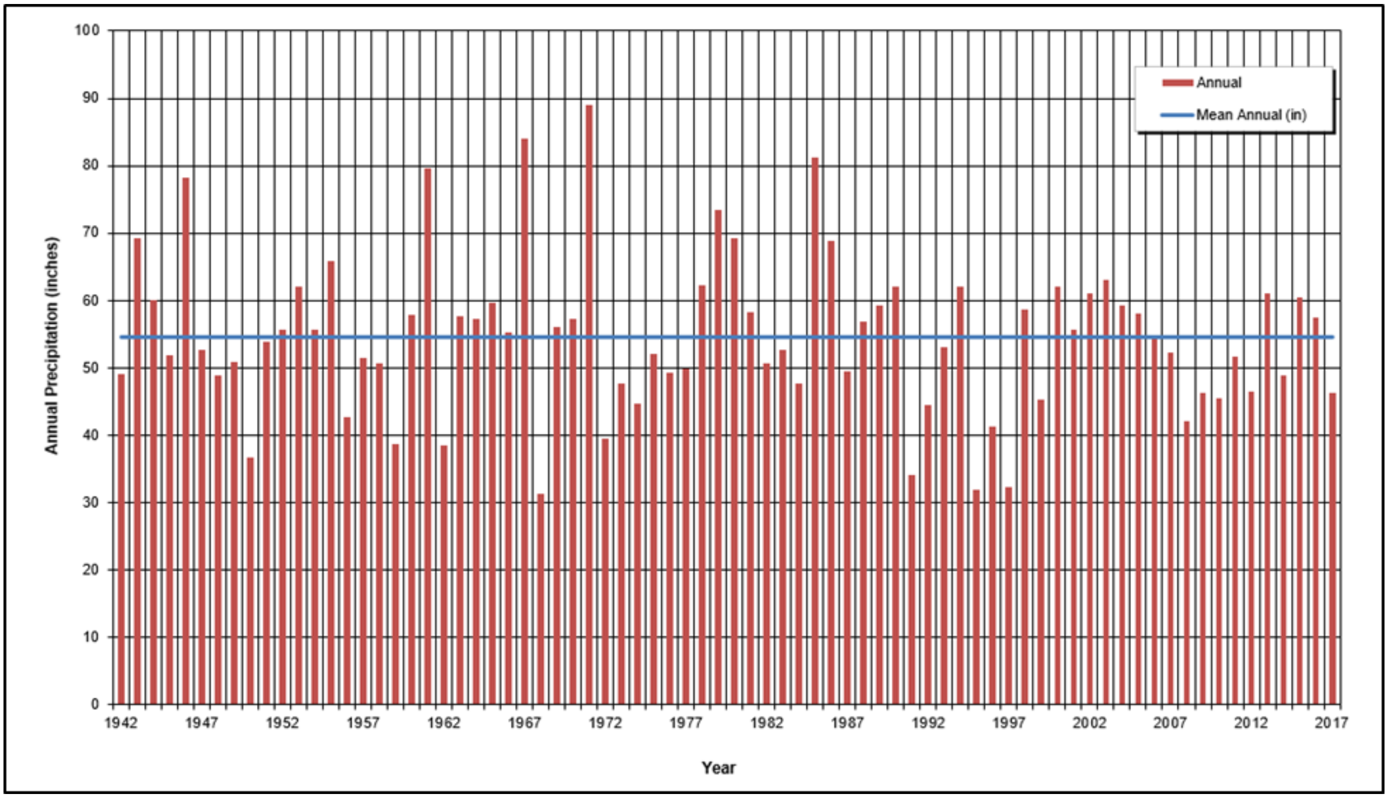
18.4.2 Site Wide Water Balance

The Pebble water balance consists of three primary models: the watershed model, the groundwater model, and the mine plan model. These three models collectively provide the means of quantifying the numerous water flows in the streams, in the ground, and in the various pipes, ponds, and mine structures associated with the mine development. The watershed model focuses on water flows throughout the NFK, SFK, and Upper Talarik Creek (UTC) drainages. The groundwater model focuses on the detailed simulation and understanding of groundwater flows within those drainages, and serves to inform the watershed model, and vice versa. The mine plan model focuses on mine site water inflows and uses.

18.4.2.1 Watershed Model

The watershed model for the NFK, SFK, and UTC drainages considers both surface and groundwater. This model incorporates all key components of the hydrologic cycle, including precipitation as rain and snow, evaporation, sublimation, runoff, surface storage, and groundwater recharge, discharge, and storage. The primary input is monthly precipitation and temperature data collected at the Iliamna Airport from 1942 through 2017. The modelled annual precipitation series for the 76-year period of record is presented in Figure 18-4. The model was calibrated to measured site flow data collected at various locations in all three drainages over a nine-year period. The watershed model also provided input for the instream fish habitat-flow model, as well as the initial boundary parameters associated with groundwater recharge and runoff conditions for the groundwater model.

Figure 18-4: **Modelled Annual Precipitation Series**



Source: Knight Piésold, 2020

18.4.2.2 Groundwater Model

The groundwater model focuses on the sub-surface movement of water within the NFK, SFK, and UTC drainages. It models hydrogeological conditions in a more sophisticated and detailed manner than the watershed model, and its outputs provide a check of reasonableness for the watershed model. In addition, the groundwater model simulates groundwater flow rates and groundwater-surface water interactions throughout the study area, whereas the watershed model considers surface and groundwater flow rates only at the streamflow gaging stations.

18.4.2.3 Mine Plan Model

The mine plan model focuses on water movement within the Pebble Project footprint area. The Mine Plan Model is a site-wide water balance and considers all mine facilities including the bulk TSF, pyritic TSF, open pit, process plant, and the WMPs. This model tracks water movement throughout the Pebble Project footprint area including runoff from the mine facilities, water contained in the ore, groundwater inflows, evaporation and water stored in the tailings voids. The mine plan model was also the base model for the water quality model and is used to predict the flow regime on the mine site and whether there is a water surplus or deficit. It is also used to estimate the water storage capacity requirements for the mine under normal operating conditions and the amount of surplus water available for treatment and release to the surrounding environment.

The mine plan model uses inputs from the watershed model and the groundwater model that have been developed for the Project. Inputs from the watershed model were used to define the hydrologic parameters at the mine site and were used to determine groundwater recharge and surface water runoff. Inputs from the groundwater model were used to define the groundwater and seepage flow rates and directions in the Project area.

The mine plan model was developed using a monthly time step, using mean monthly temperature and total monthly precipitation inputs, allowing for the water management strategies to be assessed on a long-term scale. The mine plan model addresses the possible range of wet and dry conditions at the mine by incorporating climate variability, which is used to define the operating storage requirements for the water management facilities. The storm storage and freeboard requirements are considered in addition to the maximum operating pond storage requirements determined with the mine plan model.

The mine plan model indicates that there is sufficient water to satisfy the mill requirements without additional make-up water even under the driest climate conditions. The site-wide water balance demonstrates that the mine site is estimated to have an annual surplus while the volume of water requiring treatment is expected to vary based on the climatic conditions and the amount of water in the water management ponds. Operating rules would be used to limit the maximum amount of water that must be stored while maintaining a sufficient water supply during extended dry periods to maintain mill operations. The amount of water stored within the water management ponds during drier climate conditions would generally decrease, while during wetter climate conditions, the amount of water stored within the water management ponds would generally increase.

18.5 Water Treatment

The Pebble site receives an average of 54 in. of precipitation per year. A portion of the resulting runoff would be consumed in the process, primarily locked up in the tailings deposits, but the remainder, approximately 30 ft^3/s on average, must be released back to the environment. To accomplish this, the proposed Project incorporates a sophisticated water management plan with water collection, treatment, and discharge. That plan requires attention to the annual and seasonal variability of the incoming flows and achieving very specific water quality standards for the released water.

Temporary water treatment facilities would be in place during construction followed by three WTPs during the operations and closure phases of the Project (Table 18-1). The table correlates the water WTP number with the phase of mine life (in cases when a WTP serves in more than one phase), and influent stream treated (in cases when there is more than one influent stream to a WTP) and thus defines the WTP naming convention.

Table 18-1: Overview of Pebble WTPs during Operations, Closure, and Post-Closure

WTP Name	Phase of Mine Life	Influent Stream Treated	Notes
WTP #1	Operations Phase	Open Pit Water Management Pond	
WTP #2	Operations Phase	Main Water Management Pond	
	Closure Phase 1	Main Water Management Pond	
WTP #3	Closure Phase 1	Open Pit	
	Closure Phase 2	n/a	No surplus water to treat in Closure Phase 2

	Closure Phase 3	Bulk Tailings Storage Facility - Main Seepage Collection Pond	
		Open Pit	
	Closure Phase 4 (Post-Closure)	Bulk Tailings Storage Facility - Main Seepage Collection Pond	
		Open Pit	

18.5.1 Influent Stream Characteristics

18.5.1.1 Influent Water Quality

Predicted influent water quality varies based on the phase of mine life and the stream being treated. Influent water quality was predicted through a sequence of geochemistry testwork and modeling to determine source terms, modeling of hydrologic processes, and modeling of mineral processing. The resulting water quality predictions were then iterated with water treatment modeling to verify the long-term impact of WTP residuals returned to the mine water management system.

In general, there are two categories of water quality to be treated by the WTPs: a) water quality in which only specific metals, metalloids, and nonmetals exceed anticipated discharge limits; and b) water quality in which specific metals, metalloids, nonmetals, total dissolved solids (TDS), and sulfate exceed anticipated discharge limits. The metals, metalloids, and nonmetals that exceed anticipated discharge limits generally include antimony, arsenic, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, and zinc.

18.5.1.2 Influent Flow Rate

Predicted Influent flow rates to the WTPs vary greatly based on the phase of mine life, the stream being treated, and the time of year. Predicted influent flow rates were developed through a sequence of hydrologic and mine water balance modeling. Predicted influent flows range from as little as 3,591 gallons per minute (gpm) (WTP#1 – average flow) to 20,646 gpm (WTP#2 – maximum flow).

A standardized treatment train with a capacity of 4,000 gpm was designed to enable standardization of equipment, parts, and operational practices. To accommodate the wide range in flow while avoiding water treatment equipment of varying size and capacity, WTPs were designed with multiple treatment trains installed in parallel to treat the influent flow, with the number of operating trains adjusted depending on seasonal and annual variations in flow.

18.5.2 WTP Processes

18.5.2.1 Base Treatment Train Processes

The base 4,000 gpm treatment train used in all WTPs would include the following treatment steps:

1. Dissolved metals would be oxidized with potassium permanganate in a reaction tank, followed by co-precipitation with a ferric iron salt in a second reaction tank. Hydrochloric acid or lime would be added as needed to maintain the water pH for optimal precipitation.

2. A ballasted high-rate flocculator/clarifier would be used to separate out the co-precipitated solids. Most of the solids from the clarifier would be recycled back to the oxidation reaction tank. The balance of clarifier solids would be thickened and transferred to disposal.

3. Clarified water would then be treated with sodium hydrogen sulfide, lime, and a ferrous iron salt to further precipitate remaining metals, metalloids, and nonmetals under reducing conditions.

4. Water from the sulfide reaction tanks would be filtered with sand filters and ultrafiltration (UF) membranes to remove precipitated solids. Backwash from the sand filters and UF membranes would be thickened and transferred to disposal.

Each base treatment train would include the necessary pumps, heat exchangers, instrumentation, chemical feed systems, control systems, and other appurtenances. UF membrane permeate would either be discharged to the environment or further treated by additional WTP-specific processes as described below:

18.5.2.1.1 WTP #1

A portion of the UF membrane permeate from WTP #1 base treatment trains would be further treated with four stages of reverse osmosis (RO) membranes to further remove TDS. Permeate from the fourth stage of RO membranes would be recombined with the main effluent stream for discharge to the environment. Brine from the fourth stage of RO membranes would be transferred to disposal.

18.5.2.1.2 WTP #2

UF membrane permeate from the WTP #2 base treatment trains would be further treated with full stream RO membranes for additional metals and metalloids removal as well as removal of TDS and sulfate. Permeate from the RO membranes would be discharged to the environment. Brine from the RO membranes would be concentrated with three stages of a brine concentration system consisting of calcium sulfate precipitation with lime softening, clarification, UF membranes, and RO membranes. Permeate from the RO membranes of each stage of brine concentration would be discharged to the environment. Brine from the third stage of brine concentration would be transferred to disposal.

18.5.2.1.3 WTP #3

WTP #3 would be constructed for use during closure and post-closure and would treat two influent streams separately within the same facility.

The portion of WTP #3 treating water from the open pit during closure phase 1 would be treated by base treatment trains followed by nanofiltration (NF) membranes. Permeate from the NF membranes would be discharged to the environment. Brine from the NF membranes would be concentrated with three stages of a brine concentration system consisting of calcium sulfate precipitation with lime softening, clarification, UF membranes, and RO membranes. Permeate from the RO membranes of each stage of brine concentration would be discharged to the environment. Depending on the volume and concentration, brine from the third stage of brine concentration would either be transferred to disposal or sent to brine evaporation and crystallization systems to be converted into solid salt crystals.

The portion of WTP #3 treating water from the open pit during closure phase 1 is repurposed to treat water from the SCP during closure phase 3 and post closure with all of the same processes employed except the brine evaporation and crystallization system.

The portion of WTP #3 treating water from the open pit during closure phase 3 and post-closure would use only base treatment trains.

18.5.2.2 WTP Residuals Disposal

WTP residuals would include thickened sludge, thickened filter backwash, and RO brine in the case of WTPs that have RO membranes. During operations all WTP residuals would be disposed of in the pyritic TSF. During closure and post-closure all WTP residuals would be disposed of in the open pit. Solid salt crystals from the brine evaporation and crystallization systems of WTP #3 during closure phase 1 would be sent to an approved facility for disposal.

18.5.2.3 WTP Process Water Heating

WTPs would use waste heat from the mine site power plant for heating the water to be treated as well as for heating the building. WTPs would include a system of heat exchangers to add power plant waste heat to the process water prior to treatment. Heating the water even just several degrees Celsius would have a significant impact on treatment efficiency and could be especially critical during winter operation.

The WTPs would include a second set of heat exchangers to remove heat from treated water and recycle this heat back into the colder inlet water. This second set of heat exchangers would also help reduce treated water temperature to be better meet environmental conditions at the point of discharge.

18.5.3 WTP Buildings and Appurtenances

WTP buildings are envisioned to have pre-insulated metal panel wall and roof systems, concrete foundations, and concrete slab-on-grade floors.

WTPs would include treatment residuals processing equipment; treatment reagent storage, mixing, and dosing systems; a laboratory; spare parts storage; a workshop; backup electricity generation; and electrical and mechanical systems.

18.6 Mine Site Facilities

18.6.1 Mine Site Conditions and Design Criteria

The proposed mine site is located at an elevation of approximately 1,000 ft above sea level. Terrain in the mine site area features rolling hills and low mountains, separated by wide shallow valleys blanketed with glacial deposits and numerous streams and small, shallow lakes.

The deposit is located at the head of three drainages: SFK, NFK and UTC. The SFK and NFK meet in a confluence several miles downstream of the mine site to form the Koktuli River, which in turn drains southwest to the Mulchatna River and then into the Nushagak River. The UTC, which drains the eastern portion of the deposit area, flows directly into Iliamna Lake.

The following key design criteria were applied for development of the mine site layout, and engineering design for supporting infrastructure:

- minimize footprint;

- site runoff and drainage would be contained by perimeter ditches and directed to sedimentation ponds, then to either the TSF or the WTPs for reuse or release;
- minimize the difference in elevation and the horizontal distances between the open pit, mill site, crusher and TSF, with the intent of minimizing the capital cost and operating cost of the truck haul, conveyor haul and pipelines between these sites;
- snow loads:
  - ground snow load at the mine site = 130 lb/ft^2
  - ground snow load at the port = 160 lb/ft^2
- wind loads:
  - design wind speed at the mine site = 90 mi/h
  - design wind speed at the marine terminal = 104 mi/h
- seismic loads:
  - for the mine/mill site, the following design parameters will apply: S =0.559 g; S1 =0.206 g
  - for the marine terminal, the following design parameters apply: Ss =1.191 g; S1 =0.372 g

The mine site would be developed in discrete areas: the open pit area, the process plant site, the mine services area, the two TSFs, and the three water collection ponds and two water treatment plants. A network of on-site roads and utilities would connect these sites.

The process plant and associated facilities would be located approximately 1,000 ft north of the open pit on level to rolling ground at the edge of the knoll which marks the north edge of the deposit. The site is covered with overburden, generally sand and gravel, and frost shattered bedrock. Site preparation would consist of levelling the site with cut to fill. The major components, such as the grinding mills, would be founded on bedrock. The current design includes a significant surplus of excavated rock, which offers an opportunity to reduce costs by utilizing this material as fill for haul roads or tailings embankment construction.

18.6.2 Mine Service Facilities

18.6.2.1 Truck Shop

The truck shop complex at the mine site would consist of a 700 ft long x 330 ft wide structural steel, pre-engineered building designed to accommodate facilities for repair, maintenance and rebuilding of both open pit mining equipment and light vehicles. The facility would house storage space for spare parts and consumables and offices for the mine supervisors, mine engineers and planning staff. Change facilities for mine personnel would also be provided.

The building would be covered with insulated profiled steel and founded on spread footings on rock.

The service bays of the truck shop complex would consist of:

- twelve heavy vehicle repair bays;
- two heavy vehicle tire repair bays;
- two light vehicle service bays; and
- one welding bay.

The truck shop would be equipped with two 50 ton overhead cranes that would provide service to both the heavy and light vehicle repair bays. The drive-through bays would be 55 ft wide x 75 ft long and provide for the full dump height of a 400 ton capacity haul truck. One of the bays would serve as a wash bay.

Other support facilities and shops for maintenance and repair would include the following:

- lubricant storage building (including distribution system and used oil collection);
- machine shop/plate shop;
- electrical/instrument repair facilities; and
- compressor room to supply mill and instrument air to the facilities within the truck shop.

The parts warehouse integrated into the truck shop would house materials, service parts and supplies for mine mobile equipment maintenance. The warehouse would have a ground floor area of 15,000 ft^2 and an additional 2,000 ft^2 of mezzanine space.

Men's and women's change facilities, complete with lockers, showers and washroom facilities, would be provided for the pit and truck shop crews and would be located on the ground floor.

Offices occupying an area of 16,000 ft^2 would be located on the third floor of the truck shop complex for the pit supervisors as well as mine engineering and planning staff. A lunchroom equipped with fridge, stove, microwave, dishwasher and cupboards would also be on the ground floor.

18.6.2.2 Main Warehouse

The warehouse would be a rectangular, single-storey, pre-engineered building, 100 ft wide x 150 ft long x 23.5 ft high with a gross floor area of 15,000 ft^2. An 80 x 80 ft mezzanine floor would be used for three offices, a filing/storage area, a washroom and an entrance corridor. A fenced yard, 150 x 200 ft, with two truck gates and one man gate would be provided on the north side of the process building.

18.6.2.3 Administration Building

The administration building at the mine site would be a two storey, pre-engineered building, 150 ft wide x 200 ft long. It would be located adjacent to and connected with the permanent camp complex via an Arctic-type access corridor. A total of 166 offices and cubicles would be provided for mine management and supervisory staff, as well as for human resources, accounting, procurement, information technology (IT) and safety staff. The ground floor would include a lunch room, training room and 64 offices, including 10 open cubicles and 44 closed offices. The second floor would include 51 offices, including 36 open cubicles and 44 closed offices. The building would be clad with insulated profiled steel and founded on spread footings on soil.

18.6.2.4 Process Administration

Administration offices for the process plant would be located within the process building and would occupy two floors totalling 25 ft wide x 232 ft long. The space would include 23 offices, 2 conference rooms, a lunch room, laboratory facilities, open working areas and washroom facilities.

18.6.2.5 Gatehouse Security

The gatehouse would be a rectangular, single storey, pre-engineered building, 26 ft wide x 50 ft long x 10 ft high, with a gross floor area of 1,300 ft^2 and would provide a security checkpoint for all incoming and outgoing traffic to the process and mill site.

18.6.3 Water Systems

18.6.3.1 Fresh Water

Fresh water from groundwater wells would be pumped to sand filters located on the north side of the process plant building. Water from the sand filters would be added to the filtered water tank. From the filtered water tank, most of the water would be pumped to the clean service/firewater tank located in the same area and the balance would be used as cooling water for the grinding mills. From the clean service/firewater tank the fresh/filtered water would be distributed via underground pipelines to the process plant and the primary crusher raw water tank for use as process water.

18.6.3.2 Fire Water

The clean service/firewater tank would have a reserve in the lower portion of the tank that would be drawn from below the primary water nozzles. The fire-fighting reserve in each tank would meet a two-hour demand at 2,000 US gpm at 100 psi boost. Firewater pump skids complete with diesel-driven fire pump, jockey pump and controls would be installed. Dedicated fire mains complete with hydrants would be provided at the process plant and ancillary buildings, the camp, truck shop and the primary crushers. Fire extinguishers would also be provided throughout the facilities. Fire hose reels and cabinets would be installed throughout the process plant building and truck shop. Sprinkler systems would be installed in the warehouse, the main office and the truck shop.

Fire alarm systems at the warehouse and truck shop would report to the plant control room or to the main gatehouse, both of which would be manned 24 hours a day.

18.6.3.3 Potable Water

Potable water at the mine site would be supplied from wells. The water would be pumped to the potable WTP, potable water tank and potable water pump house at the mill and then distributed to the various facilities, including the camp, administration building, warehouse, gatehouse, truck shop and process buildings.

18.6.3.4 Process Water Distribution

Process water would be a combination of surface water catchments and tailings reclaim water. Process water would be pumped from the tailings pond and various collection sumps to the process water ponds located on the west side of the process plant. Process water would be pumped from the process water pond and distributed via pipelines to the various areas of the process plant. In addition, fresh water added to the system via the clean service/firewater tank would be distributed via underground pipelines to the process plant as described in Section 18.6.3.1.

18.6.4 Medical and First Aid

First aid posts would be provided at the accommodations camp, truck, shop, process plant and the port. A full-time physician assistant would be in attendance at the first aid station at the camp and roaming first aid attendants/security staff would patrol the Pebble Project.

One ambulance and a fire truck would be located at each of the mine site and at the port. A tensioned fabric structure three-bay garage for the emergency vehicles would be located near the respective gatehouses. Patients requiring evacuation would be driven by ambulance to the clinic at Iliamna or flown from Iliamna to hospitals in Anchorage.

18.6.5 Camp

The first camp to be constructed at the mine site would be a 250-person fabric-type camp to support early site construction activities and throughout the pre-production phase as required for seasonal peak overflows. The main construction camp would be built in a double occupancy configuration to accommodate 1,700 workers. This facility would later be refurbished for 850 permanent single occupancy rooms for the operations phase.

The camp would include dormitories, kitchen and dining facilities, incinerator, recreation facilities, check-in and check-out areas, administrative offices and first aid facilities. The dormitory modules would be connected with field constructed or prefabricated, fire-rated egress corridors and would comply with all building and fire code requirements.

The mine would operate on a fly-in, fly-out basis, except for those personnel residing in the communities connected to the access road corridor. Non-resident personnel would be flown in and out of the Iliamna Airport and transported to the site by road. Workers would remain on site throughout their work period. Site rules would prohibit hunting, fishing, or gathering while on site to minimize impacts to local subsistence resources.

18.6.6 Cold Storage Building

Cold storage buildings are required for short- and long-term storage of supplies requiring protection from the elements, but not heated storage. Two buildings are required: one adjacent to the truck shop and one near the process plant maintenance facility. Both buildings would be unheated single-storey, fabric-clad structures, 75 ft wide x 150 ft long x 23.5 ft high.

18.6.7 Utilities and Services

18.6.7.1 Communications

The mine site would be connected to external networks via the fibre optic line contained in the natural gas pipeline trench and the sub-sea natural gas pipeline to the Kenai Peninsula. A backup satellite system rated to handle the full communications bandwidth would also be installed.

A communications network would be established utilizing fibre optic technology and wireless communication for voice, fax, Internet, and intranet traffic. The communications and IT infrastructure would include an Internet gateway, telephone private branch exchange system, Ethernet local area network, IT servers, desktop computers, a backup power system, copper and fibre cabling and site very high frequency (VHF) radio system.

Voice communications would be based on voice over internet protocol technology, using wide area network links. A VHF radio system would be installed with provision for handheld units, mobile units and base stations. A mobile phone cellular service would be included in the system.

18.6.7.2 Heating, Ventilation and Dust Control

18.6.7.2.1 Heating

Heating for buildings and facilities at the mine site would be provided primarily by heat recovery from a combined cycle gas turbine power plant. Waste heat from the power plant would be transferred by transfer pumps through a glycol circulating system throughout the plant site and truck shop areas. A boiler adjacent to the process plant building would be used as a supplemental heat source when required.

Remote buildings that are relatively small, such as small warehouses and gatehouses, would be heated with indirect fired gas heaters, or electric heaters if gas lines cannot be run to those locations.

18.6.7.2.2 Ventilation

Continuous ventilation would be provided for all personnel occupied and selected unoccupied spaces.

Ventilation systems would include make-up air units for continuous supply of tempered air, general exhaust fans for contaminant removal and, where appropriate, localized exhaust fans to remove contaminants directly. Glycol supply to the make-up air units would be the primary heat supply source.

18.6.7.2.3 Dust and Fume Control

Dust control systems would include hoods, ductwork, dry bag house-style dust collectors and/or wet scrubbers and enclosures designed to capture fugitive dust or fume emissions at the source. These systems would be designed and selected to reduce particulate emissions to meet applicable air quality regulations.

Dust collection within the process buildings, such as the coarse ore storage reclaim area and pebble crushers, would use wet scrubbers to collect airborne dust. The collected dust slurry would be pumped back to the process.

18.6.7.3 Solid Waste Disposal

18.6.7.3.1 Hazardous Waste

As part of the overall plant design, all hazardous wastes outside of tailings and waste rock would be segregated at the point of generation, placed into appropriate storage containers and shipped off-site to an appropriate recycling or disposal facility. A lined storage facility would be constructed within or near the site fuel storage facilities to store the hazardous waste held in segregation, pending periodic off-site shipment.

18.6.7.3.2 Non-hazardous Waste

Non-hazardous waste would be segregated into the following two streams:

- Putrescible kitchen wastes, organic food wastes from kitchen facilities, would be segregated and burned daily in on-site incinerators (or a closed circuit digester system) to help limit wildlife attraction associated with disposal of food wastes; and,

- Non-putrescible waste, all other non-hazardous, inorganic garbage, would be collected and disposed of within an on-site landfill to be located in a suitable area that drains by gravity into the tailings impoundment. Non-hazardous garbage placed within this landfill would be periodically buried under a layer of soil or non-acid generating waste rock to prevent loss of garbage through wind action and to control drainage.

Construction, operation and closure wastes would likely be managed under one waste management permit.

18.7 Gas Line and Power Supply

18.7.1 Power Supply

A natural gas-fired combined cycle gas turbine plant would supply power to the mine site. Power at the marine terminal would be provided by natural gas fired reciprocating engine-based power generators.

18.7.1.1 Power Plant Configuration and Design Details

The power plant design is based on the following criteria:

- The power plant design includes multiple gas turbines, heat-recovery steam generators (HRSG), steam turbines operating in parallel completely with balance of plant equipment and systems. The power plant would be built in two phases. The first phase of the power plant was designed with N+1 redundancy to meet the initial mine site load demand of 270 MW net during the warmer summer period. The gross capacity of the power plant as installed would be about 318 MW at the summer ambient. The gross capacity would be somewhat higher at lower ambient. The plant is designed to support 270 MW net mine demand with any one gas turbine generator (GTG) or steam turbine generator (STG) outage scenario in degraded condition within the site specified ambient operating temperature range (N+1 redundancy).

- All gas turbines would be dry, low NOx, single fuel, designed for low emissions while firing pipeline-quality natural gas. The gas turbines would be provided with spray assisted inter-stage cooling (SPRINT) systems to augment power production during moderate to high ambient temperature conditions.

- Fuel gas is assumed to be delivered by the pipeline system at 725 psig, eliminating the need for additional, on-site gas compression to increase the minimum inlet pressure to the units.

- Natural gas is assumed to be of pipeline quality with a higher heating value/lower heating value ratio of 1.108.

- A degradation factor of 2% is assumed for the life of the power plant output in all cases for normal equipment degradation.

The site parameters and fuel assumptions are summarized in Table 18-2.

Table 18-2: Site Parameters and Design Operating Conditions for Proposed Project Power Plant

Parameter	Basis
Elevation	1,500 ft amsl
Primary Fuel	Natural Gas
Design Basis Temperature/Relative Humidity	Summer 74°F/40%, Average 32°F/72% RH
Plant Net Installed Capacity at Summer Ambient	328 MW
Fuel consumption at normal 270 MW net output	55 MMSCFD
Redundancy Requirements	N + 1 (2)

Note:
1. Includes a margin for degradation impacts and allowances.
2. N+1 redundancy means that the power plant is capable of delivering the guaranteed Net output even when One (1) Prime Mover – that is either the gas turbine (or) steam turbine is out of operation (planned maintenance or un-planned trip conditions). The use of the N+1 rating is a compromise from usual standard of N+2 due to the average temperature conditions at site, which are significantly lower than the based temperature used for the N+2 calculation. Power generation is anticipated to be more efficient at site than industry standards because of the low ambient temperatures.
3. MMSCFD – million standard cubic feet per day.

18.7.1.2 Mine Site Power Plant Selection Process

The combined natural gas-fired turbine power plant was selected because:

- it provides the lowest fuel consumption and life-cycle costs over the plant life, as compared to other options;
- it is a proven, readily available technology with high reliability ratings; The light weight of the units reduces shipping costs and transportation constraints; and,
- it is the cleanest and least carbon intensive solution for fossil-based generation to provide power for the scale of the Project.

18.7.1.3 Plant Efficiency and Electrical Performance

The power plant operating capacity and performance are based on the mine and processing plant configuration as defined at initial start-up.

18.7.1.4 Dispatch Scenarios and Fuel Usage

Five GE LM6000 PF+ SPRINT gas turbines along with two condensing steam turbines would be required for mine operation. All units would be operating during normal operation (when available) to maintain the N+1 scenario. This mode of operation would have minimum impact on the electrical system when one prime mover – that is one GTG unit or one STG unit trips during operation to support the full load demand of the mining operation.

In the event of a unit trip, system frequency is expected to be maintained by a ramping up the load of the remaining operating gas turbines and steam turbines. If the gas turbines are maxed out on the load, additional duct firing in the HRSGs would increase the STG output to stabilize the frequency until the standby GT/ST unit is brought online.

18.7.1.5 Power Distribution

Power would be distributed throughout the mine site via 34.5 kV wood-pole overhead electrical power lines. A similar distribution arrangement would be used at the marine terminal, though at a significantly lower voltage of 4.16 kV. At both sites, power would be routed from the electrical substations to the distribution systems connecting the equipment, facilities and buildings.

18.7.1.6 Power Plant at Marine Terminal

The marine terminal power plant, which would consist of three 2 MW natural gas-fired engine generators in (N+1) configuration with heat recovery, would be located in close proximity to the substation.

Natural gas would be supplied to the marine terminal plant by an off-take from the pipeline that transports natural gas to the mine site.

18.7.2 Natural Gas Supply

18.7.2.1 Source and Pipeline Routing

The natural gas pipeline to supply the Project would originate from an existing natural gas pipeline on the west side of the Kenai Peninsula. The supply gas would be available at approximately 500 psig. This pressure is not sufficient to send the required gas volumes to the proposed mine and meet the required delivery pressure. A compressor station would be sited near the tie-in point with the existing natural gas pipeline at a location approximately 3 miles north of Anchor Point. This compressor station would have a gas turbine driven centrifugal gas compressor capable of providing the required gas at the required 725 psig delivery pressure. The selected pipe would be a nominal 12 in., 12.75 in. outside diameter (OD) pipeline.

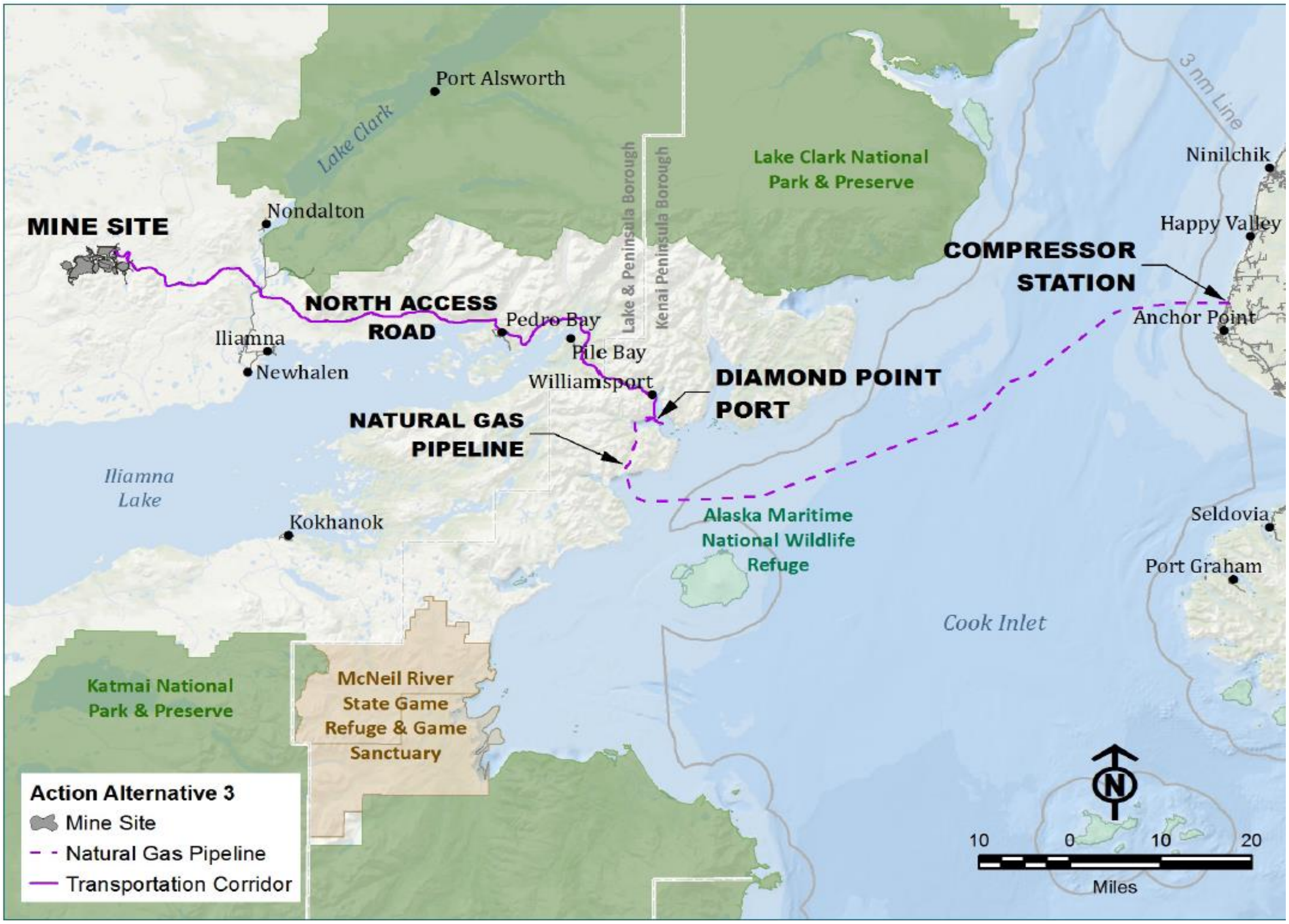
The natural gas pipeline would transition to a subsea pipeline from the compressor station, crossing Cook Inlet from east to west to landfall at Ursus Cove, then overland to Cottonwood Bay, and a crossing of the intertidal zone in Cottonwood Bay to the marine terminal site north of Diamond Point on Iliamna Bay. From there, a buried onshore pipeline would parallel the mine access road to the mine site. The approximate lengths of the offshore segments are provided below. The Anchor Point direct pipe shore crossing length assumes encased direct pipe exiting into the offshore trench at the 49 ft water depth contour. The Ursus Cove shore crossing assumes the shore crossing trench starts at the 16.5 ft water depth. The two shore crossings for the Cottonwood Bay crossing were assumed to be 300 ft long.

The natural gas pipeline segments would be:

- Anchor Point onshore surfacing point to offshore direct pipe exit point (direct pipe shore crossing segment) is 7,334 ft;
- direct pipe exit point to Ursus Cove shore crossing trench (offshore segment) is 73.0 miles (385,272 ft);
- Ursus Cove trench shore crossing trench is 2,017 ft;
- Cottonwood Bay South side shore crossing trench is 300 ft;
- Cottonwood Bay crossing (offshore segment) is 17,424 ft; and
- Diamond Point shore crossing is 300 ft.

The proposed route is shown in Figure 18-5.

Figure 18-5: Proposed Pebble Pipeline Route – Anchor Point Mine Site



Note: Prepared by NANA Worley, 2020.

The subsea portion of the Pebble Mine gas supply line would be a 12.75 in. OD x 0.812 in. API Spec 5L grade X52 pipeline. The heavy-wall pipe would ensure negative buoyancy and increase resistance against physical damage from external forces. The pipeline would have a 16-22 mils external anti-corrosion coating of fusion bonded epoxy (FBE) along the entire length of the offshore segments, with the exception of the direct pipe shore crossing segment at Anchor Point, which would have an abrasion resistant overcoating (ARO) consisting of 8-10 mils FBE anti-corrosion coating plus 40 mils of dual-layer FBE ARO top coating. The entire length would also have an internal liquid epoxy flow coating with a thickness of 2 mils.

Cathodic protection of the subsea pipeline would be provided by aluminum-zinc bracelet anodes. The anticipated life expectancy of the anodes would exceed the design life of the pipeline. Preliminary estimates indicate up to 160 tonnes of anode material may be needed for the Ursus Cove Route and Cottonwood Bay Crossing marine pipelines.

A fiber optic cable for communications is also required to be installed along the same offshore route and would be an armored subsea 24 strand fiber optic cable with a 1 in. diameter. The design life for the pipeline and fiber optic cable is 50 years.

On the west side of Cook Inlet, the Pebble Mine gas onshore supply line would be a 12.75 in. outside diameter x 0.250 in. API Spec 5L grade X 60 pipeline. The onshore portion of the pipeline would have an external anti-corrosion coating consisting of 8 - 20 mils FBE. Cathodic protection for the pipeline would be in the form of two magnesium ribbons installed in the pipe trench such that they have “visibility” of the pipeline. The pipeline would come ashore at Ursus Cove and then transit the peninsula between Ursus Cove and Cottonwood Bay for approximately 5.5 mi. The gas pipeline would be tapped for power generation at the Diamond Point marine terminal. The bulk of the natural gas would be routed west approximately 74 mi via buried pipeline adjacent and parallel to the road route (see Figure 18-5) to the power plant at the mine site.

The pipeline would be buried in a ditch with a minimum 30 in. of cover. Common resources would be used for construction.

18.7.2.2 Water Crossings

At minor stream crossings, when and where in stream construction would not affect downstream water quality, the pipeline would be installed under the water body. At larger stream crossings, the pipeline would be brought above ground and either supported on vehicle bridges or separate pipe bridges. Leak Detection System

Appropriate leak detection methods would be selected during front end engineering and design and could include combination of a reliable computational pipeline monitoring system and a periodic (passive) system such as intelligent internal pipeline inspection (smart-pigging).

18.8 Concentrate Slurry and Return Water Pipeline

The average production of copper concentrate from the process plant would be 560,000 tonnes per year, with transportation from the mine site to the terminal site at Diamond Point to utilize a slurry pipeline system. This system would be operated in batches to maintain pipeline velocity and is capable of transporting the planned peak rate of 880,000 ton/y copper concentrate slurry through the 81.6-mile distance following the same corridor as the main access road.

The slurry pipeline would be an 8.625 in. API 5L X 70 steel pipe with high density polyethylene (HDPE) internal liners, fed from a pump station at the mine site process plant. The pump station would require positive displacement pumps, with centrifugal slurry charge pumps and gland seal water pumps as supporting equipment. Slurry storage tanks are required at the pump station and the dewatering system at the terminal, which would include a thickener and filter press.

A choke station would be required at the terminal, consisting of a series of wear-resistant orifices to maintain backpressure and packed flow conditions in the pipeline during batching operations. Four pressure monitoring stations would be spaced along the length of the pipeline for leak detection.

