PEBBLE PROJECT
ENVIRONMENTAL BASELINE DOCUMENT
2004 through 2008

APPENDIX F.
FIELD SAMPLING PLANS

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APPENDIX F, FIELD SAMPLING PLANS

This appendix contains the field sampling plans developed by individual consultants for their respective study disciplines during the 4-year period 2005 through 2008. The purpose of field sampling plans is to describe in detail the procedures and protocols researchers will use to gather physical samples in the field for analysis. The sampling plans serve as instructions for use in the field to ensure that proper techniques are used and to ensure adequate documentation for reviewers of the data.

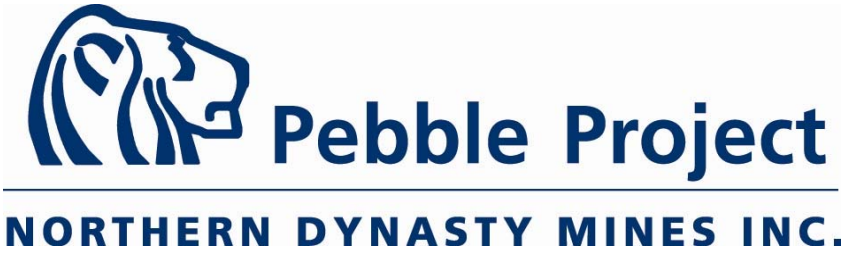
Not all disciplines have field sampling plans because many do not require collection of physical samples for analysis. Field sampling plans were not necessarily developed each year for a given discipline because once a refined plan existed that plan was used in subsequent years.

Some of the field sampling plans contain references to various port sites, road and transportation routes, and other possible component locations that were working concepts at the time of the plans' development. Since that time, the project has gone back to the design phase and is not necessarily carrying these concepts forward. While these concepts are retained in the field sampling plans as written at that time, they are not discussed in the body of the environmental baseline document as their continued use could lead to confusion because they may differ from whatever design components are decided upon for inclusion in the actual project proposal.

The 26 field sampling plans provided in this appendix are organized under seven general headings (listed below) that contain related individual annual plans. The titles of sampling plans varied between years in some cases, and the organization of this appendix generally groups the plans for similar disciplines together. Note that, while most plans focus on mine area studies, several address studies in the transportation-corridor study area, Iliamna Lake, and the Cook Inlet drainages.

- Fish and Aquatic Resources.
- Iliamna Lake Study.
- Marine Studies.
- Metal Leaching and Acid Rock Drainage Characterization.
- Trace Elements and Other Naturally Occurring Constituents.
- Groundwater Quality and Hydrology.
- Surface Water Quality and Hydrology.

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Fish and Aquatic Resources



DRAFT ENVIRONMENTAL BASELINE STUDIES

2005 FIELD SAMPLING PLAN

FISH & AQUATIC HABITAT

NOVEMBER 2005

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Appendices

Appendix A: Fish Tissue Data Sheets

Appendix B: Macroinvertebrate and Periphyton Data Sheets

ACRONYMS

ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ASCI	Alaska Stream Condition Index
CAS	Columbia Analytical Services
COC	chain-of-custody
DI	deionized
EPA	U.S. Environmental Protection Agency
GPS	global positioning system
µm	micrometer
NDM	Northern Dynasty Mines Inc.
QA	quality assurance
QC	quality control
RBP	rapid bioassessment protocol

1. PROJECT BACKGROUND

Northern Dynasty Mines Inc. (NDM) is proposing an open-pit mining operation in southwestern Alaska. The prospect contains gold, copper, molybdenum, and silver deposits. The site is located approximately 15 miles north of Lake Iliamna in the eastern drainage of the Mulchatna River. It is on the divide separating the watersheds of Upper Talarik Creek and of the South Fork of the Koktuli River. NDM has launched extensive programs to collect data on engineering, environmental, and socioeconomic aspects in preparation for the permit-application process.

2. STUDY SCOPE AND OBJECTIVES

The overall objective of the fish and aquatic-resources studies is to document the distribution and relative abundance of aquatic resources within the project area in sufficient detail to provide information required for impact assessment and mitigation planning. A predevelopment baseline will be determined for post-development monitoring.

3. FISH-TISSUE SAMPLING

3.1 Introduction

This field sampling plan provides the protocol that is followed by all fisheries field crews for the Pebble Project. This plan describes in detail the methods for all the fish-tissue collection and handling procedures including dissection, preservation, and shipping. The same procedures used for the 2004 fish-tissue collection effort will be followed in 2005.

3.2 Purpose and Scope

A series of biological sample sites was established in 2004 within and adjacent to the project area to determine baseline conditions and to provide a basis for detecting potential changes within the surrounding waterbodies. These collection sites were established and sampled in 2004 and will continue to be used in 2005 for water-quality and hydrology monitoring, fish-abundance index sampling, macroinvertebrate and periphyton sampling, and fish-tissue collection. It should be noted that two additional lakes will be sampled during 2005 as part of the fish-tissue collection program (Figure 11-1).

Fish-tissue samples will be collected at 20 sites in the mine area and at five locations along the proposed road alignment. Depending on the specific task, fish will be collected using baited minnow traps, electrofisher, gill-nets, or seines (see *Draft Environmental Baseline Studies, Proposed 2005 Study Plan, Fish and Aquatic Habitat* [NDM, in press]). A variety of species will be used for tissue analysis including northern pike, arctic grayling, whitefish, Dolly Varden, and juvenile salmon.

3.3 Site Description

The sampling sites are located primarily within a 10-mile radius of the ore body (Figure 11-1) and along the proposed road alignment (Figure 11-2). There are also sites located on the Kaskanak River and downstream of the 10-mile radius on the north and south forks of the Koktuli River. In addition to Frying Pan Lake and Big Wiggly Lake, two additional lake sites will be selected: one lake in the North Fork Koktuli drainage (i.e., Black Lake) and an additional lake located in either the South Fork Koktuli or the Lower Talarik drainage.

3.4 Objectives

The objectives of the fish-tissue analysis are to determine if migratory and resident fish contain specific metals within their tissues. The baseline data will provide documentation of the natural levels of trace elements within the fish tissue prior to the commencement of mining operations. Fish tissues will be analyzed for a suite of trace metals including Sb (Antimony), As (Arsenic), Be (beryllium), Cd (cadmium), Cr (chromium), Cu (copper), Pb (lead), Mo (molybdenum), Ni (nickel), Se (selenium), Ag (silver), Zn (zinc), Tl (thallium), and total Hg (total mercury). A variety of fish species will be collected for tissue samples. Due to their position as an apex predator, northern pike will be used for tissue samples in areas where enough are captured.

3.5 Sample Analysis Summary

Collected samples will be analyzed by Columbia Analytical Services, Inc. (CAS) for the parameters that are defined for fish tissue in the *Draft Environmental Baseline Studies, Proposed 2005 Quality Assurance Project Plan*. or QAPP (NDM, 2005). Reports will be sent to the quality assurance (QA)/quality control (QC) manager and NDM by CAS.

3.6 Study Organization and Responsibility

The fish-tissue study will be organized by the senior fisheries biologists: Paul McLarnon of HDR Alaska, Inc., and John Morsell of Northern Ecological Services. They will be responsible for assigning tasks and ensuring that protocols are followed. Shaw Environmental Inc. will be responsible for filling out electronic chain-of-custody forms (e-Chain) for fish-tissue samples that will be sent to CAS for analysis.

3.7 Field Activities

Field activities involved with the fish-tissue collection will include collection of fish using baited minnow traps and/or electrofishing at stream sites and angling and/or gill nets at lake sites. Electrofishing will be used in place of, or as a supplement to, minnow traps when insufficient fish are collected by traps alone. Collection efforts will take place at each of the selected locations as described in Table 1.

TABLE 1: Fish Tissue Sample Sites

Location	Fish Species	No. of Primary Samples	No. of QC Samples	Analytes
Frying Pan Lake	Northern Pike	10 fish, 20 samples: 10 liver, 10 muscle	1 fish, 2 samples: 1 liver, 1 muscle (split of homogenate)	Ag, As, Be, Cd, Cr, Cu, Mo, Pb, Ni, Se, Sb, Tl, Zn, Total Hg,
Big Wiggly Lake	Northern Pike	10 fish, 20 samples: 10 liver, 10 muscle	1 fish, 2 samples: 1 liver, 1 muscle (split of homogenate)	Same as above
2 additional lakes (Black Lake and a lake to be determined)	Northern Pike (if present)	20 fish, 40 samples: 20 liver, 20 muscle	2 fish, 4 samples: 2 liver, 2 muscle (split of homogenate)	Same as above
same 2 lakes as above	Grayling (if present)	10 whole body	Split of Homogenate (1 fish)	Same as above
same 2 lakes as above	Whitefish (if present)	10 whole body	Split of Homogenate (1 fish)	Same as above
SK100A	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
SK100B	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
SK119A	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
SK100C	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
SK100F	Juvenile northern pike and grayling	20 whole body	Split of Homogenate (1 fish)	Same as above
SK100G	Arctic grayling	10 whole body	Split of Homogenate (1 fish)	Same as above
KC100A	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
NK100A	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
NK100B	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
NK100C	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
NK119A	Dolly Varden	10 whole body	Split of Homogenate (1 fish)	Same as above
UT119A	Dolly Varden	10 whole body	Split of Homogenate (1 fish)	Same as above
UT100B	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above

Location	Fish Species	No. of Primary Samples	No. of QC Samples	Analytes
UT100C	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
UT100D	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
UT100E	Dolly Varden	10 whole body	Split of Homogenate (1 fish)	Same as above
Ursa 100B	Dolly Varden	10 whole body	Split of Homogenate (1 fish)	Same as above
UT138	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
Bear Den Creek	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
Y Creek	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above
Red Creek	Juvenile salmon	10 whole body	Split of Homogenate (1 fish)	Same as above

3.8 Fish-tissue Sampling Protocols

3.8.1 Sampling Procedures

Processing of fish for tissue samples, subsequent handling, chain-of-custody, and transport to the analytical laboratory will follow procedures outlined in the QAPP (NDM, 2005).

3.8.1.1 Fish Sampling

Stream Sample Sites

At the stream sampling sites, one or more key fish species will be selected for each monitoring site and will be sampled for tissue metals analysis. In most cases, juvenile salmonid species will be selected as key species based on abundance and catchability. A total of 10 discrete whole-body samples will be collected for individual analysis at each site to provide an adequate measure of variability. Individual fish will be a minimum of 25 grams or about 50 millimeters in length to provide adequate tissue mass to complete the required analyses. Length to weight relationships will be verified in the field.

Each fish will be placed into an individual plastic bag and immediately placed on ice in a clean cooler. Samples will be returned to Iliamna and frozen as soon as possible, but within 12 hours of capture. Collection personnel will use powder-free surgical gloves to handle fish samples. Handling of fish will be minimized to the extent possible. Fish will be measured inside the collection bag. A field blank will be prepared for each collection day by rinsing an empty sample bag with deionized (DI) water in the field and collecting the rinsate in an acid-preserved sample jar.

Lake Sample Sites

Large fish from lake samples will be placed in clean plastic bags and put on ice immediately after capture. Dissection of liver and muscle tissues will be conducted in a clean indoor location on an uncontaminated surface. Tissue samples will be placed in individually labeled plastic bags and frozen as soon as possible. Procedures for sample labeling, washing tools and work surfaces, and preparing QC equipment blanks will follow the QAPP (NDM, 2005). Specific steps to be taken in processing the dissected samples are as follows:

- Immediately upon capture, fish will be placed in a clean plastic bag (heavy-duty trash-compactor type) and placed on ice in a freshly washed cooler.
- Dissection will take place as soon as possible on the same day as capture at a selected indoor location in Iliamna.
- Prior to dissection the fish will be measured to fork length, weighed, and a scale sample obtained. Scale samples will placed on gum cards provided by the Alaska Department of Fish and Game (ADF&G).
- The cutting surface will be washed with soap and water, rinsed with hot tap water followed by DI water, and covered with heavy-duty aluminum foil. The aluminum-foil cutting surface will be replaced after each dissection.
- Stainless steel, disposable scalpels and/or high-quality stainless steel knives will be used for dissection.
- Knives will be washed with soap and water and rinsed with DI water between uses. If scalpels are used, a new blade will be used for each fish dissected.
- Personnel handling or dissecting fish will wear powder-free surgical gloves, and the gloves will be changed after each dissection.
- Fish undergoing field dissection will be photographed with a visible sample identification number prior to and after dissection.
- Samples of liver and muscle tissue will be extracted from each fish and placed in an individually labeled Ziploc bag. the label will include the sample ID and a suffix of “M” for muscle and “L” for liver tissue. Where possible, each sample will consist of a minimum of 50 grams of tissue.
- Bagged tissue samples will immediately be placed in a freezer
- A composite equipment blank will be prepared before each set of dissections by rinsing the foil cutting surface and the stainless steel knives (if used) with DI water and collecting the rinsate in an acid-preserved sample jar. DI water for use in blanks will be provided by the analytical laboratory.
- Frozen tissue samples will be packed in a cooler and sent to the laboratory within 24 hours using packaging recommendations provided by the lab.
- A field blank will be prepared for each sample day at the field collection site by rinsing an empty plastic fish bag with DI water and collecting the rinsate in an acid-preserved sample jar.
- Chain-of-custody procedures will be followed.

3.8.2 Sampling Equipment Decontamination

Where stainless steel, disposable scalpels are used for dissection, a fresh scalpel blade will be used for each fish. All stainless steel knives used will be washed with soap and water and rinsed with DI water between uses. All cutting surfaces will be washed with soap and water, rinsed with hot tap water and DI water, and covered with heavy-duty aluminum foil.

3.8.3 Sample Handling

3.8.3.1 Sample Containers

Sampling containers will consist of clean Ziploc bags for all whole-body and tissue samples. The preservation method will be to keep samples frozen at below 0°C. The hold time is six months, but samples will be sent to the laboratory for analysis within 24 hours of collection.

3.8.3.2 Sample Volumes, Containers, and Preservation

Sample volume will be made up of the whole body for fish less than 6 inches in length or the combined volume of muscle sample and liver tissue from fish longer than 6 inches. Approximately 25 grams (3x3x1 inches) of liver and 25 grams of muscle will be collected from each fish. Tissue and whole-body samples will be stored in plastic Ziploc bags and preserved through freezing.

3.8.3.3 Field Data Forms and Document Management

A field data sheet (Appendix A) will be completed for each fish collected at each location where whole-body samples are collected. A data sheet also will be completed for each fish dissected. Data sheets will be completed in the field at each location where whole-body samples are collected.

All data sheets will be printed on write-in-the-rain paper and will be completed using waterproof ink. At the end of each working day completed field data sheets will be turned over to John Morsell or Paul McLarnon. All photographs will be downloaded to a field laptop computer once all field activities are completed.

3.8.3.4 Sample Identification

Each sample will be labeled individually with a waterproof label listing the following information:

- Project name: Pebble Project.
- Date: month/day/year.
- Time.
- Preservation method: Keep Frozen.
- Sample code (example: 0605UT100ETF001).

- Analysis.
- Sampler's initials.

The sampler will identify each sampling location on the field form. The sample identification format is as follows:

Example: 0605UT100ETF001

Where:

0605 is the date as month and year. If sampling begun in a given month carries over into the next month, samples are still labeled according to the month during which the sampling event began. For example, the last few samples for the June collection may be taken in early July, but the sample date will still read "0605."

UT100E is the location ID.
TF is the matrix code for fish tissue.
001 is a sequential sample number.
201 = sequential sample number for field duplicates.
301 = sequential sample number for field triplicates.
401 = sequential sample number for field equipment blanks.
501 = sequential sample number for DI water blanks.

For analysis conducted on muscle or liver tissue an "M" or "L," respectively, will be placed at the end of the sample identification number:

Example: 0605UT100ETF001L

3.8.4 Sample Custody

Chain-of-custody (COC) information will be completed by a Shaw Environmental employee in the field at the time the sample is collected. All COC information will be entered in an e-Chain database.

The COC information for the fish-tissue samples will, at a minimum, include the following information:

- Sample identification code: TF (fish tissue).
- Signature of sampler.
- Date of collection: month/day/year.
- Time of collection.
- Project name: Pebble Project.
- Type of sample: "M" for muscle, "L" for liver, or whole body.
- Number and type of containers: _x_ Ziploc bags.

- Sample preservation: Keep Frozen.
- Sample analysis requested: e.g., suite of trace metals.
- Inclusive dates of possession.
- Signature of receiver.

Also included on the COC form will be the following:

- HDR Alaska, Inc.
  2525 C Street Suite 305
  Anchorage, Alaska 99503
  (907) 644-2000.
- Instructions to laboratory to invoice Northern Dynasty Mines Inc. and to mail reports to:

  Jane Whitsett
  Shaw Environmental, Inc.
  2000 West International Airport Road, Suite A11
  Anchorage, Alaska 99502

3.8.5 Field Quality Control Samples

3.8.5.1 Equipment Blank

Equipment blanks will be prepared after each set of dissections by rinsing the cutting surface with DI water and collecting the rinsate in an acid-preserved jar. Equipment blanks should occur at a frequency of 5 percent or one per day, whichever is greater.

3.8.5.2 Field Duplicates

Field duplicates will be a split of homogenate prepared by CAS.

3.8.5.3 Field Triplicates

Field triplicates will be a split of homogenate prepared by CAS and analyzed by the QA laboratory (North Creek Analytical).

4. MACROINVERTEBRATE AND PERIPHYTON SAMPLING

4.1 Introduction

This field sampling plan provides the protocol that is followed by all macroinvertebrate and periphyton field crews for the Pebble Project. This plan describes in detail the methods for all the macroinvertebrate and chlorophyll-*a,b,c* (periphyton) collection, and handling procedures including sampling, preservation, and shipping. The same procedures used for the 2004 macroinvertebrate collection will be followed in 2005. Also, an additional method (ADF&G, 1998) that provides more quantitative population information will be used. This method was

successfully tested by the Alaska Department of Fish and Game (ADF&G) and has been used by the Alaska Department of Natural Resources (ADNR) for sampling macroinvertebrates and periphyton.

4.2 Purpose and Scope

A series of collection sites was established in 2004 within and adjacent to the project area to determine baseline conditions. The baseline will provide a basis for detecting potential changes within the waterbodies. These collection sites were established and used in 2004, and many will continue to be used in 2005 for macroinvertebrate and periphyton sampling.

Macroinvertebrate and periphyton samples will be collected at seven sites in the mine area (including two lake sites) and at five locations along the proposed road alignment and at the proposed port location.

4.3 Site Description

The sampling sites are located primarily within a 10-mile radius of the ore body (Figure 11-1) and along the proposed road alignment (Figure 11-2). Specific study sites, as described below, have been selected to characterize macroinvertebrate and periphyton populations upstream and downstream of proposed project facilities. Macroinvertebrate and periphyton studies will not be required at all of the biological sampling sites designated for hydrology, water-quality, and fisheries studies. Mine-area study sites will be located on the north and south forks of Koktuli River, on Upper Talarik Creek, and at two lake sites (Frying Pan Lake and Big Wiggly Lake) (Figure 11-1). There will be four road-corridor sites and one port site (Figure 11-2).

4.4 Objectives

Macroinvertebrate and periphyton populations are effective indicators of water quality, productivity, and habitat health. The varied life histories and contaminant tolerances of indicator species integrate both short- and long-term environmental changes. The objective of the macroinvertebrate and periphyton study is to characterize baseline populations and habitat conditions. The preliminary results from the data collected in 2004 helped in refining the 2005 sampling effort.

4.5 Sample Analysis Summary

Macroinvertebrate samples will be processed (sorted) and identified in the HDR laboratory by HDR personnel. Periphyton samples will be sent to the Alaska Department of Natural Resources (ADNR) laboratory in Fairbanks for analysis of chlorophyll-*a,b,c* using ultraviolet and visible spectrophotometry.

4.6 Study Organization and Responsibility

The macroinvertebrate and periphyton study will be organized by the senior macroinvertebrate biologists: Andra Love of HDR Alaska, Inc., and Sally Morsell of Northern Ecological Services. They will be responsible for assigning tasks and ensuring that protocols are followed.

4.7 Field Activities

The methods used in 2004 to characterize the macroinvertebrate and periphyton populations within the proposed mine and road corridor study areas followed those outlined in the *Alaska Stream Condition Index (ASCI): A Modification of the USEPA Rapid Bioassessment Protocols* (Major and Barbour, 1997).

Two study approaches have been adopted for 2005. The ADNR Office of Habitat Management and Permitting (OHMP) has used methods for sampling macroinvertebrates and periphyton that are intended to provide more quantitative population information (ADF&G, 1998). These methods call for collection of a minimum of five replicate macroinvertebrate samples and 10 periphyton samples from a specific habitat type (riffles) and location that can be resampled in successive years. In 2005, an ASCI macroinvertebrate sample will again be collected at each site; however an additional five macroinvertebrate samples will be collected at each site in accordance with the ADNR methodology for comparison. The methods in the rapid bioassessment protocols (RBPs) for collection and processing of diatom (periphyton) data will not be used in 2005. Instead, the periphyton data collection will consist of 10 periphyton samples collected in each riffle location in accordance with the ADNR methods. Samples will be analyzed for chlorophyll-*a*,*b*,*c* and, the data will be used to assess productivity at each site.

Seven sites in the proposed mine area will be sampled and have been selected to collect information upstream and downstream of proposed facilities. (Because of hydrological limitations, only a downstream site can be used on the South Fork of Koktuli River.) The sampling effort will take place in early June at the seven sites shown in Figure 11-1 and listed in Table 2.

TABLE 2: Sampling Sites for Macroinvertebrate and Periphyton Samples

Location	Sampling Method/Type	No. of Samples	No. of QC Samples	Total No. of Samples
Sampling Sites for Mine Area				
Frying Pan Lake	Modified ASCI, dredge	1	1 for ASCI samples	83 Total: 82 primary samples and 1 QC sample
Big Wiggly Lake	Modified ASCI, dredge	1		
SK100B	ASCI, Surber, Chlorophyll-*a,b,c*	16		
NK100A	ASCI, Surber, Chlorophyll-*a,b,c*	16		
NK100C	ASCI, Surber, Chlorophyll-*a,b,c*	16		
UT100B	ASCI, Surber, Chlorophyll-*a,b,c*	16		
UT100D	ASCI, Surber, Chlorophyll-*a,b,c*	16		
Sampling Sites for Proposed Road Corridor and Port Location				
Ursa 100B	ASCI, Surber, Chlorophyll-*a,b,c*	16	1 for ASCI samples	81 Total: 80 primary samples and 1 QC sample
UT138	ASCI, Surber, Chlorophyll-*a,b,c*	16		
Bear Den Creek	ASCI, Surber, Chlorophyll-*a,b,c*	16		
Red Creek	ASCI, Surber, Chlorophyll-*a,b,c*	16		
Y Valley Creek	ASCI, Surber, Chlorophyll-*a,b,c*	16		

4.8 Environmental Sampling Protocols

This section includes information about the macroinvertebrate and periphyton sampling procedures. It also includes information about equipment maintenance and sample handling.

4.8.1 Field Sampling Procedures

The ASCI sampling protocol (Major and Barbour, 1997) includes the methods used in 2004 for macroinvertebrate and periphyton samples. The same methods will be used in 2005 for macroinvertebrate sampling; however ADNR methods (ADF&G, 1998) will be used in collecting additional macroinvertebrate samples and in collecting periphyton samples.

4.8.1.1 ASCI and Modified ASCI Methods

The ASCI protocols require 20 “jabs or kicks” with a D-frame, 363-micrometer-mesh kick net, resulting in approximately three square meters of habitat being sampled. Kick nets are used by disturbing or kicking the substrate upstream of the net so that organisms and debris flow into the net and are trapped. The jabs or kicks are partitioned proportionally between habitat types in the 100-meter reach, and the collected macroinvertebrates and debris are composited into one sample. The samples will be preserved with alcohol and labeled for later sorting and identification in the laboratory.

In addition to sampling the macroinvertebrate population, a visual aquatic and riparian habitat assessment will be completed and ambient water-quality data will be recorded on field data sheets such as those presented in Major and Barbour (1997) and those found in Appendix B. The visual

assessment of aquatic and riparian habitat is an integral part of the bioassessment process and considers the following habitat parameters:

- Epifaunal substrate/available cover.
- Embeddedness.
- Velocity/depth combinations.
- Sediment deposition.,
- Channel flow status.
- Channel alteration.
- Channel sinuosity.
- Bank stability.
- Bank vegetative protection.
- Riparian-zone vegetation width.

Dissolved oxygen, ph, conductivity, temperature, and oxidation reduction potential will be measured using a YSI 556 MPS multiprobe. The probe will be calibrated each morning before sampling begins.

Two lakes in the mine area, Big Wiggly and Frying Pan, will be sampled once using a modified ASCI approach and again using an Ekman dredge. The ASCI approach described above will be modified primarily to account for the lack of flowing water. Instead of placing the D-frame net in a stationary position, organisms will be collected by dragging the net through the habitat substrate. The habitat substrate may be disturbed beforehand, depending on substrate material, so that organisms enter the net.

4.8.1.2 ADNR Surber-Sampler Methods

Use of a Surber sampler is a semi-quantitative method to determine the density and composition of macroinvertebrate populations on stream-bottom habitats. The sampler is constructed of a rectangular frame net of 363-micrometer mesh size. Attached to the bottom of the net frame and oriented upstream is a metal frame that delineates the area of substrate to be sampled. The substrate within the frame is disturbed and cobbles are “scrubbed” clean of debris and organisms. The debris and organisms then flow into the net and are trapped.

Five samples will be collected with a Surber sampler from a selected riffle/cobble area at each sampling site. The sampling site will be documented using a global positioning system (GPS) and will be flagged to ensure that any subsequent sampling will occur in the same area. Samples will be placed in separate containers and preserved with alcohol.

4.8.1.3 ADNR Modified Periphyton Methods

At each sampling site, ten periphyton samples will be collected within the same riffle/cobble area from which macroinvertebrate samples are collected by the Surber sampler. The periphyton

sampling area will be flagged, and a GPS location will be recorded so that any future samples can be collected in the same place for continuity and comparison.

At each sampling site, periphyton will be removed from 10 cobbles from a riffle/cobble area that will not be disturbed by macroinvertebrate sampling. The sampling protocol that will be used to collect periphyton samples (ADF&G, 1998) has been used by ADNR on other Alaska projects. A square of high-density foam that is five square centimeters will be placed on each cobble. All material surrounding the foam square will be removed by scrubbing the cobble with a clean toothbrush. This area will then be rinsed clean. The area under the foam square then will be brushed with another clean toothbrush and rinsed clean onto a 45-micrometer glass fiber filter attached to a hand vacuum pump. Most of the water will be extracted and one milliliter of saturated magnesium carbonate solution will be added to the filter as a preservative. The remaining water will be extracted. The damp filter will be wrapped in a clean, large coffee filter (to absorb any additional water), labeled, placed in a Ziploc bag, and packed over silica gel desiccant. This process will be repeated so that ten discrete periphyton samples (one sample per cobble) will be collected from each sampling station. Filters will be frozen in a lightproof container with desiccant for shipment to the laboratory.

4.8.2 Sampling-Equipment Maintenance

Before the field-sampling trip the nets will be examined for damage which may cause loss of organisms. Repairs or replacements will be made as needed. In the field the nets used for macroinvertebrate sampling will be rinsed with ambient water and examined for clinging organisms and debris after each sample collection. When sampling is completed at each stream site, the nets will again be rinsed and examined.

Sampling equipment for periphyton will not be reused between samples collected on the same day. The toothbrushes used to scrub the rocks of material will be placed in a Ziploc bag for the remainder of the field day. Upon returning from the field sampling each day, the dirty toothbrushes will be thoroughly cleaned using denatured alcohol. The foam squares will be placed in a Ziploc bag and cleaned upon returning from each field-sampling day.

The YSI 556 water-quality meters will be calibrated before the field-sampling event. Calibration will occur as needed during the field sampling to maintain the accuracy of the meters. Each meter will have a manual explaining the steps for calibration. Fresh calibration standards will be used during each calibration. The calibration menu for each parameter can be reached through the main menu of the meter. To calibrate the meter for a given parameter, the steps on the meter and in the manual will be followed and the proper levels for the solution being used will be entered.

A spare set of meters and nets will be taken on the field-sampling trip as a backup in case replacement of equipment is necessary. Extra sample bottles will also be taken on the sampling trip.

4.8.3 Sample Handling

4.8.3.1 Sample Containers and Preservation

Macroinvertebrate sample containers will be one-liter Nalgene bottles. Each sample will be stored in a separate bottle. Some samples will require multiple bottles due to the amount of material collected in the nets. The bottles will be labeled accordingly to clarify how many bottles each sample comprises and which sampling method was used (ASCI or Surber). These samples will be stored in a cooler during the field day. Upon returning from the field-sampling day, the bottles will be filled with denatured alcohol. Labels will be examined, samples will be logged on a sample-tracking form, and all bottles will be stored in coolers for transport back to the lab.

Sampling containers for all periphyton samples will consist of clean Ziploc bags. All the sample bags will be clearly labeled. The preservation method will be to keep samples frozen at below 0°C and stored in light-proof containers. The periphyton samples will be sent to the laboratory for analysis immediately upon returning from the field-sampling trip.

4.8.3.2 Sample Identification

Each sample will be labeled individually with a waterproof marker listing the following information:

- Project Name: Pebble Project.
- Date: month/day/year.
- Sample Site ID.
- Sample Type: macroinvertebrate or periphyton.
- Sample Method and/or Number Code: e.g., Surber 1 = macroinvertebrate Surber-sample #1.
- Bottle Number (if one sample needs more than one bottle): e.g., 1 of 3 (macroinvertebrate)
- Preservation Method: Keep Frozen (periphyton)
- Duplicate (if applicable).

4.8.4 Sample Custody

The macroinvertebrate samples will be sorted and identified by HDR employees so no custody forms will be necessary; however, all samples will be logged in using the Macroinvertebrate Sample Login Sheet (Appendix B). Periphyton samples will be recorded on the Periphyton Sample Login and Shipment Tracking Sheet. This sheet includes the following:

- Site identification and sample number.
- Stream name.

- GPS coordinates.
- Date and time of collection.
- Samplers' initials.
- Shipping date.
- Shipper's initials.

Periphyton samples will be shipped to Bill Morris of the ADNR Office of Habitat Management and Permitting for laboratory analysis of chlorophyll-*a,b,c* concentrations.

4.8.5 Field Quality Control Samples

Field duplicates are the quality control samples. These will occur at a frequency of 10 percent for the ASCI samples. There will be one duplicate macroinvertebrate ASCI sample collected at the mine area and an additional duplicate macroinvertebrate ASCI sample collected at one of the road-corridor sites. These samples will be placed in separate bottles and labeled "duplicate" at the bottom of the label.

5. REFERENCES

Alaska Department of Fish and Game (ADF&G). 1998. Methods for Aquatic Life Monitoring to Satisfy Requirements under 1998 NPDES Permit: NPDES AK-003865-2, Red Dog Mine Site. ADF&G, Division of Habitat and Restoration, Fairbanks, Alaska.

Major, E.B., and M.T. Barbour. 1997. The Alaska Stream Condition Index (ASCI): A Modification of the USEPA Rapid Bioassessment Protocols. Prepared for Alaska Department of Environmental Conservation, Anchorage, Alaska.

Northern Dynasty Mines Inc. (NDM). In press. Pebble Project, Draft Environmental Baseline Studies, Proposed 2005 Study Plan, Fish and Aquatic Habitat. Prepared by HDR Alaska, Inc.

———. 2005. Pebble Project, Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan.

FIGURES

Northern Dynasty Mines Inc.

Pebble Project

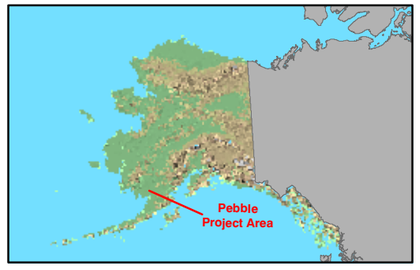
Fish and Aquatic Field Sampling Plan
Fish Tissue, Macroinvertebrate, and Periphyton Sampling Sites
Mine Study Area
Figure 1

Legend

- 2005 Sampling Sites (Fish & Macro)
- Fish Tissue Only Sampling Sites
- Possible Fish Tissue Sampling Sites
- Ore Body
- Inner Mine Area
- Outer Mine Area

Sites from HDR, file date 01/25/2005

Privileged and Confidential



0 0.5 1 2 3 4 5 Miles

0 0.5 1 2 3 4 5 Kilometers

N

Scale 1:166,756

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Fig 1 Fish_Aquatic_Field_Sampling_Plan	Date: March 21, 2005
Version: 1	Author: HDR-JS

Z:\200847 Northern Dynasty Minerals\12628 Fisheries - Mine Site\GIS\MXD\Fish_Aquatic_Field_Sampling_Plan

Northern Dynasty Mines Inc.

Pebble Project

Fish and Aquatic Field Sampling Plan
Fish Tissue, Macroinvertebrate, and Periphyton Sampling Sites - Road, Port, and Transmission Line Study Area
Figure 2

Legend

- 2005 Sampling Sites
- Barge Landing Areas
- Road Corridor
- Transmission Line

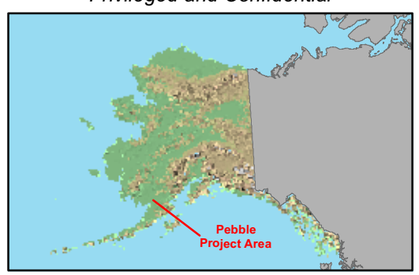
UT 138
Ursa 100B
Bear Den Creek
Red Creek
Y Valley Creek

155°24'0"W 155°12'0"W 155°0'0"W 154°48'0"W 154°36'0"W 154°24'0"W 154°12'0"W 154°0'0"W 153°48'0"W 153°36'0"W 153°24'0"W 153°12'0"W

60°24'0"N
60°12'0"N
60°0'0"N
59°48'0"N
59°36'0"N

Sites from HDR, file date 01/25/2005

Privileged and Confidential



N

0 1 2 4 6 8 Miles

0 1 2 4 6 8 Kilometers

Scale 1:445,627

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Fig2 Fish_Aquatic_FieldSamplingPlan	**Date: March 17, 2005**
Version: 1	**Author: HDR-DS**

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APPENDIX A
Fish Tissue Data Sheets

Fish Tissue Dissection Data Sheet

(Complete a new data sheet for each fish dissected)

Date_____

Time_____

Sample Team Members_____
_____

Sample Location_____

Capture Method_____

Species _____

Length _____

Weight _____

Photo Numbers_____

Scale Card Number_____ Scale Sample Numbers_____

Sample I.D. Number(s) _____

Weight of Liver Sample _____

Weight of Muscle Sample _____

Stomach Contents_____
_____

Recapture? Tag No. and Color _____

Comments_____
_____
_____
_____
_____
_____
_____
_____
_____

PEBBLE PROJECT

COLLECTION OF FISH FOR WHOLE BODY TISSUE ANALYSIS AND INDEX SPECIES

Sample Team_____	**Date_____**
Stream Name_____	**Time_____**
Sample Station Code_____	**Photo #'s_____**
Weather Conditions_____	**GPS Waypoint_____**
_____	**Water Temp_____**

Designated Sample Species – Fish Tissue_____

Designated Sample Species – Index Sampling_____

Sketch of Sample Station Locations

Minnow Trap Catch

Species	Length (mm)	Comments

Minnow Trap Catch (Continued)

Species	Length (mm)	Comments

Fish Retained for Tissue Analysis

Sample Number	Species	Length (mm) must be greater than 75 mm

General Comments

APPENDIX B
Macroinvertebrate and Periphyton Data Sheets

Macroinvertebrate/Periphyton/Water Quality
Field Data Collection Form

<table>
<tr><td>Site Identification:

Site Name:</td><td colspan="2">Date:

Time:</td><td>Crew Initials:</td></tr>
<tr><td colspan="4">GPS Periphyton Coordinates:</td></tr>
<tr><td colspan="4">GPS Surber Coordinates:</td></tr>
<tr><td colspan="4">Conditions (Site and Weather):</td></tr>
<tr><td>Sample Collected:

Y N</td><td colspan="3">Type: Water Macro – ASCI

Periphyton Macro – Surber

Duplicate Macro – Modified ASCI

Macro – Drift</td></tr>
<tr><td colspan="2">Surber/Periphyton Sample Location Sketch Map</td><td colspan="2">Flow Data:

_____

_____

_____

_____

_____</td></tr>
<tr><td colspan="4">Water Quality Data:
Temperature C: DO: Conductivity: pH:</td></tr>
</table>

Macroinvertebrate and Periphyton Sites: Mine Area

Site ID	Latitude	Longitude	ASCI collected Y/N	Surber collected Y/N	Periphyton collected Y/N
NK100C	N59º 55.822’	W155º 24.595’			
	59.930367	-155.409917			
	2169195.77	1381799.13			
NK100A	N59º 50.584’	W155º 43.136’			
	59.843067	-155.718933			
	2138635.82	1324296.58			
UT100D	N59º 54.481’	W155º 11.995’			
	59.908017	-155.199917			
	2160268.79	1420167.83			
UT100B	N59º 47.215’	W155º 15.215’			
	59.786917	-155.253583			
	2116196.90	1409480.53			
SK100B	N59º 47.591’	W155º 31.452’			
	59.793183	-155.524200			
	2119531.23	1359685.25			
Big Wiggly	N59º 53.334	W155º 16.3619			
	59.8889	-155.2727			
	2153632.73	1406923.30			
Frying Pan	N59º 51.768	W155º 17.214			
	59.8628	-155.2869			
	2144189.11	1403839.67			

Macroinvertebrate and Periphyton Sites: Road/Port Area

Site ID	Latitude	Longitude	ASCI collected Y/N	Surber collected Y/N	Periphyton collected Y/N
UT138	N59º 54.510	W155º 11.430’			
	59.942667	-155.159433			
	1420376.38	2166265.82			
Ursa 100B	N59º 54.5736	W154º 55.6524			
	59.90956	-154.92754			
	2159790.52	1470186.40			
Bear Den Creek	N59º 50.75418	W154º 27.57042			
	59.845903	-154.459507			
	2135881.70	1555859.65			
Red Creek	N59º 48.0468	W153º 57.8304			
	59.80078	-153.96384			
	2118946.29	1647510.10			
Y Valley Creek (Chum)	N59º 56.7162	W153º 31.6614			
	59.94527	-153.52769			
	2062162.86	1728700.44			

SAMPLE LOGIN SHEET

Sample ID	Stream Name	Collect Date	Samplers ID	Sample Processing						QC	
				# Jars	SS Y/N	5' Pick Y/N	Sorting Date/Init	ID Date/Init	Chiro Date/Init	Processing Date/Init	ID Date/Init

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2006 FIELD SAMPLING PLAN

FISH AND AQUATIC RESOURCES
Mine and Transportation Corridor Studies

August 2006

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LIST OF FIGURES (attached)

Figure 1-1, 2006 Fish and Aquatic Resources, Field Sampling Plan for Mine Study Area

Figure 5-1, 2005-2006 Iliamna Lake Study, Sample Sites

Northern Dynasty Mines Inc. is proposing to develop the Pebble Project; therefore, a series of environmental studies is being conducted to provide background information necessary for mine permitting, planning, and development. This plan updates the field sampling methodology for the collection of fish and macroinvertebrate data for baseline studies during 2006. Although the protocols for 2006 are for the most part consistent with those detailed in the 2005 field sampling plan for these disciplines, changes and additions to the 2005 protocols and sampling schedule are included here.

1. Fish Studies for Mine Study Area

1.1 Objectives/Study Area/Methods

The objective of the fish tissue-sample program is to support the future development of a long-term monitoring program by collecting a total of two years of fish tissue data for the mine study area and the proposed transportation corridor. Sampling protocols for fish tissue-sample collection described in the 2005 field sampling plan will remain the same in 2006. This information will be considered by a technical work group for the development of a long-term fish tissue-sampling plan.

1.2 2006 Changes

Biological monitoring in 2004 and 2005 for the mine study area included trace-metal analysis of fish tissues collected from four lakes and 16 river environments. In 2005, two additional lakes, Black Lake and Lake #2, were added to the sampling program. To date, only one year of fish tissue data has been collected for these two lakes. Thus, Black Lake and Lake #2 will be sampled again in 2006 (Figure 1-1). Additionally, Big Wiggly will be sampled again in 2006 to obtain muscle tissue from arctic grayling.

1.3 Schedule

Sampling is currently scheduled to occur in early September and is estimated to require approximately three days of field time with a two-person field crew.

2. Macroinvertebrate and Periphyton Studies for Mine Study Area

2.1 Objectives/Study Area/Methods

The objective of this program in 2006 is to fill data gaps that currently exist for invertebrate information in the mine study area. Key changes to the program in 2006 include the addition of zooplankton in four lakes and no sampling for macroinvertebrates and periphyton in the stream sites. Details of these and other changes are provided below.

2.2 2006 Changes

To complete the baseline characterization of the project area, zooplankton sampling will be added in four lakes in the mine study area—Frying Pan, Big Wiggly, Black Lake, and Lake #2 (Figure 1-1). The field crew also will search for freshwater mussels in the Upper Talarik, and North and South Fork Koktuli drainages.

Macroinvertebrates and periphyton will not be collected from the stream sites detailed in the 2005 study plan. Monitoring efforts are expected to resume in future years to complete the amount of long-term monitoring necessary for this project. A technical advisory group initiated in 2006 will discuss the future goals and objectives of this sampling program to ensure that it meets the needs of the project.

2.3 Schedule

Sampling is currently scheduled to occur in mid-August and is estimated to require approximately three days of field time with a three-person field crew. Laboratory analysis of the zooplankton samples will begin in the fall of 2006 and is expected to be completed by the end of November.

3. Fish Studies for the Transportation Corridor

3.1 Objectives/Study Area/Methods

Objectives of the fish tissue studies in the transportation corridor remain the same as in previous years, and since two consecutive years of fish tissue data have been collected from five sample sites in the proposed transportation corridor, no fish tissue-sample collection is planned for the transportation corridor in 2006.

3.2 2006 Changes

Fish tissue will not be collected from the stream sites in the transportation corridor as detailed in the 2005 study plan. The effort associated with baseline characterization of fish tissue in the transportation corridor is complete. Monitoring efforts are expected to resume in future years to complete the amount of baseline monitoring necessary for this project. A technical work group initiated in 2006 will discuss the future goals and objectives of this sampling program to ensure that it meets the needs of the project.

4. Macroinvertebrate and Periphyton Studies for the Transportation Corridor

4.1 Objectives/Study Area/Methods

Objectives of the macroinvertebrate and periphyton studies in the transportation corridor remain the same as in previous years; however, macroinvertebrate and periphyton sample collection will not occur for the transportation corridor in 2006.

4.2 2006 Changes

Macroinvertebrates and periphyton will not be collected from the stream sites in the transportation corridor as detailed in the 2005 study plan. Monitoring efforts are expected to resume in future years to complete the amount of long-term monitoring necessary for this project. A technical advisory group initiated in 2006 will discuss the future goals and objectives of this sampling program to ensure that it meets the needs of the project.

5. Iliamna Lake Study

5.1 Objectives/Study Area/Methods

The objectives of the Iliamna Lake study include characterization of the existing conditions related to water quality, sediments, mussel tissues, and zooplankton at sites in the littoral zone of the northeast end of Iliamna Lake. The study also aims to build a pre-project data set to which post-project data sets can be compared. The work conducted in 2006 will consist of sampling for mussels, sediments, and water quality at the four mussel sites sampled during the 2005 field effort—Bucket Lake, Whistlewing Bay, Flat Island, and Finn Bay (Figure 5-1). The five water quality sites will not be sampled in 2006. Zooplankton will not be sampled in 2006. Details of these and other changes are provided below.

5.2 2006 Changes

One sampling event will be conducted in July at the four mussel sites—Bucket Lake, Whistlewing Bay, Flat Island, and Finn Bay. One water quality sample, one sediment sample, and one set of mussels will be collected from each of these sites. YSI readings and an in situ turbidity reading will be recorded at each of these four sites. All samples will be submitted to the appropriate laboratories for analyses (refer to the 2005 field sampling plan and 2005 study plan for detailed collection and processing methods).

Pile Bay, Knutson Bay, Northeast Bay, Roadhouse Bay, and the outlet of Upper Talarik Creek will not be sampled in 2006 because the proposed transportation routes for the project are still under consideration. A technical advisory group initiated in 2006 will discuss the future goals and objectives of this sampling program to ensure that it meets the needs of the project.

5.3 Schedule

Sampling is currently scheduled to occur in mid-August and is estimated to require approximately two days of field time with a three-person field crew.

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2007 FIELD SAMPLING PLANS

FISH TISSUE STUDY
Mine Study Area

DRAFT

SEPTEMBER 2007

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Figure 1, Fish Tissue Field Sampling Plan, Sampling Sites, Mine Study Area

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Appendix A, Fish Tissue Program, Year-to-Year Changes

Appendix B, Fish Tissue Data Sheets

ACRONYMS AND ABBREVIATIONS

CAS	Columbia Analytical Services
COC	chain-of-custody
DI	deionized
NDM	Northern Dynasty Mines Inc.
POP	Persistent Organic Pollutant
QAPP	quality assurance project plan

FISH TISSUE STUDY, MINE STUDY AREA

2007 FIELD SAMPLING PLAN

1. Introduction

This field sampling plan provides the protocol for collection of adult fish tissue samples in 2007; this protocol will be followed by all fisheries field crews for the Pebble Project. This plan describes in detail the methods for all the fish tissue collection and handling including dissection, preservation, and shipping. These are the same procedures used for collection of fish tissue in all previous years of the study. Appendix A is a description of year-to-year changes in the fish tissue program.

The fish tissue study will be organized by fisheries biologists Paul McLarnon of HDR Alaska, Inc., and John Morsell of Northern Ecological Services. They will be responsible for assigning tasks and ensuring that protocols are followed. Shaw Environmental Inc. will be responsible for filling out electronic chain-of-custody forms for fish tissue samples that will be sent to Columbia Analytical Services, Inc., (CAS) for analysis.

2. Objectives and Scope

The environmental baseline studies for Pebble Project, of which this sampling effort is a part, have four general objectives:

- Characterize the natural environment, including fish and aquatic resources, in the vicinity of the project.
- Gather and organize information that will be needed for permitting and processes required under the National Environmental Protection Act (NEPA).
- Develop information that can help guide project layout and engineering design.
- Generate a predevelopment database that will form the basis for long-term monitoring and post-development comparison.

The fish tissue study for the Pebble Project is designed to determine body burdens (i.e., accumulations in the fishes' bodies) of trace elements for certain representative fish populations in the mine study area. This study is intended to help satisfy the first and fourth of the four general objectives listed above.

The fish tissue program is divided into two parts. The first part involves collecting yearling or older juvenile salmonid fish and analyzing for whole-body (including unevacuated viscera) burdens. This sampling process was developed by the Alaska Department of Natural Resources for state-wide application in all long-term monitoring programs for mining projects. Yearling and older juvenile salmonids were chosen as target aquatic organisms because they are old enough to have accumulated trace elements over several seasons and are thought to have resided at or near the point of capture long

enough to have established a steady-state body burden. Salmon are preferred for this part of the sampling program because of their value as a resource. These fish also are at least two trophic levels (i.e., feeding positions on the food chain) above periphyton (algae) and are thought to be good ecological indicators for trace elements.

The second part of the sampling program relates to potential human consumption of fish in the vicinity of the project. This effort involves collecting and analyzing muscle tissue from adult fish that may be used for subsistence or may be consumed by recreational fishermen. The primary species of interest in this part of the sampling program is northern pike, because of its position as the apex aquatic predator in this part of southwestern Alaska. This is relevant because many trace elements, especially persistent organic pollutants (POPs) such as methyl mercury, are trophically bioaccumulated, meaning that methyl mercury becomes more concentrated in animals that are higher on the food chain.

The fish tissue study collected and analyzed two years of yearling and older juvenile salmonids for whole-body burdens of trace element from 16 stream sampling stations in the mine study area. These collection sites were established in 2004 and have been and will be sampled in 2007 for water quality and hydrology monitoring. In future years, a carefully selected subset of these sites will be sampled for fish-abundance, macroinvertebrates and periphyton, and juvenile fish tissue as part of the long-term monitoring program. Because sampling episodes among years are independent events (results from any one year are not dependent on results from another year), and because the permitting process for the Pebble Project has been extended substantially beyond what was originally conceived, Northern Dynasty Mines Inc. (NDM) decided to suspend juvenile fish tissue sampling for 2007. It is thought that this will not compromise the quality of the pre-operational data in the monitoring database, because several more years remain available for sampling prior to the earliest reasonable development start-up date.

Less information has been collected to date for burdens in adult fish tissue, however. For this reason, NDM decided to continue with that part of the program for 2007. In earlier years, both livers and fillets of adult fish were sampled to establish the tissue-burden relationship between these two tissue types. This relationship has now been established; therefore, only fillets, the tissue type most commonly ingested by humans, will be analyzed in 2007. Livers will be collected and archived (frozen) for future analysis if necessary. Fish tissue samples will be collected at seven sites in the mine study area. Depending on the specific task, fish will be collected using electrofishers, gill nets, seines, or hooks and lines. A variety of species, including northern pike (the apex aquatic predator, where present), arctic grayling, and whitefish, will be collected for tissue analysis.

3. Sampling Site Description and Schedule

The sampling sites are located primarily within a 10-mile radius of the ore body (Figure 1). Samples will be collected in late August and early September. Lake sites include Frying Pan Lake, Big Wiggly Lake, Black Lake (North Fork Koktuli drainage), and Lake #2 (Lower Talarik Creek drainage near the Upper Talarik Creek drainage). One stream site in each of the three major drainages in the project vicinity (North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek) also will be sampled. Stream sample sites will be selected in the field, but will be located at one of the previously established sample sites in each major drainage. Sample site selection will be based on the target species being present. As in previous years, each stream site will be a location also sampled for periphyton and

macroinvertebrates, and water quality and that offers the best opportunity to capture the target number of each species.

4. Field Activities and Methods

Field activities for the fish tissue collection will include collection of adult fish using an electrofisher or seines or by angling at stream sites, and by angling and gill nets at lake sites. The collection locations are listed in Table 1.

4.1 Sample Collection

Processing of fish for tissue samples, subsequent handling, chain-of-custody, and transport to the analytical laboratories will follow the procedures outlined in the 2007 quality assurance project plan (QAPP; NDM, In press2). Procedures for sample labeling, washing tools and work surfaces, and preparing quality control equipment blanks also will follow the QAPP (NDM, In press2).

Specific steps to be taken in processing adult fish from stream and lake sites to obtain dissected samples are as follows:

- Immediately upon capture, fish will be placed in a clean plastic bag (heavy-duty trash-compactor type) and placed on ice in a freshly washed cooler to be transported to Iliamna for processing.
- Dissection will take place as soon as possible on the same day as capture at a selected indoor location in Iliamna.
- Prior to dissection the fish will be measured to fork length and weighed, and both before and after dissection, the fish will be photographed with a visible sample identification number.
- The work surface will be washed with soap and water, rinsed with hot tap water followed by deionized (DI) water, and covered with heavy-duty aluminum foil. The aluminum-foil cutting surface will be replaced after each dissection.
- Stainless steel, disposable scalpels and/or high-quality stainless steel knives will be used for dissection.
- If scalpels are used, a new blade will be used for each fish dissected. Knives will be washed with soap and water and rinsed with DI water between uses.
- Personnel handling or dissecting fish will wear powder-free surgical gloves, and the gloves will be changed after each dissection.
- Samples of liver (northern pike, lake sites only) and muscle tissue (all adult fish) will be extracted from each fish and placed in a zipper-seal bag which will be labeled as described under Sample Identification, below. Where possible, each sample will consist of a minimum of 50 grams of muscle tissue or 25 grams of liver tissue (northern pike only).
- Bagged tissue samples will immediately be placed in a freezer.
- Before each set of dissections, a composite equipment blank will be prepared by rinsing the foil cutting surface and the stainless steel knives (if used) with DI water and collecting the rinsate in

an acid-preserved sample jar. DI water to be used for blanks will be provided by the analytical laboratory.

- Frozen tissue samples will be packed in a cooler and sent to the laboratory within 24 hours using packaging recommendations provided by the lab.
- Chain-of-custody procedures will be in accordance with the QAPP (NDM, In press2).

4.2 Field Data Forms and Document Management

A standardized data sheet (Appendix B) will be completed for each fish dissected. All data sheets will be printed on write-in-the-rain paper. At the end of each working day completed field data sheets will be turned over to John Morsell or Paul McLarnon. All photographs will be downloaded to a laptop computer once all field activities are completed.

4.3 Sample Handling

4.3.1 Sample Containers

Sampling containers will consist of clean zipper-seal bags for all whole-body and tissue samples. The preservation method will be to keep samples frozen at below 0 degrees Celsius. The hold time is six months, but samples will be sent to the laboratory for analysis within 24 hours of collection.

4.3.2 Sample Identification

Each sample will be labeled individually with a waterproof label listing the following information:

- Project name: Pebble Project.
- Date: month/day/year.
- Time.
- Preservation method: Keep Frozen.
- Sample identification code (see below).
- Analysis.
- Sampler's initials.

The following example illustrates the format for sample identification codes:

Example: 0607UT100ETF001M

Where:

0607 is the date as month and year. If sampling begun in a given month carries over into the next month, samples are labeled according to the month during which the sampling event began. For example, the last few samples for the June collection may be taken in early July, but the sample date will still read "0607."

UT100E is the location identification, where UT is the code for Upper Talarik Creek and 100E identifies the sampling site.

BL = code for Black Lake.
BWL = code for Big Wiggly Lake.
FPL = code for Frying Pan Lake.
L2 = code for Lake #2.
NFK = code for North Fork Koktuli River.
SFK = code for South Fork Koktuli River.

TF is the matrix code for fish tissue.

001 is a sequential sample number.

201 = sequential sample number for field duplicates.
301 = sequential sample number for field triplicates.

M indicates that the sample is muscle tissue. L would indicate liver tissue.

4.3.3 Sample Custody

Electronic chain-of-custody (COC) forms will be completed by Shaw Alaska Inc. personnel in Iliamna. All COC information will be entered in a chain-of-custody database.

The COC forms for the fish tissue samples will, at a minimum, include the following information:

- Sample identification code (see above).
- Signature of sampler.
- Date of collection: month/day/year.
- Time of collection.
- Project name: Pebble Project.
- Type of sample: muscle or liver.
- Number and type of containers: _x_ zipper-seal bags.
- Sample preservation: Keep Frozen.
- Sample analysis requested: e.g., suite of trace metals.
- Inclusive dates of possession.
- Signature of receiver.

The following additional information also will be included on the COC form:

- Consultant's contact information

  HDR Alaska, Inc.
  2525 C Street Suite 305
  Anchorage, Alaska 99503
  (907) 644-2000

- Instructions to the laboratory to invoice Northern Dynasty Mines Inc. and to mail reports to:

  Steve Crupi
  Shaw Environmental, Inc.
  2000 West International Airport Road, Suite C-1
  Anchorage, Alaska 99502

4.4 Quality Control Samples

4.4.1 Field Duplicates

Field duplicates will be a split of homogenate prepared by CAS.

4.4.2 Field Triplicates

Field triplicates will be a split of homogenate prepared by CAS and analyzed by the quality assurance laboratory (Severn Trent Laboratory).

5. Sample Analysis Summary

Fish tissues will be analyzed for a suite of trace metals and metalloids including antimony, arsenic, beryllium, cadmium, chromium, copper, lead, molybdenum, nickel, selenium, silver, zinc, thallium, and total mercury.

Collected samples will be analyzed by CAS for the parameters that are defined for fish tissue in QAPP (NDM, In press). Reports will be sent to the quality assurance/quality control manager and to NDM by CAS.

6. References

Northern Dynasty Mines Inc. (NDM). In press. Draft Environmental Baseline Studies, 2007 Quality Assurance Project Plan.

TABLE

TABLE 1
Fish Tissue Sample Sites

Location	Sample Species	No. of Primary Samples	Tissue Type	Total Samples Collected	Analysis
Frying Pan Lake	Northern Pike	10	Muscle and Liver	20	Trace Metals Archive (liver only)
	Arctic Grayling[1]	10	Muscle	10	Trace Metals
	Whitefish[2]	10	Muscle	10	Trace Metals
Big Wiggly Lake	Northern Pike	10	Muscle and Liver	20	Trace Metals Archive (liver only)
	Arctic Grayling	10	Muscle	10	Trace Metals
	Whitefish	10	Muscle	10	Trace Metals
Black Lake	Northern Pike	10	Muscle and Liver	20	Trace Metals Archive (liver only)
	Arctic Grayling	10	Muscle	10	Trace Metals
	Whitefish	10	Muscle	10	Trace Metals
Lake #2	Northern Pike	10	Muscle and Liver	20	Trace Metals Archive (liver only)
	Arctic Grayling	10	Muscle	10	Trace Metals
	Whitefish	10	Muscle	10	Trace Metals
SFK Stream Collection Site	Arctic Grayling	10	Muscle	10	Trace Metals
	Whitefish	10	Muscle	10	Trace Metals
UT Stream Collection Site	Arctic Grayling	10	Muscle	10	Trace Metals
	Whitefish	10	Muscle	10	Trace Metals
NFK Stream Collection Site	Arctic Grayling	10	Muscle	10	Trace Metals
	Whitefish	10	Muscle	10	Trace Metals
Number of fish tissue samples to be analyzed in 2007				140	
Number of samples to be archived in 2007				80	
Total number of fish tissue samples collected in 2007				220	

1. Because of the high densities of northern pike in Frying Pan Lake, arctic grayling will likely be collected from the main tributary to the lake.
2. To date, no whitefish have been documented in Frying Pan Lake; however, an effort will be made to capture whitefish directly above or below Frying Pan Lake.

