Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

CHAPTER 5. GROUND WATER
MINE

NOVEMBER 2005

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Acronyms

ADEC	Alaska Department of Environmental Conservation
ASPCS	Alaska State Plane Coordinate System
ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
COC	chain of custody
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
FD	field duplicate
FSP	field sampling plan
GPS	global positioning system
ID	inner diameter
IDW	investigation-derived waste
KP	Knight Piesold
µm	micrometer
mg/L	milligrams per liter
NAD	North American Datum
NAVD	North American Vertical Datum
NDM	Northern Dynasty Mines, Inc.
NIST	National Institute of Standards and Technology
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QC	quality control
Shaw	Shaw Alaska Inc.
SLR	SLR Alaska
TDS	total dissolved solids
TSS	total suspended solids
WMC	Water Management Consultants, Inc.

1. Introduction

An environmental monitoring program is being conducted to develop baseline environmental data for the Pebble Project. Information on the proposed development and an overview of the environmental program are described in the Pebble Project *Draft Environmental Baseline Studies, Proposed 2005 Study Plan* (NDM, in press).

The purpose of this field sampling plan (FSP) is to detail tasks and to establish field procedures for conducting a study of groundwater hydrology and chemistry in the Pebble Project mine area. The field work for this study will involve drilling and installing groundwater monitoring wells, piezometers, and pumping test wells; collecting and analyzing groundwater samples; and performing pumping tests. This FSP also provides the basis for appropriate quality assurance (QA) and quality control (QC) measures to be instituted and monitored during data collection activities.

2. Project Background

The Pebble deposit is located in the headwater areas of the Koktuli River and Upper Talarik Creek. The main stems of the creek and the river flow primarily in flood-plain channels eroded into widespread glacial deposits. The valley glacial in-fill is bounded by bedrock mantled with glacial deposits. Pre-mining groundwater levels, flow, and chemistry will be defined within major bedrock units and within the overburden, which will allow an assessment of potential impacts during mining operations and after closure. The study area encompasses local and regional groundwater that might be affected by the proposed project or that could affect the surface-water system.

The proposed location of the open pit of the mine is along the margins of the valley in-fill deposits, so that certain sectors of the pit wall could be excavated into saturated overburden. Mining is expected to require dewatering of the overburden and some additional dewatering of bedrock. During dewatering, local groundwater levels will change within the overburden. The baseline groundwater study is intended to quantify the pre-mining conditions in the vicinity of the proposed pit.

The underlying groundwater system will be an important consideration for the operational and post-closure water balance of the tailings area. The evaluation of groundwater interaction will consider the size of the tailings pond, infiltration into the tailings beaches, the lateral and vertical hydraulic conductivity of the deposited tailings material, and the hydrogeologic characteristics of the foundation material. Baseline groundwater conditions will be carefully assessed to allow evaluation of the effect of the tailings facility on the local water tables, groundwater underflow, surface-water baseflow, and local and down-gradient surface-water and groundwater quality.

The detailed assessment of the groundwater system will include collection of adequate data to develop groundwater models appropriate for evaluating potential changes in local and regional water tables and the groundwater interaction with local streams, wetlands, and lakes.

3. Project Scope and Objectives

3.1 Objectives

The Pebble Project is located in an area that has a complex interaction of groundwater and surface water. The objectives of this groundwater hydrology study include the following:

- Characterize the existing groundwater flow regime within the project area.
- Characterize the baseline groundwater conditions in order to identify potential changes to the groundwater regime that might result from construction, operation, and closure of the mine.
- Collect additional groundwater information to supplement project-design activities.

3.2 Sample Analysis Summary

Sample analysis will include analysis of groundwater samples from selected monitoring wells. The wells and piezometers currently included in the groundwater-sampling and water-level-measurement program are listed in Table 1, and the locations are shown on Figure 1. The groundwater analysis methods are detailed in the Pebble Project *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (NDM, 2005).

3.3 Field Activities

The baseline study program includes establishing hydrogeologic parameters (such as potentiometric levels and hydraulic-conductivity values) and assessing groundwater quality in areas of mineralized and barren rock, as well as in the alluvial aquifers. The field work—which consists of drilling, installing, and developing monitoring wells; aquifer testing; groundwater level measurement; and groundwater sampling—is scheduled to begin by January 2005 and to be completed in December 2005.

The field activities planned for 2005 are discussed below.

3.3.1 Water-level Monitoring

The purpose of the water-level monitoring program is to collect groundwater potentiometric data to assist in hydrogeological studies in the mine study area. Water-level measurements will be taken in selected monitoring wells and piezometers monthly during 2005.

3.3.2 Install and Sample Piezometers and Monitoring Wells

The purpose of the piezometers and monitoring wells is to collect information on stratigraphy, hydraulic conductivity, groundwater levels, and groundwater quality. Wells may be installed in clusters, and each well-cluster location may include up to three wells installed at nominal depths of 30, 100, and 200 feet. The number of wells at each site and the actual depths will vary depending on site conditions. Baseline monitoring wells will be installed with a helicopter-portable ODEX drilling rig with a 5-inch inner diameter (ID) temporary drill casing.

3.3.3 Install Pumping Wells and Perform Pumping Tests

Pumping tests to define hydraulic properties may be conducted.

Each pumping site will consist of one or two 5-inch ID pumping wells installed in proximity to one another for each of the overburden pumping tests. The wells will be completed with continuous wire-wrapped screens and K-packers. These wells and related piezometers will be installed by the ODEX drilling rig.

The wells will be pumped via the airlift method with compressors or with submersible pumps. A step test will precede the pumping test to determine the most appropriate pumping rate for the constant-rate test. The contractor will be equipped to collect groundwater and to measure the pumping rate and water levels in piezometers.

4. Project Organization and Responsibility

The groundwater studies field work will be conducted by SLR Alaska (SLR) under direct contract to Northern Dynasty Mines Inc. (NDM). SLR will conduct groundwater sampling and field work according to guidelines in the quality assurance project plan (NDM, 2005) and this field sampling plan.

While in the field, SLR will e-mail brief daily updates to Water Management Consultants (WMC) and will fax daily field logs of drilling and testing to WMC and Knight Piesold (KP). Before installing a monitoring well, SLR personnel will most likely call WMC personnel via a satellite phone to confirm details such as well-screen interval. Trip reports will be submitted to WMC within approximately one week of completion of field events.

Samples will be submitted to Shaw Alaska Inc. (Shaw) laboratory personnel in Iliamna on the same day as the samples are collected. If Shaw representatives are not in Iliamna, the samples will be priority shipped to Shaw personnel in Anchorage. It is understood by SLR that Shaw personnel will log and ship the samples under chain-of-custody procedures.

SLR will coordinate field efforts with several companies under direct contract with NDM, including drillers, surveyors, and helicopter contractors.

5. Groundwater Analytical Sampling Methods

The following sections outline basic requirements for drilling, installing, sampling, and measuring monitoring wells, pumping wells, and piezometers. These requirements are designed to maximize sample quality and facilitate the permitting process. Topics covered include well locations, drilling method, drill-hole logging, drilling observations, well installation, well development and sampling, and pumping and response tests.

5.1 Surveying and Identifying Well/Piezometer Locations

5.1.1 Locating and Surveying

Before drilling begins, SLR field team members and drilling contractors will locate each well and piezometer using cadastral survey and global positioning system (GPS) coordinates, and will then visit the sites with WMC personnel. Surface routes will be located for drilling rigs to travel between wells (approximately 15 feet between wells in one cluster). No intrusive action will begin until SLR, NDM, and the drilling contractor agree that drilling rigs can be safely moved without causing harm to human health and the environment.

After wells and piezometers are installed, a surveying crew will be mobilized to the site. Horizontal control will use the Alaska State Plane Coordinate System (ASPCS), North American Datum of 1983 (NAD83), and will be conducted to first-order accuracy (±1.0 foot). Vertical control will use both North American Vertical Datum of 1929 (NAVD29) (old) and NAVD88 (new) and will be conducted to third-order accuracy (±0.01 foot) under the supervision of an Alaska registered land surveyor.

ASPCS coordinates and elevations of all newly installed monitoring wells will be surveyed. Well elevations will be surveyed at the top of the polyvinyl chloride (PVC) riser pipe and at the ground surface. All surveying data will be recorded in a bound field logbook. A printout of computerized transit data and a plot of all surveyed locations will be provided.

5.1.2 Identification

Wells and piezometers will be identified using the following well identification system:

- MW, P, or PW = abbreviation for monitoring well, piezometer, or pumping well, respectively.
- Year = two digit number for the last two digits of the date.
- Well-site number = two digit sequential number from 01 to 99.
- Well type (if in cluster) = single character denoting general well depth, as follows:

  S = shallow—30 to 50 feet deep

  M = intermediate—70 to 100 feet deep

  D = deep—150 to 200 feet deep

Well and piezometer numbers will be assigned sequentially by completion. For example:

- MW-05-20S denotes the shallow monitoring well drilled at the twentieth well site or array.
- MW-05-20M, and MW-05-20D denote the intermediate and deep monitoring wells drilled at the twentieth well site (array).
- P-05-25S will be the identification for a shallow piezometer drilled at the twenty-fifth piezometer site or array.

5.2 Groundwater Monitoring Wells

Drilling, installation, and construction of monitoring wells will follow requirements outlined in *Recommended Practices for Monitoring Well Design, Installation and Decommissioning* (ADEC, 1992) and American Society for Testing and Materials (ASTM) Method D 5092-04e1, *Standard Practice for Design and Installation of Groundwater Monitoring Wells* (ASTM, 2004).

5.2.1.1 Drilling

Well borings will be drilled either with an ODEX drilling system that employs a down-hole hammer and a 5-inch-ID continuous casing or with a rotary rig with PQ drill-rod system. The rotary rig will collect bulk samples in the pit area and will be used to install monitoring wells and piezometers in that area whenever possible. Use of the rotary method instead of the ODEX method in other areas will depend on the relative efficiency, availability, and effectiveness of each rig, which will be determined in the field.

Past drilling in the study area has revealed heaving sands. Heaving sands will be controlled with water, but should this prove not to be possible, screens can be jetted into place by hooking the water hose to the top of the PVC riser after the casing has been pulled back.

Field personnel will collect cuttings from borings in order to prepare soil descriptions. Cuttings will be bagged and labeled at five-foot intervals and stored for future reference. The bagged samples will be stored in white buckets labeled with the drill-hole number and depths of samples. Visual inspection of the cuttings together with observations of drilling activity will provide information about the characteristics of geologic materials.

Each soil boring will be logged to provide a record of subsurface conditions encountered during drilling. The logs will be prepared and maintained by the field supervisor overseeing the drilling activities. Observations will be recorded on soil-boring log forms (Appendix A). Boring logs will be prepared in accordance with ASTM Method D 2488-00 (ASTM, 2000). Other drilling observations to be documented include the following:

- Drilling behavior, such as rate and chatter, plugging of return hose, and driller’s observations.
- Rate of water flow into hole (if any).
- Rate of water flow out of hole.

- Specific conductance and pH of return water as function of depth.
- Photos of cuttings at five-foot intervals.

5.2.1.2 Monitoring Well Design

Proposed monitoring well depths and drilling methods are summarized in Table 2, and the proposed locations are shown on Figure 2. Examples of shallow, intermediate, and deep well-construction logs are presented in Appendix B, along with well-material types.

In well arrays (or clusters), each well will be installed in a separate hole, with 15-foot horizontal separation between holes. These borings will be drilled to predetermined depths (Table 2) and then over-drilled by about 10 feet before the drive shoe is knocked off to create a rathole. Well screen placement will be determined after the rathole has been sealed during construction.

Screens will typically be placed across two or three depth intervals (shallow, intermediate, and/or deep) in each well array as follows:

- In shallow wells (30 to 50 feet), 15-foot well screen will be installed across the water table.
- In intermediate wells (70 to 100 feet), well screen will be installed beneath the water table across the most permeable horizon of deep overburden.
- In deep wells (150 to 200 feet), well screen will be placed beneath the water table in fractured bedrock surface or sealed into bedrock.

Decisions on what intervals to screen will be made after drilling through overburden to bedrock. At sites where geotechnical coring results are not available or where permeable bedrock is indicated, the ODEX drilling system may drill approximately 20 feet into bedrock, if the supervising hydrogeologist finds it necessary. As shown above, well screen length will vary to allow for screening and sampling of all aquifer materials in a target horizon being monitored, but will be short enough to avoid crossing aquitards and joining adjacent aquifers. No screens will be installed across confining units or across the bedrock/overburden interface unless an upper fractured bedrock surface is being monitored.