Filtrate water from the slurry pipeline would be sent back to the mine site through a similar 8.625 in. HDPE lined steel return water pipeline at a maximum design rate of 615 gpm, and nominal operating rate of 410 gpm. This pipeline would have similar corrosion protection and safety controls to the concentrate pipeline with no intermediate pump station.

The selected pipeline diameter of 8.625 in. was confirmed through an optimization analysis as the lowest cost system for combined capital and operating expenditures. While a 6 in. diameter pipe may have been able to handle the required concentrate volumes, the resulting high pressure drop along the line length required an intermediate pump station and power generation at the midpoint. The slightly larger 8 in. line eliminates this pump station and can operate at a range of concentrations and flowrates with minimal additional investment for future expansion. At the currently planned throughput, the pipeline would operate at minimum slurry concentrations along with slurry-water batching to maintain the minimum velocity required to prevent solids deposition in the line.

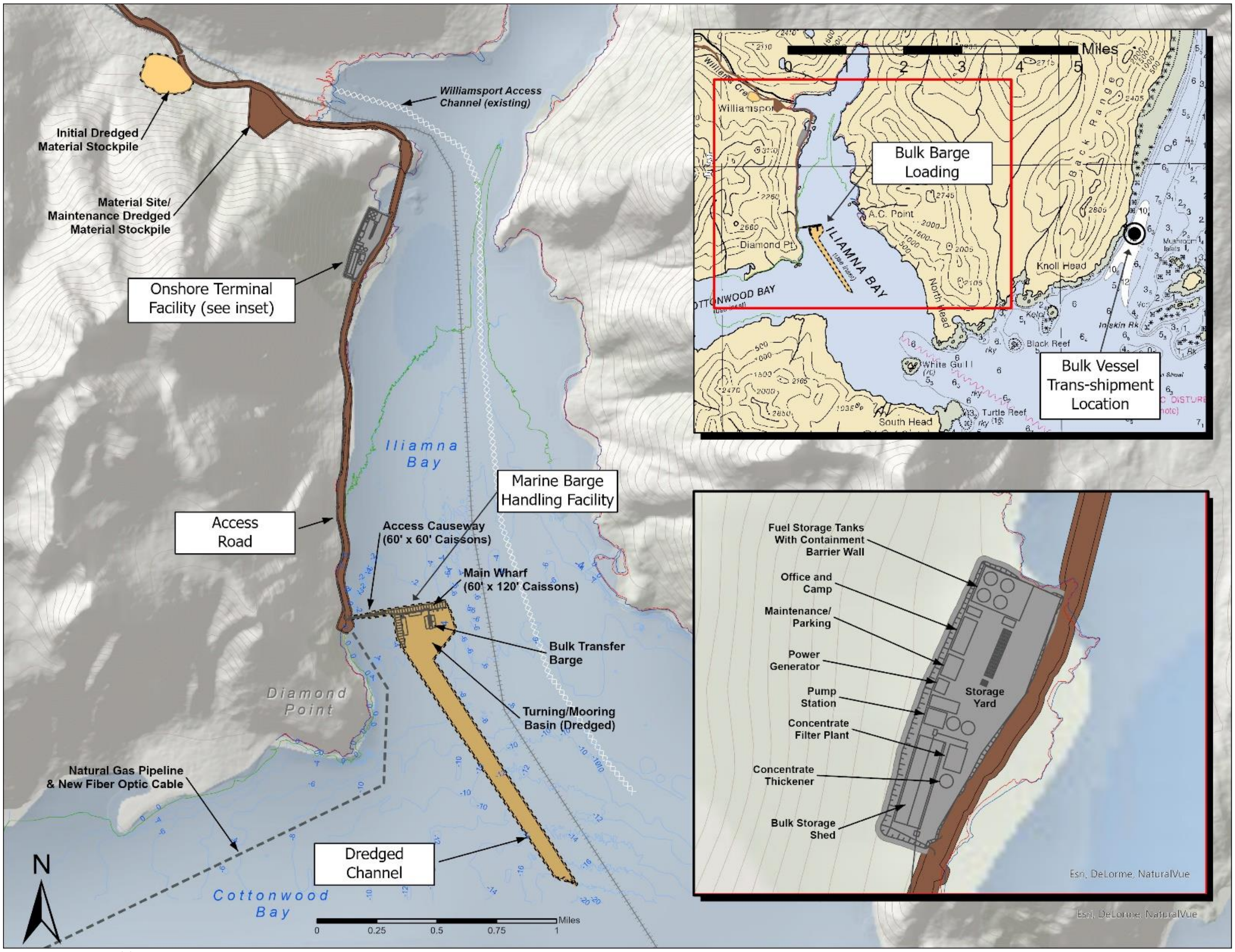
Both the slurry line and the return water line would be installed in a common trench with the natural gas line following the main access road from Diamond Point to the mine site. A dedicated fiber optic cable for controlling the pipeline operations and connecting to the pressure monitoring stations along the length would be buried in the same trench.

18.9 Marine Infrastructure

A new marine terminal facility would be constructed north of Diamond Point in Iliamna Bay on the west side of Cook Inlet. This greenfield site would be built to accommodate the delivery of equipment and supplies to the Pebble Project for construction, the export of concentrate and receipt of consumables (both containerized and break bulk) and diesel fuel via barge.

Figure 18-6 illustrates the marine terminal facilities site plan, showing the locations for the marine barge handling facility, the onshore terminal facility, and the transhipment location for mooring bulk vessels.

Figure 18-6: Proposed Marine Terminal Facilities Site Plan

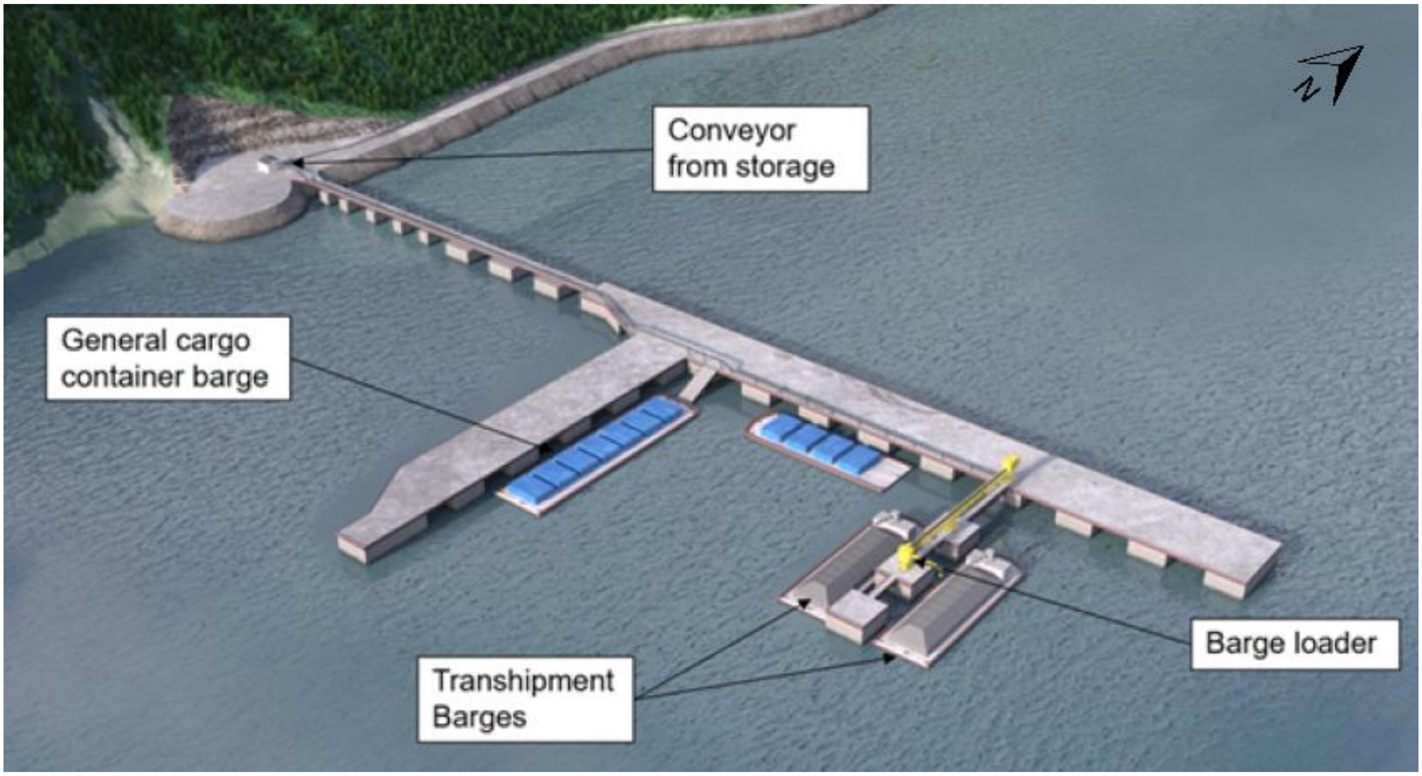


Note: Prepared by NDM, 2020.

18.9.1 Marine Barge Handling Facility

Marine terminal infrastructure would include an "L" shaped jetty, capable of handling barges for concentrate bulk transhipment as well as large ocean barges (400 x 100 ft) for transport of construction materials and operating supplies by container. Barge access from Cook Inlet to the marine site would include a dredged channel and turning basin in front of the dock structures with a minimum 15 ft draft limit. Figure 18-7 is a schematic showing the proposed layout of the marine facilities.

Figure 18-7: Schematic Rendering of the Marine Facilities



Note: Prepared by NDM, 2020

The marine structures would include a main jetty area that would be constructed with 120 x 60 ft pre-cast concrete caissons. The jetty area would be connected to the shore via causeway. The jetty caissons would be placed 60 ft apart to allow water to flow around them and would be topped with pre-cast concrete beams and a concrete deck. The structure would be designed to accommodate the movement of heavy construction modules and mine equipment. In addition to the main jetty structure, a series of three caissons would be placed within the dredged basin to provide mooring and loading for the concentrate lighter barges. An overhead gantry structure would support an enclosed conveyor from the jetty to a barge loader mounted on the caissons. The jetty structures would be equipped with marine fenders and mooring bollards to safely berth a range of barge sizes, and a floating ramp system would be installed at the corner of the jetty to facilitate handling roll-on-roll off (ro-ro) barges where a forklift or truck can carry the cargo onto the dock and onto shore.

To prepare for caisson placement, the basin footprint under the caissons would be excavated and leveled to a depth of approximately 5 ft below the dredged basin or seabed using a barge mounted excavator. The approximately 58 ft high caissons would then be floated into place using a tug for guidance at high tide and seated on the leveled seabed on the falling tide or slowly lowered by pumping water into the caisson. Once placed, the caissons would be filled with coarse material from the dredging and additional quarried material of a size that would achieve proper compaction when filled to avoid settlement over time. The additional fill material would be sourced from onshore material sites. The construction sequence would have a narrow channel dredged to the jetty location for movement of the caissons, which would be followed by the completion of the dredged turning basin, and the balance of the access channel.

Draft requirements for the concentrate and supply barges and tugs used during construction and operations are 15 ft. The dredged depth for the access channel and turning basin is 18 ft below mean lower low water to provide access to the jetty under all tidal conditions. This allows an additional 3 ft to accommodate for accumulated sedimentation between forecast maintenance dredging (estimated at 20 in. over 5 years) and over depth excavation. The channel would be approximately 2.9 mi in length and 300 ft wide (3 times the maximum expected barge width), while the turning basin would incorporate an area of approximately 1,100 ft by 800 ft. The total volume of dredged material for the initial dredging is estimated at 1,100,000 yd^3. Maintenance dredging is expected to total 700,000 yd3 over twenty years (four times).

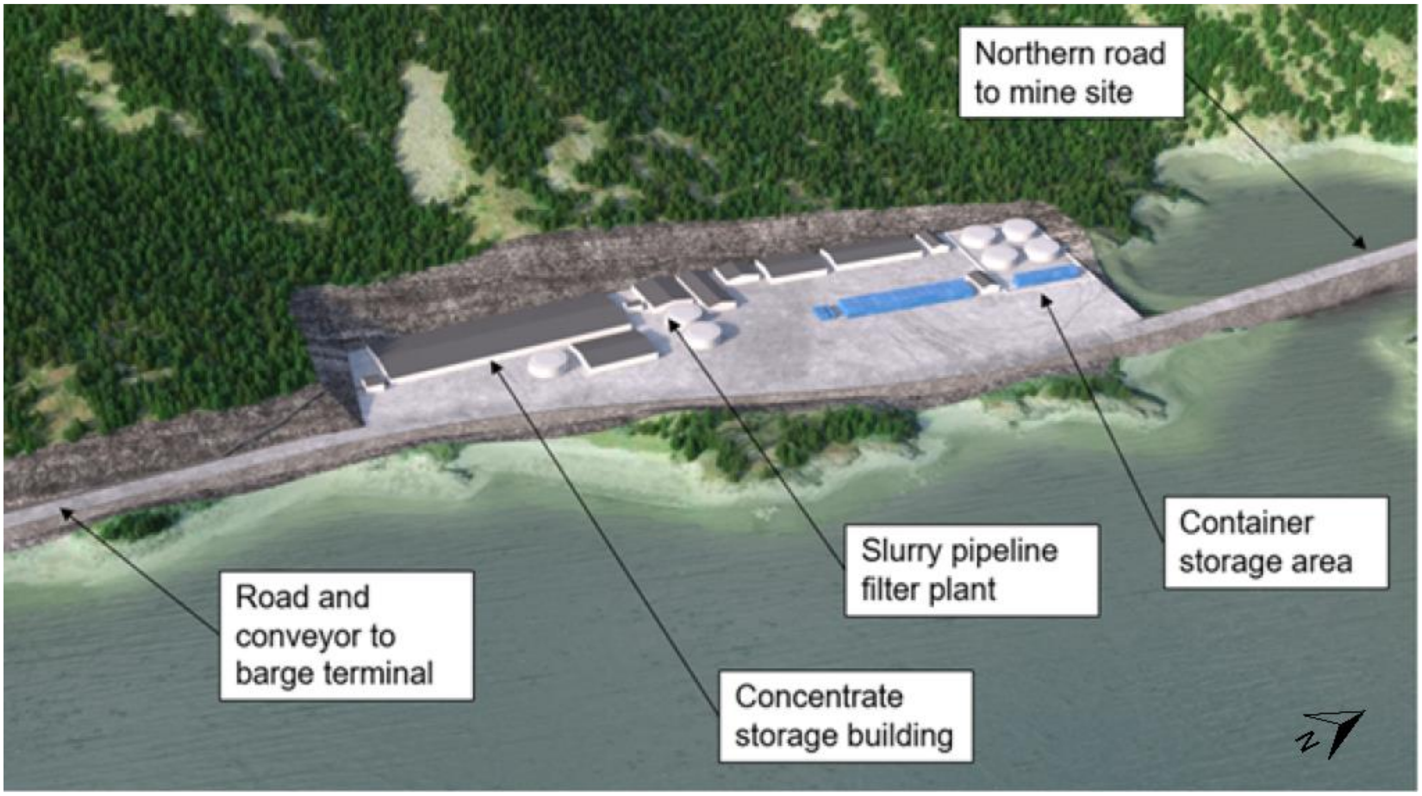
Handysize bulk carriers would be secured at a mooring point located in Iniskin Bay, which would include a spread mooring system using floating points attached to gravity anchors in approximately 45 ft deep water. Bulk concentrate would be transported in 6,000 tonne covered barges from the marine facility to the waiting ships which would be loaded with transshipment operations where wheel loaders on the barges would feed a reclaim conveyor and ship loading system on each barge. The conveyor discharge would include a telescoping spout to minimize dust as concentrate is loaded into the ship's hold. Depending on the size of the shipment, about five to six trips by the barges would be required to load a bulk carrier, which would be anchored for three to four days at the lightering location.

Approximately 27 Handysize bulk carrier vessels would be required annually to transport concentrate to offshore markets. In addition to the outbound concentrate movement, up to 33 barge loads of supplies and consumables would be required annually to service the mine, as well as fuel barges delivering diesel every quarter. The marine facility operations would be subject to periodic ice build-up in the winter months, but two ice-breaking tugboats would be used to support year-round availability.

18.9.2 Onshore Terminal Facilities

Separate onshore terminal facilities would include concentrate filtration and storage, a pumping station for the water return pipeline, facilities to receive and store containers and fuel, as well as natural gas powered generators, maintenance facilities, employee accommodations, and offices. A schematic showing the proposed onshore facilities is provided in Figure 18-8.

Figure 18-8: Schematic Rendering of the Onshore Facilities



Note: Prepared by NDM, 2020.

Specific features of the onshore facility include the following:

- a concentrate slurry pipeline termination system including choke station, buffer tank, clarifier tank, filtration plant, and return water line pumping system;
- a concentrate conveyor system from the filter plant to move product into an "A-frame" storage shed with 50,000 tonnes of capacity;
- reclaim system from the concentrate storage shed including a fully enclosed "pipe conveyor" to transfer cargo to the barge loader at the marine facility;
- an open area material laydown yard for equipment and container storage for about 2,000 twenty-foot equivalent units (TEU);
- a fuel storage depot with four 1,325,000 USG vertical storage tanks providing 5.3 million USG capacity;
- a truck shop combined with an emergency vehicle building (ambulance, fire truck);
- two 2 MW natural gas fired generators (plus backups) with heat recovery system plus and emergency diesel generator;

- an administration building with permanent camp facilities for local site employees;
- warehouse and cold storage buildings;
- domestic water storage and treatment facilities;
- refrigerated container storage racks; and
- a spill response container complete with spill response booms, pads etc.

The alignment interval from the marine terminal to Williamsport (MP 3) is considered the coastal portion of the mine access road route. This section is along the west side of Iliamna Bay at the toe of the mountain slopes and partially within the intertidal zone. Mass rock excavation is required, as is placement of rock fill with associated armor rock protection in the intertidal zone.

18.9.3 Fuel Supply

Diesel fuel to support the mining operation and logistics systems would be imported to the Diamond Point terminal using marine barges and pumped to the 5.3 million USG capacity onshore storage facility. The expected maximum parcel size for delivery is 4 million USG, which would allow for one month of buffer for variations in barge arrivals in winter months.

Diesel fuel would be transferred from Diamond Point to the mine site using ISO tank container units, which have a capacity of 6,350 USG. These units would be loaded at the port and transported by truck to the mine site. Additional containers would be stored at the mine site to provide for a fuel reserve in the event of a supply disruption.

The main mine site fuel storage area would contain fuel tanks in a dual-lined and bermed area designed to meet regulatory requirements. Sump and truck pump out facilities would be installed to handle any spills. There would also be pump systems for delivering fuel to the rest of the mine site. Dispensing lines would have automatic shutoff devices, and spill response supplies would be stored and maintained on site wherever fuel would be dispensed.

Fuel would be dispensed to a pump house located in a fuel storage area for fueling light vehicles. It would also be dispensed to the fuel tanks in the truck shop complex, which are used for fueling of heavy mining equipment. These tanks would also be in a lined secondary containment area.

19 MARKET STUDIES AND CONTRACTS

19.1 Introduction

The Project would produce copper-gold and molybdenum flotation concentrates and a precious metals gravity concentrate. The copper-gold concentrate would be transported via buried pipeline from the mine site to the marine terminal where it would be filtered, loaded onto the lightering barges, and then unloaded directly into the holds of Handysize bulk carriers for shipment to smelter customers in Asia and Europe. The molybdenum concentrate would be filtered at the mine site and placed in large sacks which are in turn placed in conventional shipping containers. The containers would be trucked to the port and shipped to refineries located outside Alaska. Other economically valuable minerals (gold, silver and palladium in the copper-gold concentrate and rhenium in the molybdenum concentrate) would be present and likely payable in the concentrates. The gravity concentrate would be treated in a manner similar to the molybdenum concentrate but shipped to precious metal specific refineries.

For the 2021 PEA, Northern Dynasty relied on published consensus long term pricing estimates and previous market analysis. A marketing plan and more precise terms of sale of the final products would be prepared during the next phase of study of the Pebble Project.

19.2 Metal Prices

The long-term metal prices used in the 2021 PEA economic analysis are shown in Table 19-1. These prices are consistent with current consensus forecasts, based on investigations by Northern Dynasty. Table 19-1 also contains prices prevailing during the period of preparing the 2021 PEA.

Table 19-1: Metal Prices

Metal Type	Unit	Long term Value ($)	Prevailing Value ($)
Copper	lb	3.50	4.25
Gold	Oz	1,600	1,800
Molybdenum	Lb	10	18
Silver	Oz	22	24
Rhenium	kg	1,500	1,600

Beginning in 2000, the copper market moved from an extended period of relatively stable prices to a period in which demand, particularly from China, resulted in copper prices moving well above the cost of production, peaking at about $4.71/lb in February 2011. Since that time, global economic and political uncertainty has been a dominant theme and the copper price has fluctuated. With the commodity boom led by Chinese growth over the COVID-19 pandemic recovery from 2020, the copper price breached the $4.00/lb level in 2021. As of July 27, 2021, the spot copper price was approximately $4.37/lb. A recent consensus published from the major banks estimates a long-term copper price in the $3.20 to $3.70/lb range, with a median of $3.30/lb and average of $3.37/lb.

The gold price rose from a range of $300 to $400/oz experienced in the 1990s and the first years of the 21st century to an average of $1,675/oz in 2012. With more recent global economic uncertainty due to COVID-19, gold prices have risen. The spot price on July 27, 2021 was approximately $1,799/oz. Current analyst consensus for long-term gold prices are in the range of $1,400 to $1,800/oz, with a median and average forecast long-term gold price of $1,600/oz, consistent with the marginal cost of production.

Silver price trends have generally followed gold, given its similar use as a store of value, providing investors a hedge against inflation amid the current economic uncertainty. As of July 27, 2021, the spot silver price was approximately $25/oz. The recent analyst consensus is for a long-term silver price in the $18 to $25/oz range, with a median of $20/oz and an average of $22/oz.

Historically, the molybdenum price has averaged about $5.50/lb over the 25-year period leading up to the early years of the last decade. This average reflects the majority of years when molybdenum was at a lower price, with the average brought up by substantial spikes related to strikes or cuts of by-product production coupled with specific growth in molybdenum demand. In most years during this period, a floor price was established at the production cost of the highest cost primary producer; however, in the mid part of the last decade, the molybdenum price surged. Molybdenum prices peaked around $32/lb but have since dropped and, in 2021, averaged about $12/lb. At this price, it would seem that Chinese primary producers are operating at or below cost, establishing a floor price at a level of around the $12/lb. As of July 27, 2021, the spot molybdenum price was approximately $18/lb. Current analyst consensus is for a long-term molybdenum price in the $8 to $12/lb range, with a median of $10/lb.

19.3 Smelter Terms

The assumed smelter/refinery terms in the 2021 PEA are shown in Table 19-2.

For copper concentrate, ocean transportation costs are assumed to be $50.00/wet tonne and concentrate moisture content was assumed to be 8%. For molybdenum concentrate, ocean transportation costs are assumed to be $171.12/wet tonne and concentrate moisture content was assumed to be 5%.

Table 19-2: Smelter and Refinery Terms

Item		Units	Value
Metal Payable	Copper in Copper concentrate	%	96.15
	Gold in Copper concentrate	%	97.00
	Silver in Copper concentrate	%	90.00
	Molybdenum in Molybdenum concentrate	%	100
Marketing	Copper Concentrate Losses	%	0.15
	Molybdenum Concentrate Losses	%	0.10
	Insurance	% of value	0.15
	Representation	$/wet tonne of concentrate	2.50

Item		Units	Value
Treatment Smelting and Refining Terms	Treatment of Cu concentrate	US$/dry tonne of concentrate	70
	Refining of Cu in Cu Concentrate	US$/payable lb	0.07
	Refining of Au in Cu Concentrate	US$/payable oz	7.00
	Refining of Ag in Cu Concentrate	US$/payable oz	0.60
	Refining of Au/Ag Doré	US$/payable oz	1.00
	Roasting of Mo in Mo Concentrate	US$/payable lb	3.00

Copper is one of the most widely-used metals on the planet. China, Europe and the USA are the main global consumers of copper. A tight copper market is expected to continue through 2021 due to COVID-19 restrictions and is expected to resume in 2022 and peak in 2023.

The copper concentrate market has seen significant structural imbalances in the recent past between a shortage in mine concentrate production and excesses in smelting capacity. Since 2000, there has been a significant expansion of smelting and refining capacity, particularly in China and India, resulting in benchmark treatment and refining levels being sub-economic, benefiting the miners. With increased smelter and refinery operating costs and copper concentrate surplus forecast in the near term from mine production, smelter terms moved upwards from the 2019 benchmark levels of $63.50/dmt and $6.35/lb to $70/dmt and $0.07/lb for 2021.

Smelter terms for copper are 96.15% payable with a minimum deduction of 1 unit (amount deducted has to equate to a minimum of 1% of the agreed concentrate copper assay). As the Pebble Project is expected to have an average copper concentrate grade of 26%, the 1 unit threshold should apply and has been assumed in the financial evaluation.

Payable gold and silver in the copper concentrate would depend on the ultimate smelter location. In Japan, Korea and India, for the Pebble Project's expected concentrate specifications of 20 g/dmt for gold and 102 g/dmt for silver, gold is expected to be 97% payable and silver 90% payable. There is some variance in terms between Asia and Europe.

It is unlikely that any materially significant penalties would be applicable for the Pebble copper concentrate, particularly given the projected production volume.

Molybdenum concentrates are generally sold at a percentage discount to the quoted price. This would depend on supply and demand fundamentals as well as on the quality of the particular concentrate. Discounts, for standard quality molybdenum concentrates, which normally capture all offsite costs, would typically range between 10-13% depending on grade and impurity levels with 12% assumed as an average. In addition, there has been a trend towards minimum and maximum dollar levels to be applied to the percentage deduction. The molybdenum deduction and discount are included in the $3/lb of payable molybdenum treatment charge.

The molybdenum concentrate is expected to contain approximately 1.8% Cu and significant rhenium, estimated at 861 ppm. Rhenium is included in the resource estimate, and therefore is estimated in the production forecast and used in the financial model. Not all of the major custom roasting operations can effectively recover rhenium, and thus it is likely that the rhenium content would be subject to a deduction.

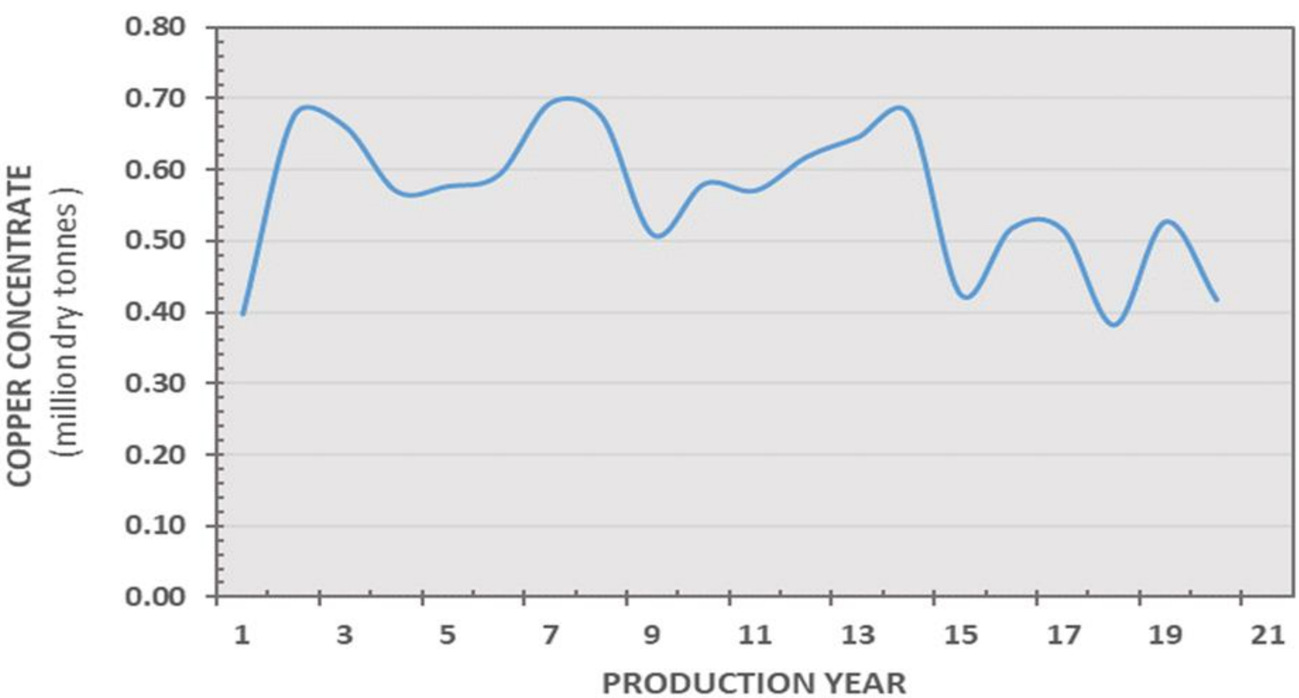
Rhenium is one of the rarest elements present on earth. The occurrence of rhenium is mostly as a substitute for molybdenum in molybdenite and rarely occurs in native form or as its own mineral. Most of the rhenium is produced from porphyry copper-molybdenum-gold deposits across the world. The price of rhenium has decreased consistently for the last 9 years. Due to the low metal prices and low demand for rhenium during the global Covid-19 pandemic, many primary producers of rhenium are now focusing on secondary products. Based on USGS data, the price of the metal has decreased from approximately $4,500/kg in 2011 to $2,000/kg in 2016 to $1,000/kg in 2020.

The copper content in the molybdenum concentrate is subject to a penalty that is normally applied on a dollar scale, depending on the level. In theory, for example, at the indicated copper grade in the molybdenum concentrates, about one dollar in penalties would be added over and above the other charges. Therefore, if Northern Dynasty was able to sell molybdenum concentrate with a projected copper content of 1.8%, it should expect a discount of at least 5% greater, or up to 17% of the molybdenum price. In practice, at these levels of copper in molybdenum, the high probability is that the concentrate would have to be leached to reduce the content to around 0.45% with such a level of copper or less.

19.4 Concentrate Logistics

The average annual copper-gold concentrate output is estimated to be 559,000 tonnes (dry concentrate). Figure 19-1 illustrates the estimated copper concentrate output over the 20 year Project life.

Figure 19-1: Copper Concentrate Production

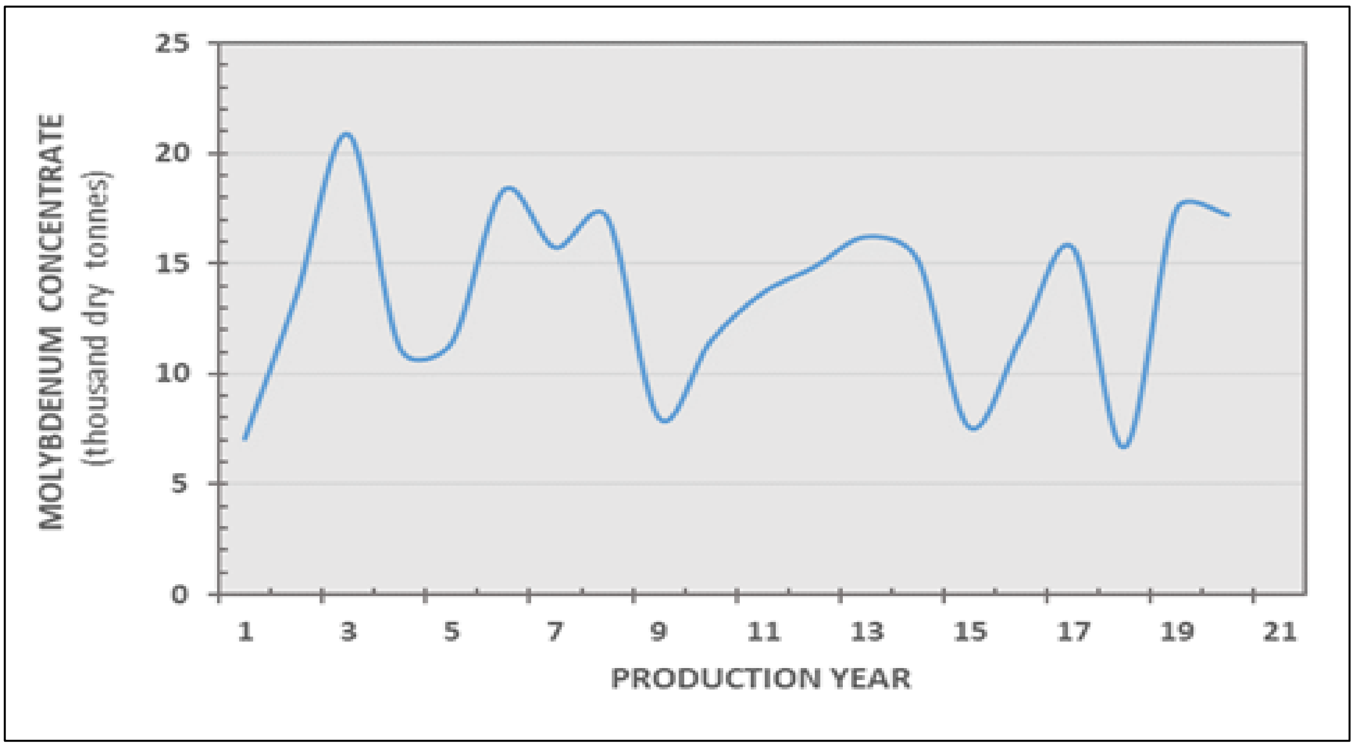


The copper concentrate preliminary market distribution is anticipated to be:

- China (50%);
- Japan (20%);
- Korea (5%);
- India (20%); and
- Europe (5%).

The average annual molybdenum concentration production (dry concentrate) is estimated at 14,000 tonnes. Figure 19-2 illustrates the estimated molybdenum concentrate output over the Project life. The molybdenum concentrate would be loaded in 1 ton bags and loaded into containers which would be transported via truck to the marine terminal. Containers would be shipped via ocean barge to Seattle, WA, and then loaded onto container vessels with regular service to Asia.

Figure 19-2: Molybdenum Concentrate Production



19.5 Contracts

No contracts for transportation or off-take of the concentrates are currently in place, but if and when they are negotiated, they are expected to be within norms for Alaska. Similarly, there are no contracts currently in place for supply of reagents, utilities, or other bulk commodities required to construct and operate the Project.

20 ENVIRONMENTAL STUDIES, PERMITTING, AND SOCIAL OR COMMUNITY IMPACT

20.1 Project Setting

20.1.1 Jurisdictional Setting

The Pebble Project is located in Alaska, a State with a constitution that encourages resource development and a citizenry that broadly supports such development. Alaska has a strong tradition of mineral development and hard-rock mining. The Pebble deposit is located on State land that has been specifically designated for mineral exploration and development. The Project area has been the subject of two comprehensive land-use planning exercises conducted by the Alaska Department of Natural Resources (ADNR); the first in the 1980s and the second completed in 2005 and subsequently revised in 2013. ADNR identified five land parcels (including Pebble) within the Bristol Bay planning area as having "significant mineral potential," and where the planning intent is to accommodate mineral exploration and development. These parcels total 2.7% of the total planning area (ADNR, 2013).

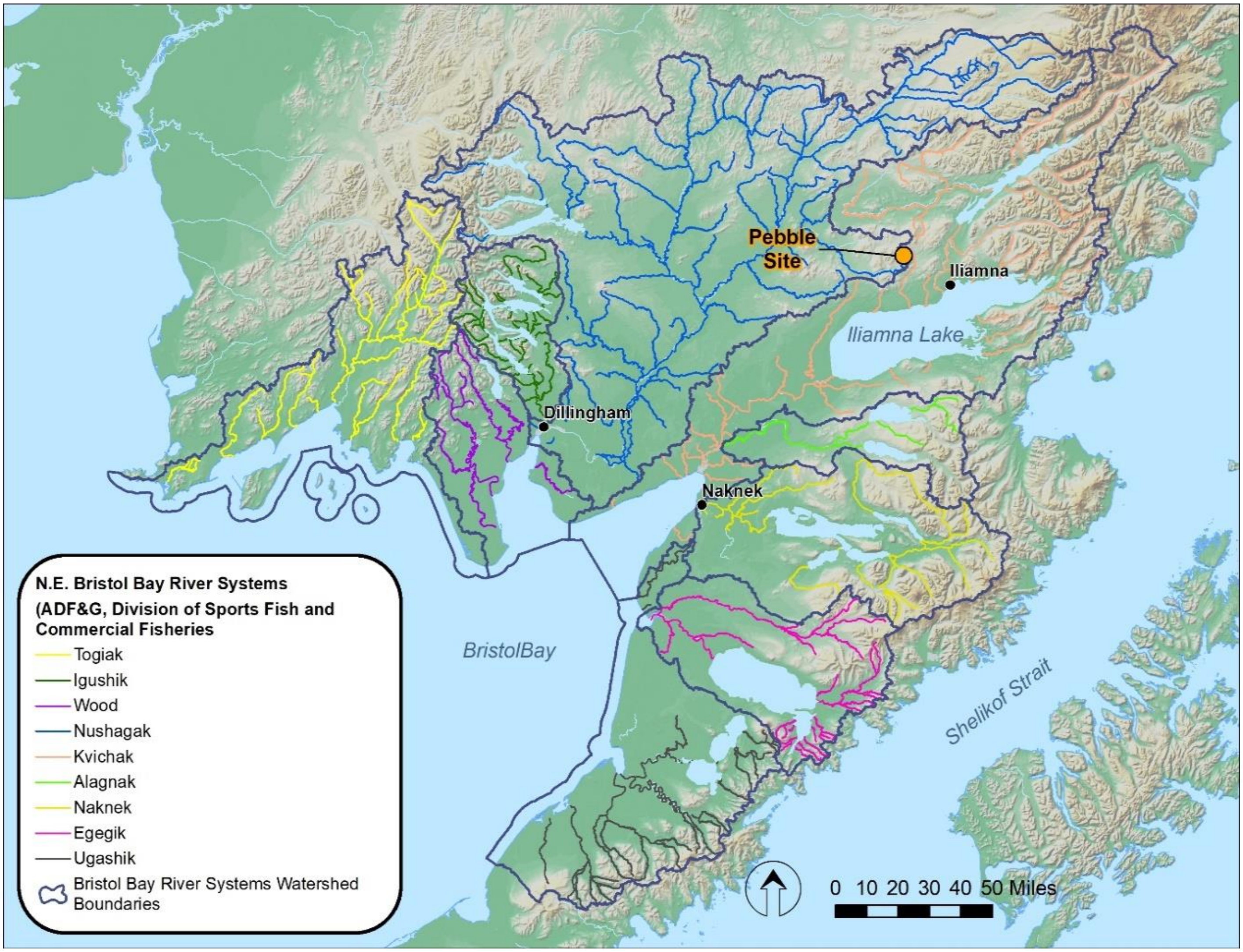
20.1.2 Environmental and Social Setting

The surface elevation over the deposit ranges from approximately 800 to 1,200 ft amsl, although mountains in the region reach 3,000 to 4,000 ft amsl. Vegetation generally consists of wetland and scrub communities with some coniferous and deciduous forested areas that become more common eastward toward the Aleutian Range.

The deposit area lies at a drainage divide between the Nushagak River and Kvichak River systems (Figure 20-1). The Nushagak River system drains to Bristol Bay at Dillingham, 220 river miles southwest of the deposit area. The Kvichak River system covers drains into Bristol Bay via the Kvichak River 140 river/lake miles to the southwest.

In the deposit area, the tributaries of the Nushagak River in the deposit area are the NFK, SFK, while the tributary of the Kvichak River is the UTC. The deposit area is within the uppermost reaches of these streams and their flow is small within the project footprint. Approximately 17 mi from the deposit area, the NFK and SFK streams merge to form the main Koktuli River. The Koktuli River is a tributary to the lower Mulchatna River, which drains Figure 20-1 via the lower Nushagak River to Bristol Bay at Dillingham. The UTC flows into Iliamna Lake, which in turn drains into Bristol Bay via the Kvichak River (Figure 20-1).