FIGURES

155°48'0"W 155°36'0"W 155°24'0"W 155°12'0"W 155°0'0"W

60°0'0"N

59°48'0"N

Black Lake

Big Wiggly Lake

Frying Pan Lake

Lake #2

Groundhog Creek

North Fork Kokhuli River

South Fork Kokhuli River

Kokhuli River

Stayohok River

North East Tributary UT

Upper Talarik Creek

Lower Talarik Creek

Kokhuli Creek

Iliamna Lake

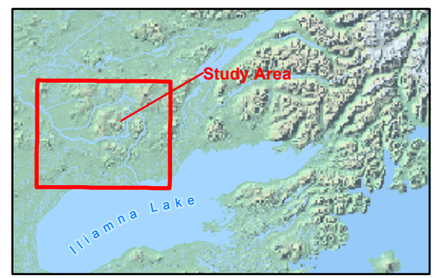
Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 1
Fish Tissue Field Sampling Plan
Sampling Sites
(Mine Study Area)
DRAFT

Legend

- Fish Tissue Sample Site
- Stream
- Waterbody
- General Pit Outline
- Village Corporation Boundary



0 1.25 2.5 3.75 5 Miles

0 1.25 2.5 3.75 5 Kilometers

N

Scale 1:170,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: HDR_Fig11.1x.mxd	Date: June 28. 2007
Version: 1	Author: HDR - JC

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APPENDIX A

Fish Tissue Program
Year-to-Year Changes

Fish Tissue Program, Year-to-Year Changes

Biological monitoring in 2004, 2005, and 2006 for the mine study area included analysis for trace metals in fish tissues collected from four lakes and 16 river environments. These sampling efforts mainly targeted juvenile salmon in rivers and northern pike in lakes.

Fish tissue sampling in 2007 will target adult arctic grayling and whitefish occupying river habitats. Because whitefish and grayling can be present in lake environments, Frying Pan Lake, Big Wiggly Lake, Black Lake, and Lake #2 also will be sampled. Northern pike also will be collected from the lakes; both muscle and liver tissues will be collected, but liver samples will be archived for future analysis, if needed.

APPENDIX B

Fish Tissue Data Sheets

Fish Tissue Dissection Data Sheet

(Complete a new data sheet for each fish dissected)

Date_____

Time_____

Sample Team Members_____
_____

Sample Location_____

Capture Method_____

Species _____

Length _____

Weight _____

Photo Numbers_____

Scale Card Number_____ Scale Sample Numbers_____

Sample I.D. Number(s) _____

Weight of Liver Sample _____

Weight of Muscle Sample _____

Stomach Contents_____
_____

Recapture? Tag No. and Color _____

Comments_____
_____
_____
_____
_____
_____
_____
_____
_____

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES 2007 FIELD SAMPLING PLANS

MACROINVERTEBRATES AND PERIPHYTON
Mine Study Area

DRAFT

SEPTEMBER 2007

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Appendix B, Field Forms

Appendix C, Macroinvertebrate and Periphyton Login and Tracking Sheets

ACRONYMS AND ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ASCI	Alaska Stream Condition Index
CAS	Columbia Analytical Services, Inc.
COC	chain of custody
DI	deionized
DO	dissolved oxygen
FSP	field sampling plan
GPS	global positioning system
HDR	HDR Alaska, Inc.
NDM	Northern Dynasty Mines Inc.
ORP	oxidation reduction potential
PAH	polynuclear aromatic hydrocarbon
QAPP	Quality Assurance Project Plan
QA	quality assurance
QC	quality control
SGS	SGS Environmental Services, Inc.
Shaw	Shaw Alaska, Inc.
STL	Severn Trent Laboratories

MACROINVERTEBRATE AND PERIPHYTON STUDY, MINE STUDY AREA

2007 FIELD SAMPLING PLAN

1. Introduction

This field sampling plan (FSP) provides the protocol to be followed by all field crews for macroinvertebrates and periphyton studies for the Pebble Project in 2007. The FSP supersedes all FSPs previously written for this macroinvertebrates and periphyton program. An overview of year-to-year changes for the macroinvertebrates and periphyton studies is provided in Appendix A. This FSP describes in detail the procedures for the collection and handling of macroinvertebrates and periphyton, including sampling, preservation, and shipping. Alaska Department of Fish and Game (ADF&G) methods (ADF&G, 1998) and protocols described in *The Alaska Stream Condition Index (ASCI): A Modification of the USEPA Rapid Bioassessment Protocols* (Major and Barbour, 1997) will be used. These methods will assist in characterizing the macroinvertebrate and periphyton populations in the study area.

2. Study Organization and Responsibility

The macroinvertebrate and periphyton study will be managed by lead scientist Andra Love of HDR Alaska, Inc. (HDR). She will be responsible for assigning tasks and for ensuring that protocols are followed. Isaac Watkins of HDR will be the field task leader for this study.

3. Field Sampling Procedures

This section provides information about the sampling procedures for macroinvertebrates, periphyton, and freshwater mussels. Collection of water quality and sediment samples also is discussed. In addition, protocols for equipment maintenance and sample handling are described.

3.1 Sample Collection and Field Measurements

Ten sites in the mine study area have been selected for sampling of macroinvertebrates and periphyton to collect information upstream and downstream of proposed facilities. Because of hydrological limitations, on the South Fork of Koktuli River, only downstream sites can be used. The sampling effort will take place in June at the 10 stations shown in Figure 1 and listed in Table 1. In addition, up to three lakes in the mine study area will be sampled for mussels, sediment, and water chemistry.

3.1.1 ASCI Sampling—Macroinvertebrates and Habitat Analysis

ASCI sampling is made up of two key components: macroinvertebrate sampling and habitat analysis. The macroinvertebrates are indicators of stream health. Analysis of habitat parameters is necessary for

determining where macroinvertebrates should be collected. Habitat parameters also help characterize the stream and surrounding areas as a whole ecosystem unit.

3.1.1.1 Habitat Analysis

Habitat parameters will be recorded for all macroinvertebrate and periphyton sampling stations. A visual assessment of aquatic and riparian habitat will be completed, and data on ambient water quality will be recorded on field data sheets such as those shown in Appendix B (Major and Barbour, 1997). The visual assessment of aquatic and riparian habitat is an integral part of the bioassessment process and considers the following habitat parameters:

- Epifaunal substrate and available cover.
- Embeddedness.
- Velocity and depth combinations.
- Sediment deposition.
- Channel flow status.
- Channel alteration.
- Channel sinuosity.
- Bank stability.
- Bank vegetative protection.
- Riparian-zone vegetation width.

3.1.1.2 Macroinvertebrate Sampling

ASCI sampling will consist of collecting macroinvertebrates from five primary habitat types within a given stream reach using a D-frame dip net. Each stream reach is a 100-meter-long section of the stream located around specific latitude and longitude coordinates. The stream reach and macroinvertebrate habitats to be sampled will be defined while completing the habitat analysis described above. The five habitat types and the procedures for collecting organisms from each are described below.

- **Riffle/Cobble.** Macroinvertebrates will be collected from riffle areas by placing the dip net on the substrate facing upstream. A field team member will then estimate a 1-square-foot area and kick or rub the substrate material to loosen all invertebrates. Large cobbles will be rubbed clean by hand and then removed from the sampling area first. The loosened material then will be allowed to wash downstream into the open net.
- **Undercut Banks.** A field team member will stand downstream of a selected section of wetted undercut bank. The sampler will jab the net into the undercut bank, scraping the net along the bank material to loosen the macroinvertebrates. This action will be repeated three to five times. The field team member will then drag the net upstream through the water (taking care not to lose material already in the net) to capture loose floating material.
- **Snags/Downed Woody Debris.** A field team member will select an area of approximately 1 square foot. The dip net will be held downstream of the sampling area to collect loosened

material that becomes suspended in the water. All material within the sampling area will be scrubbed by hand to loosen macroinvertebrates. If the material can be lifted, it will be scrubbed within the opening of the net underwater.

- **Aquatic Vegetation.** A field team member will select an area of aquatic vegetation covering approximately 1 square foot. The dip net will be held downstream of the vegetation to collect any suspended loosened material. The field team member will rub the vegetation down to the substrate to remove macroinvertebrates.
- **Sand/Soft Sediment.** Sand/soft sediment sampling is performed by bumping the net along the sandy or soft stream bottom to collect material. In this habitat type, it is unlikely that material will have to be rubbed by hand.

A total of 20 kick or jab subsamples will be collected from these five habitat types in each stream reach sampled. The number of subsamples collected from each habitat type will be proportional to the amount of each habitat type in the defined stream reach. All material from the 20 subsamples will be combined to make one composite sample for each sampling station. The collected material will be stored in 1-liter Nalgene bottles and preserved with alcohol.

3.1.2 ADF&G Methods for the Surber Sampler

The Surber sampler is a semi-quantitative method to determine the density and composition of macroinvertebrate populations in substrate habitats. The sampler is constructed of a rectangular-frame net with a 363-micrometer mesh size. Attached to the bottom of and perpendicular to the net frame is a metal frame that delineates the area of substrate to be sampled.

A field team member will orient the net upstream within a selected riffle/cobble area. The material within the substrate frame will be disturbed, and cobbles will be scrubbed clean of debris and organisms. The debris and organisms will then flow into the net and be trapped. Samples will be placed in separate containers and preserved with alcohol.

Five samples will be collected with a Surber sampler from the selected riffle/cobble area at each sampling station. The riffle/cobble site will be documented using a global positioning system (GPS) and will be flagged to ensure that any subsequent sampling will occur in the same area.

3.1.3 ADF&G Methods for Periphyton Sampling

Periphyton will be collected within a riffle/cobble area at the same sampling stations from which macroinvertebrates are collected. The riffle/cobble area for periphyton sampling will be flagged, and a GPS location will be recorded (if different from the Surber sampling location) so that any future samples can be collected in the same place for continuity and comparison.

At each sampling station, periphyton will be removed from 10 cobbles from the riffle/cobble area. The sampling protocol that will be used to collect periphyton samples (ADF&G, 1998) has been used by the Alaska Department of Natural Resources (ADNR) on other Alaska projects. A square of high-density foam that is 25 square centimeters (5 centimeters per side) will be placed on each cobble. All material surrounding the foam square will be removed by scrubbing the cobble with a clean toothbrush. This area will then be rinsed clean with ambient water. Next, the area under the foam square will be brushed with

another clean toothbrush and rinsed into a sampling tray. All the rinsate will then be filtered through a 45-micrometer glass-fiber filter attached to a hand vacuum pump. Most of the water will be extracted, and 1 milliliter of saturated magnesium carbonate solution will be added to the rinsate as a preservative. The remaining water will be extracted. The filter will be wrapped in a clean large coffee filter (to absorb any additional water), labeled, placed in a zipper-seal bag, and packed over silica gel desiccant.

The sampling tray will be scrubbed and rinsed clean before the next sample is processed. This process will be repeated until 10 discrete periphyton samples—one sample per cobble—have been collected from each sampling station. All samples will be placed in the same zipper-seal bag. Filters will be frozen in a light-proof container with desiccant for shipment to the laboratory.

3.1.4 Measurement of Ambient Water-quality Parameters

Ambient water-quality parameters will be measured in the field at each macroinvertebrate and mussel sampling station.

YSI 556 Multi-probe Meter

A YSI 556 multi-probe will be used to measure the following parameters: specific conductance, relative conductance, temperature, pH, dissolved oxygen (DO), and oxidation reduction potential (ORP). Calibration procedures are described in Section 3.2.

1. Turn the YSI 556 on.
2. Place the probe in the stream and allow it to equilibrate for at least 5 minutes or until the DO is steady before recording the readings for pH, specific conductance, DO, and ORP.
3. All required readings will be displayed on the screen at the same time. Record all measurements, including millimeters of mercury.

3.1.5 Freshwater Mussel Sampling

Mussels will be collected from three lakes in the mine study area. The specific collection locations are yet to be determined, as described below. At the same locations, ambient water-quality readings will be recorded, and water chemistry and sediment samples will be collected.

3.1.5.1 Mussel Collection

Three lakes in the mine study area will be examined for the presence of mussels. Freshwater mussels are generally found in calm, relatively shallow waters with soft or fine-grained substrate where fish are present. Because mussels frequently bury themselves in the sand or soft sediment, the study team will examine the lakes for mussel beds using a mussel rake. If no mussels are present at an examined lake, field notes and GPS coordinates will be recorded for documentation.

Snorkeling equipment, an Aqua-scope, or both will be used to locate mussel beds during the June macroinvertebrate sampling event. The field team will collect approximately ten mussels (or enough to achieve 75 grams of wet weight) using a mussel rake from each of the three lakes. At each sampling site, the collected mussels will be kept whole, will be double-bagged in zipper-seal bags, and will be labeled in

accordance with procedures in the QAPP (NDM, 2007). The bagged mussels, along with surface water-quality samples and sediment samples, will be placed the in coolers that will be kept cold until the samples reach the field lab in Iliamna. At Iliamna, the mussels will be logged in, measured with calipers, and frozen and then placed on gel ice for shipping to the appropriate laboratories. Personnel from Shaw Alaska, Inc. will be responsible for filling out chain-of-custody forms and for shipping samples to the analytical laboratories. The laboratories will analyze the mussel tissue for the analytes listed below.

- Total Metals: Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Ag, Tl, and Zn.
- Semivolatile organic compounds, including PAHs (polynuclear aromatic hydrocarbons).
- Lipids.

3.1.5.2 Water Sample Collection

Water-chemistry samples will be collected by the technique of grab sampling. Grab sampling in lakes contains some specific procedures due to the torpid nature of the flow of the water. Detailed methods for sampling are described below:

1. Label sample bottles with sample station, analysis, date, time, and "HDR Pebble Project."
2. Put on clean nitrile gloves.
3. Locate the sampling area. Once the team members are in place, remain motionless to allow the disturbed sediment to settle.
4. Samples to be analyzed for low-level mercury will be collected first. Remove the sample bottle from the zipper-seal bags only as far as needed to remove the lid. To prevent atmospheric contamination, first submerge the bottle in the water, and then remove the lid. Allow the bottle to fill without overflowing, and replace the lid under water. Drain excess water from the zipper-seal bags, and the seal both bags.
5. Organics collection bottles will then be filled individually using the same method described for low-level mercury. These bottles are amber glass and are not sealed in zipper-seal bags.
6. For the remaining samples, use a clean 1-liter unpreserved sample bottle to fill up the other bottles, and then fill that bottle.
7. Place samples in a cooler with sufficient gel ice.
8. Fill out the appropriate field form documenting sampling location, time, and other pertinent information before leaving the sampling station.
9. Transport samples to field lab. If coolers are sent back on a helicopter unaccompanied by an HDR field team member, radio the Northern Dynasty Mines (NDM) base to ensure someone will be at the Weathered Inn to take possession of the samples when they arrive.

3.1.5.3 Turbidity Measurements

A Hach 2100P meter will be used to collect turbidity measurements at mussel collection sites. Section 3.2 outlines the calibration procedures for this meter. The meter will be calibrated before the field event and checked with calibration solution each morning before sampling begins.

1. Turn on the instrument and place on a flat, sturdy surface.
2. Clean the sample cell using a KimWipe and several rinses with DI water. Be careful to handle the cell by the top to avoid smudging or scratching the glass. Do not use paper towels on cells.
3. Read the cell with DI water to find the best orientation for the sample cell (this may not be the factory mark). This should be done by taking several readings with a cell containing DI and rotating slightly between each reading. When the lowest reading is found, make a mark near the top of the cell where it aligns with the raised mark on the meter. This will be the orientation mark and the cell should be placed in the meter this way for all samples.
4. Collect the sample in a clean container (amber glass vial) and keep it cool in a dark cooler until transferring the sample to the sample cell. Avoid introducing bubbles because they will cause interference. Cold water will cause condensation that also will interfere with accurate readings.
5. Invert the collection vial once and then transfer sample to the testing cell.
6. Wipe the cell with a clean, lint-free cloth to remove fingerprints and water.
7. Apply a thin film of silicone oil to the outside of the cell. Wipe with a clean, lint-free cloth to create an even film on the surface of the cell. Avoid excess oil.
8. Place the sample cell in the instrument compartment making sure that the orientation mark on the cell aligns with the raised mark on the meter. Close the lid.
9. Press the Range key until AUTO RNG is displayed.
10. Press **Read.** The final measurement will display after approximately 13 seconds. If the reading is very unstable, press **Signal Average** key to average 10 measurements. This action takes approximately 20 seconds.
11. Record the reading on the turbidity log sheet and on the stream sampling field form.

3.1.5.4 Sediment Sample Collection

Sediment samples also will be collected from mussel-bed locations. Label an amber glass collection jar with the station identification, date, time, and sample type. Using Alconox, decontaminate the Ekman Dredge and rinse with DI water and then rinse at least three times with ambient water. Put on clean nitrile gloves before sample collection. Use the decontaminated Ekman Dredge to collect fine-grain bed sediment from the mussel-bed location. Place this material in the collection jar. Place enough material in the jar so that as little water as possible and little to no air remains in the jar when the lid is replaced. Place the jar in a cooler on ice until it is transported to the field camp.

3.1.6 Field Quality Control Samples

Field duplicates are the quality control (QC) samples for ASCI macroinvertebrate samples. The duplicates will be collected at a frequency of 10 percent. Samples will be labeled to indicate that they are duplicate samples.

For water-quality and sediment samples, duplicate and triplicate samples will be collected at a frequency of 10 percent. The containers will be labeled to indicate whether the sample is a duplicate or triplicate.

Mussel samples will be sent to the primary laboratory. The primary laboratory will split the samples to create duplicate and triplicate samples and will ship the quality assurance (QA) samples to the proper QA laboratory.

3.2 Maintenance of Sampling Equipment

Before the field-sampling trip, the nets used for macroinvertebrate sampling will be examined for damage that may cause loss of organisms. Repairs or replacements will be made as needed. In the field, the nets will be rinsed with ambient water and examined for clinging organisms and debris after each sample collection. When sampling is completed at each sampling station, the nets will again be rinsed and examined.

Sampling equipment for periphyton will not be reused for collection of samples on the same day. The toothbrushes used to scrub the rocks of material will be placed in a zipper-seal bag after use for the remainder of the field day. Upon returning from field sampling each day, the dirty toothbrushes will be thoroughly cleaned by using denatured alcohol. The foam squares will be placed in a zipper-seal bag after use and cleaned upon returning from each field sampling day.

The YSI 556 water-quality meters will be calibrated before the field event. Each morning during the field sampling event, each meter will be checked using confidence solutions and will be calibrated as needed to maintain accuracy. Each meter will have a manual explaining the steps for calibration. Fresh calibration and confidence solutions will be used for the field event. To calibrate the meter for a given parameter, the steps in the manual will be followed and the proper levels for the solution being used will be entered.

A spare set of meters and nets will be taken to the field as a backup, in case replacement of equipment is necessary. Extra sample bottles will also be taken on the sampling trip.

3.3 Sample Handling

3.3.1 Sample Containers and Preservation

3.3.1.1 Macroinvertebrates

Macroinvertebrates will be collected in 1-liter Nalgene bottles. Each individual Surber sample will be stored in a separate bottle. The 20 subsamples that comprise an ASCI sample will be composited into a single 1-liter Nalgene bottle. Some samples will require multiple bottles because of the amount of material collected in the nets. The bottles will be labeled accordingly to show how many bottles each sample comprises (see Sample Labeling, below). These samples will be stored in a cooler during the field day. Upon the return from field sampling each day, the bottles will be filled with denatured alcohol. Labels will be examined, samples will be logged on a tracking form (Appendix C), and all bottles will be stored in coolers for transport to the laboratory.

3.3.1.2 Periphyton

Containers for all periphyton samples will consist of clean zipper-seal bags. All sample bags will be clearly labeled. Samples will be dried with desiccant and preserved by keeping the samples frozen at below 0°C and stored in lightproof containers. The periphyton samples from all sites will be sent to the

laboratory for analysis immediately upon returning from the field sampling event. Samples will be kept frozen during transport to the ADNR, who will perform the periphyton analysis.

3.3.1.3 Freshwater Mussels

At the field camp, mussels will be measured with calipers to identify length, height, and width. Mussels will be placed in a clean zipper-seal bag, which will be labeled as described below. The mussels will be frozen and then placed on gel ice for shipping to the appropriate laboratories by Shaw.

3.3.1.4 Water and Sediment

Water quality samples will be collected in plastic bottles of various sizes. Certain analytes require preservatives, including acids and bases. Care will be taken in handling these sample bottles before, during, and after filling them with sample water. Sediment samples will be collected in amber glass jars in the field; the jars will be wrapped in bubble wrap to prevent breakage.

3.3.2 Sample Labeling

Each sample will be labeled individually with a waterproof and alcohol-proof pen. The following information will be listed on waterproof labels:

- Project name: Pebble Project.
- Date (month/day/year).
- Sample station identification.
- Sample type: macroinvertebrate, periphyton, mussel, sediment, or surface water.
- Bottle number, for example, 1 of 1, 2 of 2.
- Preservation method, e.g., “Keep Frozen” (periphyton) or “HCL” (for hydrogen chloride).
- Duplicate, triplicate, or MS/MSD, if applicable.

3.3.3 Sample Custody

Macroinvertebrate samples will be shipped to the HDR laboratory where they will be sorted and identified by HDR scientists. All samples will be logged in before shipment using the sample login sheet (Appendix C).

At the field camp, periphyton samples will be recorded on the sample login and shipment tracking sheet for periphyton (Appendix C). This sheet includes the following information:

- Site identification and sample number
- Stream name
- GPS coordinates
- Date and time of collection
- Samplers’ initials

- Shipping date
- Shipper's initials

Shaw Alaska, Inc. (Shaw), will be responsible for completing a chain-of-custody (COC) form and for packing and shipping samples. Periphyton samples will be shipped to Bill Morris of the ADNR Office of Habitat Management and Permitting for laboratory analysis of chlorophyll *a* concentrations.

Electronic COC forms will be completed by Shaw for mussel, sediment, and surface water-quality samples. Shaw will ship these samples to the appropriate laboratories for processing and analysis as outlined in the QAPP (NDM, in press).

After collection, all samples will remain with field staff until turned over to Shaw personnel unless warm conditions, freezing conditions, or weight or space on the helicopter becomes an issue; if one of those situations arises, the NDM base will be called and asked to contact the Shaw personnel to meet the samples when they arrive. HDR personnel will enter samples in the Shaw transfer log at the end of each day.

COC forms will accompany each cooler shipped to analytical laboratories. Electronic COC forms will be generated by Shaw personnel at field camp. Once the COC form is completed, it will be sealed inside a zipper-seal bag. The bagged COC form will be taped to the inside of the cooler lid. Other COC components will include sample labels, custody seals, field notebooks, cooler tracking log, sample shipment receipts, and the laboratory logbook.

If no Shaw personnel are on site, HDR personnel will pack the sample coolers by according to the following procedures:

1. Line the cooler first with cardboard and then with a large trash bag.
2. Pack individual sample sets together in two large zipper-seal bags.
3. Insert zipper-seal bags in a trash bag, place frozen gel ice inside trash bag, and close the trash bag tightly.
4. Insert bubble wrap to fill remaining space in the cooler to secure the sample sets.
5. Tape COC form to inside of the cooler lid.
6. Close cooler and secure the lid with strapping tape by wrapping tape around the entire cooler and back onto itself. Press tape to secure it to cooler, especially on the bottom to prevent tape from ripping when coolers slide across a surface.
7. Attach two signed, dated, and timed custody seals onto cooler lid, one on the front and one on the back opposite corner of the cooler and tape over with clear packaging tape.
8. Attach shipping label that includes the COC identification to the top of cooler and tape over completely with clear packaging tape.
9. Complete the Anchorage to Iliamna columns on the Cooler Tracking Form.

Sample coolers will be shipped on Iliamna Air Taxi from Iliamna to Anchorage, where Shaw personnel will receive them and arrange delivery to the appropriate analytical laboratories. If no Shaw personnel are

on site, the following procedures must be followed for shipping laboratory samples from Iliamna to Anchorage.

1. Complete and place the following shipping information on the coolers for shipment from Iliamna to Anchorage:

   Shaw Environmental, Inc.
   Anchorage Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   COOLER Identification Number

2. Place "Keep Chilled" labels on the coolers.

3. Deliver the samples to Iliamna Air Taxi (or other airport-to-airport service) and complete the air bill information for shipment. Write on the air bill:

   Shaw Environmental, Inc.
   Anchorage Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   "KEEP COOL"

4. Complete the cooler tracking log for Iliamna to Anchorage shipping and convey the information to Shaw personnel in Anchorage as soon as possible.

Coolers going to SGS Environmental Services, Inc. (SGS), will be hand delivered, and coolers going to Columbia Analytical Services, Inc. (CAS), and Test America (formerly North Creek Analytical, Inc.) will be shipped by Alaska Airlines Gold Streak (or other airport-to-airport service equivalent).

The addresses and contact information for the analytical laboratories are provided below.

Columbia Analytical Services, Inc.
1317 S. 13th Avenue
Kelso, WA 98626-284
Phone: (360) 577-7222
Fax: (360) 636-1068
Project Chemist: Lynda Huckestein
E-mail: LHuckestein@kelso.caslab.com
Direct phone: (360) 501-3358

Test America, Inc.
9405 SW. Nimbus Avenue
Beaverton, OR 97008-7132
Phone: (503) 906-9200
Fax: (503) 906-9210
Project Chemist: Crystal Jones
E-mail: CJones@testamericainc.com
Direct phone: (503) 906-9234

SGS Environmental Services, Inc.
200 W. Potter Drive
Anchorage, AK 99518-1605
Phone (907) 562-2343
Fax (907) 561-5301
Project Chemist: Karen Waak
E-mail: karen.waak@sgs.com
Direct phone: (907) 550-3213

Severn Trent Laboratories—Seattle
5755 8th Street East
Tacoma, WA 98424
Phone: 253-922-2310
Project Chemist: Terri Torres
E-mail: ttorres@stl-inc.com

4. Sample Analysis Summary

Macroinvertebrate samples will be processed (sorted) and identified in the HDR laboratory by HDR personnel.

Periphyton samples will be sent to the ADNR laboratory in Fairbanks for analysis of chlorophyll *a* with ultraviolet and visible spectrophotometry.

Mussel tissue, sediment, and water-quality samples will be analyzed for a suite of trace metals and other analytes. Details about methods, method detection limits, and QA/QC protocols are presented in the QAPP (NDM, in press). The mussel samples will be shipped to CAS. CAS will split the sample and send a triplicate sample to Severn Trent Laboratories (STL). Primary and duplicate samples for sediment and water quality will be shipped to SGS, and triplicate samples will be shipped to CAS. Sample handling and transportation to the analytical laboratories will follow procedures outlined in the QAPP (NDM, in press).

5. References

Alaska Department of Fish and Game (ADF&G). 1998. Methods for Aquatic Life Monitoring to Satisfy Requirements under 1998 NPDES Permit: NPDES AK-003865-2, Red Dog Mine Site. ADF&G, Division of Habitat and Restoration, Fairbanks, Alaska.

Major, E.B., and M.T. Barbour. 1997. The Alaska Stream Condition Index (ASCI): A Modification of the USEPA Rapid Bioassessment Protocols. Prepared for Alaska Department of Environmental Conservation, Anchorage, Alaska.

Northern Dynasty Mines Inc. (NDM). in press. Environmental Baseline Studies, 2007 Quality Assurance Project Plan.

TABLE

TABLE 1
Stations and Sample Types for Macroinvertebrate, Periphyton, Mussel, Water, and Sediment Samples

Location	Sampling Method/Type	No. of Samples	No. of QC Samples	Total No. of Samples
NK100A	Surber	5	Duplicate Surber and periphyton samples at each site serve as QC	160 total: 100 periphyton, 50 Surber, and 10 ASCI samples
	Periphyton	10		
	ASCI	1		
NK100C	Surber	5		
	Periphyton	10		
	ASCI	1		
NK119A	Surber	5		
	Periphyton	10		
	ASCI	1		
SK100A	Surber	5		
	Periphyton	10		
	ASCI	1		
SK100B	Surber	5		
	Periphyton	10		
	ASCI	1		
SK100D	Surber	5		
	Periphyton	10		
	ASCI	1		
UT100B	Surber	5		
	Periphyton	10		
	ASCI	1		
UT100C	Surber	5		
	Periphyton	10		
	ASCI	1		
UT100D	Surber	5		
	Periphyton	10		
	ASCI	1		
UT119A	Surber	5		
	Periphyton	10		
	ASCI	1		
Mine Area Lakes (Up to three stations)	Freshwater Mussels	3	1 duplicate and 1 triplicate for sediment and water. [a]	13 total: 9 primary, 2 duplicate, 2 triplicate
	Surface Water Quality	3		
	Sediments	3		

Notes:

a. Mussel QC samples will be split by the primary laboratory.

FIGURE

1,300,000 1,350,000 1,400,000 1,450,000

2,200,000

2,150,000

2,100,000

North Fork Koktuli

Koktuli River

South Fork Koktuli

Upper Talarik

Kaskanak Creek

"Cone (Black) Mountain"

Groundhog Mountain

Sharp Mountain

Koktuli Mountain

NK100C

NK 119A

UT 100D

NK100A

SK100A

SK100D

SK100B

UT100C

UT119A

UT100B

Pebble Project

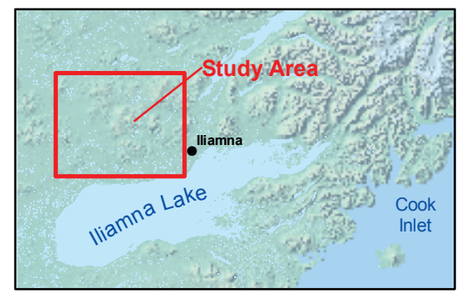
NORTHERN DYNASTY MINES INC.

Figure 1. 2007 Field Sampling Plan Macroinvertebrate and Periphyton Sampling Stations

DRAFT

Legend

- Macroinvertebrate and Periphyton Sampling Station
- Stream
- Waterbody
- General Pit Outline
- Watershed Boundary



0 1.25 2.5 3.75 5 Miles

0 1.25 2.5 3.75 5 Kilometers

N

Scale 1:170,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: StudyArea.mxd	Date: January 15, 2007
Version: 2	Author: HDR - JC, SS, AL

APPENDIX A

Macroinvertebrate and Periphyton Program Year-to-Year Changes

Macroinvertebrate and Periphyton Program, Year-to-Year Changes

Since its inception in 2004, the macroinvertebrate and periphyton program has evolved in response to project-specific requirements and agency comments. These changes are documented below.

2004 Study Overview

The Pebble Project macroinvertebrate and periphyton study was initiated in 2004. The first year of studies included sampling stations in the mine study area, along the possible road corridor, and at the possible port site. Seventeen stations were established in the proposed mine area and seven were set up in the possible road corridor (Table A).

TABLE A
Sampling Stations, 2004

Station ID	Location	June	August	Sample Type
CR199A	Mine	X		A, D, diatom
KC100A	Mine	X	X	A, D, diatom
NK100A	Mine	X	X	A, D, diatom
NK100B	Mine	X		A, D, diatom
NK100C	Mine	X	X	A, D, diatom
NK119A	Mine	X	X	A, D, diatom
SK100A	Mine	X	X	A, D, diatom
SK100B	Mine	X	X	A, D, diatom
SK100C	Mine	X		A, D, diatom
SK100F	Mine	X	X	A, D, diatom
SK100G	Mine	X	X	A, D, diatom
SK119A	Mine	X	X	A, D, diatom
UT100B	Mine	X	X	A, D, diatom
UT100C	Mine	X	X	A, D, diatom
UT100D	Mine	X	X	A, D, diatom
UT100E	Mine	X	X	A, D, diatom
UT119A	Mine	X	X	A, D, diatom
Bear Den Cr.	Road		X	A, D, diatom
Red Cr.	Road		X	A, D, diatom
Ursa 100A	Road		X	A, D, diatom
Ursa 100B	Road		X	A, D, diatom
UT138A	Road		X	A, D, diatom
Y Cr.	Road		X	A, D, diatom
Y Valley Cr.	Road		X	A, D, diatom

A = ASCI, D = drift net

Sampling methods for macroinvertebrates included Alaska Stream Condition Index (ASCI) protocols and collection with drift nets. Periphyton collection was conducted using a modified EPA Rapid Bioassessment Protocol and samples were analyzed for diatom species assemblage.

Stations Ursa 100A and Y Creek were dropped between the June and August sampling events and Ursa 100B and Y Valley Creek were added because of road alignment changes. Road corridor stations were sampled only in August.

The mine study area stations were sampled twice during 2004; however, not all stations were sampled the second time. Three stations—CR199A, NK100B, and SK100C—were dropped after June due to changes in the proposed project design.

2005 Study Overview

The 2005 macroinvertebrate and periphyton study incorporated changes based on findings from the 2004 study and agency recommendations. Five of the mine study area stations from 2004 were sampled in 2005. Two lake sites in the mine study area were added (Table B). Five road corridor stations were sampled.

TABLE B
Sampling Stations, 2005

Station ID	Location	Sample Type
Big Wiggly	Mine	modified A, D
Frying Pan	Mine	modified A, D
NK100A	Mine	A, S, chlorophyll *a*
NK100C	Mine	A, S, chlorophyll *a*
SK100B	Mine	A, S, chlorophyll *a*
UT100B	Mine	A, S, chlorophyll *a*
UT100D	Mine	A, S, chlorophyll *a*
Bear Den Cr.	Road	A, S, chlorophyll *a*
Red Cr.	Road	A, S, chlorophyll *a*
Ursa 100B	Road	A, S, chlorophyll *a*
UT138A	Road	A, S, chlorophyll *a*
Y Valley Cr.	Road	A, S, chlorophyll *a*

A = ASCI, S = Surber, D = dredge

Sampling methodologies were modified in 2005 in response to agency comments. ASCI and Surber sampling were conducted side by side during June at the five mine area sites. Field collection of periphyton in 2005 was similar to that done in 2004. Instead of collecting the rinsate and identifying individual diatom frustules, however, the rinsate was filtered and the periphyton was analyzed for chlorophyll *a* content.

The 2005 sampling program included sampling at two lake stations in the mine study area (Frying Pan Lake and Big Wiggly, Table B). The ASCI protocol was modified to account for the lack of current in

lake environments. Although the same amount of area was disturbed, because there was no flow, the net was dragged through the disturbed area to capture suspended material and organisms. Surber samples were not collected because this sampling method requires current. Instead, dredge samples were collected.

2006 Study Overview

The 2006 data collection effort was focused on filling existing data gaps for the mine study area. Four stations on the North Fork Koktuli were sampled for drifting organisms. Two of the stations (NK100A and NK100C) had been previously established, and two others (Mouth of Big Wiggly and NK100B1) were established specifically for this study. The Big Wiggly station is located on the North Fork Koktuli River directly at the outfall of Big Wiggly Lake. Station NK100B1 is upstream of NK100B, near a large sloughing stream bank.

Five drift nets were set up at each station for a minimum of 1 hour. While the nets were in place, the sampling team moved downstream and captured a selection of fish using an electrofisher. A subsample of these fish was preserved for an analysis of their stomach contents.

Additional sampling was performed in four lakes in the mine study area. Frying Pan, Big Wiggly Lake, Black Lake, and Lake #2 were sampled for zooplankton. Zooplankton was collected using an inflatable boat to conduct a horizontal tow. Organisms were preserved and identified to the lowest practicable taxon.

2007 Study Overview

The baseline study for macroinvertebrates and periphyton will continue in 2007. Macroinvertebrates will be collected using Surber and ASCI methods in June. Sample analysis will occur as in 2005.

The number of sampling stations will be increased from the 2005 study, but will not include as many stations as sampled in 2004. The 10 stream stations included in the 2007 study will all be in the mine study area (Table C). Five of the ten sites are those sampled in 2005 and five sites are additions to the sampling program based on the most recent project design information. Up to three lakes in the mine study area will be sampled for metals in freshwater mussel tissues; the number of lakes sampled will depend on success at identifying mussel beds. Ambient surface water conditions will be recorded, and water chemistry and sediment samples will be collected at these sites.

TABLE C
Sampling Stations, 2007

Location	Location Type	Sample Type
NK100A	Stream	ASCI, Surber, Periphyton
NK100C	Stream	ASCI, Surber, Periphyton
NK119A	Stream	ASCI, Surber, Periphyton
SK100A	Stream	ASCI, Surber, Periphyton
SK100B	Stream	ASCI, Surber, Periphyton
SK100D	Stream	ASCI, Surber, Periphyton
UT100B	Stream	ASCI, Surber, Periphyton
UT100C	Stream	ASCI, Surber, Periphyton
UT100D	Stream	ASCI, Surber, Periphyton
UT119A	Stream	ASCI, Surber, Periphyton
Three mine area lakes[a]	Lake	Mussel, Water, Sediment

Note:

a. Three lakes will be examined for mussels. If mussels are not found, additional lakes will be examined.

APPENDIX B

Field Forms

FIELD DATA SHEET: Benthos/Water Quality

Station ID **Lat** **Long**

Stream/River Name **Watershed**

Date **Start Time** **Investigators**
End Time

Describe Site Location

Comments

Weather Conditions

Previous 7-day precipitation *(Circle one)*: Fl. Flood Heavy Mod Light None

Air Temperature _____ (°F) Other:_____

Riparian Vegetation (18 m buffer) *(Circle the dominant type and height)*

Spruce/Hemlock/Coniferous Veg. Height <1.5 m

Birch/Alder Grasses 1.5 – 3 m

Willow Cottonwood >3 m

Canopy Cover

<20% open 20-40% open 40-60% open 60-80% open >80% open

Water Quality Measurements **Instrument used**

Temperature ____ °C Hydrolab MiniSonde/surveyor 4 _____

pH _____ Other _____

TDS_____mg/L

Specific Conductance _____µS @25°C

Turbidity _____ NTUs D.O. _____mg/L _____% Saturation

Local Watershed Characteristics *(Circle)*

Land Use: Forest Field Agricultural Residential Logging Mining

Commercial/Industrial Recreational Other_____

Watershed Erosion: None Slight Moderate Heavy

Watershed NPS Pollution: No evidence Some sources Obvious sources

Map Characteristics *(To be completed in office from candidate list info)*:

Map_____ T/R/S_____ HUC _____Ecoregion_____

Elevation_____ft Drainage Area_____ Gradient _____

Anadromous Fish: Spawning___ Rearing_____

% Wetland_____ % Lake _____ % Forested_____

Site Location Map *(Draw map & indicate gross characteristics)*

Photos: Roll#_____ Picture#_____ Description:

Sample Allocation Formula Circle one: Riffle/Run Glide/Pool

SZ–R/R	=	_____ m at bank *x* 1 or 2 banks *x* 100 m	= _____(1)
SZ–G/P	=	2(_____m at bank *x* 2 banks *x* 100 m)	= _____(2)
BZ	=	_____m avg wetted w *x* 100m	= _____(3)
Total Area	=	SZ + BZ _____+_____	= _____(4)
% SZ	=	(1) or (2) / (4) *x* 100	= _____% SZ
% Bottom	=	100–% SZ *(Including snags & aquatic vegetation)*	= _____% *BZ*

% Total & No. jabs/kicks from each habitat type Total Jars _____

Cobble	____% _____	Stream Banks	_____% _____
Snags	____% _____	Aquatic Veg.	_____% _____
Sand/Soft Sed	____% _____	Other	_____% _____

Water samples collected ____ yes ____ no

Number of jars: _____ Filtered _____ Unfiltered

Avg. Estimated Stream Depth

Riffle _____ Run _____ Pool _____

Alternate Site ID Code Agency_____

Site ID _____

Notes:

HABITAT ASSESSMENT FIELD DATA SHEET

Station ID_____Stream Name_____ Date_____ Investigators_____ Total Score_____

Stream Type *(Circle one)*: **Riffle/Run (coarse substrate) or Glide/Pool (fine substrate)**

Habitat Parameter (#1–5 evaluate in sample reach)	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. **Epifaunal Substrate/ Available Instream Cover**	>70% of substrate favorable for epifaunal colonization, mix of snags, submerged logs, undercut banks, cobble, or other stable habitat and not new fall.	40–70% mix of stable habitat; well suited for full colonization potential; adequate habitat; new fall, but not ready for colonization.	20–40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	<20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. **Embeddedness (Riffle/Run)**	Gravel, cobble, and boulder particles are 0–25% surrounded by fine sediment. Substantial niche space.	Gravel, cobble, and boulder particles are 25–50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50–75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are >75% surrounded by fine sediment.
Pool Substrate Characterization (For Glide/Pool)	Mixture of substrate materials, gravel and firm sand may be prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud, clay, or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. **Velocity-Depth Combinations (Riffle/Run)**	All 4 velocity-depth combinations present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 combinations present (if fast-shallow is missing, score lower than if missing other combinations).	Only 2 of the 4 habitat combinations present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity-depth combination (usually slow-deep).
Pool Variability (Glide/Pool)	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. **Sediment Deposition (Riffle/Run)**	Little or no enlargement of islands or point bars and <5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 5–30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand on old and new bars; 30–50% of the bottom affected; deposits at obstructions, bends, & constrictions; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; >50% of the bottom changing frequently; pools almost absent due to major sediment deposition.
(Glide/Pool)	<20% of the bottom affected by sediment deposition; slight accumulation of CPOM & FPOM; little or no enlargement of point bars.	20–50% affected; moderate accumulation; substantial sediment movement only during major storm event; some new increase in bar formation.	50–80% affected; major deposition; pools shallow, heavily silted; embankments may be present on both banks; sediment movement during storm events.	>80% affected, channelized; mud silt or sand in braided or non-braided channels; pools almost absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. **Channel Flow Status**	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of available channel or <25% of channel substrate is exposed.	Water fills 25–75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 1	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Riffle/Run prevalent: Moderate to high gradient streams with primarily coarse substrate (i.e., gravel or larger).
Glide/Pool prevalent: Lower gradient streams with primarily fine substrate or infrequent aggregations of more coarse sediment.

Habitat Parameter (6–10 evaluate broader than sample reach)	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. **Channel Alteration**	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.).	Channelization may be extensive; embankments or shoring structures present on both banks; 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. **Frequency of Riffles or Bends (Riffle/Run)**	Occurrence of riffles (or bends) relatively frequent; distance between riffles divided by stream width = 5 to 7; with continuous riffles, placement of natural obstruction important.	Occurrence of riffles (or bends) infrequent; distance between riffles divided by width of stream is between 7 and 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles (or bends) divided by width of stream is between 15 and 25.	Generally all flat water or shallow riffles (or bends); poor habitat; distance between riffles divided by width of stream is >25.
Channel Sinuosity (Glide Pool)	Bends in stream increase stream length 3–4 times longer than if it were in a straight line.	Bends in stream increase stream length 2–3 times longer than if it were a straight line.	Bends in stream increase stream length 1–2 times longer than if it were a straight line.	Channel straight; waterway has been channelized for long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. **Bank Stability (Score each bank)** ***Note: Determine left or right side by facing downstream.***	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5–30% of bank in reach has areas of erosion.	Moderately unstable; 30–60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60–100% of bank has erosional scars.
SCORE	**Left bank** 10 9	8 7 6	5 4 3	2 1 0
SCORE	**Right bank** 10 9	8 7 6	5 4 3	2 1 0
9. **Bank Vegetative Protection (Score each bank)**	>90% of streambank and immediate riparian zone surfaces covered by native vegetation, including trees, shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70–90% of stream-bank surfaces covered by native vegetation, but one class of plants not well represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of potential plant stubble height remaining.	50–70% of streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of potential plant stubble height remaining.	<50% of streambank surfaces covered by vegetation; disruption of streambank vegetation very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE	**Left bank** 10 9	8 7 6	5 4 3	2 1 0
SCORE	**Right bank** 10 9	8 7 6	5 4 3	2 1 0
10. **Riparian Vegetative Zone Width (Score each bank riparian zone)**	Riparian zone width >18 m; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Riparian zone width 12–18 m; human activities have impacted zone only minimally.	Riparian zone width 6–12 m; human activities have impacted zone a great deal.	Riparian zone width <6 m; little or no riparian vegetation due to human activities.
SCORE	**Left bank** 10 9	8 7 6	5 4 3	2 1 0
SCORE	**Right bank** 10 9	8 7 6	5 4 3	2 1 0

TOTAL HABITAT ASSESSMENT SCORE _____

FIELD DATA SHEET: Physical Characterization

Station ID _____ Stream Name _____ Date_____

River Basin _____ Investigators _____

Purpose *(Circle as many as apply)*: Reconnaissance Habitat Macroinvertebrate Fish Flow WQ

Stream Characterization

Subsystem Classification Stream Type
_____ Glacial _____ Stained
_____ Clear _____ Other

Gradient _____change in height over 25 m (82 ft) %_____
Channelized _____ Y _____N
Dam Present _____ Y _____ N *(beaver, manmade)*

Instream Features

Rosgen Classification: _____ Substrate *(Circle one)* Low gradient-fine Low gradient-coarse High
High Water Mark *(Estimate from deepest point in stream)* _____ m
Velocity *(In run, if no discharge recorded)* 1)_____ 2)_____ 3)_____ ft/sec Avg. _____ ft/sec

Sediment/Substrate

Odors	Oils
____ None/normal	____ None
____ Petroleum	____ Slight
____ Sewage	____ Moderate
____ Anaerobic	____ Profuse
____ Other	

Water

Odors	Surface Oils	Est. Turbidity
____ None/normal	____ None/normal	____ Clear
____ Sewage	____ Sheen	____ Stained
____ Petroleum	____ Slick	____ Slightly turbid
____ Chemical	____ Other	____ Turbid
____ Fish		

INORGANIC SUBSTRATE COMPONENTS		
Type	***Diameter***	***Percent Composition In Reach*** *(=100%)*
Bedrock		
Boulder	>256 mm (10 in)	
Cobble	64-256 mm (2.5-10 in)	
Gravel	2-64 mm (0.1-2.5 in)	
Sand	0.06-2 mm (gritty)	
Silt	0.004-0.06 mm	
Clay	<0.005 mm (slick)	

ORGANIC COMPONENTS		
Type	***Size***	***Amount*** *(none,slight, moderate, heavy)*
Aquatic Vegetation		
Detritus	Sticks, wood (CPOM)	
Muck-Mud	Fine organic (FPOM)	
	Moss	
Algae	Periphyton	
NOTES		

DISCHARGE/VELOCITY RECORDS		
Distance from Bank	***Depth***	***Velocity***

Pebble Count Completed? ____yes ____ no

Discharge _____cfs

APPENDIX C

Macroinvertebrate and Periphyton Login and Tracking Sheets

PEBBLE PROJECT: PERIPHYTON SAMPLE LOGIN AND SHIPMENT TRACKING SHEET

HDR Alaska, Inc. 2525 C. Street Suite 305 Anchorage, Alaska 99503 (907) 644-2000

Sample ID & Number	Stream Name	Dup Y/N	GPS Coordinates	Collect Date	Collect Time	Samplers Initials	Ship Date	Shippers Initials

Notes:

SAMPLE LOGIN SHEET

Sample ID	Stream Name	Collect Date	Samplers ID	Sample Processing						QC	
				# Jars	SS Y/N	5' Pick Y/N	Sorting Date/Init	ID Date/Init	Chiro Date/Init	Processing Date/Init	ID Date/Init



PEBBLE PROJECT
ENVIRONMENTAL BASELINE STUDIES
2008 FIELD SAMPLING PLAN

FISH TISSUE STUDY
Mine Study Area

DRAFT

June 2008

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ACRONYMS AND ABBREVIATIONS

CAS	Columbia Analytical Services, Inc.
COC	chain-of-custody
QAPP	quality assurance project plan
QA	quality assurance
QC	quality control

2008 FIELD SAMPLING PLAN

FISH TISSUE STUDY, MINE STUDY AREA

1. Introduction

This field sampling plan describes the protocols for collecting samples of adult fish tissue in the mine study area in 2008. These protocols will be followed by all fisheries field crews working in the mine study area. This plan describes in detail the methods for the fish tissue collection, handling, and shipping. Prior to 2007 fish were dissected in the field, and dissected tissues were sent to Columbia Analytical Services, Inc. (CAS), for analysis. Starting in 2007, whole-fish specimens were sent to CAS for dissection, storage, and analysis. This process will continue in 2008. Appendix A is a description of year-to-year changes in the fish tissue program.

The fish tissue study will be organized by fisheries biologists Betsy Torell and Dr. MaryLouise Keefe of R2 Resource Consultants, Inc. They will be responsible for assigning field tasks and ensuring that collection protocols are followed. Shaw Alaska, Inc., will be responsible for filling out electronic chain-of-custody forms and for shipping fish tissue samples to CAS for dissection and analysis.

2. Objectives and Scope

The fish tissue study is one of several environmental baseline studies for Pebble Project. These studies, in combination, will address the four objectives of the Pebble environmental program, as summarized below:

- Characterize the natural environment, including fish and aquatic resources, in the vicinity of the project.
- Gather and organize information that will be needed for permitting and processes required under the National Environmental Policy Act.
- Develop information that can help guide project layout and engineering design.
- Generate a predevelopment database that will form the basis for long-term monitoring and post-development comparison.

In addition, the specific objective of the fish tissue study is to characterize the predevelopment levels of targeted constituents in the tissues of fish residing in the vicinity of Pebble Project. As such, the fish tissue study provides information important both to characterizing fish resources and to generating a predevelopment database.

The fish tissue study incorporates two separate approaches for sampling. The first approach involves collecting yearling salmonids and evaluating the level of trace-element accumulations using whole-body homogenates (including unevacuated viscera). This sampling process was developed by the Alaska Department of Natural Resources for state-wide application in all long-term monitoring programs for mining projects. Yearling juvenile salmonids—including coho salmon, Chinook salmon, and Dolly varden, in order of preference—are targeted because they have spent sufficient time in the freshwater environment to have accumulated any trace elements occurring in the environment and are thought to be relatively stationary within the stream, residing at or near the point of capture long enough to have established a steady-state body burden (defined as an accumulation of trace elements within all body tissues). These salmonids are also preferred study targets because of their widespread distribution, position within the food web (predators of smaller organisms that consume algae, plants, insects, detritus), and value as a resource to the people of Alaska.

The second approach used in this study addresses the potential for effects from trace elements on humans through consumption of fish in the project vicinity. This approach involves collecting and analyzing tissue from adult fish that are of suitable size for subsistence and recreational fisheries. Northern pike was selected as a primary target because of its position as the apex aquatic predator in this part of southwestern Alaska; thus, trace elements that bioaccumulate should be more readily detected in this species. In addition to northern pike, arctic grayling and whitefish are selected target species because of their importance to subsistence fisheries in this area.

The fish tissue study has been ongoing since 2004. Year-to-year changes in the program are described in Appendix A. In 2008, whole-fish samples will be collected, frozen, and shipped on ice to CAS for dissection and laboratory analysis or, in the case of liver tissue, storage for possible future analysis.

3. Sampling Site Description and Schedule

All established sampling sites for fish tissue are located within a 12-mile radius of the ore body. Samples will be collected in late August and early September. Lake sites include Frying Pan Lake, Big Wiggly Lake, Black Lake (North Fork Koktuli drainage), and Lake #2 (Lower Talarik Creek drainage near the Upper Talarik Creek drainage; Figure 1 and Table 1). One stream site in each of the three major drainages in the project vicinity (North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek) also will be sampled. Stream sampling sites will be selected in the field, but will be located at one of the previously established sampling sites in each major drainage. Selection of sampling sites will be based on the target species being present. Each stream site will be a location that is also sampled for water quality and that offers the best opportunity to capture the target number of each species.

4. Field Activities and Methods

4.1 Sample Collection

Field activities will include collection of adult fish using seines, gill nets, or at lake sites, rods and reels. The collection locations are listed in Table 1. Immediately upon capture, fish will be placed in a clean zipper-seal plastic bag enclosed within a second clean zipper-seal bag and placed on ice in a freshly

washed cooler to be transported to Iliamna. Each sample container will be labeled as described in Section 4.3.2.

4.2 Field Data Forms and Document Management

A standardized field data form will be completed to document the collection of each fish. All data forms will be printed on write-in-the-rain paper. At the end of each working day the field data forms will be checked for accuracy and completeness (Level 1 quality assurance [QA]/quality control [QC]) and then turned in to the Senior Scientist on site. The Senior Scientist will deliver all forms to Betsy McGregor at R2 Resource Consultants' Anchorage office at the end of each field rotation. Field data will be manually entered into a database weekly, if possible, or at the end of the field season. All electronic data will undergo two levels of QA/QC to check for accuracy and errors.

4.3 Sample Handling

Fish samples will be kept on ice in coolers during transport to Iliamna. At Iliamna fish will be frozen, packed on fresh ice, and sent to CAS. Chain-of-custody procedures will be in accordance with the 2008 quality assurance project plan (QAPP; Pebble Partnership, In press). At CAS, fish will be dissected and samples will be freeze-dried (as described in CAS standard operating procedure MET-TISP, Revision 5) and analyzed.

4.3.1 Sample Containers

Sampling containers will consist of clean zipper-seal bags; each specimen will be double bagged. The preservation method will be to keep samples chilled on ice until they reach Iliamna, where the fish will be frozen and kept on gel ice for transport to the laboratory.

4.3.2 Sample Identification

Each sample container will be labeled individually with a waterproof label listing the following information:

- Project name: Pebble Project.
- Collection date: month/day/year.
- Collection time.
- Preservation method: keep frozen.
- Sample identification code (see below).
- Analysis.
- Sampler's initials.

The following example illustrates the format for sample identification codes:

Example: 0808BL100ETF001-AG-a

Where:

0808 is the date as month and year. If sampling that began in any given month carries over into the next month, samples are labeled according to the month during which the sampling event began. For example, the last few samples for the August collection may be taken in early September, but the sample date will still read "0808."

BL100E is the location identification, where BL is the code for Black Lake and 100E identifies the sampling site. The codes for subject bodies of water are as follows:

BL = code for Black Lake.
BWL = code for Big Wiggly Lake.
FPL = code for Frying Pan Lake.
L2 = code for Lake #2.
NFK = code for North Fork Koktuli River.
SFK = code for South Fork Koktuli River.
UT = code for Upper Talarik Creek.

TF is the matrix code for fish tissue.

001 is a sequential sample number based on the number of samples taken at a given location for a given event.

AG is the species identifier for arctic grayling. Other species codes are NP for northern pike and WX for whitefish.

a is for adult (j would be for juvenile fish).

4.3.3 Sample Custody

Electronic chain-of-custody (COC) forms will be completed by Shaw Alaska, Inc., personnel in Iliamna. All COC information will be entered in a chain-of-custody database. The COC forms for the fish tissue samples will, at a minimum, include the following information:

- Sample identification code (see above).
- Signature of shipper.
- Date of collection.
- Time of collection.
- Project name.
- Type of sample.
- Number and type of containers.
- Sample preservation.
- Sample analysis requested.
- Inclusive dates of possession.
- Signature of receiver.

The following additional information also will be included on the COC form.

- Consultant performing the sampling:

  R2 Resource Consultants, Inc.
  2600 Cordova Street, Suite 211
  Anchorage, Alaska 99503
  (907) 771-4090

- Instructions to the laboratory to invoice to Pebble Partnership and to mail reports and invoices to:

  Steve Crupi
  Shaw Alaska, Inc.
  2000 West International Airport Road, Suite C-1
  Anchorage, Alaska 99502

4.4 Quality Control Samples

4.4.1 Field Duplicates

Field duplicates will be a split of homogenate prepared and analyzed by CAS.

4.4.2 Field Triplicates

Field triplicates will be a split of homogenate prepared by CAS for submittal to the quality assurance laboratory (Test America, Tacoma, WA).

5. Sample Analysis Summary

Fish muscle tissues will be analyzed for a suite of trace elements including antimony, arsenic, beryllium, cadmium, chromium, copper, lead, molybdenum, nickel, selenium, silver, zinc, thallium, and total mercury. Reports of test results will be sent to Shaw Alaska, Inc., for date validation.

6. References

Pebble Partnership. In press. Pebble Project Environmental Baseline Studies, 2008 Quality Assurance Project Plan.

