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NORTHERN DYNASTY MINES INC.
PEBBLE PROJECT

TAILINGS IMPOUNDMENT G
INITIAL APPLICATION REPORT
(REF. NO. VA101-176/16-12)

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EXECUTIVE SUMMARY

The Pebble Project is a proposed copper-gold-molybdenum mine, processing facility and associated Tailings Storage Facility (TSF) located latitude 59°53'54" and longitude 155°17'44" in the Bristol Bay region of southwest Alaska, approximately 238 miles southwest of Anchorage and 17 miles northwest of the Village of Iliamna. It is situated within Iliamna D6 and D7 topographic maps in Townships 3 to 5 South, Ranges 34 to 37 West in the Seward Meridian. Northern Dynasty Mines Inc., the project owner, is developing the project, and has engaged Knight Piésold Ltd. to design the TSF, which includes the staged construction of confining dams.

The procedures for applications to construct a dam are outlined in Chapter 5 of the Guidelines for Cooperation with the Alaska Dam Safety Program, dated June 2005, (the "Guidelines") published by the Dam Safety and Construction Unit, Water Resources Section, Division of Mining, Land and Water Resources of the Alaska Department of Natural Resources. This report constitutes the Initial Application Package for submission under the Alaska Dam Safety Program as the first step towards receipt by Northern Dynasty Mines Inc. of a Certificate of Approval to Construct a Dam.

The proposed impoundment will incorporate two embankment structures in an Unnamed Tributary (NK1.190) situated near the headwaters of the North Fork Koktuli River as follows:

- A main starter dam that will be progressively raised in a series of staged expansions to an ultimate height of 450 feet,
- A lower saddle dam will be constructed in stages to an ultimate height of 175 feet to provide for storage capacity during the latter years of operation.

Knight Piésold Ltd. has carried out a Hazard Potential Classification of the dams, based on the classifications set out in the Guidelines. The resulting preliminary classification for each of the dams is Class II (Significant). However, Northern Dynasty Mines Inc. is planning to incorporate more stringent design criteria for flood and earthquake events consistent with a Class I (High) classification.

This report provides a project description; an assessment of the site characteristics with respect to hydrometeorology, seismicity and geology; an overview of comprehensive siting studies carried out to date; a description of the preliminary design basis and design methods that are used in the design of the impoundment and confining dams; and an overview of the design quality assurance and design quality control procedures.

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NORTHERN DYNASTY MINES INC.
PEBBLE PROJECT

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SECTION 1.0 - INTRODUCTION

1.1 PROJECT DESCRIPTION

The Pebble Project property incorporates a copper-gold-molybdenum mineral deposit centered at latitude 59°53'54" and longitude 155°17'44" in the Bristol Bay region of southwest Alaska, approximately 238 miles southwest of Anchorage and 17 miles northwest of the Village of Iliamna. It is situated within Iliamna D6 and D7 topographic maps in Townships 3 to 5 South, Ranges 34 to 37 West in the Seward Meridian. The location of the Pebble Project within the State of Alaska is shown on Figure 1.1. The mineral deposit is situated on a drainage divide, with the Upper Talarik Creek draining to the east and south, and North Fork and South Fork Koktuli River draining to the west and southwest, respectively.

Northern Dynasty Mines Inc. (NDM) is currently planning a mine development to extract and process the mineralized resource, and has retained the specialist consulting engineering firm Knight Piésold Ltd. (KPL) to develop the designs for the tailings impoundment facilities that will be required for the proposed Pebble Mine. Mr Ken Brouwer, PE (Alaska 10963) is the Knight Piésold Project Director and is the Engineer of Record for the design of the tailings impoundments.

The design basis for the TSF at Site G will allow for secure storage of approximately 500 million tons of tailings solids discharged into an engineered containment impoundment. The tailings impoundment would be expanded in stages during on-going operations of the proposed mine development.

The design of the TSF at Site G includes a main dam along the outlet of Unnamed Tributary NK1.190 to the North Fork Koktuli River as well as a smaller saddle dam constructed along the headwaters of the tributary during later staged expansion of the tailings impoundment. This tailings storage impoundment location is referred to as the Site G Tailings Storage Facility (Site G TSF) and is the subject of this application.

1.2 SCOPE OF REPORT

This report has been prepared as part of the Initial Application Package for the proposed Site G TSF in accordance with the *Guidelines for Cooperation with the Alaska Dam Safety Program, June 2005* and based on the comments received from Mr Charles F. Cobb; State Dam Safety Engineer on August 21, 2006.

This Initial Application Package is submitted in support of NDM water right application for the Pebble Project as requested by the Water Resources Section, Division of Mining Land and Water, Alaska Department of Natural Resources. This application package is intended to support the NDM water right application for Unnamed Tributary NK1.190 to the North Fork Koktuli River.

This Initial Application Package is the first step in the application process for the Alaska Dam Safety Program and is intended to establish agreement on important information early in the project planning. The Application Form is included in this report as Appendix A.

SECTION 2.0 - HAZARD POTENTIAL CLASSIFICATION

The Hazard Potential Classification (HPC) is the basis for evaluating the level of attention that is required for a dam throughout its lifetime as defined by Alaska Dam Safety Program (ADSP). The Hazard Classification and Jurisdictional Review form (Version 7, 3/2005) has been completed for each of the dam sites by Mr Ken Brouwer, P.E. and these are included in Appendix B.

The proposed hazard classification has been carried out on the basis of KPL site investigations, tailings impoundment siting studies, preliminary analyses and the initial discussions with the Dam Safety and Construction Unit of Alaska Department of Natural Resources (ADNR) on August 21, 2006.

The proposed classification for each of the dams at the Site G TSF is Class II (significant). However, NDM has determined that further precautions may be appropriate for hydrologic and seismic design parameters consistent with the more conservative Class I (high) hazard potential standards. Therefore, the design of the tailings impoundment dam structures has been based on extreme hydrologic and seismic events that will be further discussed in the following sections.

SECTION 3.0 - SITE CHARACTERISTICS

3.1 METEOROLOGY AND HYDROLOGY

Detailed baseline studies have been implemented and the third year of site specific data is currently being compiled by a number of specialist consulting groups that have been retained by NDM. Processing of data and updating of hydrometerologic values for the project are ongoing. A number of data reports and various compilations are presently available, including the Knight Piésold (KP) report “Pebble Hydrometeorology” (Report No. 101-176/7-4, September 15, 2005) some of the findings from relevant studies are summarized below.

The mean annual precipitation (MAP) for the project site is estimated to be between 35 inches and 40 inches. A range of values is provided to reflect the uncertainty in deriving the MAP value, which is determined on the basis of extrapolating long-term regional records at Iliamna to the site, according to KP’s current understanding of factors that influence climatic conditions in the region. Which value should be used for a particular modeling application depends on the purpose of the modeling, as determined by the engineer. Mean monthly precipitation values are highest in August and lowest in April, with variations from year to year represented by coefficients of variation ranging from approximately 0.5 to 1.0. Two climate stations are currently operating on the site, as shown on Figure 3.1, with the intent of using the collected data to refine the current estimated values.

Mean annual runoff is estimated to be equivalent to MAP, based on the concept that any increase in precipitation with elevation is largely offset by runoff losses to evapotranspiration and deep groundwater. Runoff patterns in the region differ substantially from precipitation patterns due to the effects of snow accumulation and melt. Peak runoff periods are in the spring due to snowmelt and in the fall due to rain and rain combined with the melt of immature snowpacks, while the lowest flow period occurs during the coldest winter months.

Return period peak flow estimates have not yet been determined for the site. However, it is the intent to generate such values for specific design purposes, as required, on the basis of the limited relevant historical regional peak flow data, peak flow equations for the region developed by the USGS, peak flow data currently being collected at sixteen gauging stations in the Pebble Project mine site area, snowpack data currently being collected on site, and historical regional extreme precipitation data. The locations of the site gauging stations, three of which are operated by the USGS, are shown on Figure 3.1.

The probable maximum flood (PMF) has been selected as the inflow design flood (IDF) for the tailings impoundment embankments at Pebble. The PMF is the flow resulting from the most severe combination of probable maximum precipitation (PMP) and basin hydrological conditions. The PMP is the precipitation that results from the worst possible meteorological conditions.

The PMF will be evaluated using a mathematical model to convert PMP and snowmelt into basin runoff. The HEC-HMS computer program will most likely be the model used for this analysis. HEC-HMS is a flood hydrograph package developed by the Hydrological Engineering Center of the U.S. Army Corps of Engineers. This updated model was previously called HEC-1 and is recognized as one of the leading computer models for computing runoff hydrographs from precipitation data. Inputs into the HEC-HMS model include precipitation, precipitation distribution and various physical characteristics of the watershed.

There are three model input parameters that are site specific to each basin that will be considered: the time of concentration, the basin area, and the baseflow. The time of concentration reflects how quickly a basin responds to precipitation. This parameter essentially determines the maximum slope of the hydrograph curve, and therefore the time before peak flow is observed at the basin outlet.