Figure 20-1: Bristol Bay Watersheds



Note: Prepared by NDM, 2021

The Kvichak and Nushagak River systems are two of nine major systems that drain to Bristol Bay and support important Pacific salmon runs, most notably sockeye salmon (Jones et al., 2013). The Kvichak and Nushagak Watersheds total 22,965 mi^2, of which the NFK, SFK and UTC Watersheds comprise only 355 mi^2, or approximately 0.8% of the total Bristol Bay Watershed of 45,246 mi^2 (USGS, 2013). Government data indicate that, over the past decades, the combined Kvichak and Nushagak river systems have contributed about 20 to 30% of total Bristol Bay sockeye salmon escapement. In 2019, these systems accounted for 23% of sockeye returns (ADFG, 2020). Thus, some 70 to 80% of Bristol Bay sockeye production is hydrologically isolated from any potential effects of the Pebble Project.

Based on field studies conducted by the Pebble Partnership over 10 years, along with other government studies, e.g., ADFG, (2009), independent consultants estimated the NFK, SFK and UTC Watersheds generally produce less than 0.5% of the total

Bristol Bay sockeye run (harvest plus escapement). The NFK and SFK Watersheds, within which all major mine site infrastructure is located, produces less than 1/10th of 1% (or <0.1%) of all Bristol Bay sockeye.

Wildlife using the deposit area includes various species of raptors and upland birds, brown bear, caribou and moose. Although no listed species are known to use the deposit area, several species listed under the Endangered Species Act—Steller's eider, northern sea otter, Steller sea lion, humpback whale, and the Cook Inlet beluga whale—as well as harbour seals protected under the Marine Mammal Protection Act, are known to be present in Cook Inlet and some western Cook Inlet shoreline communities.

The deposit area and transportation corridor are isolated and sparsely populated. The Pebble deposit is located within the Lake and Peninsula Borough, which has a population of about 1,600 persons in 18 communities. The closest villages – Iliamna, Newhalen and Nondalton – lie approximately 17-19 miles from the deposit site. Pedro Bay, a small village 43 mi from the deposit, sits adjacent to the proposed transportation corridor. The population of Newhalen, the largest village, is about 215 full-time residents. A road connects the villages of Newhalen and Iliamna and extends to a proposed crossing of the Newhalen River just south of Nondalton. Otherwise, there are only local roads in the villages. Another road connects Williamsport on Iliamna Bay in Cook Inlet with Pile Bay at the east end of Iliamna Lake. Summer barges up the Kvichak River and on Iliamna Lake provide some freight service into the communities on Iliamna Lake. All of the communities are serviced by an airport or airstrip to provide year-round access. The airport serving Iliamna and Newhalen is a substantial facility that is available to a wide range of aircraft.

The total population within the Bristol Bay region is approximately 7,000. The largest population center of the region is Dillingham. It has a population size of about 2,300, or 30% of the region.

20.2 Baseline Studies – Existing Environment

Northern Dynasty began an extensive field study program in 2004 to characterize the existing physical, chemical, biological and social environments in the Bristol Bay and Cook Inlet areas where the Pebble Project might occur. The Pebble Partnership compiled the data for the 2004 to 2008 study period into a multi-volume Environmental Baseline Document (EBD) (PLP, 2012). Supplemental environmental baseline reports (SEBD) incorporated data collected from the period 2009 to 2012. Additional monitoring data collected through 2019 was provided to USACE in support of the ongoing permitting process. These studies have been designed to:

- fully characterize the existing biophysical and socioeconomic environment;
- support environmental analyses required for effective input into the Pebble Project design;
- provide a strong foundation for internal environmental and social impact assessment to support corporate decision-making;
- provide the information required for stakeholder consultation and mine permitting in Alaska; and
- establish a baseline for long- term monitoring to assess potential changes associated with future mine development

The baseline study program includes:

- surface water hydrology;
- groundwater hydrology;
- surface and groundwater quality;
- wildlife;
- air quality;
- cultural resources;

- geochemistry;
- snow surveys;
- fish and aquatic resources;
- noise;
- wetlands;
- trace elements;
- fish habitat – stream flow modelling;
- marine;
- subsistence;
- land use;
- recreation
- socioeconomics;
- visual aesthetics;
- climate and meteorology;
- Iliamna Lake

The following sections highlight key environmental topics; more detail is provided in the EBD, SEBD and the Project FEIS.

20.2.1 Climate and Meteorology

Meteorological monitoring data were collected from six meteorological stations located in the mine (Bristol Bay drainage) study area and three stations located in the Cook Inlet study area near Iliamna Bay (PLP, 2012). Meteorological monitoring in the area near the deposit occurs at an elevation between 800 to 2,300 ft amsl. Monitoring in the Cook Inlet study area occurs near sea level.

Data collected at all stations included wind speed and direction, wind direction standard deviation and air temperature. Collected data at stations where instrumentation has been installed include differential temperature, solar radiation, barometric pressure, relative humidity, precipitation and, in summer, evaporation. Meteorological monitoring was suspended at the Pebble 1 station in 2014 and restarted in 2017. A new monitoring station was installed near the then proposed Amakdedori marine terminal in 2017. Monitoring at the remaining stations was suspended in 2013 after sufficient baseline data was collected.

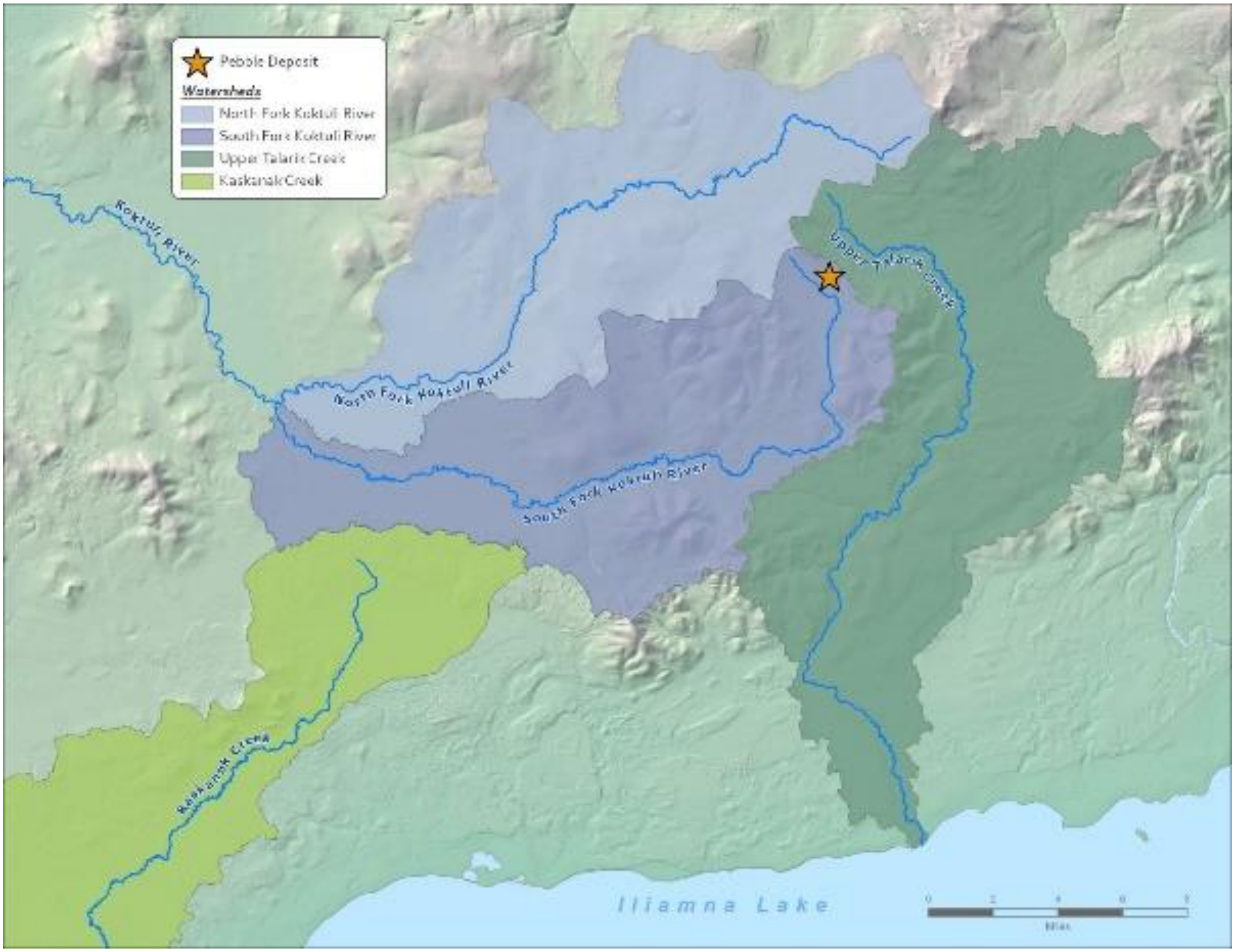
Mean monthly temperatures in the deposit area range from about 50.8°F in July to 11.4°F in January. The mean annual precipitation is estimated to be 54.6 in. per year, about one-third of which falls as snow. The wettest months are August through October.

20.2.2 Surface Water Hydrology and Quality

20.2.2.1 Surface Water Hydrology

The Bristol Bay drainage basin encompasses 45,246 mi^2 in southwest Alaska. The map in Figure 20-2shows the study area, which is principally defined as the 355 mi^2 within the SFK, NFK and UTC drainages. The Nushagak and Kvichak Watersheds constitute 51% of the Bristol Bay basin area (USGS 2013). The deposit location straddles the watershed boundary between the SFK and UTC and lies close to the headwaters of the NFK. The area studied near the deposit encompasses the drainages of these three watercourses as well as the headwaters of Kaskanak Creek (KC). While the deposit area and potential mine footprint does not affect the Kaskanak Creek headwaters, it was included in the study design to allow for comprehensive long term monitoring of mine operations.

Figure 20-2: Local Watershed Boundaries



Note: Prepared by NDM, 2021.

Annual stream flow patterns in the mine study area are generally characterized by a bi-modal hydrograph with high flows in spring resulting from snowmelt and low flows in early to mid-summer resulting from dry conditions and depleting snowpacks. Frequent rainstorms in late summer and early autumn contribute to another high-flow period. The lowest flows occur in winter when most precipitation falls as snow and remains frozen until spring. Loss and gain of surface flow to groundwater plays a prominent role in the flow patterns of all study area creeks and rivers, causing some upstream sites to run dry seasonally while causing others to be dominated by baseflow due to gains.

During winter and summer low-flow periods, stream flows are primarily fed by groundwater discharge. Observed baseflows were higher during summers than winters due to snowmelt recharge of aquifers and intermittent rainstorms. Baseflows were lowest in late winter after several months without surface runoff. Low-flow conditions are also influenced by fluctuations in surface storage features such as lakes, ponds and wetlands; however, changes in surface storage are minimized during the late winter freeze.

20.2.2.2 Surface Water Quality

Surface water quality sampling within the study area occurred between 2004 and 2014 at numerous locations in the NFK, SFK, UTC and KC drainages. Stream samples were collected from 44 locations during 50 sampling events from April 2004 through December 2008. Lake and pond samples were collected from 19 lakes once or twice per year during 2006 and 2007. Seep samples were collected from 11 to 127 sample locations, depending on the year, two to five times per year. Altogether, over 1,000 samples were collected from streams, more than 600 samples from seeps, and approximately 50 samples from lakes.

Surface water in the study area is characterized by cool, clear waters with near-neutral pH that are well-oxygenated, low in alkalinity, and generally low in nutrients and other trace elements. Water types ranged from calcium-magnesium-sodium-bicarbonate to calcium-magnesium-sodium-sulphate. Water quality occasionally exceeded Alaska water quality criteria for trace elements such as copper and iron, likely due to mineralized rock in the area. Additionally, cyanide was present in detectable concentrations; there were consistently detectable concentrations of dissolved organic carbon; and no detectable concentrations of petroleum hydrocarbons, polychlorinated biphenyls (PCBs), or pesticides were found.

20.2.3 Groundwater Hydrology and Quality

20.2.3.1 Groundwater Hydrology

Beginning in 2004, Northern Dynasty established an extensive groundwater monitoring network across the study area. The Pebble Partnership expanded the monitoring network to refine the understanding of the groundwater flow regime; between 2004 and 2019 groundwater monitoring data were collected over variable periods of time at more than 500 monitoring locations.

The hydrostratigraphy of the Project area includes three main units: unconsolidated sediments, weathered bedrock, and competent bedrock. The unconsolidated sediments, deposited during multiple episodes of glaciation, have variable hydrogeologic properties ranging from highly permeable sands and gravels to very low permeability clays. The weathered bedrock unit, which outcrops along ridges and hilltops, tends to be more permeable than the underlying competent bedrock. No permafrost has been identified in the study area.

In 2019 six boreholes were drilled and instrumented to the northeast of the proposed open pit. The stratigraphy encountered in these holes was broadly similar, consisting of 90 to 100 ft of Quaternary glacial sediments overlying Tertiary conglomerate and Cretaceous granodiorite. Two 6 in. nominal diameter pumping wells were installed to target zones interpreted to be more permeable (i.e., weathered bedrock and Tertiary-Cretaceous contact). Monitoring wells were installed in the weathered bedrock and vibrating wire piezometers were installed in both bedrock units and unconsolidated sediments. Slug tests conducted in the two monitoring wells yielded hydraulic conductivity estimates for the weathered bedrock at this location ranging from the order of 10^{-3} to 10^{-5} ft/s.

In addition, a 72-hour pumping test was conducted in a previously installed pumping well in the bulk TSF SPC area. The pumping test was conducted at a rate of approximately 4 gpm, and drawdown was observed in the pumping well and at instruments located approximately 30 ft away. Hydraulic conductivity estimates from this test for the interpreted bedrock aquifer were on the order of 10^{-6} ft/s, comparable to values for weathered bedrock from previous studies at the site.

Throughout the study area the water table mimics surface topography in a subdued fashion; it is generally located near or at ground surface in low-lying areas, and at greater depths near ridges and ridge tops. Flowing artesian conditions, where groundwater levels are above ground surface, are observed in some low-lying discharge areas. Groundwater elevations are typically observed to be lowest during the spring prior to snowmelt, and highest immediately following freshet and/or autumn rains. Groundwater-surface water interactions within the study area are complex due to the heterogeneous nature of the surficial geology and variable topography.

20.2.3.2 Groundwater Quality

Groundwater wells were located within the Pebble deposit resource area (10 wells at seven locations), and along the three surface water drainage basins identified as reflective of groundwater flow from the Pebble deposit resource area. Sample analysis shows high dissolved oxygen levels at most locations, with most median pH values ranging from 5.3 to 8.5. Sites with elevated trace metal concentrations were generally in the vicinity of the deposit. The EBD and SEBD compared the results of groundwater quality sampling with the most stringent benchmark water quality criteria derived from Title 18 of the Alaska Administrative Code, Chapter 75 (18AAC75), and Alaska Water Quality Criteria (ADEC, 2008).

20.2.4 Geochemical Characterization

Northern Dynasty and the Pebble Partnership conducted a comprehensive geochemical characterization program to understand the ML and acid rock drainage (ARD) potential associated with the rock types present in the general deposit area within the Pebble Project study area. The ML/ARD study was designed to characterize the materials that could be produced from the mining and milling process at the Pebble deposit, including both waste rock and tailings material (PLP, 2012). Classification of acid generating potential is based on Mine Environment Neutral Drainage (MEND, 1991) guidelines that classify rock as PAG, uncertain or non-PAG based on the neutralization potential ratio (NPR), defined as the neutralization potential (NP) divided by maximum potential acidity (MPA). Detailed characterization and classification of PAG and non-PAG materials enable engineers to design appropriate materials handling, sorting and storage strategies to ensure the long-term protection of water quality.

Acid-base accounting results indicate that the Tertiary units are dominantly non-PAG. Minor components of the Tertiary volcanic rocks (less than 1% based on testing) contain pyrite mineralization and have been found to be PAG and some generated acid in laboratory tests. The pre-Tertiary samples from the porphyry-mineralized rock from the deposit area have variable acid generation potential. Pre-Tertiary rock was found to be dominantly PAG due to elevated acid potential (AP) values resulting from increased sulphur concentrations and the low levels of carbonate minerals. In the pre-Tertiary samples, acidic conditions occur quickly in core with low NP. Field data suggest that the onset to acidic conditions is about 20 years, while laboratory kinetic tests show that the delay to the onset of acidic conditions is expected to be between a decade and several decades for PAG rock.

The majority of the overburden samples analyzed have been classified as non-PAG, with very low total sulphur content dominated by sulphide. For pre-Tertiary material, metal mobility tests identified copper as the main contaminant in the leachate. Subaqueous conditions also produced the dissolution of gypsum and iron carbonate, as well as arsenic leaching. Weathering of the mineralized pre-Tertiary material under oxidizing conditions produced an acidic leachate dominated by sulphate and calcium. Non-PAG tests indicated that the oxidation of pyrite resulted in low pH conditions, which increased metal mobility.

20.2.5 Wetlands

Section 404 of the CWA governs the discharge of dredged or fill materials into waters of the U.S., including wetlands. USACE issues Section 404 permits with oversight by the U.S. Environmental Protection Agency (EPA). Given the Pebble Project's location and scope, the information required to support the Pebble Partnership's Department of the Army permit application is significant. Accordingly, Northern Dynasty and the Pebble Partnership conducted an extensive, multi-year wetlands study program at Pebble in both the Bristol Bay and Cook Inlet drainages.

The study area is much larger than the deposit area. This entire study area has been mapped to determine the occurrence of wetlands and to characterize baseline conditions. Overall, water bodies, wetlands and transitional wetlands represent 9,826 acres, or 33.4%, of the study area. Of the 375 water features evaluated in the overall study area, 308 (82.1%) were classified as lakes or perennial ponds, the vast majority of which were open water. The remaining 67 water features (17.9%) were classified as seasonal ponds or the drawdown areas of perennial ponds, which were roughly evenly encountered as open water or partially vegetated/barren ground.

All wetlands delineation in the field for the transportation corridor has been completed.

20.2.6 Fish, Fish Habitat and Aquatic Invertebrates

Extensive aquatic habitat studies, initiated in 2004, were conducted from 2004 to 2013. Additional fish habitat studies were conducted on the NFK in 2018. They have varied in scope, study area and level of effort, as the information base has grown, and specific data needs have become more defined. The aquatic habitat study program encompassed the three main deposit area drainages (NFK, SFK and UTC) and the Koktuli River, and in and around Iliamna Lake. Completed studies include:

- fish population and density estimates using various field methods (dip netting, electrofishing, snorkelling and aerial surveys);
- fish habitat studies (main-channel and off-channel transects and habitat preferences);
- fish habitats/assemblages above Frying Pan Lake;
- salmon escapement estimates;
- spring spawning counts and radio telemetry for rainbow trout;
- radio telemetry of arctic grayling to assess stream fidelity;
- overwintering studies for salmon, trout and grayling;
- Frying Pan Lake northern pike population estimate;
- geo-referenced video aquatic habitat mapping;
- intermittent flow reach, habitat and fish use; and
- fish tissue measurements for trace metals.

20.2.6.1 Fish and Fish Habitat

20.2.6.1.1 Project Site

The deposit area is characterized by small headwater streams of poor-quality habitat and low fish density. Fish production is naturally limited by physical and chemical factors in these reaches, most notably intermittent flow with extreme low flow hydrology and oligotrophic conditions that constrain aquatic productivity. The lowest reaches of the three study area streams outside the deposit area have more stable hydrologic conditions and support numerous salmon and resident species.

The macro-invertebrate and periphyton studies near the Pebble deposit are part of the overall program of baseline investigations to describe the current aquatic conditions in the study area. Baseline information on macro-invertebrate and periphyton community assemblages is valued because the biota are essential components of the aquatic food web, and their community structure, particularly with respect to the more sensitive taxa, are an indicator of habitat and water quality.

The main objective of the macro-invertebrate and periphyton field and laboratory program was to characterize the diversity, abundance and density of macro-invertebrates and periphyton within freshwater habitats in the study area. Macro-invertebrates and periphyton were sampled in the study area in 2004, 2005 and 2007 as part of the environmental baseline studies for the Pebble Project. In 2004, 20 sites in the study area were sampled and of these, eight sites (five in the immediate vicinity of the deposit) were selected for continued sampling in 2005, and 10 were sampled in 2007.

20.2.6.1.2 Transportation Corridor

Data from the AWC and field observations by independent experts indicate that many, but not all, waters in the area support anadromous fish populations, including all five Pacific salmon species (Chinook, sockeye, coho, pink, and chum) plus rainbow trout, Dolly Varden, and Arctic char. Population densities vary based on stream size and morphology, which can restrict population sizes or limit access to upstream habitats.

20.2.7 Marine Habitats

20.2.7.1 Marine Nearshore Habitats

The nearshore marine habitat study area focused on areas in the lower Cook Inlet region. The western shorelines from Kameshak Bay north to Knoll Head are composed of a diversity of habitats, including steep rocky cliffs, cobble or pebble beaches and extensive sand/mud flats. Eelgrass is found at a number of locations and habitats; eelgrass, along with macro-algae, is an important substrate for spawning Pacific herring. Overall, the habitats in the study area provide a wide range of habitat types, resulting in a wide range of biological assemblages.

Data collected in Iliamna and Iniskin Bays in 2010 and 2011 indicate that Pacific herring are the predominant species present in the nearshore environment, primarily in Iniskin Bay. Chum and pink salmon are the predominant salmonids found in the bays, with smaller populations of coho and sockeye also present.

20.2.7.2 Marine Benthos

The littoral and subtidal habitats in lower Cook Inlet support diverse communities of marine and anadromous species of ecological and economic importance. The marine benthos study's intent was to characterize benthic assemblages in marine habitats in the lower Cook Inlet region.

The marine investigations were undertaken over a five-year period from 2004 to 2008, and included several habitat sampling events, mostly in mid to late summer. Each intertidal habitat type provides feeding areas for different pelagic and demersal fish and invertebrates that forage over the intertidal zone during high tides. The estuarine and nearshore rearing habitats of juvenile salmonids are an important component of the intertidal zone, especially for pink and chum salmon that out-migrate from streams along the shoreline and elsewhere in Cook Inlet. Another important component of the intertidal zone is the substrate used for spawning by Pacific herring.

20.2.7.3 Nearshore Fish and Invertebrates

The study of nearshore fish and macroinvertebrates has been undertaken to collect baseline data on the abundance, distribution and seasonality of major aquatic species on the western side of Cook Inlet (PLP, 2012). Principal marine investigations were undertaken between 2004 and 2008. Additional herring spawn surveys were conducted in 2018. The study area is a complex marine ecosystem with numerous fish and macro-invertebrate species that use the area for juvenile rearing, refuge, adult residence, migration, foraging, staging and reproduction.

The study area also functions as a rearing area for juvenile Pacific herring. Herring was the dominant fish species, and young-of-the-year and one-year-olds were the dominant life stages found from March through November in the several sampling years, with peak occurrences noted during the summer (PLP, 2012).

The nearshore area is also a rearing area for juvenile salmon, which, as a group, were second to herring in abundance. Juvenile pink and chum salmon were the most abundant salmonid species and showed a typical spring and summer outmigration as young-of-the-year fish. Juvenile chum displayed a short outmigration period during May and June, while juvenile pink salmon remained in the area into August. Both species were largely gone by September.

20.3 Potential Environmental Effects and Proposed Mitigation Measures

The application of sound engineering, environmental planning and best management practices, including compliance with existing U.S. federal and State environmental laws, regulations and guidelines, will help ensure that all of the environmental issues associated with the development and operation of the Pebble Project can be effectively addressed and managed.

The major environmental pathways include air, water and terrestrial resources. During the preliminary stages of the Pebble Project, Northern Dynasty identified key environmental issues and design drivers that have formed the basis of baseline data collection, environmental and social analysis and continuing stakeholder consultations influencing the Pebble Project design. The effects assessment has confirmed these as important issues and design drivers and has identified mitigation measures for each. The key mitigation strategies for these drivers include:

- Water: development of a water management plan that maximizes the collection and diversion of groundwater, snowmelt and direct precipitation away from the mine site.
- Wetlands: development of a project design and site selection which focussed on avoiding wetlands where possible and minimizing impacts where avoidance was not possible.

- Aquatic habitats: development of a water management plan and habitat mitigation measures that includes strategies to effectively manage the release of treated water in compliance with anticipated regulatory requirements to maintain downstream flows and to maximize downstream fish habitat and aquatic environments.

- Air quality: implementation of air emissions and dust suppression strategies.

- Marine environment: minimize the port facility's footprint in the intertidal zone, particularly in soft sediment intertidal areas.

Direct integration of these and other appropriate measures into the Pebble Project design and operational strategies are expected to effectively mitigate possible environmental effects and minimize residual environmental effects associated with the construction, operation and eventual closure of any proposed mine at the Pebble Project.

20.4 Economy and Social Conditions

The Alaska economy is dependent on natural resources for both employment and government revenue. Oil and natural gas, mining, transportation, forestry, fishing and seafood processing, as well as tourism, represent a significant proportion of the overall private sector economy, with oil and gas contributing a significant majority of State government revenues on an annual basis. Recent declines in resource commodity prices, notably for oil, have substantially reduced State government revenues and triggered a fiscal crisis for the Alaska State Legislature. The COVID-19 pandemic's effect on oil prices and other Alaska industries has steepened the State's economic and fiscal decline, while also contributing to significant job losses.

Of the approximately 733,000 people living in Alaska on a full-time basis, more than half live in the greater Anchorage area. Approximately 15% of Alaska's population is of Native ancestry.

The Pebble deposit is located in southwest Alaska's Lake and Peninsula Borough, home to an estimated 1,500 people in 18 local villages. At more 30,000 mi^2, the Lake and Peninsula Borough is among the least densely populated boroughs or counties in the country. There are no roads into the borough, and few roads within it, contributing to an extremely high cost of living and limited job and other economic opportunities for local residents.

The communities in closest proximity to Pebble are Nondalton, Iliamna, and Newhalen. Pedro Bay lies on the northern shore of Iliamna Lake, approximately 43 miles east of Iliamna and adjacent to the proposed transportation corridor. Igiugig and Kokhanok are the other two villages located on Iliamna Lake. While the Pebble Partnership has generated employment for residents of villages through the Lake and Peninsula Borough and broader Bristol Bay region over the past 15 years, those communities surrounding Iliamna Lake have provided the greatest proportion of the local workforce.

With Project infrastructure planned to connect the proposed mine site to the villages of Iliamna, Newhalen and Pedro Bay, these and other communities are expected to continue to be important sources of Project labour in future.

The Bristol Bay Borough is the only other organized borough in the Bristol Bay region, with about 844 full-time residents in three villages. A significant portion of the Bristol Bay region is not contained within an organized borough; the Dillingham Census Area comprises 11 different communities. About 7,000 people call the Bristol Bay region home, with the largest population center in Dillingham.

Most Bristol Bay villages have fewer than 150 - 200 full-time residents. A majority of the population is of Alaska Native descent and Yup'ik or Dena'ina heritage. Virtually all the region's residents participate to some degree in subsistence fishing, hunting and gathering activities. Subsistence is considered to be central to Alaska Native culture and provides an important food source for local residents.

There are 13 incorporated first and second class cities in the Bristol Bay region and 31 tribal entities as recognized by the US Bureau of Indian Affairs. There are also 24 Alaska Native Village Corporations created under the Alaska Native Claims Settlement Act, three of which – Alaska Peninsula Corporation, Iliamna Natives Limited, and Pedro Bay Corporation – hold surface rights for significant areas of land near the Pebble Project and along its proposed transportation infrastructure corridor. Separate Native Village Corporations are also centered in Igiugig (Igiugig Native Corporation) and Nondalton (Kijik Corporation).

The private sector economy of the Bristol Bay region is dominated by commercial salmon fishing. Although the resource upon which the industry is based remains healthy, the economics of the fishery have declined significantly over the past several decades due to the rise of global salmon aquaculture and various domestic policy and market factors. Ex-vessel prices for sockeye salmon, the dominant species in the Bristol Bay fishery, have fallen from an inflation-adjusted peak of $3.75/lb in 1988 to a 10-year average of just under $1.00/lb in the 1990s and $0.60/lb in the 2000s. In recent years, ex-vessel prices have exceeded $1.00/lb; the 2020 price was approximately $1.04/lb.

As a result of these declines, the percentage of Bristol Bay fishing licenses and related employment held by residents of the region has fallen precipitously, as has the region's overall economic health. Bristol Bay's economy today is characterized by a high proportion of non-resident labour and business ownership. Key private-sector industries are highly seasonal, such that unemployment among year-round residents is particularly high.

Bristol Bay communities also face among the highest costs of living in the US, due to the requirement to fly in many of the goods and commodities required for daily life, including fuel for heating homes and operating vehicles. Energy costs, in particular, are a significant deterrent to economic development.

As a result of a lack of jobs and economic opportunity in the region, Bristol Bay communities are slowly losing population as residents seek opportunities in other parts of the State. For example, between 2000 and 2010 the population of the Lake and Peninsula Borough declined 17% between 2000 and 2010, while the Bristol Bay Borough lost more than 23% of its population. These population outflows have continued through the most recent census period (2010-2020), with population losses of 9.5% in the Lake and Peninsula Borough and 15% in the Bristol Bay Borough. In several communities, schools have closed or are threatened with closure as a result of diminishing enrolment.

A subsistence lifestyle is practiced by the vast majority of residents of Bristol Bay communities, including fishing for salmon and other species, hunting of terrestrial mammals and birds, and gathering berries. Salmon, in particular, are considered a critically important resource for the region, from a cultural, economic and environmental perspective.

20.5 Community Consultation and Stakeholder Relations

Pebble Project technical programs are supported by stakeholder engagement activities in Alaska. The objective of stakeholder outreach programs undertaken by the Pebble Partnership are to:

- advise residents of nearby communities and other regional interests about Pebble work programs and other activities being undertaken in the field;
- provide information about the proposed development plan for the Pebble Project, including potential environmental, social and operational effects, proposed mitigation and environmental safeguards;

- allow the Pebble Partnership to better understand and address stakeholder priorities and concerns with respect to development of the Pebble Project;
- encourage stakeholder and public participation in the USACE-led EIS permitting process for Pebble; and
- facilitate economic and other opportunities associated with advancement and development of the Pebble Project for local residents, communities and companies.

In addition to meeting with stakeholder groups and individuals, and providing project briefings in communities throughout Bristol Bay and the State of Alaska, the Pebble Partnership's outreach and engagement program includes:

- workforce and business development initiatives intended to enhance economic opportunities for regional residents and Alaska Native corporations;
- initiatives to develop partnerships with Alaska Native corporations, commercial fishing interests and other in-region groups and individuals;
- outreach to elected officials and political staff at the national, State and local levels; and
- outreach to third-party organizations and special interest groups with an interest in the Pebble Project, including business organizations, community groups, outdoor recreation interests, Alaska Native entities, commercial and sport fishery interests, conservation organizations, among others.

Through these various stakeholder initiatives, the Pebble Partnership seeks to advance a science-based project design that is responsive to stakeholder priorities and concerns, provides meaningful benefits and opportunities to local residents, businesses and Alaska Native corporations, and energizes the economy of Southwest Alaska.

20.6 Permitting

On December 22, 2017, the Pebble Partnership submitted a Department of the Army permit application to USACE for authorization to discharge fill material and conduct work in navigable waters, which requires approval under Section 404 of the CWA and Section 10 of the RHA. USACE confirmed that the permit application was complete on January 8, 2018 and an EIS was required to comply with its NEPA review of the Pebble Project. As the lead federal agency for the EIS, USACE identified other federal actions that would be required for the project and invited those agencies to participate in the EIS process. Other Federal, State, tribal, and local entities with jurisdiction or special expertise were also invited to participate as cooperating agencies to assist with EIS development. The NEPA EIS process included a comprehensive alternatives assessment that considered a broad range of development alternatives. The scoping phase of the EIS commenced on April 1, 2018, including 90 days for public comment. USACE issued the scoping report on August 31, 2018. The report outlined the numerous environmental, social, and cultural issues that would be carried forward for analysis in the EIS. In addition, the report identified a range of development alternatives that would be considered in addition to the initial proposal by the Pebble Partnership. The Project design and operating parameters for the Pebble Project and associated infrastructure described as follows are derived from Project Description submitted in June 2020 with the Revised Permit Application. This Project Description is the basis for USACE's LEDPA determination and is attached to the FEIS published by USACE in July 2020.

The draft EIS was published on February 20, 2019. USACE initiated a public comment period, which included public hearings in affected communities and in Anchorage and was completed on July 2, 2019. More than 300,000 comments were received by USACE and were considered in the preparation of the FEIS. A preliminary FEIS was provided to cooperating agencies in February 2020.

On March 17, 2020, USACE informed the Pebble Partnership that its draft LEDPA would be the option which used a transportation route north of Iliamna Lake, versus the Pebble Partnership's proposed project of a ferry crossing of Iliamna Lake to a port southeast of the lake. After consideration, the Pebble Partnership changed its proposed project to the LEDPA. The revised proposal eliminated the ferry crossing of Iliamna Lake and replaced it with an 82-mile road, concentrate pipeline, and water return pipeline paralleling the north shore of Iliamna Lake to a new marine terminal in Iliamna Bay. The alignment of the natural gas pipeline was also revised to come ashore at the proposed marine terminal and to follow the revised road route. These revisions required collection of additional environmental and engineering data. The revised Project Description was submitted to USACE on June 8, 2020 as part of it Revised Permit Application.

The Pebble Partnership was actively engaged with USACE through the permitting process, including numerous meetings regarding, among other things, compensatory mitigation. The Pebble Partnership submitted several draft compensatory mitigation plans (CMPs) to USACE, each refined to address comments from USACE and that the Pebble Partnership believed were consistent with mitigation proposed and approved for other major development projects in Alaska.

In late June 2020, USACE verbally identified a preliminary finding of significant degradation of certain aquatic resources, with the requirement of new compensatory mitigation. The Pebble Partnership understood from these discussions that the new compensatory mitigation plan for the Pebble Project would include in-kind, in-watershed mitigation and continued its work to meet these new USACE requirements.

The FEIS was published on July 24, 2020. The document was viewed by the Pebble Partnership as favourable in that it found impacts to fish and wildlife would not be expected to affect subsistence harvest levels, there would be no measurable change to the commercial fishing industry including prices, and a number of positive socioeconomic impacts on local communities.

USACE formally advised the Pebble Partnership by letter dated August 20, 2020 that it had made preliminary factual determinations under Section 404(b)(1) of the CWA that the Pebble Project as proposed would result in significant degradation to aquatic resources. In connection with this preliminary finding of significant degradation, USACE formally informed the Pebble Partnership that in-kind compensatory mitigation within the Koktuli River Watershed would be required to compensate for all direct and indirect impacts caused by discharges into aquatic resources at the mine site. USACE requested the submission of a new CMP to address this finding within 90 days of its letter.

In response, the Pebble Partnership developed a CMP to align with the requirements outlined by USACE. This plan envisioned creation of a 112,445-acre Koktuli Conservation Area on land belonging to the State of Alaska in the Koktuli River Watershed downstream of the Pebble Project. The objective of the preservation of the Koktuli Conservation Area was to allow the long-term protection of a large and contiguous ecosystem that contains valuable aquatic and upland habitats. If adopted, the Koktuli Conservation Area would preserve 31,026 acres of aquatic resources within the Koktuli River Watershed, which has been designated as an aquatic resource of national importance. The proposed conservation area was selected to protect and preserve physical, chemical, and biological functions found to be important during the project review. Preservation of the Koktuli Conservation Area was designed to minimize the threat to, and prevent the decline of, aquatic resources in the Koktuli River Watershed resulting from potential future actions, with the objective of ensuring the sustainability of fish and wildlife species that depend on these aquatic resources, while protecting the subsistence lifestyle of the residents of Bristol Bay and commercial and recreational sport fisheries. The revised CMP was submitted to USACE on November 4, 2020.

On November 25, 2020, USACE issued a ROD rejecting Pebble Partnership's permit application. USACE determined the CMP to be "non-compliant" and the Project would cause "Significant Degradation" and be contrary to the public interest.

The Pebble Partnership submitted its request for appeal of the ROD on January 19, 2021. The request for appeal reflects the Pebble Partnership's position that USACE's ROD and permitting decision, including its significant degradation finding, its public interest review findings, and its rejection of Pebble's CMP, are contrary to law, unprecedented in Alaska, and unsupported by the administrative record, in particular the Pebble Project FEIS. The specific reasons for appeal asserted by the Pebble Partnership include: (i) the finding of "Significant Degradation" by USACE is contrary to law and unsupported by the record; (ii) USACE's rejection of the CMP is contrary to USACE regulations and guidance, including the failure to provide the Pebble Partnership with an opportunity to correct the alleged deficiencies; and, (iii) the determination by USACE that the Pebble Project is not in the public interest is contrary to law and unsupported by the public record.

In a letter dated February 24, 2021, USACE confirmed the Pebble Partnership's RFA is "complete and meets the criteria for appeal." USACE has appointed a Review Officer to oversee the administrative appeal process. The appeal process will now move to consideration by USACE of the merits of the appeal. The appeal will be reviewed by USACE based on the administrative record and any clarifying information provided, and the Pebble Partnership will be provided with a written decision on the merits of the appeal at the conclusion of the process. The appeal is governed by the policies and procedures of USACE administrative appeal regulations. While federal guidelines suggest the appeal should conclude within 90 days, USACE has indicated the complexity of issues and volume of materials associated with Pebble's case means the review will likely take additional time.

On January 8, 2021, the State of Alaska, acting in its role as owner of the Pebble deposit, announced that it would also appeal the decision. The State's news release characterized the ROD as a "… flawed decision [that] creates a dangerous precedent that will undoubtedly harm Alaska's future …". The State filed its request for appeal on January 22, 2021. That appeal was rejected on the basis that the State did not have standing to pursue an administrative appeal with USACE.

In addition to USACE permits, the Project will require Federal permits from the US Coast Guard and the Bureau of Safety and Environmental Enforcement, as well as authorizations from National Oceanic and Atmospheric Administration (NOAA) Fisheries and the US Fish and Wildlife Service. Several other federal approvals will also be required. There is no certainty that these federal permits and authorizations will be granted.

Numerous environmental permits and plans will also be required by various State and local agencies. The Pebble Partnership will work with applicable permitting agencies and the State of Alaska's large mine permitting team to provide complete permit applications in an orderly manner. There is no certainty that these Federal permits and authorizations will be granted.

On September 9, 2021, the EPA announced they planned to reinitiate the process of making a CWA Section 404(c) determination for the waters of Bristol Bay, which would set aside the 2019 withdrawal of that action that was based on a 2017 settlement agreement between the EPA and Pebble Partnership and supported by the results of the 2020 EIS. The 2019 withdrawal was contested by project opponents and is currently subject to ongoing litigation. In that litigation, EPA has requested the court to remand the case to EPA, which would likely result in the reinstatement of the Proposed Determination. The Pebble Partnership has filed an Opposition, asking the Court to impose a schedule requiring EPA to issue a final appealable decision on the 2014 Proposed Determination under the CWA, whether that be to withdraw or finalize. The imposition of a schedule is necessary to ensure that EPA is not allowed to regulate by inaction. In addition to the permits issued by USACE, the Pebble Project must receive an array of additional Federal permits from the US Coast Guard, the Bureau of Safety and Environmental Enforcement, as well as authorizations from NOAA Fisheries, the US Fish and Wildlife Service, and several other federal agencies.

Numerous environmental permits and plans will also be required by various State and local agencies. The State of Alaska utilizes a process for permitting mines through its large mine permitting team, with involvement from all State agencies required to issue permits for mine construction and operation. The Pebble Partnership will work with applicable permitting agencies and the large mine permitting team to provide complete permit applications in an orderly manner. Table 20-1 lists the types of permits that are expected to be required for the Pebble Project. Multiple permits of certain types may have to be applied for to accommodate the full scope of facilities.

In November 2014, Alaskan voters approved the Bristol Bay Forever public initiative. Based on that initiative, development of the Pebble Project requires legislative approval upon securing all other permits and authorizations.