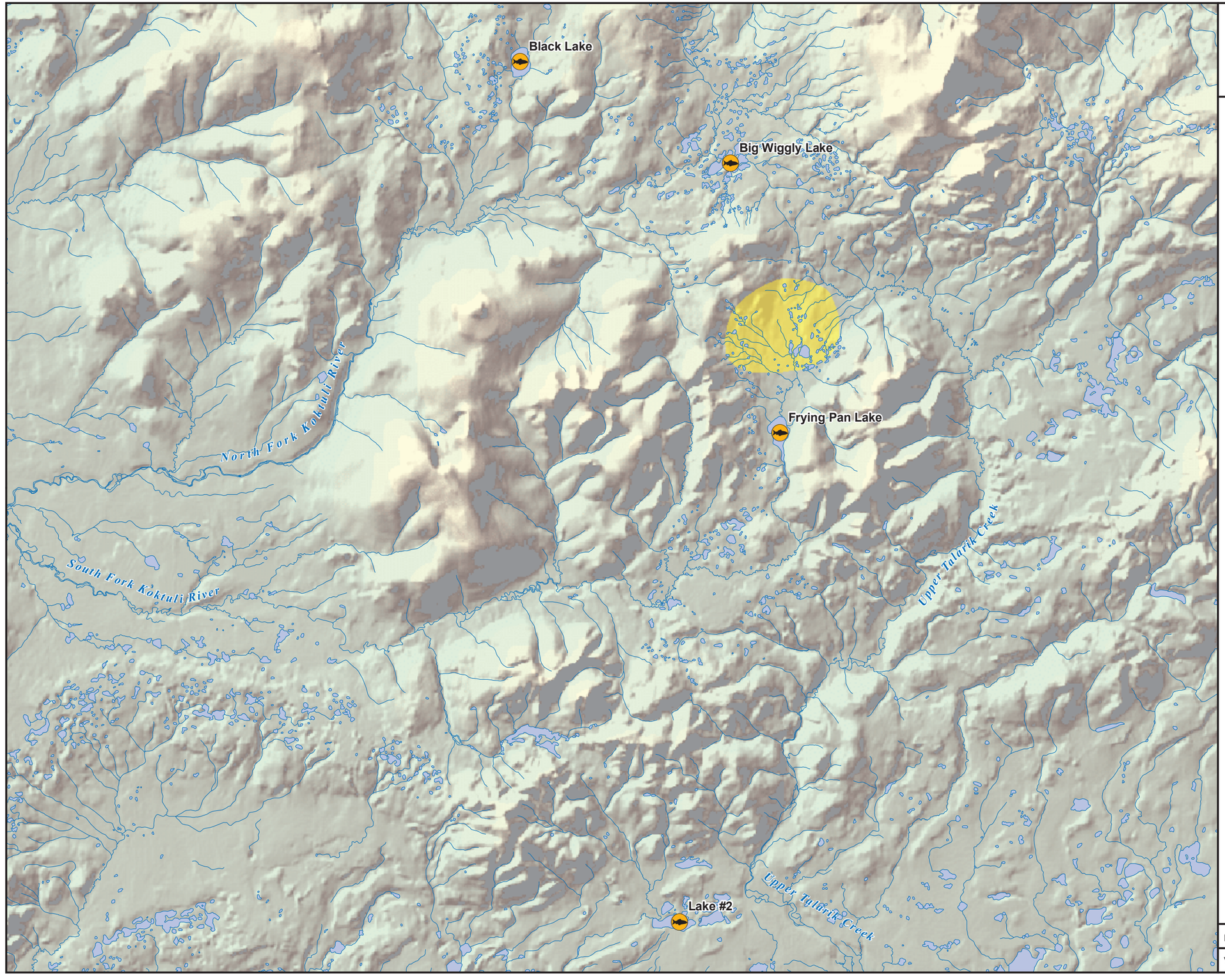
TABLE

TABLE 1
2008 Fish Tissue Sampling Program

Location	Target Species	No. Fish Collected	Tissue Type	No. Tissue Samples	Analysis
Frying Pan Lake	Northern Pike	10	Muscle and Liver	20	Trace Elements Archive (liver only)
	Arctic Grayling[1]	10	Muscle	10	Trace Elements
	Whitefish[2]	10	Muscle	10	Trace Elements
Big Wiggly Lake	Northern Pike	10	Muscle and Liver	20	Trace Elements Archive (liver only)
	Arctic Grayling	10	Muscle	10	Trace Elements
	Whitefish	10	Muscle	10	Trace Elements
Black Lake	Northern Pike	10	Muscle and Liver	20	Trace Elements Archive (liver only)
	Arctic Grayling	10	Muscle	10	Trace Elements
	Whitefish	10	Muscle	10	Trace Elements
Lake #2	Northern Pike	10	Muscle and Liver	20	Trace Elements Archive (liver only)
	Arctic Grayling	10	Muscle	10	Trace Elements
	Whitefish	10	Muscle	10	Trace Elements
South Fork Koktuli River	Arctic Grayling	10	Muscle	10	Trace Elements
	Whitefish	10	Muscle	10	Trace Elements
Upper Talarik Creek	Arctic Grayling	10	Muscle	10	Trace Elements
	Whitefish	10	Muscle	10	Trace Elements
North Fork Koktuli River	Arctic Grayling	10	Muscle	10	Trace Elements
	Whitefish	10	Muscle	10	Trace Elements
Totals		**180**		**220**	

1. Because of the high densities of northern pike in Frying Pan Lake, arctic grayling will likely be collected from the main tributary to the lake.
2. To date, no whitefish have been documented in Frying Pan Lake; however, an effort will be made to capture whitefish directly above or below Frying Pan Lake.

FIGURE

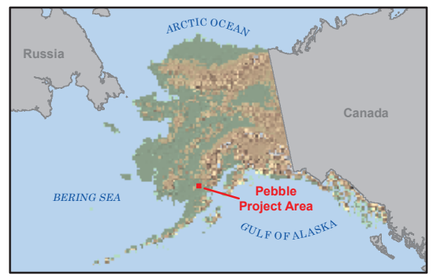


THE pebble PARTNERSHIP

Figure 1
2008 Field Sampling Plan, Fish Tissue Sampling Sites, Mine Study Area
DRAFT

Legend

- Fish Tissue Sample Site
- General Deposit Location
- Stream
- Waterbody



Miles
0 1 2 3 4 5

Kilometers
0 1 2 3 4 5 6 7

N

Scale 1:135,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_R2_FSP_Mine_11x17L_V01.mxd	Date:June 6, 2008
Version: 1	Author: RDI-LS

APPENDIX A

Fish Tissue Program
Year-to-Year Changes

Fish Tissue Program, Year-to-Year Changes

During the first two years of the study (2004 and 2005), yearling and older juvenile salmonids were collected from 16 stream sampling stations in the mine study area and analyzed for whole-body burdens of trace elements. In 2006 and 2007 the sampling program was changed to collecting adult fish from lakes for assessing human consumption risk. In 2006, both livers and fillets of adult fish were sampled to establish the tissue-burden relationship between these two tissue types. This relationship was established; therefore, only fillets, the tissue type most commonly ingested by humans, were analyzed in 2007, although liver samples were collected and archived for possible future analysis. Sampling of adult fish will continue in 2008, with muscle tissue to be analyzed and liver tissue to be freeze-dried and stored for possible future analysis.

Prior to 2007 fish were dissected in the field, and dissected tissues were sent to CAS for analysis. In 2007, this process changed: whole fish samples were frozen, placed on ice, and shipped directly to CAS for laboratory dissection and analysis. In 2008, whole fish samples again will be frozen and shipped on ice to CAS for laboratory dissection and analysis for trace elements or, in the case of liver tissues, storage.

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Iliamna Lake Study

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

ILIAMNA LAKE STUDY

NOVEMBER 2005

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Appendix

Appendix, Field Forms

Acronyms

QAPP	quality assurance project plan
QA	quality assurance
NDM	Northern Dynasty Mines Inc.
ORP	oxidation reduction potential
GPS	global positioning system
DI	deionized
SGS	SGS Environmental Services Inc.
NCA	North Creek Analytical Services Inc.
CAS	Columbia Analytical Service
MS	matrix spike
MSD	matrix spike duplicate
HDPE	high density polyethylene
TDS	total dissolved solids
TSS	total suspended solids
ml	milliliter(s)
VOA	volatile organic analysis
VOC	volatile organic compound
SVOC	semivolatile organic compound
BTEX	benzene, toluene, ethylbenzene, and xylenes
PCBs	polychlorinated biphenyls
L	liter(s)
oz	ounce
PAH	polyaromatic hydrocarbon
mS/cm	milliSiemens/centimeter

1. Introduction

This field sampling plan provides the protocol that is followed during the Iliamna Lake study. This plan describes in detail the methods for collection of water-quality, sediment, mussel-tissue, and zooplankton samples and the procedures for storage, handling, and shipping of samples. While every effort will be made to follow the protocols and timing outlined in this sampling plan, it should be noted that weather, field conditions and boating conditions are likely to be variable during the course of this program, and sampling protocols and timing may be modified in response to these conditions.

2. Project Background

2.1 Project Purpose and Scope

Northern Dynasty Minerals, Ltd., a Canadian company based out of Vancouver, British Columbia, and its U.S. affiliate Northern Dynasty Mines, Inc., are proposing an open-pit mining operation in southwestern Alaska. The prospect contains gold, copper, molybdenum, and silver deposits. The site is located approximately 15 miles north of Lake Iliamna within the eastern drainage of the Mulchatna River. It is on the divide separating the watersheds of Upper Talarik Creek and the south fork of the Koktuli River. NDM has launched extensive programs to collect data on engineering, environmental, and socioeconomic aspects in preparation for the permitting process.

In 2005 a series of biological sampling locations will be established in the northeastern portion of Lake Iliamna. Data collected at these sampling sites will be used to determine baseline conditions and to provide a basis for detecting potential changes in the waterbody.

Ambient water-quality conditions, water-chemistry samples, and zooplankton will be collected at five sites in the lake once per month for six consecutive months (May through October). In addition, organics, sediment, and mussel tissue will be collected during the June and September sampling efforts.

2.2 Project Site Description

The study area is located in the northeast portion of Lake Iliamna, is bounded on the west by the confluence of Upper Talarik Creek with Lake Iliamna, and extends eastward as far as the port site at Pile Bay Village (Figure 1). These boundaries allow the study to incorporate runoff from the mine area (via Upper Talarik Creek), three potential barge-landing sites, and representative rivers that are hydrologically up-gradient of the north shore of the lake.

The five nearshore sampling sites will be located in Pile Bay, Knutson Bay, Northeast Bay (just east of Iliamna boat dock), Roadhouse Bay, and at the mouth of Upper Talarik Creek. Activities

at the sites will involve both surface and benthic sampling. Sites were chosen based on their proximity to the proposed road alignment, barge-landing sites, and currently populated villages.

3. Project Scope and Objectives

3.1 Objectives

The objective of the Iliamna Lake study is to establish baseline conditions in the lake relative to chemical and physical water quality, trace metals in sediments, zooplankton diversity, and contaminant levels in mussel tissue. Collection of these data will supplement the ongoing investigations of fresh-water systems in the project area.

3.2 Sample Analysis Summary

Samples of water, sediment, and mussel tissue collected for analysis will be analyzed by the laboratory for the parameters defined in the *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (QAPP; NDM, 2005). Reports will be sent to the quality assurance (QA)/quality control (QC) manager and Northern Dynasty Mines Inc. (NDM) by the laboratory.

Samples collected for zooplankton will be processed and identified by laboratory technicians at HDR Alaska Inc. A final report with results will be prepared and delivered to NDM in early 2006.

4. Project Organization and Responsibility

4.1 Project Team

The project will be managed by Andra Love, Senior Environmental Scientist at HDR Alaska Inc. She will be responsible for assigning tasks and ensuring that protocols are followed. Rebecca Moore will act as the Assistant Project Lead for this study. Field collection will be performed by a three-person team. Additional team members may be added during May for mussel-bed reconnaissance and in June and September for mussel and sediment collections. Shaw Environmental Inc. will be responsible for filling out electronic chain-of-custody forms (e-Chain) for samples that will be sent to the laboratory for analysis.

4.2 Subcontractors

Tony Yeo, with the University of Alaska Anchorage, will be providing advice on sampling methods and statistical analyses. The Environment and Natural Resources Institute (ENRI) will provide QA/QC on the zooplankton identifications performed by HDR Alaska Inc. John Baechler will provide transportation services by boat between sites on Iliamna Lake.

5. Field Activities Summary

Sample collection for the Iliamna Lake study will include surface and subsurface water samples, sediment samples, mussel-tissue samples, and zooplankton tows. Ambient water conditions (field parameters) also will be measured and recorded. The following is a summary of field activities to occur at each site.

- Dissolved oxygen, pH levels, specific conductance, oxidation reduction potential (ORP), and temperature will be measured at each sampling location.
- A secchi disk reading will be recorded at each location.
- Water-chemistry samples will be collected at three depths from each location. Water samples will be unfiltered except for the dissolved metals sample. During the June and September sampling efforts, additional water samples will be collected to analyze for organics. Two additional sets of samples will be collected for purposes of duplicate and triplicate samples. All samples will be shipped to the appropriate laboratories by Shaw Environmental Inc. Primary and duplicate samples will be analyzed at SGS and triplicate samples will be analyzed by CAS.
- During June and September, sediment samples will be gathered at five locations. Duplicate and triplicate samples will be collected at one of the five sampling location. All samples will be shipped to the appropriate laboratories by Shaw Environmental Inc. Samples will be sieved at the laboratory and analyzed for a designated suite of trace metals. Primary and duplicate samples will be analyzed at SGS and triplicate samples will be analyzed at CAS.
- One vertical zooplankton tow will be conducted at each site. Three zooplankton tows will be collected at one of the five sites to provide duplicate and triplicate samples. Zooplankton from each tow will be stored separately in plastic bottles and preserved in alcohol within 24 hours. Samples will be transported to the HDR laboratory for later taxonomic identification.
- Ten mussel-tissue samples (or enough to achieve 75 grams of wet weight) will be collected at each site. Whole samples will be stored double-bagged in Ziploc bags and frozen. Samples will be shipped on gel-ice by Shaw Environmental Inc. Tissue will be analyzed for a designated suite of trace metals at the appropriate laboratories. Primary samples will be analyzed by CAS. CAS will divide tissue for duplicate and triplicate samples and ship to North Creek Analytical for analysis.

6. Analytical Sample Collection and Handling

6.1 Sampling Procedures

Upon arrival at the sampling location, the boat will be anchored and turned off. Sampling equipment will be prepared by one scientist while another team member records site-specific information and ambient water-quality measurements. Notes will be recorded on a field form

created for the lake study or in field notebooks in accordance with the procedures outlined in the QAPP (NDM, 2005). The information recorded will include date and time, site conditions, station identification (global positioning system [GPS] and landmark features), sampler identification, weather observations, sample location depths, number of samples/sample containers at the site, and presence of notable biological species.

To avoid stirring the water column, every attempt will be made to collect samples in the following order (note that this order may change in the instance of challenging weather or boating conditions):

1. Field parameters measured and recorded, thermocline established (Section 7).
2. Water-chemistry samples collected: 1 meter, thermocline (or half-depth), and 1 meter from substrate (turbidity sample also collected at this time).
3. Plankton tow sample(s) collected.
4. Secchi disk measurement recorded (Section 7).
5. Sediment sample(s) collected.
6. Mussel sample collected.

6.1.1 Surface and Sub-Surface Water Collection

Water samples will be collected monthly from the five sampling stations (Figure 1) from May through October to characterize and establish baseline water-quality conditions in Iliamna Lake. Sample sites will be accessed by boat operated by a local hire. Exact sample locations will be marked with a handheld GPS. Water samples will be analyzed for a suite of trace metals and analytes as specified in the QAPP (NDM, 2005). Samples for organics analyses will be collected only in June and September. The processing of water samples (filtration, when necessary), handling, and transport to the analytical laboratories will follow procedures outlined in the QAPP.

Water-chemistry samples will be collected at three depths using an 8-liter Model 1010 Niskin water sampler for a total of three samples per site. The Niskin sampler will be used to collect a sample approximately 1 meter below the surface of the water, then at the mid-point of the thermocline (or at the mid-point of the total depth at the site), and finally at 1 meter above the substrate on the lake bottom. Every attempt will be made to collect the water samples in that order to avoid water-column mixing.

The Niskin sampler will be lowered until the top of the unit is at the desired sample depth. A messenger will be dropped down the line to trigger the sample bottle to collect the water at the specified depth. The sampler will be raised to the boat for sample volume extraction. All Niskin handling will be conducted by a gloved scientist designated as the “dirty hands” technician. A gloved “clean hands” technician will be responsible for handling the prepared laboratory bottles, lids, and/or other containers and will physically place the container into the cooler. Sampling will continue until all three depths have been sampled with all scientists changing gloves between samples. Sample equipment will be made of non-metallic materials and will be properly cleaned between samples and between sites (Section 6.2).

6.1.2 Zooplankton Collection

Zooplankton tows will occur during all six sampling events, May through October. One vertical tow will occur per site. Three tows will be collected at one site during each sampling event for duplicate and triplicate QC purposes.

Sample tows will be taken at a depth of 20 meters (or at the substrate depth) using an 80-micrometer-mesh tow net. The net will be lowered until the mouth reaches the bottom or a depth of 20 meters and then will be raised at a constant speed to collect the sample. The net will be lifted out of the water and rinsed from the outside to wash organisms from the side of the net into the attached sample bucket. The sample bucket will be removed, and the net will be turned inside out and rinsed into a white tray. The sample and rinse water will be transferred to a plastic container and will be preserved with alcohol within 24 hours. Samples will be transported to the HDR laboratory with HDR scientists at the completion of each field event. At the laboratory, samples will be processed in accordance with the zooplankton section of *Standard Methods for the Examination of Water and Wastewater* (APHA, 1998).

6.1.3 Sediment Collection

Sediment samples will be collected during the June and September sampling events. Sediment will be extracted from the substrate at Pile Bay, Knutson Bay, Northeast Bay, Roadhouse Bay, and at the Upper Talarik outlet (Figure 1) after water-quality and zooplankton collections have occurred. In addition, sediment samples may be collected from the mussel bed locations in September. Samples will be collected with an Ekman dredge sampler and a flat-bottom container that will be cleaned as described in Section 6.2. Samples will be transferred from the flat-bottom container to clean sample bottles provided by the laboratory. Sample bottles will be transferred to Shaw Environmental Inc. personnel in Iliamna for transportation to the appropriate laboratories.

6.1.4 Mussel Collection

Mussels will be collected during the June and September sampling events. For reconnaissance purposes, in May mussel beds will be located and an estimated ratio of mussel size to wet weight will be determined with a small hand-held spring-loaded scale. During the June sampling event, mussels will be collected at each site (assuming mussels are present at each site). If no mussels are present at the site, the field team will locate mussel beds near the site, when possible. Enough mussels will be collected to achieve 75 grams of wet weight (approximately 10 mussels as estimated before field reconnaissance).

At each sample site the collected mussels will be kept whole, double-bagged in Ziploc bags, and labeled in accordance with procedures in the QAPP (NDM, 2005). A laboratory split will provide duplicate and triplicate QC samples. The mussels will be frozen and then placed on gel-ice for shipping to the appropriate laboratories by Shaw Environmental Inc.

6.2 Sampling Equipment Decontamination

For water-chemistry, sediment, and mussel-tissue collections, a “clean hands” and a “dirty hands” technician will be established. The “clean hands” technician will be responsible for handling the sample bottles, removing and replacing sample-bottle lids, storing the bottles in the sample cooler, and handling of all the gel-ice packs. The designated “dirty hands” technician will be responsible for handling the sampling equipment, taking notes, and opening and closing of the sample cooler. This technician will lower the Niskin sampler, send down the messenger, raise the sampler, and prepare the sampler for transfer of the collected water to the sample bottles. All technicians will wear powder-free latex gloves.

To determine the most effective cleaning method for the field equipment, two methods of sample-equipment washing will occur during the May sampling event. Between sites, sampling equipment will be washed in an Alconox solution and rinsed three times in deionized (DI) water. An equipment rinse blank will be collected after this decontamination. Following the Alconox procedure, the sampling equipment will be washed in a 1 percent hydrochloric acid bath and rinsed three times in DI water. A second equipment blank will be collected after this decontamination procedure. All remaining wastewater from the rinsing procedures will be stored in 5-gallon buckets for later disposal.

The results of the analysis of the two initial equipment blanks will determine the preferred method of equipment cleaning for all subsequent sampling events, for which equipment blanks will be collected at a 5 percent frequency.

6.3 Sample Handling

Mussel samples will be stored in coolers on gel-ice in the field until they can be frozen and transferred to Shaw Environmental Inc. in Iliamna. Water and sediment samples will be stored in coolers and kept cool on gel-ice in the field until they can be transferred to Shaw Environmental Inc. in Iliamna. Zooplankton samples will be stored in plastic bottles and will be preserved with alcohol within 24 hours. The zooplankton samples will be transported to the HDR laboratory with HDR scientists.

6.3.1 Sample containers, volumes, and preservation requirements for water, sediment, mussel tissue, and zooplankton

The Niskin samplers are capable of collecting 8 liters of water per sample, which should be close to the volume needed for analysis. Samples will be collected in pre-preserved bottles (when necessary) provided in advance by the final-destination laboratory. Table 1 reflects the water-sample container requirements for the Iliamna Lake study.

Zooplankton will be collected and stored in plastic bottles. Samples will be preserved in a solution of 70 percent denatured alcohol. Approximately seven clean bottles and about two gallons of denatured alcohol will be needed per month.

TABLE 1. Sample containers and preservation requirements for water samples

Analytical Set	Bottle Type (SGS/NCA)	Bottle Type (CAS)	Analysis	Lab Method	Preservative	Hold Time	Req. Temp.	Comments
1	1 extra volume for MS/MSD	no extra volume for MS/MSD	Total Metals[1]	E200.8/200.7	HNO_3	6 months	None	Unfiltered
2	(1) 1L HDPE 1 extra volume for MS/MSD	(1) 1 L HDPE no extra volume for MS/MSD	Dissolved Metals[2]	E200.8/200.7	HNO_3	6 months	None	Filtered
3	(2) 250 ml HDPE no extra volume for MS/MSD	(1) 1 L HDPE no extra volume for MS/MSD	Cyanide Total	4500CN-E	NaOH	14 days	4 °C	Unfiltered
			Cyanide (weak acid dissociable)	4500CN-I				
4	500 ml HDPE no extra volume for MS/MSD	(1) 1 L HDPE no extra volume for MS/MSD	Ammonia as N	SM4500-NH3-G	H_2SO_4	28 days	4 °C	Unfiltered
			Phosphorus total	E365.3				
			Nitrate-nitrite total	E300.0, E353.2				
5	(2) 1 L HDPE 2 extra volumes for TDS/TSS lab duplicates 60 ml Nalgene (Cl, F, SO_4 only) 1 extra volume for MS and 1 extra volume for lab duplicate	(2) 1 L HDPE no extra volume for MS/MSD	TDS	E160.1 or SM2540C	None	7 days	4 °C	Unfiltered
			TSS	E160.2		7 days		
			Alkalinity	2320B		14 days		
			Acidity	305.2		14 days		
			Specific conductance	SM2510B		28 days		
			pH	E150.1		24 hours		
			Chloride	E300.0		28 days		
			Fluoride	E300.0		28 days		
			Sulfate	E300.0		28 days		

Analytical Set	Bottle Type (SGS/NCA)	Bottle Type (CAS)	Analysis	Lab Method	Preservative	Hold Time	Req. Temp.	Comments
6	250 ml HDPE no extra volume for MS/MSD	250 ml HDPE no extra volume for MS/MSD	Thiocyanate	Lab SOP	HNO_3	28 days	4 °C	Unfiltered
7	500 ml Fluoropoly no extra volume for MS/MSD	500 ml Fluoropoly no extra volume for MS/MSD	Low level Hg	E1631	HCl	90 days	None	Unfiltered
8	See analytical set 4 above	1 L HDPE Same bottle as analytical set 4	Nitrate-nitrite total	E353.2	H_2SO_4	28 days	4 °C	Unfiltered
9	(3) 40 ml VOA vial with Teflon septum lid 6 extra VOA vials for MS/MSD	(3) 40 ml VOA vial with Teflon septum lid no extra VOA vials for MS/MSD	VOCs (or BTEX)	SW8260B	HCl	14 days	4 °C	Unfiltered
10	(2) 1 L amber glass jar with Teflon cap 4 extra volumes for MS/MSD	(2) 1 L amber glass jar with Teflon cap no extra volumes for MS/MSD	SVOCs	SW8270C	None	7 days to extraction; 40 days to analysis of extract	4 °C	Unfiltered
11	(2) 1 L amber glass jar with Teflon cap 4 extra volumes for MS/MSD	(2) 1 L amber glass jar with Teflon cap no extra volumes for MS/MSD	Pesticides/PCBs	E508	None	7 days to extraction; 40 days to analysis of extract	4 °C	Unfiltered

1 - Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl, Hardness, B

2 - Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl, B, Si

Please refer to acronyms list for definitions of acronyms and abbreviations used in table.

The required sample volume for sediment is approximately 7 ounces per sample. Samples are to be stored in clean 8-ounce glass vials that will be provided by the laboratory. Samples will be kept on gel-ice at 4°C. Table 2 reflects the necessary container requirements and analyses for the sediment samples.

The required sample volume for mussel tissue is 75 grams of wet weight, homogenized tissue per sample. Samples are to be stored in clean Ziploc bags and kept frozen for preservation. Approximately 200 clean Ziploc bags will be needed for this effort.

6.3.2 Sample Identification

Sampling locations will be identified on the field forms and in the logbooks. Each sample will be labeled individually with a waterproof label listing the following information:

- Project name: Pebble Project
- Date: month/day/year
- Time
- Preservation method
- Sample identification (example: 060504UT100ETF001, see below)
- Analysis
- Sampler's initials

Each sampling location will be identified by the sampler on the field form. The sample identification format is as described in the following example:

060505PB1ATF001

Where:

060505 is the date as month/day/year
PB1A is the location ID
TF is the matrix code for fish (or mussel) tissue
001 is a sequential sample number

201—sequential number for field duplicates
301—sequential number for field triplicates
401—sequential number for field equipment rinse blanks
501—sequential number for field DI water blanks
601—sequential number for field trip blanks

WS is the matrix code for surface water
SE is the matrix code for sediment

TABLE 2. Sample containers and parameters for sediment samples

Analytical Set	Bottle Type (SGS)	Bottle Type (CAS)	Analysis	Lab Method	Preservative	Hold time	Required Temp
1	(1) 8 oz.	(1) 8 oz.	Total Metals[1]	SW6010B/6020/7471 (Hg)	None	6 months	None
2	(1) 4 oz prewt'd[4] amber	(1) 4 oz prewt'd[4] amber	Gasoline Range Organics	AK101	MeOH w/BFB	28 days	4°C
3	(1) 4 oz prewt'd[4] amber	(1) 4 oz prewt'd[4] amber	Benzene, toluene, ethylbenzene, and xylenes	SW8260B	MeOH w/surrogate	14 days	4°C
4	(1) 8 oz	(1) 8 oz	Diesel and residual range organics	AK102/103	None	14 days to extraction, 40 days to analysis of extract	4°C
5	(1) 8 oz	(1) 8 oz	PCBs/ Pesticides, PAH	SW8081/8082	None	14 days to extraction, 40 days to analysis of extract	4°C
6	(1) 4 oz	(1) 4 oz	Cyanide	SM4500CN-E	None	28 days[2]	4°C
7	(1) 4 oz	(1) 4 oz	Ammonia as N	SM4500NH3	None	28 days	4°C
8	(1) 4 oz	(1) 4 oz	Chloride	E300.0	None	28 days[3]	4°C
			Fluoride	E300.0	None		
			Sulfate	E300.0	None		
9	(1) 4 oz	(1) 4 oz	Fraction Organic Carbon	ASTMD4129	None	180 days	4°C

1. Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl, B, Hg

2. Per EPA methods fact sheet titled: "Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity"

3. Holding time is from date of preparation

4. Preweighed and tared

Please refer to acronyms list for definitions of acronyms and abbreviations used in table.

6.4 Sample Custody

6.4.1 Chain of Custody

The chain-of-custody forms for the analytical samples will include the following:

- Sample identification code
- Signature of sampler
- Date and time of collection: month/day/year
- Project name: Pebble-Project
- Number and type of containers: number of Ziploc bags or bottles containing samples
- Sample preservation
- Sample analysis requested
- Inclusive dates of possession
- Signature of receiver

Also include the following on the chain-of-custody form:

HDR Alaska, Inc.
2525 C. Street Suite 305
Anchorage, Alaska 99503
(907) 644-2000.

Samples will remain with field staff throughout the day. Chain-of-custody forms will accompany each cooler shipped to analytical laboratories. Completed forms will be sealed in a Ziploc bag and taped to the inside of the cooler lid. Other chain-of-custody components will include sample labels, custody seals, field notebooks, cooler tracking log, and sample shipment receipts.

6.4.2 Sample cooler procedures

- Place bubble wrap in the bottom and along the sides of coolers.
- Place glass containers in individual bubble-wrap sleeves.
- Fill spaces between sample bottles with gel-ice and additional bubble wrap.
- Place a minimum of two layers of frozen gel-ice over the containers. Pack coolers with 50 percent gel-ice and 50 percent samples.
- Place bubble wrap over gel-ice to fill remaining void.
- Secure cooler lid with strapping tape.
- Attach two signed, dated, and timed custody seals onto cooler lid.
- Attach shipping label that includes the chain-of-custody identification to the top of the cooler.

Sample coolers will be shipped from Iliamna to Anchorage by Shaw Environmental personnel via Iliamna Air Taxi. A Shaw Environmental cooler custodian will receive the samples in Anchorage and arranges delivery to one of the three analytical laboratories. Coolers designated to go to SGS will be hand delivered, and coolers designated to go to Columbia Analytical Services (CAS) and North Creek Analytical (NCA) will be shipped by Alaska Airlines Gold Streak.

6.4.3 Laboratory Contacts

Columbia Analytical Services, Inc.
1317 S. 13th Ave
Kelso, WA 98626-2845
Phone: (360) 577-7222
Fax (360) 636-1068

Contact: Lynda Huckestein
LHuckestein@kelso.caslab.com
Direct: (360) 501-13358

North Creek Analytical
9405 SW Nimbus Avenue
Beaverton, OR 97008-7132
Phone: (503) 906-9200
Fax: (503) 906-9210

Contact: Crystal Jones
CJones@ncalabs.conm
Direct: (503) 906-9234

SGS Environmental Services, Inc.
200 W. Potter Dr.
Anchorage, AK 99518
Phone: (907) 562-2343
Fax: (907) 561-5301

Contact: Steve Crupi
Steve_Crupi@sgs.com
Direct: (907) 550-3213

6.5 Field Quality Control Samples

6.5.1 Deionized Water Blank

One DI blank will be collected for each sampling event for total metals. The DI water used for decontamination will be collected in an empty total metals analysis bottle and submitted to the primary laboratory.

6.5.2 Equipment Blank

Equipment blanks will occur at a frequency of 5 percent and will be analyzed for dissolved metals.

6.5.3 Field Duplicates

Field duplicates are the quality control sample and will occur at a frequency of 10 percent.

6.5.4 Field Triplicates

Field triplicates are the quality assurance sample and will occur at a frequency of 10 percent.

7. Measurement of Field Parameters

Ambient water-quality parameters that will be measured are temperature, dissolved oxygen, conductivity, pH, and ORP. These field parameters will be measured at 1-meter depth increments from the surface to the substrate (or 20 meters maximum) using a YSI 556 Multi-probe System. Measurements will be taken by placing the probe into the water, activating the YSI meter, and reading the output screen with all the parameters on it. The instrument will be checked in confidence solution or calibrated daily. The YSI temperature measurements will be used to determine depth at thermocline for later water-chemistry sampling. Maintenance of the YSI meter will be performed by TTT Environmental in Anchorage, Alaska.

Secchi disk transparency will be recorded during each of the five sampling events. The Secchi disk will be lowered into the lake until the disk disappears completely from view. Due to the potentially large variability due to wind and wave action on Iliamna Lake, observation of the disk will be made through an aquascope. The disk will be lowered until it is out of view and the depth will be recorded. The disk then will be lowered approximately 0.3 meters and then raised until it reappears. The second depth will also be recorded, and the average of the two depth readings will be calculated to the nearest 0.25 meter. This value will be recorded as the Secchi disk transparency reading.

8. Equipment Calibration for YSI 556

Prior to initial use, electrolyte solution must be added to the membrane cap. Install the membrane cap as follows:

- Unscrew and remove probe sensor guard.
- Discard old membrane cap.
- Thoroughly rinse the sensor tip with distilled water.
- Prepare electrolyte solution.
- Fill membrane cap half full with electrolyte solution.
- Reattach membrane cap onto sensor, moderately tight. A small amount of solution should overflow.
- DO NOT touch the membrane surface.
- Screw probe sensor guard on moderately tight.

All of the sensors, except temperature, require calibration if air pressure changes occur.

Calibration tips are as follows:

- Ensure that all sensors are completely immersed in calibration solutions.
- The top vent hole of the conductivity sensor must also be immersed during some of the calibrations.
- Loosen the transport/calibration cup during dissolved oxygen calibration to allow pressure equilibration.
- For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the probe module. You may wish to save old calibration standards for this purpose.
- Rinse probe module between calibration solutions with ambient-temperature water.
- Use paper towels or clean cotton cloths to dry probe between rinses. Making sure the probe is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.
- Install all port plugs in the ports where the sensors are not installed. It is extremely important to keep these electrical connectors dry.

TABLE 3. Calibration solution volumes

Sensor to calibrate	Upright	Upside Down
Conductivity	55 ml	55 ml
pH/ORP	30 ml	60 ml

8.1.1 Conductivity Calibration

- Make sure an O-ring is installed in the groove of the bottom cap of the transport/calibration cup, and that the bottom cap is securely tightened.
- Remove probe sensor guard.
- Remove O-ring from the probe module.

1. Press **On/Off** key to display the run screen.
2. Press the **Escape** key to display main menu.
3. Use arrow keys to highlight the Calibrate selection.
4. Press **Enter**. The Calibrate screen is displayed.
5. Use the arrow keys to highlight the Conductivity selection.
6. Press **Enter**. The Conductivity Calibration Selection Screen is displayed.
7. Use the arrow keys to highlight the Specific Conductance selection.
8. Press **Enter**. The Conductivity Calibration Entry Screen is displayed.

9. Pour the correct amount of conductivity standard into a clean, dry or pre-rinsed transport/calibration cup.
10. Use caution when working with calibration solution, which may be hazardous to your health.
11. Rinse conductivity sensor with a small amount of standard that can be discarded. Make certain you avoid cross-contamination of solutions. Be certain that there are no salt deposits around the oxygen and pH/ORP sensors, especially if you are employing standards of low conductivity.
12. Immerse sensor into the solution completely past its vent hole.
13. Move probe up and down in the solution to remove any bubbles from the conductivity cell.
14. Screw the transport/calibration cup on the probe securely.
15. Use the keypad to enter the calibration value of the standard you are using. Enter the value in milliSiemens per centimeter (mS/cm) at 25°C.

Conductivity Standards:

- Fresh water: 1 mS/cm
- Brackish water: 10 mS/cm
- Sea water: 50 mS/cm

16. Press **Enter**. The Conductivity Calibration Screen is displayed.
17. Allow one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on screen and will change with time as they stabilize.
18. Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted. Press **Enter**.
19. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen.
20. Press Escape to return to the calibrate menu.
21. Rinse the probe module and sensors in tap or purified water and dry.

8.1.2 Dissolved Oxygen Calibration in Percent Saturation

1. Press **On/Off** key to display the run screen.
2. Press the **Escape** key to display the main menu.
3. Use arrow keys to highlight the Calibrate selection.
4. Press **Enter**. The Calibrate screen is displayed.

NOTE: the instrument must be on for at lease 20 minutes to polarize the dissolved oxygen (DO) sensor before calibrating.

5. Use the arrow keys to highlight the Dissolved Oxygen selection.
6. Press **Enter**. The dissolved oxygen calibration screen is displayed.
7. Use the arrow keys to highlight the DO% selection.
8. Press **Enter**. The DO Barometric Pressure Entry Screen is displayed.
9. Place approximately 3 millimeters (1/8 inch) of water in the bottom of the transport/calibration cup.
10. Place the probe module into the transport/calibration cup.
11. Make sure that the DO and temperature sensors are NOT immersed in the water.
12. Secure the transport/calibration cup to the module using only one or two threads to ensure the DO sensor is vented to the atmosphere.
13. Use the keypad to enter the current local barometric pressure.
14. Press **Enter**. The DO% saturation calibration screen is displayed.
15. Allow approximately 10 minutes for the air in the transport/calibration cup to become water saturated and for the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
16. Observe the reading under the DO%. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
17. Press **Enter**. This returns you to the DO calibration screen.
18. Press **Escape** to return to the calibration menu.
19. Rinse the probe module and sensors in tap or purified water and dry.

8.1.3 Dissolved Oxygen Calibration in Milligrams per Liter

1. Press **On/Off** key to display the run screen.
2. Press the **Escape** key to display the main menu.
3. Use arrow keys to highlight the Calibrate selection.
4. Press **Enter**. The Calibrate screen is displayed.

NOTE: the instrument must be on for at lease 20 minutes to polarize the DO sensor before calibrating.

5. Use the arrow keys to highlight the Dissolved Oxygen selection.
6. Press **Enter**. The dissolved oxygen calibration screen is displayed.

7. Use the arrow keys to highlight the DO mg/L selection.
8. Press **Enter**. The DO mg/L Entry Screen is displayed.
9. Place the probe module in the water with a known DO concentration. Be sure to completely immerse all of the sensors.
10. Use the keypad to enter the known DO concentration of the water.
11. Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.
12. Stir the probe through the water to provide fresh sample to the DO sensor.
13. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
14. Observe the DO mg/L reading, and when the reading stabilizes for at least 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted. Press **Enter**.
15. Press **Enter**. This returns you to the DO calibration screen.
16. Press **Escape** to return to the calibrate menu.
17. Rinse the probe module and sensors in tap or purified water and dry.

8.1.4 ph Calibration

1. Press **On/Off** key to display the run screen.
2. Press the **Escape** key to display the main menu.
3. Use arrow keys to highlight the Calibrate selection.
4. Press **Enter**. The Calibrate screen is displayed.
5. Use the arrow keys to highlight the pH selection.
6. Press **Enter**. The pH calibration screen is displayed.
7. Select the 3-point option. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. This method assures maximum accuracy.
8. Use the arrow keys to highlight the 3-point selection.
9. Press **Enter**. The pH Entry Screen is displayed.
10. Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.
11. Ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.
12. Immerse the sensor end of the probe module into the solution.
13. Move the probe up and down in the solution to remove any bubbles.

14. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
15. Use the keypad to enter the calibration value of the buffer you are using at the current temperature—pH vs. temperature values are printed on the labels of all YSI pH buffers.
16. Press **Enter**. The pH calibration screen is displayed.
17. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
18. Observe the reading under pH. When the reading shows no significant change after 30 seconds, press **Enter.** The screen will indicate that the calibration has been accepted and prompt you to press **Enter**.
19. Press **Enter**. This returns you to the Specified pH Calibration Screen.
20. Rinse the probe module, transport/calibration cup, and sensors in tap or purified water and dry.
21. Repeat steps 10 through 18 above using the second pH buffer.
22. Press **Enter**.
23. Press **Escape**.
24. Rinse the probe module and sensors in tap or purified water and dry.

8.1.5 Oxidation Reduction Potential Calibration

1. Press **On/Off** key to display the run screen.
2. Press the **Escape** key to display the main menu.
3. Use arrow keys to highlight the Calibrate selection.
4. Press **Enter**. The Calibrate screen is displayed.
5. Use the arrow keys to highlight the ORP selection.
6. Press **Enter**. The ORP calibration screen is displayed.
7. Place the correct amount of a known ORP solution (Zobell solution) into a clean, dry or pre-rinsed transport/calibration cup. Rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.
8. Immerse sensor end of probe into the solution.
9. Move the probe up and down in the solution to remove any bubbles from the ORP sensor.
10. Screw the transport/calibration cup on the threaded end of the probe module and tighten securely.
11. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature.

TABLE 4. Zobell solution values

Temperature °C	Zobell Solution Value (mV)
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

12. Press **Enter**. The ORP calibration screen is displayed.
13. Allow at lease one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize. Verify that the temperature reading matches the value you used from Table 4.
14. Observe the reading under ORP. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted. Press **Enter**.
15. Rinse the probe module and sensors in tap or purified water and dry.

8.1.6 Return to Factory Settings

1. Press **On/Off** key to display the run screen.
2. Press the **Escape** key to display the main menu.
3. Use arrow keys to highlight the Calibrate selection.
4. Press **Enter**. The Calibrate screen is displayed.
5. Use the arrow keys to highlight the Conductivity selection. Note: the conductivity sensor is being used as an example; however, this process will work for any sensor.
6. Press **Enter**.
7. Use the arrow keys to highlight the Specific Conductance.
8. Press **Enter**.
9. Press and hold the **Enter** key down and press the **Escape** key.
10. Use the arrow keys to highlight the YES selection. This returns a sensor to the factory settings.

11. Press **Enter**.
12. Press **Escape**.

9. Record Keeping

9.1.1 Field Calibration Logbook

Each case for a YSI meter contains a yellow write-in-the-rain calibration logbook. YSI meters must be calibrated daily, and the calibration results should be recorded in the logbook each time along with any information pertaining to the meter.

9.1.2 Field Data Forms

Field forms (see appendix) will be used to record all field data, including the location of the sampling station, recorded measurements, and primary and quality control samples collected at the site.

10. References

APHA 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association, Washington DC

Northern Dynasty Mines Inc. (NDM). 2005. Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan.

FIGURE

155°12'0"W 155°0'0"W 154°48'0"W 154°36'0"W 154°24'0"W 154°12'0"W 154°0'0"W 153°48'0"W 153°36'0"W

60°12'0"N

60°0'0"N

59°48'0"N

59°36'0"N

Port Alsworth

Nondalton

Iliamna

Northeast Bay

Bucket Lake

Whistlewing Bay

Roadhouse Bay

Newhalen

Upper Talarik

Knutson Bay

Pedro Bay

Flat Island

Finn Bay

Pile Bay

Pile Bay

Northern Dynasty Mines Inc.

Pebble Project

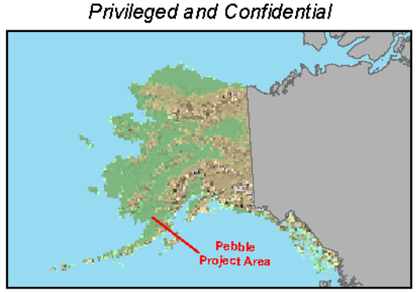
Iliamna Lake Field Sampling Plan
Figure 1

Legend

- Villages
- Lake Sampling Sites (water quality, zooplankton, sediments)
- Mussel Sampling Sites (mussels, sediments)

Sites from HDR, file date 01/25/2005

Privileged and Confidential



0 1.25 2.5 5 7.5 10 Miles

0 2 4 8 12 16 Kilometers

N

Scale 1:331,028

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Fig3Iliamna LakeFieldSamplingPlan.mxd	Date: March 3, 2005
Version: 1	Author: HDR-DS

Z:\200847 Northern Dynasty Mine\als\13988 Macroinvertebrate Road\GIS\MXD\Fig1IliamnastdypIn.mxd

APPENDIX
Field Forms

Site ID: _____ **Date:** _____ **Iliamna Lake Study Field Data Collection Form – Pebble Project - 2005**

GPS: N_____ **Start time:**_____ **Weather:** Air Temp:~_____°F/C,_____ _____

W_____ **End time:** _____ **Team:** _____

Collection Plan Checklist: Depth Profile: Y N **Water:** Y N **WQ Field Param's:** Y N **Secchi Trans**: Y N **Zooplankton:** Y N **Sediment:** Y N **Mussels:** Y N

Depth	Temperature	Conductivity	DO (% sat)	pH (pH units)	DO	ORP	Notes
1 m	°C	mS/cm	%	pH	mg/L	mV	
2 m	°C	mS/cm	%	pH	mg/L	mV	
3 m	°C	mS/cm	%	pH	mg/L	mV	
4 m	°C	mS/cm	%	pH	mg/L	mV	
5 m	°C	mS/cm	%	pH	mg/L	mV	
6 m	°C	mS/cm	%	pH	mg/L	mV	
7 m	°C	mS/cm	%	pH	mg/L	mV	
8 m	°C	mS/cm	%	pH	mg/L	mV	
9 m	°C	mS/cm	%	pH	mg/L	mV	
10 m	°C	mS/cm	%	pH	mg/L	mV	
11 m	°C	mS/cm	%	pH	mg/L	mV	
12 m	°C	mS/cm	%	pH	mg/L	mV	
13 m	°C	mS/cm	%	pH	mg/L	mV	
14 m	°C	mS/cm	%	pH	mg/L	mV	
15 m	°C	mS/cm	%	pH	mg/L	mV	
16 m	°C	mS/cm	%	pH	mg/L	mV	
17 m	°C	mS/cm	%	pH	mg/L	mV	
18 m	°C	mS/cm	%	pH	mg/L	mV	
19 m	°C	mS/cm	%	pH	mg/L	mV	
20 m	°C	mS/cm	%	pH	mg/L	mV	

Depth Profile Notes/Site Sketch:

Site ID: **Date:**

Water Quality Sample and Field Parameter Collection ***Remember to bring trip blanks into the field with you!***

Sample ID:_____	**Sample ID:**_____	**Sample ID:**_____
Sample Depth:_____ **Time:**_____	**Sample Depth:**_____ **Time:**_____	**Sample Depth:**_____ **Time:**_____
Low Hg____**(1)** 500mL TSS/TDS___ ___**(2)** 1-L	Low Hg____**(1)** 500mL TSS/TDS___ ___**(2)** 1-L	Low Hg____**(1)** 500mL TSS/TDS___ ___**(2)** 1-L
Metals____ ____**(2)** 1-L Nutrients___**(1)** 500mL	Metals____ ____**(2)** 1-L Nutrients___**(1)** 500mL	Metals____ ____**(2)** 1-L Nutrients___**(1)** 500mL
Cn/Thio___ ___**(2)** 250mL Anions____**(1)** 120mL	Cn/Thio___ ___**(2)** 250mL Anions____**(1)** 120mL	Cn/Thio___ ___**(2)** 250mL Anions____**(1)** 120mL
June/Sept: SVOCs/Pests__ __ __ __(4) 1-L ambers	**June**/Sept: SVOCs/Pests__ __ __ __(4) 1-L ambers	**June**/Sept: SVOCs/Pests__ __ __ __(4) 1-L ambers
June/Sept: VOCs___ ___ ___(3) 40ml VOAs	**June**/Sept: VOCs___ ___ ___(3) 40ml VOAs	**June**/Sept: VOCs___ ___ ___(3) 40ml VOAs
Duplicate: Y N **Triplicate:** Y N **MS/MSD:** Y N	**Duplicate:** Y N **Triplicate:** Y N **MS/MSD:** Y N	**Duplicate:** Y N **Triplicate:** Y N **MS/MSD:** Y N
pH:_____units Temp:_____^{o}C	pH:_____units Temp:_____^{o}C	pH:_____units Temp:_____^{o}C
DO_____mg/L DO _____% sat	DO_____mg/L DO _____% sat	DO_____mg/L DO _____% sat
Cond_____mS/cm ORP_____mV	Cond_____mS/cm ORP_____mV	Cond_____mS/cm ORP_____mV
Turb_____NTU Time _____	Turb_____NTU Time _____	Turb_____NTU Time _____
Notes:	Notes:	Notes:

Secchi Disk Transparency: Y N

Disappear Depth_____

Reappear Depth_____ Average Depth_____ Time_____

Tow Net Zooplankton Collection: Y N

# of sample bottles: _____

Notes:

Sediment Collection: Y N **Mussel Collection:** Y N **Station Coordinates: N** **W**

Sediment Sample ID: _____ Time_____

Collection Depth_____Collection Method/Team_____

____ (1) 8oz jar

Duplicate: Y N **Triplicate:** Y N **MS/MSD:** Y N

Notes:

Mussel Sample ID: _____ Time_____

Collection Depth_____Collection Method/Team_____

Duplicate: Y N **Triplicate:** Y N **MS/MSD:** Y N

# of organisms/sample:_____Notes:

General Site Notes:

Collection Summary: Depth Profile: Y N **Water:** Y N **WQ Field Param's:** Y N **Secchi Trans**: Y N **Zooplankton:** Y N **Sediment:** Y N **Mussels:** Y N

*Notes: (1) 250-ml (HNO3 preserved) for thiocynate, and (1) 250-ml (NaOH preserved) for Cn; **for triplicate samples: use (1) 1-L bottle for cyanide instead of (1) 250ml (as in primary/duplicates)

MUSSEL AND SEDIMENT SAMPLE LOGIN AND SHIPMENT TRACKING SHEET

Station ID	Dup Y/N	GPS Coordinates	Collection Depth	Collect Date	Collect Time	Samplers Initials	Ship Date	Shippers Initials

Notes:

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES 2007 FIELD SAMPLING PLANS

ILIAMNA LAKE STUDY

DRAFT

SEPTEMBER 2007

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Appendix A, Iliamna Lake Program, Year-to-Year Changes

Appendix B, Field Forms

ACRONYMS AND ABBREVIATIONS

CAS	Columbia Analytical Services, Inc.
cm	centimeter(s)
DI	deionized
DO	dissolved oxygen
GPS	global positioning system
HDR	HDR Alaska, Inc.
m	meter(s)
µm	micrometer(s)
mS	milliSiemen(s)
NDM	Northern Dynasty Mines Inc.
ORP	oxidation reduction potential
QAPP	quality assurance project plan
QA	quality assurance
QC	quality control
SGS	SGS Environmental Services, Inc.
Shaw	Shaw Environmental, Inc.

ILIAMNA LAKE STUDY
2007 FIELD SAMPLING PLAN

1. Introduction

This field sampling plan provides the sampling protocols for the Iliamna Lake study in 2007. This field sampling plan for the 2007 Iliamna Lake study supersedes all previously written field sampling plans for this program. Appendix A contains an overview of year-to-year changes in the program. This plan describes in detail the methods for collection of water-quality and zooplankton samples and the procedures for storage, handling, and shipping of samples. Although every effort will be made to follow the protocols and timing outlined in this sampling plan, it should be noted that weather, field conditions, and boating conditions are likely to vary during the course of this program, and sampling protocols and timing may be modified in response to these conditions.

2. Study Organization and Responsibility

2.1 Study Team

The program will be managed by Andra Love at HDR Alaska, Inc (HDR). She will be responsible for assigning tasks and ensuring that protocols are followed. Brent Fenty will act as the Assistant Project Lead for this study. Field collection will be performed by a three-person team. Shaw Alaska, Inc. (Shaw), will be responsible for filling out electronic chain-of-custody forms for samples that will be sent to the laboratory for analysis. Shaw will ship all samples to the appropriate laboratories. SGS Environmental Services, Inc. (SGS) will analyze primary and duplicate samples, and Columbia Analytical Services, Inc. (CAS), will analyze triplicate samples.

2.2 Subcontractors

The Environment and Natural Resources Institute (ENRI) will provide quality assurance and quality control for the zooplankton identifications performed by HDR. John Baechler will provide transportation services by boat between sites on Iliamna Lake.

3. Sample Collection and Handling

Sample collection for the 2007 Iliamna Lake study will include surface water-quality samples and vertical tows for zooplankton at five locations: Pile Bay, Knutson Bay, Northeast Bay, Roadhouse Bay, and the outlet of the Upper Talarik Creek (Figure 1). Ambient water conditions (field parameters) also will be measured at each location and recorded.

Upon arrival at the sampling location, the boat will be anchored and the engine turned off. Sampling equipment will be prepared by one scientist while another team member records site-specific information and ambient water-quality measurements. Notes will be recorded on a field form created for the lake study (Appendix B) or in field notebooks in accordance with the procedures outlined in the 2007 quality assurance project plan (QAPP; NDM, in press). The information recorded will include date and time, station identification code, global positioning system (GPS) coordinates, sampler identification, weather observations, sample location depths, number of samples collected and number of sample containers at the site, and noticeable presence of fish and wildlife or unusual conditions.

To avoid stirring the water column, measurements and samples will be collected in the following order whenever possible (this order may change in instances of challenging weather or boating conditions):

1. Using a YSI 556 meter dissolved oxygen (DO), pH levels, specific conductance, oxidation reduction potential (ORP), and temperature will be measured at each sampling station at depth increments of 1 meter beginning at the surface and going to 20 meters deep or the substrate. Presence or absence of a thermocline will be noted.
2. Water-chemistry and turbidity samples will be collected at three depths from each location. During the June and September sampling efforts, additional water samples will be collected to be analyzed for organics. Duplicate and triplicate samples for quality control (QC) and quality assurance (QA) purposes will be collected at a 10 percent frequency for the entire year. Water-chemistry and turbidity samples will be collected in the following order:
    a. At 1 meter below water surface
    b. At thermocline (or half-depth).
    c. At 1 meter from substrate.
3. A transparency reading, using a Secchi disk, will be recorded at each station.
4. One vertical zooplankton tow will be conducted at each site. Duplicate zooplankton tows will be collected at one of the five sites, at a 10 percent frequency for the entire year, to provide QA samples.

3.1 Collection of Analytical Samples

3.1.1 Surface Water Collection

Water samples will be collected monthly from May through October from the five sampling stations (Figure 1). A boat operated by a locally hired party will provide access to sample sites. Exact sample locations will be identified with a hand-held GPS. Water samples will be analyzed for a suite of trace metals and analytes as specified in the QAPP (NDM, in press). Samples for organics analyses will be collected only in June and September. The water samples will be processed (filtration, when necessary), handled, and transported to the analytical laboratories in accordance with procedures outlined in the QAPP.

For collection of water quality samples, a “clean hands” and a “dirty hands” technician will be established. The clean hands technician will be responsible for handling the sample bottles, removing and replacing sample bottle lids, and storing the bottles in the sample cooler. The designated dirty hands

technician will be responsible for handling the sampling equipment, taking notes, opening and closing the sample cooler, and handling all gel-ice packs. This technician will lower the Niskin sampler, send down the messenger, raise the sampler, and prepare the sampler for transfer of the collected water to the sample bottles. All technicians will wear powder-free latex gloves.

Water-chemistry samples will be collected at three depths by using an 8-liter, Model 1010, Niskin water sampler, for a total of three samples per site. The Niskin sampler will be used to collect samples in the following order to avoid mixing the water column whenever possible:

1. At approximately 1 meter below the surface of the water.
2. At the midpoint of the thermocline (or the midpoint of the total depth at the site).
3. At 1 meter above the substrate on the lake bottom.

The Niskin sampler will be lowered until the top of the unit is at the desired sample depth. A messenger will be dropped down the line to trigger the sample bottle to collect the water at the specified depth. The sampler will be raised to the boat for extraction of the sample volume. All Niskin handling will be conducted by the dirty hands technician. The clean hands technician will be responsible for handling the prepared laboratory bottles, lids, and other containers and will physically place the container into the cooler. Sampling will continue until all three depths have been sampled, with all technicians changing gloves between samples. Sample equipment will be made of non-metallic materials and will be cleaned between sites using the method described in Section 3.1.

3.1.2 Decontamination of Sampling Equipment

Between sites, sampling equipment will be washed in an Alconox solution and rinsed three times in deionized (DI) water. For QA/QC purposes, an equipment rinse blank will be collected after this decontamination at 5 percent of the sites. All remaining wastewater from the rinsing procedures will be stored in 5-gallon buckets for later disposal.

3.1.3 Sample Filtration

All samples for dissolved metals analysis will be filtered within 12 hours of the time they are collected. Samples will be filtered at the base camp after each field day. Two people are required to filter samples; one person will be "clean hands" and the other will be "dirty hands." Sample filtration procedures are outlined below:

1. Mark the lids of a field sample bottle (non-preserved) and a filtered sample bottle (preserved) with the same number to prevent confusion when the bottle label is transferred.
2. Transfer bottle label from the field sample bottle (non-preserved) to the filtered sample collection bottle (preserved) and tape it on.
3. On the field form, record the lot numbers of filters to be used.
4. *Both sample handlers:* Put on nitrile gloves.
5. *Clean hands:* Using titanium scissors, kept in clean zipper-seal bag, cut tubing to length.

6. *Dirty hands:* Place one pair of bottles inside the filter hood, and open them without touching the inside of the lids or the water.
7. *Dirty hands:* Open the filter bag without touching the filter. *Clean hands:* Remove the filter and attach it to the silicone tubing. Be sure that the ends of the tubing are not touched by dirty hands and are not resting on an unclean surface.
8. *Clean hands:* Put one end of the silicone tubing through the hole in the hood. *Dirty hands:* Arrange the tubing into the peristaltic pump. *Clean hands:* Place the filter over the filtered sample bottle and the other end of the tubing in the field sample bottle without touching the bottles themselves.
9. *Clean hands:* Fill the filtered sample container labeled for dissolved metals.
10. *Dirty hands:* Cap and remove the bottles. C*lean hands:* remove and discard the tubing.
11. Put the full dissolved-metals sample bottle with other bottles from same station to be packaged for shipping.

3.1.4 Zooplankton Collection

Zooplankton tows will occur during all six sampling events, May through October. One vertical tow will occur per site. Duplicate tows will be collected at a 10 percent frequency for the entire year for QA purposes.

Sample tows will be conducted using a tow net of 80-micrometer (μm) mesh with an opening diameter of 30.5 centimeters (cm). The net will be lowered using a 5-kilogram weight until the mouth reaches the bottom or a depth of 20 meters and will be raised vertically at a speed of 0.5 meters per second as determined using a stopwatch and calibrated cable and reel. The net will be lifted out of the water and rinsed from the outside to wash organisms from the net into the attached sample bucket. The sample bucket will be removed, and the net will be turned inside out and rinsed into a white tray. The sample and rinse water will be transferred to a plastic container and will be preserved with alcohol within 12 hours. Samples will be transported to the HDR laboratory in Anchorage with HDR scientists at the completion of each field trip. At the laboratory, samples will be processed in accordance with the applicable portions of the zooplankton section of *Standard Methods for the Examination of Water and Wastewater* (APHA, 1998).

3.2 Sample Handling

3.2.1 Sample Containers, Volumes, and Preservation for Water and Zooplankton

For water samples, the Niskin samplers are capable of collecting 8 liters of water per sample, which is approximately the volume needed for analysis. Samples will be collected in pre-preserved bottles (when necessary) provided in advance by the final-destination laboratory. Table 1 identifies the requirements for containers and preservatives for water samples for the Iliamna Lake study. Water samples will be stored in coolers and kept cool on gel ice in the field until they can be transferred to Shaw representatives in Iliamna for transport to the laboratory.

Zooplankton will be collected and stored in plastic bottles. Within 12 hours, samples will be preserved in a solution of 70 percent denatured alcohol. Approximately seven clean bottles and about 2 gallons of denatured alcohol will be needed per month. The zooplankton samples will be transported to the HDR laboratory in Anchorage accompanied by HDR scientists.

3.2.2 Sample Identification

Each sampling location will be identified on the field form and in the logbooks by the team member performing the sampling. Each sample will be labeled individually with a waterproof label listing the following information:

- Project name: Pebble Project
- Date: month/day/year
- Time
- Preservation method
- Sample code (see below)
- Analysis
- Sampler's initials

The sample code is formatted to indicate sample date, location, matrix, and number, as illustrated in the following example:

0607PB1AWS001

Where:

0607 is the date as month/year.

PB1A is the location identification.

WS is the matrix code for surface water.

001 is a sequential number coded to indicate a primary sample.

Additional sequential codes are as follows:

201 is a sequential number coded to indicate a field duplicate sample.

301 is a sequential number coded to indicate a triplicate sample.

401 is a sequential number coded to indicate a field equipment rinse blank.

501 is a sequential number coded to indicate a field DI water blank.

601 is a sequential number coded to indicate a field trip blank.

3.2.3 Sample Custody

Samples will remain with field staff throughout the day. Chain-of-custody forms will be prepared for the samples at the base camp in Iliamna. Preparation of the chain-of-custody forms for the analytical samples, as described in the QAPP (NDM, in press), will be the responsibility of Shaw personnel. These forms will include the following:

- Sample identification code
- Signature of sampler
- Date and time of collection: month/day/year
- Project name: Pebble-Project
- Type of sample
- Number and type of containers: number of bottles containing samples
- Sample preservation
- Sample analysis requested
- Inclusive dates of possession
- Signature of receiver

Chain-of-custody forms will accompany each cooler shipped to analytical laboratories. Completed forms will be sealed in a zipper-seal bag and taped to the inside of the cooler lid. Other chain-of-custody components will include sample labels, custody seals, field notebooks, cooler tracking logs, and sample shipment receipts.