The snowmelt contribution to the PMF will be determined using the U.S. Army Corps of Engineer publication, Engineering and Design – Runoff from Snowmelt (1998).

Several environmental factors influence snowmelt and its potential contribution to the PMF. These factors are the snowpack depth at the time of the PMP storm event, the temperature during the storm event, the wind speed during the storm event and the precipitation depth for the duration of the storm event. Available site specific baseline data and published guidelines will be used to determine these parameters.

3.2 SEISMICITY

3.2.1 Regional Seismicity

Alaska is the most seismically active state in the United States and in 1964 experienced the second largest earthquake ever recorded worldwide. Both crustal earthquakes in the continental North American Plate and subduction earthquakes affect the Alaska region. Historically, the level of seismic activity is highest along the south coast, where earthquakes are generated by the Pacific Plate subducting under the North American plate. This seismic source region, known as the Alaska-Aleutian megathrust, has been responsible for several of the largest earthquakes recorded, including the 1964 Prince William Sound magnitude 9.2 (M9.2) earthquake. There is potential for a future large subduction earthquake (M9.2+) along the southern coast of Alaska, and this seismic source zone is located approximately 125 miles from the project site.

Several major active faults in Alaska have generated large crustal earthquakes within the last century. A magnitude 7.9 earthquake occurred along part of the Denali fault in 2002, approximately 44 miles south of Fairbanks. The western portion of the Denali Fault trends in a northeast-southwest direction, approximately 125 miles north of the project site. Approximately 19 miles northeast of the project site is the western end of the northeast-southwest trending Castle Mountain Fault, which terminates approximately at the northwest end of Lake Clark. A magnitude 7.0 earthquake associated with this fault occurred in 1933. The Denali and Castle Mountain faults are capable of generating large earthquakes with magnitudes in the range of M7.5 to M8.0.

3.2.2 Seismic Hazard Analyses

The seismic hazard for the Pebble project has been examined using both probabilistic and deterministic methods of analysis.

Maximum bedrock accelerations have been determined based on the published USGS probabilistic seismic hazard model for Alaska. This was developed by the USGS to produce their latest seismic hazard maps for Alaska. Maximum horizontal acceleration values have been determined for return periods ranging from 100 years to 5000 years. The results have been summarized in Table 3.1**,** in terms of earthquake return period, probability of exceedance and maximum acceleration. The calculated probabilities of exceedance assume a design operating life of 20 years. For a return period of 475 years the corresponding maximum acceleration is 0.14g, implying a moderate seismic hazard.

A deterministic analysis has been carried out by considering known seismic sources and fault systems in the region and applying a maximum earthquake magnitude to each potential source. The resulting deterministic acceleration at the study site for each source is considered to be the maximum credible acceleration that can occur, on the basis of available geologic and tectonic information. The maximum accelerations were calculated using the mean plus one standard deviation values with appropriate ground motion attenuation relationships. The ground motion attenuation relationships used are applicable to western North American earthquakes, and are consistent with those used by the USGS. As indicated by the review of regional seismicity summarized above, the three most prominent seismic sources in the region of southwestern Alaska are the Denali Fault, Castle Mountain Fault and the Alaska-Aleutian megathrust. The results of the deterministic analysis are presented in Table 3.2, including the potential maximum magnitude for each of these seismic sources, the estimated minimum epicentral distance and the calculated maximum acceleration at the project site. Based on these results a Maximum Credible Earthquake (MCE) of M7.8 causing a maximum bedrock acceleration of 0.3g has been selected for the Pebble project site.

3.2.3 Design Earthquakes

Consistent with current design philosophy for geotechnical structures such as dams, two levels of design earthquake have been considered: the Operating Basis Earthquake (OBE) for normal operations; and the Maximum Design Earthquake (MDE) for extreme conditions (ICOLD, 1995).

Appropriate OBE and MDE events for the facilities are determined based on a hazard classification of the facility, with consideration of the consequences of failure. The hazard classification was carried out using the criteria provided by the document “Guidelines for Cooperation with the Alaska Dam Safety Program” (2005). Classification of the facilities is carried out by considering the potential consequences of failure, including loss of life, economic loss and environmental damage. The hazard classification has been assessed as at least Class II (Significant). The OBE and MDE are selected based on the dam hazard classification and an appropriate earthquake return period, as defined by the “Guidelines for Cooperation with the Alaska Dam Safety Program” (2005).

For a Class II hazard classification, the OBE is selected from a range of return periods from 70 to 200 years, depending on the operating life of the facility, the frequency of regional earthquakes and the difficulty of quickly assessing the site for repairs. The impoundment would be expected to remain functional during and after the OBE and any resulting damage should be easily repairable in a limited period of time.

The MDE is typically selected from a range of return periods from 1,000 to 2,500 years for a Class II hazard classification. However, the MDE for the Pebble tailings storage facilities embankments have been conservatively based on a Class I hazard classification making it equivalent to the MCE, which has a bedrock acceleration of 0.30 g corresponding to a magnitude M7.8 earthquake, occurring along the nearby Castle Mountain Fault system. The MCE is considered to be the seismic event with the highest possible maximum ground acceleration at the project site. A M9.2+ megathrust earthquake does not impose the highest maximum ground acceleration at the Pebble site (predicted maximum acceleration of 0.17 g), but the event is also considered in seismic design analyses due to the very long duration of ground shaking associated with earthquakes of this magnitude.

The tailings storage facility embankments will be designed to meet or exceed the Alaska Dam Safety requirements to ensure the embankment will remain stable without release of tailings or process water for all loading cases, including the MDE and the M9.2+ megathrust event.

3.3 GEOLOGIC AND GEOTECHNICAL CONDITIONS

General

The geotechnical investigations completed at the site through the end of 2005 include testpits and boreholes. These are illustrated on Figure 3.2 and Figure 3.3, respectively. The field and laboratory investigation programs are summarized in the following reports:

- KP 2005 Geotechnical Investigation Data Report VA101-00176/8-6 Draft in Progress
- KP 2004 Geotechnical Investigation Data Report VA101-00176/8-3
- KP 2005 Open Pit Geotechnical Investigations VA101-00176/8-5
- KP 2004 Open Pit Geotechnical Investigations VA101-00176/8-2
- WMC Draft 2004 Progress Report – Hydrogeology.

NDM is currently continuing to collect geologic and geotechnical information at the Pebble project site. This updated geologic, geotechnical and hydrogeologic information will continue to be compiled and integrated into on-going project planning and design. The following sections provide a general overview of the bedrock and overburden geology of the Pebble project site and at the proposed tailings impoundment site.

Bedrock Geology

The Pebble property lies within the northern circum-Pacific orogenic belt, a part of Alaska structurally controlled by the complex tectonic characteristics of an active continental margin. The structural grain in this area is defined by northeasterly trending faults related to translational motion along the Lake Clark structure that marks a lithotectonic boundary between the Peninsular terrane in the east and the Kahiltna terrane in the west. The Pebble deposit is situated immediately west of this boundary.

The Peninsular terrane consists of Permian limestone, Upper Triassic limestone, chert, tuff and agglomerate, together with Early to Middle Jurassic volcanic and intrusive rocks and Middle Jurassic to Cretaceous clastic rocks. The bedded rocks of the Peninsular terrane are bounded on the east side by an intrusive complex which is dominantly comprised of quartz diorite, and has been dated as Middle to Upper Jurassic in age.

The Kahiltna terrane consists of Late Triassic and younger basalt, andesite, tuff, chert, shale and limestone that may correlate with the Lower Peninsular terrane. The southern Kahiltna terrane was intruded by Cretaceous to Tertiary plutons, including the Later Cretaceous Kaskanak Batholith and coeval, proximal stocks, dikes, sills and irregular bodies associated with the Pebble deposit, which is made of granodiorite, quartz monzonite or quartz diorite. They are partly covered by Tertiary and Quaternary volcanic and sedimentary rocks.

Overburden Geology

The Pebble property falls into the Nushagak-Big River Hill physiographic division (Detterman and Reed, 1973). This is an area of low rolling hills separated by wide shallow valleys. Most of the area is an upland surface that stands 650 feet to 1,000 feet above the lowlands around Iliamna Lake. The project is located in a heavily glaciated area. The normally consolidated glacial debris has been extensively reworked and transported a short distance downstream from the source areas.

Four major glacial advances from the Alaska Range, to the northeast, formed most of the deposits in this area. The soil deposits consist mainly of till (ground moraine, terminal moraine and ablation), outwash plains, modified moraine (terraces) and glacio-fluvial sediments. Other soil deposits that occur less extensively in the region include swamp, landslide and solifluction deposits.

The underlying soil stratigraphy is very complex and heterogeneous both vertically and horizontally, due to the multiple stages of glaciation that have modified the area.

The river basins were generally formed as a result of numerous glaciations and is predominantly composed of ablation till and outwash moraine, with localized fluvial and swamp deposits. The till has been eroded and re-deposited in both fluvial and lacustrine environments along ancient and existing drainage courses. Given the multiple glaciations, there are areas where more recent till has been deposited over glaciofluvial and glaciolacustrine deposits of more ancient periods.