Table 20-1: Permits Required for the Pebble Project

Agency	Approval Type	Project-related Examples
Federal		
BATF	License to Transport Explosives	Construction explosives acquisition and use
	Permit and License for Use of Explosives	Construction explosives acquisition and use
BSEE	Right-of-Way Authorization for Natural Gas Pipeline	Subsea natural gas pipeline in OCS waters
DHS	Airport Security Operations Plan	Iliamna Airport
	Port Facility Security Coordinator Certification	Marine terminal
	Port Security Operations Plan	Marine terminal
EPA	Facility Response Plan (required to be submitted to EPA, however EPA does not provide plan approvals)	Fuel storage facilities, fuel transport on the mine roadway
	RCRA Registration for Identification Number	Storage and disposal of hazardous wastes
	Spill Prevention, Control, and Countermeasure (SPCC) Plan (SPCC plans are not required to be submitted or approved by EPA. The plan will be reviewed and certified by a Professional Engineer licensed in Alaska)	Fuel storage facilities
FAA	Notice of Controlled Firing Area for Blasting	Construction and mining blasting activity
FCC	Radio License	Radios
MSHA	Mine Identification Number	Mine site
	Notification of Legal Identity	Mine site
NMFS	Magnuson-Stevens Fishery Conservation and Management Act Consultation documentation	Necessary in areas where mine, road, or marine terminal activity affect essential fish habitat

Agency	Approval Type	Project-related Examples
USACE	Clean Water Act Section 404 permit for Discharge of Dredge or Fill Material into Waters of the U.S.	Fill into wetlands for a variety of facilities at the mine, road, pipelines, marine terminal
	Rivers and Harbors Act Section 10 Construction of any structure in or over any Navigable Waters of the U.S.	Road bridges and causeway; marine terminal docking and ship-loading facilities and maintenance dredging.
USCG	Facility Response Plan	Fuel storage facilities
	Fuel Offloading Plan; Person in Charge Certification	Offloading fuel from barges at the port
	Hazardous Cargo Offloading Plan; Port Operations Manual Approval	Offloading hazardous cargo from ships
	Navigation Lighting and Marking Aids Permit	Port facilities
	Rivers and Harbors Act Section 9 Construction Permit for a Bridge or Causeway across Navigable Waters	Bridge along road
USDOT	Registration for Identification Number to Transport Hazardous Wastes	Transport of hazardous wastes to approved disposal site
USFWS	Bald and Golden Eagle Protection Act Programmatic Take Permit	May be necessary in areas where mine, road, or marine terminal activity may disturb eagles
	Migratory Bird Treaty Act Consultation documentation	May be necessary in areas where mine, road, or marine terminal activity may disturb migratory birds
USFWS/NMFS	Endangered Species Act Incidental Take Authorization	May be necessary at the marine terminal and for sub-sea pipeline construction where activities could disturb northern sea otter, Beluga whale, Steller sea lion, Steller's eider
	Marine Mammal Protection Act Incidental Take Authorization; Letter of Authorization	May be necessary at marine terminal where activities could disturb northern sea otter, Beluga whale, Steller sea lion, harbor seal, Dall's porpoise
State		
ADEC	Alaska Solid Waste Program Integrated Waste Management Permit/Plan Approval	Tailings disposal, waste rock disposal, landfills
	Reclamation Plan Approval and Bonding	Required prior to construction.
	Alaska Solid Waste Program Solid Waste Disposal Permit; Open Burn Permit	Construction waste material disposal

Agency	Approval Type	Project-related Examples
	Clean Water Act Section 402 Alaska Pollutant Discharge Elimination System Water Discharge Permit	Water discharges from water treatment plans at the mine site.
	Approval to Construct and Operate a Public Water Supply System	Mine and port, and construction camps
	Clean Air Act Air Quality Control Permit to Construct and Operate – Prevention of Significant Deterioration	Power plant and other non-mobile air emissions; fugitive dust; applicable to mine, road, and port
	Clean Air Act Title V Operating Permit	Power plant and other non-mobile air emissions; fugitive dust; applicable to mine and road
	Clean Air Act Title I Operating Permit	Non-mobile air emissions; stationary sources, fugitive dust; applicable to port and Kenai compressor station
	Clean Water Act Section 401 Certification	Certification of the Section 404 Permit.
	Clean Water Act Section 402 Stormwater Construction and Multi-Sector General Permit; Stormwater Discharge Pollution Prevention Plan	Surface water runoff discharges at mine, road, and marine terminal
	Food Sanitation Permit	Mine and port, and construction camps
	Oil Discharge Prevention and Contingency Plan (ODPCP or "C" Plan)	Fuel storage and transfer facilities, port and mine
ADF&G	Fish collection permits for monitoring	Required for construction and monitoring
	Fish Habitat Permit	Required for most work in anadromous streams and for most work in resident fish streams that might affect fish passage.
ADNR	Alaska Dam Safety Program Certificate of Approval to Construct a Dam	Tailings dam, seepage control dams
	Alaska Dam Safety Program Certificate of Approval to Operate a Dam	Tailings dam, seepage control dams
	Reclamation Plan Approval and Bonding	Required prior to construction.
	Lease of other State Lands	Any miscellaneous other state lands to be used by the Pebble Project – none identified at this time
	Material Sale on State Land	Materials removed from quarry sites for construction
	Mill Site Permit	All facilities on State lands

Agency	Approval Type	Project-related Examples
	Mining license	All facilities on State lands
	Miscellaneous Land Use Permit	All facilities on State lands
	National Historic Preservation Act Section 106 Review	Area of Potential Effect
	Pipeline Rights-of-Way Lease	Natural gas, concentrate, and water return pipelines on State lands and natural gas pipeline in State waters
	Fiber Optic Cable Right-of-Way Lease	Fiber Optic Cable on State lands and in State waters
	Powerline Right-of-Way Lease	Powerlines to support electric power distribution
	Road Right-of-Way Lease	Road between mine and marine terminal
	Temporary Water Use Permit; Permit to Appropriate Water	Surface and groundwater flow reductions
	Tidelands Lease	Port structures below high tide line
	Upland Mining Lease	All facilities on State lands
ADOL	Certificate of Inspection for Fired and Unfired Pressure Vessels	
ADOT&PF	Driveway Permit	Road
	Utility Permit on Right-of-Way	Natural gas pipeline on the Kenai Peninsula
ADPS	Approval to Transport Hazardous Materials	Transport of hazardous materials along the road
	Life and Fire Safety Plan Check	Mine and port
	State Fire Marshall Plan Review Certificate of Approval	For each individual building
Local		
KPB	Conditional Use Permit	
	Floodplain Development Permit	
	Multi-Agency Permit Application	
L&PB	Lake and Peninsula Borough Development Permit	Mine and road area within the Lake and Peninsula Borough

ADEC = Alaska Department of Environmental Conservation
ADF&G = Alaska Department of Fish and Game
ADOT/PF = Alaska Department of Transportation and Public Facilities

ADPS = Alaska Department of Public Safety
BATF = U.S. Bureau of Alcohol, Tobacco, and Firearms
BSEE = Bureau of Safety and Environmental Enforcement
DHS = U.S. Department of Homeland Security
EPA = U.S. Environmental Protection Agency
FAA = Federal Aviation Administration
FCC = Federal Communications Commission
FERC = Federal Energy Regulatory Commission
L&PB = Lake and Peninsula Borough
MSHA = U.S. Mine Safety and Health Administration
NMFS = National Marine Fisheries Service
RCRA = Resource Conservation and Recovery Act
SHPO = State Historic Preservation Officer
USACE = U.S. Army Corps of Engineers
USCG = U.S. Coast Guard
USDOT = U.S. Department of Transportation
USFWS = U.S. Fish and Wildlife Service

20.7 Closure

The Pebble Partnership's core operating principles are governed by a commitment to conduct all mining operations, including reclamation and closure, in a manner that adheres to socially and environmentally responsible stewardship while maximizing benefits to State and local stakeholders. The Pebble Partnership has adopted a philosophy of "design for closure" in the development of the Project that incorporates closure and long-term post-closure water management considerations into all aspects of the project design to ensure that all regulatory requirements, as well as landowner obligations, are met at closure.

Reclamation and closure of the Project falls under the jurisdiction of the ADNR Division of Mining, Land, and Water, and the ADEC. A miner may not engage in a mining operation until the ADNR has approved a reclamation plan for the operation. The Pebble Partnership submitted a preliminary closure plan to USACE in support of the EIS analysis. Four phases of closure are envisioned for the project. This plan would be subject to analysis and review during the State's permitting processes.

Phase 1

Most of the structures required to support the mine operation would be removed during this phase. The key closure component of this phase is the decommissioning of the pyritic TSF. The co-disposed PAG waste rock and pyritic tailings would be relocated to the bottom of the open pit, thus preventing acid generation and providing safe long-term storage. Reclamation of the bulk TSF would also commence during this phase. After allowing for consolidation of the bulk tailings, reclamation of that facility would commence with covering the tailings with a capillary break and growth medium. WTP #1 would be reconfigured for long term closure requirements. Water collection, treatment and discharge would continue per the operations phase.

Phase 2

Phase 2 would commence with completion of the relocation of the pyritic tailings and PAG waste rock at which point the site of the pyritic tailings storage facility would be reclaimed. The main Water Management Pond would be decommissioned at this point and the site reclaimed. At this point, all water from the bulk TSF would be diverted to the open pit, which would be allowed to fill to a defined control level, at which point Phase 3 would commence. No water treatment and discharge would occur during this phase.

Phase 3

The primary activity during Phase 3 would be to collect contact water, divert it to the open pit, and treat the surplus for discharge. The quality of the surface runoff water from the bulk TSF would be monitored during this phase and once it reaches discharge water quality, the next phase would commence.

Phase 4

Phase 4 would consist of long term water treatment and monitoring. The surface runoff from the bulk TSF would be allowed to discharge directly, while seepage from the facility and open pit runoff would be collected in the open pit, treated and discharged.

Additional information regarding reclamation, closure, and bonding costs is presented in Sections 21, 22 and 24.

21 CAPITAL AND OPERATING COSTS

21.1 Introduction

The following basic information pertains to the estimate of both capital and operating costs:

- Base date for these estimates is Q1 – 2021.
- All costs are expressed in United States dollars ($ or US$).
- United States to Canadian (C$) currency exchange rate used is US$0.75 = C$1.00.
- Estimate accuracy is reflective of the stage of project development at ±50%.
- All estimates are based on average production of 180,000 tons/d milled.
- Operating and sustaining capital costs are based on a 20-year project life cycle.
- Cost estimate is based on an engineering, procurement and construction management (EPCM) implementation approach, with selected scope areas being developed under discrete engineer, procure and construct (EPC) packages.

21.2 Capital Cost Estimate

21.2.1 Estimate Responsibility

The overall capital cost estimate was developed by Ausenco with contributions from a team of engineers from the following companies:

- Tetra Tech: development of the mining costs;
- Knight Piésold: site excavation, and the TSF and overall site water management;
- HDR: water treatment plant facilities;
- Nana Worley Parsons/Intecsea: natural gas pipeline and power generation;
- RECON: on-site and off-site roadway infrastructure;
- Northern Dynasty: Owner's costs and input to execution strategy.

21.2.2 Summary

The total estimated initial capital cost for the design, construction, installation, and commissioning of the Pebble Project is $6.05 billion, which includes all direct, indirect, Owner's, growth and contingency costs.

Sustaining capital investment in the Proposed Project is limited to incremental TSF expansions and replacement of mobile equipment for mining and road maintenance, over the life of mine. These life cycle costs are applied in the financial model on a year by year basis, with a cumulative total of $1.5 billion including indirect, Owner's and contingency costs.

Mine closure and reclamation costs are not included in the capital or operating costs but are factored into the financial model to account for long-term water treatment plant requirements.

A breakdown of capital cost figures by major work area is presented in Table 21-1.

Table 21-1: Summary of Capital Cost Estimate

Area Description	Initial Capital (US$M)	Sustaining Capital (US$M)	Total Capital to Y20 (US$M)
Site General	116.0	n/a	116.0
Power Supply	532.4	n/a	532.4
Natural Gas Line	246.4	n/a	246.4
Open Pit Mining	229.1	218.7	447.8
Ore Handling to Mill	91.5	n/a	91.5
Process Plant	736.3	n/a	736.3
Earthworks, Tailings and Water Mgmt.	1,008.2	1,085.2	2,093.4
Water Treatment Plants	269.7	n/a	269.7
On-site Infrastructure	228.8	n/a	228.8
Concentrate Pipeline	188.5	n/a	188.5
Marine Terminal Site	245.7	n/a	245.7
External Access Roads	296.1	n/a	296.1
Subtotal Direct Costs	*4,188.7*	*1,304.0*	*5,492.9*
Indirect Costs	857.2	45.2	902.4
Owner's Costs	325.0	10.0	335.0
Contingency and growth	678.4	162.8	841.2
Total Capital Cost	6,049.3	1,521.9	7,571.2

21.2.3 Direct Costs

Direct capital costs are those directly attributed to a specific scope of work for the project, and would typically be inclusive of installed equipment, material, labour and supervision directly or immediately involved in the physical construction of the permanent facility.

Each of the contributing parties noted in Section 21.2 have provided the direct costs associated with the works in their respective areas following a traditional engineering, procurement and construction management (EPCM) execution strategy, with indirect costs, Owner's costs and contingency to be applied separately. The exception to this is for the power generation and gas pipeline scopes which have been priced to reflect the intent to construct these as separate EPC packages that do not have indirect costs applied. Supplemental information and breakdown of costs for specific work areas are provided in the following sub-sections to provide clarity where certain costs have been allocated.

21.2.3.1 Site General Capital

The estimate of capital costs for the site general development is predominantly driven by the costs of site preparation, earthworks, and on-site access roads. These were estimated by Knight Piésold as part of their effort on tailings and water management, making use of the same equipment, and includes sustaining costs for the roads as the mine site grows over time. The balance of site general capital is for the establishment of power distribution, site wide controls and communications systems, the cost of which was factored by Ausenco from a previous estimate provided by Northern Dynasty. The cost breakdown has been shown in Table 21-2: Site General Capital.

Table 21-2: Site General Capital

Capital Category	Initial Cost (US$M)		
Site earthworks general construction	64.9		
Access and haul roads	38.4		
Electrical power distribution, site wide controls and communications	12.7		
Total	*116.0*		

21.2.3.2 Power Generation and Natural Gas Pipeline

The capital cost estimates for the supply and installation of the power generation equipment at both the mine site and marine terminal site, along with the installation of a compressed natural gas pipeline across Cook Inlet to the mine site have been provided by Nana Worley Parsons with support from their affiliate company Intecsea for the sub-sea pipeline. These estimates are based on preliminary designs and historical information for the installation of combined cycle gas generators.

The on-shore gas pipeline would be installed in a common trench with the concentrate slurry and water return pipes where the excavation and backfill costs are included in the off-site access road estimate.

A breakdown of the costs by work area is provided in Table 21-3, and all figures are based on an all-inclusive EPC delivery for each segment which would not attract any indirect construction costs.

Table 21-3: **Power Generation and Natural Gas Pipeline Capital Cost Summary**

Capital Category	Initial Cost ($M)
Mine site power generation plant	521.9
Marine terminal site power generation plant	10.5
Off-Shore natural gas pipeline (sub-sea placement)	169.4
On-shore natural gas pipeline (trenching in roads)	77.0
Total Direct Costs	*778.8*

21.2.3.3 Open Pit Mine Capital Costs

The estimate of initial capital cost for the development of the open pit mine area includes all mobile equipment purchase, and miscellaneous mining infrastructure, as well as pre-production stripping costs expected prior to the process plant going into production.

The sustaining capital costs include all equipment purchases necessary to manage the growth in the pit from the first year of production onward as well as fleet replacements. The cost breakdown has been shown in Table 21-4.

Table 21-4: **Mining Direct Capital Cost Estimate**

Capital Category	Initial Cost (US$M)	Sustaining Cost (US$M)	Total Capital Cost (US$M)
Pre-production stripping	66.2	n/a	66.2
Mine equipment capital	156.6	218.7	375.3
Miscellaneous mine capital	6.3	n/a	6.3
Total	*229.1*	*218.7*	*447.8*

21.2.3.4 Mineralized Material Handling and Process Plant Capital Cost Estimate

The capital cost estimates for these areas were developed by Ausenco using the conceptual design layout, design criteria, and flow sheet developed for this project. Process and major mechanical equipment costs were derived using recent similar copper projects, and historical budget quotes on file from vendors. Delivery and installation of process equipment was a factored cost relative to the total purchase price of equipment. The costs of the pumps for copper concentrate pipeline transport were included in the pipeline area, and the filtration plant costs for this system were included in the marine terminal area.

Earthworks and excavation costs for site preparation were included in the site general costs; there are no sustaining capital items associated with this area, as mill liner replacements are part of regular maintenance and included in the operating cost estimate. A summary of the direct capital costs is shown in Table 21-5.

Table 21-5: Ore Handling and Process Plant Capital Cost Summary

Capital Category	Initial Cost (US$M)
Primary Crushing to Stockpile Feed	91.5
Stockpile, Grinding, Pebble-Crushing	433.0
Cu-Mo Flotation, Regrind, Bulk & Pyritic Tailings Thickeners	190.7
Mo Flotation	34.5
Thickening & Mo Concentrate Filtration	39.0
Water & Air Systems	17.5
Reagents	21.6
Total Direct Costs	*827.8*

21.2.3.5 Tailings and Water Management

The estimate of capital costs for the TSF and general water management on the site was prepared by Knight Piésold using nominal unit rates for construction of work areas and quantities developed from their preliminary design of the facilities. The initial capital was broken out into earthworks and mechanical systems for water management, along with purchase of mobile excavation and hauling equipment that would be transitioned to the mining fleet following the initial construction. A similar estimate of the cumulative sustaining capital for both the TSF and mechanical equipment was also prepared. The cost breakdown is shown in Table 21-6.

Table 21-6: Tailings and Water Management Direct Capital Cost Estimate

Capital Category	Initial Cost ($M)	Sustaining Cost ($M)	Total Capital Cost ($M)
Earthworks	639.0	967.9	1,606.9
Mechanical equipment	100.3	117.4	217.7
Mobile equipment purchase	268.9	n/a	268.9
Total	*1,008.2*	*1,085.2*	*2,093.4*

21.2.3.6 Water Treatment Plants

HDR developed the capital cost estimate for the WTPs through the entire mine life based on the assumptions shown in Table 21-7, using reference data developed for a mine WTP designed by HDR that used many of the same water treatment processes and a similar parallel treatment train approach. The costs for the benchmark WTP were developed using manufacturer quotes for major equipment and detailed material take-off and unit prices for the divisions of construction.

Capital costs for each WTP were developed by factoring the differences in flow and water quality from the benchmark WTP, escalating costs to Q1 2021 US dollars, and by adding costs for the additional processes for the Project. Factoring was based on installed capacity and maximum flows.

Table 21-7: Water Treatment Plants Direct Capital Cost Estimate

WTP #	Phase of Mine Life	Influent Stream Treated	Direct Costs ($M)	Notes
WTP #1	Operations	Open Pit WMP	64.7	Included in direct capital cost summary
WTP #2	Operations	Main WMP	205.0	Included in direct capital cost summary
WTP #3	Closure Phase 1	Open Pit	107.7	Operations Phase WTP#1 base treatment trains would be reused for WTP#3 Closure Phase 1. This is not included in the initial or sustaining capital.
	Closure Phase 2	n/a	n/a	No further WTP investment in Closure Phase 2.
	Closure Phase 3	Bulk TSF Main SCP	n/a	2 trains from the Closure Phase 1 Open Pit stream WTP systems are repurposed for Bulk TSF Main SCP stream starting in Closure Phase 3.
		Open Pit	103.0	2 of the base trains from Closure Phase 1 Open Pit stream WTP are repurposed for Closure Phase 3/4. This is not included in the initial or sustaining capital.
	Closure Phase 4 (Post-Closure)	Bulk TSF Main SCP	n/a	No additional capital investment in Phase 4.
		Open Pit	n/a	No additional capital investment in Phase 4.

21.2.3.7 On-site Infrastructure

The cost of on-site general infrastructure and temporary facilities required during construction was factored by Ausenco from a previous estimate for site development provided by Northern Dynasty.

The provision of a 2,300 person construction camp is based on 50/50 permanent and temporary facilities with the full cost of $115 million being carried in the temporary construction area.

The cost breakdown is shown in Table 21-8.

Table 21-8: **On-Site Infrastructure Direct Capital Cost Estimate**

Capital Category	Initial Cost (US$M)
Site buildings	73.5
Site services and utilities	15.0
Plant mobile fleet (not including mining equipment)	9.0
Temporary facilities for construction	131.3
Total	*228.8*

21.2.3.8 Concentrate Pipeline

The capital cost estimate for the copper concentrate slurry pipeline system was developed by Ausenco using the conceptual design developed for this project, along with unit rates for construction established from similar projects and historical budget quotes on file from vendors.

The costs for the thickening and filtration plant at the end of this system are included in the marine terminal area. Trenching costs for the installation of the pipeline are included in the external road construction cost. A summary of the direct costs for this area is presented in Table 21-9.

Table 21-9: **Concentrate Slurry Pipeline Direct Capital Costs**

Capital Category	Initial Cost (US$M)
Slurry and return water pipeline supply and installation	115.0
Pumping station supply and installation	70.0
Fiber optic cable for pipeline system control	3.5
Total	*188.5*

21.2.3.9 Marine Terminal Site

The capital cost estimate for the marine terminal site was developed by Ausenco using the conceptual design developed for this project, along with unit rates for construction established from similar projects and historical budget quotes on file from vendors.

A summary of the direct costs for this area is presented in Table 21-10.

Table 21-10: Marine Terminal Facilities Direct Capital Costs

Capital Category	Initial Cost (US$M)
Site civil works and utilities	12.8
Auxiliary buildings	6.1
Fuel receiving and storage system	9.5
Mobile equipment	9.1
Concentrate filtration plant	38.5
Concentrate handling, storage, and barge loading	58.1
Power distribution, lighting, and controls system	8.3
Marine infrastructure (incl. dredging and tug purchase)	103.3
Total	*245.7*

21.2.3.10 External Access Roads

The capital cost estimate for the external access road was developed by Alaska-based road consultant, RECON, which has been involved with the Project for years and had previously prepared a design for this route. Costs were based on typical unit rates of construction for the region with locally sourced materials from borrow pits along the route. Mobile equipment acquired for the construction of the roadway would be retained for maintenance, with the replacement of this equipment included in sustaining capital. For the Base Case, sustaining capital costs for external access roads were assumed to be provided by third party infrastructure partners and were reflected in annual lease payments.

A summary of the initial and sustaining capital costs for this area are presented in Table 21-11.

Table 21-11: External Access Roads Direct Capital Cost Estimate

Capital Category	Initial Cost (US$M)	Sustaining Cost (US$M)	Total Capital Cost (US$M)
Permanent access road construction	274.9	n/a	274.9
Temporary bridges	14.7	n/a	14.7
Mobile equipment purchase	6.5	n/a	6.5
Total	*296.1*	*16.7*	*312.8*

21.2.4 Indirect Costs

Indirect costs are those that are required during the Project delivery period to enable and support the construction activities. Ausenco has estimated a total of $857.2 million which represents an average of 20.5% of the total direct costs, which is built up from a distribution of the following elements and rates against the applicable construction activities as shown in Table 21-12.

Table 21-12: Distribution of Indirect Costs

Indirect Cost Category	% of Direct	Applied to Direct Costs
Engineering and Procurement (EP)	8.0%	All - excluding EPC, mining equipment & 75% of TSF
Construction Management (CM)	4.0%	All - excluding EPC packages and mining
Construction Indirect costs	10.0%	All - excluding EPC, mining, marine infrastructure
Freight and Logistics	7.7%	All – excluding EPC, mining, TSF, marine & roads
First fills	1.0%	Mill feed material handling + process + p/l stations + con handling
Spares	1.0%	Mill feed material handling + process + p/l stations + con handling
Start up and commissioning	0.75%	Mill feed material handling + process + p/l stations + con handling
Vendor representation at site	0.40%	Mill feed material handling + process + p/l stations + con handling

21.2.5 Owners Costs

Owner's costs are costs borne by the Owner in support and execution of the Project.

The Project execution strategy involves an EPCM organization supervising one or more general contractors. Ausenco assumed an allowance of $325 million for Owner's costs, which equates to approximately 8% of direct costs and was confirmed by Northern Dynasty. Some of the items included are home office staffing, home office travel, home office general expenses, field staffing, field travel, general field expenses, environmental baseline monitoring and Owner's contingency.

21.2.6 Contingency on Capital

The total contingency amount of $678.4 million is equal to an average of 16.2% of total direct costs and is reflective of a range between 15% and 20% being applied to the individual work areas based on the level of detail and construction cost risk associate with each area.

21.3 Operating Costs

21.3.1 Summary

The average annual operating cost for the Project is estimated to be $708 million per year over the proposed 20 year life, which equates to $10.98 /ton milled, based on the 180,000 ton/day plant capacity. A summary of the individual components that make up this estimate is presented in Table 21-13 and is based on a combination of first-principal calculations, experience and historical pricing, reference projects and factors as appropriate for a PEA.

Table 21-13: Summary of Annual Average Operating Cost Estimate

Operating Area	Annual Cost (US$M)	Unit Cost (US$/ton milled)
General & Administrative	56.8	0.88
Open Pit Mining	112.7	1.75
Mineralized Material Handling & Process Plant	269.0	4.17
Tailings Operation & Maintenance	10.0	0.16
Water Treatment Plant	21.5	0.33
Concentrate Pipeline	1.9	0.03
Marine Terminal	15.7	0.24
External Access Roads	29.7	0.46
Consumables Freight Costs	10.2	0.16
Infrastructure Leases	180.8	2.80
Total	*708.3*	*10.98*

21.3.2 General & Administrative

The estimate of general and administrative (G&A) costs for the operation of the Project is based on previously-developed information provided by Northern Dynasty for this project and factored to suit the currently-planned milling rate with labour and expenses updated for the current market. The labour costs are inclusive of base salaries and overhead burdens at 30%. Head office salaries are based on a normal 40 hour week in Anchorage, while site based costs include for remote work with a 2 & 1 rotation (2 weeks on – 1 week off) for both salaries and headcount.

While this summary includes the mine site, any G&A labour cost and headcount associated with the marine terminal is included in the operations summary for that area.

A summary of the individual cost areas is presented in Table 21-14.

Table 21-14: Summary of Annual G&A Operating Cost Estimate

Operating Area	Head Count	Annual Cost (US$M)	Unit Cost (US$/ton milled)
Administration Office	27	3.33	0.052
Mine Site Services	40	5.52	0.086
Materials & Other Directs	n/a	7.60	0.118
Overheads	n/a	28.83	0.447
Labour Transportation	n/a	11.44	0.177
Total	*67*	*56.8*	*0.88*

21.3.3 Power Supply Costs

The capital costs for installation of natural gas line and power generation equipment have been included in the overall project development, and the combined operating costs of these assets are charged to the individual operating areas at the rate of $0.066/kWh for power consumption.

21.3.4 Mining

Mining costs were estimated by Tetra Tech from historical equipment productivity calculations and, more generally. Annual equipment utilization hours were derived from calculated available hours less estimated operating delays and then applied to the hourly equipment costs to estimate the direct mining operating costs.

Pre-production stripping costs of $66.2 million were included in the initial capital cost estimates for mining and are not included in these average operating costs and production rates.

Open pit mining costs are summarized in Table 21-15.

Table 21-15: Open Pit Mine Operating Costs

Open Pit Category	Unit Rate (US$/ton mined)	Life of Mine Cost (US$ M)	Average Cost (US$ M/year)	Average Rate (US$/ton milled)
Drilling	0.030	42.22	2.111	0.033
Blasting	0.202	283.03	14.152	0.219
Loading	0.137	191.59	9.580	0.148
Hauling	0.476	667.12	33.356	0.517
Dewatering	0.048	66.96	3.348	0.052
Support	0.163	227.99	11.399	0.177
Ancillary	0.029	40.54	2.027	0.031
Labour	0.495	694.29	34.715	0.538
Other	0.029	40.01	2.000	0.031
Total	*1.607*	*2,254*	*112.7*	*1.746*

A summary of the average annual consumables included in the mine operating costs are presented in Table 21-16.

Table 21-16: Mining Consumable Costs

Processing Cost item	Units	Annual Usage
Electricity	MWh	50,050
Diesel fuel	USG 1,000's	7,250
Lubricants	USG 1,000's	490
Tires	EA	185
ANFO	Short Ton	13,830
Emulsion	Short Ton	2,590

Ausenco developed the estimate of operating costs for the mill feed material handling system and process plant based on historical costs from similar projects in a remote location. Processing costs for power, consumables, maintenance consumables and labour are summarised in Table 21-17: Processing Costs.

Table 21-17: Processing Costs

Processing Cost item	Annual Cost ($M)	Annual Cost ($/ST milled)
Power	92.2	1.429
Operating consumables	139.7	2.165
Maintenance consumables	12.5	0.194
Labour	24.6	0.381
Total	*269.0*	*4.169*

21.3.4.1 Power

Power consumption was derived from calculated power draw of major mechanical equipment required for the process, plus an allowance for the remainder of the plant, based on typical flotation plants. The average on-line power draw is estimated at 160 MW.

Annual energy consumption is estimated at 1,400 GWh, or about $92.4 million at $0.066/kWh.

21.3.4.2 Consumables

Processing reagent and consumable costs were estimated based on the throughput with rates from the process design criteria and flow sheets. Costs for mill media, mill liners, and other plant consumables were estimated based on vendor information and benchmarking on similar plants.

A breakdown of these costs is summarized in Table 21-18.

Table 21-18: Operating Consumable Costs

Consumable Cost item	Annual Cost (US$M)	Annual Cost (US$/ton Milled)
Reagents	53.6	0.831
Mill media	64.7	1.003
Liners	17.5	0.271
Filters, laboratory and miscellaneous.	3.9	0.060
Total	*139.7*	*2.165*

21.3.4.3 Maintenance Consumables

Annual maintenance spares and consumable costs were estimated at 2% of the $624 million total installed capital costs for mechanical equipment, plate work, support steel and electrics of, or $12.5 million per year.

21.3.4.4 Labour

Labour costs include all processing and maintenance costs (Table 21-19).

Costs were estimated from a breakdown of staffing positions, estimated at 120 in total, excluding G&A manpower.

Table 21-19: Labour Costs

Cost Centre	Number	Annual Cost (US$M)
Operations staff and supervision	18	3.70
Crushing, grinding & flotation crews	56	7.93
Metallurgical laboratory	26	3.68
Maintenance staff	10	1.85
Maintenance personnel	48	7.43
Total	*158*	*24.59*

21.3.5 Tailings Operation & Maintenance

The operating and maintenance costs for the TSF facilities were estimated by Knight Piésold based on their preliminary design development and unit rates for similar operations. The average annual cost of $10.0 million includes labour and power and consumables for the operation and maintenance of the water management mechanical systems but does not include WTP costs.

21.3.6 Water Treatment Plant

HDR developed the water treatment plant operating cost estimate based on similar WTP facilities designed by HDR and was developed using mass balance-derived estimates for chemical reagents, a detailed electrical load analysis, and detailed estimates of operational manpower, consumables, and replacement parts.

Costs for each WTP were developed by factoring based on differences in flow and water quality from the similar WTP facilities designed by HDR, escalating costs to 2020 US dollars, and by adding costs for the additional processes that the current case has based on average flows.

A summary of the estimated annual WTP operating costs during mine production and through to mine closure are presented in Table 21-20.

Table 21-20: WTP Annual Operating Cost Summary

WTP #	Phase of Mine Life	Influent Stream Treated	Operating Costs ($M)	Notes
WTP #1	Operations	Open Pit WMP	3.01	Included in operating cost summary
WTP #2	Operations	Main WMP	18.45	Included in operating cost summary
WTP #3	Closure Phase 1	Open Pit	9.79	Operations Phase WTP#1 base treatment trains would be reused for WTP#3 Closure Phase 1.
	Closure Phase 2	n/a	0.16	No further WTP investment in Closure Phase 2.
	Closure Phase 3	Bulk TSF Main SCP	9.18	2 trains from the Closure Phase 1 Open Pit stream WTP systems are repurposed for Bulk TSF Main SCP stream starting in Closure Phase 3.
		Open Pit	12.52	2 of the base trains from Closure Phase 1 Open Pit stream WTP are repurposed for Closure Phase 3/4.
	Closure Phase 4 (Post-Closure)	Bulk TSF Main SCP	9.18	No additional capital investment in Phase 4.
		Open Pit	3.62	No additional capital investment in Phase 4.

21.3.7 Concentrate Pipeline

Ausenco estimated the annual operating cost of the slurry pipeline and return water system at $1.9 million ($0.029/ton milled), which includes approximately $1.0 million in electrical power consumption, with the balance in maintenance materials and contract services for the pump and pipeline equipment.

Labour associated with the pipeline operations and maintenance is carried in the marine terminal.

21.3.8 Marine Terminal

Ausenco estimated the operating and maintenance costs for the marine terminal facilities based on nominal staff and crew requirements, power consumption costs, maintenance materials, as well as the supply of contract transhipment services to load the copper concentrate from transfer barges to ocean going bulk carriers anchored at deep water in Iliamna Bay.

A summary of the operating costs for the marine terminal is presented in Table 21-21.

Table 21-21: Marine Terminal Operating Costs

Processing Cost item	Annual Cost (US$M)	Annual Cost ($/ton milled)
Electrical power	1.0	0.015
Maintenance consumables	1.4	0.021
Labour	10.5	0.160
Transhipment	2.8	0.043
Total	*15.7*	*0.239*

Electrical power costs are based on an average annual consumption of 12.1 GWh and the common rate for the project of $0.066/kWh. This includes the copper concentrate filter plant air compressors, and the downstream concentrate handling system, with the balance to lighting and general services.

Maintenance consumables are based on a percentage of capital on material handling equipment, an allowance for marine structures, and $230,000 annually for replacement filter cloth.

Site labour includes both management, operations, and maintenance crews for the marine terminal as well as the slurry pipeline system. A total of 71 site personnel were assigned to this site.

Due to the water depth in the area, the marine facilities are designed for barge access only, and loading of copper concentrate to bulk carriers must be done through barge transhipment. This would be done as an external service by a contractor that would supply the self-unloading barges and crews at an "all-in" rate. Based on historical data for similar operations, Ausenco has made an allowance of $2.8 million per year for this service using a nominal rate of $3.50/tonne of concentrate shipped.

21.3.9 External Access Roads

The operating cost estimate for the external access roads has been prepared by RECON, and is based on typical requirements for fuel, labour and materials usage to maintain the road surface and bridges for all-season traffic between the marine terminal and the mine site. The cost of mobile equipment is included in the initial capital cost, and replacement equipment in sustaining costs. Transportation rights and toll payments based on anticipated future commitments have also been included in the operating cost estimates.

21.3.10 Consumables Freight Costs

Ausenco has included an allowance in the operating costs for the transportation of consumable materials to the remote mine site. The capital costs include the purchase of standard shipping containers for use in moving cargo from either Prince Rupert, Vancouver or Seattle where consumables would be consolidated and "stuffed" into these containers for movement to the Pebble Project marine terminal by barge, and then moved to the mine site by truck.

This allowance is based on a nominal rate of $35/ton applied to approximately 130,000 tons of mine site and process plant consumables being moved to the site in containers per year.

22 ECONOMIC ANALYSIS

22.1 Forward-Looking Information Cautionary Statements

The results of the economic analyses discussed in this section represent forward-looking information as defined under Canadian securities law. The results depend on inputs that are subject to several known and unknown risks, uncertainties, and other factors that may cause actual results to differ materially from those presented herein. Information that is forward-looking includes the following:

- Assumed commodity prices and exchange rates.
- Proposed mine and process production plan.
- Projected mining and process recovery rates.
- Ability to market the three types of concentrate on favourable terms.
- Ability to control the levels of deleterious elements expected in some of the concentrate batches.
- Assumptions as to initial capital costs, sustaining capital costs, on-site and off-site operating costs.
- Assumptions as to closure costs and closure requirements, including water treatment requirements.
- Assumptions as to timeframe of development.
- Assumptions as to income, royalty, severance and other tax rates, the timing of costs and other deductions for tax purposes as well as other statutory tax rules and regulations.
- Assumptions as to the value and timing of payments to and from precious metal stream and infrastructure development partners.
- Assumptions as to the ability to permit the project, including receipt of all required permits under the laws of the United States, from USACE and meeting all relevant Federal, State and local regulatory requirements and that such permitted mine can be economically developed.
- Assumptions about environmental, permitting, legal and social risks including the ability to demonstrate that a mine at the Pebble Project can be developed and operated in an environmentally sound and socially responsible manner.
- Assumptions about the ability to secure rights-of-way and legal access required for the infrastructure for the Pebble Project, including the transportation corridor
- The uncertainties with respect to the effects of COVID-19, including whether it could materially impact or delay the ability to obtain permitting for a mine at the Pebble Project.

Additional risks to the forward-looking information include:

- Changes to commodity prices from what is assumed including the volatility of copper, gold, molybdenum, silver and rhenium prices and share prices of mining companies.
- Changes to costs of production from what is assumed.
- Unrecognised environmental risks.
- Unanticipated reclamation expenses.
- Unexpected variations in quantity of mineralization, grade or recovery rates.
- Geotechnical or hydrogeological considerations during operations being different from what was assumed including the presence of unknown geological and other physical and environmental hazards at the Pebble Project.
- Failure of mining methods to operate as anticipated.
- Failure of plant, equipment or processes to operate as anticipated.
- Failure to obtain key personnel and executives necessary to permit, construct and operate the mine as anticipated.
- Changes to the timeframe of development and other factors which impact expected financial performance.
- Changes to assumptions as to the generation of electrical power, and the power rates used in the operating cost estimates and financial analysis.
- Ability to maintain the social licence to operate.
- Accidents, labour disputes and other risks of the mining industry.
- The highly-cyclical and speculative nature of the mineral resource exploration business.
- Outcomes to current and future litigation and potential claims by third parties to titles or rights involving the Pebble Project.
- Changes to interest rates and the ability to secure adequate financing on acceptable terms.
- Ability to continue to fund exploration and development activities and other operating costs.
- Changes to tax rates.
- Changes to applicable laws, regulations and government policies or the introduction of new government regulations relating to mining, including laws and regulations relating to the protection of the environment and project legal titles.
- Receipt of all required permits.
- The possible inability to insure operations against all risks.
- The highly competitive nature of the mining business.

The mine plan in the 2021 PEA is partly based on Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves, and there is no certainty that the PEA based on these Mineral Resources will be realized. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

22.2 Summary

The project was assessed under two scenarios – a full capital cost scenario and a scenario in which the effective capital cost is reduced by engaging partners to provide primary infrastructure (access road, marine facility, natural gas pipeline, and mine site power plant). Given the latter scenario is the more likely route to development, it is defined as the Base Case. Using long term metal price assumptions, the 20-year Base Case has an 18.2% pre-tax internal rate of return, a 4.5 year pre-tax payback on $4.4 billion initial capital and a $3.5 billion pre-tax net present value at a 7% discount rate. A summary of results for the Base Case and Full Capital Case at long term metal prices is set out in Table 22-1.

Table 22-1: Forecast of Proposed Project Results at Long Term Metal Prices – Summary

Description	Units	Base Case	Full Capital Case
Mine Life	years	20	20
Mining Method		Open Pit	Open Pit
Pre-tax NPV at 0%	$US millions	11,828	14,746
Pre-tax NPV at 5%	$US millions	5,007	5,459
Pre-tax NPV at 7%	$US millions	3,506	3,445
Pre-tax NPV at 8%	$US millions	2,913	2,657
Pre-tax NPV at 10%	$US millions	1,967	1,405
Pre-tax IRR	%	18.2%	13.4%
Pre-tax Payback	years	4.5	5.8
Initial Capital	$US millions	4,370	6,049
NSR per Ton Milled	$/ton	24.59	26.38
Operating Cost Per Ton	$/ton	10.98	8.31
C1 Copper Cost (co-product basis)	$/lb CuEq	1.65	1.32
Production Rate	million ton/year	66	66
Post-tax NPV at 0%	$US millions	8,224	10,646
Post-tax NPV at 5%	$US millions	3,366	3,546
Post-tax NPV at 7%	$US millions	2,281	2,004
Post-tax NPV at 8%	$US millions	1,851	1,400
Post-tax NPV at 10%	$US millions	1,160	442
Post-tax IRR	%	15.7%	11.2%
Post-tax Payback	years	4.8	6.1
Strip Ratio	waste : ore	0.12	0.12
Total Processed	M ton	1,291	1,291
Copper Equivalent Grade	%	0.57	0.57
Copper Grade	%	0.29	0.29
Gold Grade	oz/ton	0.009	0.009
Molybdenum Grade	ppm	154	154

- Note: Copper equivalent (CuEq) calculations use the following metal prices: US$1.85 /lb for Cu, US$902 /oz for Au and US$12.50 /lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).

A summary of results for the Base Case and Full Capital Case of a sensitivity analysis using prevailing metal prices is set out in Table 22-2.