3.2.4 Sample Cooler Procedures

Sample coolers will be shipped from Iliamna to Anchorage by Shaw personnel on Iliamna Air Taxi. If Shaw personnel are not present, HDR personnel will ship the coolers, after packing them as described below:

1. Place bubble wrap in the bottom and along the sides of coolers.
2. Place glass containers in individual bubble-wrap sleeves.
3. Fill spaces between sample bottles with gel ice and additional bubble wrap.
4. Place a minimum of six bags of frozen gel ice over the containers.
5. Place bubble wrap over gel ice to fill remaining void.
6. Tape zipper-seal bag containing chain-of-custody form inside cooler lid.
7. Secure cooler lid with strapping tape.
8. Attach two signed, dated, and time-stamped custody seals on opposite corners of cooler lid.
9. Attach shipping label that includes the chain-of-custody identification to the top of the cooler.

A Shaw cooler custodian will receive the samples in Anchorage and arrange delivery to one of the three analytical laboratories. Coolers designated to go to SGS will be hand-delivered, and coolers designated to go to CAS will be shipped by Alaska Airlines Gold Streak.

3.2.5 Laboratory Contacts

Columbia Analytical Services
1317 S. 13th Ave
Kelso, WA 98626-2845
Phone: (360) 577-7222
Fax: (360) 636-1068
Contact: Lynda Huckestein
LHuckestein@kelso.caslab.com
Direct phone: (360) 501-3358

SGS Environmental Services, Inc.
200 W. Potter Dr.
Anchorage, AK 99518
Phone: (907) 562-2343
Fax: (907) 561-5301
Contact: Karen Waak
Karen.Waak@sgs.com
Direct phone: (907) 550-3213

Test America, Inc.
(previously North Creek Analytical, Inc.)
9405 SW Nimbus Ave.
Beaverton, OR 97008-7132
Phone: (503) 906-9200
Fax: (503) 906-9210
Contact: Crystal Jones
cjones@testamericainc.com
Direct phone: (503) 906-9234

3.3 Field Quality Control Samples

3.3.1 Deionized Water Blank

One DI blank will be collected for each sample trip for total metals. The DI water used for decontamination will be collected in an empty total bottle appropriate for a sample for metals analysis and submitted to the primary laboratory.

3.3.2 Equipment Blank

Equipment blanks will occur at a frequency of 5 percent (and at least one per filter lot) and will be analyzed for dissolved metals and total metals. These blanks will consist of the DI rinse water used to decontaminate the Niskin sampler; one blank (for dissolved metals) will be run through a filter and one (for total metals) will not. An additional equipment blank consisting of clean DI water run through a filter (but not used to rinse equipment) will be collected to test the filter.

3.3.3 Field Duplicates

Field duplicates are the QC samples and will occur at a frequency of 10 percent for the entire year.

3.3.4 Field Triplicates

Field triplicates are the QA samples and will occur at a frequency of 10 percent for the entire year.

3.3.5 Trip Blanks

Mercury trip blanks will travel with primary sample sets during each field day. Each triplicate sample set will have its individual mercury trip blank. These blanks are for QA purposes.

4. Measurement of Field Parameters

Ambient water-quality parameters that will be measured are DO, pH, conductivity, ORP, temperature, and turbidity. All parameters except turbidity will be measured at 1-meter depth increments from the surface to the substrate (or to 20 meters maximum) using the YSI 556 multi-probe meter. The temperature measurements will be used to determine the depth at thermocline for water quality sampling. Turbidity samples will be collected from three depths in amber bottles and taken back to camp for analysis using a Hach turbidimeter. Secchi disk transparency will be recorded during each of the five sampling events.

Following are the procedures for measuring the field parameters:

4.1 YSI 556 Multi-probe Meter

1. Turn the YSI 556 on.
2. Place the probe in the lake and allow it to equilibrate. Once the temperature reading has stabilized read the all parameters within 5 minutes.

4.2 Hach 2100P Meter

1. Turn on the instrument and place on a flat, sturdy surface
2. Clean the sample cell using a Kim Wipe and several rinses with DI water. Be careful to handle the cell by the top to avoid smudging or scratching the glass. Do not use paper towels on cells.
3. Read the cell with DI water to find the best orientation for the sample cell (this may not be the factory mark). This should be done by taking several readings with a cell containing DI and rotating slightly between each reading. When the lowest reading is found make a mark near the top of the cell where it aligns with the raised mark on the meter. This will be the orientation mark, and the cell should be placed in the meter this way for all samples.
4. Collect the sample in a clean container (amber glass vial) and keep it cool in a dark cooler until transferring the sample to the sample cell. Avoid introducing bubbles, because they will cause interference. Cold water will cause condensation that also will interfere with accurate readings.
5. Invert the collection vial once and then transfer the sample to the testing cell.
6. Wipe the cell with a clean, lint-free cloth to remove fingerprints and water.
7. Apply a thin film of silicone oil to the outside of the cell. Wipe with a clean, lint-free cloth to create an even film on the surface of the cell. Avoid excess oil.

8. Place the sample cell in the instrument compartment making sure that the orientation mark on the cell aligns with the raised mark on the meter. Close the lid.
9. Press the Range key until AUTO RNG is displayed.
10. Press **Read.** The final measurement will display after approximately 13 seconds. If the reading is very unstable, press the **Signal Average** key to average 10 measurements. This action takes approximately 20 seconds.
11. Record the reading on the turbidity log sheet and on the stream sampling field form.

4.3 Secchi Disk

The Secchi disk will be lowered into the lake until the disk disappears completely from view. Because of the potentially large variability resulting from wind and wave action on Iliamna Lake, the disk will be observed through an aquascope. The disk will be lowered until it is out of view, and the depth will be recorded. The disk then will be lowered approximately 0.3 meter and then raised until it reappears. The depth at which the disc reappears also will be recorded, and the average of the two depth readings will be calculated to the nearest 0.25 meter. This value will be recorded as the Secchi disk transparency reading.

5. Equipment Calibration

5.1 YSI 556

Maintenance of the YSI 556 multi-probe system and Hach turbidimeter will be performed by TTT Environmental Instruments and Supplies in Anchorage, Alaska. In the field, the instruments will be checked daily using confidence solution and will be calibrated as needed. All results from the calibrations and daily calibration checks will be logged in a calibration log that will accompany each meter.

Electrolyte solution must be added to the membrane cap before initial use. Install the membrane cap as follows:

1. Unscrew and remove probe sensor guard.
2. Discard old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare electrolyte solution.
5. Fill membrane cap half full with electrolyte solution.
6. Reattach membrane cap onto sensor, moderately tightly. A small amount of solution should overflow.
7. DO NOT touch the membrane surface.
8. Screw probe sensor guard on moderately tight.

All of the sensors, except the one for temperature, require calibration if air-pressure changes occur. Calibration tips are as follows:

- Ensure that all sensors are completely immersed in calibration solutions.
- The top vent hole of the conductivity sensor must also be immersed during some of the calibrations.
- Loosen the transport/calibration cup during DO calibration to allow pressure equilibration.
- For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the probe module. It may be desirable to save the old calibration standards for this purpose.
- Rinse the probe module between calibration solutions with ambient-temperature water.
- Use paper towels or clean cotton cloths to dry the probe between rinses. Making sure the probe is dry reduces carry-over contamination of calibration solutions and increases the accuracy of the calibration.
- Install port plugs in all the ports where the sensors are not installed. It is extremely important to keep these electrical connectors dry.

Below are detailed procedures for calibration of the YSI meter for conductivity, DO, pH, and ORP, as well as for returning the meter to factory settings.

5.1.1 Conductivity Calibration

1. Make sure an O-ring is installed in the groove in the bottom cap of the transport/calibration cup, and that the bottom cap is securely tightened.
2. Remove probe sensor guard.
3. Remove O-ring from the probe module.
4. Press **On/Off** key to display the Run screen.
5. Press **Escape** to display Main Menu.
6. Use arrow keys to highlight the Calibration selection.
7. Press **Enter**. The Calibration screen is displayed.
8. Use the arrow keys to highlight the Conductivity selection.
9. Press **Enter**. The Conductivity calibration screen is displayed.
10. Use the arrow keys to highlight the Specific Conductance selection.
11. Press **Enter**. The Specific Conductance calibration screen is displayed.
12. Pour the correct amount of conductivity standard into a clean, dry or pre-rinsed transport/calibration cup. Use caution when working with calibration solution, which may be hazardous to health.
13. Rinse conductivity sensor with a small amount of standard that can be discarded. Make certain that cross-contamination of solutions is avoided. Be certain that there are no salt deposits around the oxygen and pH/ORP sensors, especially if standards of low conductivity are being employed.
14. Immerse sensor in the solution completely past sensor's vent hole.

15. Move probe up and down in the solution to remove any bubbles from the conductivity cell.
16. Screw the transport/calibration cup onto the probe securely.
17. Use the keypad to enter the calibration value of the standard being used. Enter the value in milliSiemens per centimeter (mS/cm) at 25°Celsius. The conductivity standards are as follows:
    - Fresh water: 1 mS/cm
    - Brackish water: 10 mS/cm
    - Sea water: 50 mS/cm
18. Press **Enter**. The Conductivity calibration screen is displayed.
19. Allow 1 minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on screen and will change with time as they stabilize.
20. Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted. Press **Enter**.
21. Press **Enter**. The Conductivity calibration screen is displayed again.
22. Press **Escape** to return to the Calibration menu.
23. Rinse the probe module and sensors in tap or purified water and dry.

5.1.2 Dissolved Oxygen Calibration in Percent Saturation

1. Press **On/Off** key to display the Run screen.
2. Press the **Escape** key to display the Main Menu.
3. Use arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.

   Note: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.
5. Use the arrow keys to highlight the Dissolved Oxygen selection.
6. Press **Enter**. The Dissolved Oxygen calibration screen is displayed.
7. Use the arrow keys to highlight the DO% selection.
8. Press **Enter**. The DO Barometric Pressure screen is displayed.
9. Place approximately 3 millimeters (1/8 inch) of water in the bottom of the transport/calibration cup.
10. Place the probe module into the transport/calibration cup.
11. Make sure that the DO and temperature sensors are NOT immersed in the water.
12. Secure the transport/calibration cup to the module using only one or two threads to ensure the DO sensor is vented to the atmosphere.
13. Use the keypad to enter the current local barometric pressure.

14. Press **Enter**. The DO% calibration screen is displayed.
15. Allow approximately 10 minutes for the air in the transport/calibration cup to become water saturated and for the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
16. Observe the reading under the DO%. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
17. Press **Enter**. The DO calibration screen is displayed again.
18. Press **Escape** to return to the Calibration menu.
19. Rinse the probe module and sensors in tap or purified water and dry them.

5.1.3 Dissolved Oxygen Calibration in Milligrams per Liter

1. Press **On/Off** key to display the Run screen.
2. Press the **Escape** key to display the Main Menu.
3. Use arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.

   Note: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.
5. Use the arrow keys to highlight the Dissolved Oxygen selection.
6. Press **Enter**. The Dissolved Oxygen calibration screen is displayed.
7. Use the arrow keys to highlight the DO mg/L selection.
8. Press **Enter**. The DO mg/L screen is displayed.
9. Place the probe module in the water with a known DO concentration. Be sure to completely immerse all of the sensors.
10. Use the keypad to enter the known DO concentration of the water.
11. Press **Enter**. The DO mg/L calibration screen is displayed.
12. Stir the probe through the water to provide a fresh sample to the DO sensor.
13. Then allow at least 1 minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
14. Observe the DO mg/L reading, and when the reading stabilizes for at least 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted. Press **Enter**.
15. Press **Enter** again. The Dissolved Oxygen calibration screen is displayed again.
16. Press **Escape** to return to the Calibration menu.
17. Rinse the probe module and sensors in tap or purified water and dry them.

5.1.4 pH Calibration

1. Press the **On/Off** key to display the Run screen.
2. Press the **Escape** key to display the Main Menu.
3. Use arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.
5. Use the arrow keys to highlight the pH selection.
6. Press **Enter**. The pH calibration screen is displayed.
7. Use the arrow keys to highlight the 3-point selection. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. This method ensures maximum accuracy.
8. Press **Enter**. The pH screen is displayed.
9. Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.
10. Ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Make certain that cross-contamination of buffers with other solutions is avoided.
11. Immerse the sensor end of the probe module in the solution.
12. Move the probe up and down in the solution to remove any bubbles.
13. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
14. Use the keypad to enter the calibration value of the buffer that is being used at the current temperature—pH and temperature values are printed on the labels of all YSI pH buffers.
15. Press **Enter**. The pH calibration screen is displayed.
16. Allow at least 1 minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
17. Observe the reading under pH. When the reading shows no significant change after 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** .
18. Press **Enter**. The specified pH calibration screen is displayed again.
19. Rinse the probe module, transport/calibration cup, and sensors in tap or purified water and dry them.
20. Repeat steps 9 through 17 above using a second pH buffer.
21. Press **Enter**.
22. Press **Escape**.
23. Rinse the probe module and sensors in tap or purified water and dry them.

5.1.5 Oxidation Reduction Potential Calibration

1. Press the **On/Off** key to display the Run screen.
2. Press **Escape** to display the Main Menu.
3. Use the arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.
5. Use the arrow keys to highlight the ORP selection.
6. Press **Enter**. The ORP calibration screen is displayed.
7. Place the correct amount of a known ORP solution (Zobell solution) into a clean, dry or pre-rinsed transport/calibration cup. Rinse the ORP sensor with a small amount of solution that can be discarded. Make certain that cross-contamination with other solutions is avoided.
8. Immerse the sensor end of probe in the solution.
9. Move the probe up and down in the solution to remove any bubbles from the ORP sensor.
10. Screw the transport/calibration cup on the threaded end of the probe module and tighten securely.
11. Use the keypad to enter the correct value of the calibration solution being used at the current temperature. The values for Zobell solution are as follows:

Temperature, in °C	Millivolts	Temperature, in °C	Millivolts
-5	270.0	25	231.0
0	263.5	30	224.5
5	257.0	35	218.0
10	250.5	40	211.5
15	244.0	45	205.0
20	237.5	50	198.5

12. Press **Enter**. The ORP calibration screen is displayed.
13. Allow at lease 1 minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize. Verify that the temperature reading matches the value used from the list above (in Step 11).
14. Observe the reading under ORP. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted. Press **Enter**.
15. Rinse the probe module and sensors in tap or purified water and dry them.

5.1.6 Return to Factory Settings

1. Press the **On/Off** key to display the Run screen.
2. Press the **Escape** key to display the Main Menu.

3. Use arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.
5. Use the arrow keys to highlight the Conductivity selection. Note: The conductivity sensor is being used as an example; however, this process will work for any sensor.
6. Press **Enter**.
7. Use the arrow keys to highlight the Specific Conductance selection.
8. Press **Enter**.
9. Press and hold down the **Enter** key and press the **Escape** key.
10. Use the arrow keys to highlight the YES selection. This returns a sensor to the factory settings.
11. Press **Enter**.
12. Press **Escape**.

5.2 Hach 2100P Turbidimeter

Routine calibration checks will be performed on the Hach 2100P turbidimeter using Gelex secondary turbidity standards. In order to be used for checking calibration in the future, the Gelex standards must have values assigned to them by TTT Environmental Instruments and Supplies immediately after calibration has been performed with formazin. These standards will be used as a calibration check before every field day. If the readings are not within 5 percent accuracy, the instrument will be recalibrated using four StablCal stabilized formazin standards. A recalibration will be performed at a minimum of once every three months. Methods for calibrating the turbidimeter with the formazin standards and checking the calibration are outlined below.

Use the following procedure to calibrate the turbidimeter with the four formazin standards:

1. If the StablCal standards have been sitting for longer than one month, shake them to break the condensed suspension into its original particle size. If the standards are used on a weekly interval, start at Step 2 below. Standards of less than 0.1 nephelometric turbidity units (NTU) should not be shaken.
    a. Shake the standard vigorously for 2 to 3 minutes to resuspend any particles.
    b. Allow the standard to stand undisturbed for 5 minutes.
2. Gently invert the bottle five to seven times.
3. Prepare the standard vial.
    a. Clean the vial with a KimWipe (outside) and a DI water rinse. Do not using paper towels on vials.
    b. Allow the vial to air dry. Handle the vial by the top to avoid scratching or contaminating the glass surface.

c. Apply a small bead of silicone oil to the surface of the vial and rub with a lint-free cloth. Note that the cloth will absorb oil. After a few applications, it will be sufficient to rub the cloth over the vial. Avoid using too much oil; the vial should appear dry with little or no visible oil.

4. Turn on the instrument by pressing **I/O**.
5. Press **CAL**. The CAL and SO icons will display, indicating that the instrument is calibrating the first standard at 0 NTU.
6. Rinse the sample vial one time with the standard and discard the rinsate.
7. Fill the vial with the standard. Cap the vial and let it stand for one minute.
8. Insert the vial in the compartment by aligning the orientation mark on the vial with the mark on the front of the compartment.
9. Close the lid.
10. Press the → arrow key to get a numerical display.
11. Press **Read**. The instrument will count from 60 to 0.
12. Repeat steps 6 through 11 for each of the three remaining standards.
13. When the last standard is done, the display will increment back to S0. Press **CAL** to accept the calibration, and the instrument will return to measurement mode.
14. If E1, E2, or CAL? is flashing after the CAL button is pressed, check the standards and repeat the calibration. Refer to the instrument manual for troubleshooting guidelines.

Once the instrument has been calibrated with the formazin standards, check the calibration using Gelex standards by following Steps 6 through 10 in Section 4.6.2, Hach 2100P Meter, above. If the readings are not within 5 percent of the previously established values for the Gelex standards, recalibrate using the StablCal stabilized formazin standards.

6. References

American Public Health Association (APHA). 1998. Standard Methods for the Examination of Water and Wastewater. 20th edition. Washington, DC.

Northern Dynasty Mines Inc. (NDM). in press. Draft Environmental Baseline Studies, 2007 Quality Assurance Project Plan.

TABLE

TABLE 1
Sample Containers and Preservation Requirements for Water Samples

Bottle Type—SGS (P, D, or MS/MSD)	Bottle Type—CAS (Triplicate)	Analysis	Preservative	Hold Time	Req. Temp.	Comments
(1) 500-mL HDPE (P, D)	(1) 1-L HDPE	Total metals	HNO_3	6 months	None	Unfiltered
(1) 500-mL HDPE (P, D)	(1) 1-L HDPE	Dissolved metals	HNO_3	6 months	None	Filtered
(1) 250-mL HDPE (P, D)	(1) 1-L HDPE	Cyanide total	NaOH	14 days	4°C	Unfiltered
		Cyanide (weak acid dissociable)				
(1) 500-mL HDPE (P, D) *1 extra volume for MS/MSD*	(1) 1-L HDPE	Ammonia as N	H_2SO_4	28 days	4°C	Unfiltered
		Phosphorus total				
		Nitrate-nitrite total				
(2) 1-L HDPE (P, D) *2 extra volumes for MS/MSD* (1) 120-mL Nalgene (P, D) (chloride, fluoride, and sulfate only) *1 extra volume for MS/MSD*	(1) 1-L HDPE	Total dissolved solids	None	7 days	4°C	Unfiltered
		Total suspended solids		7 days		
		Alkalinity		14 days		
		Acidity		14 days		
		Specific conductance		28 days		
		pH		24 hours		
		Chloride		28 days		
		Fluoride		28 days		
		Sulfate		28 days		
(1) 250-mL HDPE (P, D)	(1) 1-L HDPE Same bottle as first set	Thiocyanate	HNO_3	28 days	4°C	Unfiltered
(1) 500-mL fluoropoly (P, D) (Test America)	(1) 500-mL fluoropoly	Low-level mercury	HCl	90 days	None	Unfiltered
(3) 40-mL VOA vial with Teflon septum lid *6 extra VOA vials for MS/MSD*	(3) 40-mL VOA vial with Teflon septum lid	VOCs (or BTEX)	HCl	14 days	4°C	Unfiltered

Bottle Type—SGS (P, D, or MS/MSD)	Bottle Type—CAS (Triplicate)	Analysis	Preservative	Hold Time	Req. Temp.	Comments
(2) 1-L amber glass bottle with Teflon cap *4 extra volumes for MS/MSD*	(2) 1-L amber glass jar with Teflon cap *No extra volumes for MS/MSD*	SVOCs	None	7 days to extraction, 40 days to analysis of extract	4°C	Unfiltered
(2) 1-L amber glass bottle with Teflon cap *4 extra volumes for MS/MSD*	(2) 1-L amber glass jar with Teflon cap *No extra volumes for MS/MSD*	Pesticides/PCBs	None	7 days to extraction, 40 days to analysis of extract	4°C	Unfiltered
(1) 250 mL amber glass jar *No extra volumes for MS/MSD*	(1) 250 mL amber glass jar *No extra volumes for MS/MSD*	TOC	HCl	28 days	4°C	Unfiltered

BTEX = benzene, toluene, ethylbenzene, and xylenes
°C = degrees Celsius
D = duplicate
HCl = hydrogen chloride
HDPE = high-density polyethylene
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
L = liter
mL = milliliter
NaOH = sodium hydroxide
P = primary
PCB = polychlorinated biphenyl
MS/MSD = matrix spike/matrix spike duplicate
SVOC = semivolatile organic compound
TOC = total organic carbon
VOA = volatile organic analysis
VOC = volatile organic compound

FIGURE

155°12'0"W 155°0'0"W 154°48'0"W 154°36'0"W 154°24'0"W 154°12'0"W 154°0'0"W 153°48'0"W

59°48'0"N

59°36'0"N

Lake Clark National Preserve

Upper Talarik Creek

Roadhouse Mountain

Knutson Mountain

Chekok

Knutson Bay

Pile Bay

Northeast Bay

Millets Point

Chekok Point

Hat Is.

Jackrabbit Is.

Eagle Bay Is.

Roadhouse Bay

Flat Island

Porcupine Island

Triangle Is.

Lonesome Point

Old Iliamna

Iliamna Lake

Chigmit

Upper Talarik

155°12'0"W 155°0'0"W 154°48'0"W 154°36'0"W 154°24'0"W 154°12'0"W 154°0'0"W 153°48'0"W

Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 1

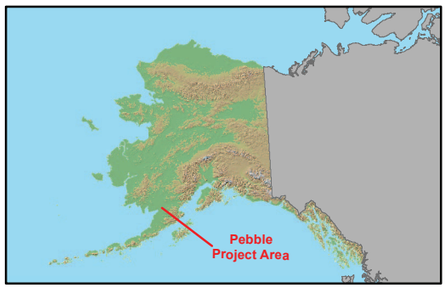
2007 Field Sampling Plan
Iliamna Lake Study
Sampling Stations

DRAFT

Legend

- Nearshore Sampling Stations (water quality, zooplankton)

Sites from HDR, file date 01/25/2005



0 1 2 4 6 8 Miles

0 1.5 3 6 9 12 Kilometers

N

Scale 1:268,590

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Fig3Iliamna LakeFieldSamplingPlan.mxd	Date: June 25, 2007
Version: 1	Author: HDR-DS

Z:\200847 Northern Dynasty Minerals\13988 Macroinvertebrate Road\GIS\MXD\Fig1\iliamnastdyplh.mxd

APPENDIX A

Iliamna Lake Program
Year-to-Year Changes

Iliamna Lake Program, Year-to-Year Changes

The Iliamna Lake study program was initiated in 2005 in response to agency requests that background data be collected in the region of the lake that would receive waters from the area around the proposed project. The methods instituted to collect samples have remained consistent throughout the course of the Iliamna Lake study program, although analysis of surface water for pesticides, volatile organic compounds, and semivolatile organic compounds was removed from the program after 2005 because these parameters were not commonly detected. The types of samples collected have varied by study year. A summary of annual sample collection efforts is presented in the matrix below.

The initial sampling program in 2005 consisted of sampling at nine sites along the northeast shores of the lake monthly from May through October: Pile Bay, Knutson Bay, Northeast Bay, Roadhouse Bay, and the outlet of the Upper Talarik Creek were sampled for field parameters, surface water chemistry, sediment chemistry, and zooplankton. Flat Island, Finn Bay, Whistlewing Bay, and Bucket Lake were sampled for freshwater mussels (*Anadonta beringiana*), and sediments.

In 2006, the four freshwater mussel sites were sampled once in August for field parameters, surface water chemistry, sediment chemistry, and freshwater mussels.

In 2007, Pile Bay, Knutson Bay, Northeast Bay, Roadhouse Bay, and the outlet of the Upper Talarik Creek will be sampled for field parameters, surface water chemistry, and zooplankton. Sampling is scheduled to occur on a monthly basis from May through October.

Summary of Sample Types Collected by Study Year and Sample Site

	2005					2006					2007				
Site Name	Field Parameters*	Surface Water Chemistry	Sediment Chemistry	Mussels	Zooplankton	Field Parameters*	Surface Water Chemistry	Sediment Chemistry	Mussels	Zooplankton	Field Parameters*	Surface Water Chemistry	Sediment Chemistry	Mussels	Zooplankton
Bucket Lake			X	X		X	X	X	X						
Flat Island			X	X		X	X	X	X						
Finn Bay			X	X		X	X	X	X						
Whistlewing Bay				X		X	X	X	X						
Pile Bay	X	X	X		X						X	X			X
Knutson Bay	X	X	X		X						X	X			X
Northeast Bay	X	X	X		X						X	X			X
Roadhouse Bay	X	X	X		X						X	X			X
Upper Talarik	X	X	X		X						X	X			X

*Includes temperature, conductivity, dissolved oxygen, pH, ORP, and turbidity.

APPENDIX B

Field Forms

Pebble Project - Iliamna Lake Study - 2007- Field Data Collection Form

Station ID:	**Date:** / /07	**Start Time :** **End Time:**	**GPS - Lat:**
Team:		**Site Observer:**	**Long:**
Photos:	**Camera:**	**Weather: Air:** º (C) **Wind:**	**Precip:**

WATER QUALITY: Y N **Duplicate:** Y N **Triplicate:** Y N **MS/MSD:** Y N **Collection Method:** (Niskin)

Turbidity-Sample 1 (NTU):	**Depth-Sample 1 (m):**	**Turbidity Meter: HACH 2100 #**	**Turbidity Sampler:**
Turbidity-Sample 2 (NTU):	**Depth-Sample 2 (m):**	**Dissolved Metals Filter Lot #:**	**Filtered by:**
Turbidity-Sample 3 (NTU):	**Depth-Sample 3 (m):**	Hg Trip Blank: _____07TAPOWS60_____ (prim)	_____07CASKWS60_____ (trip)

Comments:

SECCHI DISK TRANSPARENCY: Y N

Disappear Depth: **Time:**

Reappear Depth: **Average Depth:**

Notes:

ZOOPLANKTON COLLECTION: Y N

Duplicate: Y N **# of sample bottles:**

Notes:

SEDIMENT COLLECTION: Y N

Duplicate: Y N **Triplicate:** Y N **MS/MSD:** Y N

Sediment Sample ID: **Collection Time:**

Collection Depth: **Collection Method:** (Ekman Dredge)

MUSSEL COLLECTION: Y N

Duplicate: Y N **Triplicate:** Y N **Collection Time:**

Mussel Sample ID: **Collection Depth (m):**

No. of organisms collected/sample: **Collection Method:** (Clam rake)

Mussel/Sediment Station Coordinates - Lat: **Long:**

Mussel/Sediment Notes:

Depth Profile Notes/Site Sketch:

Collection Summary: Depth Profile: Y N Water: Y N WQ Field Parameters: Y N Secchi Trans: Y N Zooplankton: Y N Sediment: Y N Mussels: Y N

Station ID:	**Date:** / /07	**Team:**
Meter Make and Model: YSI 556# _____		**Altimeter Reading:** **mm Hg**

Depth	Temperature	Relative Conductivity	Specific Conductivity	DO	DO (% sat)	pH	ORP	Notes
1 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
2 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
3 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
4 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
5 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
6 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
7 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
8 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
9 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
10 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
11 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
12 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
13 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
14 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
15 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
16 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
17 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
18 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
19 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
20 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Marine Studies

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

MARINE STUDIES

NOVEMBER 2005

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Figure A-2: Field Inventory Form

Figure A-3: Specimen Log Form

Figure A-4: Sample Transfer Form

Figure A-5: Fish Catch Record

Figure A-6: Field Team Member Acknowledgement Form

B – Field Instrument Manual and Calibration Procedures

C – Fish and Invertebrate Tissue Sampling Procedures

D – ADF&G Fish Collection Permit and Sampling Plan

E – Station Coordinates for 2005 Marine Studies Sampling Sites

Acronyms

ADF&G.....Alaska Department of Fish and Game
ADOT&PF.....Alaska Department of Transportation and Public Facilities
BEESC.....Bristol Environmental and Engineering Services Corporation
CAS..... Columbia Analytical Services, Inc.
cm.....centimeter
COC .....Chain-of-Custody
CORI.....Coastal & Oceans Resources Inc.
DI .....Deionized
FSP.....Field Sampling Plan
GIS .....Geographic Information System
GPS .....Global Positioning System
IIE .....Iniskin/Iliamna Estuary
m ..... meter
mm .....millimeter
NCA .....North Creek Analytical, Inc.
NDM ..... Northern Dynasty Mines Inc.
NEPA .....National Environmental Policy Act
NOAA .....National Oceanic and Atmospheric Administration
OCSEAP .....Outer Continental Shelf Environmental Assessment Program
Pentec.....Pentec Environmental
PN&D .....Peratrovich, Nottingham & Drage, Inc.
QAPP ..... Quality Assurance Project Plan
QA/QC .....Quality Assurance/Quality Control
SGS .....SGS Environmental Services, Inc.
Shaw.....Shaw Environmental, Inc.
TKN .....Total Kjedahl nitrogen
TL.....Total length
TOC.....Total organic carbon
UAF..... University of Alaska Fairbanks
USACE .....U.S. Army Corps of Engineers

1.0 Introduction

This Field Sampling Plan (FSP) presents protocols for collection of marine sediment and fish tissue samples to be collected during the 2005 Marine Studies Program for the Pebble Project. The Pebble Project is a proposed open pit mine being considered to recover gold, copper, molybdenum, and other metals from a deposit located near Iliamna, Alaska. Northern Dynasty Mines Inc. (NDM), the project sponsor, has commenced extensive study programs to collect the engineering, environmental, and socioeconomic data necessary for a bankable feasibility study and for applications for state and federal permits. The *Pebble Project, Draft Environmental Baseline Studies, Proposed 2005 Study Plan* (NDM, 2005a) provides a comprehensive description of the environmental studies being conducted in the onshore and offshore environments.

The Marine Studies Program will be conducted in Iniskin and Iliamna Bays (Figure 1-1) which comprise one of several estuarine complexes and embayments along the west side of lower Cook Inlet. The objective of the 2005 Marine Studies is to further characterize the fauna, flora, and habitat conditions in marine areas that could be affected by development of a port and related activities in the Iniskin Iliamna estuary (IIE). The intent of this study is to raise the information base to a level adequate to evaluate potential impacts of the project for compliance with the National Environmental Policy Act (NEPA) and to support other permitting activities. The 2005 study will build on historic information, including the results of the 2004 marine reconnaissance survey.

The field sampling effort in 2005 will be focused on intertidal and near-shore areas near the preferred potential port site (Port Site 1), and along shorelines that could be affected by the road route under consideration at this time. Figure 1-1 shows key features in the IIE considered for design of the reconnaissance study. Key assumptions include:

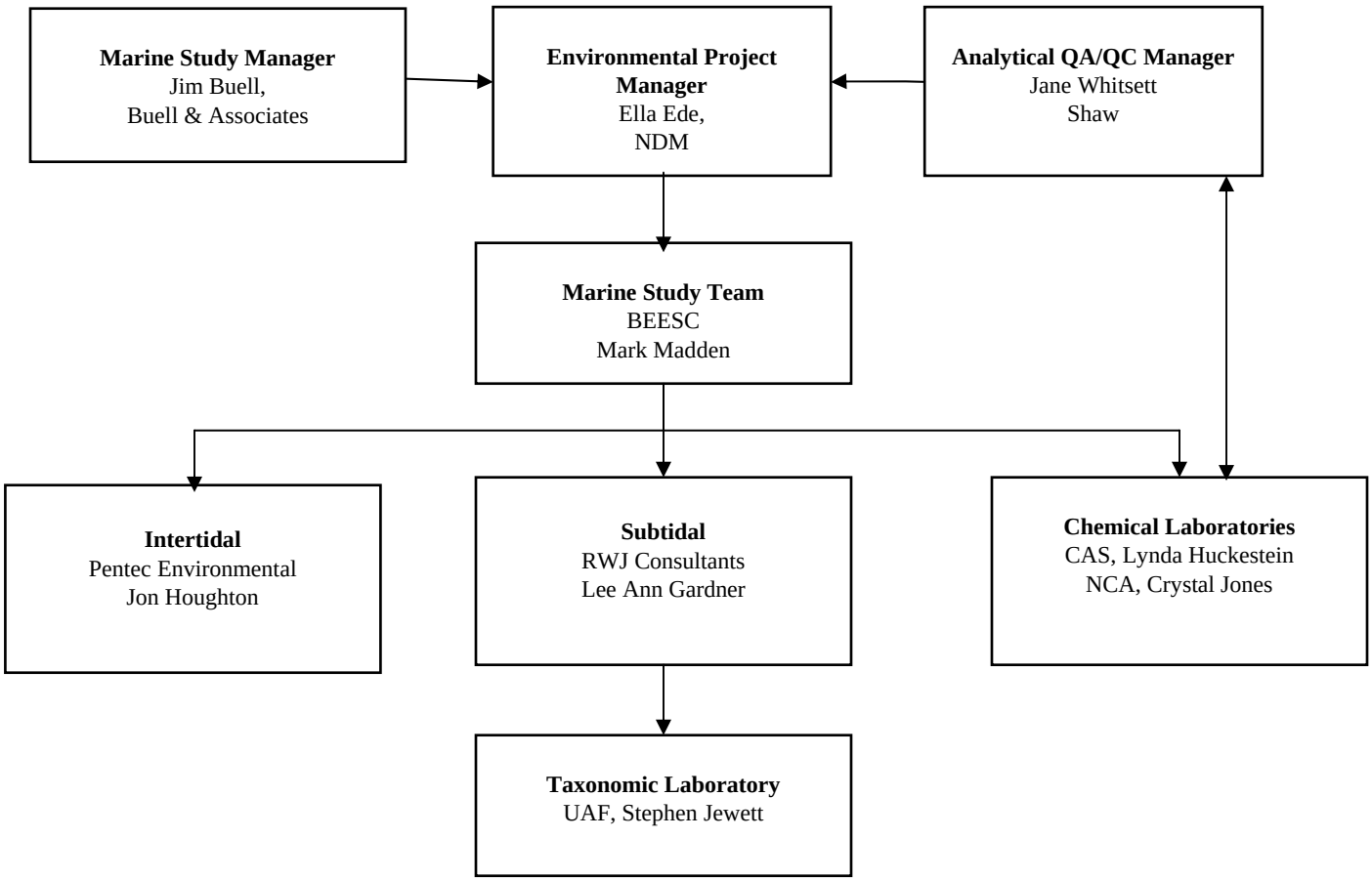
- A port facility to be constructed at or near the proposed Port Site 1, as identified in the Alaska Department of Transportation and Public Facilities (ADOT&PF) *Iliamna Regional Transportation Corridor Analysis* (PN&D, 2004). Upland port facilities would be located immediately adjacent to Port Site 1.
- A road will connect the port facilities to the mine. This study will focus on road development east of Williamsport to Port Site 1. The ADOT&PF preferred route Crosses Iliamna Bay near Williamsport, then runs along the eastern shore of Iliamna Bay, rounding North Head and Knoll Head. An alternate route (not shown on Figure 1-1) which crosses Iliamna Bay near Williamsport, then continues inland, down the ‘Y’ Valley to Knoll Head is also under consideration.

2.0 Organization and Responsibilities

2.1 Project Organization

NDM has selected Bristol Environmental and Engineering Services Corporation (BEESC) and its team of subcontractors to conduct the marine studies. This team will collect all field samples for laboratory analyses. Shaw Environmental, Inc. (Shaw) will provide analytical quality assurance and quality control (QA/QC) management for the project in accordance with the Quality Assurance Project Plan ([QAPP] NDM 2005b). Key personnel and their roles are identified in the organizational chart (Figure 2-1) and are described in Table 2-1. Table 2-2 summarizes the primary and QA analytical laboratories for the marine studies. Table 2-3 provides complete contact information for the analytical laboratories.

Figure 2-1
Pebble Project Marine Studies Organization Chart



2.2 Project Responsibilities

Project responsibilities for the Pebble Project marine studies are described in Table 2-1.

Table 2-1

Summary of Pebble Project Marine Studies Key Personnel and Roles

Personnel	Responsibilities
NORTHERN DYNASTY MINES INC.	
Bruce Jenkins, Chief Operating Officer	Responsible for development and execution of overall project scope and schedule.
Ella Ede, Environmental Project Manager	Provides oversight of project team, deliverables, and schedule.
Jim Buell, Buell & Associates, Marine Studies Manager	Responsible for oversight of sample collection and laboratory analyses associated with the marine studies at the proposed project port site as well as marine areas potentially impacted by the project.
SHAW ENVIRONMENTAL, INC.	
Jane Whitsett, Analytical QA/QC Manager	Responsible for preparation of QAPP and review of laboratory data and deliverables to ensure technical and quality requirements stipulated by regulatory agencies and NDM are met.
FIELD TEAM	
BEESC, Mark Madden, Marine Studies Project Manager	Provides oversight of marine studies field team, deliverables, vessel support, field work/collections, and schedule.
Jon Houghton, Intertidal Task Manager (**Pentec**)	Responsible for collection of data and samples in intertidal habitat, field documentation, and coordination of intertidal study team.
J. Starkes, Fishery Biologist (**Pentec**) S. Lindstrom, Algaogist (**Sandra Lindstrom**) D. Lees, Marine Biologist (**Littoral Ecological & Environmental Services**) L. Pedersen, Field Tech. (**BEESC**) M. Chambers, Field Tech. (**Pentec**)	Intertidal field team members responsible for collection of data and samples in intertidal habitat as directed by the Intertidal Task Manager.
Stephen Jewett, (**UAF**)	Responsible for oversight of taxonomic analyses.

Table 2-1
Summary of Pebble Project Marine Studies Key Personnel and Roles (Cont'd)

Personnel	Responsibilities
CHEMICAL LABORATORIES	
Columbia Analytical Services, Inc. Lynda Huckestein, Project Chemist	Responsible for executing and reporting laboratory scope of work for primary marine sediment, fish tissues, and invertebrate tissues collected by field teams.
North Creek Analytical Services, Inc. Crystal Jones, Project Chemist	Responsible for executing and reporting laboratory scope of work for QA samples for marine sediment, fish tissues, and invertebrate tissues collected by field teams.
TAXONOMIC LABORATORY	
University of Alaska Fairbanks Stephen Jewett, Lab Manager	Responsible for executing and reporting laboratory scope of work for taxonomic analysis of sediment infauna samples and prey species found in various fish species collected by field teams.

Table 2-2
Summary of Primary and Quality Assurance Analytical Laboratories for Marine Studies

Media	Primary Laboratory	QA Laboratory
Marine water and sediment	CAS – Kelso, WA	NCA – Portland, OR
Fish tissue and invertebrate tissue	CAS – Kelso, WA	NCA – Portland, OR

CAS = Columbia Analytical Services, Inc.
NCA = North Creek Analytical, Inc.

Table 2-3
Analytical Laboratory Contact Information

Crystal Jones North Creek Analytical, Inc. 9405 SW Nimbus Ave. Beaverton, OR 97008 503-906-9234 direct phone 503-906-9210 fax cjones@ncalabs.com	**Lynda Huckestein** Columbia Analytical Services, Inc. 1317 S. 13th Avenue Kelso, WA 98626 360-501-3358 direct phone 360-636-1068 fax lhuckestein@kelso.caslab.com	**Mike Priebe (local contact)** North Creek Analytical, Inc. 2000 W. International Airport Road, Suite A10 Anchorage, Alaska 99502 907-563-9200 phone, 907-317-3412 cell 907-563-9210 fax mpriebe@ncalabs.com

3.0 Marine Studies 2005 Sampling Plan

3.1 Field Study Program Activities

Field sampling tasks to be conducted for the Marine Studies Program in 2005 will include:

- Map and characterize intertidal habitat.
- Describe typical assemblages on major habitat types and in the several vertical zones or "biobands" at selected sites, including previously unsampled sites that might be affected by port access road.
- Collect infauna samples for quantitative analysis.
- Assess fish use of littoral habitat in intertidal and shallow subtidal areas by beach seining and otter trawling, respectively.
- Conduct *in situ* water quality measurements at beach seining and trawling sites.
- Collect littoral sediment and animal tissues for laboratory analysis of baseline metals and hydrocarbon concentrations.
- Collect pelagic and demersal fish in offshore subtidal areas with otter trawling for species identification and tissue analyses for baseline metals concentrations.

3.2 Field Sampling Schedule

Field sampling for the marine studies will be conducted by Pentec Environmental (Pentec) and BEESC personnel from May through September 2005 as shown in Table 3-1. Matrix codes, used to assist in uniquely identifying/labeling samples, are identified in Table 3-1 where applicable, and are discussed with specific examples in Section 5.5, Labeling and Field Documentation.

Table 3-1

Pebble Project Marine Studies Field Sampling Schedule for 2005

2005										
Consultant	**Area**	**Media**	**Matrix Code**	**Anal-ysis**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**
Pentec	Intertidal	Sediment	MZ	Chem-ical				X		
Pentec	Intertidal	Fish/Invert. tissues	TF	Chem-ical		X	X	X	X	X
Pentec	Intertidal	Sediment Infauna	-	Taxo-nomic				X		
Pentec	Seining / Trawling	Fish Stomachs	-	Taxo-nomic		X	X	X	X	X

Table 3-2 summarizes the analyses to be performed on each media to be collected, including reference to the analytical method to be used. Table 3-3 summarizes the anticipated samples to be collected and analyzed during the 2005 marine studies, including the number of samples by laboratory and matrix.

Table 3-2
Pebble Project 2005 Marine Studies Analytical Methods and Analytes

Parameter	Method (Solids)	Media	
		Sediment	Fish Tissue
Ammonia as N	SM4500NH3G	x	
Chloride	E300.0	x	
Cyanide, total	SM4500CN or E335.2	x	
Fluoride	E300.00	x	
Sulfate	E300.0	x	
TOC	E415.1	x	
Low-level mercury	E1631		x
Mercury	SW7471A	x	
Metals[1,2]	SW6010B/6020/7000/ E200.8	x	x
GRO	AK101	x	
BTEX	SW8260B	x	
DRO/RRO	AK102/103	x	
PAH	SW8270CSIM	x	x

[1] Metals to be analyzed in sediment include Al, Sb, As, Ba, Be, Bi, B, Ca, Cd, Co, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, Sn, V, Zn.
[2] Metals to be analyzed in fish tissue include Sb, As, Be, Cd, Cr, Cu, Pb, Mo, Ni, Se, Ag, Tl, Zn

BTEX = benzene, toluene, ethylbenzene, xylenes
DRO = diesel-range organics
GRO = gasoline-range organics
PAH = polycyclic aromatic hydrocarbons
RRO = residual-range organics
TOC = total organic carbon
E = EPA (1983, 1991 and 2001)
M = modified
SW = EPA (1993)
SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition. 1998.

Table 3-3

Pebble Project 2005 Marine Studies Expected Sample Quantities

Task	Medium	May	June	July	Aug	Sept	Total # of samples
Analytical Samples for 2005 – Primary Lab (Columbia Analytical Services, Inc.)							
Trace Elements/Inorganics[1]	Sediment			8			8
TOC/Ammonia as N, TKN	Sediment			8			8
Trace Elements[2]	Tissue — seine / trawl	5	5	5	5	5	25
GRO/BTEX/DRO/RRO/PAH	Sediment			8			8
Analytical Samples for 2005 —QA Lab (North Creek Analytical)							
QA Trace Elements/Inorganics	Sediment			1			1
QA Trace Elements[2]	Tissue — seine/trawl			2			2
QA TOC/TKN	Sediment			1			1
QA GRO/BTEX/DRO/RRO/PAH	Sediment			**1**			**1**
Infauna and Fish Stomach Samples for 2005 — Lab (University of Alaska Fairbanks)							
Infauna Species Identification/Quantification	Sediment - intertidal			40			40
Stomach – Prey Species Identification	Fish stomachs - seining	10	10	10	10	10	50
Stomach – Prey Species Identification	Fish stomachs - trawling	10	10	10	10	10	50

1 —Al, Ba, Be, Bi, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl , Cl, F, SO_4,and CN
2— Sb, As, Be, Cd, Cr, Cu, Pb, Mo, Ni, Se, Ag, Tl, Zn, and low level Hg
TKN = total Kjeldahl nitrogen
TOC = total organic carbon
GRO = gasoline-range organics
DRO = diesel-range organics
RRO = residual-range organics
PAH = polycyclic aromatic hydrocarbons
BTEX = benzene, toluene, ethylbenzene, and xylenes

3.3 Sample Locations

The 2005 field activities will occur at a variety of locations in the IIE. Some of these stations were previously occupied in 2004. Stations proposed for sampling in 2005 and those sampled in 2004 are shown in Figure 3-1.

Table 3-4 provides a summary of the marine studies stations, including types of sampling activities to be performed. Table E-1 in Appendix E provides a complete listing of the global positioning system (GPS) coordinates for all 2005 marine studies sampling stations.

The sampling station names noted in Table 3-4 follow the station naming convention as stipulated in the QAPP. That is, the station name must be no more than 5 letters/numbers, with the replicate number added at the end of the data field, e.g., 1 through 5, so that the total site identification does not exceed 6 characters.

3.4 Field Instruments/Equipment

Where applicable, makes and models of field instruments to be used for the 2005 marine studies are:

- YSI Model 85 Handheld Oxygen, Conductivity, Salinity and Temperature System (see Appendix B of this FSP for the Operations Manual containing detailed procedures and calibration procedures)

- Turbidity meter
- Beach seine (standard 37-m, fine mesh)
- 10' Otter Trawl (Research Nets, Inc.): Four-seam semi-balloon style, 1/2"-#9 body, 1"-#15 cod end and 1/4" knotless nylon liner; headrope 10' x 3/8" braided nylon with 2' extensions and 3 2-1/2"x3" floats; footrope 12' x 3/8" braided nylon with 2' extensions and 7 - 4 oz. rolling leads; treated with latex netcoat (green or black). Otter doors are 12"x24" plywood with runners and chain bridles. "V" – Bridle is 3/8" braided nylon with 2 - 20' legs

Field instruments will be calibrated according to the manufacturers' recommendations. See Appendix B of this FSP for field instrument manuals and calibration procedures. Where applicable, time and date of calibrations will be recorded in the field logbook. An entry will be made in the field logbook each time the field instrument is calibrated.

TABLE 3-4
Summary of Marine Studies Station Locations in Iniskin and Iliamna Bays

Station Name	Station ID	Sampling Activities			
		Beach Seining	Intertidal Mapping/ Sampling	Off-shore Trawls[1]	Water Qual. *In Situ* Meas.
Beach Seine Site 1	MBS1	X			X
Beach Seine Site A	MBSA	X			X
Beach Seine Site A1	MBSA1	X			X
Beach Seine Site 3	MBS3	X			X
Beach Seine Site 3A	MBS3A	X			X
Beach Seine Site 4	MBS4	X			X
Port Site 1	MPS1		X		X
Port Site 1 Seine Site A	MPS1A	X	X		X
Port Site 1 Seine Site B	MPS1B	X			X
Port Site 1 Seine Site C	MPS1C	X			X
Port Site 1 Trawl Site	MPS1T			X	X
Port Site 2	MPS2		X		X
Port Site 2 Trawl Site	MPS2T			X	X
Port Site 2 Trawl Site A	MPS2TA			X	X
Port Site 2 Trawl Site B	MPS2TB			X	X
Port Site 3	MPS3		X		
Port Site 4A	MPS4A	X	X	X	X
Port Site Existing (Williamsport)	MPSE	X			X
Port Site Existing Seine Site 1	MPSE1	X			X
Scott Island	MSI		X		
Blacky Beach	MBB	X	X		X
Trawl Site 1	MTR1			X	
Trawl Site 1A	MTR1A			X	
Trawl Site 2	MTR2			X	
Trawl Site 3	MTR3			X	

[1] Note: Trawling will only occur in soft bottom areas without rocky substrates to prevent damage to gear; if unknown, the status of bottom type will first be determined by inspection during low tides or vessel instrumentation.

4.0 Field Methods

For all field sampling, team members will follow the procedures identified in this FSP and abide by the Alaska Department of Fish & Game (ADF&G) collection permit requirements (see Appendix D, ADF&G Fish Collection Permit, Application, and Sampling Plan). All biological samples must be recorded on the Fisheries Resources Permit Collection Log (included in the field forms).

The sampling program will study the nature and usage of the nearshore and intertidal habitats in the project area. The intertidal studies will include habitat mapping, epibiota quantification on hard substrata, infauna and sediment collections on soft substrata, tissue collections, and beach seining.

4.1. Intertidal Mapping and Characterization

Intertidal habitat types present around portions of the IIE that may be directly impacted by port development will be mapped, including the Williamsport area and the east side Iliamna Bay, the southwest side of Iniskin Bay, and the headlands between the two bays. Intertidal habitat mapping will build on the base information from the Cook Inlet Regional Citizen's Advisory Council (CIRCAC and EVOS, 2005).

Where field observations differ significantly from existing mapping, dominant substrate types observed in the upper, middle, and lower intertidal zones will be recorded separately. Mapping will include documentation of transitions between habitat types using GPS for later incorporation into the project Geographical Information System (GIS) database.

4.2 Intertidal Epibenthic Assemblages

Intertidal epibenthic assemblages on rocky and boulder/cobble substrata will be quantified in fixed quadrats on fixed transects. The sampling program will revisit some sites established in 1978, 1996, and 2004 and will establish new sites along Iliamna Bay to evaluate potential impact from construction of the port access road. Key historic sampling locations will be revisited to ensure that monuments are well established for future reference as well as to evaluate trends observed in algae and epibiota on these beaches. Proposed sampling locations are shown on Figure 3-1 and listed in Table 3-4.

With the help of photographs and previously placed markers, previously sampled intertidal rocky sites and elevations will be resampled as close as possible to the locations (specific quadrats) previously sampled. New sites will be located to be representative of intertidal habitats along previously unsampled shorelines in the IIE that may be impacted by the port or port access road alternatives. At each intertidal sampling site, two or three elevations will be sampled that are representative of the gradient of assemblages present. At some sites, there may be significant substrate changes between the upper and lower elevations. For most of the new Iliamna Bay sites, only upper and possibly middle elevations will be rocky, with many middle and all lower elevations occurring on the mudflats and sampled as soft sites.

At each elevation sampled on rocky or boulder/cobble habitat types, a 30-meter transect line will be laid out along the tidal elevation contour line. Along each transect, five to ten 0.25-m^2 quadrats will be randomly located, or, in the case of previously sampled random quadrats,

relocated. In 2005, we will seek to establish permanent marks of marine epoxy, nails, or rebar to allow precise repositioning of each quadrat in subsequent sampling.

Once the quadrat is positioned, a photograph will be taken of the quadrat and immediate surrounding substrate. A pre-printed label showing date, site, elevation and quadrat number will be included in each photograph. In each quadrat, the nature of the substrate and percent cover of all algal species and all sessile animals will be estimated and recorded on the Intertidal Field Form (see Figure A-1 in Appendix A). Area of coverage less than 0.5 percent will be recorded as 0.5 percent. Counts will be made of all mobile species larger than about 4 millimeters (mm) in size. Dominant species will be identified along with less numerically abundant but ecologically important "keystone species." Very abundant organisms may be subsampled by counting the numbers in a randomly selected subsection of the quadrat; data recorded will reflect that subsampling ("=count x 1/fraction of quadrat counted"). Detailed species lists will be compiled for each habitat type and elevation and recorded on the Intertidal Field Form (Figure A-1). These data will provide a quantitative baseline for comparison with the data available from previous work in the IIE, and for assessment of potential project impacts.

4.3 Intertidal Infauna and Sediment Characterization

Intertidal infaunal and sediment sampling in soft-bottom habitats (sand or mud) will be conducted to establish the type and distribution of infaunal species in the soft intertidal areas (Figure 3-1). Previously sampled sites will be relocated by using pre-recorded GPS coordinates; previously placed rebar stakes; or other means (e.g., large boulder). New sites along the east side of Iliamna Bay will be similarly marked; most, if not all will comprise the lowest elevation sampled at sites with rocky upper and/or middle elevation stations. At most soft sites, only a single elevation will be sampled.

At each elevation, five replicate samples will be taken at random distances from a transect head stake. Samples will be taken with a 15-centimeter (cm) deep, 80-cm^2 hand corer. In addition, at each infaunal core location, two, 2-cm deep sediment samples will be taken from undisturbed sediments adjacent to each core location to form three composite samples: one sample for analysis of total organic carbon (TOC) , ammonia as N and total Kjeldahl nitrogen (TKN), and one for analysis of metals and petroleum hydrocarbon concentrations.

Infauna samples will be processed in the field by washing and sieving through a 1.0-mm mesh screen. Infauna will then be preserved in 10 percent neutral buffered formalin solution with 0.1 percent rose Bengal dye. Each sample will be checked off by the sampler on the Field Inventory Form (Figure A-2). The preserved samples will then be transported to the University of Alaska - Fairbanks (UAF) laboratory in Fairbanks, Alaska. At the taxonomic laboratory, the samples will be transferred from the formalin solution to a 50 percent isopropyl alcohol solution for archival and storage until their analysis (i.e., taxonomic identification).

Each sediment and infaunal sample will be checked off by the sampler on the Field Inventory Form (Figure A-2 in Appendix A). These samples will be entered on the Sampling Transfer Form (Figure A-4) and then packed in coolers and delivered to Shaw as prescribed in the Project QAPP (NDM, 2005b). The Sample Transfer Form will accompany each cooler shipment at all times. Prior to shipment, samples will be segregated into coolers based on laboratory destination. See additional information in Section 5.5, Labeling and Field Documentation.

At selected soft intertidal sites, additional sampling will be conducted to quantify epibiota and larger mega-infauna such as large clams, polychaetes, and echiurids. Each randomly located 0.25-m^2 quadrat will first be photographed in the manner described for rocky sites above. All epibiota will be recorded as described for rocky sites. The quadrat will then be excavated to approximately 25 to 30 cm and either sieved or visually examined for animals larger than approximately 5 mm. Organisms may be identified in the field or collected in clean plastic bags for later identification and enumeration on the support vessel; alternatively, they may be preserved and returned to the analytical or taxonomic laboratory for processing.

4.4 Intertidal Tissue Collections

Selected species (e.g., bivalves *Mya* spp. or *Macoma* spp.) from soft bottom sampling in the larger (0.25-m^2) quadrats or from selective searching in the vicinity of soft bottom sites will be saved for trace metal analyses. Additional species (e.g., mussels *Mytilus trossulus*) which are available at many rocky sites also will be collected for trace metals analysis. Sampling will be done opportunistically in the immediate vicinity of established study sites shown in Figures 3-1. All tissue samples will be listed in the Specimen Log Form (Figure A-3), with information filled out as completely as possible when applicable.

Specimens collected for laboratory analysis of baseline trace metals concentrations will be counted, identified by species, the date and collection locations noted, and if applicable, sex, life stage, age, and lengths and weights will be recorded. For mussels, because their size will be generally small, and because they were consistently found in the IIE in 2004, enough animals will be collected over a wide geographical area at each site to approximate a 25 gram sample of tissue, as noted in the sampling plan submitted to the Alaska Department of Fish and Game (ADF&G) as part of BEESC's 2005 Fish Resource Collection Permit application (see Appendix D). See Figure A-3 and the accompanying documentation in Appendix A for the Specimen Log Form.

All tissue samples will be packaged and shipped to the appropriate analytical laboratory according to the Project QAPP (NDM, 2005b).

4.5 Nearshore Fish Assemblages (Seining)

An important function of the littoral zone is its role as a nursery for juvenile salmonids and other forage fish as well as for several important invertebrates. Seining will be performed monthly from May though mid September with more intensive surveys in late May and early June during expected salmonid out-migration through the estuary (see Table 3-1 for the 2005 marine studies field sampling schedule). Proposed beach seining locations are identified in Table 3-4 and shown on Figure 3-1. Beach seining will be conducted using a standard 37-m, fine-mesh seine at up to 11 locations along moderate to low gradient, mud, sand or gravel beaches in Iniskin and Iliamna Bays. Catch will be identified by species and recorded on the Fish Catch Record (see Figure A-5). Total lengths of a representative number of each cohort will be measured to determine the dominant size classes using this shallow water habitat at that time; these data will also be recorded on the Fish Catch Record (Figure A-5).

BEESC will rely on ADF&G herring spawn survey data in the IIE and adjacent bays to further characterize the IIE intertidal habitat. ADF&G currently surveys the study area by air on a

weekly basis, weather permitting, with at least one on-water survey annually. Use of ADF&G personnel will ensure that the surveys methods are consistent with ongoing surveys in the area and defensible. ADF&G has already provided data to our team on surveys conducted between 1978 and 2002. Field crews will seek to minimize the catch of adult herring but will document locations along the shoreline where herring schools and spawning are observed. If time permits, they will also take GPS readings on areas of spawn deposition and notes on algal species receiving spawn deposition.

During seining events, water quality measurements will be made with *in situ* field instruments to record turbidity, conductivity, salinity and temperature.

4.6 Offshore Otter Trawling

Trawling with a "try-net" will be conducted concurrent with other marine studies activities to evaluate both resident and migratory species and event-related species interaction such as herring spawning (see the 2005 field sampling schedule in Table 3-1)**.** During the intertidal beach-seining program, the try net will be fished at 4 to 6 locations over flooded tide flats and channels in both Iniskin and Iliamna bays. The locations include at least 3 of the 4 sites sampled in 2004 with additional stations located in Iliamna Bay.