Area G will encompass a relatively short and broad tributary valley to the North Fork Koktuli River. Recent alluvial deposits are likely found immediately adjacent to the stream channel, with terraced morainal deposits bordering and underlying these materials. An extensive area of landslide deposits (colluvium) has been mapped in the southeast portion of the impoundment. These deposits likely consist of poorly sorted till and rock.

According to the Permafrost Map of Alaska (Ferrians, 1965), the Pebble site lies within a zone of sporadic permafrost. Permafrost in this region is most likely a relic from previous periods of glaciation. Permafrost was not observed during the 2004/2005/2006 site investigations.

SECTION 4.0 - TAILINGS IMPOUNDMENT SITING STUDIES

Comprehensive site selection studies have been systematically carried out in order to determine the best options for waste and water management for the proposed Pebble Mine. Over 25 different mine development concepts have been evaluated, and various revisions and optimizations for some of these concepts have also been completed. The assessment approach integrated engineering and environmental team members in order to develop practicable options for the proposed development. The overall process used for evaluation of different mine development concepts is illustrated on Figure 4.1. A list of the reports prepared for the various siting studies is as follows:

- KP Preliminary Assessment of Mine Development Alternatives VA101-00176/5-1
- KP Optimization of Preferred Mine Development Concepts VA101-00176/7-3
- KP Supplemental Optimization of Preferred Mine Development Concepts VA101-00176/7-5
- NDM miscellaneous environmental studies in support of site selection.

The preliminary engineering desktop study initially completed in July 2004 (Knight Piésold, 2004), considered conceptual mine development concepts from a technical and economic perspective, based on conceptual mine development criteria and limited preliminary site information. The conceptual mine development concept study utilized preliminary topography and rough estimates of the ultimate mineable resource to determine potential locations for the waste rock and tailings management facilities.

Selection of potential waste rock and tailings management facility sites considered the following engineering considerations:

- Storage capacity,
- Tailings disposal characteristics (i.e., pipeline lengths, number of pipelines, head difference from the mill, etc.)
- Site characteristics (i.e., preliminary topography, catchment area, hydrology, etc.),
- Minimizing environmental impacts (i.e., minimize diversion requirements, preliminary water balance),
- Construction requirements (i.e., embankment height and length, number of embankments) and
- Closure and reclamation requirements.

A total of 15 mine development concepts were developed using the above criteria. Thirteen of the concepts incorporate on-land waste storage within 10 miles of the proposed deposit, and one concept contemplated deep-water storage in Iliamna Lake. The concepts were evaluated based upon technical merit and economic feasibility for this preliminary comparative assessment. The comparative evaluations allowed for staged development of the impoundments, and considered the use of cycloned tailings sand in the embankment shell zones.

Of these initial engineering technical studies, three mine development concepts were short listed for further study: Mine Development Concept (MDC) 12 contemplated deep-water storage of tailings in Iliamna Lake and thus represents an option that does not require a dam. MDC 14 incorporated a waste storage facility in the headwaters of the main stem of the North Fork Koktuli River (Site K) and MDC 15 considered tailings disposal in two separate impoundments situated in Site J and Site G respectively. The tailings storage facility locations for these initial fifteen mine development concepts are illustrated on Figure 4.2.

The environmental team evaluated the fifteen mine development concepts (MDCs 1 to 15), subsequent to the preliminary technical and economic evaluation. Environmental factors were considered at a preliminary level, in order to determine particular opportunities and constraints for the proposed mine development concepts from an environmental management perspective (KP Report No. 101-176/5-1).

The environmental team confirmed that three general watershed areas were less environmentally sensitive, namely: the South Fork Koktuli River Area (Site J), a tributary to the North Fork Koktuli River (Site G) and the upper reaches of the South Fork Koktuli basin (Site A). These sites were determined to be less sensitive due to comparatively lower environmental values as compared to other sites. These lower environmental ratings were partially due to the absence of any significant populations of anadromous fish in the impacted stream reaches. The environmental overview evaluation, in combination with the initial engineering technical studies determined that MDC 15 provided the best opportunities for further design and evaluation (waste management in Sites A, J and G). MDCs 12 and 14 were not carried forward to additional optimization studies, due to technical, environmental, regulatory and economic considerations.

Integration of environmental considerations resulted in the creation of five optimized mine development concepts (MDCs 16 to 20). A joint review of critical issues and fatal flaws by both the engineering and environmental teams identified MDCs 18, 19 and 20 as preferred options. Additional optimization of these three preferred concepts resulted in the development of MDCs 18B, 19B and 20B. Additional engineering and environmental considerations identified MDC 20B as the preferred option.

Supplemental optimization studies, based on an expanded mine plan, resulted in the development of a further five concepts (MDCs 21 to 25), and suggested that MDC 25 would be the currently preferred option for development. However, optimization of the preferred mine development concept is ongoing, and is adjusted as appropriate to deal with refinements to the mine plan and updated technical and environmental information (i.e., mine plan, site conditions, topography, mill process data, etc.). The general arrangements for waste/water management facilities evaluated during these subsequent site selection studies are included on Figure 4.3.

The objectives for on-going optimization of the tailings, waste rock and water management systems are to ensure that the facilities are developed within the least environmentally sensitive parts of the least sensitive watersheds. The ongoing optimization of the preferred waste and water management facilities will include integration of information obtained from updated mine development plans, from on-going site investigation programs and from on-going environmental studies. Current information and analyses indicate that the least environmentally sensitive, and hence preferred sites for development include a site at a tributary of the upper South Fork Koktuli River Area (Site J), on a tributary to the North Fork Koktuli River (Site G) and along the upper reaches of the South Fork Koktuli River Basin (Site A) immediately adjacent to the proposed open pit mine development.

SECTION 5.0 - DESIGN OF THE TAILINGS IMPOUNDMENT DAMS

5.1 GENERAL

The Tailings Storage Facility (TSF) makes use of the storage provided by the natural topography within the drainage basin with additional capacity and confinement provided by the construction of the main Site G Tailings Dam and later construction of the Site G Saddle Dam during on-going staged expansion of the impoundment. The area has been surveyed using aerial photogrammetry and Lidar radar technology to develop detailed contour plans for the area. The detailed topography has been used to develop depth-area-capacity relationships for the storage basin.

The TSF will be designed to securely store tailings from the mill process. The tailings will be discharged into the impoundment in a controlled manner on an on-going basis and the tailings dams will be progressively raised during operations in order to provide for secure storage of solids and process water. The general arrangement of the ultimate tailings impoundment is included in Figure 5.1. A representative section for the proposed dams is included in Figure 5.2.

5.2 DESIGN OBJECTIVES

The principal objectives of the design and operation of the tailings storage facility are to provide secure containment for tailings solids, potentially reactive waste rock and impounded process water. The design and operation of the tailings storage impoundment is integrated with the overall water management objectives for the entire mine development in that surface runoff from disturbed areas within the mine site is controlled, collected, and contained. An additional requirement is to allow effective reclamation of the tailings impoundment and associated disturbed areas at closure to meet end use land objectives.

Preliminary studies have been conducted to develop feasible options that satisfy these fundamental objectives at this stage of design, but additional investigation and design work will be necessary as contemplated in the Alaska Dam Safety Program. The preliminary Design Basis for the impoundment is included in Table 5.1.

5.3 DESIGN FEATURES

The tailings embankments will be designed and constructed for staged expansion in order to reduce initial capital expenditures, provide maximum flexibility to accommodate inevitable changes in the mining plans, and to allow the observational approach to be utilized in the ongoing design, construction and operation of the impoundments. The observational approach is a powerful technique that can deliver substantial cost savings at an acceptable level of safety. It also enhances knowledge and understanding of site-specific conditions. For the method to be applicable, the character of the project must be such that it can be altered during construction (Peck, 1969). The preliminary design concept for the tailings dams at the Pebble Project is a combined downstream/centerline construction, where initial staged expansion of the dam will be by the downstream method followed by centerline construction in later years.

The initial Site G Tailings Dams are proposed to be developed as Geomembrane Faced Zoned Dam (GFZD) structures. This type of dam was selected based on the lack of sufficient quantities of fine-grained borrow materials near the project site to construct a conventional zoned earthfill/rockfill dam. The zoned tailings dams will be constructed using selected mine overburden, non-reactive waste rock and/or the coarse sand fraction derived from the tailings as potential construction materials. The inclusion of selected mine waste materials as the primary construction materials allows for reduced requirements for external borrow areas and a reduction in the area of disturbance required for separate disposal of waste rock and overburden from mining activities. The first stage of the tailings storage facility embankments will be built during the initial construction of the Pebble Project. This stage will provide the required capacity to store the tailings and potentially reactive waste rock produced during the first year or two of mine operation. Each stage of the impoundment will be designed to store the waste solids plus the supernatant process water pond, while providing appropriate freeboard allowances for full containment of the PMF (Probable Maximum Flood) storm event. The design will also include appropriate allowances for wave run-up, ice and contingency freeboard.