Table 22-2: Forecast of Proposed Project Results at Prevailing Metal Prices - Summary

Description	Units	Base Case	Full Capital Case
Mine Life	years	20	20
Mining Method		Open Pit	Open Pit
Pre-tax NPV at 0%	$US millions	19,856	22,967
Pre-tax NPV at 5%	$US millions	9,222	9,701
Pre-tax NPV at 7%	$US millions	6,862	6,794
Pre-tax NPV at 8%	$US millions	5,925	5,647
Pre-tax NPV at 10%	$US millions	4,418	3,816
Pre-tax IRR	%	27.1%	18.2%
Pre-tax Payback	years	2.9	4.3
Initial Capital	$US millions	4,370	6,049
NSR per Ton Milled	$/ton	30.86	32.98
Operating Cost Per Ton	$/ton	11.18	8.53
C1 Copper Cost (co-product basis)	$/lb CuEq	1.67	1.35
Production Rate	million ton/year	66	66
Post-tax NPV at 0%	$US millions	13,882	16,507
Post-tax NPV at 5%	$US millions	6,413	6,607
Post-tax NPV at 7%	$US millions	4,736	4,435
Post-tax NPV at 8%	$US millions	4,068	3,578
Post-tax NPV at 10%	$US millions	2,987	2,209
Post-tax IRR	%	23.7%	15.4%
Post-tax Payback	years	3.1	4.7
Strip Ratio	waste:ore	0.12	0.12
Total Processed	million ton	1,291	1,291
Copper Equivalent Grade	%	0.57	0.57
Copper Grade	%	0.29	0.29
Gold Grade	oz/ton	0.009	0.009
Molybdenum Grade	ppm	154	154

- Note: Copper equivalent (CuEq) calculations use the following metal prices: US$1.85 /lb for Cu, US$902 /oz for Au and US$12.50 /lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).

22.3 Methodology

An economic model was developed to estimate annual pre-tax and post-tax cash flows of the project. Net present value was calculated based on a 7% discount rate. By convention, a discount rate of 8% is typically applied to copper and other base metal projects, while 5% is applied to gold and other precious metal projects. Given the polymetallic nature of the Pebble deposit and the large contribution of gold to total project revenues, a 7% blended discount rate was selected and considered appropriate for the purposes of discounted cash flow analyses.

All amounts expressed are in US dollars in real terms unless otherwise stated. Net present value (NPV) is calculated by discounting cash flows to the start of construction using a mid-year convention. The commencement of project construction is the valuation date on which the NPV, internal rate of return (IRR) and other financial results are calculated.

Calendar years used in the economic analysis are provided for conceptual purposes only. Permits still must be obtained in support of operations and approval to proceed is still required from Northern Dynasty's Board of Directors.

22.4 Inputs to the Cash Flow Model

The Project would consist of a four-and-a-half-year pre-production construction period, followed by 20 years of production as outlined in the mine plan set out in Section 16. The NPV and IRR were calculated at the beginning of the construction period in Year -4.5.

The cost and revenue estimates were assembled using real dollars, treating Year -4.5 as the base year. No escalation was applied to any of the estimates beyond this date.

The projected long-term consensus metal price assumptions included in Section 19.2 are provided for reference in Table 22-3.

Table 22-3: Forecast Long-Term Metal Price Assumptions

Metal Type	Unit	Value ($)
Copper	lb	3.50
Gold	Oz	1,600
Molybdenum	Lb	10
Silver	Oz	22
Rhenium	kg	1,500

The impact on the financial results using prevailing prices, as outlined in Section 19.2, was calculated using the prices set out in Table 22-4.

Table 22-4: Prevailing Metal Price Assumptions

Metal Type	Unit	Value ($)
Copper	lb	4.25
Gold	Oz	1,800
Molybdenum	Lb	18
Silver	Oz	24
Rhenium	kg	1,600

The financial results of the 2021 PEA were prepared based on a nominal 180,000 tons per day milling capacity. Forecast LOM production results are summarized in Table 22-5.

Table 22-5: Forecast of Proposed Project Production Summary

Description	Units	Values
Mine Life	years	20
Mining Method		Open Pit
Production Rate	M ton/year	66
Strip Ratio	waste:ore	0.12
Total Processed	M ton	1,291
Copper Equivalent Grade	%	0.57
Copper Grade	%	0.29
Gold Grade	oz/ton	0.009
Molybdenum Grade	ppm	154
Copper Recovery	%	86.9
Gold Recovery	%	59.9
Molybdenum Recovery	%	75.3
Copper Recovered	M lb	6.409
Gold Recovered	k oz	7,367
Molybdenum Recovered	M lb	300
Avg Annual Copper Recovered	M lb	320
Avg Annual Gold Recovered	k oz	368
Avg Annual Molybdenum Recovered	M lb	15

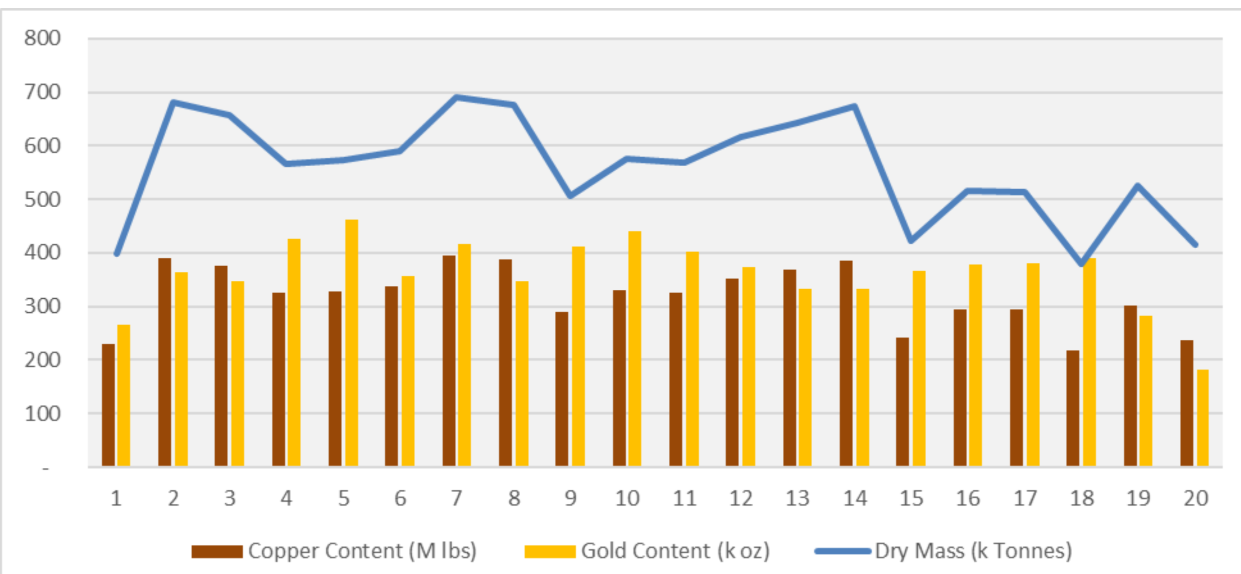
The predicted LOM material tonnages and payable metal production used in the cash flow model are included in Table 22-6

Table 22-6: Forecast of Proposed Project LOM Material Tonnages and Payable Metal Production

Description	Units	Values
Total Tons Mined	M ton	1,443
Mill Feed	M ton	1,291
Concentrate		
Cu Concentrate (DMT)	k tonnes	11,181
Mo Concentrate (DMT)	k tonnes	272
Payable Metal		
Payable Cu	M lb	6,153
Payable Au	k oz	7,127
Payable Mo	M lb	300
Payable Ag	k oz	32,901
Payable Re	tonnes	208

Copper-gold concentrate production, including contained copper and gold metal over the proposed 20-year production period, is illustrated in Figure 22-1 Figure 22-1.Copper-gold concentrate production, including contained copper and gold metal over the proposed 20-year production period, is illustrated in Figure 22-1

Figure 22-1: Forecast Copper-Gold Concentrate Production



Note: Prepared by NDM, 2021

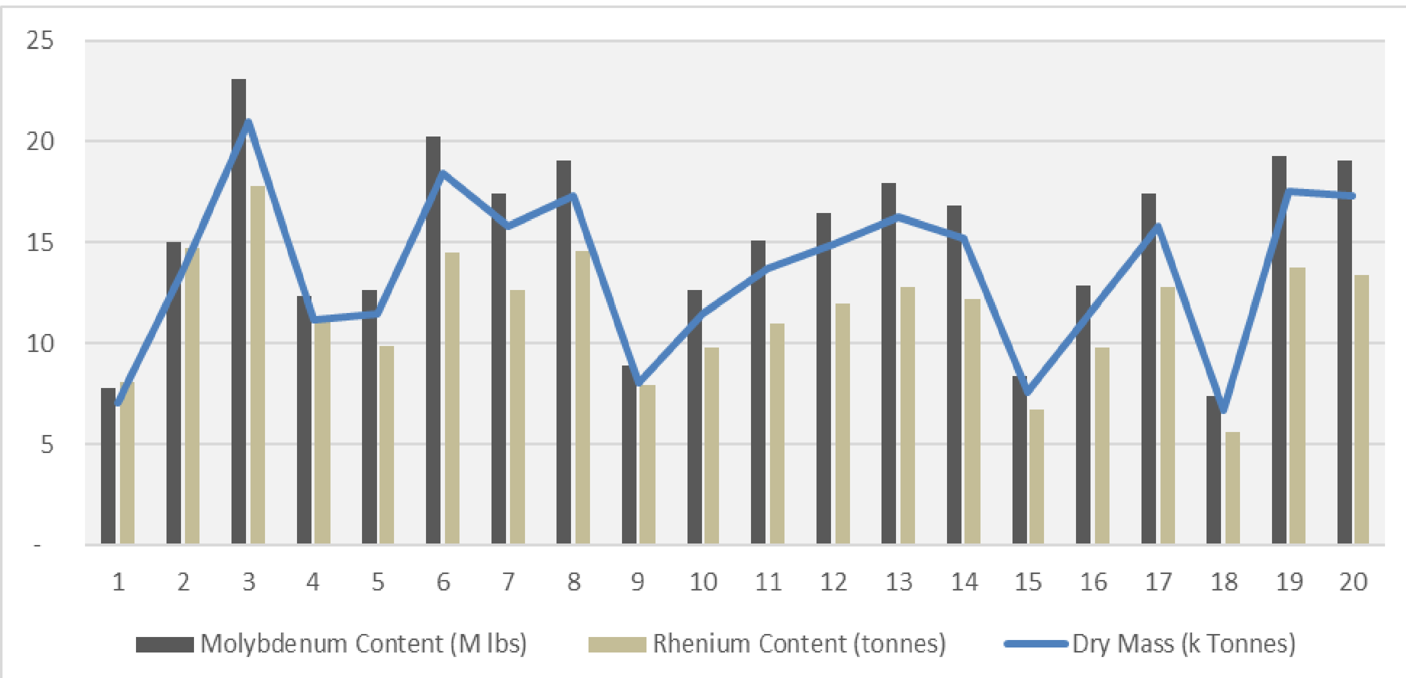
Projected copper, gold, and silver grades within the copper-gold concentrate are shown in Table 22-7.

Table 22-7: Forecast of Proposed Project Copper-Gold Concentrate Statistics

Description	Units	Values
Cu-Au Concentrate Produced	k dmt	11,181
Copper Grade	% Cu	26.0
Gold Grade	g/dmt	20.2
Silver Grade	g/dmt	101.8
Moisture Content	%	8.0

Anticipated molybdenum-rhenium concentrate production, including contained molybdenum and rhenium metal over the 20-year production period, is illustrated in Figure 22-2.

Figure 22-2: Forecast Molybdenum-Rhenium Concentrate Production



Note: Prepared by NDM, 2021.

Predicted molybdenum and rhenium grades within the concentrate are shown in Table 22-8.

Table 22-8: Forecast of Proposed Project Molybdenum-Rhenium Concentrate Statistics

Description	Units	Values
Molybdenum-Rhenium Concentrate Produced	k dmt	272
Molybdenum Grade	% Mo	50.0
Rhenium Grade	ppm	861
Moisture Content	%	5.0

The initial capital investment assumed in the Base Case 2021 PEA, net of gold stream proceeds and third party infrastructure investment, is $3.4 billion. The estimate includes direct costs for executing the Project; indirect costs associated with design, construction and commissioning; Owner's costs for permitting, environmental, and corporate support; all capital costs to completion of construction and commissioning between years -4.5 and -1; as well as contingencies. The estimate also reflects assumptions regarding infrastructure development partners for the port, road and power plant, pre-production proceeds from gold stream partners, reclamation trust funding and surety requirements during construction.

The initial capital investment assumed in the Full Capital Case 2021 PEA is $6.3 billion without the assumptions regarding infrastructure development partners for the port, road and power plant and without the assumptions regarding gold stream partners.

The methodology for the capital and operating cost estimates, including accuracy and contingency basis are included in Section 21.

The Base Case financial evaluation assumes that strategic industry partners would develop, finance, own and operate a number of infrastructure assets including the transportation corridor (marine facility and access road) and the power infrastructure (natural gas pipeline and mine site power plant) and lease these assets back to the project through toll charges or lease payments. This assumption is based on historical experience with mining project infrastructure in Alaska. These partners could include utility and construction companies, independent power producers, special purpose financing vehicles or strategic financial investors. The discounted cash flow analysis assumes that these long term infrastructure assets are repaid over the proposed 20-year operating period with ownership reverting back to the project at maturity with a return on capital to the third party built into the lease rate. Pebble's existing relationships and commitments to Alaska Native Village Corporations in the project area have been assumed in this financial analysis as well as assumptions to foster on-going business-partnering initiatives.

With gold production estimated at 7.4 million oz over 20 years, gold is projected to be significant component of gross revenues and Net Smelter Return (NSR) with approximately 25% of gross revenues attributable to gold. In addition, the Pebble deposit resource estimate contains more than 70 million oz gold in the Measured and Indicated categories and 36 million ounces in the Inferred category. As such, Northern Dynasty believes a gold stream partner is a material consideration in the economic evaluation of the Project. This assumption is based on historical precious metal stream transactions and market data. Based on current market conditions and the assumptions noted in this Report, Northern Dynasty estimates proceeds during construction of approximately $1.1 billion from potential gold streaming partners assumed in the Base Case.

The 2021 PEA financial analysis assumes that sufficient financial surety is provided to cover closure costs if the proposed mine should close prematurely as required by the ADNR and the ADEC. Closure costs and obligations are reviewed by the State of Alaska every five years and updated accordingly.

The financial model includes annual contributions to a reclamation trust and assumes that any shortfall between the accumulated value of the reclamation trust and the reclamation liability would be covered with financial assurances in the form of a letter of credit. The reclamation trust assumptions include a 4% real rate of return.

There is no salvage value included in the financial analysis.

The Proposed Project reclamation trust value at cessation of operations is estimated to be $1.4 billion. The total estimated closure costs for the Proposed Project are $2.37 billion, all of which are scheduled for completion after the cessation of operations. In addition, the estimated post-closure water treatment costs are $16 million per year, requiring a residual reclamation trust balance of $400 million. The on-going return in the reclamation trust accounts for the difference in value at cessation of operations and that required for closure and post closure.

Table 22-9 contains a summary of costs, closure funding, and taxes for the Base Case and Full Capital Case for the Proposed Project. The estimated initial capital cost breakdown is shown in Table 22-10.

Table 22-9: Proposed Project Cost and Tax Summary

		Base Case	Full Capital
Costs			
Total Initial Capital Cost	$billion	6.05	6.05
Infrastructure Lease	$billion	1.68	-
Net Initial Capital Cost	$billion	4.37	6.05
Sustaining Capital Cost	$billion	1.52	1.54
Life of Mine Operating Cost[22]	$/ton	10.98	8.31
Copper C1 Cost[23]	$/lb CuEq	1.65	1.32
AISC (Co-Product Basis)	$/lb CuEq	1.88	1.56
Gold C1 Cost	$/oz AuEq	753	605
Closure Funding			
Annual Contribution	$million/yr	34	34
Life of Mine Contribution	$billion	0.83	0.83
Life of Mine Bond Premium	$billion	0.16	0.16
Closure Fund[24]	$billion	1.4	1.4
Life of Mine Taxes[25]			
Alaska Mining License	$billion	0.69	0.76
Alaska Royalty	$billion	0.30	0.33
Alaska Income Tax	$billion	0.75	0.87
Borough Severance & Tax	$billion	0.49	0.53
Federal Income Tax	$billion	1.38	1.61
Annual Taxes[26]			
Alaska Mining License	$million	34	38
Alaska Royalty	$million	15	17
Alaska Income Tax	$million	38	44
Borough Severance & Tax	$million	25	26
Federal Income Tax	$million	69	81

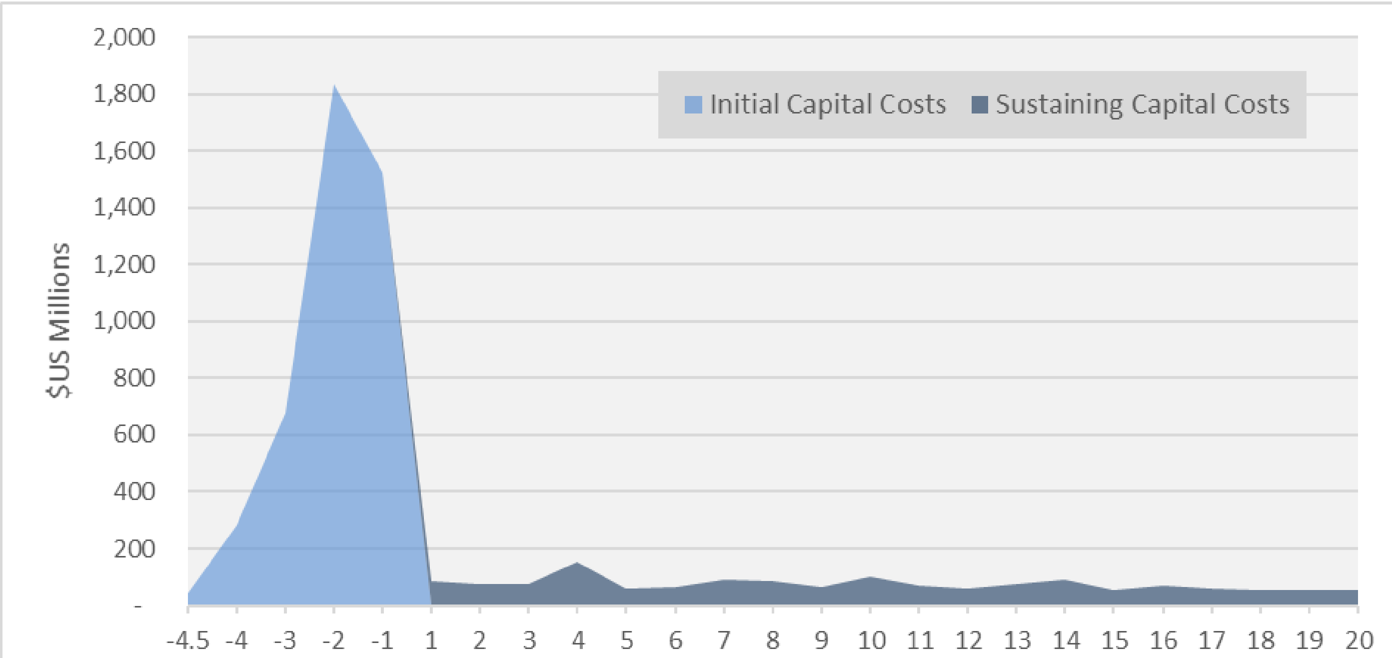
[22] Includes cost of infrastructure lease - $2.80/ton milled
[23] C1 costs calculated on co product basis
[24] Maximum value of closure fund during life of mine based on 4% compound interest
[25] Estimated based on current Alaskan statutes
[26] Life of mine taxes ÷ life of mine years

Table 22-10: Pebble Project – Initial Capital

Description	Cost ($M)
Mining	321
Process	736
Other Infrastructure	345
Tailings	1,278
Pipelines	189
Access Road	296
Port Infrastructure	246
Power Generation	779
Indirect Costs	1,182
Contingency	678
Total Capital Cost Estimate	**6,049**
Add: Reclamation funding during construction	211
Initial Capital Investment – Full Capital Case	**6,259**
Less: Outsourced Infrastructure	(1,680)
Less: Pre-production proceeds from gold stream partner	(1,142)
Initial Capital Investment - Base Case	**3,439**

The phasing of initial capital expenditures and sustaining capital expenditures are illustrated in Figure 22-3. Figure 22-3 Sustaining capital expenditures over the 20 year operating period are estimated to total $1,522 million including $219 million for open pit mining equipment and $1,293 million for TSF and WTP costs.

Figure 22-3: Pebble Project – Initial and Sustaining Capital Phasing



Note: Prepared by NDM, 2021.

An allowance for working capital was made in the financial model on the basis of 45 days debtor and creditor terms with an annual inventory investment equal to 5% of costs. Total working capital at the end of year 20 is estimated to be $80 million.

The on-site operating cost assumptions included in Section 21.3 are provided for reference in Table 22-11.

Table 22-11: Forecast Proposed Project Base Case Operating Costs – per Ton and Total LOM

Description	$/ton	LOM ($M)
Total Operating Costs	10.98	14,166
Open Pit	1.75	2,254
Process	4.17	5,380
Transportation	0.89	1,150
Environmental	0.49	630
G&A	0.88	1,136
Infrastructure	2.80	3,616

The on-site operating cost assumptions for the Full Capital Case, which exclude the assumptions regarding infrastructure development partners, are $10,724 million LOM and $8.31/ton milled.

Key smelter terms and off-site operating cost assumptions included in Section 19.3 and Section 21.3, respectively, are provided for reference in Table 22-12.

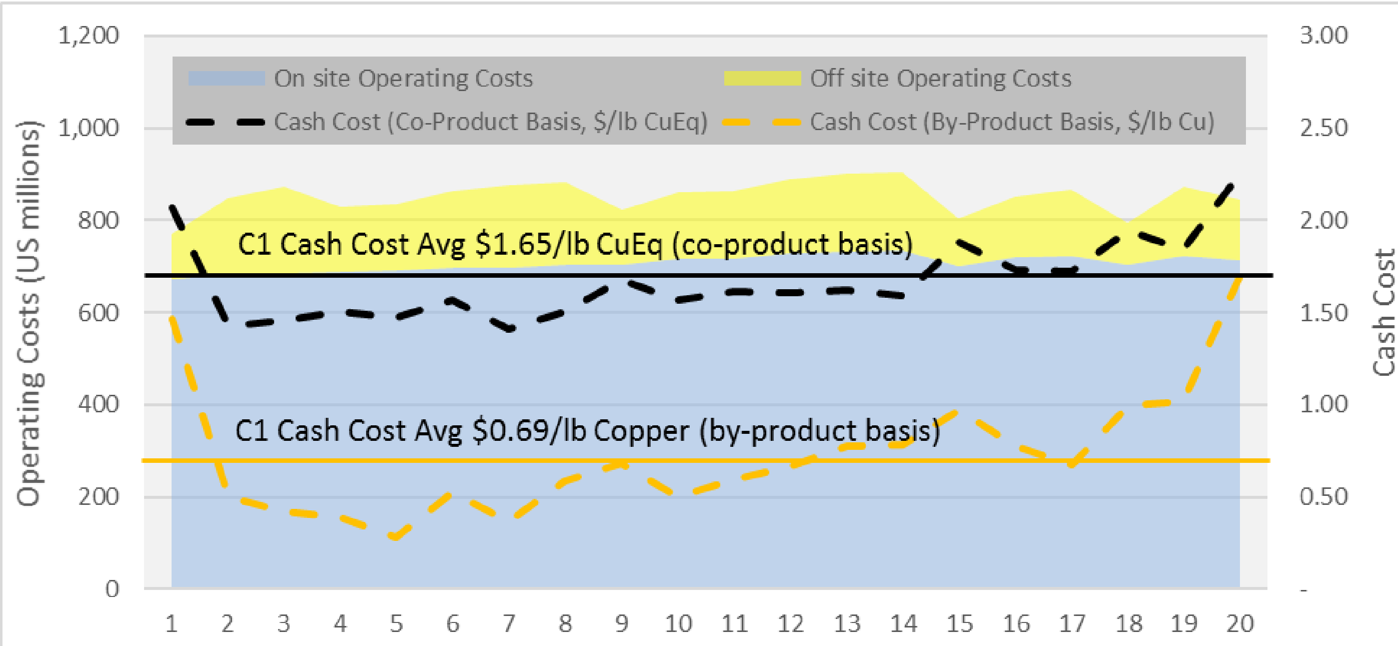
Table 22-12: Key Smelter Terms and Off-Site Costs

Description	Units	Terms
Copper Treatment Charges	$/DMT	70.00
Copper Refining Charges	$/lb	0.07
Copper Deduction	Concentrate %	1.0
Gold Refining Charges	$/oz	7.00
Gold Deduction	% of Production	3.0
Silver Refining Charges	$/oz	0.60
Silver Deduction	% of Production	10.0
Copper Concentrate Ocean Freight	$ / WMT	50.0
Molybdenum Concentrate Ocean Freight	$ / WMT	171.1

An insurance rate of 0.15% was applied to the provisional invoice value of all metal products to cover land-based and ocean transport from the mine site to the smelter. In addition, off-site representation and marketing costs have been assumed for the copper concentrate at $2.50/WMT.

Projected total on-site and off-site operating costs as well as C1 copper cash costs (on both a co-product and by-product basis) are illustrated in Figure 22-4 over the proposed 20-year operating period. C1 Cash Cost (US$/lb) is a non-IFRS measure and is calculated as the sum of production costs, offsite costs (treatment, refining and transportation) costs, and royalties divided by the copper pounds produced. C1 cash cost per copper pound is a non-IFRS measure that is widely reported in the mining industry but does not have a standardized meaning and is disclosed in addition to IFRS measures.

Figure 22-4: Forecast C1 Cash Costs, Base Case



Note: Prepared by NDM, 2021.

22.5 Pre-Tax Financial Evaluation

22.5.1 Pre-Tax Evaluation Basis

The pre-tax financial model incorporated the production schedule and smelter term assumptions to produce annual recovered payable metal and gross revenue, in each concentrate stream, by year. Off-site costs, including the applicable refining and treatment costs, penalties, concentrate transportation charges, and marketing and representation fees, and royalties were then deducted from gross revenue to determine the NSR. Further details of the smelter terms used to calculate the recovered metal value and off-site operating costs can be found in Section 19.3.

That portion of the Pebble property within the Exploration Lands is subject to a NPI royalty payable to Teck. The terms include a 4% pre-payback net profits interest (after all costs including debt services and taxes) which increases to a 5% net profits interest after payback. However, the portion of the deposit to be mined by the proposed Project lies outside the portion subject to the NPI and is therefore not subject to the Teck royalty. The Project is subject to a State of Alaska royalty as described with other State taxes in Section 22.6.

The operating cash flow was calculated by deducting annual mining, processing, transportation, environmental, infrastructure lease (Base Case only) and G&A costs from the NSR.

Initial, sustaining, and working capital as well as reclamation funding were deducted from and assumed proceeds from potential precious metal streaming partners (Base Case only) were added to the operating cash flow in the years they are projected to occur, to determine the net cash flow before taxes.

Initial capital cost included all estimated expenditures in the construction period, from Year -4.5 to Year -1 inclusive. First production would occur at the beginning of Year 1. Sustaining capital expenditure includes all capital expenditures purchased after first production.

The financial analysis was carried out on a 100% ownership basis. The power, port and road infrastructure assets are assumed to be owned by third-party partners in the Base Case.

22.5.2 Pre-Tax Financial Results

A summary of the pre-tax financial results for the Base Case is provided in Table 22-13.

Table 22-13: Forecast of Proposed Project Base Case Pre-Tax Financial Results

Description	Units	LOM Values L/T Prices	LOM Values Prevailing Prices
Recovered Metal Value			
Copper	US$ million	$21,536	$26,151
Gold	US$ million	$9,084	$10,088
Molybdenum	US$ million	$2,995	$5,392
Silver	US$ million	$724	$790
Rhenium	US$ million	$312	$333
Total Recovered Metal Value	US$ million	$34,652	$42,754
Off-Site Operating Costs			
Refining and treatment Charges, Penalties, Insurance, Marketing and Representation & Concentrate Transportation	US$ million	$2,919	$2,931
On-Site Operating Costs			
Open Pit	US$/ton milled	$1.75	$1.75
Process	US$/ton milled	$4.17	$4.17
Transportation	US$/ton milled	$0.89	$1.10
Environmental	US$/ton milled	$0.49	$0.49
G&A	US$/ton milled	$0.88	$0.88
Infrastructure Lease	US$/ton milled	$2.80	$2.80
Total Operating Cost	US$/ton milled	$10.98	$11.18
Capital Expenditure			
Initial Capital	US$ million	$6,049	$6,049
Add: Pre-production Reclamation Funding	US$ million	$212	$212

Description	Units	LOM Values L/T Prices	LOM Values Prevailing Prices
Less: Outsourced Infrastructure	US$ million	$(1,680)	$(1,680)
Less: Pre-production proceeds from gold stream partner	US$ million	$(1,142)	$(1,349)
Initial Capital Investment during Construction	US$ million	$3,439	$3,231
Sustaining Capital	US$ million	$1,522	$1,522
Financial Summary			
Pre - Tax Undiscounted Cash Flow	US$ million	$11,828	$19,856
Pre - Tax NPV at 7%	US$ million	$3,506	$6,862
Pre-Tax IRR	%	18.2	27.1
Pre-Tax Payback Period	Years	4.5	2.9
Cash Cost (Co-Product Basis)	US$/lb CuEq	$1.65	$1.67
All-in Sustaining Cost (Co-Product Basis)	US$/lb CuEq	$1.88	$1.90

A summary of the pre-tax financial results for the Full Capital Case, which exclude the assumptions regarding infrastructure development partners and precious metal streaming partners, is provided in Table 22-14.

Table 22-14: Forecast of Proposed Project Full Capital Case Pre-Tax Financial Results

Description	Units	LOM Values L/T Prices	LOM Values Prevailing Prices
Recovered Metal Value			
Copper	US$ million	$21,536	$26,151
Gold	US$ million	$11,404	$12,829
Molybdenum	US$ million	$2,995	$5,392
Silver	US$ million	$724	$790
Rhenium	US$ million	$312	$333
Total Recovered Metal Value	US$ million	$36,971	$45,495
Off-Site Operating Costs			
Refining and treatment Charges, Penalties, Insurance, Marketing and Representation & Concentrate Transportation	US$ million	$2,922	$2,935
On-Site Operating Costs			
Open Pit	US$/ton milled	$1.75	$1.75
Process	US$/ton milled	$4.17	$4.17

Description	Units	LOM Values L/T Prices	LOM Values Prevailing Prices
Transportation	US$/ton milled	$1.03	$1.25
Environmental	US$/ton milled	$0.49	$0.49
G&A	US$/ton milled	$0.88	$0.88
Infrastructure Lease	US$/ton milled	-	-
Total Operating Cost	US$/ton milled	$8.31	$8.53
Capital Expenditure			
Initial Capital	US$ million	$6,049	$6,049
Add: Pre-production Reclamation Funding	US$ million	$212	$212
Less: Outsourced Infrastructure	US$ million	-	-
Less: Pre-production proceeds from gold stream partner	US$ million	-	-
Initial Capital Investment during Construction	US$ million	$6,260	$6,260
Sustaining Capital	US$ million	$1,541	$1,541
Financial Summary			
Pre - Tax Undiscounted Cash Flow	US$ million	$14,746	$22,967
Pre - Tax NPV at 7%	US$ million	$3,445	$6,794
Pre-Tax IRR	%	13.4	18.2
Pre-Tax Payback Period	Years	5.8	4.3
Cash Cost (Co-Product Basis)	US$/lb CuEq	$1.32	$1.35
All-in Sustaining Cost (Co-Product Basis)	US$/lb CuEq	$1.56	$1.59

22.6 Post-Tax Financial Analysis

22.6.1 Overview

The Pebble Project is 100% owned by the Pebble Partnership. As a partnership is not a taxable entity for U.S. tax purposes, tax liabilities accrue to each partner based on its proportionate share of the income from the project in a fiscal period.

The economic analysis assumed that the Project would be subject to tax as if it was held 100% by a U.S. corporate resident entity. This approach has been taken to facilitate comparison to other mining projects that are owned on a 100% basis.

Taxable income from sales of concentrate produced from the Project will be subject to taxation by multiple levels of government. Given that the Pebble Project is one of the world's most significant copper-gold deposits, tax revenues derived from mining would contribute significantly to US Federal, State and local governments. The following tax regimes were incorporated in the post-tax analysis: US Federal Income Tax, Alaska State Income Tax, Alaska Severance Tax, Alaska State

Royalty Tax and Alaska Mining License Tax. Taxes were calculated based on currently-enacted United States and State of Alaska tax laws and regulations under the Internal Revenue Code (IRC).

Using long-term metal prices, the total taxes payable for the Base Case over the 20-year operating period are estimated to be $3.6 billion, including $1.4 billion in federal income tax, $1.7 billion in State income taxes, royalty and mining license taxes and $500 million in municipal severance and property taxes.

At current prevailing metal prices, total taxes payable for the Base Case over the 20 year operating period are estimated to be $6.0 billion, including $2.5 billion in Federal income tax, $2.9 billion in State income taxes, royalty and mining license taxes and $600 million in municipal severance and property taxes.

22.6.2 US Federal and Alaska State Corporate Income Tax

The statutory federal income tax rate is 21%. The Alaska State income tax rate is 9.4%. As State taxes are deductible for Federal purposes, the combined statutory income tax rate for the Pebble Project is expected to be 28.4% of taxable income for the Base Case.

Taxable losses generated in a given year may be carried forward indefinitely and applied to taxable income when it arises. The IRC also provides certain deductions to incentivize investment by mining companies, including depletion and resource development expenditure pools.

The benefits of depletion and other deductions under the IRC for the Project reduces the average mine life effective income tax rate from the combined statutory tax rate of 28.4% to the effective income tax rate of 20.5% for the Base Case.

Combined with State production taxes and the borough severance tax, the total effective income tax rate on the Pebble Project is 30.5% for the Base Case.

22.6.3 Lake and Peninsula Borough Severance Tax

Municipal and borough governments in the State of Alaska assess property, sales and use and/or severance taxes. The Lake and Peninsula Borough, in which the project is located, has enacted a municipal severance tax of 1.5% of the gross production value and this tax has been applied in the financial model. There is no provision in the legislation to carry losses forward to offset future profits in the State severance tax calculation.

22.6.4 Alaska State Royalty Tax

The Alaska State royalty is calculated at 3% of net income from mining operations on Alaska State lands.

22.6.5 Alaska Mining License Tax

The Alaska mining licence tax is assessed on net income from mining operations. Legislation allows for a 3.5 year hiatus from the mining licence tax after the commencement of initial production. The maximum mining licence rate is 7% on net income over $100,000.

22.6.6 Post-Tax Financial Results

The forecast total corporate income tax payable on the Pebble Project profits is $2,125 million for the Base Case over the 20-year mine life at long term metal prices.

The post-tax financial results are summarized in Table 22-15 for the Base Case.

Table 22-15: Forecast of Proposed Project Base Case Post-Tax Financial Results

Description	Units	LOM Values L/T Prices	LOM Values Prevailing Prices
Financial Summary			
Mining Taxes & Government Royalties	US$ million	$1,479	$2,173
Corporate Income Tax	US$ million	$2,125	$3,800
Post-Tax Undiscounted Cash Flow	US$ million	$8,224	$13,882
Post-tax NPV at 7%	US$ million	$2,281	$4,736
Post-Tax IRR	%	15.7	23.7
Post-Tax Payback Period	years	4.8	3.1

The forecast total corporate income tax payable on the Pebble Project profits are $2,486 million for the Full Capital Case over the 20-year mine life at long term metal prices.

The post-tax financial results are summarized in Table 22-16 for the Full Capital Case.

Table 22-16: Full Capital Case Post-Tax Financial Results

Description	Units	LOM Values L/T Prices	LOM Values Prevailing Prices
Financial Summary			
Mining Taxes & Government Royalties	US$ million	$1,614	$2,325
Corporate Income Tax	US$ million	$2,486	$4,135
Post-Tax Undiscounted Cash Flow	US$ million	$10,647	$16,507
Post-tax NPV at 7%	US$ million	$2,005	$4,435
Post-Tax IRR	%	11.2	15.4
Post-Tax Payback Period	years	6.1	4.7

22.7 Cash Flow

The annual production schedule and estimated cash flow forecast for the Pebble Project as envisaged in the 2021 PEA Base Case can be found in Table 22-17.