5.2.1.3 Well Construction

Subsurface well construction will include (from the bottom up) the following salient features (Figure 3):

- The casing shoe will be sealed at the bottom of the drill hole beneath at least 3 feet of bentonite pellets and 3 feet of transition sand before the PVC riser pipe is placed in the casing.
- Monitoring wells will be constructed of 2-inch-diameter, Schedule 80, flush-joint threaded PVC riser pipe with O-rings, extending at least 3 feet above surface grade.
- Well screens will be constructed of pre-packed or non-pre-packed Schedule 80, 0.020-inch machine-slotted PVC pipe capable of retaining filter sand.

- Filter sand packs will be 10-20 silica sand, placed to at least 2 feet above the top of the screen while pulling the casing in small increments and maintaining the filter sand below the bottom of casing. Filter sand will not be required if sands are heaving after the screen is placed.

- Transition sand will follow the filter sand, placed at least 3 feet above the filter pack. If this allowance is not feasible (e.g. in shallow installations), a 5-foot bentonite plug will be placed above the sand to hold the grout out of the monitoring zone.

- A 5-foot bentonite pellet plug will be placed above the transition sand, where feasible, to seal the annulus above the transition sand. This plug does not have to be placed when heaving sands are collapsing around the riser. Instead, the casing will be pulled until the heaving stops, and then the plug will be installed. If bentonite plug placement is not feasible, the grout will be placed directly on top of the transition sand. An additional 1-foot of transition sand will be placed for every 10 feet of grout to prevent the grout from penetrating the monitoring zone.

- Bentonite grout will be placed above the plug through a tremie pipe from the bottom up, with at least 30 percent solids by weight. The grout will be pumped until return is observed at the surface. The casing will be removed in sections and grout will be pumped until return is again observed. The bentonite grout will be completed to a depth of 10 feet below ground surface (bgs).

- At a depth of 10 feet bgs in each well, a cement-bentonite grout mixture (10 gallons water; 10 pounds bentonite; 100 pounds Portland cement) will be used to seal the annular space to ground surface and set the protective casing.

- Grout fallback at surface will be recorded approximately one day after well completion.

The length of PVC riser installed in the hole will be verified with the following procedure:

- Verify the length of each PVC pipe before it goes into the well. The PVC pipe to be installed will be laid out on the ground, lengths will be double-checked and recorded, and the number of PVC pipe sections will be recorded.

- Measure the cutoff.

- Calculate the total length of PVC installed in the hole.

- Measure the total depth of the well from the top of the PVC casing prior to placing any backfill and verify that the measured total length of PVC matches that placed in the well.

Surface completion will include cementing a 5-foot locking steel protective surface casing into place, placing filter sand in the annulus between the casing and the riser pipe, and attaching a 10-foot-tall reflective road marker to the steel casing.

5.2.1.4 Well Development

Newly constructed monitoring wells will be developed before being sampled to remove fines from the borehole, to enhance the flow of formation water through the well, and to provide water samples with a minimal amount of suspended solids. Monitoring wells will be developed after the surface seal has hardened and a minimum of 24 hours has passed after installation. Wells will be developed with a high-capacity, 1-inch-diameter Waterra pump fitted with a surge block and powered by an electric actuator. This method will be used to maximize the sediment drawn in from the filter pack during development. A fire pump may be used in some cases to polish the well. During the development process, groundwater will be monitored for pH, temperature, specific conductance, and turbidity. Piezometers will also be developed but for a shorter period of time in order to verify that the piezometers are responding to aquifer piezometric level changes.

All development data will be recorded on a well development log form (Appendix A).

The following parameters will be monitored during development:

- Volume of water pumped.
- Quantity, color, and size of sediment removed, which is the most relevant observation.
- pH and specific conductance of water.
- Comments on well yield and results of development.
- Photos of water and sediment being removed.

The following technique will be used for developing monitoring wells and piezometers:

- Record the water level and total depth of the well by means of a water-level indicator. Note any accumulated sediment thickness and record all information in a logbook.
- Lower the Waterra pump with surge block to the bottom of the screen, and start the pump. After one or two minutes, collect a water sample for filtration.
- Filter the water sample through a 0.45-micometer (µm) filter, and take a "before" picture of the filter.
- Continue development until a noticeable decrease in sediment yield has been observed to a maximum of 45 to 60 minutes.
- Move the surge block approximately 2 feet up the screen and repeat the process.
- Continue moving the surge block up the screen until the full screen has been developed.
- After completing the screen surging, remove the surge block and lower the pump to the bottom of the well to remove the accumulated sediment. Then move the foot valve to about 5 feet above the top of the screen, and pump the well to polish the development.

- The well will be considered adequately developed if the water pumped by the Waterra is clear and includes less than 1 tablespoon of fine sand per 5 gallons. If more sand than this is present, repeat the process for up to 4 hours.
- After stabilization (or 4 hours of surging and pumping), pass development water through a 0.45-µm filter and take an “after” picture of the filter. Measure pH, temperature, and specific conductance of the final developed water.
- As a final step, lower the foot valve to the bottom of the well again to collect any sediment that accumulated during polishing of the well.

5.2.1.5 Response Testing

Response (slug) tests will be completed in all wells shortly after development and will follow the standard test method in ASTM Method D 4044 (ASTM, 1996).

Before the response test is conducted, the depth to water will be measured from the top of the PVC riser pipe with an electric sounder. The length that the PVC extends above the ground surface also will be recorded. A down-well pressure transducer will then be lowered into the well. Depths to groundwater as a function of time will be recorded in the logbook to demonstrate that the water level in the monitoring well has reached its static level or is responding only to regional changes in piezometric head after the transducer has been placed in the well. There will be adequate correlation between the sounder measurements and the transducer readings. The watch time for recording manual readings will be synchronized with the time being recorded by the datalogger.

A slug of known volume will then be rapidly lowered into the well. This slug will likely be a one-inch-diameter Waterra tube that is sealed at the end. The water level will be monitored by means of the down-well pressure transducer and datalogger as it returns to the static level. After the water level has returned to the static level, the slug will be rapidly removed from the water. The water level will again be monitored as it returns to the static level. The water-level recovery data will be plotted in the field, to determine that enough data for analysis have been collected. If necessary, a field computer will be used to plot and evaluate the data. The response test will be repeated until two tests with enough data have been completed. If the water-level recovery is slow, the recovery will be monitored for up to one hour. Test monitoring may therefore be up to two hours (monitoring of slug insertion and slug withdrawal).

5.3 Piezometers

5.3.1 Piezometer Installation

Piezometers will be designed, drilled, installed, constructed, and documented in the same manner as monitoring wells (Figure 3 and Section 5.2). Piezometers will be used to measure piezometric levels and aquifer response to pumping tests. The proposed piezometers are summarized in Table 2.

5.3.2 Development and Sampling

Sampling from piezometers is not planned. Piezometers will be developed using procedures similar to those for monitoring wells, but for a shorter duration, as development is necessary to improve response to piezometric level changes rather than to remove sample turbidity.

5.3.3 Response Testing

Piezometers will be response tested in the same manner as monitoring wells (Section 5.2.1.5).

5.4 Pumping Test Wells

5.4.1 Well Design

Logistical considerations preclude the use of a large drilling rig to install 6- or 8-inch-ID pumping wells; therefore, arrays of one or two 5-inch-ID pumping wells will be installed in proximity to one another for each of the pumping tests. Pumping wells for the pumping test will be installed using the ODEX drilling rig, except for the bedrock test at the pit, which may be installed by a rotary drilling rig with a PQ drill-rod system, depending on rig availability. Selection of pumping-well locations and design will be based on the information gained during the installation of nearby piezometers. The locations and the depths will be selected in the field and approved by project personnel at SLR and WMC.

The pumping-well screen will probably be placed in the most permeable horizon encountered during drilling. The screen length will be decided in consultation with WMC. Well-screen placement and length will vary to allow for screening and sampling of the target aquifer materials and will be short enough to avoid crossing aquitards and joining adjacent aquifers.

5.4.2 Installation and Construction

During drilling, each pumping well will be logged in the same manner as the monitoring wells. Pumping test wells will be drilled with 5-inch-diameter welded casing rather than the threaded casing used for monitoring wells and piezometers. After drilling to final depth, the casing shoe will be knocked off. The screen size will be selected from available stock based on grain-size distribution of the screened horizon and in consultation with WMC. The screen and K-packer assembly will be lowered into the well and the casing retracted to expose the screen.

5.4.3 Development and Sampling

Pumping wells will be developed by the drilling contractor using air-jet and airlift methods. Development will continue until the return has cleaned significantly and/or optimal well yield has been achieved.

5.4.4 Pumping Tests

The ODEX drilling contractor will carry out the pumping tests under the supervision of SLR. The wells will be pumped with the airlift method, with compressors supplied by the ODEX drilling contractor, or with submersible pumps. The actual pumping method will be determined in the field based on field conditions. Therefore, the ODEX drilling contractor will be required to mobilize the equipment necessary to airlift from multiple small diameter wells; to collect and measure the airlifted water, pumping rate, and piezometer water levels; and to discharge the water at a suitable location 1,000 feet from the well. The discharge will be to land, with infiltration occurring prior to reaching surface water.

A 24-hour pumping test is planned for each site with a 24-hour monitored recovery. The pumping test will be preceded by a step test to determine the optimal pumping rate for the constant-rate test.

The pumping tests will be conducted according to the following procedure:

- Install a transducer for monitoring background groundwater levels at least two days before the test starts.
- Install transducers in the piezometers to be used in the pumping test as they are completed and at least two days before the test starts and before starting drilling of the pumping well.
- Install the barologger in a nearby piezometer simultaneously with installation of the first transducer.
- During the full testing period, measure the water level manually at regular intervals to confirm the transducer readings and to relate the transducer data to surveyed elevations.
- Conduct a step test in the pumping well by adjusting the submergence of the pipe used for injecting compressed air. The duration of the step test will be one to four hours.
- Based on the results of the step test, choose a submergence for the pipe for the constant-rate test.
- Monitor the recovery from the step test.
- Start the constant-rate test at the chosen rate after the water levels have fully recovered.
- Transmit the water-level data to WMC at the end of the first day.
- Continue the constant-rate test until one of the following conditions has been observed:
  - The drawdown capacity of the transducer has been surpassed.
  - The water levels have stabilized and are unlikely to change.
  - 24 hours has passed.
- After the test is terminated, monitor recovery for a period equal to the duration of the test and the pre-test monitoring.

5.5 Water-level Measurements

Water levels in wells and piezometers will be measured with an electronic sounder. Water levels will be documented on water level measurement logs (Appendix A). For the water-level survey, all water levels in a sampling area will be measured on the same day. The following protocol will be employed while collecting water-level data:

- An electronic sounder will be used to measure water levels and total depths in all wells and groundwater piezometers.
- That portion of the probe cable submerged below fluid levels in wells will be cleaned according to the decontamination procedure described in Section 5.7.
- Electronic sounders will be kept clean and will be maintained in accordance with manufacturer's instructions.
- The reference point for water-level measurements will be the access port on those installations that have submersible pumps or the high point of the PVC casing on those installations that do not have submersible pumps.

5.6 Sampling Procedures

5.6.1 General Techniques

The groundwater monitoring wells will be purged and sampled with a dedicated submersible pump. Dedicated 3/4-inch-diameter polyethylene (or equivalent) tubing will be permanently installed between the well cap and the pump. Samples will be collected from non-dedicated 3/8-inch-diameter polyethylene tubing connected at the well cap. New tubing will be used between the well cap and the sample container for each sample. The tubing will facilitate the use of in-line filters as needed for specific analyses. All required field measurements will be collected as described in the quality assurance project plan (NDM, 2005). Purge water will be disposed of on site.

The proposed number of samples and sample types are shown in the quality assurance project plan (NDM, 2005); container types, holding times, and preservatives also are described.

5.6.2 Monitoring Well Purging

All wells will be purged prior to sampling by means of the low-flow purging method promulgated by the U.S. Environmental Protection Agency (EPA, 1998) and described here. The objective is to remove the resident water in the well below the pump within the riser.

Measurement data and the make and models of all equipment used will be recorded on a well purging and sampling field sheet (Appendix A).

Wells will be purged and sampled with the dedicated submersible pump. Purging will begin with an emphasis on maintaining a low flow rate, typically 0.5 liters per minute. During these initial stages, drawdown from the static water level will be monitored. The goal is to minimize drawdown during purging. A guideline of 25 percent of the height of the water column above the pump intake is suggested for maximum drawdown. Readings of water-level elevation and the determined drawdown will be recorded approximately every 5 minutes. Priority will be given to ensuring that two volumes are purged and especially that the water level is stable or rising when recording field parameters and collecting samples.

During well purging, the following field parameters will be monitored by means of a flow-through cell:

- Dissolved oxygen (DO).
- Conductivity.
- Temperature.
- pH.