The tailings storage facility embankments will be raised in stages, with each stage providing the required capacity for that particular period until the next stage is completed. A proposed filling schedule is presented on Figure 5.3. The staged construction of the tailings storage facilities will directly integrate mine waste materials from the mine operations. The scheduled placement of fill within the downstream shell zone can accommodate fluctuating quantities of non-reactive mine waste to coincide with the mine plan. Some of the finer grained overburden material produced from the pit development will be stockpiled, as the majority of the overburden will be mined early on in the mine life but will be required at various later periods during ongoing staged expansion of the tailings storage facilities. The staged design of the embankments will be reviewed annually and refined, as required, to accommodate the availability of construction materials and to incorporate experience gained with local conditions and constraints.

On-going staged expansion of the main embankment will result in a final height of 450 feet. The saddle dam will be developed to a height of 175 feet during the later years of impoundment filling.

The nature and extent of the embankment zones, the respective construction material borrow sources and seepage control measures ultimately incorporated into the design of the tailings dams will be progressively modified during the various phases of the design process. Initial studies conducted to date in support of site investigation planning and in the development of mine development concepts have resulted in an initial configuration for the tailings dams as illustrated in Figure 5.2, and described as follows:

<u>Face Liner - HDPE Geomembrane Liner</u>

A synthetic High Density Polyethylene (HDPE) geomembrane liner will be included along the upstream face of the initial embankments to control embankment seepage prior to the development of low permeability tailings beaches. The liner will tie into suitable low permeability foundation materials and seepage cutoff measures (ie grout curtains). The

HDPE liner will be placed on low permeability core zone material (Zone S) which serves as a bedding layer for the liner and provides an added level of seepage control in that the combined HDPE liner and Zone S material behaves as a compound liner. The HDPE liner will not be required once the low permeability tailings beaches have been developed and the supernatant pond is located away from the embankments.

Core Zone/ Low Permeability Blanket - Zone S

The core zone/low permeability till blanket (Zone S) will be constructed with low permeability glacial till excavated from the pit. The core zone combined with the HDPE liner will behave as a compound liner and serve as the primary seepage control zone for the initial embankment stages, until tailings beaches are established for additional seepage control. The core zone will provide the primary embankment seepage control feature (along with the tailings) for the upper section of the embankments. The dam foundations will be prepared such that seepage and infiltration reports to the downstream seepage collection sumps for recycle back to the tailings storage facility.

Transition Zones - Zone F/T

The filter and transition zones (Zone F/T) will be incorporated to ensure internal stability between embankment zones and will act to prevent the migration of fines from the core zone into the adjacent pervious downstream shell zone materials. The transition zone will comprise both a specified sand filter adjacent to the core zone and a coarser gravelly sand transition zone between the filter sand and the downstream shell zone.

Shell Zone - Zone C1 (non-reactive)

The downstream shell zone (C1), adjacent to the transition zone, will be constructed in controlled compacted layers comprising well graded non-reactive waste rock and overburden from the open pit.

Shell Zone – Zone C2 (non-reactive)

The downstream shell zone (C2), downstream of shell zone (C1), will be constructed with similar to Zone C1, but will typically incorporate thicker layers of non-reactive coarse rockfill material from the open pit.

Shell Zone - Zone C (potentially reactive)

The upstream embankment shell will also be constructed from mine waste rock during on-going staged expansion using the centerline construction method. This upstream zone will be within the tailings storage impoundment and may selectively incorporate potentially reactive waste rock where it can subsequently become fully encapsulated within saturated non-reactive materials.

Seepage Cutoff Measures

The embankment will be keyed into low permeability foundation materials to minimize seepage from the tailings storage facility. Seepage cutoff walls and grout injection of fractured bedrock will be included as appropriate to ensure appropriate seepage control.

Seepage Collection Measures

Suitable embankment drainage zones will be incorporated as appropriate to facilitate seepage collection and recovery. The seepage collection systems will drain into seepage collection sumps for recycling back to the tailings storage facility.

Seepage Collection Sumps

The seepage collection sumps will be located at the downstream toe of the embankments. The sumps will collect seepage water from the embankment seepage collection measures, for pumping back into the tailings impoundment.

Groundwater Monitoring Wells

Groundwater monitoring wells will be installed downstream of all embankments to monitor groundwater quality data downgradient of the impoundment.

5.4 SURFACE WATER MANAGEMENT

Surface runoff and supernatant process water will form a permanent water cover over a portion of the deposited tailings. A floating reclaim barge and pumping system will transfer water from the supernatant pond for reuse in the milling process. The water management plan contemplates total containment and recycling of all process water within the tailings impoundment with no surface discharge to the environment.

Storm surge capacity, corresponding to full containment of runoff from the PMF event will be accommodated above the operating pond level. Additional freeboard will also be provided as an allowance for wave runup in addition to the allowance for PMF flood storage.

5.5 SEEPAGE ANALYSES

Steady state numerical seepage analyses will be carried out to evaluate the potential for seepage at the tailings impoundment. The initial analyses will be conducted using the finite element computer program SEEP/W (2004). Preliminary seepage analyses will also be conducted using simplified flow nets in order to confirm numerical calculations.

Typical seepage control components incorporated into the seepage analyses include the following:

- The thickness of tailings which progressively increases during on-going operations,
- Seepage cutoff measures in low permeability foundation soils and/or bedrock;

- Geomembrane liner extending along the upstream face of the initial embankment, which is keyed into a seepage cutoff, grout curtain or a low permeability foundation layer;
- Low permeability core zone and adjacent filter zones, transition zone, and shell zones;
- Embankment seepage collection systems;
- Seepage collection / recycle sumps, and
- Groundwater monitoring wells.

The seepage analyses will be performed to evaluate seepage quantities and gradients through embankment zones and foundation materials during operations and post-closure. The post closure cases will evaluate the change in seepage rate over time if it is assumed that the geomembrane facing deteriorates and no longer provides a barrier to seepage through the embankment.

Additional seepage analysis and groundwater flow models will also be conducted using 3-dimensional numerical models such as MODFLOW.

Foundation conditions incorporated into the seepage analyses will be based on data gathered during the site investigation programs, including packer permeability tests, falling head tests, laboratory tests and test pit and boreholes logs Material parameters for the seepage analyses will be determined based on in-situ testing, laboratory tests, index properties, together with recommendations from published data. The following parameters will be determined:

- The thickness, extent and permeability (ie hydraulic conductivity) of the foundation materials
- The thickness and permeability characteristics of the different zones of segregated tailings stored within the tailings impoundment;
- Permeability values of the various embankment fill and drainage zones.

5.6 STABILITY ANALYSIS

Detailed stability analyses will be conducted to evaluate the stability of the proposed embankment structures. These analyses will utilize appropriate reputable computer software programs along with appropriate hand checks where appropriate. The computer analyses will initially incorporate Limit Equilibrium analyses techniques and more sophisticated finite element modeling is anticipated during the later stages of design.

Both upstream and downstream stability analyses for the initial preliminary design studies will be completed for the Pebble embankments. Embankment stability analyses will be carried out using the limit equilibrium computer program SLOPE/W (2004).

Analyses will be performed to investigate the stability of the embankments under static, seismic and post earthquake conditions. The tailings storage facility embankments will be designed to meet or exceed the specific regulatory requirements and to ensure the embankments will remain stable without release of tailings or process water for all loading cases. Seismic (pseudo-static) analyses were undertaken by applying a horizontal force (seismic coefficient) to the embankment to simulate earthquake loading for all seismic loading cases, including the OBE and the MDE.

The facility will be required to remain functional during and after the OBE, and any resulting damage will be easily repairable in a limited time. Limited deformation of the facility is acceptable under seismic loading from the MDE, provided that the overall stability and integrity of the facility is maintained and that there is no release of stored tailings or water.

Material parameters used in the stability analyses will be based on best available information and analyses. The geologic and hydrogeologic conditions beneath the embankments will be based on data collected from site investigation programs, including test pits and boreholes. Bulk unit weights and strength parameters for embankment and foundation materials will be determined by a combination of field testing, laboratory testing and/or recommendations contained in published reference material. The location of the phreatic surface within the embankment will be based on both in-situ piezometric water levels and results of SEEP/W analyses.

Additional field and laboratory investigations, along with other analytical methods will also be used as appropriate to evaluate the shear strength characteristics of the materials for the various loading conditions. These methods and procedures will be developed in consultation with Independent specialists (ie, Independent Review Panel) and Alaska Dam Safety personnel.

5.7 CLOSURE REQUIREMENTS

The main objective of closure is to minimize adverse environmental and social impacts of the mine development and return disturbed site areas to conditions consistent with an approved end-use plan.

Preliminary closure planning will be carried out concurrently with the various stages of dam and impoundment design in order to integrate the post closure objectives into the design, construction and operation of the tailings facility. The closure and reclamation plan will be developed in consultation with the NDM environmental team, local stakeholders and the appropriate regulatory authorities. It is anticipated that the following objectives will be incorporated into the design of the tailings facilities in order to facilitate an acceptable closure and reclamation plan:

- Long-term stability of the dams and other engineered structures.
- Long-term preservation of water quality within and downstream of decommissioned operations.
- Removal and proper disposal of all access roads, structures, and equipment not required beyond the end-of-mine-life
- Long-term stabilization of all exposed erodable materials.
- Natural integration of disturbed lands into surrounding landscape, and restoration of the natural appearance of the area after mining ceases, to the greatest possible extent.
- Establishment of a self-sustaining vegetative cover consistent with existing wildlife needs.
- Routine monitoring to evaluate facility performance.