A 3-meter "try net" will be used in soft bottom, subtidal areas and flooded low intertidal soft bottom areas identified during low tides, to sample demersal fish and large invertebrates that may be missed by other sampling protocols. Catch will be identified by species and recorded on the Fish Catch Record (Figure A-5) as well as the Specimen Log Form (Figure A-3) for ADF&G Collection Permit reporting. A representative number of each cohort will be measured to identify dominant size classes using this habitat. Selected specimens will also be retained for tissue metals analyses and/or stomach content analysis (see Table 3-3 and Section 4.4, Offshore Tissue Collections, and Section 4.7, Offshore Fish Stomach Sampling). Fish dissections will follow the procedures noted in Appendix C of this FSP. In addition, procedures will meet the ADF&G Collection Permit requirements (see Appendix D).

During trawling events, water quality measurements will be made with *in situ* field instruments to record turbidity, conductivity, salinity and temperature.

4.7 Offshore Fish Stomach Sampling

Stomach samples will be collected during the field season as noted in the field schedule Table 3-1 and in the sample quantities noted in Table 3-3. Fish will be collected in the IIE during beach seining, trawling, and with hook and line.

Stomach dissection and sampling methods are modified from Nielson and Johnson (1983) and are summarized in Section C.1.4 of Appendix C. For large fish (i.e., >155 mm or 6 inches, total fork length [TL]), the fish stomach will be extracted and preserved in the field. For smaller fish (<155 mm or 6 inches TL), the fish stomach will remain in the fish, using the methods detailed in Section C.1.4.2.

5.0 Environmental Sampling

5.1 Field Tissue Collection

Fish, invertebrates and other organisms collected for tissue sampling will be rinsed in clean seawater upon collection to remove mud, sediment, or other debris from the outer surfaces as needed. Specimens will be placed in a clean plastic bag. Smaller fish and invertebrates that will be combined into a single tissue sample may be placed in the same bag. Larger fish or specimens that will be submitted as separate samples to the laboratory shall be segregated into separate bags. All samples will be kept on ice until properly prepared and packaged for shipment to the laboratory.

5.2 Decontamination Procedures – Sediment Sampling

All sample collection equipment which comes into contact with a sample will be decontaminated by means of the following procedure prior to each sample collection. Sample collections which require multiple attempts or passes to acquire adequate sample volume are considered a single sample collection:

1. Rinse in potable fresh water.
2. Wash with Alconox, or the equivalent in potable fresh water or distilled water.
3. Rinse in distilled water. If sampling is being done for low-level mercury, use deionized (DI) water instead for this step.
4. Rinse in DI water (i.e., if sampling is for low level mercury, do second rinse with DI water).

5.3 Sample Containers

For all field samples collected for chemical analysis (except biological tissues), containers will be provided by the laboratory selected to conduct the analysis. Samples for chemical analysis will be submitted to Shaw for entry into the electronic chain-of-custody (COC) system. Shaw will be responsible for final shipping and delivery of samples to the analytical lab. Samples for taxonomic analyses will be shipped by the field team to the UAF laboratory. Tables 5-1, summarizes the required containers, sample volumes, preservation, and maximum holding times for all parameters for inorganic sample media. Tables 5-2, summarizes the required containers, sample volumes, preservation, and maximum holding times for all parameters for tissue samples.

Table 5-1
Pebble Project Sample Bottle Schedule and Sampling Parameters for Marine Sediment

Analytical Set	Bottle Type (CAS)	Analysis	Lab Method	Preservative	Hold Time	Req. Temp.	Comments
	(1) 1L HDPE No extra volume for MS/MSD	Total Metals[1] (water)	E200.8/200.7	HNO_3	6 Months	None	Equipment rinsate blanks
1	(1) 8oz	Total Metals[1]	SW6010B/6020/ 7471 (Hg)	None	6 Months	None	
2	(1) 4 oz prewt'd amber	Gasoline Range Organics	AK101	MeOH w/surrogate	28 days	4 °C	2nd 4 oz % solids jar if no other analyses
3	(1) 4 oz prewt'd amber	Benzene, toluene, ethylbenzene, and xylenes	SW8260B	MeOH w/surrogate	14 days	4 °C	2nd 4 oz % solids jar if no other analyses
4	(1) 8 oz	Diesel/ residual range organics	AK102/103	None	14 days to extraction, 40 days to analysis of extract	4 °C	
5	(1) 8 oz	PAHs	8270C SIM	None	14 days to extraction, 40 days to analysis of extract	4 °C	
6	(1) 4 oz	Cyanide	SM4500CN-E	None	28 days [2]	4 °C	
7	(1) 4 oz	Ammonia as N, TKN	SM4500NH3	None	28 days	4 °C	
8	(1) 4 oz	Chloride	E300.0	None	28 Days [3]	4 °C	
		Fluoride	E300.0	None	28 Days [3]	4 °C	
		Sulfate	E300.0	None	28 Days [3]	4 °C	
9	(1) 4 oz	Total Organic Carbon	E415.1	None	180 Days	4 °C	

1 — Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl, B, Hg
2 — As per EPA methods fact sheet titled "Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity"
3 — Holding time is from the date of preparation
oz = ounce
prewt'd = preweighed and tared
CAS - Columbia Analytical Services, Inc.
MeOH = methanol
PAH = polycyclic aromatic hydrocarbons
TKN = total Kjeldahl nitrogen

Table 5-2
Pebble Project
Sample Container Schedule and Sampling Parameters for Biological Tissue Collection

Tissue Type	Minimum Sample Amount, (grams)	Bottle Type (CAS/NCA)	Analysis	Lab Method	Shipping Preservation and Time	Hold Time	Required Laboratory Storage Temp.
Fish & Inverts.	45	Ziploc or similar plastic bag	PAHs	8270C SIM	Cool on blue ice or freeze on dry ice if shipping time will exceed 24 hours. Samples must arrive at the lab within 48 hours of shipment.	1 year	Freeze at ≤ -20 °C
			Low-level Hg	E1631		28 days	
			Total Metals[1]	SW6010B(Cr) E200.8 SW7740 (Se) SW6010B/6020		6 Months	

1 — Sb, As, Be, Cd, Cr, Cu, Pb, Mo, Ni, Se, Ag, Tl and Zn.

5.4 Sample Collection and Handling

Field collection and handling procedures will be used to meet QA/QC objectives. Sample handling and custody procedures are required in the field and the laboratory, and during transport. These procedures take into account the nature of the samples, the maximum holding times, and shipping options from the project site to the laboratories. The Field Task Managers are responsible for implementing the sample handling and shipping procedures and will check for QA measures on these activities.

5.4.1 Sediment Sampling

Sediment samples will be collected for analysis in the following order, in order of sensitivity of the analysis. That is:

1. Organics/hydrocarbons
2. Total metals
3. Miscellaneous parameters (e.g., ammonia, phosphorus, Cyanide, etc.).

To expedite filling of sample containers, a suitable transfer container (e.g., large bowl for sediment) of the appropriate type of material will be used to speed the filling process and to minimize spillage. These containers and the spoons or other implements used to do the sample transfer will be decontaminated after each sampling event at each station.

Sample containers will be discarded if the container has been damaged or it is apparent that the preservative (if applicable) has leaked out of the container.

5.4.2 Tissue Sampling

For fish being collected for contaminant analyses, fish collection procedures will follow many of the methods of Zhang et al. (2001) and Jewett et al. (2003). Also see Appendix C of this FSP, Fish and Invertebrate Tissue Sampling Procedures. General procedures include:

- Total fish fork length and sex will be recorded for each specimen in the field, when feasible; any necessary dissection to determine sex will be done using surgical sheets, powder-free latex gloves, and an acid-washed titanium or high-quality stainless steel knife or scalpel. The disposable gloves will be changed out between each dissection.
- For smaller fish (e.g., < 6 inches or 155 mm TL), the entire animal will be placed in a Ziploc-type plastic bag and frozen immediately.
- For larger fish (e.g., > 6 inches or 155 mm TL), immediate freezing of all tissues in an entire animal would be difficult under field conditions.

Therefore, tissue dissections for muscle and liver samples in larger fish will be done in the field as follows:

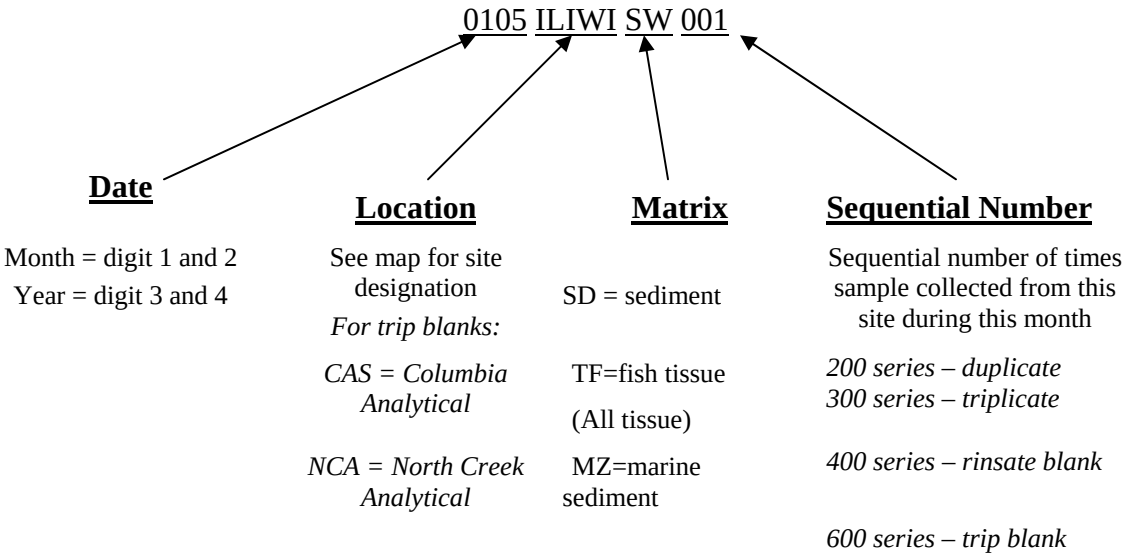
- Immediately upon capture, fish will be placed in clean plastic bags and placed in a cooler with ice.
- Dissection will occur indoors onboard the ship.
- The cutting surface will be washed with soap and water and covered with heavy-duty aluminum foil.
- Either stainless steel disposable scalpels or stainless steel knives will be used for dissection. Scalpels/knives with visible rusting will not be used. Knives will be washed with soap and water and rinsed with DI water between uses. Scalpels will be replaced between fish.
- An approximate 50-gram sample of liver and muscle tissue will be extracted from each fish using powder free gloves and placed in an individually labeled Ziploc bag. Tissue samples will be immediately placed in a freezer.
- An equipment blank will be prepared BEFORE each set of dissections by rinsing the cutting surface and the knives with DI water and collecting the rinse water in an acid-washed jar provided by the analytical laboratory.
- Frozen tissue samples will be packaged in a cooler and sent to the laboratory using packaging recommendations provided by the lab. Chain-of-custody procedures will be followed.
- Each sample from an individual fish will be labeled with the sample ID number and include a suffix of “M” for muscle or “L” for liver tissue (see Section 5.5).
- For the fish tissue samples from large fish, the muscle tissue will be collected immediately below the dorsal fin. When doing the tissue dissections, at least 50 grams of tissue for each type of tissue sample, or about a 3x3x2-inch piece of tissue, will be collected.
- Collect at least 75 grams of tissue for 10 percent of the fish samples. This will allow the preparation of QA/QC samples at the primary tissue laboratory (CAS). CAS will then ship QA samples to NCA for analysis.

5.5 Labeling and Field Documentation

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 sample will be checked off by the sampler on the Field Inventory Form (Figure A-2) noting day and time of collection and to ensure that all samples are collected and labeled properly prior to moving onto the next sampling station.

In addition to the bottle label, the following information will be entered onto the Sample Transfer Form (see Figure A-4 in Appendix A) for placement in the shipping cooler. An example of sample identification is as follows:



For large fish with analyses conducted on both muscle and liver tissue, the sample ID will include a suffix of "M" for muscle or "L" for liver tissue. For example, fish liver tissue from location MPS4 collected on August 20, 2005, would have the following sample ID:

0805MPS4TF001L.

It is extremely important that the Specimen Log Form (Figure A-3 in Appendix A) is filled out for EVERY tissue sample collected. This log sheet includes all the information that will be needed to properly report the animals collected/sacrificed under the 2005 ADF&G Collection Permit. It is extremely important that this sheet be filled out as completely as possible for all information that is applicable to the animal (even if it is not sent to the lab, e.g., due to damage. see further discussion in Appendix C, Fish Dissection Procedures, as well as the specific Specimen Log Form directions in Appendix A for Figure A-3).

5.6 Blank, Duplicate, and Triplicate Samples

A number of QA/QC samples will be collected in the field to assess sample contamination, precision, and accuracy. A summary of field QA/QC samples and the frequency of collection is given in Table 5-3. The types of QA/QC samples are:

- Field Duplicates – For sediments, duplicate samples are taken in the field and analyzed in the laboratory to account for both the sample matrix variability and variability in sampling and analytical practices. Each field duplicate will be collected by filling two sets of containers simultaneously, using the same sampling procedure. Each sample container is treated as a separate sample. For fish tissues, the field duplicate is collected from the homogenate prepared at the laboratory.
- Equipment Rinsate Blanks (also known as decontamination blanks) - These blanks will assess the contamination effects on accuracy due to the combined activities of sampling and analysis. When decontamination occurs, field blanks will be prepared by routing deionized/distilled water through recently decontaminated sampling equipment (e.g., grab sampler, dissection knife) BEFORE beginning the actual sampling or dissection. The final rinsate will be collected in a set of sample containers and analyzed. These samples will verify the efficiency of the decontamination process by detecting any residual chemical constituents remaining on the equipment.
- Trip Blanks - These blanks are used to monitor inadvertent contamination that might occur while the sample containers for VOC in sediments are in transit. This sample is typically a sample of methanol that is placed in each cooler with the sample bottles prior to their shipment into the field. The trip blanks will verify that no inadvertent contamination occurred in the project samples while they were in transit or while stored on-site in the field location.
- Field Triplicates – For sediment samples, field triplicates are collected in the same manner as noted for field duplicates. The triplicate sample is forwarded to a separate designated QA laboratory (see Table 2-2 for the designated laboratories for the primary analyses and the QA laboratories) as an independent check of the primary laboratory. For fish tissues, the field triplicate is collected from the homogenate prepared at the laboratory from the same fish sample as the duplicate..

Each QA sample will be labeled as noted in Section 5.5, Labeling and Field Documentation.

Table 5-3
Pebble Project Marine Studies Summary of Field QA/QC Samples

Type of Field QA/QC Sample	Analysis	Frequency	Sampling Events
Field Duplicate (QC sample)	All Parameters	10 percent	All
Field Triplicate (QA sample)	All Parameters	10 percent	All
Equipment blank	Total Metals	5 percent	Marine sediment, fish tissues (liver/muscle)
Trip blank	VOCs	1 per cooler	Marine sediment

5.7 Field Corrective Action

Field sampling and quality assurance procedures are contained in this FSP. While in the field, corrective actions are the responsibility of the Task Managers, in consultation with the BEESC Project Manager. When a failure in the sampling system occurs, this management team will cooperate to investigate the failure and implement necessary corrective action(s).

6.0 References

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FIGURES

1,700,000

1,750,000

2,050,000

Sand & Mud

Right Arm

Foul

Rk

Rks

Bld

M

Cl

Reef
(Cov 1 ft at MLLW)

INISKIN BAY

Summit Lakes

Williams Creek

Williamsport

Back Range

A.C. Point

North Head

Knoll Head

Mushroom Islets

Scott I

The Toadstools

Mt Pomeroy

Diamond Pt

ILIAMNA BAY
(use inset)

COTTONWOOD BAY
(use inset)

Kelp

Vert

Iniskin Rk

Iniskin I

Iniskin Shoal

Pomeroy I

Black Reef

White Gull I
(70)

Turtle Reef
rky (15)

South Head

Big Rk
(9)

LOCAL MAGNETIC DISTURBANCE
(see note)

S Oz

S M

Northern Dynasty Mines Inc.

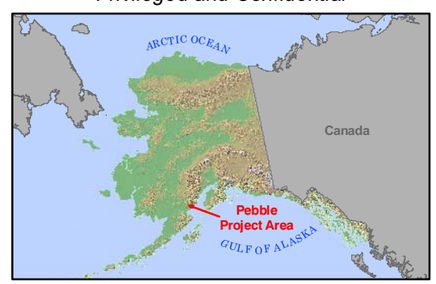
Pebble Project

Study Area,
2005 Marine Studies Program
Figure 1-1

Legend

- Port Site 1
- Preferred ADOT&PF Road Corridor

Privileged and Confidential



N

0 0.7 1.4 2.1 2.8 Miles

0 0.8 1.6 2.4 3.2 Kilometers

Scale 1:70,000

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Marine_01_V03.mxd	Date: Sept. 26, 2005
Version: 3	Author: BEESC-ME

1,700,000

1,750,000

2,050,000

Northern Dynasty Mines Inc.

Pebble Project

2005 Marine Sampling Locations

Figure 3-1

Legend

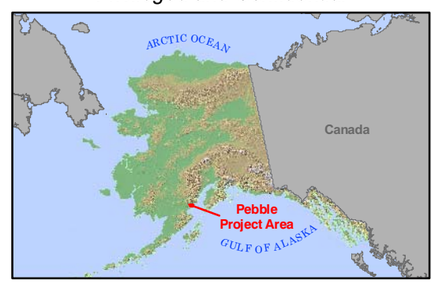
- Port Site 1

Marine05_V01

Sample_Typ

- Beach seine
- Infauna/sediment sample
- Intertidal
- Trawl
- Preferred ADOT&PF Road Corridor

Privileged and Confidential



N

Miles
0 0.7 1.4 2.1 2.8

Kilometers
0 0.8 1.6 2.4 3.2

Scale 1:70,000

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Marine05_V01.mxd	**Date: Sept. 27, 2005**
Version: 1	**Author: BEESC-ME**

APPENDIX A
FIELD DATA FORMS AND LOG FORMS

Pebble Marine Studies - Intertidal Inventory Field Form

Page of

Date: Observer:

Station: Elevation:

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Substrate										
Bedrock										
Boulder/cobble										
Gravel/sand										
Mud										
Water										
Oil Scale (prim.)										
Oil Cover (prim.)										
Oil Scale (sec.)										
Oil Cover (sec.)										
Subsurface oil										
Plants (% cover)										
Acrosiphonia areta										
Alaria marginata										
Alaria taempata										
Articulated coralline algae										
Blue-green algae, crust										
Blue-green spheroids										
Ceramium cimbricum										
Cladophora sericea										
Clathrohmorphlam reclin										
Constanfanea sub										
Corallum frondes										
Cryptosiphonia woodii										
Diatoms										
Diatoms scuz										
Elaschista fucicola										
Encrusting brown algae										
Encrusting coralline algae										
Encrusting green algae										
Encrusting red algae										
Endocladia muricata										
Enteromorpha intestinalis										
Enteromorpha Linza										
Enteromorpha prolifera										
Filamentous brown algae										
Filamentous green algae										
Filamentous red algae										
Flagelliform brown algae										
Fucus gardneri										
Fucus gardneri, germlings										
Gloiopeltis furcata										
Halosaccion glandiforme										
Hildenbrandia rubra										
Laminaria adoenlandica										
Laminaria, juv.										
Lominara sp.										
Iridaea heterocarpa										
Leathesia difformis										
Mastocarpus papillatus										
Mazzaella sp.										
Melanosiphon intestinalis										
Monostroma grevillei										
Neohypophyllum middendorfii										
Neorhodomela aculeata										
Neorhodomela larix										
Neorhodomela oregona										
Odonthalia flocccosa										
Odonthalia kamschatica?										
Odonthalia sp.										
Palmaria callophylloides										
Palmaria hecatensis										
Palmaria mollis										
Parphraa aesturlis										
Petrocelis spp.										
Pilayella littoralis										
Polysiphonia spp.										
Porphyra										
Pterosiphonia bipinnata										
Ptilota filicina										
Ralfsia fungiforms										
Ralfsia spp.										
Red Crust										
Rhodochorton purpureum										
Soranthera ulvoida										
Ulothrix spp.										
Ulva/Ulvaria supp.										
Verrucaria sp.										
Dead Plants (%)										
Articulated coralline (dead)										
Encrusting coralline (dead)										
Fucas gardneri (dead)										
Animals										
Abarenicola (casts)										
Anthophleura artemisia										
Buccinum baeri										

Figure A-1 Intertidal Field Form

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Cancer oregonensis										
Cryptobranchia concentrica										
Demasterias imbricata										
Evasterias troschelii										
Gammaridea										
Gnorimosphaeroma oreg.										
Henricia Lumida										
Hiatella arctica										
Lacuna spp.										
Leptasterias hexactis										
Ligia										
Littorina scutulata										
Littorina sitkana										
Littorina scut., juv.										
Littorina sitk., juv.										
Lottidae										
Lottidae, juv.										
Lottia digitalis										
Lottia pelta										
Lottia strigatella										
Margarites marginatus										
Margarites pupillus (spiral)										
Modiolus modiolus										
musculus spp.										
Nemertea										
Nucella lamellosa										
Nucella eggs										
Nucella lima										
Onchidella borealis										
Orange sponge										
Pagurus granosimanus										
Pagurus hirsutiusculus										
Pagurus spp.										
Paranemertes peregrina										
Pentidotea wosnesenskii										
Pholidae										
Pholis laeta										
Pholis ornata										
Pisaster ochraceus										
Searlesia dira.										
Serpula vermicularis										
Siphonaria thersites										
Tectura persona										
Tectura scutum										
Tonicella lineata										
Animal Area Cover (%)										
Balanus crenatus										
Balanus glandula										
Balanus rostratus										
Balanus/Semibalanus set										
Balanus/Semibalanus spp.										
Chthamalus dalli										
Chthamalus dalli, set										
Encrusting bryozoan										
Halichondria										
Littorina spp, eggs										
Mytilus sp.										
Mytilus sp., spat										
Nucella eggs										
Porifera, color?										
Rhynchozoon bispinosum										
Semibalanus balanoides										
Semibalanus balanoides, set										
Semibalanus cariosus										
Semibalanus cariosus, set										
Spirobidae, unid.										
Dead Animals										
Balanus crenatus, dead										
Balanus grandula dead										
Balanus/Semibal., dead										
Chthamalus dalli, dead										
Mytilus sp., dead										
Nucella lamellosa, dead										
Semibal. balanoides, dead										
Semibal. cariosus dead										
Spirobidae, dead										

Figure A-1 Intertidal Field Form

PEBBLE PROJECT MARINE SAMPLE INVENTORY

Date: _____

Media	Location	Station	Sample ID	Date/Time Collected	# of Containers	Analysis	Preservative	Lab	Comments	Sample Transfer Form #

Page _____ of _____

Figure A-2 Field Inventory Form

A.3 Specimen Log Form

It is extremely important that the Specimen Log Form (Appendix A-2) is filled out for EVERY tissue sample collected. This log sheet includes all the information that will be needed to properly report the animals collected/sacrificed under the 2005 ADF&G Collection Permit. It is therefore important that this sheet be filled out as completely as possible for all information that is applicable to the animal (even if it is not sent to an analytical laboratory but is sacrifced, e.g., due to damage—see further discussion in Appendix C, Fish Dissection Procedures). All Specimen Log Form codes are listed on the bottom of the form; some further explanation is provided below for a fish and an invertebrate.

For a fish, the Specimen Log Form (Figure A-2) fields should be filled out as follows:

- Enter Control I.D. No. - begin with 001 for all animals collected that day at that station, then 002 for the second animal etc. When move to another station, OR continue sampling the next day at the same station, start over again with 001
- Enter Station I.D. - include site number or intertidal zone (low, L; middle, M, if applicable)
- Date (MMDDYY) and Time Collected (military format e.g., 1730 for 5:30 p.m.)
- Species - if uncertain, e.g., sculpin, identify to Family or Genus if possible
- Sex - note sex if large fish and can be dissected for positive i.d.; if smaller fish, e.g., 6 inches or 155 mm, do not gut to sex but note if there are distinctive external characteristics to determine sex
- Fish fork length - in cm
- Fish weight - in gm
- Life stage - adult, juvenile, fry, larvae
- Egg Condition – if present, note if eyed/non-eyed
- Gear type – crab pot (CP), shrimp pot (SP), hook and line (HL), seine, trawl, diver, hand
- Type – QA sample (QA), voucher specimen (V), or other (specify)
- Other Comments - note number of animals in sample if more than one animal is needed to obtain 50 g of soft tissue; if animal was damaged and therefore not sent to the lab for analysis; other information of interest.

For an invertebrate, the Specimen Log Form would be filled out as above with the following differences:

- Enter Control I.D. No. - begin with 001 for first animal collected that day at that station (or for first sample of 50 g soft tissue, such as in mussels), then 002 for the second animal/sample, etc. When move to another station, OR continue sampling the next day at the same station, start over again with 001
- Sex – identify sex of crab by using characteristics on ventral side (see crab field guidebooks for differentiating characteristics)

- For crab, note carapace width/length (in mm); for group of mussels note range of shell lengths (in cm)
- For crab, note shell condition (new, old, very old i.e., w/epiphytes such as barnacles) etc.)

For a QA sample such as a Voucher Specimen for verifying species identification, the Specimen Log Form would note under “Type” that it is a Voucher (V) and under “Other Comments” that it was shipped to UAF for identification.

Sheet _____ of _____

PEBBLE PROJECT
2005 MARINE STUDIES
SPECIMEN LOG SHEET

Shipment No. _____

Date Shipped _____

Control I.D. No.	Station I.D.	Date Collected	Time Collected	Species	Sex F/M	Crab Carapace[1] Width/Length		Fish Fork Length (cm)	Fish[2] Wt. (g)	Life Stage[3] A/J/F/L	Egg/ Shell Condition[4]	Gear[5]	Type[6] QA/V /?	Other Comments

1 Carapace Width and Length in mm
2 Specify measurement units
3 Life Stage: Adult:, juvenile, fry, larvae
4 Egg: Eyed/Non-Eyed Shell: New/Old/Very Old (i.e., w/epiphytes)
5 Gear: Crab Pot (CP), Shrimp Pot (SP), Hook & Line (HL), Seine, Trawl, Diver, Hand
6 Sample Type: Quality Assurance, Voucher, Unknown

Figure A-3 Specimen Log Form

PEBBLE PROJECT
SAMPLE TRANSFER LOG

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: _____

Figure A-4 Sample Transfer Form

Fish Catch Record

Job Number: _____ Page_____ of_____

Project Name: _____ Date: _____ Recorded by:_____

			Time						Tide	
Location	Station	Sample Type	Set	Retrieve	Rep. #	Species	Length (mm)	Count (if no length taken)	Species	Temp. ●	Salinity ●	D.O. ●	Weather	Set	Retrieve

wp/forms/field/fish catch.xls

Figure A-5 - Fish Catch Record

Fish Catch Codes

Sample Type

0 = Beach Seine
1 = Fyke Net
2 = Trawl
3 = Hook and Line
4 = Tow Net

Tide

E = Ebb
F = Flood
L = Low Slack
H = High Slack

Weather

S = Sunny
P = Partly Cloudy
C = Overcast
R = Rain
F = Fog

Species

0 = No fish
1 = Pink Salmon
2 = Chum
3 = Coho
4 = Sockeye
5 = Chinook
6 = Dolly Varden
7 = Steelhead (rainbow trout)
8 = Cutthroat trout
9 = Starry Flounder
10 = Sand Sole
11 = Rock Sole
12 = Snake Blenny
13 = Pacific Sand Lance
14 = Smelt (long fin)
15 = Herring
16 = Stickleback (threespine)
17 = Sculpin
18 = Bering Cisco
19 = Perch
20 = Eulachon
21 = Pumpkinseed
22 = hermit crab (Pagurus)
23 = Rock Crab
24 = Dungeness Crab
25 = Crab - other
26 = Ninespine stickleback
27 = Saffron cod
28 = Bering Cisco
29 = Liparid (clingfish)
30 = Yellowfin sole
31 = Alaska Plaice
32 = Unidentified flatfish
33 = Crangon shrimp

Pebble Project
Northern Dynasty Mines Inc.

Field Sampling Plan Acknowledgment Form

Disciplines: Hydrology, Surface Water Quality and Sediment Trace Elements
Consultant: Bristol Environmental and Engineering Services Corp

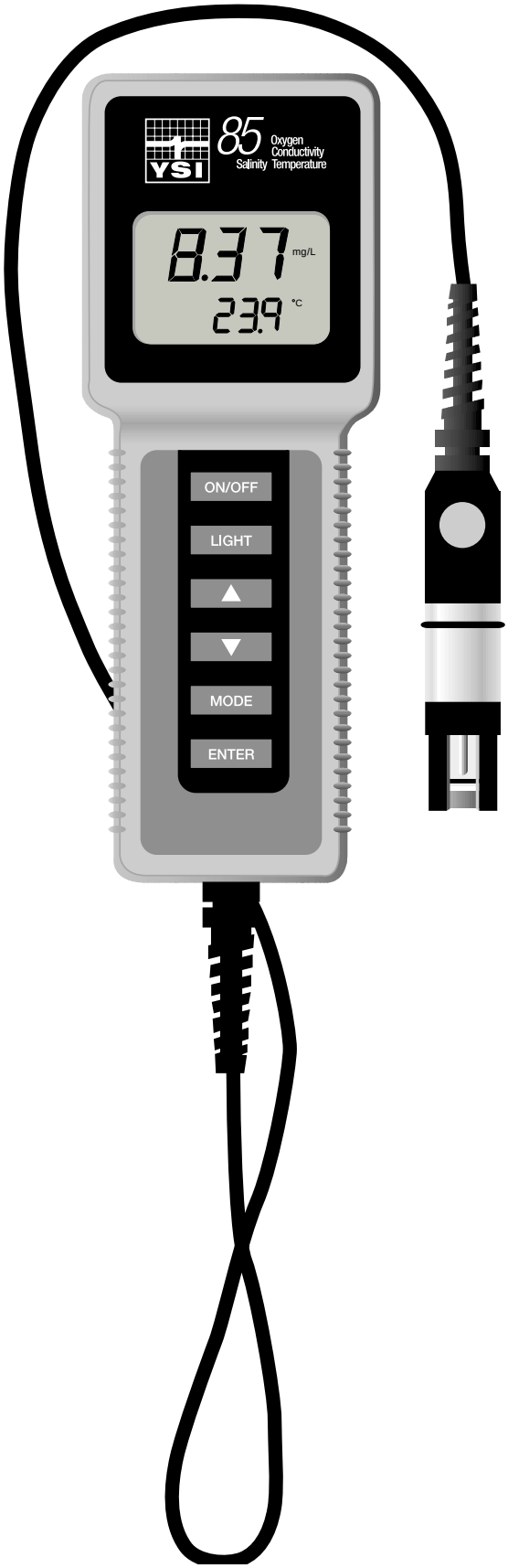
I understand and agree to abide by the procedures as detailed in this Field Sampling Plan (FSP). Should conditions prevent compliance with the FSP I will clearly document actual procedures conducted and explain the rationale for deviation from the plan.

Printed Name	Company	Signature	Date

Figure A-6 FSP Acknowledgement Form

APPENDIX B
FIELD INSTRUMENT MANUALS AND CALIBRATION PROCEDURES

YSI *incorporated*



YSI Model 85

Handheld Oxygen, Conductivity, Salinity, and Temperature System

Operations Manual

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SECTION 1 INTRODUCTION

The YSI Model 85 Handheld Dissolved Oxygen, Conductivity, Salinity and Temperature System is a rugged, micro-processor based, digital meter with an attached YSI combination conductivity and dissolved oxygen probe.

The YSI Model 85 is designed for use in field, lab, and process control applications as well as for environmental, aquaculture, and industrial uses. The Model 85 is available with cable lengths of either 10, 25, 50 or 100 feet. The body of the probe has been manufactured with stainless steel to add rugged durability and sinking weight. The probe also utilizes our easy to install cap membranes for measuring dissolved oxygen.

The YSI Model 85 probe is a non-detachable, combination sensor designed specifically for the YSI Model 85 Handheld System. The conductivity portion is a four-electrode cell with a cell constant of 5.0/cm ±4%. The dissolved oxygen portion is a polargraphic Clark type sensor.

The Model 85's microprocessor allows the system to be easily calibrated for dissolved oxygen or conductivity with the press of a few buttons. Additionally, the microprocessor performs a self-diagnostic routine each time the instrument is turned on. The self-diagnostic routine provides you with useful information about the conductivity cell constant and function of the instrument circuitry.
The system simultaneously displays temperature (in °C), along with one of the following parameters: dissolved oxygen in either mg/L (milligrams per liter) or % air saturation; conductivity; temperature compensated conductivity; (in µS/cm or mS/cm), and salinity (in parts per thousand {ppt}).

The system requires only a single calibration regardless of which dissolved oxygen display you use. The calibration of conductivity is not required but is available. A single calibration will adjust the instrument, regardless if you are reading conductivity or temperature compensated conductivity. You can switch between all of these parameters with the push of a single key.

A calibration\storage chamber is built into the instrument case. A small sponge in the chamber can be moistened to provide a water saturated air environment that is ideal for air calibration of the dissolved oxygen probe. This chamber also provides a convenient place to store the probe when the system is not in use, and provides protection for the electrodes within the conductivity probe. The Model 85 case is also waterproof (rated to IP65). You can operate your Model 85 in the rain without damage to the instrument.

Six AA-size alkaline batteries power the instrument. A new set of alkaline batteries will provide approximately 100 hours of continuous operation. When batteries need to be replaced, the LCD will display a **"LO BAT"** message.

SECTION 2 PREPARING THE METER

2.1 UNPACKING

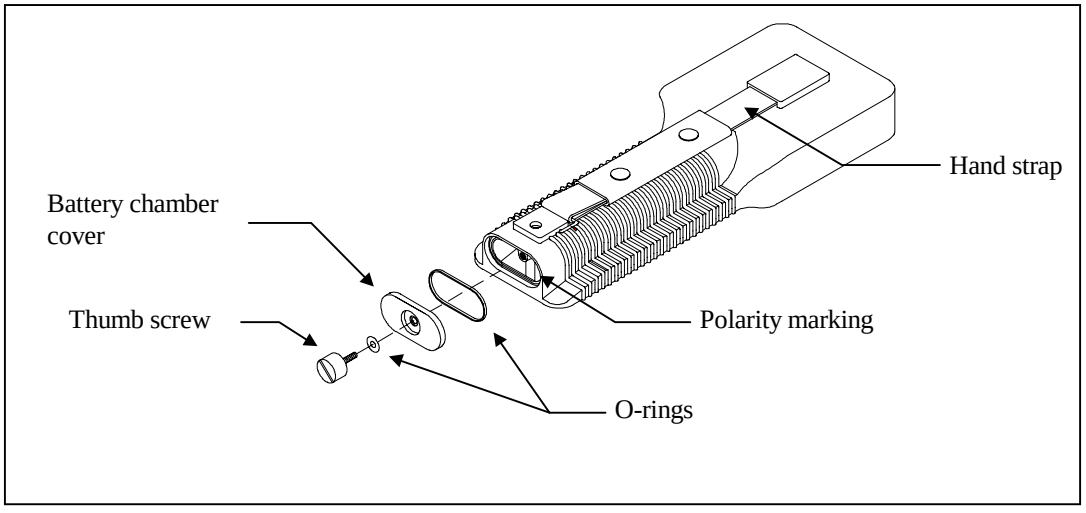
When you unpack your new YSI Model 85 Handheld Dissolved Oxygen, Conductivity, Salinity and Temperature System for the first time, check the packing list to make sure you have received everything you should have. If there is anything missing or damaged, call the dealer from whom you purchased the Model 85. If you do not know which of our authorized dealers sold the system to you, call YSI Customer Service at 800-765-4974 or 937-767-7241, and we'll be happy to help you.

2.2 WARRANTY CARD

Before you do anything else, please complete the Warranty Card and return it to YSI. This will record your purchase of this quality instrument in our computer system. Once your purchase is recorded, you will receive prompt, efficient service in the event any part of your YSI Model 85 should ever need repair and we will be able to quickly verify the warranty period.

2.3 BATTERIES

There are a few things you must do to prepare your YSI Model 85 for use. First, locate the six AA-size alkaline batteries that were included in your purchase. Use a screwdriver or a small coin to remove the thumbscrew on the bottom of the instrument. This thumbscrew holds the battery-chamber cover in place. The battery-chamber cover is marked with the words "OPEN" and "CLOSE."



NOTE: On some models, the battery cover thumbscrew may be unscrewed by hand (a screwdriver may not be required).

There is a small label inside each of the two battery-chamber sleeves. These labels illustrate the correct way to install the batteries into each sleeve of the battery-chamber.

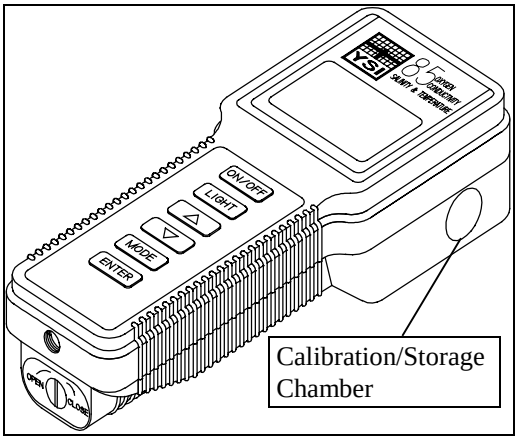
NOTE: It is very important that the batteries be installed ONLY as illustrated. The instrument will not function and may be damaged if the batteries are installed incorrectly.

Turn the instrument on by pressing and releasing the **ON/OFF** button on the front of the instrument. The liquid crystal display (LCD) should come on. Allow a few seconds for the instrument to complete its diagnostic routine. Notice that the instrument will display the specific cell constant of the conductivity probe during this diagnostic routine. If the instrument does not operate, consult the section entitled Troubleshooting.

You may also want to take the instrument into a dark room and with the instrument ON, hold down the **LIGHT** button. The instrument backlight should illuminate the LCD so that the display can be easily read.

2.4 CALIBRATION/STORAGE CHAMBER

The Model 85 has a convenient calibration storage chamber built into the instruments' side. This chamber provides an ideal storage area for the probe during transport and extended non-use. If you look into the chamber you should notice a small round sponge in the bottom of the chamber. Carefully put 3 to 6 drops of clean water into the sponge. Turn the instrument over and allow any excess water to drain out of the chamber. The wet sponge creates a 100% water saturated air environment for the probe, which is ideal for dissolved oxygen calibration.



2.5 HAND STRAP

The hand strap is designed to allow comfortable operation of the Model 85 with minimum effort. If the hand strap is adjusted correctly, it is unlikely that the instrument will be easily dropped or bumped from your hand. See figure on previous page.

To adjust the hand strap on the back of the meter, unsnap the vinyl cover and pull the two Velcro strips apart. Place your hand between the meter and the strap and adjust the strap length so that your hand is snugly held in place. Press the two Velcro strips back together and snap the vinyl cover back into place.

2.6 THE METER CASE

The meter case is sealed at the factory and is not intended to be opened, except by authorized service technicians. Do not attempt to separate the two halves of the meter case as this may damage the instrument, break the waterproof seal, and will void the manufacturer's warranty.

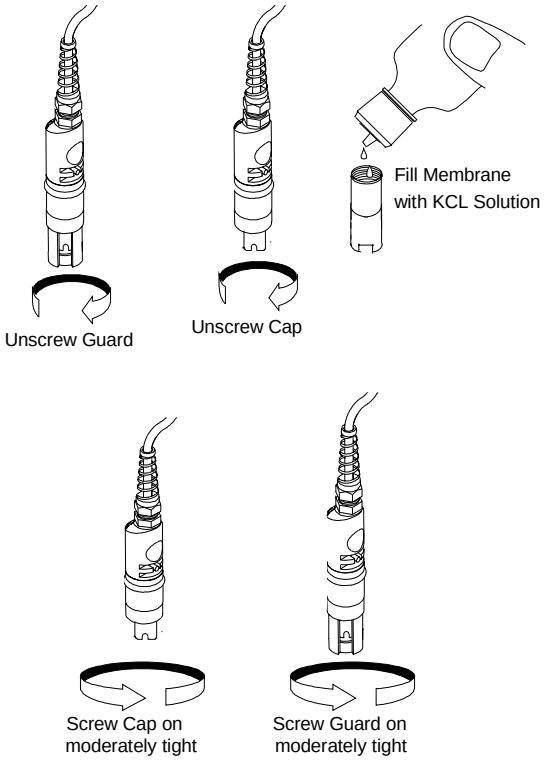
SECTION 3 PREPARING THE PROBE

The YSI Model 85 dissolved oxygen probe is shipped dry. The protective membrane cap on the probe tip must be removed and replaced with KCl solution and a new membrane cap before using the probe. Follow the instructions below to install KCl solution and the new membrane cap.

3.1 MEMBRANE CAP INSTALLATION

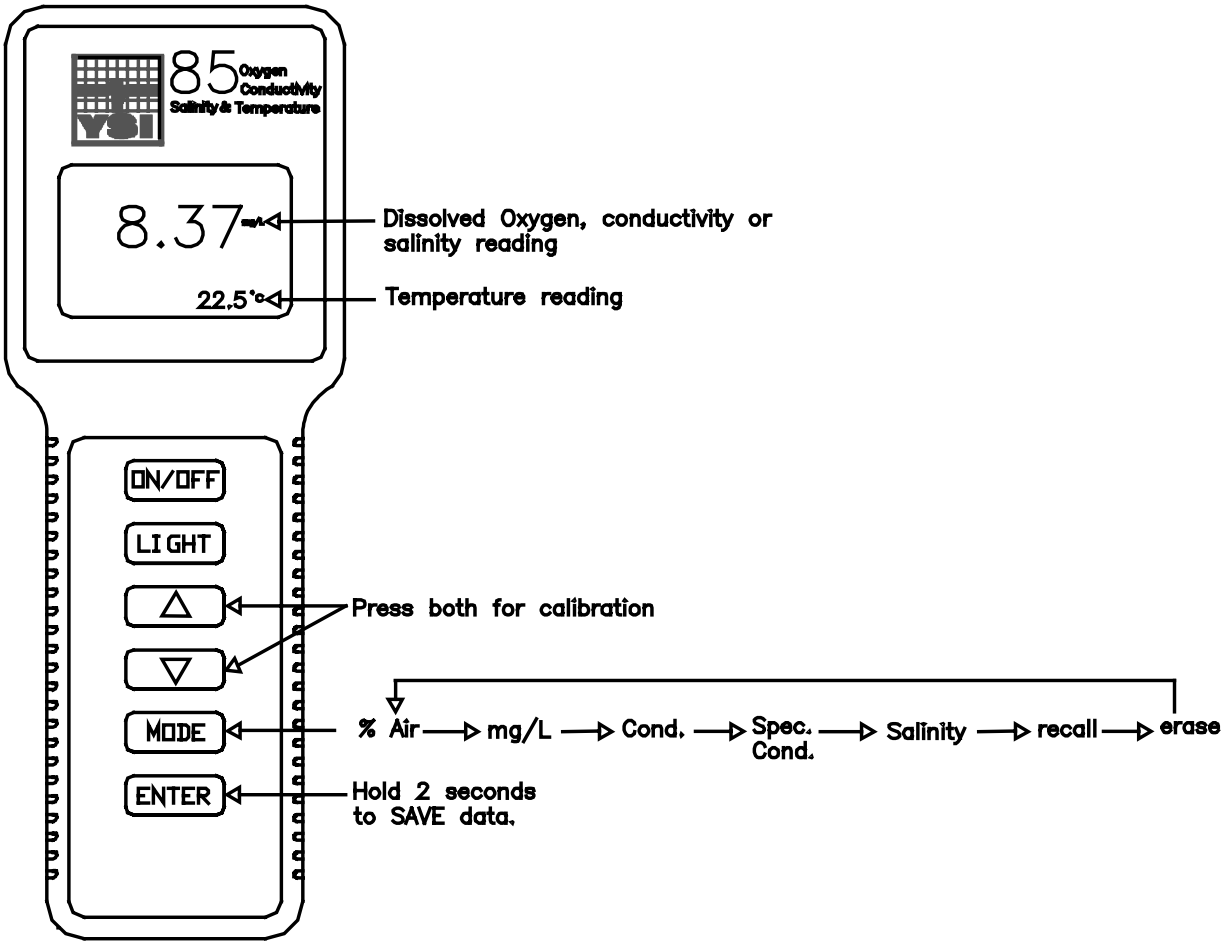
To install a new membrane on your YSI Model 85 dissolved oxygen probe:

1. Unscrew and remove the probe sensor guard.
2. Unscrew and remove the old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare the electrolyte according to the directions on the KCl solution bottle.
5. Hold the membrane cap and fill it at least 1/2 full with the electrolyte solution.
6. Screw the membrane cap onto the probe moderately tight. A small amount of electrolyte should overflow.
7. Screw the probe sensor guard on moderately tight.



SECTION 4 OVERVIEW OF OPERATION

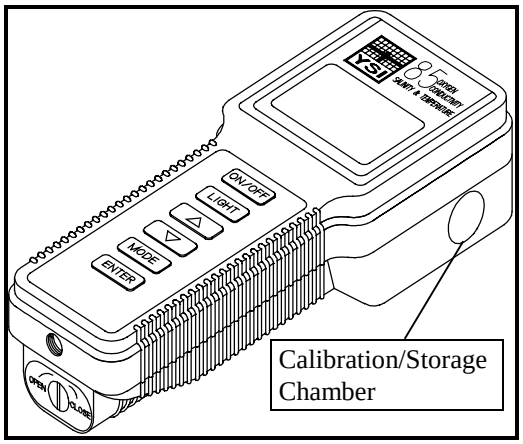
The following diagram is an overview of the operation of the Model 85. See the following sections for details of operation.



SECTION 5 CALIBRATION

5.1 CALIBRATION OF DISSOLVED OXYGEN

To accurately calibrate the YSI Model 85 you will need to know the approximate altitude of the region in which you are located.



1. Ensure that the sponge inside the instrument's calibration chamber is wet. Insert the probe into the calibration chamber.

2. Turn the instrument on by pressing the **ON/OFF** button on the front of the instrument. Press the **MODE** button until dissolved oxygen is displayed in mg/L or %. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required).

3. Use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** buttons at the same time.

4. The LCD will prompt you to enter the local altitude in hundreds of feet. Use the arrow keys to increase or decrease the altitude. When the proper altitude appears on the LCD, press the **ENTER** button once.

EXAMPLE: Entering the number 12 here indicates 1200 feet.

5. The Model 85 should now display **CAL** in the lower left of the display, the calibration value should be displayed in the lower right of the display and the current % reading (before calibration) should be on the main display. Make sure that the current % reading (large display) is stable, then press the **ENTER** button. The display should read **SAVE** then should return to the Normal Operation Mode.

Each time the Model 85 is turned off, it may be necessary to re-calibrate before taking measurements. All calibrations should be completed at a temperature which is as close as possible to the sample temperature. Dissolved oxygen readings are only as good as the calibration.

5.2 CALIBRATION OF CONDUCTIVITY

IMPORTANT: System calibration is rarely required because of the factory calibration of the YSI Model 85. However, from time to time it is wise to check the system calibration and make adjustments when necessary.

Prior to calibration of the YSI Model 85, it is important to remember the following:

1. Always use clean, properly stored, NIST traceable calibration solutions (see Accessories and Replacement Parts). When filling a calibration container prior to performing the calibration procedures, make certain that the level of calibrant buffers is high enough in the container to cover the entire probe. Gently agitate the probe to remove any bubbles in the conductivity cell.
2. Rinse the probe with distilled water (and wipe dry) between changes of calibration solutions.
3. During calibration, allow the probe time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration process. The readings after calibration are only as good as the calibration itself.
4. Perform sensor calibration at a temperature as close to 25°C as possible. This will minimize any temperature compensation error.

Follow these steps to perform an accurate calibration of the YSI Model 85:

1. Turn the instrument on and allow it to complete its self-test procedure.
2. Select a calibration solution that is most similar to the sample you will be measuring.
    - For sea water choose a 50 mS/cm conductivity standard (YSI Catalog# 3169)
    - For fresh water choose a 1 mS/cm conductivity standard (YSI Catalog# 3167)
    - For brackish water choose a 10 mS/cm conductivity standard (YSI Catalog # 3168)
3. Place at least 3 inches of solution in a clean glass beaker.
4. Use the **MODE** button to advance the instrument to display conductivity.
5. Insert the probe into the beaker deep enough so that the oval-shaped hole on the side of the probe is completely covered. Do not rest the probe on the bottom of the container -- suspend it above the bottom at least 1/4 inch.
6. Allow at least 60 seconds for the temperature reading to become stable.
7. Move the probe vigorously from side to side to dislodge any air bubbles from the electrodes.
8. Press and release the **UP ARROW** and **DOWN ARROW** buttons at the same time.

The **CAL** symbol will appear at the bottom left of the display to indicate that the instrument is now in Calibration mode.



9. Use the **UP ARROW** or **DOWN ARROW** button to adjust the reading on the display until it matches the value of the calibration solution you are using.
10. Once the display reads the exact value of the calibration solution being used (the instrument will make the appropriate compensation for temperature variation from 25°C), press the **ENTER** button once. The word "**SAVE"** will flash across the display for a second indicating that the calibration has been accepted.

The YSI Model 85 is designed to retain its last conductivity calibration permanently. Therefore, there is no need to calibrate the instrument after battery changes or power down.

SECTION 6 ADVANCED CONDUCTIVITY SETUP

The default settings of the YSI Model 85 are appropriate for the vast majority of measurement applications. However, some measurement applications require very specific measurement criteria. For that reason, we have made the YSI Model 85 flexible to accommodate these "advanced users."

If, for example, you are using the YSI Model 85 for a process control application that requires that the conductivity readings be compensated to 20 ^{o}C instead of 25 ^{o}C -- this is the section to read. Or, if your application for the YSI Model 85 involves the measurement of a very specific saline solution, the default temperature coefficient may need to be changed to get the very best measurement of that specific salt.

IMPORTANT: There is never a need to enter Advanced Setup Mode unless your special measurement application calls for a change in reference temperature and or temperature coefficient. Therefore, unless you are certain that your application requires a change to one or both of these criteria, do not modify the default reference temperature (25^{o}C) or the default temperature coefficient (1.91%).

6.1 CHANGING THE TEMPERATURE COEFFICIENT

Follow these steps to modify the temperature coefficient of the Model 85.

1. Turn the instrument on and wait for it to complete its self-test procedure.
2. Use the **MODE** button to advance the instrument to display conductivity.
3. Press and release both the **DOWN ARROW** and the **MODE** buttons at the same time.

The **CAL** symbol will appear at the bottom left of the display. The large portion of the display will show **1.91 %** (or a value set previously using Advanced Setup).

4. Use the **UP ARROW** or **DOWN ARROW** button to change the value to the desired new temperature coefficient.
5. Press the **ENTER** button. The word "**SAVE**" will flash across the display for a second to indicate that your change has been accepted.
6. Press the **MODE** button to return to normal operation; the CAL symbol will disappear from the display.

6.2 CHANGING THE REFERENCE TEMPERATURE

Follow these steps to modify the reference temperature of the Model 85.

1. Turn the instrument on and wait for it to complete its self-test procedure.
2. Use the **MODE** button to advance the instrument to display conductivity.
3. Press and release both the **DOWN ARROW** and the **MODE** buttons at the same time.

The **CAL** symbol will appear at the bottom left of the display. The large portion of the display will show **1.91 %** (or a value set previously using Advanced Setup).

4. Press and release the **MODE** button; the large portion of the display will show **25.0C** (or a value set previously using Advanced Setup).
5. Use the **UP ARROW** or **DOWN ARROW** button to change the value to the desired new reference temperature (any value between 15 ^{o}C and 25 ^{o}C is acceptable).
6. Press the **ENTER** button. The word "**SAVE**" will flash across the display for a second to indicate that your change has been accepted.
7. The instrument will automatically return to normal operation mode.

6.3 CHANGING FROM AUTORANGING TO MANUAL RANGING

If your application is easier to perform using a manual range that you select, the YSI Model 85 allows you to turn off the default autoranging feature. While you are making conductivity or temperature compensated conductivity measurements, simply press and release the **UP ARROW** button. Each additional press of the **UP ARROW** button will cycle the Model 85 to a different manual range until you return again to autoranging. Five pushes of the **UP ARROW** button will cycle the Model 85 through the four manual ranges and return the instrument to autoranging.

NOTE: You may see an error message in some manual ranges if the manual range selected is not adequate for the sample you are measuring. If this happens, simply press and release the **UP ARROW** button again until a range is selected which is suitable for your sample. If you get lost and don't know if you're in a manual range or autoranging, simply turn the instrument off and back on. Also note that the conductivity units will flash while you are in manual range. The instrument will always default to autoranging when first turned on.

The four ranges of the YSI Model 85 are:

Range 1	Range 2	Range 3	Range 4
0 to 499.9 µS/cm	0 to 4999 µS/cm	0 to 49.99 mS/cm	0 to 200.0 mS/cm

SECTION 7 MAKING MEASUREMENTS

7.1 TURNING THE INSTRUMENT ON

Once the batteries are installed correctly, press the **ON/OFF** button. The instrument will activate all segments of the display for a few seconds, which will be followed by a self-test procedure that will last for several more seconds. During this power on self-test sequence, the instrument's microprocessor is verifying that the instrument is working properly. The Model 85 will display the cell constant of the conductivity probe when the self-test is complete. If the instrument were to detect an internal problem, the display would show a **continuous** error message. See the section entitled Troubleshooting for a list of these error messages.

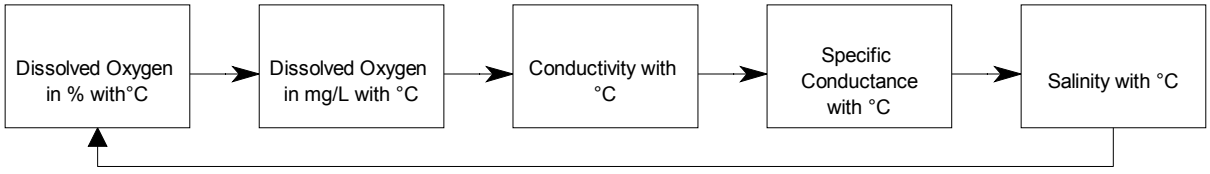
7.2 THE MEASUREMENT MODES OF THE MODEL 85

The Model 85 is designed to provide six distinct measurements:

- **Dissolved Oxygen %** -- A measurement of oxygen in percent of saturation.
- **Dissolved Oxygen mg/L** -- A measurement of oxygen in mg/L
- **Conductivity** -- A measurement of the conductive material in the liquid sample without regard to temperature
- **Specific Conductance** -- Also known as temperature compensated conductivity which automatically adjusts the reading to a calculated value which would have been read if the sample had been at 25^{o} C (or some other reference temperature which you choose). See Advanced Setup.
- **Temperature** -- which is always displayed.
- **Salinity** -- A calculation done by the instrument electronics, based upon the conductivity and temperature readings.

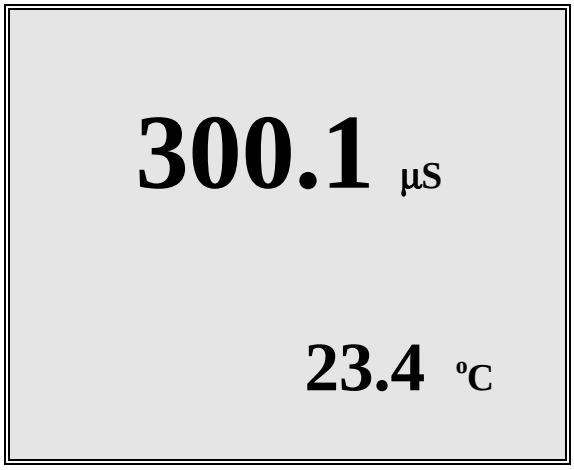
NOTE: When you turn the Model 85 off, it will "remember" which mode you used last and will return to that mode the next time the instrument is turned on.

To choose one of the measurement modes above (temperature is always displayed) simply press and release the **MODE** button. Carefully observe the small legends at the far right side of the LCD.



If the instrument is reading **Specific Conductance** the large numbers on the display will be followed by either a **µS** or an **mS.** Additionally the small portion of the display will show the **° C** flashing on and off.

If the instrument is reading **Conductivity** (not temperature compensated) the large numbers on the display will be followed by either a **µS** or an **mS.** Additionally the small portion of the display will show the **° C** **NOT** flashing.



If the instrument is reading **Dissolved Oxygen** the large numbers on the display will be followed by either a mg/L or %. It is important to remember that the dissolved oxygen probe is stirring dependent. This is due to the consumption of oxygen at the sensor tip during measurement. When taking dissolved oxygen measurements the probe must be moved through the sample at a rate of 1 foot per second to provide adequate stirring.

If the instrument is reading **Salinity** the large numbers on the display will be followed by a **ppt.**

7.3 AUTORANGING & RANGE SEARCHING

The YSI Model 85 is an autoranging instrument. This means that regardless of the conductivity or salinity of the solution (within the specifications of the instrument) all you need to do to get the most accurate reading is to put the probe in the sample. This feature makes the Model 85 as simple as possible to operate.

When you first place the Model 85 probe into a sample or calibration solution, and again when you first remove the probe the instrument will go into a range search mode that may take as long as 5 seconds. During some range searches the instrument display will flash **rANG** to indicate its movement from one range to another. The length of the range search depends on the number of ranges that must be searched in order to find the correct range for the sample. During the range search, the instrument will appear to freeze on a given reading for a few seconds then, once the range is located, will pinpoint the exact reading on the display. The display may also switch to **00.0** for a second or two during a range search before it selects the proper range.