Care will be taken to ensure that the pump's tubing is free of air bubbles along its entire length to the flow-through cell. Turbidity will be monitored visually and qualitative comments will be included on the field sampling form.

If necessary, a turbidity meter may be used to collect turbidity measurements. If used, the sample for the turbidity analysis will be drawn from upstream of the flow-through cell from a "T" fitted with a valve. Care will be taken when drawing the turbidity samples to not introduce air into the sampling tube leading to the flow-through cell and to draw the sample at a sufficiently low rate to not significantly disrupt flow to the flow-through cell.

Once the minimum purge volume has been removed (two times the combined drawdown volume due to drawdown and below the pump), the pumping rate will be decreased so that the water level is stable or rising. Following the exchange of one volume of water through the flow-through cell, readings of the field parameters will be recorded approximately every five volumes of water through the flow-through cell. The rate of water exchange will be calculated by the flow rate and the volume of the flow-through cell. The parameters will be considered stabilized when the following conditions have been met for three consecutive readings:

- DO varies by less than 15 percent or 0.3 milligrams per liter, whichever is greater.
- Conductivity varies by less than 3 percent.
- Temperature varies by less than 1.0ºC.
- pH varies by less than 0.2 pH units.
- Turbidity is observed to be minimal.
- Purged-water volume exceeds twice the volume of water below the pump plus the drawdown volume.

If it appears that the readings will not stabilize after collection of a number of readings, the parameter-measurement device will be recalibrated and/or cleaned. Purging will then be repeated. If the readings still have not stabilized following another set of readings, a field determination will be made as to whether sample collection is justified. The field determination will take into account any observations made during the purging process and possible reasons why the readings will not stabilize.

Once the parameters are stabilized, or the decision to collect a sample has been made, sample collection will begin.

5.6.3 Sample Collection

Groundwater samples will be collected for analysis in the following order:

1. Total metals.
2. Dissolved metals.
3. Total suspended solids and total dissolved solids.
4. Cyanide.
5. Miscellaneous water-quality parameters (e.g., ammonia, phosphorus).

Samples will be collected with the pump and tubing used to purge the well. Samples collected for dissolved metals analyses also will be filtered in the field with disposable, inline filters. Sample preservatives will be added to sample bottles by the laboratory prior to field sampling. Water collected in the field will be placed in bottles already containing the preservative.

For sample collection, the flow-through cell will be bypassed. At each sampling location, all bottles designated for a particular analysis will be filled sequentially before bottles designated for the next analysis are filled. If a duplicate sample is to be collected at a location, all bottles designated for a particular analysis for both duplicates will be filled sequentially before bottles for another analysis are filled. Care will be taken not to touch the tubing to the sample container during sample collection.

5.7 Sampling Equipment Decontamination

All non-disposable water-sample-collection equipment that comes into contact with a sample will be decontaminated by means of the following procedure:

1. Rinse in water.
2. Wash with Alconox or equivalent in tap or deionized water.
3. Double rinse in distilled water.
4. Double rinse with the water to be sampled.

The purpose of the water and Alconox (or equivalent) wash is to remove all visible particulate matter. The distilled water rinse removes the detergent. Because sample equipment and supplies are either pre-cleaned disposable (single use) material or dedicated to the well (pumps and tubing are dedicated to individual wells), this decontamination procedure is generally only necessary for decontaminating new sample pumps prior to installation.

5.8 Sample Handling

Samples will be packed to prevent breakage and will be kept chilled during field operations by transporting the samples in coolers with frozen gel ice. Samples and sample transfer forms will be delivered to the NDM-designated sample-handling person at Iliamna at the end of each day. Sample packing for shipment to the laboratories will be conducted by the NDM-designated sample-handling person at Iliamna.

Sample handling also includes the tasks listed below.

5.8.1 Sample Containers

Sample container requirements are contained in the quality assurance project plan (QAPP; NDM, 2005). Prior to departing for Iliamna, the field-team leader should review the bottle order received from the laboratory against the QAPP to verify that the necessary sample containers have been received.

5.8.2 Sample Volumes, Container Types, and Preservation Requirements

Sample volumes, container types, and preservation requirements are described in the QAPP (NDM, 2005). Prior to departing for Iliamna, the field-team leader should review the bottle order received from the laboratory against the QAPP to verify that the sample volumes and container types are correct and that preservation requirements have been met.

5.8.3 Sample Identification

The sample identification system will follow the protocol detailed in the QAPP (NDM, 2005) and summarized below. The current version of the QAPP should be reviewed prior to each sampling.

Each sample container will have a waterproof label large enough to contain the information needed to easily identify each sample. The information to be included on each label will include the project name, date, time, preservative (if added), sample code, analysis, and sampler's initials. The sample code will be formatted to indicate sample date (month and year), location, matrix, and number.

Each sampling location will be identified by the sampler on a well purging and sampling field control form (Appendix A). An example of sample identification is as follows:

0105MW1DGW001

Where:

0105 is the date as month/year

MW1D is the location identification

GW is the matrix code for groundwater

001 is a sequential sample number

For field duplicates, the sequential sample number will be 201, and the number for triplicates will be 301. The number 401 is used for field equipment rinse blanks, and 501 is used for deionized water blanks.

5.9 Sample Custody

Chain-of-custody (COC) forms will be used for all samples and will be prepared by the NDM/Shaw sample-handling person at Iliamna. Once collected, samples will remain within sight of the sampler or will be secured until the samples are signed over to the NDM/Shaw sample-handling person at Iliamna. The samples will be submitted to the assigned sample-handling person at Iliamna, who will be responsible for shipping and laboratory notification.

Other COC components of which SLR will provide copies include the field logbook and the field sampling sheets.

5.10 Field Quality Control Samples

To aid in evaluating the accuracy of the analytical data, sample blanks and duplicate samples will be collected and subjected to the same analyses as identified task samples. Equipment (also known as field) blanks will be collected at a frequency of 5 percent. Equipment blanks will be collected by passing deionized water through the sample collection equipment and a filter and into the sample-collection bottle. The equipment blank will be submitted for analysis for dissolved metals. Deionized water blanks will be collected once per field sampling event and analyzed for total metals. Blanks will be analyzed along with the regular project samples. Field duplicates and field triplicates will be collected at a frequency of 10 percent. The field quality control samples will be collected at the same time as the primary sample is collected.

The field QA/QC samples are summarized in the QAPP (NDM, 2005). The field-team leader will review the QAPP prior to field activities to verify that the correct field QA/QC samples are collected.

6. Field Measurements

6.1 Parameters

Portable water-quality instruments will be used for the in situ measurement of water levels, pH, temperature, dissolved oxygen, and conductivity.

6.2 Equipment Calibration and Quality Control

Field equipment used for collection, measurement, and testing is subject to a strict program of control, calibration, adjustment, and maintenance. Recorded measurements will not be taken until field readings stabilize. These values will then be recorded. Calibrations will be performed before each day's sampling. Calibration will be checked before sampling at each station with reference to standard calibration solution. The standards of calibration are in accordance with applicable criteria, such as those of the National Institute of Standards and Technology (NIST), ASTM standards, or other accepted procedures outlined in the manufacturer's handbook of specifications. All calibration activities will be documented on appropriate field calibration forms (Appendix A).

The field-team leader will review data measured in the field, and senior personnel will perform final validation by checking procedures used in the field and comparing the data with previous results.

Data that cannot be validated will be so documented; corrective action may be required. Corrective actions for field sampling include procedures to be followed when field data results are not within the acceptable error-tolerance range. These procedures include the following:

- Comparing data readings being measured with readings previously recorded.
- Recalibrating equipment (e.g., pH meters).
- Replacing or repairing faulty equipment.
- Resampling when feasible.

The field-team leader is responsible for ordering appropriate corrective actions when deemed necessary. All field corrective actions will be recorded in the field logbook.

6.3 Equipment Maintenance and Decontamination

Equipment will be maintained in good operating condition. Sampling equipment will be decontaminated as detailed in Section 5.7, except in the case where more minimal decontamination would be required, such as for the flow-through cell and water-quality meters where rinsing only may be adequate during field operations.

6.4 Recording Field Measurements

The water levels, pH, temperature, dissolved oxygen, and conductivity measurements will be recorded in the field logbook or on field sampling sheets, as appropriate.

7. Record Keeping

Field observations, field-equipment calibration information, field measurements, and sample documentation—including sample identification, sample duplicates, and date and time of sample collection—will be the responsibility of the entire sampling team. Record keeping will be accomplished with field logbooks and field forms, as described below. No general rules can specify the extent of information that must be entered on the field records; however, they will contain sufficient information so that all field activity can be reconstructed without relying on the memory of the field team.

7.1 Field Logbooks

A field logbook will be maintained on a daily basis to document all field activities, including the collection of every sample. The field logbook will be bound, with consecutively numbered pages. All field notes will be entered in indelible ink. If any changes are made to the field record, the original notation will be crossed out with a single line and initialed and dated by the person making the correction. At a minimum, field logbooks will contain the following information:

- Date and time that work commenced.
- Name and location of site.
- Description of work area.
- Date and times of sample collection or event.
- Name of the leader of the field team; names of all field personnel; and the names, addresses, and telephone numbers of all pertinent project contacts.
- Summary of equipment preparation procedures.
- Field observations (weather condition, field instrument readings).
- Number and type of samples collected and sample identification numbers.
- Sample location.
- Explanations of any deviations from this field sampling plan, with rationale for deviation.
- Problems encountered and their resolution.

Field activities, site conditions, and sampling locations will be documented with photographs.

7.2 Field Forms

All pertinent field survey and sampling information will be recorded on field forms during each day of the field effort and at each sample site. The field-team leader will be responsible for seeing that sufficient detail is recorded on the forms.

The following field forms are expected to be used during the groundwater studies:

- Soil Boring Log.
- Well Completion Diagram.
- Well Development Log.
- Sample Transfer Log.
- Well Purging and Sampling Field Control Sheet.
- Water Level Measurement Sheet.
- Calibration Log
- Pumping Test Sheet.
- Response Test Sheet.
- Transducer Control Form.

Examples of the field forms are included in Appendix A. Field forms will be printed on waterproof paper when appropriate. Maintaining proper documentation for sample custody includes keeping records of all materials and procedures involved in sampling. Project field forms will be used to record field data. Field teams will record all information about the sampling station and about the respective samples and replicates collected at each site, including the positions of each station. The field-team leader will review the field forms before leaving the sampling station.

Strict COC procedures will be maintained with the field forms used. While being used in the field, forms will remain with the field team and will be secured in a clipboard or by other appropriate means. Upon completion of the field effort, forms will be filed in an appropriately secure manner and will remain with the task manager. Completed field forms will be kept on file for future reference. Photocopies of the original data will be used as working documents.

7.3 Corrections to Documentation

Unless weather conditions prevent it, all original data will be recorded using waterproof ink. No accountable documents, which include field books and sampling forms, will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. If an error is made on an accountable document, the person responsible for the entry must make corrections by drawing a line through the error, initialing and dating the lined-out item, and entering the correct information. The erroneous information is not to be obliterated, but is to remain legible. Any error discovered on an accountable document will be corrected by the person who made the entry. All such corrections will be initialed and dated.

8. Field Performance and System Audits

At minimum, SLR will perform field performance and system audits during one groundwater sampling event and one water-level survey and during the drilling program. The field performance and system audits will be conducted by a senior-level SLR employee. The audit will evaluate if field procedures are being correctly implemented and will also identify additional measures, if any, that may be taken to improve field data collection.

WMC personnel will be present for the following activities:

- Initial siting of drill holes.
- Drilling and installation of the first monitoring well or piezometer.
- Development and response testing of the first monitoring well or piezometer.
- Execution of the first pumping test.

9. References

Alaska Department of Environmental Conservation (ADEC). 1992. Recommended Practices for Monitoring Well Design, Installation and Decommissioning.

American Society for Testing and Materials (ASTM). 1996. Method D 4044-96, Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers.