5.8 DESIGN QUALITY ASSURANCE AND DESIGN QUALITY CONTROL

Design Quality Assurance and Design Quality Control (DQA/DQC) are fundamental components of the engineering process. The DQA/DQC systems for design of the tailings impoundments include the internal KPL Quality Systems and also will incorporate independent third party review by external specialists.

The KPL internal Quality Systems are ISO 9001 registered and are designed to provide high quality consulting services to meet the needs and requirements of clients, public safety, and the environment. The KPL Quality Policy requires that:

- All professional staff are cognizant of, and committed to, the requirements of the associated bylaws and Code of Ethics of the professional associations in which they are affiliated.

- The Quality Management Systems meet the quality assurance requirements of the ISO 9001 standards.

- Appropriately qualified and experienced professional staff are assigned to carry out, or directly supervise, all tasks and to be personally responsible for the quality of the work.

- All work is subjected to peer review and that the checking of calculations is documented to enable independent auditing.

- The Quality Management System is continually reviewed, assessed and modified in order to improve KPL services.

An external independent review of the design of the Waste and Water management systems for the Pebble project is also required by NDM. This peer review will allow for independent evaluation of the preliminary designs and will provide additional confidence for NDM management, potential partners, Alaska regulatory agencies and the Alaska public. An Independent Review Panel (IRP) will be set up to facilitate this external independent review of the designs.

The objectives of the independent review process will be as follows:

1. Confirm that the Design Basis and Design Criteria are consistent with good industry practices.

2. Evaluate the geotechnical, hydrogeological and hydrologic information developed for the site and provide recommendations for additional data collection requirements for future investigation and study programs (i.e. updated Feasibility, Integrated Development Plan, Basic Engineering, Detailed Design and on-going staged development).

3. Review the designs for both the initial Stage 1 tailings impoundment and the plans for on-going staged expansion, along with the associated waste and water management systems. The IRP will evaluate and comment on the following:
    - Site selection criteria;
    - Embankment construction methods (i.e. downstream and centreline embankment raises);
    - Foundation preparation;
    - Construction materials;
    - Seepage control measures and analyses;

- Static and seismic stability assessments;
- Water balance and water management plans;
- Tailings/reclaim water systems;
- Waste rock management;
- Construction schedule and capital cost estimates;
- Options for improvement and for cost optimization;
- Consistency with 'best practices' (ICOLD, CDSA, etc) and Alaska Dam Safety Requirements.

4. Engineering review of the preliminary closure and reclamation plans including:
   - Design basis;
   - Construction schedule and cost estimates for financial assurances;
   - Consistency with 'best practices' (USFS, etc) and Alaska Reclamation Requirements.

The review strategy will be consistent with both short and longer term objectives for permitting and development of the project. The current status of the Pebble Project is still in the early stages of design and it is anticipated that the overall project will change as exploration drilling continues to define additional mineral resources in the deeper higher grade East Zone deposit. It is anticipated that the IRP will provide periodic on-going reviews for several years, throughout the various stages of design as contemplated by the Alaska Dam Safety Application and Review Process. This on-going involvement by the IRP is illustrated on Figure 5.4.

The selection of suitable reviewers for the IRP is fundamental to completing the reviews in an efficient and uncompromising manner. The IRP members must be objective as well as technically competent, and will consist of prominent and well recognized specialists, which individually and/or collectively have recognized credentials in the following:

- Tailings embankment/impoundment design for large embankments;
- Geotechnical expertise (i.e. with respect to foundation conditions for embankments);
- Seismic design of embankments;
- Hydrogeology/seepage control;
- Alaska or other cold regions experience;
- Knowledge/expertise in managing mine waste materials.

It is anticipated that the three technical specialists that will comprise the IRP will be jointly selected by NDM and Mr Charles Cobb of the Alaska Dam Safety Program. KPL experience with previous review panels for other projects has determined that one to two people is too few, and four or more is too many. Thus it is intended that the IRP will comprise three independent specialists who will be directed by Mr Cobb of the Alaska Dam Safety Program.

It is anticipated that the review process will be initiated in the first quarter of 2007. Subsequent review sessions would be scheduled on a roughly quarterly basis. The DQA/DQC process would continue to be integrated with the Alaska Dam Safety and Review Process during subsequent stages of design, as illustrated on Figure 5.4.

5.9 APPLICATION FEE DEPOSIT

Rough cost estimates have been developed for the current tailings facility design. However, these cost estimates are approximate only and need to be updated and then integrated with the overall mine development costing exercises in order to support project planning and financing activities. It is not appropriate to release this information at this time.

These initial cost estimates are typically used to determine the Application Fee Deposit that is required with the Initial Application Package. Northern Dynasty Mines Inc has a well established Reimbursable Services Agreement (RSA) with the Alaska Department of Natural Resources for use by the State's Large Mine Permitting Team in its participation and review of the Pebble Project. Mr. Charles Cobb, as Alaska Dam Safety Program Manager, is a member of that team. NDM proposes to use this RSA as an approved alternative method of payment in lieu of a lump sum application fee.

SECTION 6.0 - REFERENCES

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Knight Piésold Ltd., July 2004, Pebble Project – Draft Preliminary Assessment of Mine Development Alternatives (Ref. No. VA101-00176/5-1).

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SECTION 7.0 - CERTIFICATION

This report was prepared and reviewed by the undersigned.

Prepared by:

Les Galbraith, P.Eng.
Senior Project Engineer

STATE OF ALASKA
49TH
KEN J. BROUWER
No. 10263
CE
REGISTERED PROFESSIONAL ENGINEER

Reviewed by:

Ken J. Brouwer, P.E.
Managing Director

TABLE 3.1

NORTHERN DYNASTY MINES INC.
PEBBLE PROJECT
Tailings Impoundment G - Initial Application Report
PRELIMINARY SUMMARY OF PROBABILISTIC SEISMIC RISK

M:\1\01\00176\16\A\Report\Report 12_dam application - Site G\Rev 0\Tables\[Table 3.1 and 3.2 - Design Scope.xls]Table 3.1

Print: Sep 8, 06
Rev: Aug 16, 06

Return Period (Years)	Probability of Exceedance[1] (%)	Maximum Acceleration[2] A (g)
108	16.9	0.08
224	8.5	0.10
475	4.1	0.14
975	2.0	0.18
2475	0.8	0.24
4975	0.4	0.30

Notes:
1) Probability of Exceedance calculated for a design life of 20 years.

$$q = 1 - \exp(-L/T)$$

where, q = probability of exceedance
L = design life in years
T = return period in years

2) Maximum Accelerations are for values on bedrock/firm ground.

TABLE 3.2

NORTHERN DYNASTY MINES INC.
PEBBLE PROJECT
Tailings Impoundment G - Initial Application Report
PRELIMINARY SUMMARY OF DETERMINISTIC SEISMIC HAZARD ANALYSIS

Print: Sep 8, 06

M:\1\01\00176\16\A\Report\Report 12_dam application - Site G\Rev 0\Tables\[Table 3.1 and 3.2 - Design Scope.xls]Table 3.2 Rev: Aug 16, 06

A Earthquake Source	Maximum Magnitude (Mw)	Epicentral Distance (miles)	Maximum Acceleration[1] (g)
Castle Moutain Fault	7.8	18	0.30
Denali Fault - Central	8.0	125	0.08
Mega-Thrust Subduction Event	9.2	125	0.17

Notes:

1) Maximum Accelerations are for values on bedrock/firm ground.

TABLE 5.1

NORTHERN DYNASTY MINES INC.
PEBBLE PROJECT
Tailings Impoundment G – Initial Application Report
PRELIMINARY DESIGN BASIS

ITEM	DESIGN CRITERIA
General Tailings Storage Facility Design	
Staged Expansion Construction Method	• Initially downstream • Switches to centerline at a later stage.

Embankment Construction Zones/ Materials	• Construction material sources will be determined through extensive site investigations and laboratory testing.
	• Core Zone/ Low Permeability Blanket (Zone S)
	  o Lacustrine silts and clays, where available
	  o High silt/clay content tills, where available
	• Transition Zone (Zone F/T)
	  o Transition materials to provide filter relationship between Zone S and Zone C. Materials produced by screening and/or crushing locally available fluvial sand, gravel and cobbles.
	• Dam Shell Zones (Zone C)
	  o Overburden and waste rock from pit development.