Table 22-17: Base Case Annual Production Schedule and Estimated Cash Flow

	20 YEARS PRODUCTION				-Year 4.5	-Year 4	-Year 3	-Year 2	-Year 1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
		$/t milled	TOTAL	NPV 7%																										
Mining Volume			1,443		-	-	-	-	33.1	62.7	70.5	70.5	70.5	70.5	70.5	70.5	70.5	72.8	71.7	70.7	72.3	72.7	72.8	72.7	72.8	72.7	72.8	65.7	64.1	-
Milling Volume			1,291		-	-	-	-	-	43.8	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.7	65.6	65.7	65.6	65.7	64.1	-
Strip Ratio			*0.12*			*na*	*na*	*na*	*na*	*0.4*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*	*na*
REVENUE	100%	26.85	**34,652**	**14,241**	-	-	-	-	-	**1,215**	**1,972**	**1,989**	**1,802**	**1,863**	**1,841**	**2,083**	**1,985**	**1,626**	**1,836**	**1,797**	**1,872**	**1,889**	**1,938**	**1,406**	**1,644**	**1,689**	**1,334**	**1,610**	**1,262**	-
Copper ($US 3.5 per lb)	62%	16.69	21,536	8,895	-	-	-	-	-	769	1,311	1,266	1,090	1,105	1,137	1,331	1,301	974	1,109	1,094	1,185	1,236	1,297	813	992	988	731	1,010	799	-
Gold ($US 1600 per oz)	26%	7.04	9,084	3,721	-	-	-	-	-	333	456	435	535	578	445	520	435	516	550	503	468	417	416	461	472	475	489	353	228	-
Molybdenum ($US 10 per lb)	9%	2.32	2,995	1,205	-	-	-	-	-	78	150	231	123	126	203	174	191	89	126	151	164	179	168	84	128	174	74	193	190	-
Silver ($US 22 per oz)	2%	0.56	724	291	-	-	-	-	-	25	35	35	38	40	37	41	39	37	37	34	39	39	42	40	37	35	33	35	27	-
Rhenium ($US 1500 per kg)	1%	0.24	312	129	-	-	-	-	-	11	20	24	15	13	20	17	20	11	13	15	16	17	16	9	13	17	8	19	18	-
Realization charges	8.4%	2.26	2,919	1,195	-	-	-	-	-	95	166	188	139	142	168	176	178	118	142	148	160	169	171	102	132	146	92	153	133	-
NET SMELTER RETURN		24.59	**31,733**	**13,046**	-	-	-	-	-	**1,120**	**1,805**	**1,801**	**1,662**	**1,721**	**1,673**	**1,906**	**1,807**	**1,508**	**1,694**	**1,649**	**1,711**	**1,720**	**1,767**	**1,304**	**1,512**	**1,543**	**1,242**	**1,457**	**1,130**	-
OPERATING COSTS			**14,166**	**5,698**	**7**	**7**	**7**	**7**	**7**	**674**	**683**	**686**	**689**	**693**	**697**	**699**	**705**	**700**	**717**	**717**	**727**	**732**	**735**	**701**	**718**	**722**	**704**	**721**	**711**	-
Open Pit		1.75	2,254	891	-	-	-	-	-	94.6	103.1	106.5	104.8	106.5	110.9	112.8	118.1	106.6	108.9	111.5	117.9	123.5	124.8	111.7	114.2	119.3	115.6	118.6	124.1	-
Process		4.17	5,380	2,174	-	-	-	-	-	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	-
Transportation		0.89	1,150	459	7	7	7	7	7	42	43	43	48	48	48	48	48	55	70	67	71	70	71	51	66	65	50	64	49	-
Environmental		0.49	630	253	-	-	-	-	-	30	30	30	30	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	-
G&A		0.880	1,136	459	-	-	-	-	-	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	-
Infrastructure Lease		2.80	3,616	1,461	-	-	-	-	-	181	181	181	181	181	181	181	181	181	181	181	181	181	181	181	181	181	181	181	181	-
		10.98																												
OPERATING PROFIT (EBITDA)		13.61	**17,568**	**7,348**	**-7**	**-7**	**-7**	**-7**	**-7**	**446**	**1,122**	**1,115**	**973**	**1,028**	**976**	**1,207**	**1,102**	**808**	**977**	**932**	**984**	**989**	**1,033**	**603**	**793**	**820**	**538**	**735**	**418**	-
CAPITAL COSTS		3.39	***-4,370***	**-3,564**	**-43**	**-282**	**-680**	**-1,838**	**-1,526**	**-1**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sustaining Mining Capital		0.17	**-219**	**-110**	-	-	-	-	-	-72	-13	-8	-	-	-8	-8	-27	-3	-	-16	-1	-19	-22	-	-20	-3	-	-	-	-
Sustaining TSF and Other Capital		1.01	**-1,303**	**-552**	-	-	-	-	-	-9	-66	-70	-179	-64	-58	-89	-58	-67	-118	-53	-58	-61	-73	-56	-53	-60	-55	-54	-1	-
Reclamation Funding		0.77	**-989**	**-485**	-23	-40	-39	-39	-38	-41	-41	-41	-40	-40	-43	-42	-42	-41	-40	-43	-43	-42	-41	-41	-40	-39	-38	-37	-37	-
Pre-production Proceeds of Metal Stream		-0.88	***1,142***	**941**	13	86	206	556	281	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Working Capital			**-**	**-73**	-	-	-	-	-	-79	-84	1	30	-21	6	-25	11	35	-16	-0	-8	2	-4	50	-22	-5	35	-25	33	87
PRE-TAX PROJECT CASH FLOW		9.16	**11,828**	**3,506**	**-59.2**	**-243**	**-520**	**-1,327**	**-1,290**	**244**	**919**	**998**	**784**	**903**	**874**	**1,043**	**987**	**732**	**803**	**819**	**874**	**869**	**893**	**556**	**658**	**714**	**479**	**618**	**414**	**87**
Cumulative Pre-tax Project Cash Flow					-59	-302	-822	-2,148	-3,438	-3,194	-2,276	-1,278	-494	409	1,283	2,326	3,313	4,044	4,848	5,667	6,540	7,409	8,302	8,858	9,516	10,230	10,709	11,327	11,741	11,828
PV Factor					*0.98*	*0.93*	*0.87*	*0.82*	*0.76*	*0.71*	*0.67*	*0.62*	*0.58*	*0.54*	*0.51*	*0.48*	*0.44*	*0.41*	*0.39*	*0.36*	*0.34*	*0.32*	*0.30*	*0.28*	*0.26*	*0.24*	*0.23*	*0.21*	*0.20*	*0.18*
PRE-TAX PROJECT NPV 7			**3,506**																											
IRR			**18.2%**																											
Pre-tax Project Payback (yrs)			**4.5**																											
NPI Royalty			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alaska Mining License			-686		-	-	-	-	-	-	-	-7	-12	-25	-20	-35	-44	-46	-57	-53	-56	-56	-59	-35	-47	-49	-34	-44	-6	-
Alaska State Royalty Taxes			-303		-	-	-	-	-	-	-	-3	-5	-11	-9	-16	-20	-20	-25	-24	-25	-25	-26	-16	-21	-22	-15	-19	-3	-
Borough Severance & Property Taxes			-490		-	-	-	-	-1	-18	-28	-28	-26	-27	-26	-29	-28	-23	-26	-25	-26	-27	-27	-20	-23	-24	-19	-23	-17	-
Total Mining Taxes and Royalties		1.15	-1,479	-545	-	-	-	-	-1	-18	-28	-38	-44	-62	-55	-80	-92	-90	-108	-102	-107	-107	-112	-71	-91	-94	-68	-86	-26	-
Total Corporate Income Tax Payable		1.65	-2,125	-679	-	-	-	-	-	-	-	-4	-9	-17	-15	-25	-86	-168	-207	-194	-205	-203	-213	-128	-170	-178	-123	-159	-21	-
POST-TAX PROJECT CASH FLOW		6.37	**8,224**	**2,281**	**-59**	**-243**	**-520**	**-1,327**	**-1,291**	**227**	**891**	**955**	**731**	**824**	**804**	**938**	**809**	**475**	**488**	**522**	**562**	**558**	**568**	**357**	**397**	**442**	**287**	**374**	**367**	**87**
Cumulative Post-tax Project Cash Flow					-59	-302	-822	-2,148	-3,439	-3,213	-2,322	-1,366	-635	189	993	1,931	2,740	3,215	3,703	4,226	4,788	5,346	5,914	6,271	6,668	7,109	7,396	7,770	8,137	8,224
POST-TAX PROJECT NPV 7			**2,281**																											
IRR			**15.7%**																											
Post-tax Project Payback (yrs)			**4.8**																											

22.8 Sensitivity Analysis

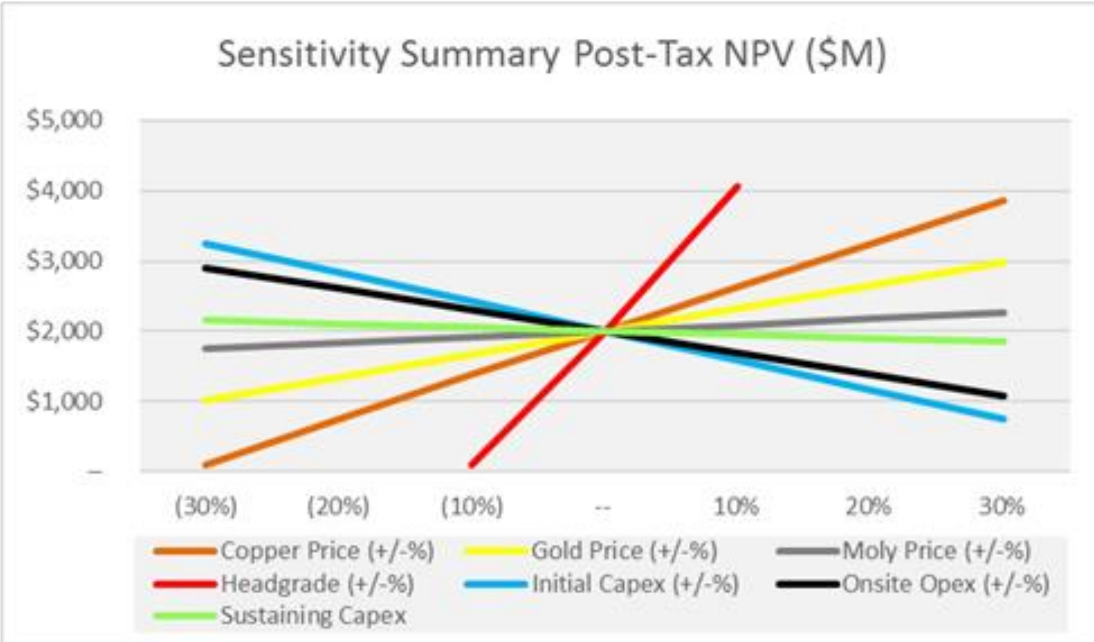
The financial analysis included testing the sensitivity of the Project's pre-tax NPV, and IRR to several Project variables. The following variables were elected for this analysis:

- copper price;
- gold price;
- molybdenum price;
- initial capital cost estimate;
- onsite operating cost estimate;
- sustaining capital cost estimate (incl. expansion); and
- head grade

Each variable, except head grade, was changed in increments of 10% between -30% to +30% while holding all other variables constant. The head grade evaluation tested a range ±10%, while holding the other all other variables constant, as variation beyond that range is extremely unlikely given the extent of the drilling defining the Mineral Resource and the methodology used to estimate the Mineral Resource. Figure 22-5 and Figure 22-6 show the results of the pre-tax sensitivity analysis.

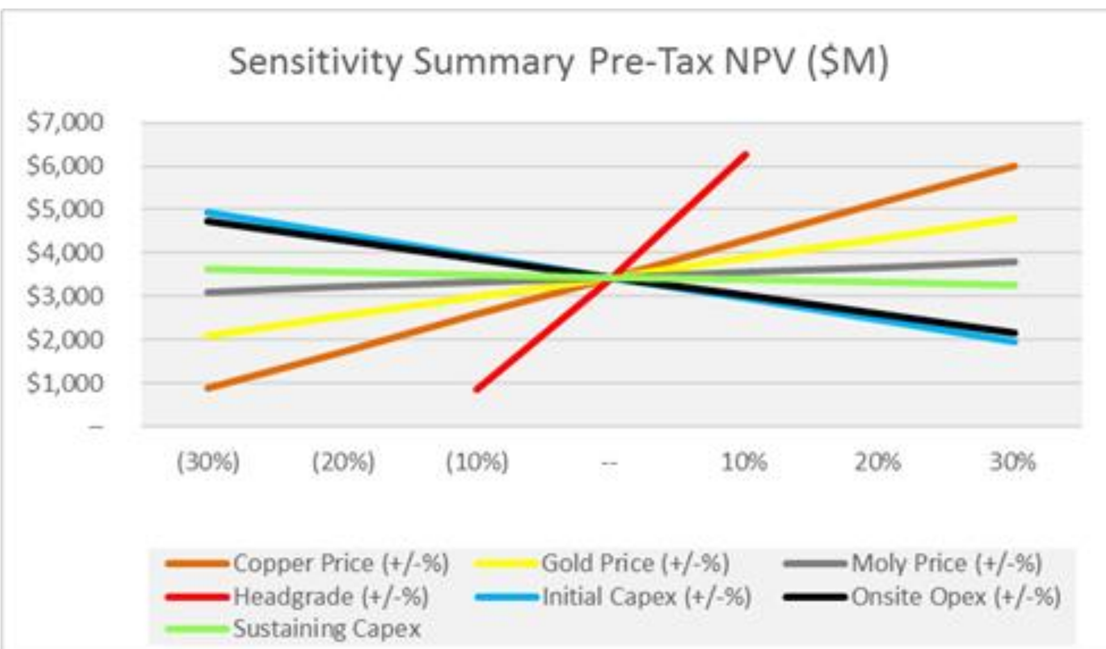
As shown in Figure 22-5 and Figure 22-6, the Project's NPV at a 7% discount rate is, from most to least, sensitive to changes in head grade, copper price, initial capital costs, on-site operating costs, gold price, molybdenum price and sustaining capital costs.

Figure 22-5: **Post-Tax Sensitivity Analysis**



Note: Prepared by NDM, 2021.

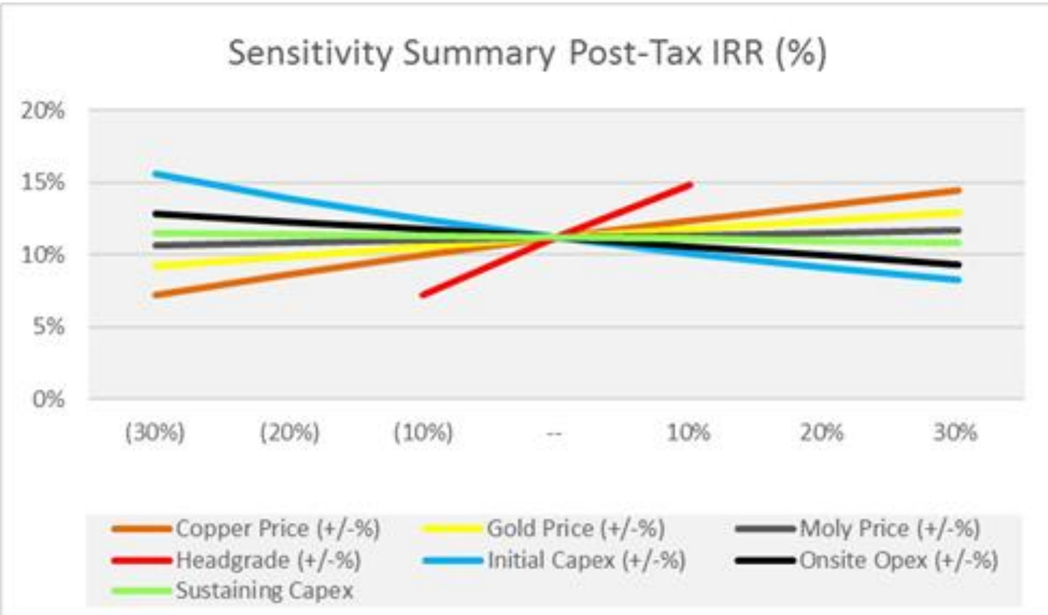
Figure 22-6: **Pre-Tax Sensitivity Analysis**



Note: Prepared by NDM, 2021.

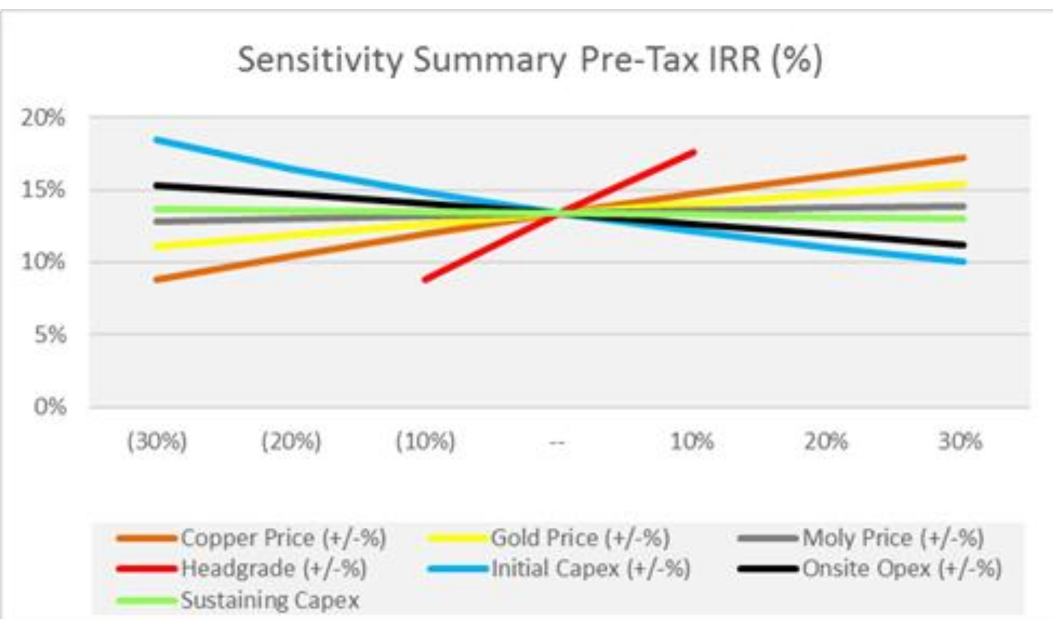
As shown in Figure 22-7 and Figure 22-8, the Project's IRR is most sensitive to changes in, from most to least sensitive, initial capital costs, copper price, on-site operating costs, gold price, molybdenum prices and sustaining capital costs.

Figure 22-7: Post-Tax IRR



Note: Prepared by NDM, 2021.

Figure 22-8: Pre-Tax IRR



Note: Prepared by NDM, 2021.

22.9 Copper and Gold Price Scenarios

Metal price scenarios were completed to determine the effects of copper and gold price on the Base Case Project IRR and NPV at a 7% discount rate. The copper price was varied from $2.50/lb to $4.50/lb and the gold price was varied from $1,200/oz to $2,000/oz, while holding all other variables constant. The results of this scenario can be found in Table 22-18. The long term metal prices are bolded in the table.

Table 22-18: Metal Price Scenarios

IRR, post tax %		Copper Price ($/lb)								
		2.50	**2.75**	**3.00**	**3.25**	**3.50**	**3.75**	**4.00**	**4.25**	**4.50**
Gold Price ($/oz)	1,200	5.0%	7.0%	8.9%	10.5%	12.1%	13.6%	15.0%	16.3%	17.6%
	1,400	6.9%	8.8%	10.6%	12.3%	13.8%	15.3%	16.7%	18.0%	19.3%
	1,600	8.8%	10.7%	12.5%	14.1%	**15.7%**	17.1%	18.5%	19.8%	21.1%
	1,800	10.8%	12.7%	14.4%	16.1%	17.6%	19.1%	20.5%	21.8%	23.1%
	2,000	12.9%	14.8%	16.5%	18.2%	19.7%	21.2%	22.6%	23.9%	25.2%

NPV7, post-tax US$ Billions		Copper Price ($/lb)								
		2.50	**2.75**	**3.00**	**3.25**	**3.50**	**3.75**	**4.00**	**4.25**	**4.50**
Gold Price ($/oz)	1,200	(0.5)	0.0	0.5	1.0	1.4	1.9	2.3	2.8	3.2
	1,400	(0.0)	0.5	0.9	1.4	1.9	2.3	2.8	3.2	3.6
	1,600	0.4	0.9	1.4	1.8	**2.3**	2.7	3.2	3.6	4.1
	1,800	0.9	1.3	1.8	2.3	2.7	3.1	3.6	4.0	4.5
	2,000	1.3	1.8	2.2	2.7	3.1	3.6	4.0	4.4	4.9

23 ADJACENT PROPERTIES

There are no properties adjacent to the Project relevant to this Report.

24 OTHER RELEVANT DATA AND INFORMATION

24.1 Project Execution Plan

24.1.1 Introduction

This preliminary Project Execution Plan (PEP) provides a general outline for the engineering, procurement, construction, and commissioning activities required to bring the Pebble Project successfully into operation. This PEP reflects the current state of the Proposed Project and would be further refined in future studies.

The Project would be designed and constructed to industry and regulatory standards, with emphasis on addressing all environmental and safety issues. Adherence to the PEP would help ensure safe, timely and cost effective completion while maintaining construction quality.

Key project deliverables encompassed by the PEP include the development of:

- an open pit mining operation;
- a copper-molybdenum mineral process plant with a possible option for gold recovery;
- two TSFs;
- water management systems including WTP facilities;
- site infrastructure, including on-site roads, workforce accommodations, offices and maintenance facilities;
- a marine terminal facility at Diamond Point on the north shore of Cook Inlet, which includes equipment for concentrate handling and barge loading for transhipment, as well as support facilities to manage inbound containerized consumables.
- a slurry pipeline system for moving concentrate from the mine to the terminal facility, which includes pumping stations and a return water line to the mine site.
- a pipeline for transferring natural gas between the east side of Cook Inlet, the marine terminal site, and the mine site;
- combined cycle natural gas-fired turbine power plant at the mine site, with a smaller gas-fired power plant at the marine terminal site;
- an all-weather access road that links the marine terminal to the mine site;
- construction camps required for the various phases and sites; and,
- temporary construction roads connecting the mine site and marine terminal to support initial construction and movement of equipment modules.

The construction time required from receipt of permits to commencement of production is expected to be 48 months. An indicative project development schedule is provided in Figure 24-1.

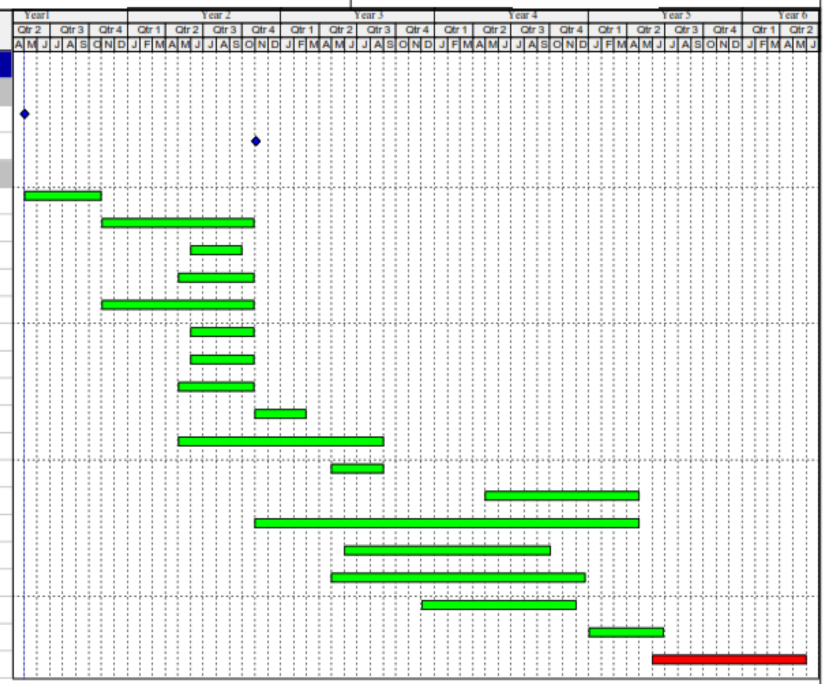
Figure 24-1: Indicative Project Development Schedule

Northern Dynasty Minerals Ltd.

Pebble 2021 PEA - Construction Schedule

Ausenco

Activity ID	Activity Name	Duration	Start	Finish
Pebble 2021 PEA - Construction Schedule				
Key Milestones				
PE-MS-1000	Diamond Point Terminal Site Capture (Land by Barge)	0	May - Year 1	May - Year 1
PE-MS-1010	Access to Site Available for Moving Major Equipment and Modules	0	Nov - Year 2	Nov - Year 2
Construction				
PE-CN-1000	Establish Mine Site (Temp Road Access to Iliamna & Pioneer Camp)	6	May - Year 1	Oct - Year 1
PE-CN-1010	Permanent Access Road Construction (Diamond Point to Mine Site)	12	Nov - Year 1	Oct - Year 2
PE-CN-1020	Construct Bridges Along Access Road	4	Jun - Year 2	Sep - Year 2
PE-CN-1030	Diamond Point Marine Infrastructure and Dredging	6	May - Year 2	Oct - Year 2
PE-CN-1040	Pipeline Construction Along Road Segments (Gas, Concentrate, Water)	12	Nov - Year 1	Oct - Year 2
PE-CN-1050	Cook Inlet Sub-sea Pipeline Placement	5	Jun - Year 2	Oct - Year 2
PE-CN-1060	Anchor Point Compressor Station	5	Jun - Year 2	Oct - Year 2
PE-CN-1070	Mine Site Preparation and Earthworks for Infrastructure	6	May - Year 2	Oct - Year 2
PE-CN-1080	Mine Site Temporary Power Plant (First Module Installation)	4	Nov - Year 2	Feb - Year 3
PE-CN-1090	Mine Site Permanent Power Plant Fabrication and Construction	16	May - Year 2	Aug - Year 3
PE-CN-1100	Diamond Point Power Plant Construction	4	May - Year 3	Aug - Year 3
PE-CN-1110	Diamond Point Terminal – Concentrate Handling and Infrastructure	12	May - Year 4	May - Year 5
PE-CN-1120	Major Site Earthworks for TSF and Water Management	30	Nov - Year 2	May - Year 5
PE-CN-1130	WTP Infrastructure Construction	16	Jun - Year 3	Oct - Year 4
PE-CN-1140	Mine Site Mill and Infrastructure Construction	20	May - Year 3	Dec - Year 4
PE-CN-1150	Pit Pre-production Mining – Stripping and Initial Ore Stockpile	12	Dec - Year 3	Dec - Year 4
PE-CN-1160	Process Plant Wet Commissioning	6	Jan - Year 5	Jun - Year 5
PE-CN-1170	Production Ramp Up Period	12	Jun - Year 5	Jun - Year 6



Remaining Level of Effort — Remaining Work — Milestone
Actual Work — Critical Remaining Work — Critical Milestone

Page 1 of 1

Date	Revision	Checked	Approved
16-Mar-2021	Construction Schedule	FR	JS

24.1.2 Health, Safety and Environment

A stringent health, safety, environment, and community (HSEC) program is essential to overall Project success. A system of integrated principles was designed, as part of the goal of achieving zero harm for employees, contractors and visitors working on the Project while ensuring protection of the environment and adherence to all permits.

24.1.2.1 Site Environmental Procedures

All design and engineering stages would incorporate criteria for responsible management of process flows, effluent and waste products to meet established capture and containment guidelines. The Project design would incorporate basic clean plant design standards, including operational safety and maintenance access requirements. A Hazard and Operability Analysis (HAZOP) would be conducted by the Project design team during the detailed design stage for each area of the Project.

24.1.2.2 Community Engagement

Early engagement with the local communities in the execution process will be important in creating a long-term partnership between the local communities and stakeholders and the mine operations, ensuring that there is mutual benefit, and that local concerns and requirements, such as employment opportunities and infrastructure development are addressed. Failure to engage in meaningful dialogue with the local communities early will lead to delays in approval and potential opposition to the mine development.

24.1.3 Engineering

The approach to engineering design is to use the best available proven technology for the Project, balanced against overall value and risk factors. The designs for specific work areas (mill facilities, power plant, pipeline, marine facilities) are to be bench-marked against similar type and scale projects together with global engineering practice standards.

Project systems and equipment would be designed to meet North American standards for northern climates with sub-zero temperatures, in remote locations.

Where applicable, the use of pre-assembled or modular components would be implemented to reduce costs associated with transportation, site erection and other variable project components through reduce on-site labour requirements.

24.1.4 Procurement and Contracts

The procurement strategy would use a global approach to minimize capital expenditure and sea freight costs. At the same time, opportunities to source materials from Alaska- or USA-based suppliers would be promoted to increase local content.

The Owner's team, working with representatives from the EPCM contractor, would procure all equipment and bulk items. A detailed procurement database would be developed in alignment with the project execution schedule and would cover all requirements from enquiry issue through to award, expediting, inspection and final delivery.

The Owner's team, together with QA/QC personnel, would conduct independent quality inspections and monitor major equipment delivery milestone dates.

24.1.5 Logistics and Construction Strategy

24.1.5.1 Logistics

The core of the plan is to construct a reliable and efficient transportation corridor between the marine terminal and the mine site prior to shipping materials and supplies to construct the permanent site infrastructure. The logistics plan follows a project construction schedule of 48 months, with the permanent access road from Diamond Point terminal facilities completed within 18 months of the start of site works, and the marine facilities prepared to receive equipment and modules for the mine site construction.

Equipment, materials and supplies would be received, and shipments consolidated at selected marshalling yards located at Seattle, WA and Central Asia. Several companies operate ocean-going barge systems into Alaska from the Seattle-Tacoma area. Depending on the source location of materials and equipment, marshalling of cargos can also be done at an alternate site in Prince Rupert, British Columbia which would reduce the barge travel distance.

Logistics would evolve over the life of the project as transportation infrastructure is developed. In general, it would fall into three phases:

- early mobilization access phase;
- temporary access phase; and
- permanent access phase.

24.1.5.2 Construction Strategy

Construction crews would work a three-week-on, one-week-off rotation; local labour would be preferred for crew positions. Contract labour for the Owner's earthwork fleet would be used until the focus of work shifts to mine site. Then, the Owner's operations team would begin recruiting full-time employees to operate equipment, with a focus on developing a core mining team during the construction phase and prior to the arrival of large open pit equipment.

The PEP is based on a combination of EPC and EPCM delivery packages including:

- open pit mine (Owner managed);
- site grading, TSF and water treatment facilities;
- early site access road and the main service corridor;
- EPCM for mill facilities and on-site infrastructure;
- concentrate slurry and return water pipeline system;
- terminal site at Diamond Point including on-shore infrastructure and marine facilities;
- natural gas pipeline in two contacts: sub-sea and on-shore; and
- EPC contract for combined cycle gas power plants: mine site and terminal site.

A key component of the construction strategy is use of pre-assembled modules, up to 2,000 tons in size. These modules would be constructed remotely, either in North America or Asia, shipped to the marine terminal site and transported along the access road using specialized self-propelled modular transport (SPMT) units.

24.1.5.3 Marine Terminal and Mine Site Access Road

The first step in achieving land access to the Project sites would be to establish marine landing facilities at the marine terminal in Iliamna Bay. Initial marine construction would be supported by a floating camp mobilized by the marine contractor. This early access would include a dredging an access channel and installation of concrete caissons that would allow the off-loading of mine mobile equipment, large modules and plant equipment from barges.

At the same time the marine facilities are being established, a temporary construction road would be constructed between the marine terminal and the mine site around the northeast corner of Lake Iliamna, passing by the village of Iliamna with connection to the airport. A temporary crossing of the Newhalen River would be required at this stage to access the mine site and would be replaced by a permanent crossing during the construction period. The equipment necessary to complete the road construction would be transported from Cook Inlet using the existing Williamsport – Pile Bay road. Until accommodations have been established at the mine site, personnel working on the road and mine site would be housed in a temporary camp at Iliamna.

The marine facilities would be available to support construction with temporary barge landing about 8 months following the initial mobilization, and the temporary mine site access route would be established within the same time frame. The permanent road would be completed for movement of heavy modules about 18 months following mobilization.

24.1.6 Construction Camp

Local accommodations at Iliamna would be utilized used until the mine site complex is established. The temporary accommodation and services complex at the mine site would be constructed as soon as the temporary construction roads has been completed, in order to enable their use for the construction phase. The temporary construction camp would eventually be converted to the permanent accommodation complex for the operations phases of the Project. The number of temporary camp rooms required at the mine site would depend on the peak manpower loading required for the construction phase.

24.1.7 Open Pit Pre-Production

The pit area would be dewatered by a sequence of wells selectively positioned to lower the water table in that area. The mining consultant estimates about six months of dewatering would be required prior to commencement of mining. Natural gas would be available at the mine site in month 26 and the initial power plant would be online in approximately month 28.

Pre-production pit activity would concentrate on clearing the overburden and soils off the first pit phase, constructing the haul roads and developing bench faces for the larger equipment. Other work undertaken by the construction fleet would include site earthworks and initial tailings embankment work. As production mine equipment is brought on stream, waste stripping would focus on supplying rock for the tailings embankments construction.

24.1.8 Tailings Storage Facility Preparation

The first stage of the TSF embankments would be constructed during this initial construction phase and would provide the capacity required to store the tailings, process water, and site runoff for approximately 2 years of operations. The first requirement for TSF construction is establishing all of the environmental controls (diversion ditches, sediment control ponds, runoff collection ponds) in the construction area to manage site runoff from construction activities. A primary objective during the construction program is to divert clean runoff to reduce the water treatment requirements. Runoff that does not meet discharge requirements would be collected, treated, and discharged downstream. The starter dam would take approximately three years to construct and would incorporate construction materials from local borrow and the open pit stripping. Foundation preparation for the TSFs includes removing and stockpiling the organic material and other materials not used for the foundation under the embankment. The organic materials would be used to reclaim the embankments at closure. The soils under the embankment would be removed to the top of bedrock and used, as appropriate, in the construction of the embankment.

24.1.9 Permanent Power

On-site generated permanent power would be required to start the open pit and process plant operations. The combined cycle gas fired power plant would be constructed and commissioned in two stages. The first stage would come on line in month 28, after the natural gas pipeline has been completed. Pit stripping would start in month 24, using diesel-powered hydraulic shovels until power becomes available for the electrically-powered shovels. Individual turbine units would be brought online as demand increases. The temporary diesel power station used to power the construction site would be replaced by the natural gas-fired power station; however, it would remain on site as a backup emergency power for critical loads during operations.

An undersea natural gas pipeline would be constructed across Cook Inlet to the marine terminal area, connecting to a pipeline that would follow the access road corridor to the mine site. A pipe-laying vessel would install the undersea portion of the pipeline.

The power plant is expected to be provided through an EPC (turnkey) design and supply package and, as a result, may require tendering and engineering commitments prior to the notice to proceed date to ensure timely installation.

24.2 Potential Expansion Scenarios

24.2.1 Mine Life Extension Scenarios

The Proposed Project evaluated in the 2021 PEA extracts only a small portion of the total Mineral Resource estimate for the Pebble deposit. To evaluate the possible extent of opportunities for the Project, seven potential expansion scenarios were identified for consideration. Six of these potential expansion scenarios contemplate an expansion of the open pit mine and increased mill throughput over a significantly longer mine life. These scenarios were modeled on an expanded scenario outlined in a response to a Request for Information from USACE during the EIS process and which is incorporated in the EIS administrative record. Three of these six scenarios consider the addition of an onsite gold plant. The seventh potential expansion scenario contemplates the addition of the onsite gold plant to the Proposed Project without changes to its throughput or mine life.

The potential extension of the mine life and expanded production capacity is predicated on the Measured, Indicated and Inferred Mineral Resources which have been identified and defined by the drilling programs to date. Any potential expansion scenario would require additional analysis, engineering and environmental assessment prior to it moving forward and any expansion scenario would be required to undergo Federal and State permitting prior to its implementation.

The potential expansion scenarios assess the extraction of a portion of the overall deposit. Additional resource and deeper high-grade intersections outside the resource boundary create a potential opportunity for future development of an underground mine. Further, replacing the expanded open pit, or a portion of it, with an underground mine may demonstrate acceptable financial results with a reduced project footprint. Additional assessment of this option is warranted to confirm the relative economics of an underground mine and define its environmental footprint.

The expansion scenarios envisioned in the 2021 PEA are preliminary in nature and include Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results, including the potential expansion scenarios, will be realized. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

24.2.1.1 Throughput Expansion Scenarios

Mining and recovery methods for the throughput expansion scenarios are similar to those presented for the proposed Project as described in Sections 16 and 17. An expanded open pit design was developed with parameters similar to those used to design the open pit for the Proposed Project. The same open pit design was used for all three expansion scenarios, with the differences in forecast and mine life dependent on the timing of the expansion. The volume of mineralized material, the grades of that material, and the volume of waste rock for the expanded open pit are shown in Table 24-1. The total volume of material in this open pit is very similar to the 78-year case examined in the 2011 PEA, with the primary difference related to the current lower cut-off grade due to higher metal prices.

The throughput expansion scenarios would use an elevated cut-off grade while the open pit is mined, with lower-grade material to be stockpiled and fed to the plant after the open pit has been exhausted. This accounts for the differences between the open pit life and the life of mine in Table 24-1. Lower-grade stockpiles and waste rock facilities could be located northeast and south of the open pit, together with additional water management and treatment facilities. The year in which the expanded process plant begins operation provides the designation for each potential expansion scenario. Expanded open pit mining would occur several years in advance of this to prepare for the expanded throughput. The mining rate would increase to handle the increased throughput and higher strip ratio, thus requiring additional mining equipment. The expanded open pit mine would also utilize in-pit crushing and conveying to reduce costs.

The same design criteria as were applied to the Proposed Project were utilized to develop the plan for the expanded process plant. In the Year 21 Expansion scenario, the process plant would expand to 250,000 tons per day, similar to the scenario assessed in the EIS. The expanded throughput rate in the Year 5 and Year 10 scenarios would be 270,000 tons per day. All expansions would utilize increased mineralized material handling capacity and a third processing line with similar equipment as employed in the Proposed Project.

The expanded projects would also require expansions of infrastructure components. The accommodations complex and related facilities would be expanded to house the increased workforce. The site footprint would expand, necessitating additional water management facilities. The basis of the water management requirements was similar to that envisioned for the Proposed Project. Additional tailings facilities locations would be selected to handle the additional volumes. As with the Proposed Project, the bulk and pyritic tailings would be stored in separate facilities. Tailings would be directed to the open pit during the stockpile reclaim phase and the accumulated pyritic tailings would be returned to the open pit, as is the case with the Proposed Project.

The water management plan for each expanded scenario was developed based on the same data used to determine water quality and quantities for the Proposed Project, adapted to suit the expanded footprint and timing of the expansions. Similar criteria for water handling and treatment were applied and the same water discharge criteria formed the basis of the water treatment schemes.

The copper concentrate dewatering system and concentrate storage at the marine terminal would be expanded to facilitate the increased production. The capacity of the copper concentrate pipeline and return water system, as identified for the Proposed Project, would be adequate for the expansion scenarios.

The estimated power demand would increase to 404 MW, necessitating an increase in the mine site power plant size. The capacity of the natural gas line would be accomplished through minor pipeline expansions on the Kenai Peninsula and installation of a second compressor station at the marine terminal.

The initial capital for all scenarios is the same, as they are based on the assumption the designs and permitting would follow the construction and initial operation of the Proposed Project. The sustaining capital and operating costs were developed for each scenario. The variations in both capital and operating costs for each expansion scenario are driven primarily by the timing of the implementation, and to a lesser extent by amount of pre-stripping, waste disposal, and water management activities for of both the open pit mine mining as well as TSF.

A summary of the potential expansion scenario production information is presented in Table 24-1 and the cost summary information is presented in Table 24-2. The methodology for estimating the capital and operating costs for the potential expansion scenarios are the same as described in Section 21.

Table 24-1: Summary Potential Expansion Scenario Production Information

		Proposed Project	Potential Expansion Scenarios		
			Year 21	Year 10	Year 5
Mineralized Material	B tons	1.3	8.6	8.6	8.6
Copper Equivalent[27]	%	0.57	0.72	0.72	0.72
Copper	%	0.29	0.39	0.39	0.39
Gold	oz/ton	0.009	0.01	0.01	0.01
Molybdenum	ppm	154	208	208	208
Silver	oz/ton	0.042	0.047	0.046	0.046
Rhenium	ppm	0.28	0.36	0.36	0.36
Waste	B tons	0.2	14.4	14.4	14.4
Open Pit Strip Ratio		0.12	1.67	1.67	1.67
Open Pit Life	Years	20	78	73	68
Life of Mine	Years	20	101	91	90
Metal Production (LOM)					
Copper	M lb	6,400	60,400	60,400	60,400
Gold (in Cu Concentrate)	k oz	7,300	50,400	50,500	50,500
Silver (in Cu Concentrate)	k oz	37,000	267,000	267,000	267,000
Gold (in Gravity Concentrate)	k oz	110	782	783	782
Molybdenum	M lb	300	2,900	2,900	2,900
Rhenium	k kg	200	2,000	2,000	2,000
Metal Production (Annual[28])					
Copper	M lb	320	600	660	670
Copper Concentrate	k tonnes	559	1,000	1,200	1,200
Gold (in Cu Concentrate)	k oz	363	500	560	560
Silver (in Cu Concentrate)	k oz	1,800	2,600	2,900	3,000
Molybdenum	M lb	15	29	32	32
Molybdenum Concentrate	k tonnes	14	26	29	29
Rhenium	k kg	12	20	22	22

[27] Copper equivalent (CuEQ) calculations use metal prices: US$1.85/lb for Cu, US$902/oz for Au and US$12.50/lb for Mo, and recoveries: 85% Cu, 69.6% Au, and 77.8% Mo (Pebble West zone) and 89.3% Cu, 76.8% Au, 83.7% Mo (Pebble East zone).
[28] Life of mine volumes÷ life of mine years

Table 24-2: Potential Expansion Scenarios Cost Summary

		Potential Expansion Scenarios		
		Year 21	Year 10	Year 5
Costs				
Total Initial Capital Cost	$billion	6.05	6.05	6.05
Infrastructure Lease	$billion	1.68	1.68	1.68
Net Initial Capital Cost	$billion	4.37	4.37	4.37
Sustaining Capital Cost	$billion	16.9	17.0	17.2
Life of Mine Operating Cost[29]	$/ton	12.46	12.14	12.21
Copper C1 Cost[30]	$/lb CuEq	1.56	1.53	1.54
AISC (Co-Product Basis)	$/lb CuEq	1.77	1.74	1.74
Gold C1 Cost	$/oz AuEq	712	699	702
Closure Funding				
Annual Contribution	$M/yr	9	10	11
Life of Mine Contribution	$billion	1.00	0.97	1.01
Life of Mine Bond Premium	$billion	1.14	0.78	0.85
Closure Fund[31]	$billion	3.2	3.3	3.1
Life of Mine Taxes[32]				
Alaska Mining License	$billion	8.16	8.34	8.32
Alaska Royalty	$billion	3.61	3.68	3.68
Alaska Income Tax	$billion	10.20	10.46	10.40
Borough Severance & Tax	$billion	4.34	4.33	4.34
Federal Income Tax	$billion	18.94	19.42	19.31
Annual Taxes[33]				
Alaska Mining License	$million	81	92	93
Alaska Royalty	$million	36	41	41
Alaska Income Tax	$million	101	115	116
Borough Severance & Tax	$million	43	48	47
Federal Income Tax	$million	188	213	215

The economic analysis methodology, inputs to cash flow model and tax considerations are as described in Section 22; however, in this section only the assumptions regarding third-party ownership of key transportation and power infrastructure and gold streaming were applied. The financial results for the potential expansion scenarios are shown in Table 24-3.