———. 2000. Method D 2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

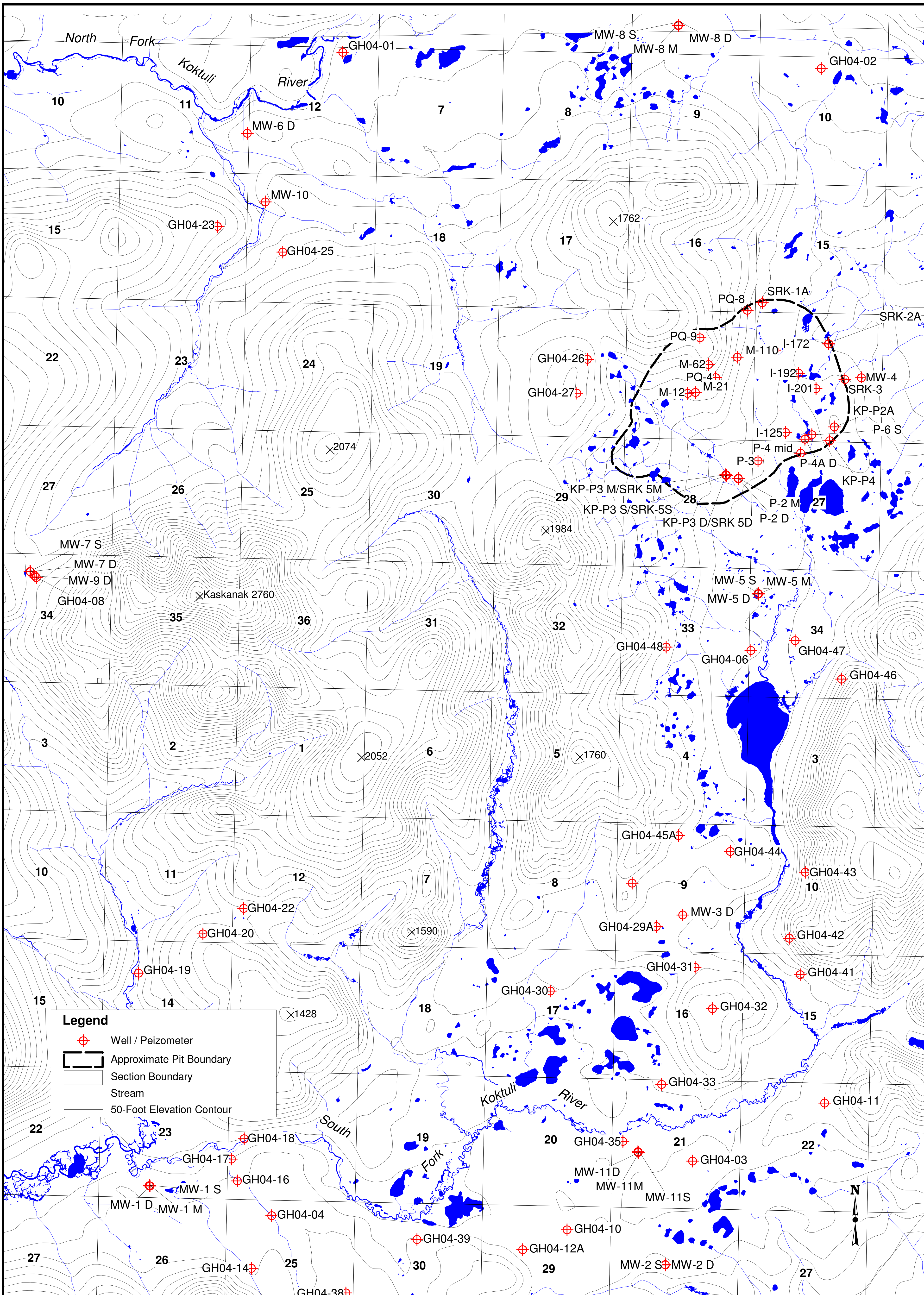
———. 2004. Method D 5092-04e1, Standard Practice for Design and Installation of Groundwater Monitoring Wells.

Northern Dynasty Mines (NDM). 2005. Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan. Prepared for the State of Alaska, Large Mine Permitting Team, Alaska Department of Natural Resources. June.

———. In press. Draft Environmental Baseline Studies, Proposed 2005 Study Plan. Prepared for the State of Alaska Large Mine Permitting Team, Alaska Department of Natural Resources.

U.S. Environmental Protection Agency (EPA). 1998. Groundwater Sampling Procedure, Low Stress (Low Flow) Purging and Sampling. EPA Region II. March 16.

FIGURES



SLR Alaska

2525 Blueberry Road, Suite 206
Anchorage, AK 99503
(907) 222-1112 Fax (907) 222-1113

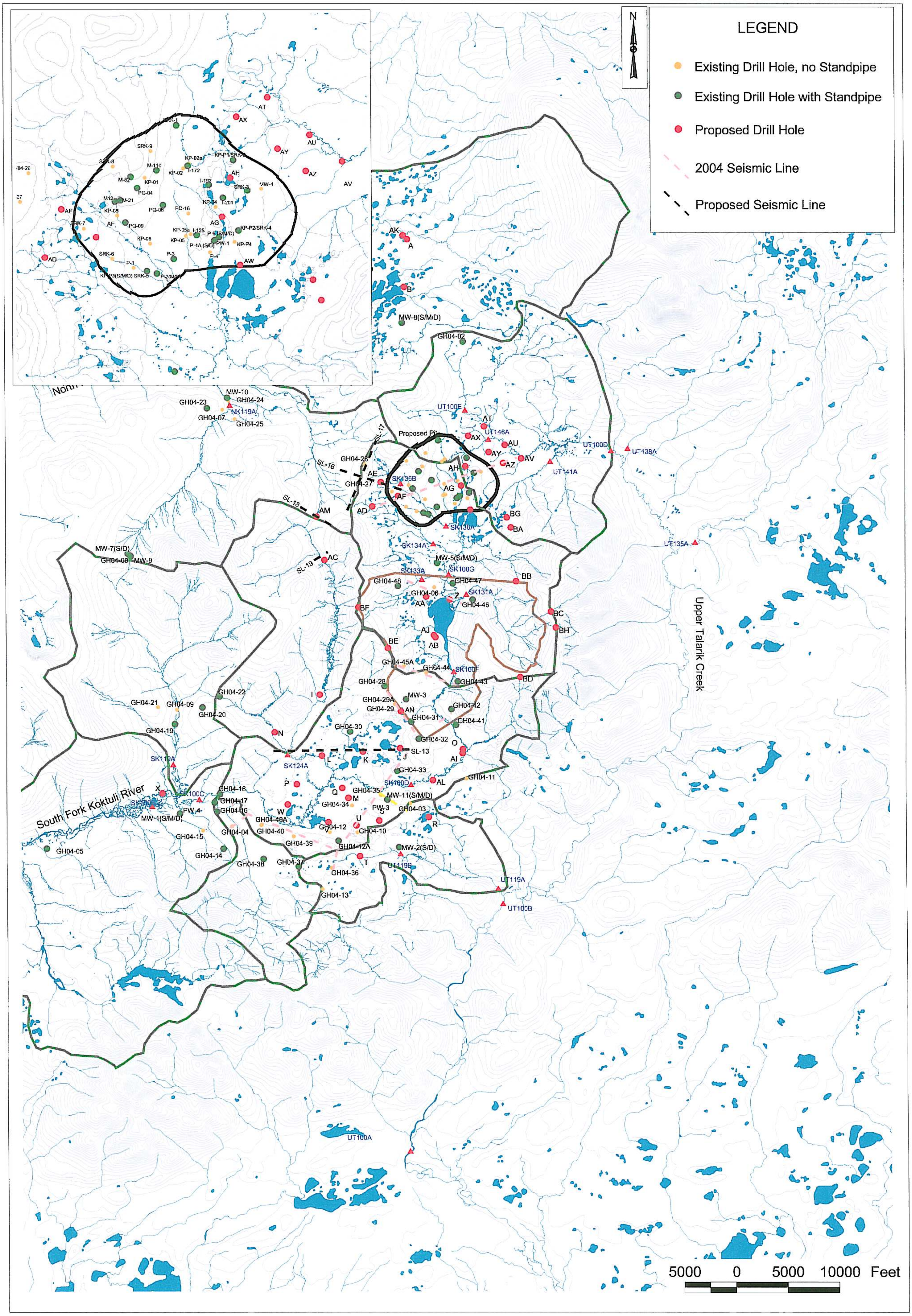
3522 International Street
Fairbanks, AK 99701
(907) 455-9005 Fax (907) 455-9015

Northern Dynasty Mines, Inc.
Existing Mine Site
Well Locations

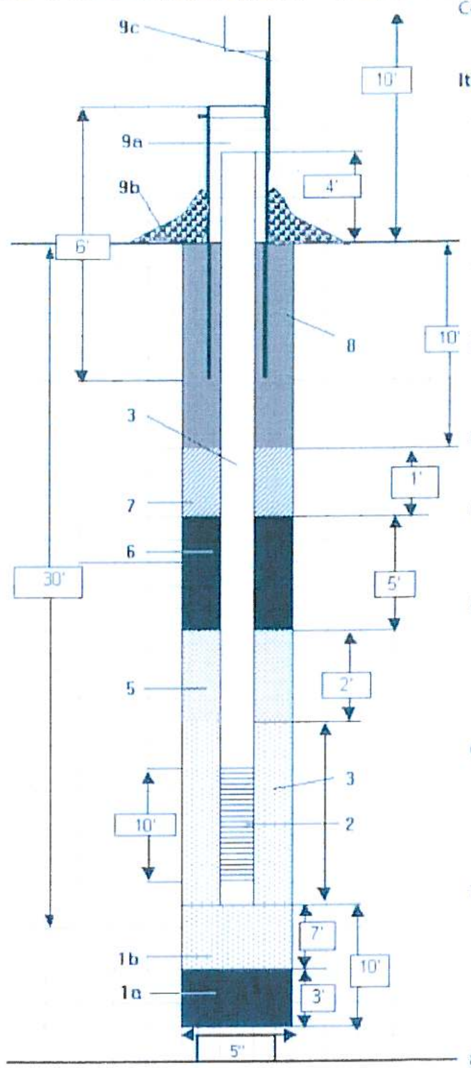
Figure

1

Figure 2 Planned Groundwater and Geotechnical Drilling Locations - June 7, 2005



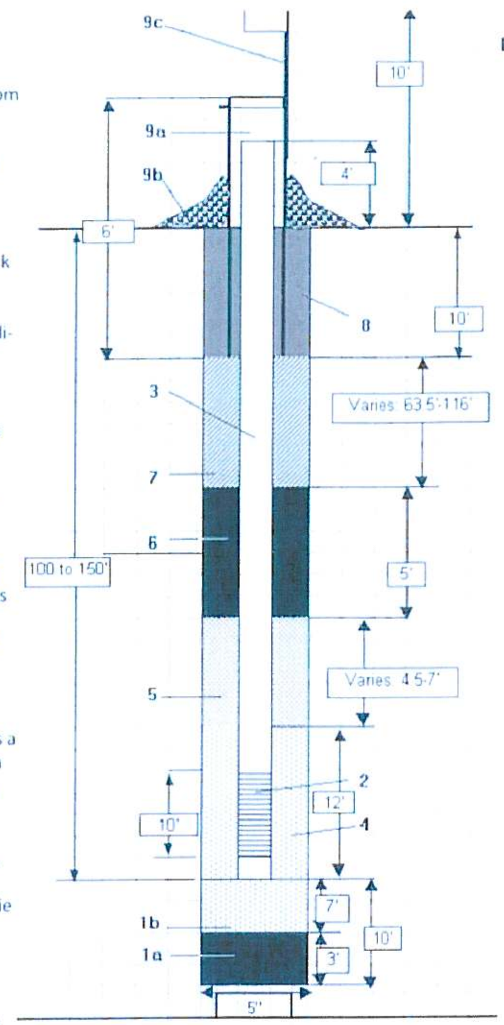
SHALLOW WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specification/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	
1	b) Type of transition sand	CSSI 10-20 silica sand, placed to least 3 feet above rathole bentonite plug
2	Type/slot size of screen	2-inch/Schedule 80 PVC Pre-pack (or Insta-pack), 0.020-inch, machine-slotted PVC, 15-foot screens in shallow and intermediate wells, varies in deep wells.
3	Dia./type of riser well casing	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
4	Type screen filter pack	CSSI 10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
5	Type of transition sand	CSSI 20-40 silica sand, placed at least 3 feet above filter pack, plus additional 1-foot of transition sand placed for every 20-feet of grout (1:20 ratio)
6	Type of plug	PureGold medium bentonite chips, (where possible) placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
7	Type seal overlying plug	For wells >50 feet in total depth, PureGold grout, >30%solids by weight bentonite; place by tremie pipe from bottom up. Native backfill collapsing as casing is pulled if <50 feet total depth.
8	Type near-surface completion	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
9	Wellhead protection	
9	a) Wellhead protective casing	8-inch dia. by 5 feet/Stainless Steel with weep hole with locking cap
9	b) Gravel blanket	Mound 10 inches around well casing, using drill cuttings if possible
9	c) Reflector	1-inch dia. PVC pole attached to protective casing with flag
9	d) Well tag	Inscribed in locking cap
10	Development	
	a) Development method	Surge and block, with 1-inch Waterra pump and fire pump
	b) Development lag after installation	24 hours
	c) Disposal of development water	Discharge to ground surface