Foundation Preparation	• Clear, strip, grub embankment footprints down to bedrock or a low permeability foundation layer. Stockpile all organics for reclamation at closure. • Existing foundation conditions will be determined through extensive site investigations, including in situ and laboratory testing, test pits, boreholes and seismic surveys.
Tailings Physical Properties	Determined by laboratory testing.
Tailings pipelines	• 2 bulk tailings pipelines (approximately 95 to 97% of the total tailings stream) • 1 pyritic tailings pipeline (approximately 3 to 5% of the total tailings stream)
Tailings Deposition	• Bulk tailings disposed around the facility to form tailings beaches. • Pyritic tailings disposed from submerged pipeline into the supernatant pond to minimize oxidation potential. • Gravity discharge from mill used while sufficient head is available. • Tailings pumping station included at mill for remote discharge locations (bulk tailings), as required in later years.
Reclaim System	• Water for the mining process will be reclaimed from the TSF supernatant pond using pumps mounted on a reclaim barge.

TABLE 5.1

NORTHERN DYNASTY MINES INC.
PEBBLE PROJECT
Tailings Impoundment G – Initial Application Report
PRELIMINARY DESIGN BASIS

ITEM	DESIGN CRITERIA
Hydrology and Hydraulics	
Baseline Climate Data Collection	• Baseline hydrometeorology studies are collecting and will continue to collect precipitation, snow pack, ice pack, frost depth, temperature, evaporation, wind speed, and wind direction data.
Inflow Design Flood (IDF)	• IDF = Probable Maximum Flood (PMF) o PMF = 24-hour PMP + snowmelt o PMP defined by USACE as "the greatest amount of precipitation that is theoretically possible for a particular geographical location over a given duration" o Snowmelt determined by ASCE guidelines. o HEC-HMS computer modeling program to convert PMP and snowmelt into basin runoff.
Freeboard	• Containment of above maximum supernatant pond level at each stage to account for: o PMF , o Wave run-up, using site specific wind speeds and directions, as defined by the U.S. Army Corps of Engineers, o Melting of snow pack and ice cover on supernatant pond.
Spillway	The TSF supernatant pond will be sized to contain all site runoff, melting of snow pack and ice cover, wave run-up, mill process water, and the IDF without requiring a spillway during operations. A site water management priority is to ensure total recycle of mining process water with no untreated surface discharge.
Water Balance	A detailed water balance will be developed to carefully monitor and maintain the freeboard allowance and contingency. The water balance will be modeled using both average precipitation conditions and variations in precipitation using the computer program @RISK to assess the potential impact that fluctuations in annual hydrometeorological conditions will have on the supernatant pond volume.
Seismicity	
Seismic Design	• At least a Hazard Class II for all tailings embankments, as defined by the Alaska Dam Safety Guidelines • Alaska Dam Safety Guidelines mandates a 70 to 200 year return interval for OBE and 1,000 to 2,500 year interval for MDE (Class II Dam) • Liquefaction assessment of foundation materials will be estimated using one-dimensional ground response analyses using the ProShake Modeling program. Standard penetration test results will be utilized to estimate the cyclic stress ratio to determine the liquefaction potential.

ITEM	DESIGN CRITERIA

	<u>KP Design Basis</u>
	• Operating Basis Earthquake (OBE) ≥ 1/200 year
	    o Magnitude = M7.5
	• Maximum Design Earthquake (MDE) = 1/2500 year
	    o Magnitude = M7.8
	    o MDE corresponds to the Maximum Credible Earthquake (MCE)
	        ▪ Maximum firm ground acceleration = 0.3g

Stability Analyses	

Stability Analyses	• Upstream and downstream stability analyses will be completed using the limit equilibrium computer modeling program SLOPE/W.
	• The embankments will be designed to meet of exceed the minimum acceptable factors of safety (based on the U.S. Army Corps of Engineers) for the following cases:
	    o End of embankment construction
	    o Long term (full tailings pond)
	    o Seismic (pseudo-static)
	    o Post-Liquefaction

Input Parameters	• The material parameters for seepage modeling will be determined through extensive site investigations and laboratory testing. Modeling parameters for the embankment materials include:
	    o Phreatic surface determined from SEEP/W analyses,
	    o Unit weight, cohesion and internal friction angle for each material.
	    o Shear strength of liquefied foundation materials, based on SPT results and relations provided by NCEER (1997).
	• Seismic coefficient = to the maximum ground acceleration for seismic design events:
	    o OBE (starter embankment)
	    o MDE (operational and closure)

Seepage Analyses	
Seepage Control Measures	• Deposition of fine-grained tailings solids. • Seepage cutoff measures in low permeability foundation soils and/or bedrock; • A geomembrane liner extending along the upstream face of the embankment, which is keyed into a seepage cutoff grout curtain or a low permeability foundation layer; • A low permeability core zone;

ITEM	DESIGN CRITERIA
	• Seepage collection drains downstream of core zone; • A low permeability blanket beneath the downstream shell zones; • Seepage collection sumps; and • Groundwater monitoring wells.
Input Parameters	The material parameters for seepage modeling will be determined through extensive site investigations and laboratory testing. Modeling parameters for the embankment materials include: • Permeability of the embankment zones; • Permeability of the foundation materials; • The thickness and permeability of the tailings stored within the TSF.
Design Quality Assurance and Design Quality Control	
	• As per Knight Piésold Quality Policy; • Additional reviews by separate internal specialists. • Review from 3 member Independent Review Panel as required and approved by Alaska Dam Safety Program.

APPENDIX A

APPLICATION FORM

Print Form

DIVISION OF MINING, LAND & WATER
DAM SAFETY AND CONSTRUCTION UNIT

Alaska Department of NATURAL RESOURCES

Action

☒ Construction ☐ Removal
☐ Modification ☐ Abandonment
☐ Repair ☐ Other

550 West 7th Avenue, Suite 1020
Anchorage, AK 99501-3577
(907) 269-8636
Fax: 269-8947

Office Use Only
Receipt Type

Office Use Only
Date/Time Stamp

APPLICATION FOR CERTIFICATE OF APPROVAL TO CONSTRUCT, MODIFY, REPAIR, REMOVE OR ABANDON A DAM

Instructions
- *Complete one application for each dam - **Incomplete applications will not be accepted***
- Include cover letter with notice of intent [see 11 AAC 93.171(f)(1)(A)]
- *Attach additional required information (see 11 AAC 93.171 or 11 AAC 93.172)*
- *Contact Dam Safety and Construction Unit for specific requirements*
- *Submit non-refundable filing fee deposit - **Minimum fee = $500** (see 11 AAC 005.01(a)(8)(J))*

Dam Owner Information

Name of Dam and Reservoir: SITE G - MAIN EMBANKMENT
Identification Number (if assigned):

Owner Name: NORTHERN DYNASTY MINES INC.
Authorized Representative: BRUCE JENKINS
Title: C.O.O.

Mailing Address: 3201 C STREET - SUITE 604
City: ANCHORAGE
State: AK
Zip Code: 99503

Phone Number: 907 339 2600
Fax Number: 907 339 2600
E-mail Address: receptionist@northerndynasty.com

Engineer Information

Company: KNIGHT PIESOLD LTD

Engineer of Record: KEN BROUWER, P.E.
Alaska Registration: 10963

Mailing Address: 1400-750 W. PENDER ST
City: VANCOUVER
State: BC
Zip Code: V6C 2T8

Phone Number: 604 685 0543
Fax Number: 604 685 0147
E-mail Address: kbrouwer@knightpiesold.com

Is dam located on anadromous fish stream?	☐ Yes	☒ No	☐ Unknown
Has application been submitted for water rights?	☒ Yes	☐ No	☐ Unknown
Is dam or reservoir located on state land?	☒ Yes	☐ No	☐ Unknown
Is dam or reservoir located on federal land?	☐ Yes	☒ No	☐ Unknown

Location and Land Owner Information		
Water Body	River Mile	Tributary To
UNNAMED TRIBUTARY (NK1.190)	HEADWATERS	NORTH FORK KOKTULI RIVER

Region	Meridian	Township	Range	Section	USGS quad map	GPS Coordinates Latitude	GPS Coordinates Longitude
BRISTOL BAY	SEPAGE	3	36	24 13,14	D7 ILIAMNA	2163200N	1382200E

Land Owner (for land under dam and reservoir)	Contact Name and Title		Phone Number
STATE OF ALASKA			
Mailing Address	**City**	**State**	**Zip Code**

Dam Information			
Purpose of Dam	Type of Dam	Proposed Hazard Potential Classification (attach HPCJR Form)	Dam Length (feet)
TAILINGS STORAGE	EARTHFILL/ROCKFILL	SIGNIFICANT II	7,800

Maximum Dam Height (feet) (dam crest to lowest point in original streambed)	Storage Capacity (acre-feet) at Spillway elevation	Storage Capacity (acre-feet) at Dam Crest elevation	Surface Area (acres)
450	N/A	366,000	2,300

Inflow Design Flood		Drainage Area (square miles)
☒ Probable Maximum Flood (PMF) ☐ ½ Probable Maximum Flood (PMF)	☐ 100-Year Return Interval ☐ Other	9

Type of Primary Spillway	Emergency Spillway	Low Level Outlet
☐ Gated ☐ Uncontrolled ☒ Other full containment(dur oper	☐ Yes ☒ No	☐ Yes ☒ No

Application Submittals: Are the following required?