7.4 THE BACKLIGHT

At times it may be necessary to take measurements with the Model 85 in dark or poorly lit areas. To help in this situation, the Model 85 comes equipped with a backlight that will illuminate the display so that it can be easily read. To activate the backlight, press and hold the **LIGHT** button. The

SECTION 8 SAVING DATA

The Model 85 is equipped with non-volatile memory that is capable of storing up to 50 different sets of readings. Non-volatile means that you do not need to worry that your data will be lost due to a power failure or power interrupt. The Model 85 will also assign a site identity number to each set of readings to allow easy review of the data. This feature is useful in situations where transcribing data is difficult or not available.

8.1 SAVING DATA TO MEMORY

1. While any parameter is displayed on the screen depress the **ENTER** button and hold for approximately 2 seconds. The meter will flash **SAVE** on the display along with the current site identity being used.

2. When all 50 sites are full the display will flash **FULL** on the screen. This message will remain on the screen (even after power down) until a button is pushed.

Once you have acknowledged the memory is full, any subsequent saved data will begin overwriting existing data starting with site #1.

8.2 RECALLING STORED DATA

1. To put the Model 85 into the **RECALL** mode depress the **MODE** button repeatedly until **rcl** is displayed on the screen along with the site ID number in the lower right corner. (see figure #1)

2. Depress the **ENTER** button to review the last set of data that was saved. The Model 85 will display the dissolved oxygen in % saturation and temperature. Another press of the **ENTER** button will display the dissolved oxygen in mg/L and the temperature.

Depress the **ENTER** button again and again to review the conductivity, specific conductivity and salinity readings. All of which are displayed with the temperature.

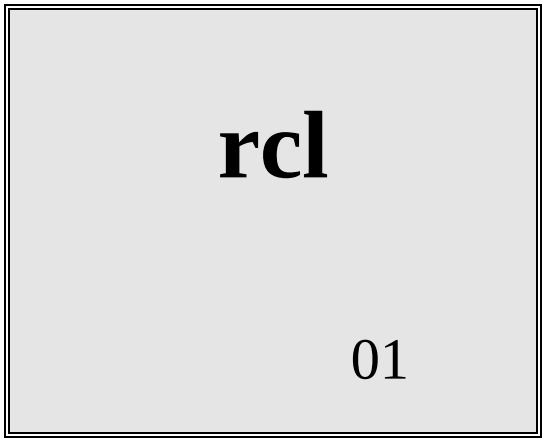


figure #1

3. Depress the **UP ARROW** button to increment through the saved sets of data.

4. Depress the **DOWN ARROW** button to decrement through the saved sets of data.

5. When the correct site ID# is displayed, press the **ENTER** button to display the data.

6. When you have finished recalling data, press the **MODE** button to return to normal operation.

NOTE: The Model 85 will recall data as a list. When the **UP ARROW** is depressed the Model 85 will display the Site ID# for the previously recorded date. For example: If you are reviewing Site ID# 5 and the **UP ARROW** is depressed the Model 85 will display Site ID# 4. If you are reviewing Site ID# 5 and Site ID# 5 was the last set of data stored the **DOWN ARROW** button will display Site ID# 1.

Here is an example of the Model 85 memory.
Site ID #1
Site ID #2
Site ID #3 ←— If the **UP ARROW** button was pressed the Model 85 would display Site ID #2
Site ID #4
Site ID #5

8.3 ERASING STORED DATA

1. To erase the data that is stored into the Model 85's memory, depress the **MODE** button repeatedly until the Model 85 displays **ErAS** on the screen. (see figure #2)

2. Depress and hold the **DOWN ARROW** and **ENTER** buttons simultaneously for approximately 5 seconds.

3. The Model 85 flashing DONE on the display for 1 to 2 seconds indicates successful erasure. The instrument will automatically change to normal operation after completion.

IMPORTANT: Data in all 50 site ID's will be erased completely and will be lost forever. Do not use the erase function until all recorded data has been transcribed to an archive outside the Model 85.

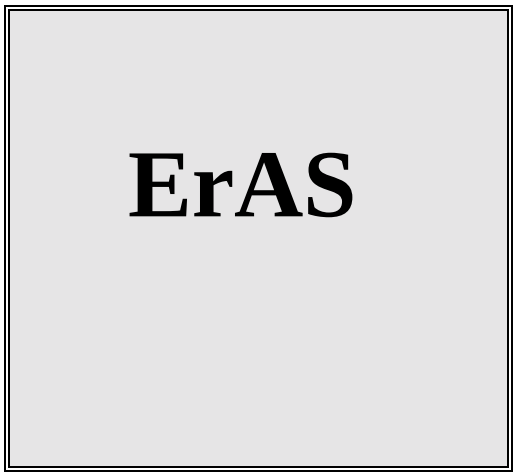


figure #2

SECTION 9 MAINTENANCE

9.1 CLEANING AND STORAGE

The single most important requirement for accurate and reproducible results in conductivity measurement is a clean cell. A dirty cell will change the conductivity of a solution by contaminating it.

NOTE: ALWAYS RINSE THE CONDUCTIVITY CELL WITH CLEAN WATER AFTER EACH USE.

To clean the conductivity cell:

1. Dip the cell in cleaning solution and agitate for two to three minutes. Any one of the foaming acid tile cleaners, such as Dow Chemical Bathroom Cleaner, will clean the cell adequately. When a stronger cleaning preparation is required, use a solution of 1:1 isopropyl alcohol and 10N HCl. Remove the cell from the cleaning solution.

2. Use the nylon brush (supplied) to dislodge any contaminants from inside the electrode chamber.

3. Repeat steps one and two until the cell is completely clean. Rinse the cell thoroughly in deionized, or clean tap water.

4. Store the conductivity cell in the meter storage chamber.

NOTE: See Section 11, Dissolved Oxygen Probe Precautions for instructions on cleaning the dissolved oxygen electrodes.

SECTION 10 PRINCIPLES OF OPERATION

The dissolved oxygen sensor utilizes an oxygen permeable membrane that covers an electrolytic cell consisting of a gold cathode and a porous silver anode. This membrane acts as a diffusion barrier and an isolation barrier preventing fouling of the cathode surface by impurities in the environment. Upon entering the cell through the membrane, oxygen is reduced at an applied potential of -0.8 V referenced to the silver electrode. The reduction current at the cathode is directly proportional to the partial pressure of oxygen in liquid (expressed as %-air saturation) which is proportional to the concentration of dissolved oxygen (in mg/L) at a particular temperature. Thus the same partial pressure of oxygen (% air-saturation) in liquid gives different concentrations of dissolved oxygen (mg/L) at different temperatures because of the different solubility's of oxygen at different temperatures.

The conductivity cell utilizes four pure nickel electrodes for the measurement of solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milli-Siemens (millimhos). To convert this value to a conductivity (specific conductance) value in milli-Siemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the Model 85 conductivity cell is 5.0/cm $\pm$ 4%. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed. Solutions with conductivity's of 1.00, 10.0, 50.0, and 100.0 mS/cm, which have been prepared in accordance with recommendation 56-1981 of the Organisation Internationale de Métrologie Légale (OIML) are available from YSI. The instrument output is in µS/cm or mS/cm for both conductivity and specific conductance. The multiplication of cell constant times conductance is carried out automatically by the software.

10.1 TEMPERATURE EFFECT ON CONDUCTIVITY

The conductivity of solutions of ionic species is highly dependent on temperature, varying as much as 3% for each change of one degree Celsius (temperature coefficient = 3%/C). In addition, the temperature coefficient itself varies with the nature of the ionic species present.

Because the exact composition of a natural media is usually not known, it is best to report a conductivity at a particular temperature, e.g. 20.2 mS/cm at 14 C. However, in many cases, it is also useful to compensate for the temperature dependence in order to determine at a glance if gross changes are occurring in the ionic content of the medium over time. For this reason, the Model 85 software also allows the user to output conductivity data in either raw or temperature compensated form. If "Conductivity" is selected, values of conductivity that are NOT compensated for temperature are output to the display. If "Specific Conductance" is selected, the Model 85 uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to a user selected reference temperature (see Advanced Setup) between 15 C and 25 C. Additionally the user can select any temperature coefficient from 0% to 4%

(see Advanced Setup). Using the Model 85 default reference temperature and temperature coefficient (25 C and 1.91%), the calculation is carried out as in equation (1) below:

$$\text{Specific Conductance (25°C)} = \frac{\text{Conductivity}}{1 + TC * (T - 25)}$$

As noted above, unless the solution being measured consists of pure KCl in water, this temperature compensated value will be somewhat inaccurate, but the equation with a value of TC = 0.0191 will provide a close approximation for solutions of many common salts such as NaCl and NH_4Cl and for seawater.

Salinity is determined automatically from the Model 85 conductivity readings according to algorithms found in Standard Methods for the Examination of Water and Wastewater (ed. 1989). The use of the Practical Salinity Scale 1978 results in values which are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 C. However, the unitless salinity values are very close to those determined by the previously-used method where the mass of dissolved salts in a given mass of water (parts per thousand) was reported. Hence, the designation "ppt" is reported by the instrument to provide a more conventional output.
For further information on conductivity and the above standard information, refer to the ASTM document, Standard Methods of Test for Electrical Conductivity of Water and Industrial Wastewater, ASTM Designation D1125-82, and OIML Recommendation Number 56. ASTM symbols for conductivity, cell constant, and path length differ from those preferred in the general literature and also from those used in this manual.

SECTION 11 DISCUSSION OF MEASUREMENT ERRORS

11.1 DISSOLVED OXYGEN MEASUREMENT ERRORS

There are three basic types of error. Type 1 errors are related to limitations of instrument design and tolerances of instrument components. These are chiefly the meter linearity and the resistor tolerances. Type 2 errors are due to basic probe accuracy tolerances, chiefly background signal, probe linearity, and variations in membrane temperature coefficient. Type 3 errors are related to the operator's ability to determine the conditions at the time of calibration. If calibration is performed against more accurately known conditions, type 3 errors are appropriately reduced.

The sample calculations that follow are for a near extreme set of conditions.

TYPE 1 ERRORS

A. Meter linearity error: ±1% of full scale reading, or ±0.15 mg/l

B. Component and circuitry error: ±0.05 mg/l

TYPE 2 ERRORS

A. Temperature compensation for membrane temperature coefficient: ±0.03 mg/l

B. Temperature measurement errors: A maximum ±0.2^{o}C probe error is equal to ±0.14 mg/l

TYPE 3 ERRORS

A. Altitude:

A 1000-foot change in altitude is equal to an error of approximately 3% at the 10 mg/l level.

B. Humidity:

Errors occur if calibration is performed at less than 100% humidity. The error varies with the temperature as follows:

TEMPERATURE	ERROR
0°C	0.02 mg/l
10°C	0.05 mg/l
20°C	0.12 mg/l
30°C	0.27 mg/l
40°C	0.68 mg/l

APPROXIMATING THE ERROR

It is unlikely that the actual error in any measurement will be the maximum possible error. A better error approximation is obtained using a root mean squared (r.m.s.) calculation:

$$\text{r.m.s. error} = \pm[1a^2 + 1b^2 + 2a^2 + 2b^2 + 3a^2 + 3b^2]^{½} \text{ mg/l}$$

11.2 CONDUCTIVITY MEASUREMENT ERRORS

System accuracy for conductivity measurements is equal to the sum of the errors contributed by the environment and the various components of the measurement setup. These include:

- Instrument accuracy
- Cell-constant error
- Solution temperature offset
- Cell contamination (including air bubbles)
- Electrical noise
- Galvanic effects

Only the first three are of major concern for typical measurements, although the user should also be careful to see that cells are clean and maintained in good condition at all times.

Instrument Accuracy = ± .5% maximum
The accuracy specified for the range being used is the worst case instrument error.

Cell-Constant Error = ± .5% maximum
Although YSI cells are warranted to be accurate to within one percent, you should still determine the exact cell constant of your particular cell. Contamination or physical damage to the cell can alter the cell constant. Performing a calibration will eliminate any error that might arise because of cell constant change.

YSI cells are calibrated to within one percent of the stated cell constant at a single point. We consider these products to be usefully linear over most instrument ranges. The cell constant can be calibrated to ±0.35% accuracy with YSI conductivity calibrator solutions.

Temperature Error = ± 1% maximum
The solution temperature error is the product of the temperature coefficient and the temperature offset from 25 C, expressed as a percentage of the reading that would have been obtained at 25 C. The error is not necessarily a linear function of temperature. The statement of error is derived from a 25 C temperature offset and a 3%/ C temperature coefficient.

Total Error
Considering only the above three factors, system accuracy under worst case conditions will be ±2%, although the actual error will be considerably less if recommended and properly calibrated cells and instrument ranges are used. Additional errors, which can essentially be eliminated with proper handling, are described below.

Cell Contamination
This error is usually due to contamination of the solution being measured, which occurs when solution is carried-over from the last solution measured. Thus, the instrument might be correctly

reporting the conductivity seen, but the reading does not accurately represent the value of the bulk solution. Errors will be most serious when low conductivity solutions are contaminated by carry-over from high conductivity solutions, and can then be of an order of magnitude or more.

Follow the cleaning instructions carefully before attempting low conductivity measurements with a cell of unknown history or one that has been previously used in higher value solutions.

An entirely different form of contamination sometimes occurs due to a buildup of foreign material directly on cell electrodes. While rare, such deposits have, on occasion, markedly reduced the effectiveness of the electrodes. The result is an erroneously low conductance reading.

Electrical-Noise Errors

Electrical noise can be a problem in any measurement range, but will contribute the most error and be the most difficult to eliminate when operating in the lowest ranges. The noise may be either line-conducted or radiated or both, and may require, grounding, shielding, or both.

Galvanic and Miscellaneous Effects

In addition to the error sources described above, there is another class of contributors that can be ignored for all but the most meticulous of laboratory measurements. These errors are always small and are generally completely masked by the error budget for cell-constant calibration, instrument accuracy, etc. Examples range from parasitic reactance associated with the solution container and its proximity to external objects to the minor galvanic effects resulting from oxide formation or deposition on electrodes. Only trial and error in the actual measurement environment can be suggested as an approach to reduce such errors. If the reading does not change as the setup is adjusted, errors due to such factors can be considered too small to see.

11.3 DISSOLVED OXYGEN PROBE PRECAUTIONS

1. Membrane life depends on usage. Membranes will last a long time if installed properly and treated with care. Erratic readings are a result of loose, wrinkled, damaged, or fouled membranes, or from large (more than 1/8" diameter) bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occurs, you should replace the membrane and the KCl solution. The average replacement interval is two to four weeks.

2. If the membrane is coated with oxygen consuming (e.g. bacteria) or oxygen evolving organisms (e.g. algae), erroneous readings may occur.

3. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the probe. If you suspect erroneous readings, it may be necessary to determine if these gases are the cause.

4. Avoid any environment that contains substances that may attack the probe materials. Some of these substances are concentrated acids, caustics, and strong solvents. The probe materials that come in contact with the sample include FEP Teflon, stainless steel, epoxy, polyetherimide and the polyurethane cable covering.

5. For correct probe operation, the gold cathode must always be bright. If it is tarnished (which can result from contact with certain gases) or plated with silver, the gold surface must be restored. To restore the cathode, you may either return the instrument to the factory or clean it using the YSI 5238 probe reconditioning kit. Never use chemicals or abrasives not supplied with this kit.

NOTE: Model 85 probes built before July, 1996 (serial numbers starting with 96F or lower), should be cleaned with the sanding disc mounted on a FLAT surface. Do NOT use the curved tool provided in the 5238 probe reconditioning kit on these probes.

6. It is also possible for the silver anode to become contaminated, which will prevent successful calibration. To clean the anode, remove the membrane and soak the probe overnight in 3% ammonium hydroxide. Next, rinse the sensor tip with deionized water, add new KCl solution, and install a new membrane. Turn the instrument on and allow the system to stabilize for at least 30 minutes. If, after several hours, you are still unable to calibrate, return the YSI Model 85 system to an authorized service center for service.

7. To keep the electrolyte from drying out, store the probe in the calibration chamber with the small piece of sponge.

SECTION 12 TROUBLESHOOTING

SYMPTOM	POSSIBLE CAUSE	ACTION
1. Instrument will not turn on	A. Low battery voltage B. Batteries installed wrong C. Meter requires service	A. Replace batteries B. Check battery polarity. C. Return system for service
2. Instrument will not calibrate (Dissolved Oxygen)	A. Membrane is fouled or damaged B. Probe anode is fouled or dark C. Probe cathode is tarnished D. System requires service	A. Replace membrane & KCl B. Clean anode C. Clean cathode D. Return system for service
3. Instrument will not calibrate (Conductivity)	A. Cell is contaminated	A. See "Maintenance" Section
4. Instrument "locks up"	A. Instrument has rec'd a shock B. Batteries are low or damaged C. System requires service	A & B. Remove battery lid, wait 15 seconds for reset, replace lid. C. Return system for service
5. Instrument readings are inaccurate (Dissolved Oxygen)	A. Cal altitude is incorrect B. Probe not in 100% O_2 saturated air during Cal procedure C. Membrane fouled or damaged D. Probe anode is fouled or dark E. Probe cathode is tarnished F. System requires service	A. Recalibrate w/correct value B. Moisten sponge & place in Cal chamber w/ probe & Recal C. Replace membrane D. Clean anode E. Clean cathode F. Return system for service
6. Instrument readings are inaccurate (Conductivity)	A. Calibration is required B. Cell is contaminated C. Tempco is set incorrectly D. Reference temperature incorrect E. Readings are or are not temperature compensated.	A. See "Calibration" Section B. See "Maintenance" Section C. See "Advanced Setup" Section D. See "Advanced Setup" Section E. See "Making Measurements" Section
7..LCD displays "LO BAT" Main display flashes "off"	A. Batteries are low or damaged	A. Replace batteries
8. Main Display reads "OVEr" (Secondary display reads "ovr") (Secondary display reads "udr")	A. Conductivity reading is >200 mS B. Temperature reading is >65°C C. Temperature reading is <-5°C D. Salinity reading is >80 ppt E. User cell constant cal K is >5.25 F. DO temperature is >46°C G. DO % saturation is >200% H. DO concentration is >20 mg/L	In all cases, check calibration values and procedures; check advanced setup settings. If each of these are set correctly, return instrument for service.
9. Main display reads "Undr"	A. User cell constant cal K is <4.9 B. DO current too low to calibrate	A. Recalibrate instrument using known good conductivity standard. Follow cell cleaning procedure in the Maintenance section. B. Replace membrane, clean probe
10. Main display reads "rErr"	A. Reading exceeds user selected manual range.	A. Use the mode key to select a higher or lower manual range, or set system to autoranging.
11. Main display reads "PErr"	A. User cell constant cal K is 0.0 B. Incorrect sequence of keystrokes.	A. See "Advanced Setup" section. B. Refer to manual section for step by step instruction for the function you are attempting.

SYMPTOM	POSSIBLE CAUSE	ACTION
12. Main display reads “LErr”	A. In temperature compensated conductivity mode, temperature exceeds the values computed using user defined temperature coefficient and/or reference temperature. B. In cell constant cal mode, temperature exceeds the values computed using user defined temperature coefficient and/or reference temperature.	A. & B. Adjust user defined tempco or reference temperature. (pg. 10)
13. Main display reads “Err” (Secondary display reads “ra”)	A. System has failed its RAM test check procedure.	A. Turn instrument OFF and back ON again. B. Return the system for service (pg. 26)
14. Main display reads “Err” (Secondary display reads “ro”)	A. System has failed its ROM test check procedure.	A. Turn instrument OFF and back ON again. B. Return the system for service (pg. 26)
15. Secondary display reads “rEr”	A. Temperature jumper is set to °F and reading is >199.9°F but <203°F.	A. Return the system for service. (pg. 26)
16. Main display reads “FAIL” (Secondary display reads “eep”)	A. EEPROM has failed to respond in time.	A. Return the system for service. (pg. 26)
17. Readings on main display don’t change	A. Meter is in recall mode.	A. Press **MODE** button to return to Normal Operation (pg. 12)

SECTION 13 WARRANTY AND REPAIR

YSI Model 85 Handheld Meters are warranted for two years from date of purchase by the end user against defects in materials and workmanship. YSI Model 85 probes and cables are warranted for one year from date of purchase by the end user against defects in material and workmanship. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

AUTHORIZED U.S. SERVICE CENTERS

North and East Region

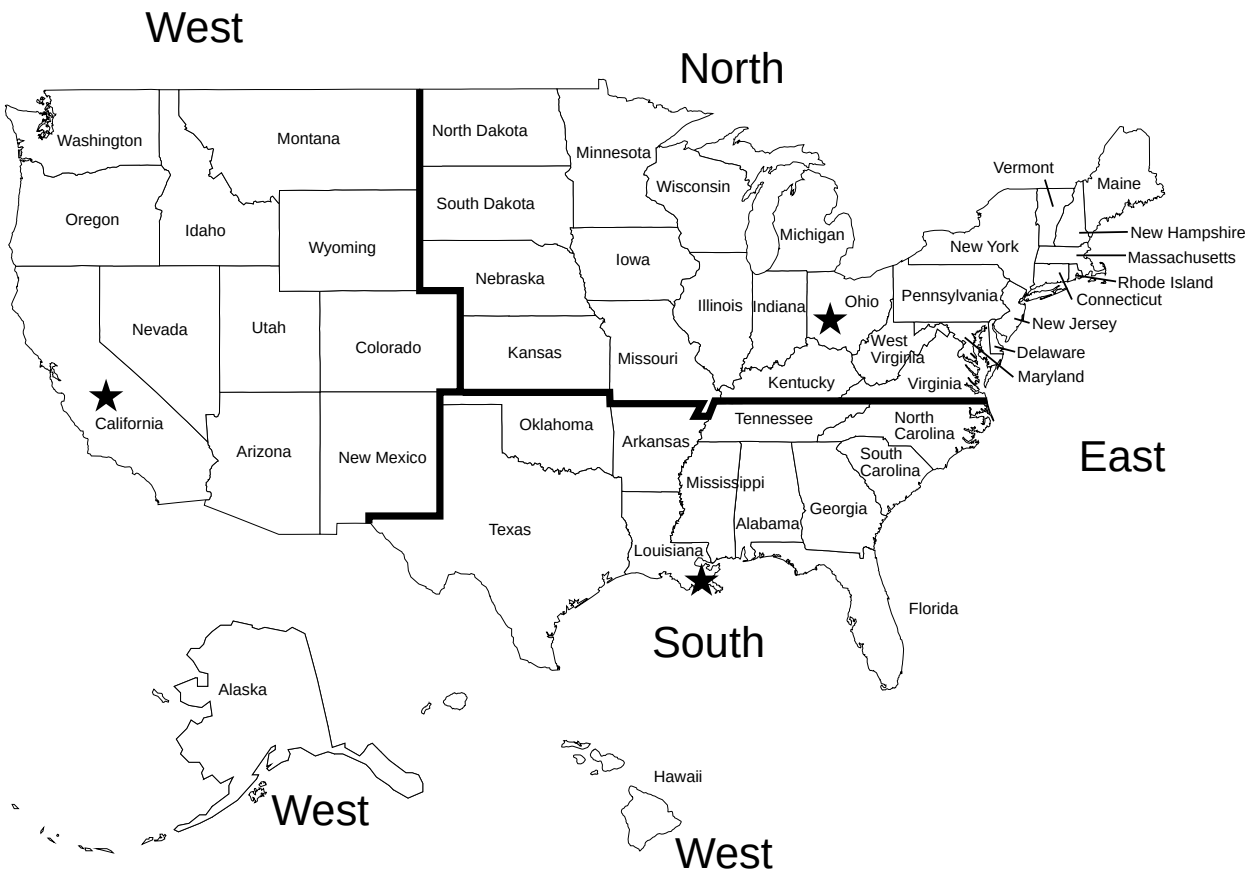
YSI Incorporated • Repair Center • 1725 Brannum Lane • Yellow Springs, Ohio • 45387 • Phone: (800) 765-4974 • (937) 767-7241• E-Mail: ysi@info.com

South Region

C.C. Lynch & Associates • 212 E. 2nd Street • Suite 203 • Pass Christian, Mississippi • 39571 • Phone: (800) 333-2252 • (228) 452-4612 • Fax: (228) 452-2563

West Region

EnviroServices & Repair • 1110 Burnett Avenue, Suite D • Concord, CA • 94520 • Phone: (800) 550-5875 • Fax: (510)674-8655



INTERNATIONAL SERVICE CENTERS

YSI Incorporated • Repair Center • 1725 Brannum Lane • Yellow Springs, Ohio • 45387 • Phone: (937) 767-7241• E-Mail: info@ysi.com

Lynchford House • Lynchford Lane • Farnborough • Hampshire • GU146LT • Phone: (44-1252) 514711 • Fax: (44-1252) 511855 • Tlx: 858210

Sakura – Building 6-5-6-13 • Shinjuku, Shinjuku-ku, Tokyo • 160 • Phone: (81-3) 5360-3561 • Fax: (81-3) 5360-3565

SPECIALTY SERVICE CENTERS

Aquaculture

Aquatic Eco Systems, Inc. • 1767 Benbow Court • Apopka, Florida • Phone: (407) 886-3939 • Fax: (407) 886-6787

Aquacenter • 166 Seven Oaks Road • Leland, Mississippi • 38756 • Phone: (601) 378-2861 • Fax: (601) 378-2862

Wastewater

Q.C. Services • P.O. Box 68 • Harrison, Maine • 04040 • Phone: (207) 583-2980

Q.C. Services • P.O. Box 14831 • Portland, Oregon • 97293 • Phone: (503) 236-2712

CLEANING INSTRUCTIONS

NOTE: Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at YSI, the following steps must be taken to insure the safety of our service personnel.

1. In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1-gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.
2. The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
3. If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
4. Any product being returned to the YSI Repair Center, should be packed securely to prevent damage.
5. Cleaning must be completed and certified on any product before returning it to YSI.

PACKING INSTRUCTIONS

1. Clean and decontaminate items to insure the safety of the handler.
2. Complete and include the Cleaning Certificate.
3. Place the product in a plastic bag to keep out dirt and packing material.
4. Use a large carton, preferably the original, and surround the product completely with packing material.
5. Insure for the replacement value of the product.

Cleaning Certificate

Organization _____

Department _____

Address _____

City _____ State _ Zip _____

Country _____ Phone _____

Model No. of Device _ Lot Number _____

Contaminant (if known) _____

Cleaning Agent(s) used _____

Radioactive Decontamination Certified?

(Answer only if there has been radioactive exposure)

_____ Yes _____ No

Cleaning Certified By _____

Name Date

SECTION 14 ACCESSORIES AND REPLACEMENT PARTS

The following parts and accessories are available from YSI or any Franchise Dealer authorized by YSI.

YSI ORDER NUMBER	DESCRIPTION
YSI 5906	Replacement Membrane Cap Kit (6 each)
YSI 5238	Probe Reconditioning Kit
YSI 3161	Conductivity Calibration Solution 1,000 µ/cm (1 Quart)
YSI 3163	Conductivity Calibration Solution 10,000 µ/cm (1 Quart)
YSI 3165	Conductivity Calibration Solution 100,000 µ/cm (1 Quart)
YSI 3167	Conductivity Calibration Solution 1,000 µ/cm (8 pints)
YSI 3168	Conductivity Calibration Solution 10,000 µ/cm (8 pints)
YSI 3169	Conductivity Calibration Solution 50,000 µ/cm (8 pints)
YSI 5520	Carrying Case
YSI 118510	Replacement Probe & Cable Assembly (10 feet)
YSI 118522	Replacement Probe & Cable Assembly (25 feet)
YSI 118527	Replacement Probe & Cable Assembly (50 feet)
YSI 118519	Replacement Probe and Cable Assembly (100 feet)
YSI 038501	Replacement Front Case Cover
YSI 055242	Replacement Rear Case Cover
YSI 055244	Replacement Battery Cover Kit
YSI 055204	Replacement Case Gasket and Screw
YSI 055219	Storage Chamber Sponge
YSI 030156	Main Board Assembly
YSI 038213	Replacement Electrode Cleaning Brush

APPENDIX A SPECIFICATIONS

Operating Environment

Medium: fresh, sea, or polluted water and most other liquid solutions.
Temperature: -5 to +65 °C
Depth: 0 to 10, 0 to 25, 0 to 50, or 0 to 100 feet (depending on cable length)

Storage Temperature: -10 to +50 °C

Material: ABS, Stainless Steel, and other materials

Dimensions:

Height:	9.5 inches	(24.13 cm)
Thickness:	2.2 inches	(5.6 cm)
Width:	3.5 inches max.	(8.89 cm)
Weight:	1.7 pounds (w/ 10' cable)	(.77 kg)
Display:	2.3"W x 1.5"L	(5.8cm W x 3.8cm L)

Power: 9 VDC -6 AA-size Alkaline Batteries (included)
Approximately 100 hours operation from each new set of batteries

Water Tightness: Meets or exceeds IP65 standards

Extensive testing of the YSI Model 85 indicates the following typical performance:

Measurement	Range	Resolution	Accuracy
Conductivity	0 to 499.9 µS/cm	0.1 µS/cm	± .5% FS
	0 to 4999 µS/cm	1.0 µS/cm	± .5% FS
	0 to 49.99 mS/cm	.01 mS/cm	± .5% FS
	0 to 200.0 mS/cm	0.1 mS/cm	± .5% FS
Salinity	0 to 80 ppt	.1 ppt	± 2%, or ± 0.1 ppt
Temperature	-5 to +65 °C	0.1 °C	± 0.1 °C (±1 lsd)
Dissolved Oxygen	0 to 200 % Air Sat.	0.1% Air Saturation	± 2% Air Saturation
	0 to 20 mg/L	0.01 mg/L	± 0.3 mg/L

Adjustable Conductivity Reference Temperature: 15°C to 25°C

Adjustable Temperature Compensation Factor for Conductivity: 0% to 4%

Temperature Compensation: Automatic

Range: Autoranging for Dissolved Oxygen

User selected or Autoranging for Conductivity

APPENDIX B - TEMPERATURE CORRECTION DATA

Temperature Correction Data for Typical Solutions

A. Potassium Chloride** (KCl)

Concentration: 1 mole/liter			Concentration: 1 x 10^{-1} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	65.10	1.67	0	7.13	1.78
5	73.89	1.70	5	8.22	1.80
10	82.97	1.72	10	9.34	1.83
15	92.33	1.75	15	10.48	1.85
20	101.97	1.77	20	11.65	1.88
25	111.90	1.80	25	12.86	1.90
			30	14.10	1.93
			35	15.38	1.96
			37.5	16.04	1.98
			40	16.70	1.99
			45	18.05	2.02
			50	19.43	2.04

Concentration: 1 x 10^{-2} mole/liter			Concentration: 1 x 10^{-3} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	0.773	1.81	0	0.080	1.84
5	0.892	1.84	5	0.092	1.88
10	1.015	1.87	10	0.105	1.92
15	1.143	1.90	15	0.119	1.96
20	1.275	1.93	20	0.133	1.99
25	1.412	1.96	25	0.147	2.02
30	1.553	1.99	30	0.162	2.05
35	1.697	2.02	35	0.178	2.07
37.5	1.771	2.03	37.5	0.186	2.08
40	1.845	2.05	40	0.194	2.09
45	1.997	2.07	45	0.210	2.11
50	2.151	2.09	50	0.226	2.13

** Charts developed by interpolating data from International Critical Tables, Vol. 6, pp. 229-253, McGraw-Hill Book Co., NY.

B. Sodium Chloride* (NaCl)

Saturated solutions at all temperatures		
C	mS/cm	%/ C (to 25 C)
0	134.50	1.86
5	155.55	1.91
10	177.90	1.95
15	201.40	1.99
20	225.92	2.02
25	251.30	2.05
30	277.40	2.08

Concentration: 0.5 mole/liter		
C	mS/cm	%/ C (to 25 C)
0	25.90	1.78
5	29.64	1.82
10	33.61	1.86
15	37.79	1.90
20	42.14	1.93
25	46.65	1.96
30	51.28	1.99
35	56.01	2.01
37.5	58.40	2.02
40	60.81	2.02
45	65.65	2.04
50	70.50	2.05

Concentration: 1 x 10^{-1} mole/liter		
C	mS/cm	%/ C (to 25 C)
0	5.77	1.83
5	6.65	1.88
10	7.58	1.92
15	8.57	1.96
20	9.60	1.99
25	10.66	2.02
30	11.75	2.04
35	12.86	2.06
37.5	13.42	2.07
40	13.99	2.08
45	15.14	2.10
50	16.30	2.12

Concentration: 1 x 10^{-2} mole/liter		
C	mS/cm	%/ C (to 25 C)
0	0.632	1.87
5	0.731	1.92
10	0.836	1.97
15	0.948	2.01
20	1.064	2.05
25	1.186	2.09
30	1.312	2.12
35	1.442	2.16
37.5	1.508	2.17
40	1.575	2.19
45	1.711	2.21
50	1.850	2.24

Concentration: 1 x 10^{-3} mole/liter		
C	mS/cm	%/ C (to 25 C)
0	0.066	1.88
5	0.076	1.93
10	0.087	1.98
15	0.099	2.02
20	0.111	2.07
25	0.124	2.11
30	0.137	2.15
35	0.151	2.19
37.5	0.158	2.20
40	0.165	2.22
45	0.180	2.25
50	0.195	2.29

* Charts developed by interpolating data from the CRC Handbook of Chemistry and Physics, 42nd ed., p. 2606, The Chemical Rubber Company, Cleveland.

C. Lithium Chloride* (LiCl)

Concentration: 1 mole/liter			Concentration: 1 x 10^{-1} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	39.85	1.82	0	5.07	1.87
5	46.01	1.85	5	5.98	1.85
10	52.42	1.89	10	6.87	1.85
15	59.07	1.92	15	7.75	1.85
20	65.97	1.95	20	8.62	1.85
25	73.10	1.98	25	9.50	1.86
30	80.47	2.02	30	10.40	1.88
35	88.08	2.05	35	11.31	1.91
37.5	91.97	2.07	37.5	11.78	1.92
40	95.92	2.08	40	12.26	1.94
45	103.99	2.11	45	13.26	1.98
50	112.30	2.15	50	14.30	2.02

Concentration: 1 x 10^{-2} mole/liter			Concentration: 1 x 10^{-3} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	0.567	1.88	0	0.059	1.93
5	0.659	1.92	5	0.068	2.03
10	0.755	1.96	10	0.078	2.12
15	0.856	2.00	15	0.089	2.19
20	0.961	2.04	20	0.101	2.25
25	1.070	2.08	25	0.114	2.28
30	1.183	2.12	30	0.127	2.31
35	1.301	2.16	35	0.140	2.32
37.5	1.362	2.18	37.5	0.147	2.32
40	1.423	2.20	40	0.154	2.31
45	1.549	2.24	45	0.166	2.29
50	1.680	2.28	50	0.178	2.25

D. Potassium Nitrate** (KNO_3)

Concentration: 1 x 10^{-1} mole/liter			Concentration: 1 x 10^{-2} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	6.68	1.78	0	0.756	1.77
5	7.71	1.79	5	0.868	1.80
10	8.75	1.81	10	0.984	1.83
15	9.81	1.83	15	1.105	1.86
20	10.90	1.85	20	1.229	1.88
25	12.01	1.87	25	1.357	1.90
30	13.15	1.90	30	1.488	1.93
35	14.32	1.92	35	1.622	1.95
37.5	14.92	1.94	37.5	1.690	1.96
40	15.52	1.95	40	1.759	1.97
45	16.75	1.97	45	1.898	1.99
50	18.00	2.00	50	2.040	2.01

* Charts developed by interpolating data from the CRC Handbook of Chemistry and Physics, 42nd ed., p. 2606, The Chemical Rubber Company, Cleveland.
** Charts developed by interpolating data from International Critical Tables, Vol. 6, pp. 229-253, McGraw-Hill Book Co., NY.

E. Ammonium Chloride* (NH_4Cl)

Concentration: 1 mole/liter			Concentration: 1×10^{-1} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	64.10	1.60	0	6.96	1.82
5	74.36	1.53	5	7.98	1.88
10	83.77	1.45	10	9.09	1.93
15	92.35	1.37	15	10.27	1.97
20	100.10	1.29	20	11.50	2.00
25	107.00	1.21	25	12.78	2.03
			30	14.09	2.06
			35	15.43	2.07
			37.5	16.10	2.08
			40	16.78	2.08
			45	18.12	2.09
			50	19.45	2.09

Concentration: 1×10^{-2} mole/liter			Concentration: 1×10^{-3} mole/liter		
C	mS/cm	%/ C (to 25 C)	C	mS/cm	%/ C (to 25 C)
0	0.764	1.84	0	0.078	1.88
5	0.889	1.86	5	0.092	1.90
10	1.015	1.88	10	0.105	1.91
15	1.144	1.91	15	0.119	1.93
20	1.277	1.94	20	0.133	1.95
25	1.414	1.97	25	0.148	1.98
30	1.557	2.02	30	0.162	2.01
35	1.706	2.06	35	0.178	2.04
37.5	1.782	2.08	37.5	0.186	2.06
40	1.860	2.10	40	0.194	2.07
45	2.020	2.14	45	0.210	2.11
50	2.186	2.18	50	0.227	2.15

* Charts developed by interpolating data from the CRC Handbook of Chemistry and Physics, 42nd ed., p. 2606, The Chemical Rubber Company, Cleveland.

APPENDIX C REQUIRED NOTICE

The Federal Communications Commission defines this product as a computing device and requires the following notice:

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. There is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- re-orient the receiving antenna
- relocate the computer with respect to the receiver
- move the computer away from the receiver
- plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 0004-000-00345-4.

APPENDIX D CONVERSION CHART

TO CONVERT FROM	TO	EQUATION
Feet	Meters	Multiply by 0.3048
Meters	Feet	Multiply by 3.2808399
Degrees Celsius	Degrees Fahrenheit	(9/5 ^{o}C)+32
Degrees Fahrenheit	Degrees Celsius	5/9 (^{o}F-32)
Milligrams per liter (mg/l)	Parts per million (ppm)	Multiply by 1

APPENDIX E OXYGEN SOLUBILITY TABLE

Table A: Solubility of Oxygen in mg/l in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.
Salinity = Measure of quantity of dissolved salts in water.
Chlorinity = Measure of chloride content, by mass, of water.
$S(^0/_{00}) = 1.80655 \times \text{Chlorinity } (^0/_{00})$

Temp °C	**Chlorinity:0 Salinity:0**	**5.0 ppt 9.0 ppt**	**10.0 ppt 18.1 ppt**	**15.0 ppt 27.1 ppt**	**20.0 ppt 36.1 ppt**	**25.0 ppt 45.2 ppt**
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61

Temp °C	Chlorinity:0 Salinity:0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

* This table is provided for your information only. It is **NOT** required when calibrating the Model 85 in accordance with the instructions outlined in the section entitled Calibration.

APPENDIX F CALIBRATION VALUES TABLE

Table A: Calibration values for various atmospheric pressures and altitudes.
Note: This table is for your information only. It is not required for calibration.

Pressure Inches of Hg	Pressure mm Hg	Pressure kPA	Altitude in feet	Altitude in meters	Calibration Value in %
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.2	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68

YSI *incorporated*



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ITEM # 038503
DRW # A38503
Revision D
November 1998

CAT. NO. 46500-88

PORTABLE TURBIDIMETER

Model 2100P

Instrument and Procedure Manual

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CERTIFICATION

Hach Company certifies this instrument was tested thoroughly, inspected and found to meet its published specifications when it was shipped from the factory.

The Model 2100P Portable Turbidimeter has been tested and is certified as indicated to the following instrumentation standards:

Product Safety

Battery/Eliminator Power Supply Only:
120 Vac, 60 Hz, UL Listed & CSA Certified, Class 2
230 Vac, 50 Hz, VDE Approved, GS & CE marked

Immunity

2100P Turbidimeter Tested with external Battery/Eliminator Power Supply:
EN 50082-1 (European Generic Immunity Standard) **per 89/336/EEC EMC:** Supporting test records with Dash Straus and Goodhue, Inc. (now Intertek Testing Services), certified compliance by Hach Company.

Standards include:
IEC 801-2 Electro-Static Discharge
IEC 801-3 Radiated RF Electro-Magnetic Fields
IEC 801-4 Electrical Fast Transients/Burst

Emissions

2100P Turbidimeter Tested with external Battery/Eliminator Power Supply:
EN 50081-1 (Emissions) **per 89/336/EEC EMC:** Supporting test records by Amador Corp. (now TUV Product Services), certified compliance by Hach Company

Standards include:
EN 55022 (CISPR 22) Emissions, Class B Limits

Canadian Radio Interference-Causing Regulation, Chapter 1374, Class A: Supporting test records by Amador Corp. (now TUV Product Services), certified compliance by Hach Company

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

CERTIFICATION, continued

FCC Part 15, Class "A" Limits: Supporting test records by Amador Corp. (now TUV Product Services), certified compliance by Hach Company.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. this device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference in which case the user will be required to correct the interference at his own expense.

The following techniques of reducing interference problems are applied easily:

1. Disconnect the battery eliminator from it's power source and from the 2100P Portable Turbidimeter to verify if it is the source of the interference
2. If the battery eliminator for the 2100P Portable Turbidimeter is plugged into the same outlet as the device with which it is interfering, try another outlet.
3. Move the 2100P Portable Turbidimeter away from the device receiving the interference.
4. Reposition the receiving antenna for the device receiving the interference.
5. Try combinations of the above.

SAFETY PRECAUTIONS

Please read this entire manual before unpacking, setting up, or operating this instrument. Pay particular attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure the protection provided by this equipment is not impaired, do not use or install this equipment in any manner other than that which is specified in this manual.

Use of Hazard Information

If multiple hazards exist, this manual will use the signal word (Danger, Caution, Note) corresponding to the greatest hazard.

DANGER
Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTE
Information that requires special emphasis.

Precautionary Labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

 This symbol, if noted on the instrument, references the instruction manual for operational and/or safety information.

SPECIFICATIONS

Specifications subject to change without notice.
Operating specifications applicable at 25 °C unless noted.
Program software copyrighted by Hach Company, 1991.

Measurement Method: Ratio Nephelometric signal (90°) scatter light ratio to transmitted light

Range: 0-1000 NTU with automatic decimal point placement or manual range selection of 0-9.99, 0-99.9 and 0-1000 NTU

Accuracy: ± 2% of reading plus stray light from 0-1000 NTU

Resolution: 0.01 NTU on lowest range

Repeatability: ±1% of reading or 0.01 NTU, whichever is greater (with Gelex standards)

Response Time: 6 seconds for full step change without signal averaging in constant reading mode

Stray Light: <0.02 NTU

Standardization: StablCal® Stabilized Formazin primary standards or Formazin primary standards

Secondary Standards: Gelex® Secondary Standards

Display: Four-digit liquid crystal; 10.16 mm (0.4 in) high digits with custom icons

Light Source: Tungsten filament lamp; lamp life typically greater than 100,000 readings

Detectors: Silicon photovoltaic

Signal Averaging: Operator selectable on or off

Sample Cells: (Height X width) 60.0 X 25 mm (2.36 X 1 in) Borosilicate glass with screw caps, marking band and fill line

Sample Required: 15 mL (0.5 oz.)

Storage Temperature: -40 to 60 °C (-40 to 140 °F) (instrument only)

SPECIFICATIONS, continued

Operating Temperature: 0 to 50 °C (32 to 122 °F) (instrument only)

Operating Humidity Range: 0 to 90% RH noncondensing at 30 °C;
0 to 80% RH noncondensing at 40 °C;
0 to 70% RH noncondensing at 50 °C

Power Requirements: Four AA Alkaline cells or optional battery eliminator

Battery Life: Typically 300 tests with signal average mode off; 180 tests with signal average mode on

Battery Eliminator (optional):

For 120 V eliminator: CSA and UL approved for 120 VAC ±10%, 60 Hz, 6 V at 800 mA DC output

For 230 V eliminator: CE (VDE) approval pending for 230 VAC ±10%, 50 Hz, 6 V at 900 mA DC output

Enclosure: High impact ABS plastic

Dimensions: 22.2 X 9.5 X 7.9 cm (8.75 X 3.75 X 3.12 in)

Instrument Weight: 520 kg (1 lb 2.5 oz)

Shipping Weight: 3.1 kg (6 lbs 8.5 oz)

OPERATION

DANGER

Handling chemical samples, standards, and reagents can be dangerous. Review the necessary Material Safety Data Sheets and become familiar with all safety procedures before handling any chemicals.

DANGER

La manipulation des échantillons chimiques, étalons et réactifs peut être dangereuse. Lire les Fiches de Données de Sécurité des Produits (FDSP) et se familiariser avec toutes les procédures de sécurité avant de manipuler tous les produits chimiques.

PELIGRO

La manipulación de muestras químicas, estándares y reactivos puede ser peligrosa. Revise las fichas de seguridad de materiales y familiarícese con los procedimientos de seguridad antes de manipular productos químicos.

GEFAHR

Das Arbeiten mit chemischen Proben, Standards und Reagenzien ist mit Gefahren verbunden. Es wird dem Benutzer dieser Produkte empfohlen, sich vor der Arbeit mit sicheren Verfahrensweisen und dem richtigen Gebrauch der Chemikalien vertraut zu machen und alle entsprechenden Materialsicherheitsdatenblätter aufmerksam zu lesen.

PERIGO

A manipulação de amostras, padrões e reagentes químicos pode ser perigosa. Reveja a folha dos dados de segurança do material e familiarize-se com todos os procedimentos de segurança antes de manipular quaisquer produtos químicos.

PERICOLO

La manipolazione di campioni, standard e reattivi chimici può essere pericolosa. La preghiamo di prendere conoscenza delle Schede Techniche necessarie legate alla Sicurezza dei Materiali e di abituarsi con tutte le procedure di sicurezza prima di manipolare ogni prodotto chimico.

SECTION 1 DESCRIPTION

1.1 General Description

The Hach Model 2100P Portable Turbidimeter (*Figure 1*) measures turbidity from 0.01 to 1000 NTU in automatic range mode with automatic decimal point placement. The manual range mode measures turbidity in three ranges: 0.01 to 9.99, 10 to 99.9 and 100 to 1000 NTU. Designed primarily for field use, the microprocessor-based Model 2100P has the range, accuracy, and resolution of many laboratory instruments. The instrument operates on four AA batteries or with an optional battery eliminator. Rechargeable nickel-cadmium cells may be used, but cannot be recharged in the instrument. The instrument automatically shuts off after 5.5 minutes if no keystrokes occur (does not influence operation). If this occurs, simply turn the instrument on – the 2100P will resume operation as if the power had not been interrupted. The instrument, all standard accessories, and the optional battery eliminator may be conveniently stored in the carrying case.

Figure 1 2100P Turbidimeter and Accessories



Note: *Avoid prolonged exposure to ultraviolet light and sunlight.*

Note: *Do not hold the instrument during measurements; place the instrument on a flat, steady surface.*

1.2 Accessories

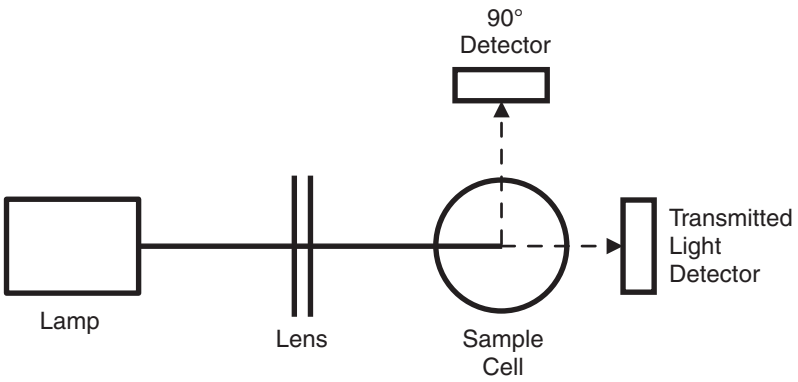
Accessories supplied with the turbidimeter include nine sample cells; three Gelex® Secondary Standards; one sealed vial each of: <0.1-NTU, 20-NTU, 100-NTU, and 800-NTU StablCal® Stabilized Formazin Standards; 4 AA alkaline batteries; 15 mL of silicone oil; oiling cloth; carrying case; instrument manual; and quick reference card.

1.3 Principle of Operation

The Model 2100P Portable Turbidimeter operates on the nephelometric principle of turbidity measurement. This instrument meets the design criteria specified by the United States Environmental Protection Agency, Method 180.1.

The optical system* (*Figure 2*) includes a tungsten-filament lamp, a 90° detector to monitor scattered light and a transmitted light detector. The instrument's microprocessor calculates the ratio of the signals from the 90° and transmitted light detectors. This ratio technique corrects for interferences from color and/or light absorbing materials (such as activated carbon) and compensates for fluctuations in lamp intensity, providing long-term calibration stability. The optical design also minimizes stray light, increasing measurement accuracy.

Figure 2 Ratio Optical System



* Patent number 4,198,161; other patents pending.

1.4 Preparation for Use

1.4.1 Unpacking

Remove the instrument and accessories from the shipping box and inspect them for damage that may have occurred due to rough handling or extreme weather conditions. Verify the following are present:

- Model 2100P Portable Turbidimeter
- Instrument Manual (with quick reference card)
- Set of StablCal Primary Standards in sealed vials, one each of:
  <0.1 NTU*
  20 NTU
  100 NTU
  800 NTU
- Standardization Kit containing Gelex Secondary Standards (0-10, 0-100 and 0-1000 ranges) plus nine sample cells with caps.
- Silicone Oil, 15-mL (0.5 oz) dropping bottle
- Oiling Cloth
- Carrying Case
- Four AA alkaline batteries

If any of the items are missing or damaged, please contact the Customer Service Department, Hach Company, Loveland, Colorado. The toll-free number in the United States is 800-227-4224. International customers should contact the Hach office or authorized distributor serving your area. Refer to *REPAIR SERVICE* on page *77*. **Please do not return the instrument without prior authorization from Hach.**

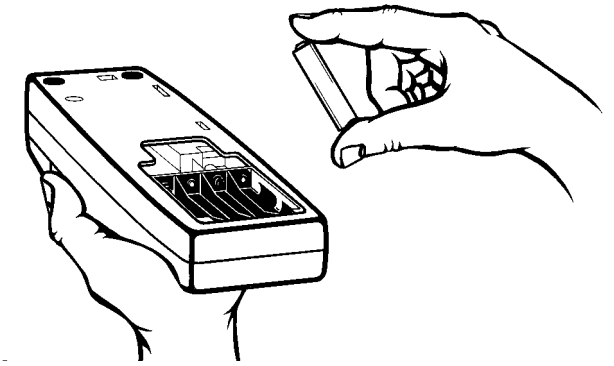
1.4.2 Battery Installation

The instrument is shipped completely assembled without the batteries installed. Before use, install the four AA alkaline batteries or connect

* Used in place of the dilution water standard when performing a calibration.

the battery eliminator (*Figure 3*). For battery operation, remove the battery compartment cover on the instrument bottom and install the batteries. Correct battery polarity is shown on the battery holder. The instrument will not function if the batteries are not installed correctly. Reinstall the battery compartment cover.

Figure 3 Battery Installation



1.4.3 Using the Battery Eliminator and Rechargeable Batteries

For operation with the optional battery eliminator, plug the eliminator jack into the connector on the turbidimeter side. The battery eliminator may be used with or without the batteries installed. **The eliminator will not charge batteries.** Rechargeable batteries may be used in the instrument, but must be removed for recharging. See *HOW TO ORDER* on page *76* for ordering information. To prolong battery life, the instrument lamp turns on temporarily when the **READ** key is depressed. Batteries are not necessary for battery eliminator operation.

1.4.4 Calibration

The 2100P Portable Turbidimeter is calibrated with Formazin Primary Standard at the factory and **does not require recalibration before use.** Hach recommends recalibration with formazin once every three months, or more often as experience dictates. The Gelex Secondary Standards supplied with the instrument are labelled with general ranges

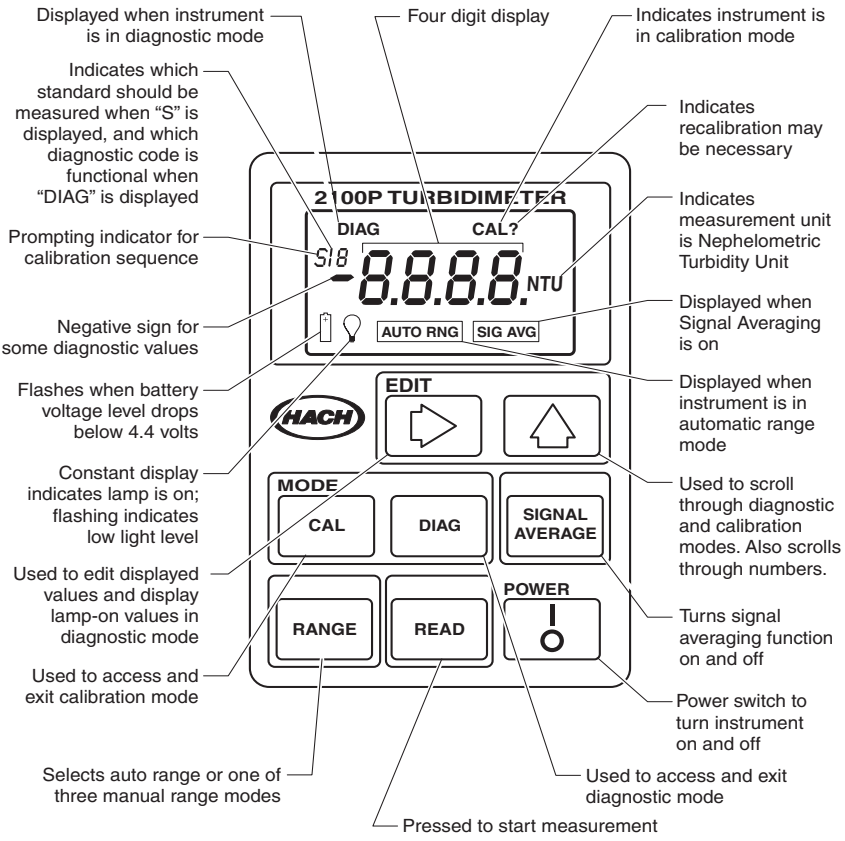
for application, but must be assigned values before use from formazin calibration. See *Section 3.6* on page *37* for calibration instructions.

SECTION 2 TURBIDITY MEASUREMENT

2.1 Operating Controls and Indicators

Figure 4 shows the 2100P controls and indicators. Refer to *SECTION 3* for a detailed description of each control and indicator.

Figure 4 Keyboard and Display with Descriptions



2.2 Turbidity Measurement

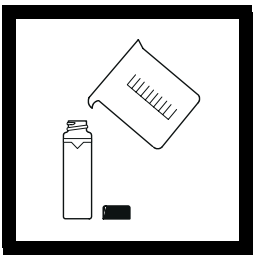
Measurements may be made with the signal average mode on or off and in manual or automatic range selection mode. Using automatic range selection is recommended. Signal averaging uses more power and should be used only when the sample causes an unstable reading. Signal averaging measures and averages ten measurements while displaying

intermediate results. The initial value is displayed after about 11 seconds and the display is updated every 1.2 seconds until all ten measurements are taken (about 20 seconds). After this, the lamp turns off, but the final measured turbidity value continues to be displayed until another key is pressed.

When not in signal average mode, the final value is displayed after about 13 seconds.

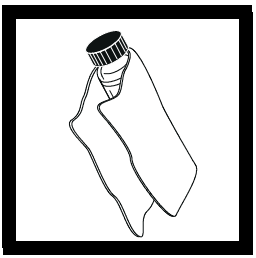
Accurate turbidity measurement depends on good measurement technique by the analyst, such as using clean sample cells in good condition and removing air bubbles (degassing). Refer to *Section 2.3* on page *22* for a detailed discussion of measurement techniques.

2.2.1 Turbidity Measurement Procedure

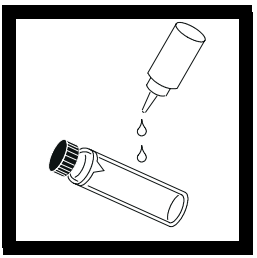


1. Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell. (See *Section 2.3* on page *22* for more information about collecting a representative sample).

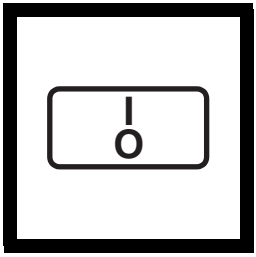
Note: *The instrument automatically shuts off after 5.5 minutes if no keystrokes occur. To resume operation, press* **I/O**.



2. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints.

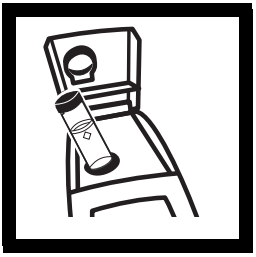


3. Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.



4. Press: **I/O**.

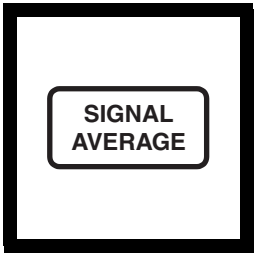
The instrument will turn on. Place the instrument on a flat, sturdy surface. Do not hold the instrument while making measurements.



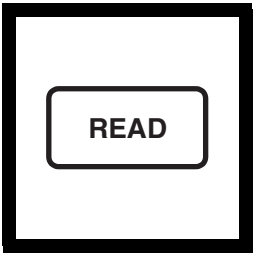
5. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment.
Close the lid.



6. Select manual or automatic range selection by pressing the **RANGE** key. The display will show **AUTO RNG** when the instrument is in automatic range selection.



7. Select signal averaging mode by pressing the **SIGNAL AVERAGE** key. The display will show **SIG AVG** when the instrument is using signal averaging. Use signal average mode if the sample causes a noisy signal (display changes constantly).



8. Press: **READ**

The display will show **- - - - NTU**, then the turbidity in NTU. Record the turbidity after the lamp symbol turns off.

Note: *The instrument defaults to the last operating mode selected. If automatic range mode and signal averaging were used on the previous measurements, these options will automatically be selected for subsequent samples.*

2.2.2 Measurement Notes

- Always cap the sample cell to prevent spillage of sample into the instrument.
- When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.
- Always close the sample compartment lid during measurement and storage.
- Always use clean sample cells in good condition. Dirty, scratched, or damaged cells can cause inaccurate readings.
- Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.
- Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).
- Avoid operating in direct sunlight.
- Make certain cold samples do not “fog” the sample cell.
- Avoid settling of sample prior to measurement.
- Keep sample compartment lid closed to prevent dust and dirt from entering.