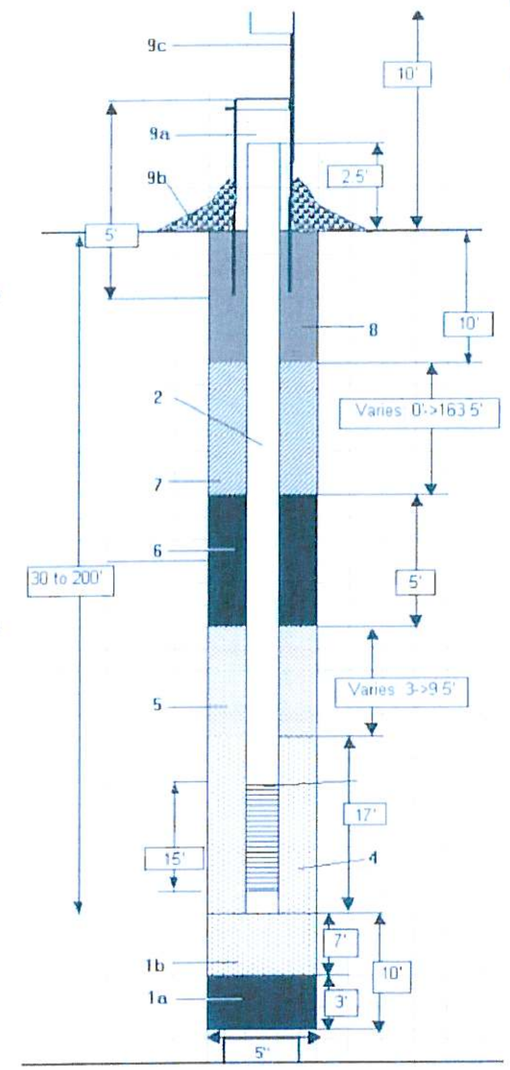
INTERMEDIATE (100 to 150 ft.) WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specification/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	
1	b) Type of transition sand	CSSI 10-20 silica sand, placed at least 7 feet above rathole bentonite plug
2	Type/slot size of screen	2-inch/Schedule 80 PVC Pre-pack (or Insta-pack), 0.020-inch, machine-slotted PVC pipe, capable of retaining filter sand
3	Dia./type of riser well casing	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
4	Type screen filter pack	CSSI 10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
5	Type of transition sand	CSSI 20-40 silica sand, placed at least 3 feet above filter pack, plus additional 1-foot of transition sand placed for every 20-feet of grout (1:20 ratio)
6	Type of plug	PureGold medium bentonite chips, placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
7	Type seal overlying plug	PureGold grout, >30%solids by weight bentonite; place by tremie pipe from bottom up
8	Type near-surface completion	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
9	Wellhead protection	
9	a) Wellhead protective casing	8-inch dia. by 6 feet/Stainless Steel with weep hole with locking cap
9	b) Gravel blanket	Mound 10 inches around well casing, using drill cuttings if possible
9	c) Reflector	1-inch dia. PVC pole attached to protective casing with flag
10	Development	
	a) Development method	Surge and block, 1-inch Waterra pump and fire pump
	b) Development lag after installation	2 hours
	c) Disposal of development water	Discharge to ground surface

DEEP (150 to >200 ft.) WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specification/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	
1	b) Type of transition sand	CSSI 10-20 silica sand, placed at least 7 feet above rathole bentonite plug
2	Type/slot size of screen	2-inch/Schedule 80 PVC Pre-pack (or Insta-pack), 0.020-inch, machine-slotted PVC pipe, capable of retaining filter sand
3	Dia./type of riser well casing	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
4	Type screen filter pack	10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled
5	Type of transition sand	CSSI 20-40 silica sand, placed at least 3 feet above filter pack, plus additional 1-foot of transition sand placed for every 20-feet of grout (1:20 ratio)
6	Type of plug	PureGold medium bentonite chips, placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
7	Type seal overlying plug	PureGold grout, >30%solids by weight bentonite; place by tremie pipe from bottom up
8	Type near-surface completion	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
9	Wellhead protection	
9	a) Wellhead protective casing	8-inch dia. by 6 feet/Stainless Steel with weep hole with locking cap
9	b) Gravel blanket	Mound 10 inches around well casing, using drill cuttings if possible
9	c) Reflector	1-inch dia. PVC pole attached to protective casing with flag
10	Development	
	a) Development method	Surge and block, 1-inch Waterra pump and fire pump
	b) Development lag after installation	2 hours
	c) Disposal of development water	Discharge to ground surface

Wells to be installed per ASTM D5092 (1990): Design and Installation of Ground Water Monitoring Wells in Aquifers and *Recommended Practices for Monitoring Well Design, Installation and Decommissioning* (ADEC, April 1992)

Figure 3
Groundwater Monitoring Well Construction Details

TABLES

Table 1. Existing Well Locations and Completions

Drillhole	NAD 1927 Coordinates Northing (m)	NAD 1927 Coordinates Easting (m)	Monthly Water Levels	Quarterly Water Sampling	Notes
GH04-01	6646681.5580	366784.1590	X (1)		
GH04-02	6646387.9420	372784.5330	X (2)		
GH04-03	6632704.1750	370962.7370	X (3)		
GH04-04	6632099.4000	365670.8370	X (4)		
GH04-05	6631519.7420	360189.9040	X (5)		
GH04-06	6639100.4510	371791.7100	X (6)		
GH04-08	6640151.2560	362837.7980	X (7)		
GH04-10	6631865.3710	369374.0300	X (8)		
GH04-11	6633407.0570	372629.7660	X (9)		
GH04-12A	6631625.4740	368815.1930	X (10)		
GH04-13	6630198.7010	368315.4040	X (11)		
GH04-14	6631443.2150	365407.5270	X (12)		
GH04-16	6632542.0000	365247.0000	X (13)		
GH04-17	6632817.3610	365177.0800	X (14)		
GH04-18	6633069.0000	365341.0000	X (15)		
GH04-19	6635166.3840	364047.9360	X (16)		
GH04-20	6635646.6080	364862.1070	X (17)		
GH04-22	6635960.1760	365378.6380	X (18)		
GH04-23	6644521.3170	365177.2360	X (19)		
GH04-25	6644186.1060	365994.2240	X (20)		
GH04-26	6642782.7500	369793.0990	X (21)		
GH04-27	6642360.5040	369656.5390	X (22)		
GH04-28	6636203.8180	370256.2630	X (23)		
GH04-29A	6635654.0000	370551.0000	X (24)		
GH04-30	6634865.7660	369209.8120	X (25)		
GH04-31	6635134.9620	371029.7630	X (26)		
GH04-32	6634612.5930	371241.3640	X (27)		
GH04-33	6633671.4850	370589.2410	X (28)		
GH04-35	6632964.2100	370092.5680	X (29)		
GH04-37	6630882.9460	367622.8450	X (30)		
GH04-38	6631115.4040	366588.1020	X (31)		
GH04-39	6631772.4570	367489.5250	X (32)		
GH04-41	6635023.0000	372348.0000	X (33)		
GH04-42	6635483.0000	372218.0000	X (34)		
GH04-43	6636307.0000	372431.0000	X (35)		
GH04-44	6636582.0000	371495.0000	X (36)		
GH04-45A	6636791.0000	370846.0000	X (37)		
GH04-46	6638723.0000	372923.0000	X (38)		
GH04-47	6639214.0000	372347.0000	X (39)		
GH04-48	6639158.0000	370727.0000	X (40)		
I-125	6641828.0000	372266.0000	X (41)		
I-172	6642863.0000	372148.0000	X (42)		
I-192	6642570.0000	372442.0000	X (43)		
I-201	6642373.0000	372658.0000	X (44)		
KP-P1/SRK-2	6642931.7640	372826.0710	X (45)	X (1)	Monument labeled KP-P1/SRK-2-1
KP-P2A	6641888.6290	372879.8180	X (46)		AKA KP-2A / Stand 3.
KP-P3 D /SRK-5D	6641305.7900	371507.4170	X (47)	X (2)	
KP-P3 M /SRK-5M	6641309.4070	371510.1710	X (48)	X (3)	
KP-P3 S /SRK-5S	6641302.2560	371516.5260	X (49)	X (4)	
KP-P4	6641716.0850	372818.4140	X (50)	X (5)	Monument Mislabeled KP-P2/SRK-4
M-110	6642783.0000	371675.0000	X (51)		
M-12	6642338.0000	371046.0000	X (52)		
M-21	6642348.0000	371142.0000	X (53)		
M-62	6642695.0000	371312.0000	X (54)		
MW-1 D	6632496.2440	364145.5550	X (55)	X (6)	
MW-1 M	6632494.0840	364149.2130	X (56)	X (7)	
MW-1 S	6632498.5920	364139.9170	X (57)	X (8)	
MW-2 D	6631411.0470	370599.5950	X (58)	X (9)	
MW-2 S	6631405.8950	370601.1460	X (59)	X (10)	

Table 1. Existing Well Locations and Completions

Drillhole	NAD 1927 Coordinates Northing (m)	NAD 1927 Coordinates Easting (m)	Monthly Water Levels	Quarterly Water Sampling	Notes
MW-3 D	6635793.2590	370885.9970	X (60)	X (11)	
MW-4 S	6642499.3710	373229.4160	X (61)		
MW-5 D	6639808.4980	371890.4710	X (62)	X (12)	
MW-5 M	6639807.5870	371895.8260	X (63)	X (13)	
MW-5 S	6639813.3320	371894.3170	X (64)	X (14)	
MW-6 D	6645684.9910	365569.4130	X (65)	X (15)	
MW-7 D	6640225.6900	362766.2390	X (66)	X (16)	
MW-7 S	6640227.4210	362760.4640	X (67)	X (17)	
MW-8 D	6646958.2210	371002.5990	X (68)	X (18)	
MW-8 M	6646953.9630	370998.3330	X (69)	X (19)	
MW-8 S	6646959.3940	370997.4790	X (70)	X (20)	
MW-9 D	6640169.3760	362821.7330	X (71)	X (21)	
MW-10	6644819.7610	365783.3140	X (72)	X (22)	
MW-11D	6632823.5350	370282.3500	X (73)	X (23)	
MW-11M	6632827.6360	370280.6040	X (74)	X (24)	
MW-11S	6632832.3640	370279.5610	X (75)	X (25)	
P-2 D	6641256.3380	371666.0440	X (76)		
P-2 M	6641262.8900	371665.4880	X (77)		
P-3	6641476.7340	371915.7080	X (78)		
P-4 mid	6641565.2000	372451.5360	X (79)		AKA P-4
P-4AD	6641739.7250	372508.0820	X (80)		
P-4AS	6641734.8780	372513.0460	X (81)		
P-6D	6641798.0450	372590.8040	X (82)		
P-6M	6641793.5220	372590.8260	X (83)		
P-6 S	6641794.7560	372595.7890	X (84)		
PQ-4	6642544.0000	371391.0000	X (85)		
PQ-8	6642265.0000	371812.0000	X (86)		
PQ-9	6642029.0000	371212.0000	X (87)		
SRK-1A	6643461.0000	372000.0000	X (88)		
SRK-2 (AKA 4251)	6642932.0000	372826.0000	X (89)		
SRK-2A	6642933.6850	372821.8560	X (90)		
SRK-3	6642482.0000	373022.0000	X (91)		

TABLE 2
2005 PROPOSED BOREHOLES

FOUNDEX (ODEX) RIG (primarily hydrogeological focussed BH's)