The closure concepts for the potential expansion scenarios are similar to those envisioned in the Proposed Project, with the exception that reclamation of the initial bulk TSF commences when that facility reaches capacity and a second bulk TSF is put into use. In addition, in all the potential expansion scenarios, the process plant is fed from stockpiles after mining

[29] Includes cost of infrastructure lease:

Year 21 Expansion - $0.54/ton milled
Year 10 Expansion - $0.53/ton milled
Year 5 Expansion - $0.53/ton milled

[30] C1 costs calculated on co product basis
[31] Maximum value of closure fund during life of mine based on 4% compounding interest
[32] Estimated based on current Alaskan statutes
[33] Life of mine taxes ÷ life of mine years

ceases, during which period the reclamation of the second bulk TSF and pyritic TSF commences. The estimated closure costs for the potential expansion scenarios, including water treatment associated with the closed bulk TSF, range between $5.9 billion and $6.25 billion, depending on the potential expansion scenario. Approximately 70% of these closure costs are scheduled for completion prior to the cessation of operations. At cessation of operations, the reclamation trust value is estimated to be $1.5 to $1.9 billion. Subsequent closure costs after cessation of operations are estimated to range between $1.6 billion and 2.1 billion. The estimated post-closure water treatment costs range between $46 million and $59 million per year, requiring a residual reclamation trust balance of $1.2 billion to $1.5 billion.

Table 24-3: Potential Expansion Scenarios Financial Results[34]

		Potential Expansion Scenarios		
		Year 21	Year 10	Year 5
Revenue[35]				
Annual Gross Revenue	$million	3,100	3,400	3,500
Life of Mine Gross Revenue	$million	312,000	312,000	312,000
Realization Charges				
Annual Charges	$million	270	300	310
Life of Mine Charges	$million	28,000	28,000	28,000
Net Smelter Return				
Annual NSR	$million	2,800	3,100	3,200
Life of Mine NSR	$million	285,000	285,000	285,000
Financial Model Results				
Post Tax IRR	%	18.1	19.5	21.5
Post Tax NPV_7	$million	5,700	7,300	8,500
Payback	Years	4.4	4.4	5.0

24.2.2 Gold Plant Scenarios

An onsite gold production plant was evaluated to add value to the Proposed Project and the potential throughput expansion scenarios. While there are no relevant changes associated with the mining methods and Project infrastructure, as discussed in Section 24.2.2, there would be the addition of a gold plant for these potential expansion scenarios. All relevant mineral processing and metallurgical testing results are presented and discussed in Section 13 of this Report.

While the gold plant scenarios utilize the metallurgical testwork results for a specific gold recovery technology, other technologies may be applicable for the Pebble deposit. Further, the addition of a gold plant under any scenario will require additional testwork and engineering and will require the receipt of pertinent Federal and State permits prior to implementation.

The onsite gold plant is designed to process a pyrite concentrate in conjunction with the gravity concentrate to produce a precious metal doré. The unit operations for the onsite gold plant would be:

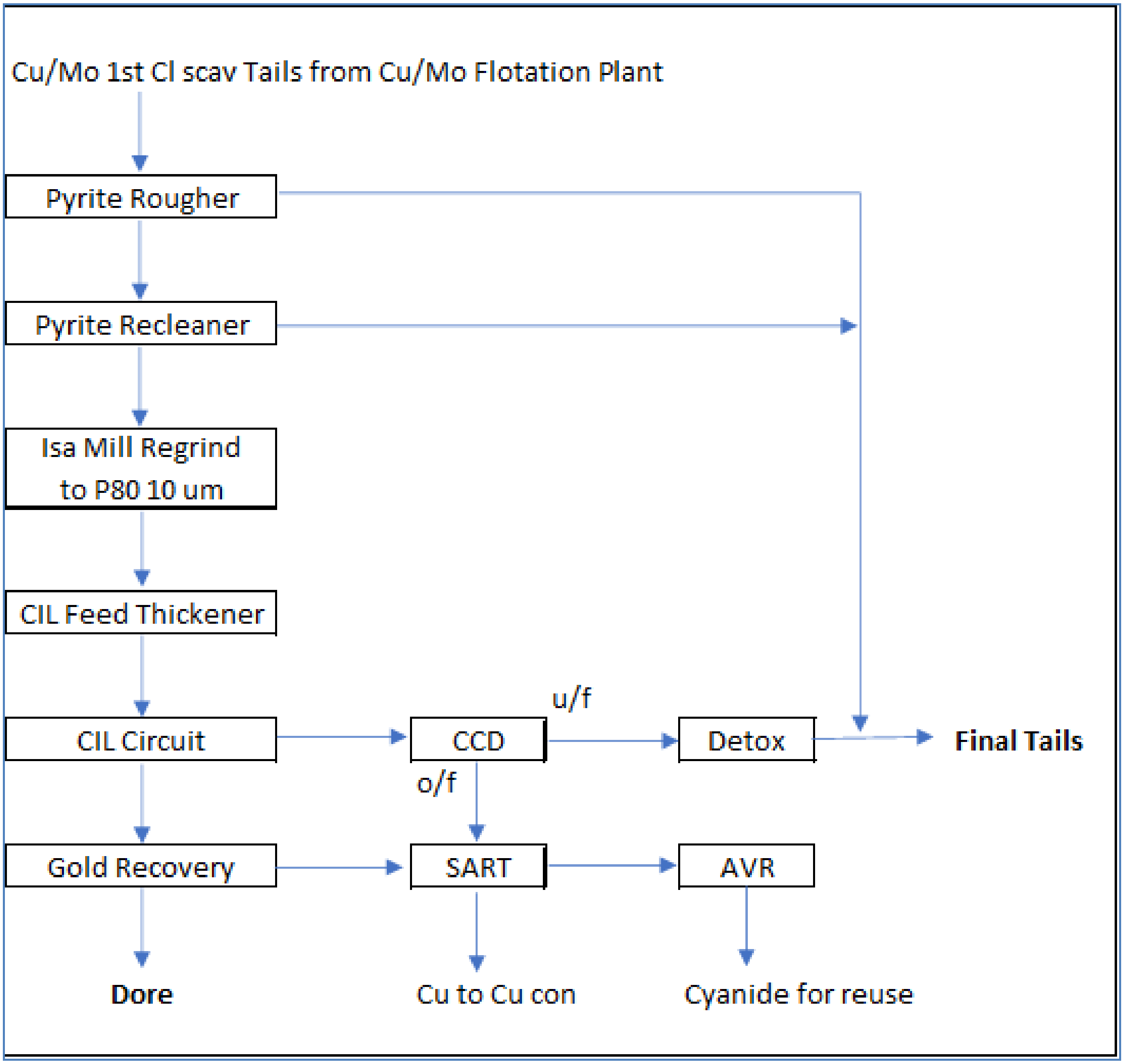
- pyrite flotation;

[34] Includes infrastructure partners and precious metal streaming
[35] Revenue values do not include a gold pl;ant contribution

- concentrate regrind;
- carbon in Leach;
- SART/acidification, volatilization and re-neutralization (AVR);
- gold recovery;
- cyanide detoxification; and
- gold room.

Figure 24-2 shows a simplified block flow diagram for the proposed onsite gold plant.

Figure 24-2: Proposed Gold Plant Block Flow Diagram



Note: Prepared by Ausenco, 2021.

Table 24-4: Summary Gold Plant Scenarios Production Information

		Proposed	Potential Expansion Scenarios		
Concentrate Production (LOM)					
Gold (in Cu Concentrate)	k oz	7,300	50,400	50,500	50,500
Silver (in Cu Concentrate)	k oz	37,000	267,000	267,000	267,000
Gold Plant (LOM)					
Gold (as Doré)	k oz	1,800	14,500	14,500	14,400
Silver (as Doré)	k oz	2,600	22,600	22,600	22,500
Total Production (LOM)					
Gold	k oz	9,000	65,000	65,100	64,900
Silver	k oz	39,000	289,000	289,000	289,000

The onsite gold plant would commence operation in Production Year 5 after acquiring the required permits. The gold plant would be designed to match the Proposed Project throughput for that scenario and for the Year 10 and Year 21 potential expansion scenarios. The plant would be expanded with the process plant expansion in the Year 10 and Year 21 potential expansion scenarios and would be constructed to match the full process plant capacity of the Year 5 potential expansion scenario.

Gold recovery plants are currently employed safely at hard rock mines in Alaska and have recently been approved for large-scale new mine developments in the State. Northern Dynasty and the Pebble Partnership continue to evaluate multiple technologies to safely produce precious metal doré at the Pebble Project. Any future plan to incorporate onsite gold recovery would require extensive Federal, State and local permitting processes and approvals before proceeding.

The financial results for the potential inclusion of a gold plant are shown in Table 24-5.

Table 24-5: Potential Gold Plant Scenario Financial Results[36]

		Proposed Project	Expansion Scenarios		
			Year 21	Year 10	Year 5
IRR	%	16.5	18.8	20.3	22.7
NPV_7	$billion	2.7	6.6	8.4	9.7
Payback	Years	4.9	4.6	4.5	5.0

[36] Proposed Project and Potential Expansion Scenarios include infrastructure partners and precious metal streaming.

25 INTERPRETATION AND CONCLUSIONS

25.1 Introduction

The QPs note the following interpretations and conclusions in their respective areas of expertise, based on the review of data available for this Report.

The results of the 2021 PEA indicate the Pebble project could provide significant economic returns on investment. Further, the potential expansion and gold plant scenarios indicate potential economic upside through the expansion of processing capacity over an extended mine life.

25.2 Mineral Tenure, Surface Rights, Water Rights, Royalties and Agreements

Information obtained from Northern Dynasty experts supports that the mineral tenure held is valid and is sufficient to support a declaration of Mineral Resources.

Northern Dynasty currently does not own any surface rights associated with the mineral claims that comprise the Pebble property. All lands are held by the State of Alaska, and surface rights may be acquired from the State government if areas required for mine development have been determined and permits awarded.

Teck holds a 4% pre-payback net profits interest (after debt service), followed by a 5% after-payback net profits interest in any mine production from the Exploration Lands.

The Pebble property is within the Lake and Peninsula Borough and is subject to a 1.5% severance tax. The life of mine severance tax payments for the Proposed Project could total approximately $480 million and range as high as $4.5 billion for the life of the Potential Expansion Scenarios with a gold plant.

The Pebble Performance Dividend LLP would distribute a 3% net profits royalty interest in the Pebble Project to adult residents of Bristol Bay villages that have subscribed as participants. The Pebble Performance Dividend would distribute a guaranteed minimum annual payment of US$3 million each year the Pebble mine operates beginning at the outset of project construction. Total life of mine payments for the Proposed Project could total approximately $200 million to $240 million and could range as high as almost $3.7 billion for the life of the Potential Expansion Scenarios with a gold plant.

The access corridor is owned by a number of landowners, including the State of Alaska, Alaska Native Village Corporations, and private individuals. Pebble Partnership has completed access agreements with two Native Village Corporations and a private individual. Negotiations have advanced with other Native Village Corporations and individuals, but no agreements are in place. In June 2021, one of the Native Village Corporations announced they had signed an agreement whereby a fund has obtained an option to buy portions of their land to create a conservation easement. The fund must exercise its option by the end of 2022. If the fund closes this agreement with the Native Village Corporation, the Pebble Partnership would be required to identify an alternate route to the proposed marine terminal on Cook Inlet.

To the extent known to the QP, there are no other significant factors and risks that may affect access, title, or the right or ability to perform work on the Project that have not been discussed in this Report.

25.3 Geology and Mineralization

The Pebble deposit is classified as a copper-gold-molybdenum porphyry deposit.

The geological understanding of the settings, lithologies, and structural and alteration controls on mineralization in the different zones is sufficient to support estimation of Mineral Resources. The geological knowledge of the area is also considered sufficiently acceptable to reliably inform mine planning.

The mineralization style and setting are well understood and can support declaration of Mineral Resources.

The Pebble property includes a number of opportunities to expand the Mineral Resource estimate through future exploration. Drill hole 6348, perhaps the most significant intersection in the Pebble deposit, demonstrates that mineralization contiguous with the current resource continues to the east beyond the ZG1 fault and remains open to expansion in that direction. Geophysical and geochemical surveys and reconnaissance exploration drilling have identified several targets located well outside the current Pebble resource estimate area that warrant future exploration.

25.4 Exploration, Drilling and Analytical Data Collection in Support of Mineral Resource Estimation

Extensive core drilling, sampling and assaying have taken place on the Pebble Project in support of exploration and delineation of the current Mineral Resource estimate. Drill holes are spatially well-distributed and oriented to test the geological and geotechnical conditions, dimensions and grade of the Pebble deposit and mineralization as it is currently known. Several other mineral exploration targets encountered on the property have received less focus and attention and require further investigation to satisfactorily assess their potential. The reliability of the topographic base maps, surveyed drill locations, down-hole positional measurements, and percentage of core recovered by drilling in the Pebble deposit area is deemed acceptable. The proficiency of the density measurements, core logging, sampling, and sub-surface geological interpretation in this area is also considered to be adequate and appropriate for use in support of this Report.

A significant amount of due diligence, verification, validation and QA/QC has been completed on the copper, gold, molybdenum, silver and rhenium analyses of the Pebble drill core samples. Assaying and check assaying was conducted by well-recognized, independent analytical laboratories. The drilling and sampling programs typically included blanks, duplicates and standard samples that were submitted at rates that met or exceeded industry-accepted norms. Independent analytical laboratory consultants were engaged, over significant portions of the Pebble deposit area drill programs, to make recommendations and provide timely monitoring and review of the processes, procedures and results of the sample preparation and analytical laboratories used. These consultants also assessed the effectiveness and outcome of the sampling and analytical QA/QC programs implemented by the Project proponents. The extent and coverage of these programs adequately addressed issues of precision, accuracy and contamination.

Significant due diligence, verification, validation and QA/QA programs were performed on the Pebble drill hole database and supporting information that attest to its veracity. This work was done to a reasonable and acceptable level in accordance with exploration best practices and industry standards at the time the programs were conducted. In consideration of these factors, the exploration, drilling, sampling and analytical methods employed are deemed appropriate and acceptable to support the current Mineral Resource estimate.

25.5 Metallurgical Testwork

Metallurgical testwork and associated analytical procedures were appropriate to the mineralization type, appropriate to establish the optimal processing routes, and were performed using samples that are typical of the mineralization styles found within the Pebble deposit.

Samples selected for testing were representative of the various types and styles of mineralization. Samples were selected from a range of depths within the deposits. Sufficient samples were taken so that tests were performed on sufficient sample mass.

Metallurgical testwork from 2011 to 2013 on the Pebble deposit indicates that significant rhenium can be recovered to the bulk copper-molybdenum flotation concentrate and further concentrated into the final molybdenum flotation concentrate. The overall rhenium recovery is determined by the rhenium recovery to the bulk copper-molybdenum concentrate and the separation efficiency of the rhenium into the molybdenum concentrate in the subsequent copper-molybdenum separation stage. The estimated rhenium recovery is about 70.8% on average for all the domains.

The testwork results were used for the recovery projections of the mine production plan followed by economic analysis for the life of mine. There are no deleterious elements that have been reported within the copper/gold concentrate.

25.6 Mineral Resource Estimates

The Pebble property hosts a globally significant copper-gold-molybdenum-silver-rhenium deposit. The exploration and drilling programs completed thus far are appropriate to the type of the deposit. The exploration, drilling, geological modelling and research work support the interpreted genesis of the mineralization and the domaining employed in the resource estimation.

The drill database for the Pebble deposit is reliable and sufficient to support the Mineral Resource estimate.

Estimations of Mineral Resources for the Pebble Project conform to industry best practices and are reported using the 2014 CIM Definition Standards.

Mineralization at Pebble is open in several directions and offers the opportunity, with additional drilling, to expand the resource base.

25.7 Mine Plan

The 2021 PEA is preliminary in nature and includes Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results will be realized. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.

The mining operations are planned to use conventional open pit mining methods and equipment. The open pit mine envisioned for the Proposed Pebble Project would be a conventional drill, blast, truck, and shovel operation with an average mining rate of approximately 70 million tons per year and an overall strip ratio of 0.12 ton of waste per ton of mineralized material.

The open pit would be developed in stages, with each stage expanding the area and deepening the previous stage. The final dimensions of the open pit would be approximately 6,800 ft long and 5,600 ft wide, with depths to 1,950 ft.

The mining schedule was generated using five pushbacks and was based on a maximum processing capacity of 180,000 ton/d. Based on the selected ultimate pit, final pit design and the generated production schedule, the Pebble Project's total LOM is 21 years, including 1 year of pre-stripping followed by 20 years of production.

25.8 Recovery Method

The designed process to treat mineralized feeds from the Project contemplate methods that are conventional and well-proven in the industry. The comminution and recovery processes are used widely in commercial practice, with no significant elements of technological innovation.

The process plant flowsheet design was based on testwork results, previous study designs and industry standard practices. Further, the testwork results support the recovery projections used in the economic analysis.

The mineralized material would be processed to produce three saleable products: a copper-gold flotation concentrate, a molybdenum flotation concentrate, and a precious metals gravity concentrate, all of which are expected to be readily marketable to several third party refiners.

25.9 Infrastructure

The Project is located in an area of Alaska that has minimal development and would require construction of both on-site and off-site infrastructure to support construction and operations. Principal off-site infrastructure would include a marine terminal facility, along with corresponding power generation and shop facilities, a natural gas pipeline supplying both port and mine sites, and all-weather access road to site including multiple water crossings and concentrate and return water pipelines between the marine terminal and mine site. Major on-site infrastructure would include, power generation facilities, power reticulation, site roads, process and administration buildings, truck shop, warehouse, and change houses. The Project site would also include tailings and waste rock storage facilities, water ponds, water management structures, and water treatment facilities. Both temporary and permanent worker accommodations would also be established at the Project.

Combined-cycle, natural gas-fired power plants would be constructed at both the mine site and the marine terminals. The natural gas for power generation would be delivered by a pipeline extending across Cook Inlet to the marine terminal and then on to the mine site along the roadway corridor.

The transportation infrastructure would consist of a marine terminal facility located north of Diamond Point in Iliamna Bay and a permanent access road, as well as a copper concentrate slurry pipeline system following the roadway from the mine site to the terminal.

Waste and water management at the Pebble Project would be an integrated system designed to safely contain these materials, to facilitate water treatment and discharge, and to provide adequate process water to support the operations. The design of these facilities incorporates a significant climate record, extensive site investigation, and a number of features intended to ensure safe operation.

The water management strategy for the Project uses water from within the Project area to the maximum practical extent. Contact water, (mine drainage and process water), from the mine site would be collected and managed using various water management facilities. Mine drainage is defined as groundwater or surface runoff that has come into direct contact with mining infrastructure and requires treatment at the water treatment plants to meet discharge water quality standards prior to discharge to the environment.

The proposed Project incorporates a sophisticated water management plan with water collection, treatment, and discharge. That plan requires attention to the annual and seasonal variability of the incoming and receiving flows and achieving very specific water quality standards for the released water. Temporary water treatment facilities would be in place during construction, followed by three WTPs during the operations and closure phases of the Project.

25.10 Environmental, Permitting, Closure and Social

Northern Dynasty began an extensive field study program in 2004 to characterize the existing physical, chemical, biological and social environments in the Bristol Bay and Cook Inlet areas where the Pebble Project might occur. The Pebble Partnership compiled the data for the 2004 to 2008 study period into a multi-volume EBD. SEBD reports incorporated data collected from the period 2009 to 2012. Additional monitoring data collected through 2019 was provided to USACE in support of the ongoing permitting process.

The major environmental pathways include air, water and terrestrial resources. During the preliminary stages of the Pebble Project, Northern Dynasty identified key environmental issues and design drivers that have formed the basis of baseline data collection, environmental and social analysis and continuing stakeholder consultations influencing the Pebble Project design. The effects assessment has confirmed these as important issues and design drivers and has identified mitigation measures for each. Direct integration of these mitigation strategies and other appropriate measures into the Pebble Project design and operational strategies are expected to effectively mitigate possible environmental effects and minimize residual environmental effects associated with the construction, operation and eventual closure of any proposed mine at the Pebble Project. The application of sound engineering, environmental planning and best management practices, including compliance with existing U.S. Federal and State environmental laws, regulations and guidelines, would help ensure that all of the environmental issues associated with the development and operation of the Pebble Project can be effectively addressed and managed.

Pebble Partnership filed a CWA 404 permitting application with USACE on December 22, 2017. USACE confirmed that Pebble's permitting application was complete in January 2018 and an Environmental Impact Statement (EIS) is required to comply with its National Environmental Policy Act (NEPA) review of the Pebble Project. The NEPA EIS process included a comprehensive 'alternatives assessment' that considered a broad range of development alternatives. The project design and operating parameters for the Pebble Project and associated infrastructure reflects the LEDPA in the FEIS published by USACE in July 2020. The FEIS document was viewed by the Pebble Partnership as favourable in that it found impacts to fish and wildlife would not be expected to affect subsistence harvest levels, there would be no measurable change to the commercial fishing industry including prices, and a number of positive socioeconomic impacts on local communities.

USACE formally advised the Pebble Partnership by letter dated August 20, 2020 that it had made preliminary factual determinations under Section 404(b)(1) of the CWA that the Pebble Project as proposed would result in significant degradation to aquatic resources. In connection with this preliminary finding of significant degradation, USACE formally informed the Pebble Partnership that in-kind compensatory mitigation within the Koktuli River Watershed would be required to compensate for all direct and indirect impacts caused by discharges into aquatic resources at the mine site. USACE requested the submission of a new compensatory mitigation plan to address this finding within 90 days of its letter.

In response, the Pebble Partnership developed a compensatory mitigation plan (CMP) to align with the requirements outlined by USACE. This plan envisioned creation of a 112,445-acre Koktuli Conservation Area on land belonging to the State of Alaska in the Koktuli River Watershed downstream of the Project. The objective of the preservation of the Koktuli Conservation Area was to allow the long-term protection of a large and contiguous ecosystem that contains valuable aquatic and upland habitats. If adopted, the Koktuli Conservation Area would preserve 31,026 acres of aquatic resources within the 'aquatic resource of national importance'-designated Koktuli River Watershed. The proposed conservation area was selected to protect and preserve physical, chemical, and biological functions found to be important during the project review. Preservation of the Koktuli Conservation Area was designed to minimize the threat to, and prevent the decline of, aquatic resources in the Koktuli River Watershed resulting from potential future actions, with the objective of ensuring the sustainability of fish and wildlife species that depend on these aquatic resources, while protecting the subsistence lifestyle of the residents of Bristol Bay and commercial and recreational sport fisheries. The plan was submitted to USACE on November 4, 2020.

On November 25, 2020, USACE issued a ROD rejecting Pebble Partnership's permit application. The ROD rejected the CMP as "non-compliant" and determined the Project would cause "Significant Degradation" and be contrary to the public interest. Accordingly, USACE rejected Pebble Partnership's permit application.

The Pebble Partnership submitted its request for appeal of the ROD on January 19, 2021. The request for appeal reflects the Pebble Partnership's position that USACE's ROD and permitting decision – including its significant degradation finding, its public interest review findings, and its rejection of Pebble's CMP – are contrary to law, unprecedented in Alaska, and unsupported by the administrative record, in particular the Pebble Project FEIS. The specific reasons for appeal asserted by the Pebble Partnership include: (i) the finding of "Significant Degradation" by USACE is contrary to law and unsupported by the record; (ii) USACE's rejection of the CMP is contrary to USACE regulations and guidance, including the failure to provide the Pebble Partnership with an opportunity to correct the alleged deficiencies; and, (iii) the determination by USACE that the Pebble Project is not in the public interest is contrary to law and unsupported by the public record.

In a letter dated February 24, 2021, USACE confirmed the Pebble Partnership's RFA is "complete and meets the criteria for appeal." USACE has appointed a Review Officer to oversee the administrative appeal process. The appeal process will now move to consideration by USACE of the merits of the appeal. The appeal will be reviewed by USACE based on the administrative record and any clarifying information provided, and the Pebble Partnership will be provided with a written decision on the merits of the appeal at the conclusion of the process. The appeal is governed by the policies and procedures of USACE administrative appeal regulations. While federal guidelines suggest the appeal should conclude within 90 days, USACE has indicated the complexity of issues and volume of materials associated with Pebble's case means the review will likely take additional time.

On September 9, 2021, the EPA announced they planned to reinitiate the process of making a CWA Section 404(c) determination for the waters of Bristol Bay, which would set aside the 2019 withdrawal of that action that was based on a 2017 settlement agreement between the EPA and Pebble Partnership and supported by the results of the 2020 EIS. The 2019 withdrawal was contested by project opponents and is currently subject to ongoing litigation. In that litigation, EPA has requested the court to remand the case to EPA, which would likely result in the reinstatement of the Proposed Determination. The Pebble Partnership has filed an Opposition, asking the Court to impose a schedule requiring EPA to issue a final appealable decision on the 2014 Proposed Determination under the CWA, whether that be to withdraw or finalize. The imposition of a schedule is necessary to ensure that EPA is not allowed to regulate by inaction.

In addition to the USACE permits, the Project will require federal permits from the U.S. Coast Guard, the Bureau of Environmental Enforcement, the National Marine Fisheries Service, and the US Fish and Wildlife Service, in addition to many other federal authorizations. There is no certainty that these federal permits and authorizations will be granted.

Numerous environmental permits and plans will also be required by various State and local agencies. The Pebble Partnership will work with applicable permitting agencies and the State of Alaska's large mine permitting team to provide complete permit applications in an orderly manner. There is no certainty that these federal permits and authorizations will be granted.

25.11 Markets and Contracts

The Pebble Project would produce copper-gold and molybdenum concentrates. The copper-gold concentrate would be transported via buried pipeline from the mine site to the marine terminal where it would be filtered, loaded onto transshipment barges, and then unloaded directly into the holds of Handysize bulk carriers for shipment to smelter customers in Asia and Europe. The molybdenum concentrate would be filtered at the mine site and placed in large sacks which are in turn placed in conventional shipping containers. The containers would be trucked to the port and shipped to refineries located outside Alaska. Other economically valuable minerals (gold, silver and palladium in the copper-gold concentrate and rhenium in the molybdenum concentrate) would be present in the concentrates.

The copper concentrate market, in order of importance, is expected to be China, Japan, India, Korea and Europe. The molybdenum concentrate market is expected to be in Asia.

For copper concentrate ocean transportation costs are assumed to be $50/wet tonne and concentrate moisture content was assumed to be 8%. For molybdenum concentrate ocean transportation costs are assumed to be $171.12/wet tonne and concentrate moisture content was assumed to be 5%.

As of the Report effective date, no contracts for supply of reagents and consumables, shipping or tolling of products have been entered into.

25.12 Capital and Operating Costs

The total estimated initial capital cost for the design, construction, installation, and commissioning of the Pebble Project is $6.05 billion, which includes all direct, indirect, Owner's and contingency costs.

Sustaining capital investment in the project over the 20 year mine life is limited to TSF improvements, and replacement of mobile equipment for mining and road maintenance. These life cycle costs are applied in the financial model on a year by year basis, with a cumulative total of $1.52 billion including indirect, Owner's and contingency costs.

Mine closure and reclamation costs are not included in the capital or operating costs but are factored into the financial model to account for site decommissioning and long term water treatment plant operations.

The average annual operating cost for the Project, is estimated to be US$708 million per year over the proposed 20-year life. This equates to US$10.98 /ton milled, based on the 180,000 ton/day plant capacity.

25.13 Economic Analysis

The economic analysis of the Proposed Project, under both the Base Case and the Full Capital Case demonstrate the Pebble Project can achieve acceptable financial results.

25.14 Potential Expansion Scenarios

The potential expansion scenarios explored in the 2021 PEA provide a glimpse into potential longer term outcomes that could potentially be achieved by the Pebble Project. These demonstrate a robust, long life project which could supply metals important for the US economy for decades. Future analysis would optimize these opportunities. Of note, any future potential expansion scenario must be subjected to Federal and State permitting processes prior to advancing.

25.15 Risks and Opportunities

A number of risks and opportunities are identified throughout the 2021 PEA. This section highlights several of these but is not an exhaustive list nor a summary of those contained in the body of the 2021 PEA.

25.15.1 Opportunities

A number of opportunities exist to enhance the Pebble Project.

25.15.1.1 Resource

- The Pebble property includes a number of opportunities to expand the Mineral Resource estimate through future exploration. The most significant opportunity is obtained in drill hole 6348 which intersected 949 ft with an average grade of 1.24% copper, 0.74 g/t gold and 0.042% molybdenum, or 1.92% CuEq. This drill hole lies east of the ZG1 Fault and follow up drilling of the Cretaceous host rocks to this mineralization has not yet been completed, thereby leaving the extent of this high-grade mineralization unknown.

- Geophysical and geochemical surveys and reconnaissance exploration drilling have identified several targets located well outside the current Pebble resource estimate area that warrant future exploration.

- Elevated levels of palladium, vanadium, titanium and tellurium have been noted in raw analytical data and in metallurgical studies and represent opportunities to further benefit the economics of the Pebble deposit.

25.15.1.2 Mining

The mine plan was developed using conventional mining technology. Three areas which could improve the mining results are:

- Use of trolley-assist haulage. Trolley-assist has been shown at other mines to improve cycle times and engine life, both of which would reduce operating costs. To accomplish this, additional capacity would likely be required for the power plant.

- In-pit crushing. While the mine plan for the expansion scenarios incorporates in-pit crushing, further evaluation for the Proposed Project as well as extending the in-pit crushing for the potential expansion scenarios may prove beneficial.

- Autonomous operation. Mine operations are increasingly moving to autonomous equipment and remote operations centres. These mines have seen real benefits, particularly in remote operation such as envisioned at Pebble.

25.15.1.3 Process

- Flotation. A number of measures have been developed recently which could improve flotation performance at Pebble, including advances in coarse particle flotation. Further analysis of these advances could benefit Pebble.

- Supergene flotation performance. The supergene domains at Pebble contribute a significant portion of the process plant feed during the first several years of operation. Additional testwork and analysis could determine if alternate strategies could be employed to improve recoveries in these zones.

- Pre-sorting. Pre-sorting techniques have become accepted components of many new process plants. A study could be warranted to determine if pre-sorting could enhance Pebble outcomes.

- Gold recovery. Analysis of alternate secondary gold recovery technologies could improve the financial results and enhance the permitting process.

- Molybdenum refinery. The molybdenum concentrate production creates the opportunity to add a molybdenum concentrate refinery to produce a value-added product in Alaska and reduce overall carbon footprint of project by reduced shipping.Concentrate pipeline. Optimization of the concentrate and return water pipeline system could improve the costs of that pipeline system.

25.15.1.4 Infrastructure

- Water treatment. Further detailed analysis of the influent water quality and water treatment schemes may see reductions in complexity and cost.

25.15.1.5 Environment

- Carbon footprint. Evaluation of carbon dioxide capture and sequestration opportunities may reveal an opportunity to reduce the Project's carbon emissions.

25.15.2 Risks

25.15.2.1 Resource

The 2021 PEA includes the use of Inferred Mineral Resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the 2021 PEA results will be realized.

The Mineral Resource estimates may ultimately be affected by a broad range of environmental, permitting, legal, title, socio-economic, marketing and political factors pertaining to the specific characteristics of the Pebble deposit (including its scale, location, orientation and polymetallic nature) as well as its setting (from a natural, social, jurisdictional and political perspective).

Factors that may affect the Mineral Resource estimate include:

- changes to the geological, geotechnical and geometallurgical models as a result of additional drilling or new studies;
- the discovery of extensions to known mineralization as a result of additional drilling;
- changes to the rhenium:molybdenum correlation coefficients and resultant regression equation due to additional drilling;
- changes to commodity prices resulting in changes to the test for reasonable prospects for eventual economic extraction; and
- changes to the metallurgical recoveries resulting in changes to the test for reasonable prospects for eventual economic extraction.

The Mineral Resource estimates contained have not been adjusted for any risk that the required environmental permits may not be obtained for the Pebble Project. The risk associated with the ability of the Pebble Project to obtain required environmental permits is a risk to the reasonable prospects for eventual economic extraction of the mineralisation and the classification of the estimate as a Mineral Resource.

25.15.2.2 Mining

- Pit wall slopes. The pit wall slope assessments were completed to a prefeasibility level of confidence. Additional field work and analysis are required to confirm these designs for operations.

25.15.2.3 Process

- Process recoveries. The metallurgical testwork completed on the Pebble deposit has been extensive but additional work is required to complete a feasibility study and design.

- Deleterious elements. The metallurgical testwork highlighted the low levels of impurity elements in the Pebble feed materials and correspondingly low deportment to saleable products, and likewise the process plant design incorporated no special treatment steps to manage impurities in the feed. There is a risk that pockets of the Pebble deposit will contain elevated levels of deleterious elements that could report to the concentrates products at levels which could incur penalty charges or adversely influence the saleability of the products. Operational controls could avoid these potential impacts.

25.15.2.4 Tailings and water management

- Tailings structures designs. The tailings and water management pond structures designs have been completed to a preliminary level. Significant additional field data and design are required to prepare these structures for construction.

- Alaska dam permitting. The tailings and water management structures will be subject to an extensive design review and permitting process in Alaska. The process could result in changes to the designs.

- Groundwater. Additional field work and analysis are required to confirm specific design criteria for open pit wall and tailings structures.

25.15.2.5 Project Execution

- Weather. Adverse weather conditions and other factors such as pandemics could impact on the construction schedule.

- Labour. The Project construction schedule and operations performance require deployment of sufficient numbers of adequately trained and experienced personnel. Inability to realize this deployment could impact the construction schedule and operational results.

25.15.2.6 Social Issues

- Land tenure. While the Pebble deposit lies within claims on State land, for which there is a defined process to gaining tenure, the transportation corridor crosses land belonging to Native Village Corporations and private individuals and agreements have not been reached with several of these entities. One of the Native Village Corporations has signed an agreement whereby a fund has obtained an option to buy portions of their land to create a conservation easement. The fund must exercise its option by the end of 2022. Closing of this agreement would require the Pebble Partnership to identify an alternate route to a marine terminal on Cook Inlet.

- Project opposition. The Pebble Project is the subject of significant public opposition, in Alaska and elsewhere in the United States.

25.15.2.7 Legal

- Legal actions. Northern Dynasty is party to several class action legal complaints and Pebble Partnership is subject to a government investigation regarding public statements made regarding the project. While these matters do not directly affect the development of the Project they could negatively impact Northern Dynasty's and the Pebble Partnership's ability to finance the development of the Project or the ability to obtain required permitting.

- EPA. The EPA has announced it plans to re-initiate the process of making a CWA Section 404(c) determination for the waters of Bristol Bay, which would set aside the 2019 withdrawal of that action that was based on a 2017 settlement agreement between the EPA and Pebble Partnership. The 2019 withdrawal was contested by Project opponents and is currently subject to ongoing litigation. Such EPA activity could negatively affect the ability of the Pebble Partnership to obtain required permitting and develop the Project.

25.15.2.8 Permitting

- USACE Record of Decision. In November 2020, USACE denied Pebble Partnership's permit application. That decision is currently under appeal but without overturning the ROD, the Proposed Project cannot proceed.

- Bristol Bay Forever. The Bristol Bay Forever was a public initiative approved by Alaskan voters in November 2014. Based on that initiative, development of the Pebble Project requires legislative approval upon securing all other permits and authorizations.

25.15.2.9 Financial results

- Cost estimates. The cost estimates contained in the 2021 PEA are completed to a preliminary level. Additional analysis and engineering are required to confirm these results.

- Metal prices and realization costs. Metal prices and realization costs are subject to significant fluctuation, particularly over the periods identified for the Proposed Project and potential expansion scenarios. These fluctuations may have a significant impact on the financial results of future studies and the actual results achieved by an operating mine.

- Taxation. The project is subject to taxation at three government levels (local, State, and Federal). These tax regimes may change over time, resulting in different results than those identified in the 2021 PEA.

26 RECOMMENDATIONS

26.1 Introduction

A number of actions are recommended to support advancing the Pebble Project should the Pebble Partnership determine further study is warranted.

26.2 Resource

26.2.1 Updating of Inferred Resource

A Mineral Resource used as the basis for a prefeasibility or feasibility study, as defined by NI 43-101, must be classified as Measured or Indicated. A small portion of the Mineral Resource within the Proposed Project is classified as Inferred and this should be upgraded by infill drilling in order to prepare for a future prefeasibility study or feasibility study.

26.2.2 Block Model Update

The block model was recently updated to include rhenium. The model should be further updated as additional data are acquired from drilling to convert Inferred resource to Measured and Indicated and from drilling to collect additional metallurgical information.

26.2.3 Drill Hole 6348

Drill hole 6348 offers compelling exploration potential yet is at a depth which has prevented the completion of holes collared to further test the zone. A scoping level study is recommended to determine the optimum methods of drilling to ensure successful completion of follow up holes.

26.2.4 Additional Metals

Elevated levels of palladium, vanadium, titanium and tellurium have been noted in raw analytical data and in metallurgical studies. A scoping level program is recommended to determine their potential for inclusion in future resource estimates. Such a study would focus on the deportment and distribution of these metals, as well as the best approach to their quantification.

26.2.5 Estimated Resource Update Cost

The estimated cost of the recommended program, including drilling, is $10.2 million.

26.3 Mining

Tetra Tech makes the following recommendations for future mining work:

- Detailed mining production schedule and designs should be developed with all mining activities to understand potential bottlenecks and assess possible cost reduction from technologies such as in-pit crushing and conveying, autonomous trucking, and blast hole drilling, and
- Detailed geotechnical studies should be conducted to better define the appropriate pit slope angles and design parameters for the pit, stockpiles, and overburden stockpiles.
- The estimated cost to complete the recommended work is $8.1 million, including drilling additional geotechnical investigation holes.

26.4 Metallurgy and Processing

26.4.1 Metallurgy Testwork

Future testwork is required to provide additional data to define silver recovery to the copper concentrate, rhenium recovery to the molybdenum concentrate, and precious metals to the gravity concentrate.

Additional analysis and circuit optimization are recommended for treatment of supergene material. This should include collection of additional metallurgical samples from drilling these specific metallurgical domains.

Complete an initial assessment of potential treatment methods of molybdenum concentrates to optimize the value of molybdenum and rhenium.

26.4.2 Grinding Circuit SAG Mill Size

Continued analysis is recommended to determine the optimum grinding circuit configuration

26.4.3 Flotation Circuit Optimization

Coarse particle and column or other means of flotation should be evaluated.

26.4.4 Estimated Metallurgical Program Cost

The estimated cost to complete the recommended metallurgical program, including sample collection, is $8.5 million.

26.5 Infrastructure

26.5.1 Process Plant and Infrastructure Location

Additional studies are necessary to finalize the location of the process plant and related infrastructure. An investigation of the soil conditions should be performed in order to simplify the design of the mill building and major equipment foundations.

The estimated cost of this program is $1 million.

26.5.2 Access Road

Further alignment information, geotechnical detail and aggregate sourcing data will be required to support access road design.

The main access and secondary road alignments and designs need to be refined to better determine issues and costs. Considerations include:

- Right of way and other permit constraints, if any;
- Optimizing the road corridor;
- Road horizontal and vertical alignments, cross-section designs and corresponding earth quantities;
- Design requirements for frost-susceptible, wet rock areas; and
- Concept level bridge general arrangement and profile designs taking into account geotechnical information.

The estimated cost to complete this work is approximately $3.5 million.

26.5.3 Tailings and Waste Disposal

Knight Piésold recommends the following be completed to support the advancement of the Pebble Project permitting case tailings and water management:

- Preparation of a detailed material balance, which includes quantities and timing for construction and closure materials (overburden/growth medium, quarried rock, PAG rock).
- Preparation of a detailed construction execution plan to support the initial construction planning. Complete additional geotechnical investigations to support prefeasibility level TSF and water management designs, such as:
  - Geotechnical infill drilling and sampling in overburden soils and rock;
  - Hydrogeological testing of soil and rock;
  - Test pitting to characterize the surficial geology;
  - Delineation of construction materials and local borrow areas;

- Additional investigations to confirm the bedrock surface below embankment structures: and
- Laboratory testing of samples collected in the field.

- Tailings testwork and tailings consolidation modelling for both TSFs.
- Revise and update the mine plan, watershed and groundwater models as appropriate during future studies.
- Initiate Alaska Dam Safety Program and engage the Independent Review Panel.

The estimated cost to complete this program, including sample collection, is $15 million.

27 REFERENCES

Alaska Department of Fish and Game (ADFG), 2010. 2009 Bristol Bay Area Annual Management Report. Fishery Management Report No. 10-25.

Alaska Department Fish and Game (ADFG), 2013. Anadromous Waters Catalog. https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm

Alaska Department of Fish and Game (ADFG), 2020. Bristol Bay Salmon Escapement (2019). https://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareabristolbay.escapement

Alaska Department of Natural Resources, 2005. Bristol Bay Area Plan for State Lands. http://dnr.alaska.gov/mlw/planning/areaplans/bristol/pdf/bbap_complete.pdf

Alaska Department of Natural Resources - ADNR, June 2005, "Guidelines for Cooperation with the Alaska Dam Safety Program."