2.3 Measurement Techniques

Proper measurement techniques are important in minimizing the effects of instrument variation, stray light and air bubbles. Regardless of the instrument used, measurements are more accurate, precise and repeatable if the analyst pays close attention to proper measurement techniques.

Measure samples immediately to prevent temperature changes and settling. Avoid sample dilution when possible. Particles suspended in the original sample may dissolve or otherwise change characteristics when the sample temperature changes or when the sample is diluted, resulting in a non-representative sample measurement.

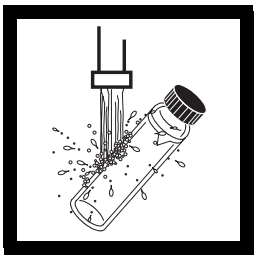
2.3.1 Cleaning Sample Cells

Cells must be extremely clean and free from significant scratches. The glass used to make cells is easily scratched – manufacturing cells free of minor scratches and other imperfections is difficult. However, minor imperfections are effectively masked by applying silicone oil as outlined in *Section 2.3.2*.

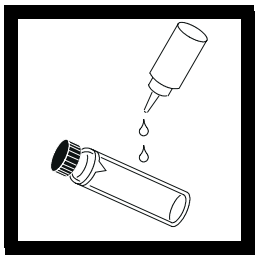
Clean the inside and outside of the cells by washing with laboratory detergent. Follow with multiple rinses of distilled or deionized water. Allow cells to air dry. Handle cells only by the top to minimize dirt, scratches and fingerprints in the light path.

2.3.2 Oiling the Sample Cell

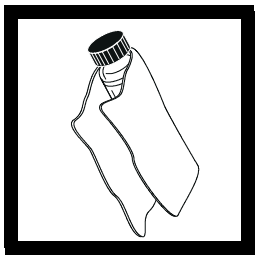
Applying a thin coat of silicone oil will mask minor imperfections and scratches which may contribute to turbidity or stray light. Use silicone oil equivalent to Hach Cat. No. 1269-36. This silicone oil has the same refractive index as glass. When applied in a thin, uniform coat, the oil fills in and masks minor scratches and other imperfections in the glass. Apply the oil uniformly by wiping with a soft, lint-free cloth.
Avoid application of excess oil. Applying excess oil may retain dirt and contaminate the instrument's cell compartment.



1. Thoroughly clean the sample cell.



2. Apply a small bead of silicone oil from the top to the bottom of the cell-- just enough to coat the cell with a thin layer of oil.



3. Using a soft, lint-free cloth, spread the oil uniformly, then wipe off the excess so that only a thin coat of oil is left. The cell should appear nearly dry with little or no visible oil.

Note: *Soft, lint-free cloth (velvet) works well for oiling. Store the oiling cloth with the sample cells and keep it free of dirt. After a few applications of oil, the cloth will contain enough residual oil that simply wiping the cell with the oiled cloth will provide a sufficient oil coat on the sample cell. Periodically, add a small amount of oil to the sample cell surface to replenish the oil in the cloth.*

Note: *Only a thin coat of oil on the sample cells is necessary.* ***Avoid using excessive amounts of oil.***

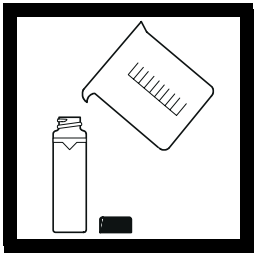
2.3.3 Orienting Sample Cells

Note: *When orienting and matching cells, it may be more efficient to use the continuous reading mode. The instrument performs continuous readings if the* **READ** *key is pressed and held. As long as the key is held, the lamp remains on and the display is updated every 1.2 seconds. The instrument cannot be used in continuous read mode if the Signal Averaging mode is on.*

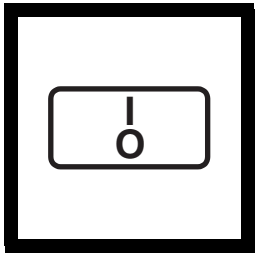
Precise measurements for very low turbidity samples require using a single cell for all measurements or optically matching the cells. Using one cell provides the best precision and repeatability. When one cell is used, an orientation mark (other than the factory-placed diamond) can be placed on the cell so it's inserted into the instrument with the same orientation each time.

2.3.3.1 Orienting a single cell

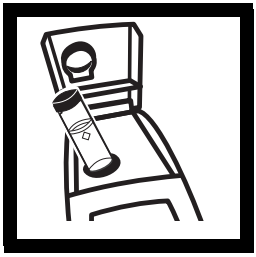
When using a single cell, make an index or orientation mark on the cell as follows:



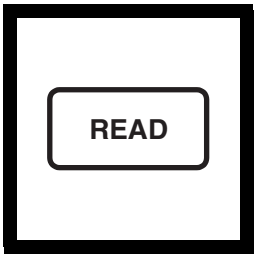
1. Fill the clean sample cell to the line with high quality water (< 0.5 NTU). Cap and wipe with lint-free cloth. Apply silicone oil. See *Section 3.6.2.2* on page *40* for more information about high quality water.



2. Press: **I/O** to turn the instrument on.



3. Insert the sample cell into the sample compartment. Close the cover.



4. Press: **READ**

Record the cell's position in the cell compartment and the displayed reading.

Note: *This procedure may be easier if the user holds the* **READ** *key through the whole process. This allows the lamp to remain on and make continuous readings.*



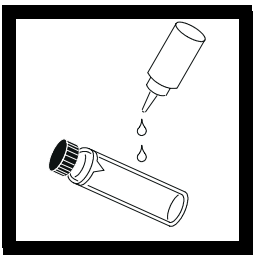
5. Remove the cell, rotate it slightly and reinsert it into the cell compartment. Close the cover, then press **READ**. Record the cell's position and the displayed reading.



6. Repeat *step 5* until the lowest reading is displayed. Place an orientation mark on the cell's marking band near the top of the cell so the cell can be consistently inserted in the position that yields the lowest reading. When using the cell, always place it in the instrument so the orientation mark aligns with the raised mark on the instrument.

2.3.4 Matching multiple sample cells

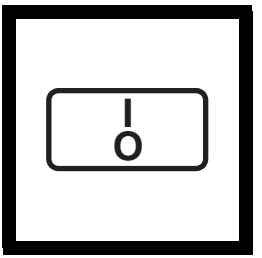
Precise measurements of very low turbidity samples require the cells be optically matched or a single cell be used for all measurements. If more than one cell is used, follow this procedure to match (index) the cells:



1. Clean and oil the sample cells as instructed in *Section 2.3.1* on page *23* and *Section 2.3.2* on page *23*.



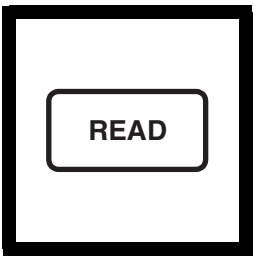
2. Fill the clean sample cells to the line with the same sample.



3. Press: **I/O** to turn the instrument on.



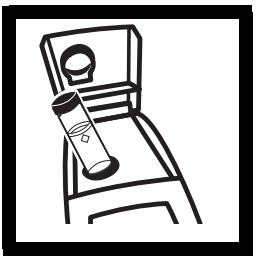
4. Insert the **first** sample cell into the sample compartment and close the cover.



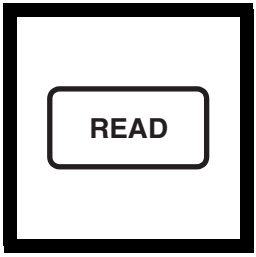
5. Press: **READ**

Record the cell's position in the cell compartment and the displayed reading. Place an orientation mark on the cell's marking band.

Note: *This procedure may be easier if the user holds the* **READ** *key through the whole process. This allows the lamp to remain on and make continuous readings.*



6. Insert the **second** sample cell into the cell compartment and close the cover.



7. Press: **READ**

Record the cell's position in the cell compartment and the displayed reading.



8. Remove the cell, rotate it slightly and reinsert into the cell compartment. Close the cover, then press **READ** again. Record the cell's position and the displayed reading.



9. Repeat *step 8* until the value displayed for the second cell is within 0.01 NTU (or 1%) of the value obtained for the first cell. Place an orientation mark on the second cell's marking band so it is consistently inserted in this position.

Note: *Due to variability in glass, it may not be possible to match all cells.*



10. Repeat *step 6* through *step 9* if matching other sample cells.

2.3.5 Removing Bubbles (Degassing)

Before measurement, removing air and other trapped gasses from the sample is strongly recommended, even if bubbles are not visible. Four degassing methods are commonly used:

1. applying a partial vacuum

2. adding a surfactant

3. using an ultrasonic bath

4. heating the sample

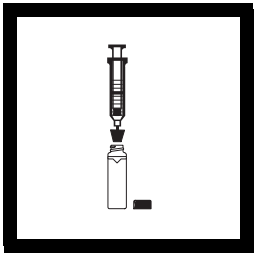
In some cases, more than one method may be necessary for effective bubble removal. For example, use of both a surfactant and ultrasonic bath may be necessary for some severe conditions. Use care with these techniques. If misused, sample turbidity can be altered.

Removing air bubbles by letting the sample stand for a period of time is not recommended. Particulates that cause turbidity may settle and the sample temperature may change. Both conditions may alter sample turbidity, resulting in measurements not representative of the original turbidity.

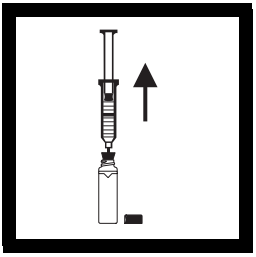
2.3.5.1 Application of vacuum

Apply a vacuum with any convenient, clean, oil-free vacuum source. The vacuum lowers the atmospheric pressure, allowing trapped bubbles to escape into the air above the sample. Vacuum works well with non-viscous samples (such as water) that don't contain volatile components. Applying vacuum to viscous, volatile-containing samples (paint resins) may cause the volatile components to come out of solution and aggravate the bubble problem.

To apply a vacuum, use a sample degassing kit equivalent to Cat No. 43975-00 (Degassing Kit) or 43975-10 (Degassing and Filtration Kit). These kits contain a syringe and rubber stopper for vacuum degassing. An electric or hand-operated pump equivalent to Cat No. 14283-00 or 14697-00, respectively, may also be used.



1. Fill a sample cell to the mark with sample. Insert a #2 single-hole rubber stopper and syringe into the cell. If using a pump, insert a piece of glass tubing into the stopper.



2. **Slowly** apply the vacuum by carefully pulling the plunger upward, then holding it. If using a hand or electric pump, connect the tubing to the vacuum pump with vacuum hose. Apply vacuum until visible gas bubbles disappear. **Slowly** release the vacuum. Remove the vacuum apparatus and cap the cell.

2.3.5.2 Adding a surfactant

Surfactants should be limited to severe problems when other degassing methods are ineffective. Surfactants change the surface tension of the water, which releases trapped gases. Hach recommends a surfactant such as Triton X-100 or the equivalent, Hach Cat No. 14096-37. Put one drop of Triton X-100 in the sample cell before adding sample.

Note: *Any turbidity contributed by surfactant addition is negligible.*

This technique is very effective when the water is super-saturated with air. However, changing the surface tension may accelerate settling of turbidity-causing particles. Mix the sample gently, but thoroughly, and analyze as soon as possible after adding the surfactant. Avoid vigorous mixing as the surfactant may foam. Rinse the sample cells thoroughly between samples to prevent surfactant accumulation.

2.3.5.3 Using an ultrasonic bath

Note: *The time necessary to expel bubbles may vary from a few seconds to a minute or more. To avoid excessive application of ultrasound, a simple procedure can be followed. First, apply ultrasound until all visible bubbles are absent. Then measure the sample turbidity. Apply ultrasound for a short time period and again measure turbidity. Continue for several repetitions, noting the treatment time and turbidity readings. If turbidity begins to increase instead of decrease, the ultrasound waves have probably started to alter the suspended particles. Note the time it takes for this to occur and record it as the maximum time limit for ultrasonic treatment.*

Ultrasonic baths effectively remove gas bubbles from most samples, especially viscous liquids. However, the ultrasonic waves which cause degassing may also alter the characteristics of the particles causing the turbidity. Turbidity depends on the size, shape, composition and refractive index of the suspended particles. Excessive ultrasound application may alter particle size and shape, thus changing sample turbidity. In some cases, ultrasound may aggravate air bubble removal by fracturing the bubbles, making degassing more difficult.

1. Fill a clean sample cell to the line with sample. Leave uncapped.

2. Immerse the cell (1/2 to 2/3 immersed) in an ultrasonic bath and allow it to stand until visible bubbles are expelled.

3. Remove the cell, cap, then thoroughly dry the cell. Apply silicone oil as directed.

2.3.5.4 Application of heat

Whenever possible, avoid using heat to degas samples because heat may change the characteristics of the suspended particles and cause volatile components to come out of solution. Gentle heating may be helpful for degassing some very viscous samples when combined with application of vacuum or ultrasound. If heat is necessary, heat the sample only until degassing occurs. The simplest technique is to prepare a warm water bath and partially immerse the filled sample cell. Use the shortest time necessary for expelling visible bubbles. Cool sample to original sample temperature before taking measurements.

2.3.6 Measuring Overrange Samples

Nephelometric turbidity measurement depends on detection of light scattered from particles suspended in the liquid. If the turbidity is very high, a significant amount of light is blocked or absorbed by the particles and only a small amount of light reaches the detector. This results in a negative interference – the measured turbidity is lower than the actual turbidity. This condition is called “going blind”. A multidetector ratioing instrument, such as the Hach 2100P Turbidimeter, minimizes this effect and extends the instrument range. Highly turbid samples may also be diluted, but this should be avoided when possible since it may alter the characteristics of the suspended particles and produce erroneous results.

Light absorbing particles such as activated carbon and highly colored samples may also cause an instrument to “go blind”. Dilution may not correct for these interferences. A ratioing instrument will correct for the presence of light absorbing particles and color.

2.3.7 Condensation (fogging)

Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at room temperature or immersing it in a warm bath for a short period. After warming, mix the sample thoroughly before measurement. Allowing samples to warm can alter sample turbidity, so it is best to avoid warming samples before measurement when possible.

2.3.8 Calibration

Turbidimeters must be properly calibrated with a primary standard. Hach recommends formazin or StablCal Stabilized Formazin for calibration. For U.S. Environmental Protection Agency (USEPA) reporting, calibrate at least as often as required by the appropriate regulatory agencies. The frequency of calibration depends on environmental conditions (humidity, temperature) and use. If necessary, calibrate more frequently.

Use secondary standards for periodic calibration checks. Please note that Gelex® standards must be assigned values after StablCal Stabilized Formazin calibration or formazin calibration and before use as secondary standards. Gelex standards must be recalibrated (values assigned) each time the instrument is calibrated with StablCal Stabilized Formazin or formazin. See *Section 3.6* on page *37* for detailed information on the use of StablCal Stabilized Formazin, formazin, and Gelex standards.

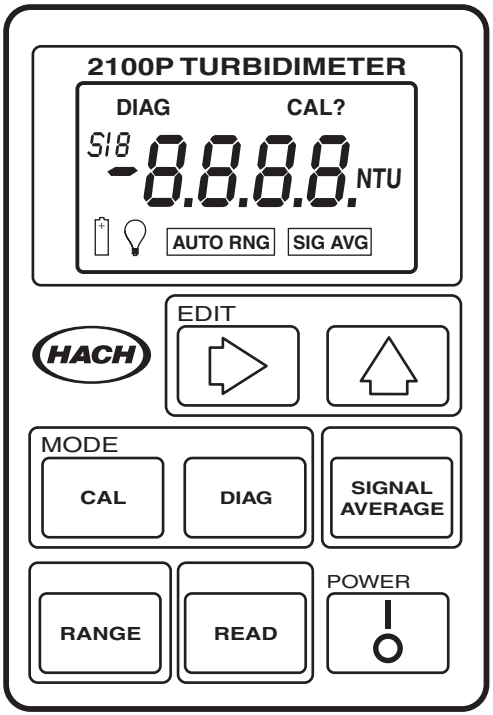
2.3.9 Representative Sampling

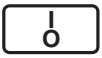
A representative sample accurately reflects the true condition of the water source from which the sample was taken. To ensure a representative sample, gently, but thoroughly, mix every sample before aliquots are taken. Do not allow the sample to settle.

When sampling from a tap in a distribution system or treatment plant, allow the water to run for at least five minutes before sampling. When sampling from a stream, reservoir, clarifier, or storage tank, collect at least one liter (l quart) and thoroughly mix before measurement. If the water source is not uniform, it may be necessary to sample several locations at varying depths and combine the samples into a single, well-mixed composite sample before measurement.

SECTION 3 OPERATION

3.1 Operational Controls and Indicators



Key	Description
	Power key to turn instrument on and off. If no keys are pressed for 5.5 minutes, the instrument turns off automatically.
	Depressed to perform a measurement. To conserve battery power, the lamp turns on only when **READ** is depressed. A reading is displayed about 12 seconds after the key is depressed. During the delay, a flashing **NTU** is displayed. After the reading is displayed, the lamp turns off and the reading continues to be displayed. Continuous readings may be done by holding this key if **not** in the Signal Averaging mode. After the initial delay, the reading is updated every 1.2 seconds.
	Used to perform a calibration or review calibration data. Also terminates a calibration or calibration review and returns to the 2100P measurement mode.

Key	Description
	Edits a flashing digit in the calibration mode or sequences through the calibration standards (S0,S1, S2, S3) or diagnostic menu.
	Used to move the editing cursor to the digits being edited in the calibration mode or initiate editing of a standard value.
SIGNAL AVERAGE	Turns the signal averaging function on or off.
DIAG	Selects the diagnostic mode.
RANGE	Selects Auto Range or Manual Range (one of three manual modes).

Display Icon	Description
DIAG	Turns on after the **DIAG** is pressed to access the diagnostic mode. A number displayed under the **DIAG** icon (1-9) indicates which diagnostic function is active. See *Section 5.1* on page *67* for more information on diagnostic codes.
CAL	Turns on after the **CAL** key is pressed to access the calibration mode and remains on during the calibration.
CAL?	Appears after calibration if a value entered during calibration is outside an acceptable range. May indicate an operator error or possible instrument malfunction. Flashing **CAL?** indicates the default calibration coefficients are being used (even after a user-calibration has been done) or that no calibration data is currently stored.
S__	Displayed during calibration. The S is followed by a number to indicate which standard value is currently being edited or displayed. Flashing number is prompting user for measurement of **S0**, **S1**, **S2** or **S3** to establish a calibration. Steady number identifies which standard's value is being displayed.
	Flashes when the battery voltage drops to 4.4 volts as an indication to change batteries. At <4.0 volts, the instrument automatically shuts off.
	The lamp symbol is constantly on when the lamp is on and flashes after a reading if a marginal light level reaches the transmitted light detector. A flashing icon indicates the sample may be too turbid (not within measurement range) and needs dilution or the lamp needs replacing.

Display Icon	Description
SIGNAL AVERAGE	Indicates the signal averaging mode is on. The icon turns off if signal averaging is not selected.
AUTO RNG	Indicates instrument is in automatic range mode. The icon turns off when manual range mode is selected.
8888	The 4-digit display is active when the instrument is on (measurements are displayed to three digits). After the **READ** key is pressed **- - - -** is displayed during wait periods.
NTU	Identifies the measurement units- Nephelometric Turbidity Units. This icon is active during measurements and in the calibration mode.

3.2 Using the Read Key

To preserve battery power and prolong lamp life, the lamp turns on only after the **READ** key is pressed. Pressing the key turns the instrument lamp on; after about 12 seconds, the lamp turns off, but the measurement value continues to be displayed. After the first measurement, a four-second recovery time occurs before another measurement can be started. If **READ** is pressed during the recovery time, the display will begin flashing, but the lamp will not turn on until the full four seconds have passed. If no other key strokes occur within 5.5 minutes, the instrument turns off.

3.2.1 Continuous Reading

The instrument cannot be used in continuous read mode if the Signal Averaging mode is on.

The instrument will perform continuous readings if the **READ** key is pressed and held. As long as the key is held, the lamp remains on and the display is updated every 1.2 seconds.

3.3 Using the Signal Averaging Key

The signal averaging mode compensates for reading fluctuations caused by drifting of sample particles through the light path. Signal averaging is turned on or off by pressing the **SIGNAL AVERAGE** key. The **SIG AVG** icon is displayed when signal averaging is on.

Signal averaging measures and averages ten measurements while displaying intermediate results. The initial value is displayed after about

11 seconds and the display is updated every 1.2 seconds until all ten measurements are taken (about 22 seconds). After 22 seconds, the lamp turns off, but the final measured turbidity value continues to be displayed until another key is pressed.

When signal averaging is off, the instrument takes three measurements, the microprocessor averages them, then displays the average. If the **READ** key is held during measurement, the initial value is displayed in 12 seconds and is updated every 1.2 seconds as long as the **READ** key is held.

When the instrument is turned on, the instrument defaults to the signal averaging mode which was used during the last measurement.

3.4 Using the Range Selection Key

As shipped, the instrument defaults to automatic range mode. The first time the **RANGE** key is pressed, the instrument goes into manual range mode. The second, third, and fourth key strokes put the instrument in the 0.00-9.99, 10 to 99.9 or 100-1000 NTU range, respectively. Another key stroke brings the selection back to automatic range mode. When the automatic range mode is selected, the **AUTO RNG** icon is displayed. Range selection can be done any time except when a measurement or calibration is in progress.

When the instrument is turned on, the instrument defaults to the range mode and measurement range which was used during the last measurement.

3.5 Restoring the Default Calibration

To restore and use the default calibration, turn the instrument off. Press and hold **DIAG**, then press and release **I/O**. Release **DIAG** when the software version number disappears from the display. (For models with serial number less than 920300000800, **2100** disappears). This clears any user-entered calibration from memory; the 2100P will use the default calibration for measurement. **CAL?** will appear and continue to flash until a user-entered calibration is successfully completed.

For best results, a user-entered calibration should be done every three months.

3.6 Calibration

Calibration of the 2100P Turbidimeter is based on formazin, the primary standard for turbidity. The instrument's electronic and optical design provide long-term stability and minimize the need for frequent calibration. The two-detector ratioing system compensates for most fluctuations in lamp output. **A formazin recalibration should be performed at least once every three months,** more often if experience indicates the need. When calibration is necessary, use a primary standard such as StablCal™ Stabilized Standards or formazin standards.

Hach Company only recommends the use of StablCal® Stabilized Formazin or formazin standards for the calibration of Hach turbidimeters. Hach Company cannot guarantee the performance of the turbidimeter if calibrated with co-polymer styrene divinylbenzene beads or other suspensions.

Important Note: DO NOT calibrate with Gelex® Secondary Standards. Gelex standards are designed for instrument verification, not calibration.

3.6.1 StablCal Stabilized Formazin Standards*

Most consistent results will be achieved with the use of StablCal Stabilized Formazin Standards for calibration. Refer to *Section 3.6.1.2* and *Section 3.6.1.3* for information on preparing the standards for use.

Note: *Hach StablCal Stabilized Formazin in 20-, 100-, and 800-NTU values is packaged in convenient sets for calibration of the 2100P Turbidimeter. The set may be ordered in 500-mL size bottles by specifying Cat. No. 26594-00, in 100-mL size bottles by specifying Cat. No. 26594-10 or in sealed vials by ordering Cat. No. 26594-05. (See OPTIONAL ACCESSORIES AND REAGENTS on page 74.)*

3.6.1.1 Storing and Handling StablCal Stabilized Standards

For optimum results when using StablCal Stabilized Standards, adhere to the following recommendations:

* StablCal Stabilized Formazin is cited as a primary standard in Hach Method 8195, an acceptable version of USEPA Method 180.1.

- Do not transfer the standard to another container for storage.
- Do not return standard from the sample cell back into the its original container. Standard contamination will result.
- Store standards between 0 and 25 °C.
- For long-term storage, refrigeration at 5 °c is recommended. Do not store above 25 °C.
- Allow the standard to acclimate to ambient instrument conditions before use (not to exceed 40 °C).
- Store away from direct sunlight. Store vials in their respective kit or shipping box with the cover in place.

3.6.1.2 Preparing Bulk StablCal Stabilized Standards

Bulk standards that have been sitting undisturbed for longer than a month must be shaken to break the condensed suspension into its original particle size. Start at *step 1* for these standards. If the standards are used on at least a weekly interval, start at *step 3*.

Important Note: These instructions do not apply to <0.1-NTU* StablCal Standards; <0.1NTU StablCal Standards should not be shaken or inverted.

1. Shake the standard vigorously for 2-3 minutes to resuspend any particles.
2. Allow the standard to stand undisturbed for 5 minutes.
3. Gently invert the bottle of StablCal 5 to 7 times.
4. Prepare the sample cell for measurement using traditional preparation techniques. This usually consists of oiling the sample cell (see*Section 2.3.2* on page *23*) and marking the cell to maintain the same orientation in the sample cell compartment (see *Section 2.3.3* on page *24*). This step will eliminate any optical variations in the sample cell.

* Used in place of the dilution water standard when performing a calibration.

5. Rinse the sample cell at least one time with the standard and discard the rinse.

6. Immediately fill the sample cell with the standard. Cap the sample cell and let it stand for one minute. The standard is now ready for use in the calibration procedure, *Section 3.6.3*.

3.6.1.3 Preparing StablCal Stabilized Standards in Sealed Vials

Sealed vials that have been sitting undisturbed for longer than a month must be shaken to break the condensed suspension into its original particle size. Start at *step 1* for these standards. If the standards are used on at least a weekly interval, start at *step 3*

Important Note: These instructions do not apply to <0.1-NTU* StablCal Standards; <0.1NTU StablCal Standards should not be shaken or inverted.

1. Shake the standard vigorously for 2-3 minutes to resuspend any particles.

2. Allow the standard to stand undisturbed for 5 minutes.

3. Gently invert the vial of StablCal 5 to 7 times.

4. Prepare the vial for measurement using traditional preparation techniques. This usually consists of oiling the vial (see *Section 2.3.2* on page *23*) and marking the vial to maintain the same orientation in the sample cell compartment (see *Section 2.3.3* on page *24*). This step will eliminate any optical variations in the sample vial.

5. Let the vial stand for one minute. The standard is now ready for use in the calibration procedure, *Section 3.6.3*.

3.6.2 Formazin Primary Standards

Perform the procedure in *Section 3.6.2.1* to prepare a 4000-NTU standard. Alternately, order a 4000-NTU stock solution from Hach by specifying Cat. 2461-49. Prepare the dilutions from the 4000-NTU stock solution by following the instructions in *Section 3.6.2.4*.

3.6.2.1 Preparing Formazin Stock Solution

Dilute formazin standard solutions from a 4000 NTU stock solution equivalent to Hach Cat. No. 2461-49. The prepared stock solution is stable for up to one year when properly prepared. An alternative to purchasing the 4000 NTU stock solution is preparing a stock solution as follows:

1. Dissolve 5.000 grams of reagent grade hydrazine sulfate ($N_2H_4 \cdot H_2SO_4$) in 400 mL of distilled water.

2. Dissolve 50.000 grams of pure hexamethylenetetramine in 400 mL of distilled water.

3. Pour the two solutions into a 1000-mL volumetric flask and dilute to the mark with distilled water.

4. Let the solution stand for 48 hours at 25 °C (77 °F) to develop the 4000-NTU stock suspension. The standing temperature is critical for correct formation of formazin polymers.

5. Mix the 4000 NTU suspension for at least ten minutes before use. Then it can be diluted with distilled or demineralized water to achieve a solution of the desired NTU value.

Instead of diluting a formazin stock solution, StablCal Stabilized Formazin Standards may be used. Order the StablCal Calibration Set for the 2100P Turbidimeter, Cat.No. 26594-00 (500-mL bottles), Cat. No. 26594-10 (100 mL bottles), or Cat. No. 26594-05 (sealed vials). (See *OPTIONAL ACCESSORIES AND REAGENTS* on page *74*.)

3.6.2.2 Correcting for Turbidity of Dilution Water

The 2100P Turbidimeter automatically compensates for turbidity contributed by dilution water when calculating the true value of the lowest formazin standard. Use high quality distilled or deionized water less than 0.5 NTU. The instrument will display E 1 after calibration if

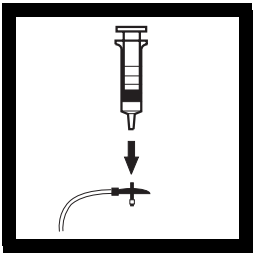
the dilution water turbidity is greater than 0.5 NTU. In this case, prepare the water as directed below.

The value of the dilution water can be arbitrarily forced to zero (see calibration procedure). This is not recommended for most applications and, if done, should be done only if the dilution water turbidity is less than 0.2 NTU.

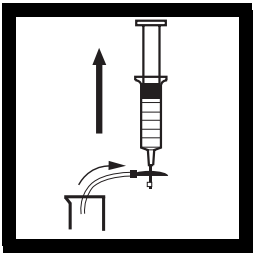
3.6.2.3 Preparing Dilution Water

Note: *Use the same dilution water for all dilutions and the sample blank.*

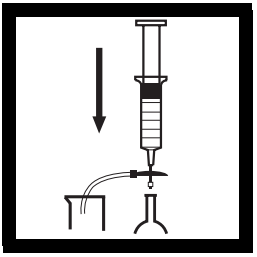
Collect at least 1000 mL of high quality dilution water (distilled or deionized water). The 2100P Turbidimeter, as received from the factory, is precalibrated and may be used to check the dilution water turbidity. If the turbidity is greater than 0.5 NTU, filter the water with the Sample Filtration and Degassing Kit (Cat. No. 43975-10) or equivalent. When measuring low range turbidity, clean all glassware with 1:1 hydrochloric acid and rinse several times with dilution water. If the glassware is not used immediately, use stoppers to prevent contamination from small particles.



1. Attach the syringe to the 3-way valve by gently twisting the square end into the syringe tip. Attach the connector, tubing and a 0.2 micron filter (clear part faces syringe) as shown. Be sure the connections are tight.



2. Fill a beaker or container with the water to be filtered. Insert the tubing into the container. Slowly draw the water into the syringe by pulling up on the syringe plunger.



3. Draw about 50 mL of sample into the syringe. Slowly push on the plunger to force the water through the filter and into a graduated cylinder or volumetric flask. Repeat Steps 2 and 3 until the desired amount of water is obtained.

Note: *As the filter clogs, it gets more difficult to push water through it. At this point, discard the filter and attach a new filter. Replacement filters are available in packages of 10 (Cat. No. 23238-10).*

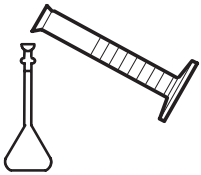
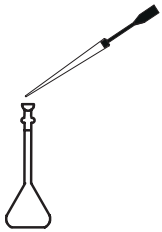
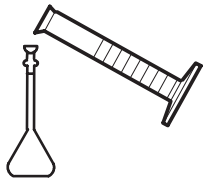
3.6.2.4 Preparing Formazin Dilutions (Factory recommended)

Hach Company recommends using 20, 100, and 800 NTU formazin standards for calibrating the 2100P Turbidimeter. Dilutions with other NTU values can be prepared and used (see *Section 3.6.3.1* on page *48*). If problems occur when using alternate solutions, use the dilutions specified here.

Prepare all formazin dilutions immediately before use and discard after calibration. The 4000 NTU solution is stable for up to a year, but dilutions deteriorate more rapidly. Use the same high quality water (turbidity <0.5 NTU) for the dilutions and the blank.

Preparing the 20, 100 and 800 NTU standards

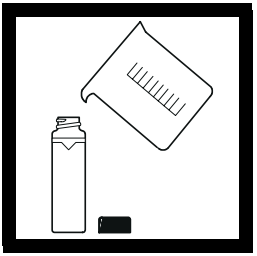
Table 1 Formazin Standard Preparation

	Step 1	Step 2	Step 3
Standards			
20 NTU	Add 100 mL of dilution water to a clean **200-mL** class A volumetric flask.	With a TenSette* pipet, add 1.00 mL of well-mixed 4000 NTU Formazin stock solution to the 200-mL flask.	Dilute to the mark with dilution water. Stopper and mix.
100 NTU	Add 100 mL of dilution water to a clean **200-mL** class A volumetric flask.	With a TenSette pipet, add 5.00 mL of well-mixed 4000 NTU Formazin stock solution to the 200-mL flask.	Dilute to the mark with dilution water. Stopper and mix.
800 NTU	Add 50 mL of dilution water to a clean **100-mL** class A volumetric flask.	With a TenSette pipet, add 20.00 mL of well-mixed 4000 NTU Formazin stock solution to the 100-mL flask.	Dilute to the mark with dilution water. Stopper and mix.

* A class A volumetric pipet may be used in place of a TenSette Pipet.

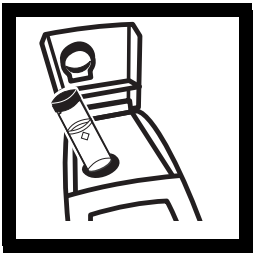
3.6.3 Calibrating the Turbidimeter

Note: *For best accuracy use the same sample cell or four matched sample cells for all measurements during calibration. Always insert the cell so the orientation mark placed on the cell during the matching procedure is correctly aligned. (See Section 2.3.4 on page 26 for matching sample cells).*



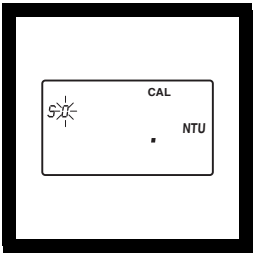
1. Rinse a clean sample cell with dilution water several times. Then fill the cell to the line (about 15 mL) with dilution water or use StablCal <0.1 NTU standard.

Note: *The same dilution water used for preparing the standards must be used in this step.*



2. Insert the sample cell in the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid. Press **I/O**.

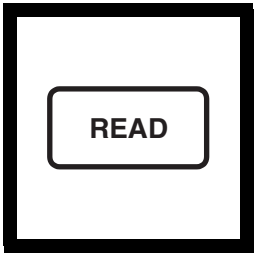
Note: *Choose signal average mode option (on or off) before pressing* **CAL** *– the* **SIGNAL AVERAGE** *key is not functional in calibration mode.*



3. Press: **CAL**

The **CAL** and **S0** icons will be displayed (the **0** will flash). The 4-digit display will show the value of the S0 standard for the previous calibration. If the blank value was forced to 0.0, the display will be blank (as shown). Press → to get a numerical display.

Hach Company only recommends the use of StablCal® Stabilized Formazin or formazin standards for the calibration of Hach turbidimeters. Hach Company cannot guarantee the performance of the turbidimeter if calibrated with co-polymer styrene divinylbenzene beads or other suspensions. DO NOT calibrate with Gelex® Secondary Standards.



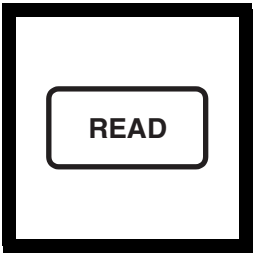
4. Press: **READ**

The instrument will count from 60 to 0, (67 to 0 if signal average is on), read the blank and use it to calculate a correction factor for the 20 NTU standard measurement. If the dilution water is ≥ 0.5 NTU, E 1 will appear when the calibration is calculated (See *Section 3.6.2.3* on page *41* for more dilution water information). The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

Note: *The turbidity of the dilution water can be "forced" to zero by pressing → rather than reading the dilution water. The display will show* **S0 NTU** *and the ↑ key must be pressed to continue with the next standard.*

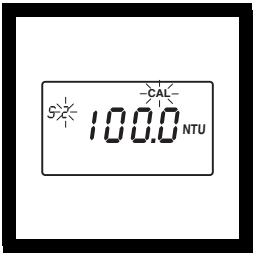


5. The display will show the **S1** (with the 1 flashing) and **20 NTU** or the value of the S1 standard for the previous calibration. If the value is incorrect, edit the value by pressing the → key until the number that needs editing flashes. Use the ↑ key to scroll to the correct number. After editing, fill a clean sample cell to the line with **well mixed** 20 NTU StablCal Standard or 20 NTU formazin standard. Insert the sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.

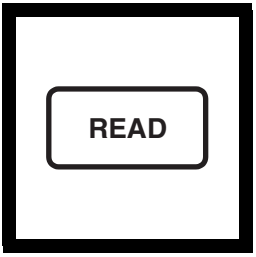


6. Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

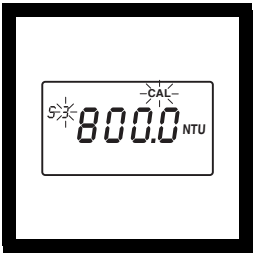


7. The display will show the **S2** (with the 2 flashing) and **100 NTU** or the value of the S2 standard for the previous calibration. If the value is incorrect, edit the value by pressing the → key until the number that needs editing flashes. Use the ↑ key to scroll to the correct number. After editing, fill a clean sample cell to the line with **well mixed** 100 NTU StablCal Standard or 100 NTU formazin standard. Insert the sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.

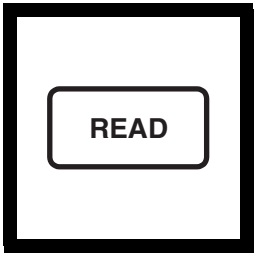


8. Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. Then, the display will automatically increment to the next standard. Remove the sample cell from the cell compartment.



9. The display will show the **S3** (with the 3 flashing) and **800 NTU** or the value of the S3 standard for the previous calibration. If the value is incorrect, edit the value by pressing the → key until the number that needs editing flashes. Use the ↑ key to scroll to the correct number. After editing, fill a clean sample cell to the line with **well mixed** 800 NTU StablCal Standard or 800 NTU formazin standard. Insert the sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.



10. Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. Then the display will increment back to the S0 display. Remove the sample cell from the cell compartment.



11. Press: **CAL** to accept the calibration. The instrument will return to measurement mode automatically.

Note: *Pressing* **CAL** *completes the calculation of the calibration coefficients. If calibration errors occurred during calibration, error messages will appear after* **CAL** *is pressed. If* **E 1** *or* **E 2** *appear, check the standard preparation and review the calibration; repeat the calibration if necessary. If* **CAL?** *appears, an error may have occurred during calibration. If* **CAL?** *is flashing, the instrument is using the default calibration.*

NOTES

- If the **I/O** key is pressed during calibration, the new calibration data is lost and the old calibration will be used for measurements. Once in calibration mode, only the **READ, I/O,** ↑, and → keys function. Signal averaging and range mode must be selected before entering the calibration mode.

- If **E 1** or **E 2** are displayed, an error occurred during calibration. Check the standard preparation and review the calibration; repeat the calibration if necessary. Press **DIAG** to cancel the error message (**E 1** or **E 2**). To continue without repeating the calibration, press **I/O** twice to restore the previous calibration. If **CAL?** is displayed, an error may have occurred during calibration. The previous calibration may not be restored. Either recalibrate or use the calibration as is.

- To review a calibration, press **CAL** and then ↑ to view the calibration standard values. As long as **READ** is never pressed and **CAL** is not flashing, the calibration will not be updated. Press **CAL** again to return to the measurement mode.

3.6.3.1 Preparing User-selected Formazin Dilutions

The formazin solutions should span the entire range of the instrument. Hach recommends preparing three standards:

1. 10 to 30 NTU

2. 90 to 110 NTU

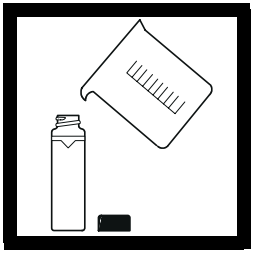
3. 700 to 900 NTU

The standards must have a difference of at least 60 NTU.
In addition, a blank made from the dilution water should be prepared.

Prepare the formazin standard solutions from the well mixed 4000 NTU stock solution as specified in *Section 3.6.2.4* on page *42* and dilution water as specified in *Section 3.6.2.2* and *Section 3.6.2.3* on page *41*. Make the standards **immediately** before use and discard them after calibration is done.

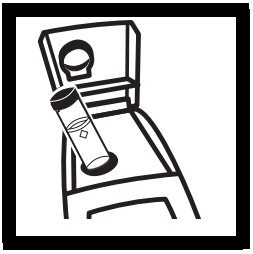
3.6.3.2 Calibrating with User-selected Standards

Note: *For best accuracy use the same sample cell or four matched sample cells for all measurements during calibration. Always insert the sample cell with the same orientation.*



1. Fill a clean sample cell to the line (about 15 mL) with dilution water.

Note: *The same dilution water used for preparing the standards must be used in this step.*



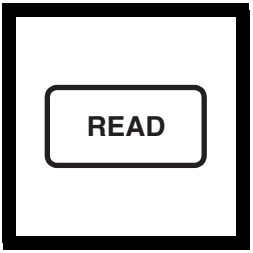
2. Insert the sample cell into the cell compartment and close the lid. Press **I/O**.

Note: *Choose signal average mode option (on or off) before pressing* **CAL** *– the* **SIGNAL AVERAGE** *key is not functional in calibration mode.*



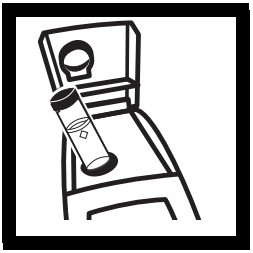
3. Press: **CAL**.

The **CAL** and **S0** icons will appear (the **0** will flash). The 4-digit display will show the value of the S0 standard for the previous calibration.

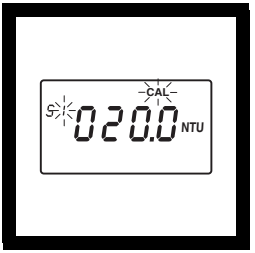


4. Press: **READ**.

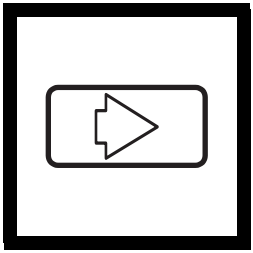
The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the blank and use it to calculate a correction factor for the lowest standard. If the dilution water is ≥0.5 NTU, **E 1** will appear (see *Section 3.6.2.3* on page *41* for more dilution water information). The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.



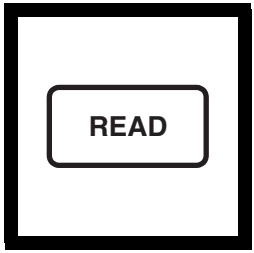
5. Thoroughly mix the 10 to 30 NTU range standard, then fill a clean sample cell to the line with the standard. Insert the sample cell into the cell compartment



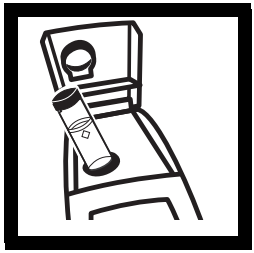
6. The display will show the **S1** icon (with the **1** flashing) and **20 NTU** or the value of the S1 standard for the previous calibration.



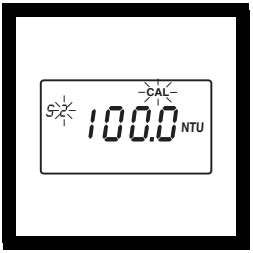
7. Edit the standard concentration by pressing →. The **1** will stop flashing and the left digit in the display will flash. Press ↑ to scroll the digit up to the appropriate number. Press → again to move the cursor to the next digit and edit it in the same manner.



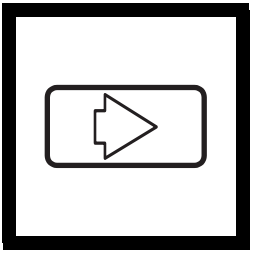
8. When all the digits show the appropriate value, press **READ**. The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.



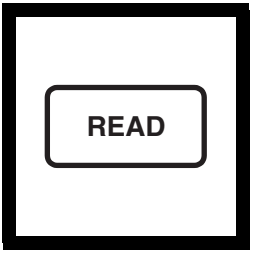
9. Thoroughly mix the 90 to 110 NTU standard, then fill a clean sample cell to the line with the standard. Insert the cell into the cell compartment.



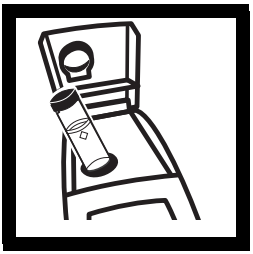
10. The display will show the **S2** icon (with the **2** flashing) and **100 NTU** or the value of the S2 standard for the previous calibration.



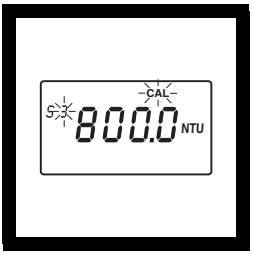
11. Edit the standard concentration by pressing →. The **2** will stop flashing and the left digit in the display will flash. Press ↑ to scroll the digit up to the appropriate number. Press → again to move the cursor to the next digit and edit it in the same manner.



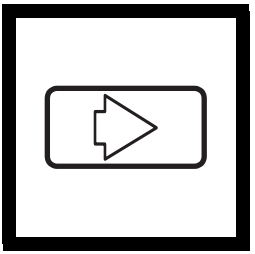
12. When all the digits show the appropriate value, press **READ**. The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. Remove the sample cell from the cell compartment.



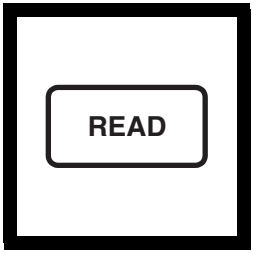
13. Thoroughly mix the 700 to 900 NTU standard, then fill a clean sample cell to the line with the standard. Insert the cell into the cell compartment.



14. The display will show the **S3** icon (with the **3** flashing) and **800 NTU** or the value of the S3 standard for the previous



15. Edit the standard concentration by pressing →. The **3** will stop flashing and the left digit in the display will flash. Press ↑ to scroll the digit up to the appropriate number. Press → again to move the cursor to the next digit and edit it in the same manner.



16. When all the digits show the appropriate value, press **READ**. The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The instrument will increment back to **S0**. Remove the sample cell from the cell compartment.



17. Press: **CAL**.

The instrument will store the new calibration data and return the instrument to the measurement mode. It will use the new calibration to calculate turbidity for subsequent measurements.

Note: *Pressing* **CAL** *completes the calculation of the calibration coefficients. If calibration errors occurred during calibration, error messages will appear after* **CAL** *is pressed. If* **E 1** *or* **E 2** *appear, check the standard preparation and review the calibration; repeat the calibration if necessary. If* **CAL?** *appears, an error may have occurred during calibration. If* **CAL?** *is flashing, the instrument is using the default calibration.*

NOTES

- If the **I/O** key is pressed during calibration, the new calibration data is lost and the old calibration will be used for measurements. Once in calibration mode, only the **READ, I/O,** ↑, and → keys function. Signal averaging and range mode must be selected before entering the calibration mode.

- If **E 1** or **E 2** are displayed, an error occurred during calibration. Check the standard preparation and review the calibration; repeat the calibration if necessary. If the error messages recur, calibrate using the factory specified standards, *Section 3.6.2.4* on page *42* and *Section 3.6.3* on page *44*. Press **DIAG** to cancel the error message (**E 1** or **E 2**). To continue without repeating the calibration, press **I/O** twice to restore the previous calibration. If **CAL?** is displayed, an error may have occurred during calibration. The previous calibration may not be restored. Either recalibrate or use the calibration as is.

- To review a calibration, press **CAL** and then only ↑ to view the calibration standard values. As long as **READ** is never pressed and **CAL** isn't flashing, the calibration will not be updated. Press **CAL** again to return to the measurement mode.

3.6.4 Using Gelex® Secondary Turbidity Standards

Note: *Store Gelex standards at room temperature. Do not allow to freeze or exceed 50 °C.*

The instrument comes with Gelex Secondary Standards which are particulate suspensions similar to formazin primary standards in light scattering characteristics. NTU values on the Gelex standards indicate the range for which they should be used. Due to minor variations in glass and individual instrument optical systems, the true value of the Gelex standards must be determined against formazin in the same instrument they will be used with for later calibration checks.

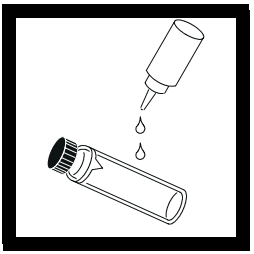
3.6.4.1 Assigning Values to Gelex Standards



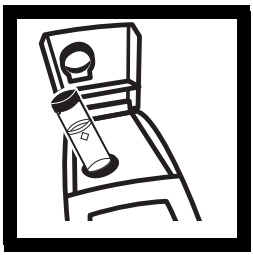
1. Calibrate the instrument with formazin.



2. Select automatic range mode using the **RANGE** key.

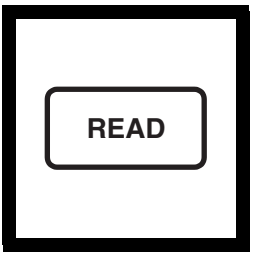


3. Thoroughly clean the outside of the Gelex vials and apply a thin coating of silicone oil.



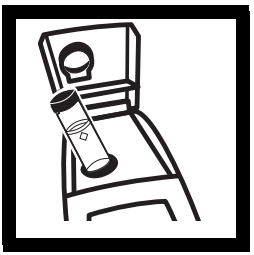
4. Place the 0-10 NTU Gelex standard in the cell compartment so the diamond on the vial aligns with the orientation mark on the instrument. Close the sample lid.

Note: *Correct cell orientation is essential to obtain accurate Gelex values. Always orient the cell so the diamond mark aligns with the orientation mark on the instrument.*

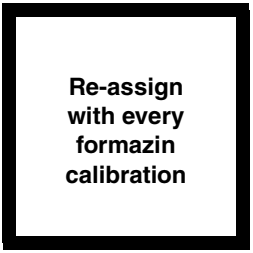


5. Press: **READ**.

Record the displayed value, remove the vial from the instrument and mark the value on the band near the top of the vial.



6. Repeat *step 3* through *step 5* for the other Gelex standards, being careful to orient the cells properly.



7. Re-assign values to the Gelex standards each time the instrument is calibrated with formazin.

3.6.4.2 Routine Calibration Check With Gelex Standards

The 2100P Turbidimeter does not require standardization before every measurement as some turbidimeters do. Periodically, as experience dictates, check the instrument calibration using the appropriate Gelex Secondary Standard. Be sure the Gelex standards are aligned correctly when inserting them (diamond aligns with orientation mark). If the reading is not within 5% of the previously established value, recalibrate the instrument with StablCal Stabilized Formazin Primary Standard or formazin primary standard (*Section 3.6.3* on page *44*).

Important Note: DO NOT calibrate with Gelex® Secondary Standards. Gelex standards are designed for instrument verification, not calibration.

MAINTENANCE

Some of the following manual sections contain information in the form of warnings, cautions and notes that require special attention. Read and follow these instructions carefully to avoid personal injury and damage to the instrument. Only personnel qualified to do so, should conduct the maintenance tasks described in this portion of the manual.

Certains des chapitres suivants de ce mode d'emploi contiennent des informations sous la forme d'avertissements, messages de prudence et notes qui demandent une attention particulière. Lire et suivre ces instructions attentivement pour éviter les risques de blessures des personnes et de détoriation de l'appareil. Les tâches d'entretien décrites dans cette partie du mode d'emploi doivent être seulement effectuées par le personnel qualifié pour le faire.

Algunos de los capítulos del manual que presentamos contienen muy importante información en forma de alertas, notas y precauciones a tomar. Lea y siga cuidadosamente estas instrucciones a fin de evitar accidentes personales y daños al instrumento. Las tareas de mantenimiento descritas en la presente sección deberán ser efectuadas únicamente por personas debidamente cualificadas.

Einige der folgenden Abschnitte dieses Handbuchs enthalten Informationen in Form von Warnungen, Vorsichtsmaßnahmen oder Anmerkungen, die besonders beachtet werden müssen. Lesen und befolgen Sie diese Instruktionen aufmerksam, um Verletzungen von Personen oder Schäden am Gerät zu vyyyermeiden. In diesem Abschnitt beschriebene Wartungsaufgaben dürfen nur von qualifiziertem Personal durchgeführt werden.

Algumas das seguintes secções do manual contêm informações em forma de advertências, precauções e notas que requerem especial atenção. Leia e siga atentamente as presentes instruções para evitar ferimentos pessoais e não danificar o instrumento. As tarefas de manutenção descritas nesta parte do manual só poderão ser executadas por pessoal qualificado.

SECTION 4 MAINTENANCE

4.1 Cleaning

Keep the turbidimeter and accessories as clean as possible and store the instrument in the carrying case when not in use. Avoid prolonged exposure to sunlight and ultraviolet light. Wipe spills up promptly. Wash sample cells with non-abrasive laboratory detergent, rinse with distilled or demineralized water, and air dry. Avoid scratching the cells and wipe all moisture and fingerprints off the cells before inserting them into the instrument. Failure to do so can give inaccurate readings. See *Section 2.3.1* on page *23* for more information about sample cell care.

4.2 Battery Replacement

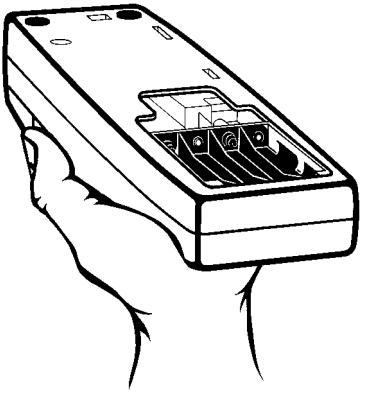
AA alkaline cells typically last for about 300 tests with the signal averaging mode off, about 180 tests if signal averaging is used. The “battery” icon flashes when battery replacement is needed. Refer to *Section 1.4.2* on page *15* for battery installation instructions. If the batteries are changed within 30 seconds, the instrument retains the latest range and signal average selections. If it takes more than 30 seconds, the instrument uses the default settings.

If, after changing batteries, the instrument will not turn off or on and the batteries are good, remove the batteries and reinstall them. If the instrument still won't function, contact Hach Service or the nearest authorized dealer.

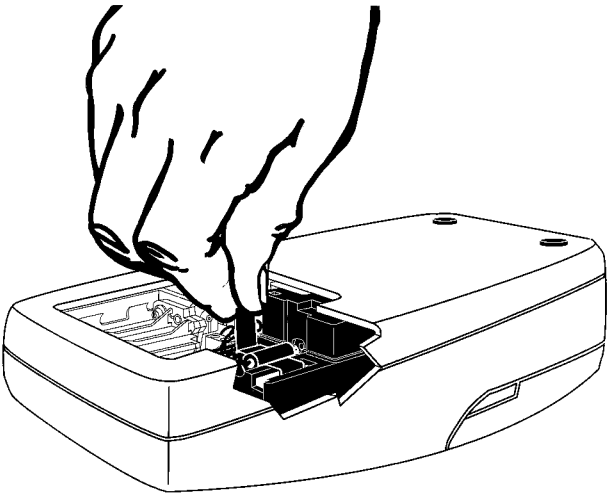
4.3 Lamp Replacement

The procedure below explains lamp installation and electrical connections. Use a small screwdriver to remove and install the lamp leads in the terminal block. The instrument requires calibration after lamp replacement.

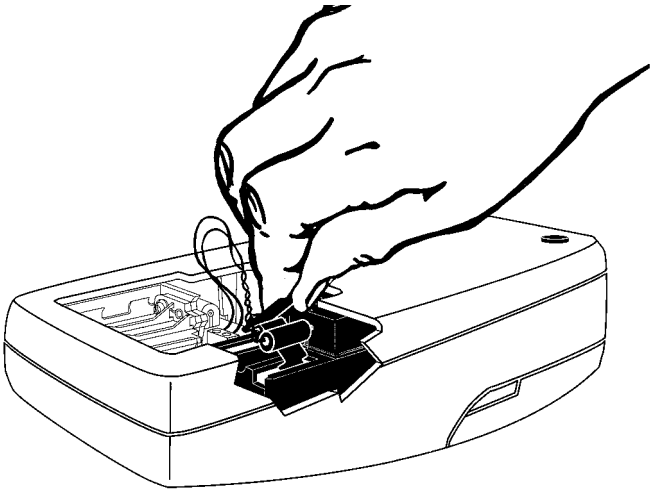
1. Orient the instrument so it is upside down and the top faces away from you. Remove the battery cover and at least one battery.



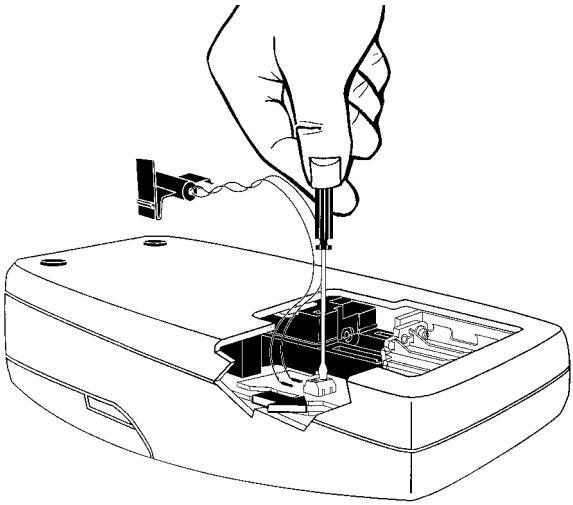
2. Remove the lamp assembly by grasping the tab on the left side of the assembly. Firmly, but gently, slide the assembly towards the rear of the instrument.



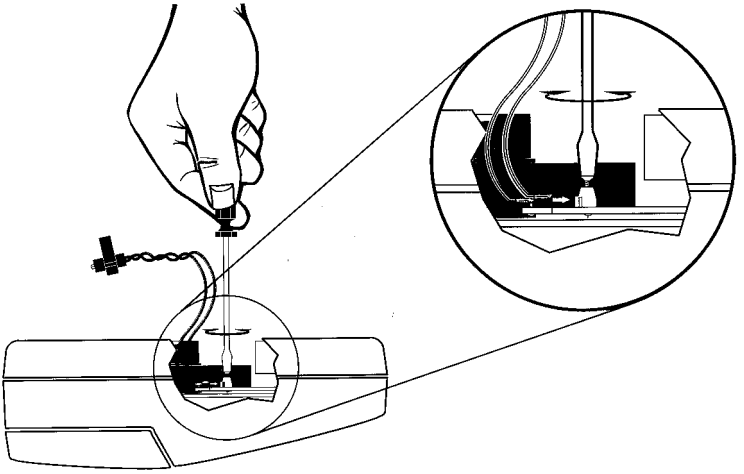
3. Rotate the tab towards the nearest outside edge. The assembly should release and slip out easily.