Borehole	NAD 83 Coordinates		NAD27 Coordinates Confirmed in Field (Original Locations)		Field Locates w/GPS NAD 27 Coordinates (Modified Locations)		Drilling Method	In Situ Testing Required [1]	Installation [2]	Purpose[3]
Name	Easting	Northing	Easting	Northing	Easting	Northing				
AD	1,397,024	2,154,831	370,011	6,641,527			ODEX		single or dual P	
AF	1,399,507	2,155,824			370,674	6,641,737	ODEX		dual MW	Pit Impacts on Groundwater, Pit Inflow
AE	1,397,834	2,157,196			370,287	6,642,229	ODEX		single or dual P	Pit Impacts on Groundwater, Pit Inflow
AH	1,406,030	2,158,744	372,775	6,642,675			ODEX		single P	Pit Impacts on Groundwater, Pit Inflow
W	1388682	2125853			366837	6632658	ODEX		dual P	Groundwater Flow Impacts to South Fork Koktuli
X	1376541	2126890			363723	6633189	ODEX		dual MW	Groundwater Flow Impacts to South Fork Koktuli
V	1392633	2124105			368531	6632202	ODEX		single or dual P	Groundwater Flow Impacts to South Fork Koktuli
P	1389573	2127792	367617	6633322			ODEX		single or dual P	Groundwater Flow Impacts to South Fork Koktuli
M	1394571	2126487			368214	6634191	ODEX		single P	Groundwater Flow Impacts to South Fork Koktuli
K	1395978	2130996			369412	6634195	ODEX		single or dual P	Groundwater Flow Impacts to South Fork Koktuli
Q	1393987	2127416			368972	6633212	ODEX		triple P	Groundwater Flow Impacts to South Fork Koktuli
T	1395642	2120790			369438	6631185	ODEX		single P	Groundwater Flow Impacts to South Fork Koktuli
U	1395311	2123785			369323	6632111	ODEX		dual P	Groundwater Flow Impacts to South Fork Koktuli
S	1,397,549	2,124,257	370,031	6,632,208			ODEX		single P	Groundwater Flow Impacts to South Fork Koktuli
Z	1,404,489	2,145,771			372,406	6,638,710	Mud Rotary	SH/SPT	single P	TSF A Seepage and Lacustrine Characteristics
AA	1,402,213	2,146,067			371,681	6,638,743	Mud Rotary	SH/SPT	single P	TSF A Seepage and Lacustrine Characteristics
AJ	1,402,929	2,142,328	371,753	6,637,690			Mud Rotary	SH/SPT	dual P	Pumping well for pumping test
AB	1,403,073	2,142,117			371,781	6,637,646	ODEX		PW	TSF A Seepage and Lacustrine Characteristics
BO	1,403,073	2,142,117					ODEX		dual P	TSF A Seepage to SFK (piezo for AB pumping test)
BP	1,403,073	2,142,117					ODEX		dual P	TSF A Seepage to SFK (piezo for AB pumping test)
J	1,399,585	2,131,331	370,684	6,634,354			ODEX		single P	Groundwater Flow Impacts to South Fork Koktuli
R	1,402,355	2,124,602			371,460	6,632,346	ODEX		single or dual P	Groundwater Flow Impacts to South Fork Koktuli
AL	1,402,774	2,128,176			371,723	6,633,343	ODEX		dual P	Groundwater Flow Impacts to South Fork Koktuli
O	1,405,685	2,131,197			372,495	6,634,390	ODEX		dual MW	Groundwater Flow Impacts to South Fork Koktuli
AI	1,405,645	2,130,805	372,528	6,634,166			ODEX		PW	Groundwater Flow Impacts to South Fork Koktuli
L	1,392,017	2,130,595	368,374	6,634,164			ODEX		PW	Groundwater Flow Impacts to South Fork Koktuli
AX	1,406,344	2,161,702	372,884	6,643,575			ODEX		single P	Pit Impacts on Groundwater, Pit Inflow
AY	1,408,332	2,160,140	373,481	6,643,092			ODEX		single P	Pit Impacts on Upper Talarik Creek
AZ	1,409,704	2,159,071	373,895	6,642,760			ODEX		single P	Pit Impacts on Upper Talarik Creek
AW	1,406,506	2,154,480	372,899	6,641,376			ODEX		dual P	Pit Impacts on Upper Talarik Creek
AG	1,405,622	2,156,839			372,688	6,642,155	ODEX		single or dual P	Pit Impacts on Groundwater, Pit Inflow
BG	1,410,038	2,153,746	373,972	6,641,136			ODEX		single P	TSF A Seepage to Upper Talarik past pit
AT	1,407,865	2,162,642	373,351	6,643,857			ODEX		single or dual P	Pit Impacts on Upper Talarik Creek
AU	1,409,887	2,160,829			373,953	6,643,188	ODEX		single or dual P	Pit Impacts on Upper Talarik Creek
AV	1,411,455	2,159,526			374,365	6,642,869	ODEX		single or dual P	Pit Impacts on Upper Talarik Creek
BH	1,404,663	2,137,914			375,337	6,637,878	ODEX		single P	TSF A Seepage to Upper Talarik (eastward)

TABLE 2 (continued)
2005 PROPOSED BOREHOLES

WETLANDS (ONLY REQUIRED FOR PERMITTING)

Borehole	NAD 83 Co-ordinates		NAD27 Coordinates Confirmed in Field (Original Locations)		Field Locates w/GPS NAD 27 Coordinates (Modified Locations)		Method	In Situ Testing Required [1]	Installation [2]	Purpose[3]
Name	Easting	Northing	Easting	Northing	Easting	Northing				
BR							ODEX		dual P	wetlands investigation
BS							ODEX		dual P	wetlands investigation
BT							ODEX		dual P	wetlands investigation
BU							ODEX		dual P	wetlands investigation
BV							ODEX		dual P	wetlands investigation
BW							ODEX		dual P	wetlands investigation
BX							ODEX		dual P	wetlands investigation
BY							ODEX		dual P	wetlands investigation
BZ							ODEX		dual P	wetlands investigation

GEOTECHNICAL - QUEST RIG

Borehole	NAD 83 Co-ordinates		NAD27 UTM Coordinates Confirmed in Field (Original Locations)		Field Locates w/GPS NAD 27 UTM Coordinates (Modified Locations)		Method	In Situ Testing Required [1]	Installation [2]	Purpose[3]
Name	Easting	Northing	Easting	Northing	Easting	Northing				
BB	1,410,947	2,147,580			374,192	6,639,207	Rotary	P/SPT	P	TSF A Seepage to Upper Talarik (eastward) and saddle dam foundations
AS	1,407,135	2,148,553					Rotary	P/SPT	P	North Embankment Foundation and Seepage Control
AR	1,405,142	2,148,589					Rotary	P/SPT	P	North Embankment Foundation and Seepage Control
AQ	1,402,435	2,148,644					Rotary	SPT	P	North Embankment Foundation and Seepage Control
AP	1,398,959	2,148,132					Rotary	P/SPT	P	North Embankment Foundation and Seepage Contro
AO	1,400,825	2,150,547					Rotary	SPT	P	Crusher Foundation
CB	1,399,176	2,152,145					Rotary	SPT	Single P	Road and Conveyor Conditions
AN	1,395,391	2,156,520					Rotary	SPT	P	Mill Site Foundation
CA	1,396,121	2,160,478					Rotary	SPT	Single P	Campsite Conditions
N	1,399,668	2,134,916			370,725	6,635,446	Rotary	P/SPT	P	South-West Embankment Foundation
I	1,399,784	2,136,779			368,389	6,636,033	Rotary	P/SPT	P	South-West Embankment Foundation
AC	1,393,516	2,144,007	368,479	6,640,069			Rotary	P/SPT	P	Water Storage Reservoir Foundation
BF	1,395,620	2,145,001			369,517	6,638,533	Rotary	P/SPT	single MW	TSF A Seepage to Bear Valley and saddle dam foundations
AM	1,391,585	2,153,823	368,349	6,641,245			Rotary	P/SPT	P	Saddle Dam Foundation
BA	1,410,428	2,152,767			374,019	6,640,785	Rotary		single P	TSF A Seepage to Upper Talarik past pit
BC	1,414,293	2,144,603			375,259	6,638,312	Rotary	P	single MW	TSF A Seepage to Upper Talarik (eastward)

Notes:

1) In Situ Testing

P = Packer Permeability Testing in bedrock
SPT = Standard Penetration Testing @ 5' or 10' intervals (depending on material type and homogeniety)
SH = Shelby Tube samples of fine-grained sediments

2) P = piezometer, PW = pumping well, MW = monitoring well

3) Primary purpose; however, geotechnical, hydrogeological and geochemical data will be collected from all boreholes, as appropriate.

APPENDICES

APPENDIX A
Field Forms

SLR Alaska
2525 Blueberry Road
Suite 206
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

FIELD LOG OF SOIL BORING

Sheet ____ of ____

Boring/Well Number: ____________

Client: Northern Dynasty Mines	**Project:** Pebble Mine Site Ground Water Program		
Site Name:	Boring Total Depth (feet):		
SLR Project # 005.0189.05002	Construction Method:		
Logged By:	Completed as Monitoring Well?		
	Borehole Diameter (inches):		
Drilling Contractor:	Water Depth (feet):	Date:	
Drill Rig Type:		Time:	
Driller's Name:	GPS Datum:		
Driller's Name:	Surface Elevation (GPS):		
Technicians Name:	North Coordinate (GPS):		
Sampling Method:	East Coordinate (GPS):		
Started/Time:	Backfill Time:	Date:	
Completed/Time:	By:		
Location Description:			

Location (Sketch)

DEPTH IN FEET	SAMPLE	TIME	FLOW TEST	SOIL DESCRIPTION	DRILLERS COMMENTS
1					
2					
3					
4					
5					

Comments:

2525 Blueberry Road
Suite 206
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

FIELD LOG OF SOIL BORING

Sheet ____ of ____

Boring/Well Number: ____________

DEPTH (FEET)	SAMPLE	TIME	FLOW TEST	SOIL DESCRIPTION	DRILLERS COMMENTS
6					
7					
8					
9					
0					
1					
2					
3					
4					
5					

Comments:

Definitions of Terms

The following is an explanation of some of the fields.

Boring/Well Number:
unique borehole identifier, preferably incorporating client or site information e.g. SWB-1

Sampling Method:
e.g. split spoon, grab sample, auger cuttings, continuous sampler, etc.

Cuttings Disposal Method:
backfilled, spread on surface, drums, supersacks, etc.

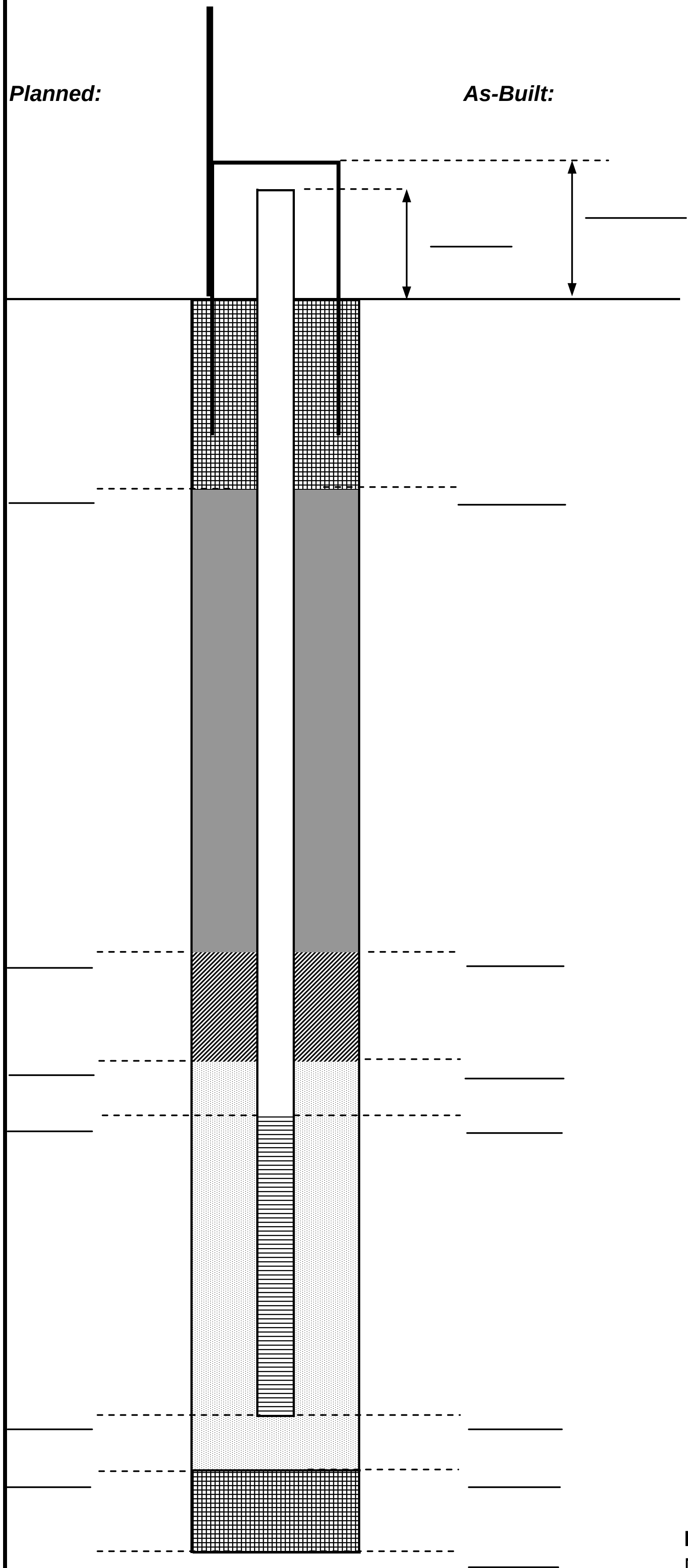
Construction Method:
refers to drill type, e.g. solid stem auger, hollow stem auger, mud rotary, air rotary, reverse air, etc.