Water Rights Application	☒ Yes	☐ No	Feasibility Study	☐ Yes	☒ No
Design Scope Proposal	☒ Yes	☐ No	Siting Study	☒ Yes	☐ No
Financial Demonstration	☐ Yes	☒ No			

Fee Deposit Calculation - Make checks payable to *"Alaska Department of Natural Resources"*

Total estimated project cost $

First $100,000	=	$	X	.02	=	$
Next $400,000	=	$	X	.01	=	$
Next $500,000	=	$	X	.005	=	$
Over $1,000,000	=	$	X	.0025	=	$
			Total Fee Deposit		=	$TBD

	CHIEF OPERATING OFFICER
Signature	Title
BRUCE JENKINS	SEPTEMBER 5, 2006
Name (please print)	Date

Print Form

DIVISION OF MINING, LAND & WATER
DAM SAFETY AND CONSTRUCTION UNIT

Alaska Department of NATURAL RESOURCES

Action	550 West 7th Avenue, Suite 1020 Anchorage, AK 99501-3577 (907) 269-8636 Fax: 269-8947	*Office Use Only* *Date/Time Stamp*
☒ Construction ☐ Removal ☐ Modification ☐ Abandonment ☐ Repair ☐ Other	*Office Use Only* *Receipt Type*	

APPLICATION FOR CERTIFICATE OF APPROVAL

- Include cover letter with notice of intent [see 11 AAC 93.171(f)(1)(A)]
- *Attach additional required information (see 11 AAC 93.171 or 11 AAC 93.172)*
- *Contact Dam Safety and Construction Unit for specific requirements*
- *Submit non-refundable filing fee deposit - **Minimum fee = $500** (see 11 AAC 005.01(a)(8)(J))*

Dam Owner Information

Name of Dam and Reservoir: SITE G - SADDLE DAM
Identification Number (if assigned):

Owner Name: NORTHERN DYNASTY MINES INC.
Authorized Representative: BRUCE JENKINS
Title: C.O.O.

Mailing Address: 3201 C STREET - SUITE 604
City: ANCHORAGE
State: AK
Zip Code: 99503

Phone Number: 907 339 2600
Fax Number: 907 339 2600
E-mail Address: receptionist@northerndynasty.com

Engineer Information

Company: KNIGHT PIESOLD LTD

Engineer of Record: KEN BROUWER, P.E.
Alaska Registration: 10963

Mailing Address: 1400-750 W. PENDER ST
City: VANCOUVER
State: BC
Zip Code: V6C 2T8

Phone Number: 604 685 0543
Fax Number: 604 685 0147
E-mail Address: kbrouwer@knightpiesold.com

Is dam located on anadromous fish stream?	☐ Yes	☒ No	☐ Unknown
Has application been submitted for water rights?	☒ Yes	☐ No	☐ Unknown
Is dam or reservoir located on state land?	☒ Yes	☐ No	☐ Unknown
Is dam or reservoir located on federal land?	☐ Yes	☒ No	☐ Unknown

A-3

Location and Land Owner Information

Water Body	River Mile	Tributary To
UNNAMED TRIBUTARY (NK1.190)	HEADWATERS	NORTH FORK KOKTULI RIVER

Region	Meridian	Township	Range	Section	USGS quad map	GPS Coordinates Latitude	GPS Coordinates Longitude
BRISTOL BAY	SEPAGE	3	36	34	D7 ILIAMNA	2150100N	1373800E

Land Owner (for land under dam and reservoir)	Contact Name and Title	Phone Number
STATE OF ALASKA		

Mailing Address	City	State	Zip Code

Dam Information

Purpose of Dam	Type of Dam	Proposed Hazard Potential Classification (attach HPCJR Form)	Dam Length (feet)
TAILINGS STORAGE	EARTHFILL/ROCKFILL	SIGNIFICANT II	1000

Maximum Dam Height (feet) (dam crest to lowest point in original streambed)	Storage Capacity (acre-feet) at Spillway elevation	Storage Capacity (acre-feet) at Dam Crest elevation	Surface Area (acres)
175	N/A	366,000	2,300

Inflow Design Flood	Drainage Area (square miles)
☒ Probable Maximum Flood (PMF) ☐ ½ Probable Maximum Flood (PMF) ☐ 100-Year Return Interval ☐ Other	9

Type of Primary Spillway	Emergency Spillway	Low Level Outlet
☐ Gated ☐ Uncontrolled ☒ Other full containment(dur oper	☐ Yes ☒ No	☐ Yes ☒ No

Application Submittals: Are the following required?

Water Rights Application	☒ Yes	☐ No	Feasibility Study	☐ Yes	☒ No
Design Scope Proposal	☒ Yes	☐ No	Siting Study	☒ Yes	☐ No
Financial Demonstration	☐ Yes	☒ No			

Fee Deposit Calculation - Make checks payable to *"Alaska Department of Natural Resources"*

Total estimated project cost $

First $100,000	=	$	X	.02	=	$
Next $400,000	=	$	X	.01	=	$
Next $500,000	=	$	X	.005	=	$
Over $1,000,000	=	$	X	.0025	=	$
			Total Fee Deposit		=	$TBD

Signature

CHIEF OPERATING OFFICER
Title

BRUCE JENKINS
Name (please print)

SEPTEMBER 5, 2006
Date

APPENDIX B

HAZARD CLASSIFICATION AND JURISDICTIONAL REVIEW FORM

Alaska Dam Safety Program

HAZARD CLASSIFICATION
AND
JURISDICTIONAL REVIEW

This form is used to state the hazard classification of a dam in accordance with 11 AAC 93.157 and to determine if a dam is under the jurisdiction of the Alaska Dam Safety Program based on the following definition, articulated under Alaska Statute 46.17.900 (3):

"Dam" includes an artificial barrier, and its appurtenant works, which may impound or divert water and which...

- ☐ has or will have an impounding capacity at maximum water storage elevation of 50 acre-feet and is at least 10 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam;
- ☐ is at least 20 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam; or
- ☐ poses a threat to lives and property as determined by the department after an inspection.

Please complete items 1 through 17. Attach additional information as necessary. This form must be certified and stamped by an Alaska-registered professional engineer on page 3.

1. Name of dam: Site G – Main Embankment

National Inventory of Dams (NID) number: ____________ (Assigned by Department)
Name of stream: Unnamed Tributary (NK1.190)
General location and region: Bristol Bay Region in Southwest Alaska
Legal location: Township 3 Range 36 Section 13, 14, 24
Meridian Seward
Purpose and type of dam: Earthfill / Rockfill Tailings Storage Embankment
This dam is: ☐ Existing ☒ Proposed ☐ Under construction
Current hazard classification: ☐ I ☐ II ☐ III ☒ Not assigned

2. Owner: Northern Dynasty Mines Inc.

Address: 3201 C Street – Suite 604
Anchorage, AK
99503

Contact name: Bruce Jenkins (C.O.O.)

Phone: 907 339 2600

3. Is dam federally owned, or regulated by the Federal Energy Regulatory Commission?
   ☐ Yes (stop here) ☒ No (complete form)

4. Maximum crest height of dam: 450 feet
   Measured from: ☐ Upstream toe ☒ Downstream toe ☐ Offstream toe
   Basis of height: ☒ Conceptual design drawing ☐ Detailed design drawing
   ☐ As-built drawing ☐ Field measurement ☐ NID data

5. Maximum impoundment volume: 366,000 acre-feet
   Surface area of reservoir at maximum storage: 2300 acres
   Average depth of reservoir above bottom of dam: 400 feet (live storage)
   Basis of volume estimate:
   ☐ Surface area multiplied by average depth
   ☐ Bathymetry
   ☐ NID data
   ☒ Other: Surface area / contour method using 5 foot contour intervals.

6. Downstream development: ☐ Yes ☒No ☐ Unknown
   Type of development (check all that apply):
   ☐ Homes
   ☐ School
   ☐ Community halls, churches, etc.
   ☐ Industrial or commercial property
   ☐ Major highway
   ☐ Primary roads
   ☐ Secondary or rural roads
   ☐ Railroads
   ☐ Power utilities
   ☐ Water or wastewater treatment facilities or lines
   ☐ Overnight campgrounds
   ☐ Public parks or trails
   ☐ Fish hatchery or processor
   ☐ Dam owner's property or facilities
   ☐ Other utilities:________
   ☐ Other development:______

   Basis of observations: ☒ Ground reconnaissance ☒ Aerial reconnaissance
   ☒ Aerial photo ☐ Other: ________
   Date of observations: 2004, 2005, 2006

7. Proximity of development to downstream channel
   Distance downstream from dam: n/a
   Distance from stream bed: n/a
   Relative elevation above streambed: n/a

8. Is development in the inundation zone of a flood from an uncontrolled release of water from the dam?
   ☐ Yes ☒ No ☐ Unknown

9. Was a dam break analysis conducted? ☐ Yes ☒ No
   Basis of determining inundation zone:
   ☐ Simplified DAMBRK model
   ☐ DAMBRK model
   (Please attach calculations)
   ☐ NWS FLDWAV model
   ☐ HEC-1 model
   ☐ Other:________
   Maximum depth and velocity of flow through development: n/a

10. Is development at risk from a "sunny day" dam failure ? ☐ Yes ☒ No ☐ Unknown

11. Is development at risk from an incremental increase in the flood if the dam fails under flood conditions?
☐ Yes ☒ No ☐ Unknown

Flood condition evaluated: ☐ 100 year ☐ ½ PMF ☒ PMF ☐ Other______

12. Could an uncontrolled release cause other significant property damage or loss?
☐ Yes ☒ No ☐ Unknown

13. Could an uncontrolled release effect public health? ☐ Yes ☒ No ☐ Unknown
Description: no, potable water should be unaffected.