Alaska Department of Natural Resources - ADNR, September 2013, "Bristol Bay Area Plan for State Lands (Adopted April 2005, Revised September 2013)"

Alaska Department of Natural Resources - ADNR, July 2017, "Guidelines for Cooperation with the Alaska Dam Safety Program." Draft revision.

Amato, J.M., Foley, C., Heizler, M., and Esser, R., 2007, 40Ar/39Ar and U-Pb geochronology, geochemistry, and tectonic setting of three episodes of Cretaceous-Eocene calc-alkaline magmatism in the Lake Clark Region, southwestern Alaska: in Ridgway, K.D., Trop, J.M., Glen, J.M.G., and O'Neill, J.M., eds., Tectonic Growth of a Collisional Continental Margin: Crustal Evolution of Southern Alaska: Geological Society of America Special Paper 431, p. 455-475.

Anderson, E.D., Hitzman, M.W., Monecke, T., Bedrosian, P.A., Shah, A.K., and Kelley, K.D., 2013, Geological analysis of aeromagnetic data from southwestern Alaska: Implications for exploration in the area of the Pebble porphyry Cu-Au-Mo deposit. Economic Geology, in press.

Bouley, B.A., St. George, P., and Wetherbee, P.K., 1995, Geology and discovery at Pebble Copper, a copper-gold porphyry system in southwest Alaska: in Schroeter, T.G., ed., Porphyry Deposits of the Northwestern Cordillera of North America, CIM Special Volume 46, p. 422-435.

Bundtzen, T.K., and Miller, M.L., 1997, Precious metals associated with Late Cretaceous-early Tertiary igneous rocks of southwestern Alaska: in Goldfarb, R.J., and Miller, L.D., eds., Mineral Deposits of Alaska: Economic Geology Monograph 9, p. 242-286.

CIM, 2003, Best Practices in Uranium Estimation Guidelines

Clark, A.H., 1993, Are outsized porphyry copper deposits either anatomically or environmentally distinctive? Society of Economic Geologists Special Publication 2, p. 213-283.

Couture, J.F., and Siddorn, J., 2007, Technical report on the Whistler Cu-Au exploration project, Alaska Range, Alaska. Available on www.sedar.com, 92 p.

Decker, J., Bergman, S.C., Blodgett, R.B., Box, S.E., Bundtzen, T.L., Clough, J.G., Coonrad, W.L., Gilbert, W.G., Miller, M.L., Murphy, J.M., Robinson, M.S., and Wallace, W.K., 1994, Geology of southwestern Alaska: in Plafker, G., and Berg, H.C., eds., The Geology of Alaska. Geological Society of America, The Geology of North America, v. G-1., p. 285-310.

Detterman, R.L., and Reed, B.L, 1973. Surficial Deposits of the Iliamna Quadrange, Alaska, U.S. Geological Survey Bulletin 1368-A, 64 p.

Detterman, R.L., and Reed, B.L., 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368-B, 86 p.

Foley, J.Y., Light, T.D., Nelson, S.W., and Harris, R.A., 1997, Mineral occurrences associated with mafic-ultramafic and related alkaline complexes in Alaska; in Goldfarb, R.J., and Miller, L.D., eds., Mineral Deposits of Alaska. Economic Geology Monograph 9, p. 396-449.

G & T Metallurgical Services Ltd., 2011. Copper Molybdenum Separation Testing on a Pebble Bulk Concentrate. September 22, 2011.

Gaunt, J.D., Rebagliati, C.M., Lang, J., Titley, E., Melis, L., Barratt, D., and Hodgson, S., 2010, Technical report on the 2009 program and update on mineral resources and metallurgy, Pebble copper-gold-molybdenum project, Alaska. Available on www.sedar.com, 195 p.

Gaunt, J.D., Rebagliati, C.M., Lang, J., Titley, E., and Lu, T., 2014, Technical report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 170 p.

Gaunt, J.D., Lang, J., Titley, E., and Lu, T., 2015, 2014 Technical Report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 182 p.

Gaunt, J.D., Rebagliati, C.M., Lang, J., Titley, E., Lu, T., and Hodgson, S., 2018, Technical report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 191 p.

Gaunt, J.D., Lang, J., Titley, E., Lu, T., and Hodgson, S., 2020, 2020 Technical Report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 239 p.

Gaunt, J.D., Lang, J., Titley, E., Ghaffari, H., and Hodgson, S., 2021, 2021 Technical Report on the Pebble Project, Southwest Alaska, USA. Available on www.sedar.com, 245 p.

Ghaffari, H., Morrison, R.S., de Ruijter, M.A., Živković, A., Hantelmann, T., Ramsey, D., and Cowie, S., 2011, Preliminary Assessment of the Pebble Project, Southwest Alaska, Available on www.sedar.com, 572 p.

Goldfarb, R.J., 1997, Metallogenic evolution of Alaska; in Goldfarb, R.J., and Miller, L.D., eds., Mineral Deposits of Alaska, Society of Economic Geologists Monograph 9, p. 4-34.

Goldfarb, R.J., Hart, C.J.R, and Anderson, E.D., 2013, Regional tectonic framework of the Pebble deposit: Economic Geology, in press.

Gregory, M.J., 2017. A fluid inclusion and stable isotope study of the Pebble porphyry copper-gold-molybdenum deposit, Alaska. Ore Geology Reviews, v. 80, p. 1279-1303.

Gregory, M., and Lang, J., 2009, Hydrothermal controls on copper sulphide speciation, metal distribution and gold deportment in the Pebble porphyry Cu-Au-Mo deposit, southwest Alaska: Proceedings of the 10th Biennial Meeting of the Society for Geology Applied to Mineral Deposits, Townsville, Australia, p. 524-526.

Gregory, M.J., and Lang, J.R., 2011, Controls on Au deportment in the Pebble Cu-Au-Mo porphyry deposit, Alaska: in Williams, P.J., Oliver, N., and Rusk, B., eds., Let's Talk Ore Deposits: Proceedings of the Eleventh Biennial SGA Meeting, Antofagasta, Chile, p. 524-526.

Gregory, M.J., and Lang, J.R., 2012, The Pebble porphyry Cu-Au-Mo deposit, Alaska. Society of Mining Engineers Annual Meeting, Seattle, preprint 12-141.

Gregory, M.J., Lang, J.R., Gilbert, S., and Hoal, K.O., 2013, Geometallurgy of the Pebble copper-gold-molybdenum deposit, Alaska: Implications for gold distribution and paragenesis: Economic Geology, in press.

Gustafson, L.B., and Hunt, J.P., 1975, The porphyry copper deposit at El Salvador, Chile: Economic Geology, v. 70, p. 857–912.

Gustafson, L.B., and Quiroga G., J., 1995, Patterns of mineralization and alteration below the porphyry copper orebody at El Salvador, Chile: Economic Geology, v. 90, p. 2-16.

Haeussler, P.J., and Saltus, R.W., 2005, 26 km of offset on the Lake Clark fault since late Eocene time: U.S. Geological Survey, Professional Paper 1709A, 4 p.

Haeussler, P.J., and Saltus, R.W., 2011, Location and Extent of Tertiary Structures in Cook Inlet Basin, Alaska, and Mantle Dynamics that Focus deformation and Subsidence, in Dumoulin, J.A., and Galloway, J.P., eds., Studies by the U.S. Geological Survey in Alaska 2008–2009: U.S. Geological Survey Professional Paper 1776–D, 26 p.

Hamilton, T., and Klieforth, R.F., 2010, Surficial geologic map of parts of the D-6 and D-7 quadrangles, Pebble project area, southwestern Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2009-4, 19 p.

Hames, B.P., and Roberts, M.D. (2020). The Whistler porphyry Au-Cu deposit, Alaska. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press.

Hampton, B.A., Ridgway, K.D., and Gehrels, G.E., 2010, A detrital record of Mesozoic island arc accretion and exhumation in the North American Cordillera: U-Pb geochronology of the Kahiltna basin, southern Alaska: Tectonics, v. 29, TC4015, doi:10.1029/2009TC002544, 21p.

Hanley, J., Kerr, M., LeFort, D., Warren, M., Mackenzie, M., and Sedge, C., 2020, Platinum-group element (PGE) enrichment in alkalic porphyry Cu-Au deposits in the Canadian cordillera: new insights from mineralogical and fluid inclusion studies. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press.

Harraden, C.L., McNulty, B.A., Gregory, M.J., and Lang, J.R., 2012, Shortwave infrared spectral analysis of hydrothermal alteration associated with the Pebble porphyry copper-gold-molybdenum deposit, Iliamna, Alaska, USA: Economic Geology, in press.

Hart CJR, 2010. Intrusive rocks associated with the Pebble porphyry Cu-Au-Mo deposit, southwest Alaska. GSA Denver annual meeting abstract 182738.

Hart, C.J., Lang, J.R., Goldfarb, R.J., and Farmer, G.L., 2010, Intrusive rocks associated with the Pebble porphyry Cu-Au-Mo deposit, southwest Alaska. Geological Society of America Abstracts with Programs, v. 42, p. 676.

Haslinger, R.J., Payne, J.G., Price, S., and Rebagliati, C.M., 2004, 2003 Summary report on the Pebble porphyry gold-copper project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com, 119 p.

Hawley, C., 2004 Alaska resource data file, Iliamna quadrangle, Alaska: U.S. Geological Survey Open-File Report 2004-105, 118 p.

Haynes, F.H., and Titley, S.R., 1980, The evolution of fracture-related permeability within the Ruby Star Granodiorite, Sierrita porphyry copper deposit, Pima County, Arizona: Economic Geology, v. 75, p. 673-683.

Iriondo, A., Kunk, M.J., and Wilson, F.H., 2003, 40Ar/39Ar geochronology of igneous rocks in the Taylor Mountains and Dillingham quadrangles in SW Alaska: U.S. Geological Survey Open-File Report 03-0421.

John, D.A., Ayuso, R.A., Barton, M.D., Blakely, R.J., Bodnar, R.J., Dilles, J.H., Gray, F., Graybeal, F.T., Mars, J.C., McPhee, D.K., Seal, R.R., Taylor, R.D., and Vikre, P.G., 2010, Porphyry copper deposit model, chapter B of Mineral Deposit Models for Resource Assessment. U.S. Geological Survey, Scientific Investigations Report 2010-5070-B, 169 p.

John, D.A., Seal, R.R., II, and Polyak, D.E., 2017, Rhenium, chapter P of Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C. (eds.), Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply. U.S. Geological Survey Professional Paper 1802, p. P1–P49

Jones, M. et al, 2012. 2012 Bristol Bay Area Management Report No. 13-20.

Kalbas, J.L., Ridgeway, K.D., and Gehrels, G.E., 2007, Stratigraphy, depositional systems, and provenance of the Lower Cretaceous Kahiltna assemblage, western Alaska Range: Basin development in response to oblique collision: in Ridgeway, K.D., Trop, J.M., Glen, J.M.G, Evolution of Southern Alaska: Geological Society of America Special Paper 431, p. 307-344.

Kelley, K.D., Eppinger, R.G., Lang, J., Smith, S.M., and Fey, D.L., 2011, Porphyry Cu indicator minerals in till as an exploration tool: example from the giant Pebble porphyry Cu-Au-Mo deposit, Alaska: Geochemistry: Exploration, Environment, Analysis, v. 11, p. 321-334.

Khashgerel, B., Rye, R.O., Kavalieris, I, and Hayashi, K., 2009, Thesericitic to advanced argillic transition: Stable isotope and mineralogical characteristics from the Hugo Dummett porphyry Cu-Au deposit, OyuTolgoi district, Mongolia: Economic Geology, v. 104, p. 1087-1110.

Knight Piésold Ltd (KP), 2020. Pebble Project – Water Balance and Water Quality Model Report. VA101 176/60-3, Rev. 1, January 2020.

Koehler, R.D., and Reger, R.D., 2011, Reconnaissance evaluation of the Lake Clark fault, Tyonek area, Alaska. State of Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys, PRELIMINARY INTERPRETIVE REPORT 2011-1, 10 p.

Koehler, R.D., 2010, Technical review of a trench across a potential fault scarp feature east of lower Talarik Creek, Lake Iliamna area, southwestern Alaska. State of Alaska Department of Natural Resources, Alaska Division of Geological & Geophysical Surveys, MISCELLANEOUS PUBLICATION 139, 12 p.

Kreiner, D.C., Jones III, J.V., Kelley, K.D., and Graham, G.E. (2020). Tectonic and magmatic controls on the metallogenesis of porphyry deposits in Alaska. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press.

Kremenetskii, A.A., Popov, V.S., and Gromalova, N.A., 2012, The formation age of ores from the Pebble Cu-Au-Mo giant deposit (Alaska, United States). Doklady Earth Sciences, v. 442, part 2, p. 196-201.

Lang, J.R., Gregory, M.J., Rebagliati, C.M., Payne, J.G., Oliver, J.L., and Roberts, K., 2013, Geology and magmatic-hydrothermal evolution of the giant Pebble porphyry copper-gold-molybdenum deposit, southwest Alaska, USA. Economic Geology, v. 108, 437-462.

Lang, J.R., Rebagliati, C.M., Roberts, K., and Payne, J.G., 2008, The Pebble copper-gold-molybdenum porphyry deposit, southwest Alaska USA: Proceedings of PACRIM 2008, AUSIMM, p. 27-32.

Lang, J.R., Stanley, C.R., and Thompson, J.F.H., 1995, Porphyry copper-gold deposits related to alkalic igneous rocks in the Triassic-Jurassic arc terranes of British Columbia. In: Pierce, F.W, and Bolm, J.G., eds., Porphyry Copper Deposits of the American Cordillera. Arizona Geological Society Digest, v. 20, p. 219-236.

McCandless, T.E., Ruiz, J., and Campbell, A.R., 1993, Rhenium behaviour in molybdenite in hypogene and near-surface environments: Implications for Re-Os Geochronometry: Geochimicaet Cosmochimica Acta, v. 57, p. 889-905.

McClelland, W.C., Gehrels, G.E., and Saleeby, J.B., 1992, Upper Jurassic-Lower Cretaceous basinal strata along the Cordilleran Margin: Implications for the accretionary history of the Alexander-Wrangellia-Peninsular Terrane: Tectonics, v. 11, p. 823-835.

McFall, K.A., Naden, J., Roberts, S., Baker, T., Spratt, J., and McDonald, I., 2018, Platinum-group minerals in the Skouries Cu-Au (Pd, Pt, Te) porphyry deposit. Ore Geology Reviews, v. 99, p. 344-364.

Meyer, C., and Hemley, J.J., 1967, Wall rock alteration. In: Barnes, H.L., ed., Geochemistry of hydrothermal ore deposits: New York, Holt, Rhinehart and Winston, p. 166-235.

Mine Environmental Neutral Drainage Program, 1991. Acid Road Drainage Prediction Manual, MEND Project 1.16.1b, CANMET – MSL Division, Department of Energy, Mines and Resources, Canada.

Nicholson Analytical Consulting, 2009, QA/QC Report 2008 Drilling Program Pebble Project, Unpublished company report. October 29, 2009.

Olson, N.H. (2015). The geology, geochronology, and geochemistry of the Kaskanak batholith, and other Late Cretaceous to Eocene magmatism at the Pebble porphyry Cu-Au-Mo deposit, SW Alaska. Unpublished M.Sc thesis, Oregon State University.

Olson, N.H., Dilles, J.H., Kent, A.J.R., and Lang, J.R. (2017). Geochemistry of the Cretaceous Kaskanak batholith and genesis of the Pebble porphyry Cu-Au-Mo deposit, Southwest Alaska. American Mineralogist, v. 102, p. 1597–1621.

Olson, N.H., Lang, J.R., and Dilles, J.H. (2020). The Pebble porphyry Cu-Au-Mo deposit, southwestern Alaska. In Sharman, E.R., Lang, J.R., and Chapman, J.B. (Eds.) Porphyry Deposits of the Northwestern Cordillera of North America: A 25-Year Update. Canadian Institute of Mining and Metallurgy Special Volume 57. Montreal, QC: Canadian Institute of Mining, Metallurgy and Petroleum. In Press

Outotec (Canada) Ltd., 2010. Outotec Thickener Interpretations and Recommendations for Test Data. Report TH-0493, Pebble Project, April 9, 2010.

Outotec (Canada) Ltd., 2010. Outotec Thickener Interpretations and Recommendations for Test Data. Report TH-0497, Pebble Project. June 17, 2010.

Pavlis, T.L., Sisson, V.B., Foster, H., Nokleberg, W.J., and Plafker, G., 1993, Constraints on crustal extension in the western Yukon-Tanana terrane, central Alaska: Tectonics, v. 12, p. 103-122.

Phillips, C.H., Gambell, N.A., and Fountain, D.S., 1974, Hydrothermal alteration, mineralization and zoning in the Ray deposit: Economic Geology, v. 69, p. 1237-1250.

Plafker, G., and Berg, H.C., 1994, Overview of the geology and tectonic evolution of Alaska: in Plafker, G., and Berg, H.C., eds., The Geology of Alaska: Geological Society of America, The Geology of North America, v. G-1, p. 989-1021.

PLP (Pebble Limited Partnership), 2012. Pebble Project Environmental Baseline Document 2004 through 2008. Pebble Limited Partnership, Anchorage, AK PLP, 2018. Pebble Project Supplemental Environmental Baseline Document. Pebble Limited Partnership Anchorage, AK PLP, 2020. Pebble Project Description. POA-2017-271 Updated May 2020 Rebagliati, C.M., and Haslinger, R.J., 2003, Summary report on the Pebble copper-gold porphyry project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.94 p.

Rebagliati. C.M. and Haslinger, R.J., Payne, J.G., and Price, C.M., 2004. Technical Report on the Pebble Project. May 2004.

Rebagliati, C.M., Payne, J.G., and Lang, J.R., 2005, 2004 summary report on the Pebble porphyry gold-copper project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.79 p.

Rebagliati, C.M., and Payne, J.G., 2006, 2005 summary report on the Pebble porphyry copper-gold project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.111 p.

Rebagliati, C.M., and Payne, J.G., 2007, 2006 summary report on the Pebble porphyry copper-gold-molybdenum project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com.119 p.

Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Melis, L., Barratt, D., and Hodgson, S., 2010, Technical report on the 2009 program and update on mineral resources and metallurgy, Pebble copper-gold-molybdenum project, Iliamna Lake area, southwestern Alaska, USA. Available on www.sedar.com, 194 p.

Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Rennie, D., Melis, L., Barratt, D., and Hodgson, S., 2008, Technical report on the 2007 program and updates on metallurgy and resources. Available on www.sedar.com.

Rebagliati, C.M., Lang, J.R., Titley, E., Gaunt, J.D., Rennie, D., Melis, L., Barratt, D., and Hodgson, S., 2009, Technical report on the 2008 program and updates on mineral resources and metallurgy. Available on www.sedar.com.

Rebagliati, M., and Lang, J., 2009, The Pebble porphyry copper-gold-molybdenum discovery, Alaska, USA. Conference Proceedings, New GenGold 2009, Case Histories of Discoveries, Perth, p. 121-132.

Reed, B.L., and Lanphere, M.A., 1973, Alaska-Aleutian Range batholith: Geochronology, chemistry, and relation to circum-Pacific plutonism: Geological Society of America Bulletin, v. 84, p. 2583-2610.

Rombach, C., and Newberry, R., 2001, Shotgun deposit: Granite porphyry-hosted gold-arsenic mineralization in southwestern Alaska, USA: Mineralium Deposita, v. 36, p. 607-621.

Schrader, C.M., 2001, Geochronology and geology of the Pebble Cu-Au-Mo porphyry and the Sill Au-Ag epithermal deposits, southwest Alaska. Unpublished M.Sc thesis, University of Georgia, Athens, 109 p.

Seedorff, E., Dilles, J.H., Proffett, J.M., Einaudi, M.T., Zurcher, L., Stavast, W.J.A., Johnson, D.A., and Barton, M.D., 2005, Porphyry deposits: Characteristics and origin of hypogene features: in Hedenquist, J.W., Thompson, J.F., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology 100thAnniversary Volume, 1905-2005. Society of Economic Geologists, p. 251-298.

SGS-Lakefield Research Ltd., 2010. An Investigation into the Pebble East and Pebble West Metallurgical Programs. Project #12072-002 Final Report, May 3, 2010.

SGS-Lakefield Research Ltd., 2010. An Investigation into the Recovery of Copper, Gold, and Molybdenum from Samples from Pebble East and West Deposits. Project #12072-002-Report #2, May 10, 2010.

SGS-Lakefield Research Ltd., 2014. A Summary of Pebble East and West Metallurgical Programs. September 5, 2014.

SGS-Lakefield Research Ltd., 2010. An Investigation into the Recovery of Copper, Gold, and Molybdenum from Samples from Pebble East and West Deposits. Project #12072-003/007-Report #3 Rev 1, September 24, 2014.

Shah, A., Bedrosian, P., Anderson, E., Kelley, K., and Lang, J., 2009, Geophysical data used to characterize the regional setting of the Pebble porphyry deposit in southwest Alaska: Geological Society of America Annual Meeting, Program with Abstracts, v. 41, p. 493.

Sillitoe, R.H., 2010, Porphyry copper systems: Economic Geology, v. 105, p. 3-41.

Sinclair, W.D., Jonasson, I., Kirkham, R.V., and Soregaroli, A.E., 2009, Rhenium and other platinum-group metals in porphyry deposits. Geological Survey of Canada, Open File 6181.

SME Mineral Processing &Extractive Metallurgy Handbook, 2018 Review of MAP Development Work, Dreisinger Consulting Inc., September 16, 2012

Srivastava, M, 2020 Prediction of Missing Rhenium for Pebble, 2020, Internal Company Memo

St. George, P., Wetherbee, P.K., Buddington, A.M., Samson, D.P., 1992, Pebble Copper Project 1991 Progress Report, Cominco Alaska, Unpublished Company Report, February 1992.

SRK Consulting (Canada) Inc., Pebble Project, 2012 Pre-Feasibility Pit Slop (Rock) Design, Progress Report, 2nd Draft.

Wallace WK, Hanks CL and JF Rogers, 1989, The southern Kahiltna terrane: Implications for the tectonic evolution of southwestern Alaska. GSA Bulletin 101, 1389-1407.

Wallace, W.E., Hanks, C.L., and Rogers, J.F., 1989, The southern Kahiltna terrane: Implications for the tectonic evolution of southwestern Alaska: Geological Society of America Bulletin, v. 101, p. 1389-1407.

Young, L.E., St. George, P., and Bouley, B.A., 1997, Porphyry copper deposits in relation to the magmatic history and palinspastic restoration of Alaska: in Goldfarb, R.J., and Miller, L.D., eds., Mineral Deposits of Alaska: Society of Economic Geologists Monograph 9, p. 306-333.

Websites

SEDAR (System for Electronic Document Analysis and Retrieval): www.sedar.com

US Army Corps of Engineers, 2020. Pebble Project EIS Final Impact Statement. Department of the Army. Alaska District. July 2020 U.S. Fish and Wildlife Service, Culvert Design Guidelines for Ecological Function, U.S. Fish and Wildlife Service Alaska Fish Passage Program, Revision 5, February 5th, 2020

US Geological Survey (USGS), 2013. Watershed Boundary Dataset. https://www.usgs.gov/core-science-systems/ngp/national-hydrography/watershed-boundary-dataset

US Geological Survey (USGS), 2017. Rhenium, Chapter P of Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply. https://pubs.usgs.gov/pp/1802/p/pp1802p.pdf

US Geological Survey (USGS), 2021. Mineral Commodity Summaries, January 2021. https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-rhenium.pdf

State of Alaska, Department of Labor and Workforce Development, January 18, 2013 Press Release No. 13.

28 DATE AND SIGNATURE PAGE

CERTIFICATE OF QUALIFIED PERSON
Robin Kalanchey, P. Eng.

To accompany the technical report entitled: "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA" prepared for Northern Dynasty Minerals Ltd. (the "Issuer"), with an effective date September 9, 2021 (the "Technical Report").

I, Robin Kalanchey, P.Eng., do hereby certify that:

1. I am a Professional Engineer, employed as Vice President, Transportation and Logistics with Ausenco Engineering Canada Inc., with an office at 855 Homer Street, Vancouver, BC V6B 2W2.
2. I am a graduate of University of British Columbia with a Bachelor of Applied Science degree in Metals and Materials Engineering, 1996.
3. I am a Professional Engineer in good standing, registered with the Association of Professional Engineers and Geoscientists of Alberta, member number 61986, and with the Engineers and Geoscientists British Columbia, registration number 53123.
4. I have practiced my profession continuously since 1996 and have been involved multiple projects for the recovery of base and precious metals, in numerous countries and jurisdictions including the United States of America. I have recognized expertise in mineral process and metallurgical testing, I process plant design and engineering, and mining project evaluation for cobalt, copper, gold, nickel, molybdenum, silver and zinc deposits.
5. As of the date of this Technical Report, I had not visited the property.
6. I have read the definition of "qualified person" set out in National Instrument 43-101 Standards of Disclosure for Mineral Projects ("NI 43-101") and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43-101.
7. As a qualified person, I am independent of the Issuer as defined in Section 1.5 of NI 43-101.
8. I am a co-author of the Technical Report, responsible for sections 1.14, 17, 18.7 18.8, 18.9 and 25.8 and co-responsible for sections 1.15, 1.18, 1.20-1.23, 2.5, 12, 21.1-21.3, 24.1, 24.2, 25.9, 25.12, 25.14 and 25.15, 26.4, 26.5 and 27 of the Technical Report, and I accept professional responsibility for those sections of the Technical Report.
9. I have not had prior involvement with the subject property.
10. As of the date of this certificate, to the best of my knowledge, information and belief, the portions of the Technical Report for which I am responsible contain all scientific and technical information that is required to be disclosed to make the portions of the Technical Report for which I am responsible not misleading.
11. I have read NI 43-101 and Form 43-101F1, and the Technical Report has been prepared in compliance with NI 43-101 and Form 43-101F1.

Dated this 22 day of October, 2021 in Vancouver, B.C., Canada.

"Signed and sealed"

Robin Kalanchey, P. Eng

Vice President, Transportation and Logistics

Ausenco Engineering Canada Inc.

CERTIFICATE OF QUALIFIED PERSON
Hassan Ghaffari, P. Eng.

I, Hassan Ghaffari, P.Eng., M.A.Sc. do hereby certify:

1. I am a Director of Metallurgy with Tetra Tech Inc. with a business address at Suite 1000, 10th Floor, 885 Dunsmuir Street, Vancouver, BC, V6C 1N5.
2. This certificate applies to the technical report entitled "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021 (the "Technical Report").
3. I am a graduate of the University of Tehran (M.A.Sc., Mining Engineering, 1990) and the University of British Columbia (M.A.Sc., Mineral Process Engineering, 2004).
4. I am a member in good standing of the Engineers and Geoscientists British Columbia (#30408).
5. My relevant experience includes 30 years of experience in mining and mineral processing plant operation, engineering, project studies and management of various types of mineral processing, including hydrometallurgical mineral processing for porphyry mineral deposits.
6. I am a "Qualified Person" for the purposes of National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101) for those sections of the Technical Report that I am responsible for preparing.
7. I conducted a personal inspection of the Pebble Property on September 1 and 2, 2010.
8. I am responsible for Sections 1.11, 13.1-13.8, 13.10, and 25.5, and jointly responsible for sections 1.22, 1.23, 2.5, 12, 13.9, 25.15, 26.4 and 27 of the Technical Report.
9. I am independent of Northern Dynasty Minerals Ltd. as independence is defined by Section 1.5 of NI 43-101.
10. I have had previous involvement with the Pebble property that is the subject of the Technical Report, in acting as a Qualified Person for the "Preliminary Assessment of the Pebble Project, southwest Alaska" with an effective date of February 15, 2011 and for the "2021 Technical Report on the Pebble Project, Southwest Alaska, USA", with an effective date of February 24, 2021.
11. I have read NI 43-101 and the sections of the Technical Report that I am responsible for have been prepared in compliance with NI 43-101.
12. As of the date of this certificate, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the technical report not misleading.

Dated this 21st day of October, 2021

"Signed and sealed"

Hassan Ghaffari, P. Eng., M.Sc.
Director of Metallurgy
Tetra Tech Inc.

CERTIFICATE OF QUALIFIED PERSON
Sabry Abdel Hafez, PhD, P. Eng.

I, Sabry Abdel Hafez, PhD, P.Eng., do hereby certify that:

1. I am a senior mining engineer with Tetra Tech Canada Inc. with a business address at Suite 1000, 10th Floor, 885 Dunsmuir Street, Vancouver, BC, V6C 1N5.
2. This certificate applies to the technical report entitled "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021 (the "Technical Report").
3. I am a graduate of Assiut University (B.Sc Mining Engineering, 1991; M.Sc. in Mining Engineering, 1996; Ph.D. in Mineral Economics, 2000).
4. I am a member in good standing of Engineers and Geoscientists British Columbia, License number 34975.
5. My relevant experience includes 25 years of experience in the evaluation of mining projects, advanced financial analysis, and mine planning and optimization. I have been involved in the technical studies of several base metals, gold, silver, and aggregate mining projects in Canada and abroad.
6. I have read the definition of "qualified person" set out in National Instrument 43-101 and certify that by reason of my education, affiliation with a professional association, as defined by NI 43-101, and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purpose of NI 43-101.
7. I conducted a personal inspection of the Pebble Property on December 10, 2013.
8. I am responsible for Sections 1.13, 15, 16, 21.3.4, 24.1.7, 25.7 and 26.3, and co-responsible for Sections 1.18, 1.20, 1.21, 1.22, 1.23, 2.5, 12, 21.1, 21.2, 24.2, 25.12, 25.14, 25.15 and 27 of the Technical Report.
9. I am independent of Northern Dynasty Minerals Ltd. as independence is defined by Section 1.5 of NI 43-101.
10. I have had prior involvement with the Pebble property that is the subject of the Technical Report in multiple internal studies since 2012.
11. I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.
12. As of the date of this certificate, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 21st day of October, 2021

"Signed and sealed"

Sabry Abdel Hafez, PhD, P.Eng.

CERTIFICATE OF QUALIFIED PERSON
Les Galbraith, P. Eng., P.E.

I, Les Galbraith, of Vancouver, British Columbia, do hereby certify that:

1. I am a Specialist Engineer | Associate with Knight Piésold Ltd. with a business address at Suite 1400 – 750 West Pender Street, Vancouver. B.C. V6C 2T8. Telephone: 604-685-0543, lgalbraith@knightpiesold.com
2. This certificate applies to the technical report entitled, "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021, (the "Technical Report").
3. I am a graduate of the University of British Columbia, B.A.Sc. (Civil Engineering), graduating in 1995.
4. I am a member in good standing of the Engineers and Geoscientists of British Columbia (#25493) and the State of Alaska Board of Registration for Architects, Engineers and Land Surveyors (#129941).
5. I have practiced my profession continuously since graduation. I have over 25 years of relevant experience in providing waste and water management engineering support to mining projects.
6. I have read the definition of "qualified person" set out in National Instrument 43-101 (NI 43-101) and certify that, by reason of my education, affiliation with a professional association (as defined in NI 43 101) and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43 101.
7. I am responsible for Sections 18.3, 18.4, 21.3.5, 24.1.8, 26.5.3 and co-responsible for Sections 1.15, 1.18, 1.21, 1.23, 2.5, 12, 21.1, 21.2, 24.2, 25.9, 25.15, and 27 of the report.
8. I have visited the Pebble Project numerous times, most recently on June 26, 2013.
9. I am independent of the Issuer as defined by Section 1.5 of the Instrument.
10. I have had prior involvement with the Pebble Project.
11. I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.
12. As of the effective date of the Technical Report, to my knowledge, information, and belief, this Technical Report or sections that I am responsible for, contain all scientific and technical information that is required to be disclosed to make the technical report not misleading.

Dated this 21st day of October, 2021

"Signed and sealed"

Les Galbraith, P.Eng., P.E.

CERTIFICATE OF QUALIFIED PERSON

David Gaunt, P. Geo.

I, J. David Gaunt, P.Geo., certify that:

1. I am a Professional Geologist with an office at 14th Floor, 1040 West Georgia St. Vancouver, British Columbia. Telephone: 604-684-6365 Fax: 604-662-8956, davidgaunt@hdimining.com
2. This certificate applies to the technical report entitled "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021 (the "Technical Report").
3. I am a member in good standing of the Engineers and Geoscientists British Columbia, registration No.20050.
4. I am a graduate of Acadia University, Nova Scotia (B.Sc., Geology, 1985).
5. I have practiced my profession continuously since graduation and have been involved in mineral exploration and resource estimation for precious and base metals in Canada, USA, Mexico, Argentina, Chile, Australia, Spain, Hungary, Afghanistan, China, and South Africa. I have previous experience with intrusion related copper-gold deposits, notably Veladero, and Pebble.
6. As a result of my qualifications and experience I am a Qualified Person as defined in National Instrument 43–101.
7. I have visited the Pebble Project several times, most recently on September 1st and 2nd, 2010. I am responsible for sections 1.12, 6.3, 6.5, 14, 25.6 and 26.2 and jointly responsible for sections 1.8, 1.21, 1.22 and 1.23, 2.5, 3.2, 3.3, 12, 25.15 and 27 of this Technical Report.
8. I am not independent of the issuer, Northern Dynasty Minerals Ltd. as independence is described by Section 1.5 of NI 43–101.
9. I have been involved with the Pebble Project since 2001 and have been involved in the resource estimates relating to Pebble since 2001. I have had previous involvement with the Pebble Project as an author of technical reports in 2021, 2020, 2018, 2014, 2010, 2009 and 2008.
10. I have read National Instrument 43-101and the sections of the Technical Report for which I am responsible have been prepared in compliance with that Instrument.
11. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections for which I am responsible, contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 21st day of October, 2021

"Signed and sealed"

J. David Gaunt, P.Geo.

CERTIFICATE OF QUALIFIED PERSON
Eric D. Titley, P. Geo.

I, Eric D. Titley, P.Geo., do hereby certify that:

1. I am the Senior Manager, Resource Geology, with an office at 14th Floor – 1040 West Georgia Street, Vancouver, British Columbia, Canada, V6E 4H1, Tel. 604-684-6365, Email: EricTitley@hdimining.com.
2. This certificate applies to the technical report entitled "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021 (the "Technical Report")
3. I am a Professional Geoscientist registered with Engineers and Geoscientists British Columbia, license number 19518.
4. I am a graduate of the University of Waterloo, Waterloo, Ontario with a Bachelor of Science degree in Earth Sciences (geography minor) in 1980.
5. I have practiced my profession continuously since graduation on mineral exploration projects in Canada, the United States, Mexico, South Africa, Poland, Brazil, Chile, Ireland and Australia. I have considerable experience related to geological data management and QAQC on mineral exploration projects, including porphyry copper deposits such as Pebble.
6. I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43101") and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43-101.
7. I conducted a site visit of the Pebble Project on the 20th of September, 2011.
8. I am the author of sections 6.2 and 11, and jointly responsible for sections 1.8, 1.10, and 1.22, 2.5, 10, 12, 25.4 and 27 of the Technical Report
9. I am not independent of Northern Dynasty and affiliated companies applying the tests in section 1.5 of National Instrument 43-101.
10. I have had prior involvement with the Pebble Project as an author of technical reports in Gaunt et al., (2021), Gaunt et al., (2020), Gaunt et al., (2018), Gaunt et al., (2014), Rebagliati et al., (2010), Rebagliati et al., (2009) and Rebagliati et al., (2008) and ongoing review of the drilling database.
11. I have read National Instrument 43-101, and the sections of the Technical Report for which I am responsible have been prepared in compliance with that Instrument.
12. At the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report for which I am responsible, contain all the scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 21st day of October, 2021

"Signed and sealed"

Eric D. Titley, P.Geo

CERTIFICATE OF QUALIFIED PERSON
Stephen Hodgson, P. Eng.

I, Stephen Hodgson, P.Eng., do hereby certify that:

1. I am an engineer with Hunter Dickinson Services Inc., with a business office at Suite 1400-1040 West Georgia Street, Vancouver, British Columbia V6E 4H1 Email: stephenhodgson@hdimining.com. I am also an officer of Northern Dynasty Minerals Ltd.
2. This certificate applies to the technical report entitled "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021 (the "Technical Report").
3. I am a graduate of the University of Alberta (B.Sc, Mineral Engineering, Mining, 1976).
4. I am a member in good standing of Engineers and Geoscientists British Columbia, License number 18501.
5. I have practiced my profession continuously since graduation in mine operations in Canada and the United States, as a consulting mining engineer in Canada, the United States, Peru, Chile, Vietnam, Venezuela, Kyrgyzstan, Australia, New Caledonia, South Africa, Russia, and Mongolia, and as a Vice President of Engineering in the United States. I have considerable experience related to project development and operations, including porphyry copper deposits such as Pebble.
6. I have read the definition of "qualified person" set out in National Instrument 43-101 and certify that by reason of my education, affiliation with a professional association, as defined by NI 43-101, and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purpose of NI 43-101.
7. I visited the Pebble Project numerous times, most recently on October 17 and 18, 2019.
8. I am responsible for Sections 1.1-1.6, 1.16, 1.17 and 1.19, 2.1-2.4 and 2.6-2.8, 4, 5, 6.4, 18.1, 18.2, 18.5-18.7, 19, 20, 22, 25.1, 25.5, 25.13 and 26.1, and co-responsible for Sections 1.15, 1.18, 1.20-1.23, 2.5, 3, 12, 18.9, 21.1-21.3, 24.1, 24.2, 25.9, 25.12, 25.14 and 25.15, 26.5 and 27 of the Technical Report.
9. I am not independent of the issuer, Northern Dynasty Minerals Ltd, applying the tests in section 1.5 of National Instrument 43-101.
10. I have had prior involvement with the Pebble Project. I have provided engineering and management services for Northern Dynasty on the project since 2005 and am involved with ongoing review of engineering work related to the Pebble Project. I have co-authored technical reports in 2021, 2020, 2018, 2014, 2010, 2009 and 2008.
11. I have read the Instrument and the sections of the Technical Report that I am responsible for have been prepared in compliance with the Instrument.
12. As of the effective date of the Technical Report, to the best of my knowledge, information and belief, the sections of the Technical Report that I am responsible for contain all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 21st day of October, 2021

"Signed and sealed"

Stephen Hodgson, P.Eng.

CERTIFICATE OF QUALIFIED PERSON
James R. Lang, PhD., P. Geo.

I, James R. Lang Ph.D, P.Geo., of Naramata, British Columbia, Canada, do hereby certify that:

1. I am consultant to Hunter Dickinson Services Inc., 14th floor, 1040 West Georgia Street Vancouver, British Columbia, V6E4H1.
2. This certificate applies to the technical report titled "Preliminary Economic Assessment NI 43-101 Technical Report, Pebble Project, Alaska, USA", effective date September 9, 2021 (the "Technical Report")
3. I am a registered member of Engineers and Geoscientists British Columbia, Registration Number 25376.
4. I graduated with a B.Sc. in geology from Michigan State University, East Lansing, Michigan, USA in 1983, and received M.Sc. and PhD degrees in economic geology from the University of Arizona, Tucson, Arizona, USA in 1986 and 1991, respectively.
5. I have worked as an economic geologist for 35 consecutive years, focused on porphyry copper deposits in the Cordillera of North America where I have conducted applied and academic research and exploration for numerous companies in the mineral sector.
6. I have read the definition of "qualified person" set out in National Instrument 43-101 ("NI 43-101") and certify that by reason of my education, affiliation with a professional association (as defined by NI 43-101) and past relevant work experience, I fulfill the requirements to be a "qualified person" for the purposes of NI 43-101.
7. I have been physically present at the project area every year from 2003 to 2019 for a total of over 650 days. From 2007 through 2010, I acted as resident Chief Geologist for the project. My most recent visit was in September 2019.
8. I am solely responsible for sections 1.7, 1.9, 6.1, 7, 8, 9, 23 and 25.3 and am jointly responsible for sections 1.8, 1.10 and 1.22, 2.5, 10, 12, 13.9, 25.4 and 27 of this report.
9. I have had prior involvement with the property as an author of technical reports in 2021, 2020, 2018, 2014, 2010, 200, 2008 and 2005.
10. I am not independent of the issuer, Northern Dynasty Minerals Ltd., applying all tests in Section 1.5 of National Instrument 43-101.
11. I have read National Instrument 43-101 and this Technical Report has been prepared in compliance with that Instrument.
12. At the effective date of the Technical Report, to the best of my knowledge, information and belief, or part that I am responsible for, contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 21st day of October, 2021,

"Signed and sealed"

James R. Lang, Ph.D., P.Geo.