Surface Elevation:
survey to mean sea level, survey to relative benchmark, estimate from topographic map, estimate relative to other site features, may be determined after drilling

North and East Coordinate:
if known, state plane coordinates, site coordinates, longitude and latitude, may be determined after drilling

Flow Test:
Complete flow test every casing change, when water is encountered, and/or whenever a change/unconformity is encountered

MONITORING WELL COMPLETION DIAGRAM



WELL ID: ____________________

Date: ____________________
Logger: ____________________

Installation time
Start: ____________________
Finish: ____________________

Stickup
before pulling casing: ____________________
after pulling casing: ____________________

PVC Casing
type: ____________________
diameter: ____________________
lengths: ____________________
____
____
total: ____________________
cutoff: ____________________
net length: ____________________
total depth (ft, bgs): ____________________
measured TD (ft, FTOC): ____________________

Cement bentonite grout
mix: ____________________
actual volume: ____________________
theoretical volume: ____________________

Bentonite grout
type: ____________________
actual volume: ____________________
theoretical volume: ____________________

Bentonite chips
type: ____________________
actual volume: ____________________
theoretical volume: ____________________

Filter sand
type: ____________________
actual volume: ____________________
theoretical volume: ____________________

Screen
type: ____________________
slot size: ____________________
length: ____________________

NOTES:
Not to scale.
Reference all depths to ground surface.
Theoretical is calculated annulus volume required.

WELL DEVELOPMENT LOG

Well ID: ____________________
Date: ____________________

Project: Pebble Mine Site Ground Water Program　Project #: 005.0189.05002 Task 5

Technician: ____________________

Summary

	Installed (Well Log)	Start	End
Water level			
Total depth			
pH			

Screen interval (btoPVC): ____________________
Top: ____________________
Bottom: ____________________
PVC stick-up height (above ground surface): ____________________

Development Observations

Time	Foot valve depth (ft btoPVC)	WL (ft btoPVC)	Flow (gpm)	Purge Volume (gal)	Cond (mS/cm)	Turbidity	Temp (deg C)	Sediment (grain size, colour, quantity)
Surge block on								
Surge block off								

PEBBLE PROJECT
SAMPLE TRANSFER LOG

SAMPLE INFORMATION						TRANSFER INFORMATION					
Date	Time	Sample Identification	matrix	type	no. bottles	relinquished by	company	date/time	received by	company	date/time

For use when samples are transferred to sample receiving and processing

Date: ______________________________

WELL PURGING AND SAMPLING FIELD CONTROL

Date: ____________________ **Well ID:** ____________________

Project: Northern Dynasty Mines, Pebble Mine Site Ground Water **Project #** 005.0189.05002, Task 3

Samplers: Robert Klieforth, Willow Weimer

Depth of pump (ft, from top of port): ____________________ Screened Interval (ft, bgs): ____________________

Depth to water (ft, ftop): (previous) ____________________ Stickup Height (ft, ags): ____________________

(current) ____________________ WL meter: Slope Indicator (51690030)

Field Meter Check

Parameter	Standard	Reading	Recalibration (if req'd)
pH	4		
	7		
Sp Cond	0.447		
(mS/cm)	1.413		

Criteria for Stable Parameters

pH	±0.2	
Temp	±1.0 C	
EC	±3%	
DO	±15%	or 0.3 mg/L
Turb	minimal	

Field Instrument Readings

	Time	**WL** (ft, ftop)	**Flow** (lpm)	**Volume** (gal)	**pH**	**ORP** (mV)	**Temp** (deg C)	**Sp Cond** (mS/cm)	**DO** (mg/L)	**Turbidity**
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										

Total Actual Volume: __________

Minimum Volume (use back of page): __________ Minimum purge volume: 2 x (drawdown volume plus volume-below-pump)

Sample Identification:

Root	Primary	Duplicate	Triplicate

Sample Date/Time: ____________________

Sample Notes:

Water parameters measured by: YSI 556 Serial #05B2462 AE

Color: clear, amber, tan, brown, grey, milky white, other

Odor: none, low, medium, high, very strong, hydrogen sulfide, petroleum, chemical?, unknown

Turbidity: none, low, medium, high, very turbid, heavy silts

WELL PURGING AND SAMPLING FIELD CONTROL

Date: ____________________ **Well ID:** ____________________

	AS1	AS2	AS3	AS4	AS5		AS6	AS7
Bottle Inventory:	Metals	Metals (F)	Cn	P, Am, N	TSS	TDS+	Anions	Thiocyanate
	HNO_3	HNO_3	NaOH	H_2SO_4	--	--	--	HNO_3
	1 x 500mL	1 x 500mL	1 x 250mL	1 X 500mL	1 x 1L	1 x 1L	1 x 120mL	1 X 500mL
MS/MSD Volume:	extra	extra	no	no	extra	extra	extra	no
CAS Volume:	1 x 1L	1 x 1L	1 x 1L	1 x 1L	1 x 1L	1 x 1L	1 x 250mL	1 x 250mL
Sample Order:	1	2	6	7	3	4	5	8
Bottle Count:	_____	_____	_____	_____	_____	_____	_____	_____

Casing Diameter (inches)	**Schedule 40** (gal/ft casing)	(liters /ft casing)	**Schedule 80** (gal/ft casing)	(liters /ft casing)
2	0.163	0.617	0.153	0.579
4	0.656	2.483	0.597	2.260

Casing Diameter 2 inches:

Circle water column length below pump and above pump. Also circle length of maximum drawdown.
Minimum purge volume: 2 x (drawdown volume plus volume-below-pump)

Length of Casing (ft)	Sch 40 (gal)	Sch 80 (gal)	Sch 40 (L)	Sch 80 (L)	Length of Casing (ft)	Sch 40 (gal)	Sch 80 (gal)	Sch 40 (L)	Sch 80 (L)
1	0.16	0.15	0.62	0.58	16	2.61	2.45	9.87	9.27
2	0.33	0.31	1.23	1.16	17	2.77	2.60	10.49	9.84
3	0.49	0.46	1.85	1.74	18	2.93	2.75	11.11	10.42
4	0.65	0.61	2.47	2.32	19	3.10	2.91	11.72	11.00
5	0.82	0.77	3.08	2.90	20	3.26	3.06	12.34	11.58
6	0.98	0.92	3.70	3.47	21	3.42	3.21	12.96	12.16
7	1.14	1.07	4.32	4.05	22	3.59	3.37	13.57	12.74
8	1.30	1.22	4.94	4.63	23	3.75	3.52	14.19	13.32
9	1.47	1.38	5.55	5.21	24	3.91	3.67	14.81	13.90
10	1.63	1.53	6.17	5.79	25	4.08	3.83	15.42	14.48
11	1.79	1.68	6.79	6.37	26	4.24	3.98	16.04	15.06
12	1.96	1.84	7.40	6.95	27	4.40	4.13	16.66	15.64
13	2.12	1.99	8.02	7.53	28	4.56	4.28	17.27	16.21
14	2.28	2.14	8.64	8.11	29	4.73	4.44	17.89	16.79
15	2.45	2.30	9.25	8.69	30	4.89	4.59	18.51	17.37

	Time	WL (ft, ftop)	Flow (lpm)	Volume (gal)	pH	ORP (mV)	Temp (deg C)	Cond (mS/cm)	DO (mg/L)	Turbidity
17										
18										
19										
20										
21										
22										
23										
24										
25										

WATER MANAGEMENT CONSULTANTS

SLR Alaska

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter

Make: Slope Indicator
Model: Slope Indicator
Cutoff: None
Units: Decimal Feet
Res: 51690030

Project: Pebble Mine Site GW
Project #: 005.0189.05002 Task 3
Logger: Klieforth, Weimer

Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	May DTW	Ref	May Total Depth	Ref	Date	DTW1	DTW2	Total Depth	Reference	
GH04-01	10.62	FTOC	28.1	FTOC						
GH04-02	4.74	FTOC	26.2	FTOC						
GH04-03	57.22	FTOC	58.1	FTOC						
GH04-04	74.84	FTOC	76.1	FTOC						
GH04-05	2.31	FTOC	37.28	FTOC						
GH04-06	Frozen	FTOC	Frozen	FTOC						
GH04-08	Flowing	FTOC	--	FTOC						
GH04-10	57.12	FTOC	58.0	FTOC						
GH04-11	Frozen	FTOC	Frozen	FTOC						Frozen/blocked?
GH04-12A	26.38	FTOC	63.1	FTOC						
GH04-13	42.28	FTOC	43.0	FTOC						
GH04-14	65.90	FTOC	74.5	FTOC						
GH04-16	Frozen	FTOC	Frozen	FTOC						
GH04-17	15.84	FTOC	37.2	FTOC						
GH04-18	5.21	FTOC	54.4	FTOC						
GH04-19	1.97	FTOC	15.45	FTOC						
GH04-20	Frozen	FTOC	Frozen	FTOC						
GH04-22	3.34	FTOC	13.34	FTOC						
GH04-23	6.20	FTOC	17.8	FTOC						
GH04-25	46.71	FTOC	75.6	FTOC						
GH04-26	Frozen	FTOC	Frozen	FTOC						
GH04-27	27.71	FTOC	32.3	FTOC						
GH04-28	38.93	FTOC	56.79	FTOC						
GH04-29A	Frozen	FTOC	Frozen	FTOC						
GH04-30	76.56	FTOC	82.0	FTOC						
GH04-31	c/not locate	FTOC	--	FTOC						
GH04-32	38.97	FTOC	39.2	FTOC						
GH04-33	Frozen	FTOC	Frozen	FTOC						
GH04-35	Frozen	FTOC	Frozen	FTOC						
GH04-37	135.93	FTOC	144.0	FTOC						
GH04-38	40.59	FTOC	60.25	FTOC						
GH04-39	Frozen	FTOC	Frozen	FTOC						
GH04-41	24.42	FTOC	92.9	FTOC						
GH04-42	Frozen	FTOC	Frozen	FTOC						
GH04-43	73.94	FTOC	99.4	FTOC						

ABBREVIATIONS:

FTOC - from top of casing
FTOP - from top of sample port

GROUND WATER LEVEL MEASUREMENTS

WATER MANAGEMENT CONSULTANTS

SLR Alaska

Water Level Meter

Make:	Slope Indicator
Model:	Slope Indicator
Cutoff:	None
Units:	Decimal Feet
Res:	51690030

Project:	Pebble Mine Site GW
Project #:	005.0189.05002 Task 3
Logger:	Klieforth, Weimer
Date start	
Date finish	

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	May DTW	Ref	May Total Depth	Ref	Date	DTW1	DTW2	Total Depth	Reference	
GH04-44	Frozen	FTOC	Frozen	FTOC						
GH04-45A	76.25	FTOC	84.1	FTOC						
GH04-46	14.14	FTOC	82.9	FTOC						
GH04-47	4.71	FTOC	42.3	FTOC						
GH04-48	32.15	FTOC	50.4	FTOC						
I-125	Frozen	FTOC	Frozen	FTOC						
I-172	9.24	FTOC	128.1	FTOC						
I-192	Flowing	FTOC	Flowing	FTOC						
I-201	58.54	FTOC	154.3	FTOC						
KP-P1/SRK-2	51.35	FTOC	--	FTOC						
KP-P4	21.25	FTOP	--	FTOP						
KP-P2A (Stand 3)	Frozen	FTOC	Frozen	FTOC						
KP-P3 D /SRK-5D	0.97	FTOP	--	FTOP						
KP-P3 M /SRK-5M	11.09	FTOP	--	FTOP						
KP-P3 S /SRK-5S	3.47	FTOP	--	FTOP						
M-110	28.62	FTOC	96.0	FTOC						
M-12	15.13	FTOC	45.9	FTOC						
M-21	34.19	FTOC	87.9	FTOC						
M-62	107.12	FTOC	147.5	FTOC						
MW-1 D	4.83	FTOP	--	FTOP						
MW-1 M	4.57	FTOP	--	FTOP						
MW-1 S	5.88	FTOP	--	FTOP						
MW-2 D	68.08	FTOP	--	FTOP						
MW-2 S	60.94	FTOC	--	FTOC						
MW-3 D	153.40	FTOC	--	FTOC						
MW-4 (Stand 1)	19.87	FTOC	20.4	FTOC						
MW-5 D	7.96	FTOP	--	FTOP						
MW-5 M	13.60	FTOP	--	FTOP						
MW-5 S	12.57	FTOP	--	FTOP						
MW-6 D	64.33	FTOP	--	FTOP						
MW-7 D	17.28	FTOP	--	FTOP						
MW-7 S	18.30	FTOP	--	FTOP						
MW-8 D	7.49	FTOP	--	FTOP						
MW-8 M	12.75	FTOP	--	FTOP						
MW-8 S	12.88	FTOP	--	FTOP						