14. Is dam located on waters important to anadromous fish? ☒ Yes ☐ No ☐ Unknown

15. Is the reservoir created by the dam the primary water supply for a community of more than 500 residents? ☐ Yes ☒ No ☐ Unknown

16. Is a backup water supply available? ☒ Yes ☐ No ☐ Unknown

17. Proposed hazard classification: ☐ Class I (High) ☒ Class II (Significant) ☐ Class III (Low)

18. Basis of classification:
☐ Quantitative - Numerical dam break analysis conducted
☐ Qualitative - Limited engineering calculations
☒ Preliminary - No engineering calculations

19. Comments:
- No residential development downstream.
- Proponent for PMF and earthquake will use more conservative Class I criteria as basis for design.

20. Certified by: Ken Brouwer, P.E. (Print name)

Date: September 5, 2006

Company: Knight Piesold Ltd.

Phone: 604-685-0543

STATE OF ALASKA
49TH
KEN J. BROUWER
No. 10963
CE
REGISTERED PROFESSIONAL ENGINEER
Engineer's Seal and Signature

Notes:
1. *The information presented in this form may be overruled based on current data that reveals a higher level of confidence in the quality of information necessary to make the appropriate determinations.*
2. *A Class I or II dam is assumed to meet the third condition under AS 46.17.900 (3).*
3. *This form must be certified and stamped by an Alaska-registered professional engineer.*

FOR DEPARTMENT USE ONLY

Jurisdictional Status of Dam:

- ☐ Under state jurisdiction
  Reasons:
  - ☐ Height
  - ☐ Height and storage volume
  - ☐ Hazard classification
  - ☐ Anadromous fish stream
  - ☐ Environmental impact
  - ☐ Other:________________

- ☐ Not under state jurisdiction
  Reasons:
  - ☐ Height
  - ☐ Height and storage volume
  - ☐ Hazard classification
  - ☐ Federal ownership or regulation
  - ☐ Other:________________

Concur with hazard classification: ☐ Yes ☐ No

Hazard classification based on current information: ☐ Yes ☐ No

Official hazard classification: ☐ Class I (High) ☐ Class II (Significant) ☐ Class III (Low)

Comments:____
____
____

Reviewed by: ________________________________

Title: ________________________________

Date: ________________________________

Alaska Dam Safety Program

HAZARD CLASSIFICATION
AND
JURISDICTIONAL REVIEW

This form is used to state the hazard classification of a dam in accordance with 11 AAC 93.157 and to determine if a dam is under the jurisdiction of the Alaska Dam Safety Program based on the following definition, articulated under Alaska Statute 46.17.900 (3):

"Dam" includes an artificial barrier, and its appurtenant works, which may impound or divert water and which...

- ☐ has or will have an impounding capacity at maximum water storage elevation of 50 acre-feet and is at least 10 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam;
- ☐ is at least 20 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam; or
- ☐ poses a threat to lives and property as determined by the department after an inspection.

Please complete items 1 through 17. Attach additional information as necessary. This form must be certified and stamped by an Alaska-registered professional engineer on page 3.

1. Name of dam: Site G – Saddle Dam

   National Inventory of Dams (NID) number: ____________ (Assigned by Department)

   Name of stream: Unnamed Tributary (NK1.190)

   General location and region: Bristol Bay Region in Southwest Alaska

   Legal location: Township 3 Range 36 Section 34

   Meridian Seward

   Purpose and type of dam: Earthfill / Rockfill Tailings Storage Embankment

   This dam is: ☐ Existing ☒ Proposed ☐ Under construction

   Current hazard classification: ☐ I ☐ II ☐ III ☒ Not assigned

2. Owner: Northern Dynasty Mines Inc.

   Address: 3201 C Street – Suite 604

   Anchorage, AK

   99503

   Contact name: Bruce Jenkins (C.O.O.)

   Phone: 907 339 2600

3. Is dam federally owned, or regulated by the Federal Energy Regulatory Commission?
   ☐ Yes (stop here) ☒ No (complete form)

4. Maximum crest height of dam: 175 feet
   Measured from: ☐ Upstream toe ☒ Downstream toe ☐ Offstream toe
   Basis of height: ☒ Conceptual design drawing ☐ Detailed design drawing ☐ As-built drawing ☐ Field measurement ☐ NID data

5. Maximum impoundment volume: 366,000 acre-feet
   Surface area of reservoir at maximum storage: 2300 acres
   Average depth of reservoir above bottom of dam: 125 feet (live storage)
   Basis of volume estimate:
   ☐ Surface area multiplied by average depth
   ☐ Bathymetry
   ☐ NID data
   ☒ Other: Surface area / contour method using 5 foot contour intervals.

6. Downstream development: ☐ Yes ☒No ☐ Unknown
   Type of development (check all that apply):
   - ☐ Homes
   - ☐ School
   - ☐ Community halls, churches, etc.
   - ☐ Industrial or commercial property
   - ☐ Major highway
   - ☐ Primary roads
   - ☐ Secondary or rural roads
   - ☐ Railroads
   - ☐ Power utilities
   - ☐ Water or wastewater treatment facilities or lines
   - ☐ Overnight campgrounds
   - ☐ Public parks or trails
   - ☐ Fish hatchery or processor
   - ☐ Dam owner's property or facilities
   - ☐ Other utilities:________
   - ☐ Other development:______

   Basis of observations: ☒ Ground reconnaissance ☒ Aerial reconnaissance ☒ Aerial photo ☐ Other: ________
   Date of observations: 2004, 2005. 2006

7. Proximity of development to downstream channel
   Distance downstream from dam: n/a
   Distance from stream bed: n/a
   Relative elevation above streambed: n/a

8. Is development in the inundation zone of a flood from an uncontrolled release of water from the dam?
   ☐ Yes ☒ No ☐ Unknown

9. Was a dam break analysis conducted? ☐ Yes ☒ No
   Basis of determining inundation zone:
   ☐ Simplified DAMBRK model
   ☐ DAMBRK model
   (Please attach calculations)
   ☐ NWS FLDWAV model
   ☐ HEC-1 model
   ☐ Other:________
   Maximum depth and velocity of flow through development: n/a

10. Is development at risk from a "sunny day" dam failure ? ☐ Yes ☒ No ☐ Unknown

11. Is development at risk from an incremental increase in the flood if the dam fails under flood conditions?
☐ Yes ☒ No ☐ Unknown
Flood condition evaluated: ☐ 100 year ☐ ½ PMF ☒ PMF ☐ Other________________

12. Could an uncontrolled release cause other significant property damage or loss?
☐ Yes ☒ No ☐ Unknown

13. Could an uncontrolled release effect public health? ☐ Yes ☒ No ☐ Unknown
Description: no, potable water should be unaffected.

residents? ☐ Yes ☒ No ☐ Unknown

16. Is a backup water supply available? ☒ Yes ☐ No ☐ Unknown

17. Proposed hazard classification: ☐ Class I (High) ☒ Class II (Significant) ☐ Class III (Low)

18. Basis of classification:
☐ Quantitative - Numerical dam break analysis conducted
☐ Qualitative - Limited engineering calculations
☒ Preliminary - No engineering calculations

19. Comments:- No residential development downstream.
- Proponent for PMF and earthquake will use more conservative Class I criteria as basis for design.

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Date: September 5, 2006

Company: Knight Piesold Ltd.

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STATE OF ALASKA
49TH
KEN J. BROUWER
No. 10963
CE
REGISTERED PROFESSIONAL ENGINEER
Sept 6, 2006

Engineer's Seal and Signature

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FOR DEPARTMENT USE ONLY

Jurisdictional Status of Dam:

- ❑ Under state jurisdiction
  Reasons:
  - ❑ Height
  - ❑ Height and storage volume
  - ❑ Hazard classification
  - ❑ Anadromous fish stream
  - ❑ Environmental impact
  - ❑ Other:__________________

- ❑ Not under state jurisdiction
  Reasons:
  - ❑ Height
  - ❑ Height and storage volume
  - ❑ Hazard classification
  - ❑ Federal ownership or regulation
  - ❑ Other:__________________

Concur with hazard classification: ❑ Yes ❑ No

Hazard classification based on current information: ❑ Yes ❑ No

Official hazard classification: ❑ Class I (High) ❑ Class II (Significant) ❑ Class III (Low)

Comments:____
____
____

Reviewed by: ______________________________

Title: ______________________________

Date: ______________________________