ABBREVIATIONS:

FTOC - from top of casing

FTOP - from top of sample port

GROUND WATER LEVEL MEASUREMENTS

WATER MANAGEMENT CONSULTANTS

SLR Alaska

Water Level Meter

Make:	Slope Indicator
Model:	Slope Indicator
Cutoff:	None
Units:	Decimal Feet
Res:	51690030

Project:	Pebble Mine Site GW
Project #:	005.0189.05002 Task 3
Logger:	Klieforth, Weimer
Date start	
Date finish	

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	May DTW	Ref	May Total Depth	Ref	Date	DTW1	DTW2	Total Depth	Reference	
MW-9 D	3.49	FTOP	--	FTOP						
MW-10	22.86	FTOP	--	FTOP						
MW-11D	44.30	FTOP	--	FTOP						
MW-11M	44.00	FTOP	--	FTOP						
MW-11S	46.64	FTOP	--	FTOP						
P-2 D	Frozen	FTOC	Frozen	FTOC						
P-2 M	Frozen	FTOC	Frozen	FTOC						
P-3	Frozen	FTOC	Frozen	FTOC						
P-4 mid	Frozen	FTOC	Frozen	FTOC						
P-4AD	16.21	FTOC	94.4	FTOC						
P-4AS	17.58	FTOC	53.1	FTOC						
P-6 D	12.87	FTOC	116.1	FTOC						
P-6 M	13.97	FTOC	89.3	FTOC						
P-6 S	15.13	FTOC	38.1	FTOC						
PQ-4	--	--	--	--						
PQ-8	5.28	FTOC	98.9	FTOC						
PQ-9	72.17	FTOC	92.1	FTOC						
SRK-1A	Flowing	FTOC	Flowing	FTOC						
SRK-2 (AKA 4251)	40.93	FTOC	200.9	FTOC						
SRK-2A	54.28	FTOC	62.6	FTOC						
SRK-3 (AKA 4250)	26.38	FTOC	73.5	FTOC						

ABBREVIATIONS:

FTOC - from top of casing

FTOP - from top of sample port

SLR Water Parameter Meter
Calibration Log

Date: ____________
Meter: YSI 556 (Serial #: 05B2462 AE)

Parameter	Standard	PreCalibration Reading	Calibration Reading
pH	4		
	7		
	10		
Conductivity (mS/cm)	1.413		
	0.447		
DO	100%		

Date: ____________
Meter: YSI 556 (Serial #: 05B2462 AE)

Parameter	Standard	PreCalibration Reading	Calibration Reading
pH	4		
	7		
	10		
Conductivity (mS/cm)	1.413		
	0.447		
DO	100%		

Date: ____________
Meter: YSI 556 (Serial #: 05B2462 AE)

Parameter	Standard	PreCalibration Reading	Calibration Reading
pH	4		
	7		
	10		
Conductivity (mS/cm)	1.413		
	0.447		
DO	100%		

Date: ____________
Meter: YSI 556 (Serial #: 05B2462 AE)

Parameter	Standard	PreCalibration Reading	Calibration Reading
pH	4		
	7		
	10		
Conductivity (mS/cm)	1.413		
	0.447		
DO	100%		

PUMPING TEST
Pumping Well

Date: ____________________ Well ID: ____________

Project: Northern Dynasty Mines, Pebble Mine Site Ground Water Project #: 005.0189.05002, Task 5
Technician: ____________________

Pumping Method: ____________________
Pipe submergence: ____________________
Depth to water (bto steel casing): (previous) ____________ Screened interval (bgs): ____________
(current) ____________ WL meter: ____________

Field Meter Check

Parameter	Standard	Reading	Recalibration (if req'd)
EC	0.447		
(mS/cm)	1.413		

Observation Wells

____________________ ____________________
____________________ ____________________
____________________ ____________________

Field Instrument Readings

	Date	Time	Volume (gal)	Elapsed Time*	Flow (gpm)	Cond (mS/cm)	Turbidity	Temp (deg C)		
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

* Elapsed time of trough. Used to confirm flow rate.

PUMPING TEST
Observation Well

Date: ____________________ Well ID: ____________________

Project: Northern Dynasty Mines, Pebble Mine Site Ground Water Project #: 005.0189.05002, Task 5

Technician: ____________________

Depth to water (ft, bto ____): (previous) ____________________ Screened interval (bgs): ____________________

(current) ____________________ WL meter: ____________________

Pumping Well ____________________

Transducer particulars

Brand ____________________ Installation depth ____________________

Model ____________________ Date of installation ____________________

Serial number ____________________ Time of installation ____________________

Pressure range ____________________ Date of removal ____________________

Time of removal ____________________

Watch time and computer synchronized with data logger time? Yes ________ No ________

Correlation of manual and transducer measurements confirmed on graph? Yes ________ No ________

Manual water level readings

	Date	Time	DTW (ft, _____)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

	Date	Time	DTW (ft, _____)
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			

RESPONSE TEST

Date: ____________________ Well ID: ____________________

Project: Northern Dynasty Mines, Pebble Mine Site Ground Water Project #: 005.0189.05002, Task 5

Technician: ____________________

Depth to water (ft, bto port): (previous) ____________________ Screened interval (bgs): ____________________

____________________ WL meter: ____________________

Transducer particulars

Brand ____________________ Installation depth ____________________

Model ____________________ Time of installation ____________________

Serial number ____________________

Pressure range ____________________

Slug description: ____________________

Correlation of manual and transducer measurements confirmed on graph? Yes ________ No ________

Manual water level readings and timing of slug insertion and removal

	Date	Time	DTW (ft, _____)		Date	Time	DTW (ft, _____)
1				22			
2				23			
3				24			
4				25			
5				26			
6				27			
7				28			
8				29			
9				30			
10				31			
11				32			
12				33			
13				34			
14				35			
15				36			
16				37			
17				38			
18				39			
19				40			
20				41			
21				42			

TRANSDUCER CONTROL FOR BACKGROUND WATER LEVELS

Date: ____________________ Well ID: ____________________

Project: Northern Dynasty Mines, Pebble Mine Site Ground Water Project #: 005.0189.05002, Task 5

Technician: ____________________

Transducer particulars

Brand ____________________ Installation depth (ft, ftoc) ____________________

Model ____________________ Date of installation ____________________

Serial number ____________________ Time of installation ____________________

Pressure range ____________________ Date of removal ____________________

Time of removal ____________________

Watch time and computer synchronized with data logger time? Yes ________ No ________

Correlation of manual and transducer measurements confirmed on graph? Yes ________ No ________

Manual water level readings

	Date	Time	DTW (ft, ______)		Date	Time	DTW (ft, ______)
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

APPENDIX B
Example Well Construction Logs

Northern Dynasty Minerals Ltd.

BORING NUMBER MW-1D

CLIENT		**PROJECT NAME**	Pebble Gold Copper Project
PROJECT NUMBER	316349.PP.GW.02.04	**PROJECT LOCATION**	Iliamna, Alaska

DATE STARTED	7/24/04	**COMPLETED**	7/24/04	**GROUND ELEVATION**		**WATER LEVELS**	feet
DRILLING DRILLING CONTRACTOR	Midnight Sun			**NORTHING**	6632496	**EASTING**	364146
DRILLING DRILLING METHOD				**EQUIPMENT**		**LOGGER**	Matt Flynn

NOTES

DEPTH BELOW SURFACE (ft)	SAMPLE TYPE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION	WELL DIAGRAM
0				3.0	**Peat (PT)** Brown, moist, soft.	
				6.0	**Well-graded sand w/ trace gravel to 3/8" (SW)** Brown, moist, fine to medium sand.	
10				13.0	**Poorly-graded sand (SP)** Brown, moist, medium to fine sand, trace gravel to 3/8". Wet at 11-12'	
					Well-graded gravel with sand (GW) Brown, moist, sub-angular to rounded gravel to 1/2"	Lost shoe. Pull string and move 3'.
20					Gravel is sub-angular to rounded up to 1". Medium to fine sand approximately 25%.	
30					Sand content approximately 40%. Gravel same as above.	

WELL COMPLETION INFORMATION

CASING

Top elevation (feet):

Vent hole?:

WELLHEAD PROTECTION COVER

Type: 6" steel casing

Weep hole?: No

Concrete pad dimensions:

WELL CASING

Dia.: 2 inches

Type: Schedule 80 PVC

SURFACE CASING

Dia.: 5 inches

Type:

SCREEN

Type: 2-inch/Schedule 40 PVC Insta-pack

Slot size: 0.020"

SCREEN FILTER

Type: 10/20 Silica sand

Quantity used:

SEAL

Type: Bentonite

Quantity used: 0.5 5-gallon bucket

GROUT

Mix used: 30% Solids Volclay

Method of placement: Tremmie Pipe

Vol. in surface casing:

Vol. in well casing:

DEVELOPMENT

Method Surge and block, with 1" Waterra pump

Time:

Estimated purge volume:

Comments:

(Continued Next Page)

BORING NUMBER MW-1D

Northern Dynasty Minerals Ltd.

CLIENT		PROJECT NAME	Pebble Gold Copper Project
PROJECT NUMBER	316349.PP.GW.02.04	PROJECT LOCATION	Iliamna, Alaska

DATE STARTED	7/24/04	COMPLETED	7/24/04	GROUND ELEVATION	
WATER LEVELS	feet				
DRILLING DRILLING CONTRACTOR	Midnight Sun	NORTHING	6632496	EASTING	364146
DRILLING DRILLING METHOD		EQUIPMENT		LOGGER	Matt Flynn
NOTES					

DEPTH BELOW SURFACE (ft)	SAMPLE TYPE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION	WELL DIAGRAM
					Sandy well-graded gravel (GW) Brown, wet, sub-angular to rounded gravel to 1", medium sand.	Flow YES/OUT
40					**Sandy well-graded gravel (GW)** Brown, wet, sub-angular to rounded gravel to 1", medium sand. 70% gravel, 30% sand	Cond=0-1, pH=6.1 Flow YES/OUT
					Sand content increasing. 60% gravel, 40% sand.	
50						
54.5					**Well-graded sand with gravel (SW)** Brown, moist to wet, medium to coarse sub-angular sand, sub-angular to rounded gravel up to 3/4". 60% sand, 40% gravel.	
60					Same as above.	Collect water at 65'. Specific Condition=5.7, pH=6.55
70					Same as above.	
					Same as above.	
80					**Gravelly well-graded sand (SW)** Brown, wet, sand is fine to coarse, gravel up to 3/4". Approximately 65% sand, 35% gravel.	Flow YES/OUT
					Decreasing sand.	
90 (90.0)					**Well-graded gravel with sand (GW)** Brown, wet, find sand to 3/4" gravel. Sub-angular gravel and sub-angular sand. 35% sand and 65% gravel	Flow YES/OUT, Specific Condition=5.3,

(Continued Next Page)

BORING NUMBER MW-1D

Northern Dynasty Minerals Ltd.

CLIENT		PROJECT NAME	Pebble Gold Copper Project
PROJECT NUMBER	316349.PP.GW.02.04	PROJECT LOCATION	Iliamna, Alaska
DATE STARTED	7/24/04	COMPLETED	7/24/04
GROUND ELEVATION		WATER LEVELS	feet
DRILLING DRILLING CONTRACTOR	Midnight Sun	NORTHING	6632496
EASTING	364146	DRILLING DRILLING METHOD	
EQUIPMENT		LOGGER	Matt Flynn
NOTES			

DEPTH BELOW SURFACE (ft)	SAMPLE TYPE NUMBER	RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	GRAPHIC LOG	SOIL DESCRIPTION	WELL DIAGRAM
						pH=6.04 Collect water at 95'.
100					45% sand and 55% gravel	Flow YES/OUT
105.0					Same	
					Silty gravel with sand (GM) Tan/brown, saturated. 20% silt, 30% sand, 50% gravel	
110						Flow YES/OUT
120					**Poorly-graded sand with gravel and silt (SP-SM)** Brown, wet, fine sand, sub-rounded gravel to 1/2".	Flow YES/OUT, Specific Condition=5.2, pH=6.52
128.0					**Bedrock** White/green, wet, calcified rock with pyrite. HCl test confirmed.	
130						Flow YES/OUT, Specific Condition=5.9, pH=6.14 Water sample at 132'.
134.5					Bottom of boring at 134.5' at 16:00 on 7/24/04 Bottom of hole at 134.5 feet.