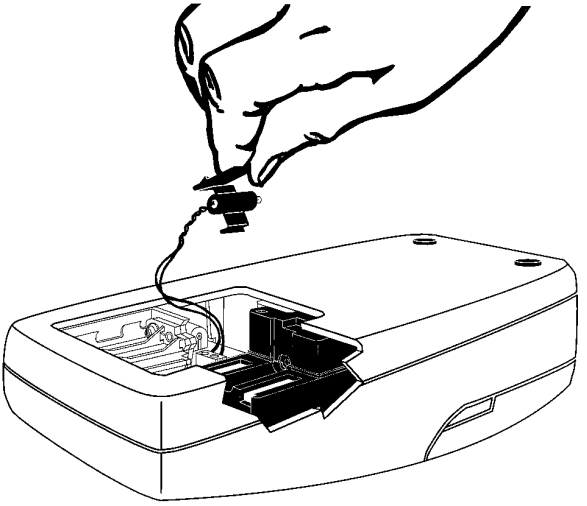
4. Back the terminal block screws **partially** out (1 to 2 turns) and remove the old lamp leads.



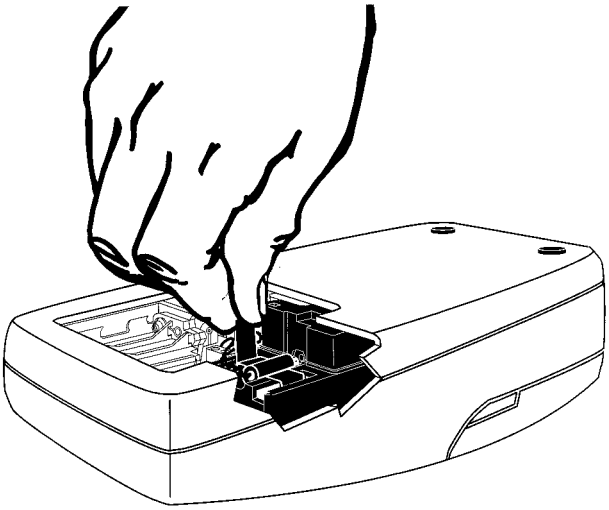
5. Gently bend the wires of the new lamp assembly into an “L” shape so they fit easily into the housing. Insert the leads into the terminal screws and tighten with clockwise turns. Gently tug on the wires to make sure they are connected to the terminal block.



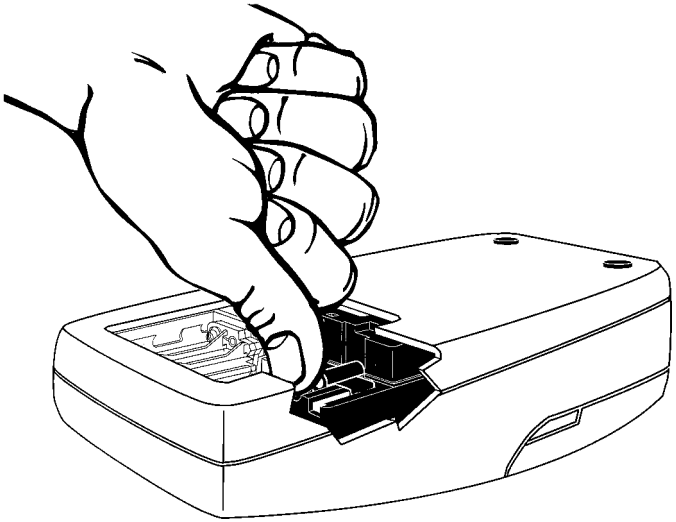
6. Hold the new lamp assembly by the tab with the lamp facing the tope (keyboard) of the instrument. Slide the small catch on the other side of the assembly into the black plastic slot (towards the nearest edge of the instrument).



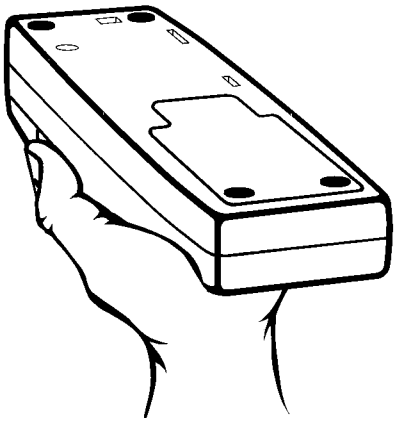
7. Snap the U-shaped bottom of the tab into the slot on the left side of the black plastic that holds the lamp assembly.



8. With your thumb, firmly slide the assembly forward until it stops. Again, push firmly against the tab to make sure the lamp is seated correctly.

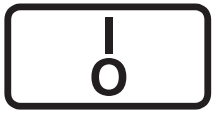


9. Replace the battery(s) and battery cover.

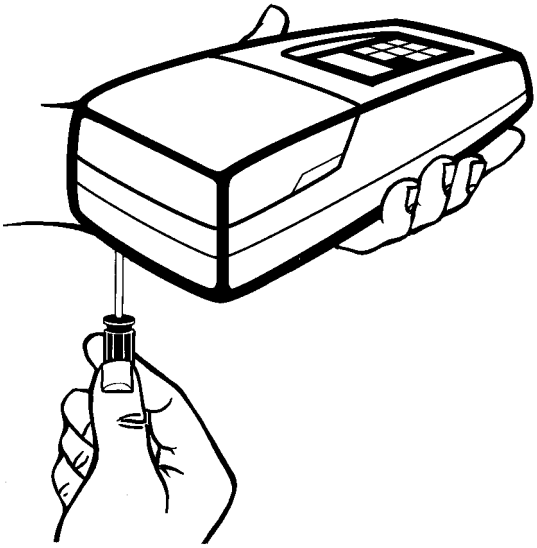


10. Insert the 800 NTU formazin standard into the sample cell. Press and hold **READ**. Then press **I/O**. Release the **READ** key after the software version number disappears from the display (for models with serial numbers less than 920300000800, **2100** disappears).





11. Adjust the scattered light amplifier output by inserting a small flat-bladed screwdriver into the trimpot hole (located on bottom). Adjust the display to read 2.5 ± 0.3 volts (2.0 volts for models that display **2100** when turned on).



12. Press **I/O** to exit gain adjust mode.

13. Perform a formazin calibration according to *Section 3.6.3* on page *44* or *Section 3.6.3.1* on page *48*.

SECTION 5 TROUBLESHOOTING

5.1 Using the Diagnostic Functions Key

Enter the diagnostic mode by pressing the **DIAG** key. Exit this mode at any time by pressing the key again. The diagnostic mode allows access to information about instrument function which may be useful for servicing and troubleshooting.

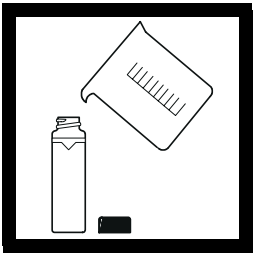
5.1.1 Basic Diagnostic Codes

The diagnostic codes are:

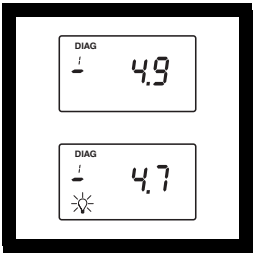
Code	Description
1	Checks the battery voltage with the lamp on, then with the lamp off. This is a dual diagnostic code.
2	Displays calibration coefficient a_o
3	Displays calibration coefficient a_1
4	Displays calibration coefficient b_o
5	Displays calibration coefficient b_1
6	Displays the lamp voltage (about 3 volts)
7	Displays the dark voltage of the transmitted light detector amplifier with the lamp off and the detector amplifier voltage with the lamp on.
8	Displays the high gain dark voltage of the 90° detector amplifier with the lamp off and the detector amplifier voltage with the lamp on.*
9	Displays the low gain dark voltage of the 90° detector amplifier with the lamp off and the detector amplifier voltage with the lamp on.

* Samples with turbidity >10 NTU may display **- - -** for the lamp-on amplifier voltage.

5.2 The Diagnostic Procedure

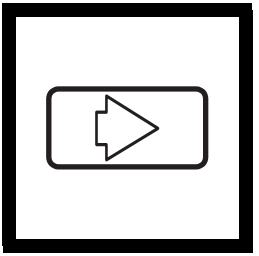


1. Fill a clean sample cell to the line with clear water, cap the cell and place it in the cell compartment. Press the **READ** key and wait until the reading is finished.

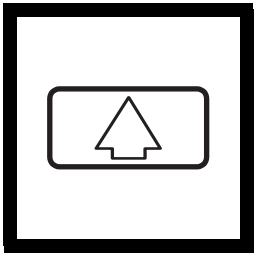


2. Press: **DIAG**

The **DIAG** icon will turn on and **1** will be displayed below the icon. The instrument will measure the battery voltage with the lamp off and display the result in volts (V). Then the lamp icon will turn on and the instrument will measure the voltage with the lamp on. The value is briefly displayed before defaulting to the lamp-off reading. To repeat the measurement, press **READ**.



3. To continuously display the lamp-on voltage, press →. The lamp icon will flash. Press → to turn the lamp icon off (the lamp is not on during this display).



4. Press the ↑ key to scroll through the other diagnostics. Each press of the key increments the digit in the small numerical display below the **DIAG** icon and the result of the diagnostic measurement is then displayed. Each press of the **READ** key updates the value. For measurements made with the lamp off and again with the lamp on, the measurement with the lamp off is displayed when the diagnostic is entered. To see the second measurement with the lamp on, press the → key (only works with diagnostic codes 1, 7, 8, & 9). The lamp icon will flash and the lamp-on measurement will be displayed in volts. Press → to turn the lamp icon off.

Note: *DIAG 8 will display* ***----*** *for the lamp-on voltage if a of >10 NTU is placed in the cell compartment.*

5.3 Other Instrument Diagnostics

5.3.1 Display Test

Pressing and holding the **I/O** key turns on all the display icons and elements so you can determine if all the elements and icons are functioning. The display test sequence will cycle as long as the key is held down.

5.4 Error Messages

Error messages indicate sample interferences and/or instrument malfunction.

5.4.1 Flashing Numeric Display

If the highest value in the range selected is flashing in the display, the sample is too turbid (or overrange) for the selected range. In automatic or manual range, **1000** flashes if the sample is over the instrument's range. In manual range mode, select the next higher range mode if **9.99** or **99.9** flashes. See *Section 2.3.6* on page *31* for measuring overrange samples. The display will stop flashing if a sample within range is inserted and read.

5.4.2 E Messages

An error message indicates either an instrument failure or an operation cannot be performed. **An error message can be cleared by pressing DIAG** (display will return to previous measurement or calibration value). The meter continues to operate as best it can. If the message occurs during a calibration, calibration can continue. If the error message occurs when a calibration is being calculated, the instrument will discard the new calibration and retain the old calibration. Error messages and corrective actions are listed below.

5.4.3 CAL?

A flashing **CAL?** appears when the instrument is using the default calibration programmed at the factory. It will appear if the analyst has erased the user-entered calibration using the procedure to restore the default calibration or after and E 4 error is cleared by pressing DIAG. Recalibrate as soon as possible when **CAL?** appears. **CAL?** (not flashing) appears when a calibration has questionable validity.

Message*	Probable Cause	Corrective Action
E1	Dilution water is ≥ 0.5 NTU.	Start calibration over with better quality dilution water or use a membrane filter to filter the water before use.
E2	Two standards have the same value or their difference is less than 60 NTU. Not all standards were read during the calibration. Standard 1 is too low (<10 NTU).	Recheck preparation of standards and repeat calibration.
E3	Low light error.	Re-read measurement. Check lamp** Check for obstructed light path. Dilution may be necessary.
E4	EEPROM malfunction.	Check sum failed. Press **I/O**. If E 4 reappears, call Hach service. If **CAL?** appears, recalibrate.
E5	A/D overrange.	Check for obstructed light path. Call Hach Service.
E6	A/D underrange.	Check for open lid during reading and re-read. Check for obstructed light path. If persists, call Hach Service.
E7	Light Leak.	Close lid before pressing **READ** key.
E8	Bad lamp circuit.	Reinsert lamp leads at terminal block-make sure the lead ends are not touching each other.If this fails, call Hach Service.

* Error messages 4, 5, and 6 may indicate a failure in the internal electronics.
** Check lamp by inserting a pencil or piece of paper into the cell compartment and pressing READ. Light should be visible on the inserted object.

GENERAL INFORMATION

At Hach Company, customer service is an important part of every product we make.

With that in mind, we have compiled the following information for your convenience.

Replacement Parts & Accessories

REPLACEMENT PARTS

Description	Cat. No.
StablCal Calibration Set for 2100P, Sealed Vials: <0.1 NTU, 20 NTU, 100 NTU, and 800 NTU	26594-05
AA Batteries, 4/pkg	19380-04
Battery Door	46005-00
Carrying Case	46506-00
Gelex® Standards, set (includes standards and 3 sample cells)	24641-05
Instrument Manual	46500-88
Lamp Assembly, with leads	46539-00
Mounting Feet, 4/pkg	41093-00
Oiling Cloth	47076-00
Sample Cells, 1 inch, with cap, 6/pkg	24347-06
Silicone Oil, 15 mL	1269-36

OPTIONAL ACCESSORIES AND REAGENTS

Deionized Water, 3.78 L	272-17
Bath, Ultrasonic, 2.8 L (0.75-gal), w/heater	24895-00
Battery Charger, 120 V	46479-00
Battery Charger, 230 V	46479-01
Battery Eliminator, 120 V	46079-00
Battery Eliminator, 230 V	46080-00
Filter, 0.2 micron, 10/pkg	23238-10
Formazin, 4000 NTU, 500 mL	2461-49
Formazin, 4000 NTU,100 mL	2461-42
Hexamethylenetetramine, 100 g	1878-26
Hexamethylenetetramine, 500 g	1878-34
Hydrazine Sulfate, 20 g	742-46
Hydrazine Sulfate, 100 g	742-26
NiCad Rechargeable Battery (4 required)	16077-00
Pipet, serologic, 1.00 mL	532-35

OPTIONAL ACCESSORIES AND REAGENTS, continued

Description	Cat. No.
Pipet, TenSette®*, 1-10 mL	19700-10
Pipet Tips, for 1-10 mL TenSette Pipet, 50/pkg	21997-96
Pipet Tips, for 1-10 mL TenSette Pipet, 1000/pkg	21997-28
Pipet, Volumetric, Class A, 1.00 mL	14515-35
Pipet, Volumetric, Class A, 5.00 mL	14515-37
Pump, Vacuum, Hand-Operated	14283-00
Pump, Vacuum, 115 V, 60 Hz	14697-00
Pump, Vacuum, 230 V, 50 Hz	14697-02
Sample Degassing Kit	43975-00
Sample Filtration and Degassing Kit	43975-10
StablCal® Calibration Set for 2100P Turbidimeter	
<0.1, 20, 100, 800 NTU, 500 mL each	26594-00
<0.1, 20, 100, 800 NTU, 100 mL each	26594-10
<0.1 NTU** StablCal®*** Stabilized	
Formazin Standard,100 mL	26597-42
20 NTU StablCal® Stabilized Formazin Standard, 100 mL	26601-42
100 NTU StablCal® Stabilized Formazin Standard, 100 mL	26602-42
800 NTU StablCal® Stabilized Formazin Standard, 100 mL	26605-42
Triton-X Solution, 118 mL (4 oz)	14096-32
Volumetric Flask, 100 mL	14574-42
Volumetric Flask, 200 mL	14574-45

* TenSette™ is a Hach Company trademark.

** <0.1 NTU StablCal® Standard is used in place of dilution water standard when performing a calibration.

*** StablCal® is a registered trademark of Hach Company.

HOW TO ORDER

By Telephone:

6:30 a.m. to 5:00 p.m. MST
Monday through Friday
(800) 227-HACH
(800-227-4224)
By FAX: (970) 669-2932

By Mail:

Hach Company
P.O. Box 389
Loveland, CO 80539-0389
U.S.A.

Ordering information by E-mail: orders@hach.com

Information Required

- Hach account number (if available)
- Your name and phone number
- Purchase order number
- Brief description or model number
- Billing address
- Shipping address
- Catalog number
- Quantity

Technical and Customer Service (U.S.A. only)

Hach Technical and Customer Service Department personnel are eager to answer questions about our products and their use. Specialists in analytical methods, they are happy to put their talents to work for you. Call **1-800-227-4224** or E-mail **techhelp@hach.com**.

International Customers

Hach maintains a worldwide network of dealers and distributors. To locate the representative nearest you, send E-mail to **intl@hach. com** or contact:

In Canada, Latin America, Africa, Asia, Pacific Rim:
Telephone: (970) 669-3050; FAX: (970) 669-2932

In Europe, the Middle East, or Mediterranean Africa:
HACH Company, c/o
Dr. Bruno Lange GmbH
Willstätterstr. 11
D-40549 Düsseldorf
Germany
Telephone: +49/[0]211.52.88.0
Fax: +49/[0]211.52.88.231

REPAIR SERVICE

Authorization must be obtained from Hach Company before sending any items for repair. Please contact the HACH Service Center serving your location.

In the United States:
Hach Company
100 Dayton Avenue
Ames, Iowa 50010
(800) 227-4224 (U.S.A. only)
Telephone: (515) 232-2533
FAX: (515) 232-1276

In Canada:
Hach Sales & Service Canada Ltd.
1313 Border Street, Unit 34
Winnipeg, Manitoba
R3H 0X4
(800) 665-7635 (Canada only)
Telephone: (204) 632-5598
FAX: (204) 694-5134
E-mail: canada@hach.com

In Latin America, the Caribbean, the Far East, the Indian Subcontinent, Africa, Europe, or the Middle East:
Hach Company World Headquarters
P.O. Box 389
Loveland, Colorado, 80539-0389
U.S.A.
Telephone: (970) 669-3050
FAX: (970) 669-2932
E-mail: intl@hach.com

WARRANTY

Hach warrants most products against defective materials or workmanship for at least one year from the date of shipment; longer warranties may apply to some items.

HACH WARRANTS TO THE ORIGINAL BUYER THAT HACH PRODUCTS WILL CONFORM TO ANY EXPRESS WRITTEN WARRANTY GIVEN BY HACH TO THE BUYER. EXCEPT AS EXPRESSLY SET FORTH IN THE PRECEDING SENTENCE, HACH MAKES NO WARRANTY OF ANY KIND WHATSOEVER WITH RESPECT TO ANY PRODUCTS. HACH EXPRESSLY DISCLAIMS ANY WARRANTIES IMPLIED BY LAW, INCLUDING BUT NOT BINDING TO ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

LIMITATION OF REMEDIES: Hach shall, at its option, replace or repair nonconforming products or refund all amounts paid by the buyer. **THIS IS THE EXCLUSIVE REMEDY FOR ANY BREACH OF WARRANTY.**

LIMITATION OF DAMAGES: IN NO EVENT SHALL HACH BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND FOR BREACH OF ANY WARRANTY, NEGLIGENCE, ON THE BASIS OF STRICT LIABILITY, OR OTHERWISE.

This warranty applies only to Hach products purchased and delivered in the United States.

Catalog descriptions, pictures and specification, although accurate to the best of our knowledge, are not a guarantee or warranty.

For a complete description of Hach Company's warranty policy, request a copy of our Terms and Conditions of Sale for U.S. Sales from our Customer Service Department.

Appendix C. Fish and Invertebrate Tissue Sampling Procedures

C.1 Sampling Procedures

Processing of fish and invertebrates for tissue/stomach samples, subsequent handling, chain of custody, and transport to the analytical laboratory will follow procedures outlined in the QAPP (NDM, 2005b) and as described in this FSP.

C.1.1 Tissue Sampling

At the sampling sites, one or more key fish species will be selected for each monitoring site and sampled for tissue metals analysis. In most cases, juvenile salmonid species will be selected as key species based on abundance and catchability. A total of 10 discrete whole body samples will be collected for individual analysis at each site to provide an adequate measure of variability. Individual fish will be a minimum of 75 mm in length to provide adequate tissue mass to complete the required analyses. Each fish will be placed into an individual plastic ZipLoc bag and immediately placed on ice within a clean cooler with ice packs. Samples will then be frozen as soon as possible in the shipboard freezer.

Collection personnel will use powder-free surgical gloves to handle fish samples. Handling of fish will be minimized to the extent possible. Fish will be measured inside the collection bag. A field blank will be prepared for each collection day by rinsing an empty sample bag with DI water in the field and collecting the rinsate in an acid preserved sample jar.

For large fish (i.e., >155 mm or 6 inches TL), liver and muscle tissues will be dissected; all dissections will take place in a clean indoor location on an uncontaminated surface such as aluminum foil. Tissue samples will be placed in individually labeled ZipLoc plastic bags and frozen as soon as possible. Procedures for sample labeling, washing tools, work surfaces and preparing QC equipment blanks will follow the QAPP (NDM, 2005b). Specific steps to be taken in processing the dissected samples are as follows:

- Immediately upon capture, the animal will be rinsed in clean potable fresh water to remove any extraneous debris and then placed in a clean plastic bag. The bag will be sealed and then placed on gel packs in a freshly washed cooler.

- Dissection will take place as soon as possible on the same day as captured, at an indoor location onboard ship. Be sure that the area is out of the wind and that no other forms of contamination are in the area e.g., ship engine exhaust; dust; grease from ship winches cables, or gear; water runoff from boat roof or ledges due to rain or other boat operations; spilled fuel, etc.

- The cutting surface will be washed with soap and water, rinsed with potable fresh water followed by deionized (DI) water, and covered with heavy-duty aluminum foil. The aluminum foil-cutting surface will be replaced between each dissection. (Note: the DI

water used during this procedure will always be the water provided by the analytical laboratory for this purpose; distilled water, such as the type purchased from grocery stores, will NOT be used as a rinse in fish dissection procedures.)

- Stainless steel disposable scalpels and/or high quality stainless steel knives will be used for dissection. The blades/knives will have no visible rust spots on them.
- Scalpel blades will be replaced between dissections and knives will be washed with soap and water and rinsed with DI water between uses. Cleaned knives will be stored in a clean, sealed Zip Loc bag until their next use and will never be placed on any surface except inside the clean Zip Loc bag.
- Personnel handling or dissecting fish will wear powder free surgical gloves and the gloves will be changed between each dissection.

C.1.2 Tissue Sample Handling and QA

- A sample of liver and muscle tissue (with no skin attached) will be extracted from each fish and placed in an individually labeled Ziploc bag. Label will include sample ID and suffix of "M" for muscle and "L" for liver tissue; the matrix code will be "TF." Where possible, a minimum of 50 grams of tissue (wet weight) will be included with each sample.
- Labeled tissue samples will immediately be placed in the shipboard freezer.
- An equipment blank will be prepared before each set of dissections by rinsing the foil cutting surface and the knife with DI water and collecting the rinsate in an acid-preserved sample jar. DI water for use in blanks will be provided by the analytical laboratory to assure the purity needed for low-level mercury analyses.
- Frozen tissue samples will be packaged in a clean cooler with ice packs as specified in the QAPP (NDM, 2005b) and as summarized in this FSP and will be sent to Shaw in Iliamna or in Anchorage using the specified handling/packaging/shipping recommendations. A fully completed and signed Sample Transfer Form (Appendix Figure A-4) will accompany EACH cooler so that Shaw personnel can complete the electronic Chain-of-Custodies (COCs) for all samples.
- A field blank will be prepared for each sample day at the field collection site by rinsing an empty plastic fish bag with DI water and collecting the rinsate in an acid preserved sample jar.
- COC procedures will be followed by filling out the Sample Transfer Form (Appendix Figure A-4) and keeping the completed form with the samples at all times. In addition, for each tissue sample collected, an entry will be made on the Specimen Log Form (Appendix Figure A-3) so that the necessary information is collected/recorded to meet the ADF&G Fish Collection Permit reporting requirements (see Appendix D).
- Any fish (or invertebrate) found to be lacerated/damaged by sampling gear (e.g., skin gashed, carapace/shell crushed) will be discarded and not used for contaminant analyses. The sacrificed animal will be recorded in the Specimen Log Form (Appendix

Figure A-3), noting that it was collected and sacrificed under the ADF&G Fish Collection Permit (Appendix D), and under Other Comments that it was not used for chemical analyses due to damage.

- To ensure that sufficient tissue is collected when animals are small in size, during the first day of sampling, extra animals will be collected and weighed to assist in estimating how many are needed to comprise a 50g sample (wet weight) of soft tissue. In the case of animals with hard exterior shells (e.g., mussels), the shells will be removed and the soft tissue weighed on a portable digital scale; this material will then subsequently be discarded. The sacrificed animals used in this QA procedure will be recorded in the Specimen Log Form (Appendix Figure A-3), noting that they were sacrificed under the ADF&G Fish Collection Permit (Appendix D) for this QA purpose. This practice will ensure that the minimum weight requirements are met for subsequent tissue samples.

C.1.3 Sampling Equipment Decontamination

Where stainless steel disposable scalpels are used for dissection, a fresh scalpel blade will be used for each fish. All knives will be washed with soap (Alconox) and water and rinsed with DI water between uses. All cutting surfaces will be washed with soap and water, rinsed with clean potable fresh water and DI water, and covered with heavy-duty aluminum foil. Be sure that the DI water used is the purer grade provided by the laboratory and not general purpose distilled water (the type purchased in grocery stores).

C.1.4 Stomach Sampling

Stomach dissection and sampling methods are modified from Nielson and Johnson (1983). For large fish (i.e., >155 mm or 6 inches TL), the fish stomach will be extracted and preserved in the field. For small fish (<155 mm or 6 inches TL), the fish stomach will remain in the fish, using the methods detailed in Section C.1.4.2.

C.1.4.1 Removal of the Fish Stomachs

Before dissection, kill the fish by severing the spinal column or applying a sharp blow to the head. Open the coelom to expose the viscera (do for all fish collected). Fish stomachs will be removed from large fish (i.e., >155 mm or 6 inches TL). For small fish, the coelom will be opened, but the stomach will be retained in the fish to avoid inadvertent loss of stomach contents.

- For large fish, to remove the stomach, use blunt scissors, sever the esophagus, the last few millimeters of the intestine, and the mesentery at its dorsal point of attachment. This allows the visceral mass to he lifted out of the coelom and into a plastic Ziploc bag for subsequent preservation.

C.1.4.2 Fixing and Preserving Stomach Contents

- Ten-percent formalin is fully adequate as a fixative. Wear plastic gloves and work in a well-ventilated area to minimize exposure to formaldehyde. Formaldehyde is suspected of being a carcinogen and can cause permanent damage to fingernail growth areas and sinus tissues so minimize your exposure as much as possible. See the Marine Studies Health and Safety Plan (BEESC, 2005) for additional information on the handling of formaldehyde and other chemicals during this field program.
- Add sufficient quantity of fixative to the Ziploc bag to fully bathe the stomach

contents. Be sure to make a small incision in the stomach to allow for the preservative to enter the stomach and bathe the contents as well. Because the fixative rapidly hardens prey tissues, partly digested prey are more likely to stay intact and, thus, are easier for the taxonomic laboratory to identify.

- Prior to sealing the Ziploc bag, remove as much air from the bag as possible so that all areas of the bag are bathed in fixative. Place an internal label (e.g., plastic tag or DuraRite paper showing sample identification information). Then seal the bag and place it into a second Ziploc bag with the exterior of the second bag clearly labeled in waterproof ink (i.e., Sharpie pen).

The availability of field time and facilities usually determines when gut contents are removed and fixed. It is best to remove and fix gut samples immediately after capture. This minimizes post-capture digestion and avoids difficulties associated with dissection of hardened fish tissues. When tens or hundreds of fish are captured at one time, however, it is necessary to fix the gut contents *in situ* with the least investment of time possible. If done in warm air temperatures, hold fish on ice if more than a few minutes will elapse before fixation. In order to halt post-capture digestion, slit the coelom or inject formaldehyde directly into the coelom. For larger fish, it is usually more efficient to fix only the digestive tract.

Concomitant fish data (length, weight, sex, etc.) should be recorded on the Fish Catch Record Form (Appendix Figure A-5) as well as the Specimen Log Form (Appendix Figure A-3), **with information filled out as completely as possible when applicable.**

When the samples reach the taxonomic laboratory, they will be examined in detail. Laboratory personnel will remove excess formaldehyde by soaking the samples in several changes of water. After excess formaldehyde is removed, the samples will be preserved in a 45 to 70% aqueous solution of alcohol (methanol, ethanol, and isopropanol are all satisfactory).

APPENDIX D
ALASKA DEPARTMENT OF FISH AND GAME
FISH RESOURCE PERMIT

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME

P.O. Box 25526
JUNEAU, ALASKA 99802-5526

Permit No. CF-05-055

Expires 12/31/2005

FISH RESOURCE PERMIT
(For Scientific/Educational Purposes)

This permit authorizes **Mark Madden** (*whose signature is required on page 2 for permit validation*)
person
of **Bristol Environmental and Engineering Services Corporation at**
agency or organization
2000 W. International Airport Rd, #C-1, Anchorage, AK 99502-1117
address
to conduct the following activities from **April 1, 2005** to **December 31, 2005** in accordance with AS 16.05.930 and AS 16.05.340(b).

Purpose: To conduct site-specific biological sampling at the Pebble Project's proposed port facility location and surrounding marine habitat in and adjacent to the proposed shipping channel. These collections will assist in assessing future project impacts and will add to the pre-existing biological data available for the project area.

Location: Cook Inlet – Iniskin Bay, Cottonwood Bay, and Iliamna Bay.

Species Collected: 50 basket cockles, 50 soft shell clams, 50 horse mussels, 50 horsehair crabs, 50 fusitriton snails, 50 lyre crabs, 100 macoma clams, 50 blue mussels, 50 neptune snails, 50 surf clams – all samples to be sacrificed for contaminant analysis. 325 salmonids (25 adult & 300 juvenile), 50 sculpins, 50 greenlings, 300 Pacific sand lances, 50 gunnels, 25 rockfish, 25 flounder, 100 Pacific herring – up to 40% of the fish collected will be sacrificed for containment analysis, the remaining will be measured and released.

Method of Capture: SCUBA dive, van Veen grab, beach seine, shrimp/crab pot, hook and line, shovel, hand collection, "try-net" otter trawl (see **Contingencies** section).

REPORT DUE **January 31, 2006**. The report shall include species, numbers, dates, and locations of collection and disposition, and if applicable, sex, age, and breeding condition, and lengths and weights of fish. The report shall also include other information as may be required under the contingencies section.

GENERAL CONDITIONS, EXCEPTIONS AND RESTRICTIONS

1. This permit must be carried by person(s) specified during approved activities who shall show it on request to persons authorized to enforce Alaska's fish and game laws. This permit is nontransferable and will be revoked or renewal denied by the Commissioner of Fish and Game if the permittee violates any of its conditions, exceptions or restrictions. No redelegation of authority may be allowed under this permit unless specifically noted.
2. No specimens taken under authority hereof may be sold or bartered. All specimens must be deposited in a public museum or a public scientific or educational institution unless otherwise stated herein. Subpermittees shall not retain possession of live animals or other specimens.
3. The permittee shall keep records of all activities conducted under authority of this permit, available for inspection at all reasonable hours upon request of any authorized state enforcement officer.
4. Permits will not be renewed until detailed reports, as specified above, have been received by the department.
5. UNLESS SPECIFICALLY STATED HEREIN, THIS PERMIT DOES NOT AUTHORIZE the exportation of specimens or the taking of specimens in areas otherwise closed to hunting and fishing; without appropriate licenses required by state regulations; during closed seasons; or in any manner, by any means, at any time not permitted by those regulations.

Division of Commercial Fisheries

Deputy Director
Division of Commercial Fisheries

CF-05-055 ***continued (page 2 of 2)***

Authorized Personnel: The following personnel may participate in collecting activities under terms of this permit:

Lee Ann Gardner; Stephen Jewett; Gerald Douthit; Jon Houghton; Sandra Lindstrom; Shawn Harper; Heloise Chenelot; Jim Starkes; Dennis Lees; Mark Madden; Cathy Gardner; Max Hoberg; Larry Pedersen.

Contingencies:

1) **Charlie Trowbridge** (Division of Commercial Fisheries, Homer, 907-235-8191) must be notified **prior** to you engaging in transport activities. Area Biologists have the right to specify methods for collecting, as well as limiting the collections of any species, and the number of specimens collected by time and area.

2) All unattended collecting gear must be labeled with the permittee's name, telephone number, and permit number.

3) Permits will indicate the number of specimens that may be taken, by species and life stage. Sampling or collecting activities must stop when the maximum allowable number of specimens is obtained. All live fish, shellfish, and aquatic plants collected in excess of the number specified on the permit must be released immediately and unharmed at the capture location, unless otherwise specified in the permit.

4) Collection of King Crab is **NOT** permitted in these areas due to low stock abundance. Both commercial and non-commercial harvest is prohibited.

5) All bycatch incidentally captured during sampling will be identified, recorded and released unharmed if possible. Bycatch data should be included in the collection report.

6) Invertebrates, especially sessile invertebrates, should be collected over a broad geographical area to avoid local depletion and disruption of local ecosystems.

7) A valid sport fishing license must be in the possession of each person collecting fish with a hook and line or clams with a shovel.

8) *A copy of this permit, including any amendments, must be made available at all field collection sites and project sites for inspection upon request by a representative of the department or a law enforcement officer.*

9) **A report of collecting activities, referenced to this fish resource permit number, must be submitted to the Alaska Department of Fish and Game, Division of Commercial Fish, PO Box 25526, Juneau, AK 99802-5526, attention Sara Larsen (465-4724; sara_larsen@fishgame.state.ak.us), within 30 days after the expiration of this permit.** This report must summarize the number of fish captured by date and by species, and include documentation of any mortalities. A report is required whether or not collecting activities were undertaken. A report must also be sent to the Biologist(s) listed under number 1 in this Contingencies section.

10) **PERMIT VALIDATION requires permittee's signature agreeing to abide by permit conditions before beginning collecting activities:**

_____
Signature of Permittee

cc: Sean Palmer
Charlie Trowbridge
Lee Hammarstrom
Tom Vania
CF Division Files
Alaska Bureau of Wildlife Enforcement-Homer

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

Permit No. CF-05-055

Expires 12/31/05

FISH RESOURCE PERMIT AMENDMENT

Amendment #1

Mark Madden
Bristol Environmental and Engineering Services Corp.
2000 W. International Airport Rd., #C-1
Anchorage, AK 99502-1117

Fish resource permit CF-05-055 is amended to include:

Species Collected: 3,000 Pacific herring, and 1,000 juvenile salmon.

This amendment was requested by Jim Starks on August 8, 2005.

All other terms and conditions of the permit remain the same and are still valid. This amendment must be attached to the original permit.

Division of Commercial Fisheries

Deputy Director
Division of Commercial Fisheries
Alaska Department of Fish and Game

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME
Fish Resource Permit Application
— Email Form —

A **FISH RESOURCE PERMIT** is required to take, possess, hold alive, or tag FISH AND THEIR EGGS (except goldfish and decorative tropical fish) FOR SCIENTIFIC OR EDUCATIONAL PURPOSES.

(in order to use this form over again as a "blank form" first re-name and save this as a new document)

Mark Madden	Bristol Environmental & Engineering Services Corporation
(Name of Applicant)	(Organization or School)

2000 W. International Airport Road, #C-1, Anchorage, AK 99502-1117

(type in complete mailing address including City, State, and Zip Code)

(907) 563-0013	(907) 563-6713	mmadden@beesc.com
(your Telephone Number)	(Fax Number)	(Email Address)

Northern Dynasty Mines Inc., 3201 C. Street, Suite 604, Anchorage, AK 99503

(type in the name and address of the organization with which you are under contract)

I am making application to capture fish of the following species and number for the specified disposition (example: identify and release, measure and release, genetic sample and release, tag and release, sacrifice, transport, hold alive, etc.)**:**

Species Common Name	Species Scientific Name	Life Stage	Number *	Disposition**
Basket Cockle	*Clinocardium nuttalli*	Adult	50	Sacrifice
Soft Shell Clam	*Mya* spp.	Adult	50	Sacrifice
Horse mussel	*Modiolus* spp.	Adult	50	Sacrifice
Horsehair crab	*Telmessus cheiragonus.*	Adult	50	Sacrifice
Lyre crab	*Hyas spp.*	Adult	50	Sacrifice
Fusitriton snail	*Fusitriton oregonensis*	Adult	50	Sacrifice
Surf clam	*Mactromeris* spp.	Adult	50	Sacrifice
Macoma clam	*Macoma* spp.	Adult	100	Sacrifice
Blue Mussel	*Mytilus* spp.	Adult	50	Sacrifice
Neptune snail	*Neptunea* spp.	Adult	50	Sacrifice
Salmonids	Family Salmonidae	Juvenile	300	80% measure/release 20% sacrifice
Salmonids	Family Salmonidae	Adult	25	90% measure/release 10% sacrifice
Sculpin	Family Cottidae	Adult	50	60% measure/release 40% sacrifice
Greenling	*Hexagrammos* spp.	Adult	50	90% measure/release 10% sacrifice
Pacific Sand Lance	*Ammodytes hexapterus*	Adult	300	90% measure/release 10% sacrifice
Gunnel	*Pholis* spp.	Adult	50	90% measure/release 10% sacrifice
Rockfish	*Sebastes* spp.	Adult	25	80% measure/release 20% sacrifice
Flounder	Family Bothidae and/or	Adult	50	60% measure/release

	Pleuronectidae			40% sacrifice
Pacific herring	*Clupea harengus*	Adult/Juvenile	3,000	90% measure/release 10% sacrifice

* Note that it is currently anticipated that fewer than the 18 species or groups listed above will be collected for contaminant analyses—the actual selection of species will be done in the field based on their ubiquity, availability, and if of sufficient size/biomass for the analyses. For *Mytilus*, the number estimated is the estimated number of samples, each approximating 25 grams of tissue; the actual number of animals within each of the up to 50 samples will vary due to the variable size of the mussels in the area.

**For multiple sample locations give detail of species and number and disposition in your study plan

I understand permits are only valid for dates within a calendar year; I am requesting this permit for the following period: (a new application is required each year)

2005	April 1	December 31
Year: (2005)	**From:** (month and day)	**To:** (month and day)

I wish to obtain the above fish [finfish, shellfish, amphibians] by means of:

SCUBA diver, van Veen grab, beach seine, shrimp/crab pot, hook and line, shovel and hand collection, "try-net" otter trawl.

(Specify gear type(s): minnow traps, hoop traps, fyke nets, gillnets, dip nets, spat collectors, etc.)

from the following location(s):

Iniskin Bay, Cottonwood Bay, and Iliamna Bay on west side of Cook Inlet. Hard copy of study area map can be forwarded to you via fax because the .pdf file is too large to e-mail (please make fax request to Mark Madden via e-mail or telephone).

(Specify location(s), i.e., X River at latitude/longitude, or ESE of Pt. Barrow, or on Kodiak Island, etc.)

The purpose of the activities for which a permit is being requested: (a brief purpose statement)

To conduct site-specific biological sampling at the Pebble Project's proposed Port facility location and surrounding marine habitat in and adjacent to the proposed shipping channel. These collections will assist in assessing future project impacts and will add to the pre-existing biological data available for the project area.

(this area and other boxes will expand as you type)

☞ **NOTE: A STUDY PLAN or RESEARCH PROPOSAL explaining the purpose and need, the objectives, and the procedures you will use must be included in/with this permit application:**

2005 Marine Biological Sampling Plan for the Pebble Project (attached as separate .pdf file)

(Study Plan)

Final disposition of collected specimens* not to be released live at the site of capture will be:

Animals collected for contaminant analyses will be frozen and then transported to a pre-designated analytical laboratory for analysis (i.e., Columbia Analytical Services, Inc., Kelso, WA ; North Creek Analytical, Inc., Beaverton, OR; and/or University of Alaska Fairbanks, Fairbanks, AK). Some animals may be archived (frozen) for future analysis at the analytical laboratory and/or retained as voucher specimens. Approximately 160 fish specimens will be selected and preserved for stomach content analysis. Sediment infauna samples, unusual specimens, and voucher specimens will be preserved with formalin and then stored in alcohol at the UAF laboratory (see attached Sampling Plan). Any unneeded tissues/samples will be disposed of in an appropriate manner at the analytical laboratory.

*(specimens may not be consumed, sold, traded, or bartered, or used in any commercial manner)

The following people will participate in field collections under terms of this requested permit:

The following subcontractors to BEESC, except as noted:	Other Comments	
Lee Ann Gardner	Has held prior collection permits	
Stephen Jewett	Has held prior collection permits	
Gerald Douthit		
Jon Houghton	Has held prior collection permits	
Sandra Lindstrom		
Shawn Harper		
Cathy Gardner		
Jim Starkes		
Max Hoberg		
Heloise Chenelot		
Dennis Lees		
Larry Pedersen	BEESC Personnel	
Mark Madden	BEESC Personnel	
	Should additional personnel be identified, their names will be provided to ADF&G, and the permit amendment received, prior to collection of any samples by them.	

I certify that all statements entered on this application are true, that I will abide by all conditions and restrictions of a permit if issued, and promise to submit a report of activities carried out under terms of such permit within 30 days of its expiration date:

N/A	Mark G. Madden	Project Manager	4/4/2005
(Latest Fish Resource Permit number, if any)	(Name: First. Middle Initial, Last)	(Title)	(Date)

(If applicant is representing a corporation or institution, a certification of affiliation may be required which must be notarized and attached to this application). **NOTE: This certification can be provided, upon request, by contacting Mark Madden (e-mail: mmadden@beesc.com).**

(completed application must be submitted to):

Email Address:

Freshwater and estuarine environment collections (Division of Sport Fish):\
sandy_sonnichsen@fishgame.state.ak.us

Marine environment collections (Division of Commercial Fisheries):
frpermits@fishgame.state.ak.us

or

Mailing Address:

Freshwater & estuarine environment collections: **Anchorage, AK 99518-1599**

Alaska Department of Fish and Game
Division of Sport Fish-RTS/FR Permits
333 Raspberry Road

Marine environment collections and permits involving propagation:

Alaska Department of Fish and Game
Division of Commercial Fisheries-Permits
P.O. Box 25526
Juneau, AK 99802-5526

Bristol
ENVIRONMENTAL & ENGINEERING
SERVICES CORPORATION

2000 W. International Airport Road, #C-1
Anchorage, AK 99502-1117
907-563-0013 Phone
907-563-6713 Fax

M E M O

DATE: April 5, 2005

TO: Alaska Department of Fish and Game
Division of Commercial Fisheries

FROM: Mark Madden

RE: 2005 Fish Resource Permit
Marine Biological Sampling Plan Summary for the Pebble Project

---

Northern Dynasty Mines Inc. (NDM) will be conducting environmental baseline studies to support development of the proposed Pebble Project, a copper-gold deposit in the Iliamna Lake region near the village of Iliamna. The proposed project would require development of a Port facility and road to facilitate development of the movement of goods to and from the proposed project site. Bristol Environmental & Engineering Services Corp. has been contracted by NDM to conduct baseline studies for this port facility. The project study area is shown on Figure 1.

To evaluate the potential impacts of port development alternatives on marine resources, it is necessary to understand what specific resources are present in the areas that would be affected by project alternatives under consideration. Biological sampling is proposed near the potential port site and surrounding marine habitat. This sampling will establish baseline conditions with site-specific data. These collections will assist in assessing future project impacts and will add to the pre-existing biological data available for the project area.

General Background

Our project team has documented the marine intertidal biota of several areas within Iniskin and Illiamna Bays (Lees et al. 1980; Pentec 1996; Lees, pers. comm. 2004; CIRCAC ShoreZone mapping) and identified important habitat types and resources. However, specific intertidal habitats at potential project sites have not been recorded and little information has been developed for subtidal habitats in either Iniskin or Illiamna Bay. Planned surveys will examine intertidal and subtidal habitats that may be impacted by potential port and road alternatives and collect data on existing contaminant levels for metals and hydrocarbons in waters, sediments, and biota.

The goals of 2004 studies are to:

- Supplement the considerable knowledge already available from long-term study sites with a broader understanding of the ecology of the Iniskin/Illiamna estuary (IIE).
- Gather new information on the specific habitats that may be at risk from port development.
- Identify environmentally-sensitive habitats/resources (e.g., kelp and eelgrass beds, stream mouth marshes, shellfish resource areas, threatened or endangered species habitats, etc.).
- Obtain samples to establish baseline levels of metals and hydrocarbon contaminants in sediments, water, and biota, focusing on currently proposed port sites and other project areas of interest.

The 2005 field work will consist of an onshore Shoreline Assessment and an Offshore Assessment.

Shoreline Assessment

The Shoreline Assessment will consist of the following tasks:

- Intertidal habitat mapping and characterization
    - Description of typical assemblages on major habitat types and in the several vertical zones or "biobands"
    - Comparison of current conditions with conditions documented in earlier work in the area
    - Collection of infauna samples for possible future analysis
- Fish use of littoral, intertidal, and shallow subtidal areas (beach seining/otter trawling)
- Collection of littoral sediment and animal tissues for laboratory analysis of baseline metals and hydrocarbon concentrations.

Offshore Assessment

The Offshore Assessment will consist of the following tasks:

- Subtidal habitat characterization diver transects including information on biota, substrate type, and water depth
- Collection of sediment samples with van Veen grab for laboratory analysis of baseline metals and hydrocarbon concentrations, and infauna samples for analysis and/or archiving
- Collection of water samples (with a Niskin or Van Dorn sampler) and animal tissues for laboratory analysis of baseline metals and hydrocarbon concentrations
- Otter trawling with "try-net in soft-bottom areas

2005 Field Survey

The 2005 marine biological field survey will be conducted off of various vessels capable of transporting and housing up to 10 scientists. The field program is planned to occur periodically between late April and early September 2005.

The following sections describe, in brief, our approach to specific tasks required to meet the project goals. Shoreline Assessment work will be broken into four subtasks:

Habitat mapping: Under this subtask, we will complete the mapping of intertidal habitat types present at project-specific sites around the IIE, building on the base information available from CIRCAC. Emphasis will be placed on areas of potential project disturbance, specifically, the west side of Iniskin Bay and the east side and head (Williamsport area) of Illiamna Bay. Where they differ significantly, dominant substrate types in the upper, middle and lower intertidal will be mapped separately. Changes in habitat types laterally along the beach will be located with GPS for later incorporation into the project GIS basemap.

Intertidal ecology: Under this subtask, we will provide detailed qualitative characterization of intertidal assemblages. Dominant species will be identified along with less numerically abundant but ecologically important "keystone species". A detailed species list will be compiled for each habitat type and elevation. This work will be completed with at least two intertidal ecologists each with over 25 years of experience in Alaska and with prior work experience in the IIE.

In key elevation zones, a limited number of quadrat counts will be made to provide a quantitative baseline for future comparisons and for comparisons with the baseline data available from previous work in IIE. On sandy or muddy substrates, these counts will include excavations to enumerate large infauna and for collections of organisms (most likely *Mya*) for tissue analysis.

Infaunal and sediment collections: In soft bottom habitats (sand or mud), stations will be established for sampling of infauna. Station location will be marked by GPS, rebar stake, or other means (e.g., large boulder) for future relocation. At each station, five replicate infauna samples will be taken with an 80-cm^2 by 15-cm deep hand corer. At each infaunal core location, two, 2-cm deep sediment samples will be taken to form three composite samples; one for analysis of sediment grain size, one for analysis of total organic carbon (TOC) and total kjeldahl nitrogen (TKN), and one for analysis of metals and petroleum hydrocarbon concentrations.

Beach seining: An important function of the littoral zone is its role as a nursery for juvenile salmonids and other forage fish, as well as several important invertebrates. Beach seining will be conducted using a standard 37-m, fine-mesh seine for at least two locations along low gradient, fine sediment beaches in each of Iniskin, Illiamna, and Cottonwood Bays. Catch will be identified to species and a representative number of each cohort will be measured to establish dominant size classes using this shallow water habitat. Selected specimens will be retained for tissue contaminant analyses (e.g., fish muscle and liver tissues).

Offshore Assessment work will include the following subtasks:

Subtidal habitat characterization: The offshore subtidal areas of the IIE are the least characterized of the marine habitats present there. SCUBA divers a will be used to obtain video and still photography of bottom habitats when visibility and tidal conditions allow. Diver and/or ROV transects will be used in primary areas of interest, e.g., areas of potential project disturbance and areas of ecologically-important habitat (e.g., eelgrass beds) to record data on biota, substrate type, and water depth.

Infaunal and sediment collections: Sediment samples will be collected with a van Veen grab, focusing on areas of potential project disturbance. Samples will be collected for laboratory analysis of baseline metals and hydrocarbon concentrations, and infauna samples for analysis and/or archiving. Infauna sampling will be stratified by water depth, and where possible, by substrate type. At each infauna sampling location, samples will be collected for grain size, TOC, TKN, and contaminants. Areas found to have larger infauna (e.g., clams or polychaetes) will be collected for laboratory analysis of baseline metals and hydrocarbon concentrations.

Water sampling: Water samples will be collected with a Niskin or Van Dorn sampler at selected infauna sampling stations.

Otter trawling: A 3-m "try net" will be used in soft bottom, subtidal areas (to be determined by divers and underwater video surveys), or flooded low intertidal soft bottom areas (identified during low tides), to sample demersal fish and large invertebrates that may be missed by other sampling protocols. Catch will be identified to species and a representative number of each cohort will be measured to establish dominant size classes using this shallow water habitat. Selected specimens will be retained for tissue contaminant analyses (e.g., fish muscle and liver tissues).

Other Sampling: Crab pots and hook and line sampling may be used to collect subtidal species. Selected specimens will be retained for tissue contaminant analyses (e.g., fish muscle and liver tissues).

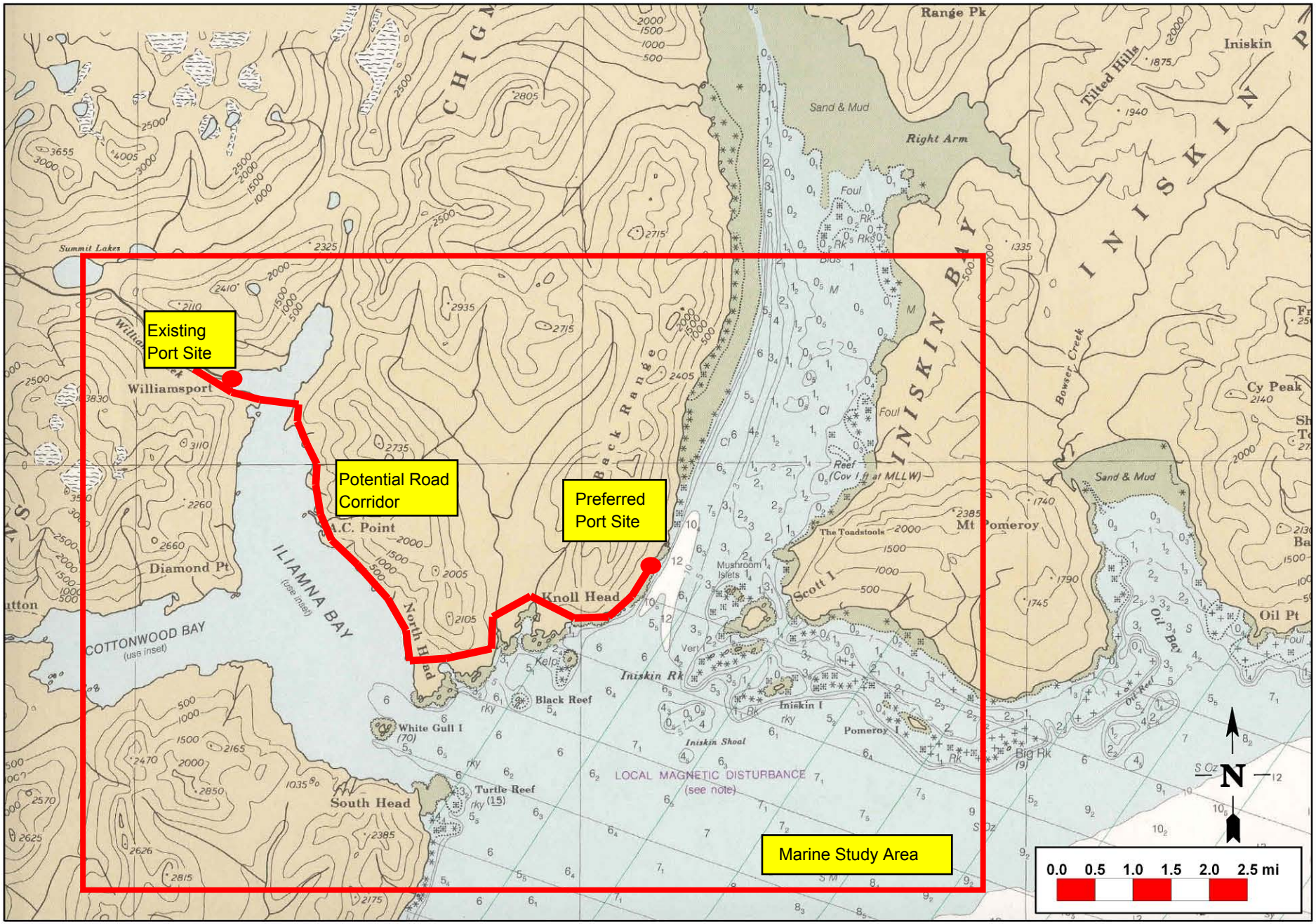
Alaska Department of Fish and Game Fish Resource Permit Requirements

In anticipation of Alaska Department of Fish and Game (ADF&G) Fish Resource Permit requirements, the project team expects to take the following actions to remain in compliance with its permit:

- All pots and nets used on this project will have an aluminum tag affixed to it with the ADF&G Fish Resource Permit number, along with the permit holder name, "BEESC," clearly labeled on it.
- A copy of the Fish Resource Permit will be affixed in a sealed Zip-Loc bag on the inside lid of each bait cooler used on this project.
- Any specimens collected and retained for shipment to the University of Alaska Institute of Marine Science (UAF/IMS) laboratory in Fairbanks, Alaska or to other analytical laboratories will be entered into a specimen log sheet, including the permit-prescribed

information for each specimen. If this information cannot be obtained in the field (e.g., positive species identification), this will be determined in the laboratory and be subsequently provided by specimen number to the Field Team Manager. A copy of the specimen log sheet will accompany all shipped samples; a copy will be provided to the BEESC Project Manager; and the original will be placed in a loose-leaf ringed binder maintained onboard the primary support boat. After the field program is completed, this binder will be retained by the Field Team Manager to assist in field data write-ups and reporting.

- A copy of the ADF&G Fish Resource Permit will be affixed in a sealed Zip-Loc bag on the inside the lid of each cooler being shipped to the laboratories along with a chain-of-custody form.
- The Field Team Leader will keep a running tally of the number of specimens retained to ensure that no permit limits are exceeded on a species by species basis. With these procedures, requests can be sent by the Field Team Leader to ADF&G to amend the permit, if necessary.
- Any person conducting fishing with hook and line will have a valid State of Alaska fishing license on their person.



Bristol ENVIRONMENTAL & ENGINEERING SERVICES CORPORATION	2005 MARINE STUDY AREA	Date: April 5, 2005	Figure 1
		Drawn by: ME / Checked By: MM	Project No: 25011

APPENDIX E
SAMPLE LOCATION COORDINATES

Table E-1
Pebble Project
2005 Marine Studies
Study site location Coordinates

	Coordinates			
Station	**Latitude**	**Longitude**	**Sample type**	**Notes:**
MBS1	N59 38 36.4	W153 34 38.5	Beach seine	
MBS1A	N59 39 11.6	W153 35 54.5	Beach seine	
MBS3	N59 39 56.6	W153 36 13.4	Beach seine	
MBS3A	N59 39 56.6	W153 36 13.4	Beach seine	
MBS4	N59 40 56.0	W153 37 33.5	Beach seine	
MPS1	N59 38 36.3	W153 28 44.2	Beach seine	
MPS1A	N59 38 16.5	W153 29 55.1	Beach seine	
MPS1B	N59 38 55.1	W153 28 25.5	Beach seine	
MPS1C	N59 39 03.5	W153 28 10.9	Beach seine	
MPS4A	N59 37 49.2	W153 33 48.6	Beach seine	
MPSE	N59 40 29.7	W153 37 24.4	Beach seine	
MPSE1	N59 40 00.9	W153 37 43.4	Beach seine	
MPS3	N59 38 38.3	W153 38 15.7	Beach seine	
MPS1T	N59 38 36.9	W153 28 23.9	Trawl	
MPS2T	N59 39 02.3	W153 26 56.5	Trawl	
MPS2TA	N59 39 42.5	W153 27 05.5	Trawl	
MPS2TB	N59 40 54.2	W153 26 23.4	Trawl	
MTR1	S59 38 16.7	W153 36 03.0	Trawl	
MTR1A	N59 38 10.2	W153 35 52.3	Trawl	
MTR2	N59 37 28.6	W153 34 15.0	Trawl	
MHALI	N59 39 34.1	W153 26 35.8	Iniskin Anchor point	Hook and line sampling
MPS1	N59 38 19.5	W153 29 05.3	Intertidal	
PS1	N59 38 05.2	W153 30 43.5	Intertidal	
PS2ARCH	N59 39 34.5	W153 27 51.9	Intertidal	
SCOTT MID	N59 38 06.2	W153 26 27.1	Intertidal	
MBS1A	N59 39 09.3	W153 35 51.4	Intertidal	
MPS4A	N59 37 47.2	W153 33 48.5	Infauna/sediment sample	Cores
MPS2	N59 39 32.6	W153 27 49.3	Infauna/sediment sample	Cores and 1/4m infauna
MPSE	N59 40 38.3	W153 37 17.8	Infauna/sediment sample	Cores
MBSA1	N59 39 19.4	W153 36 00.5	Infauna/sediment sample	Cores
MPS3	N59 38 36.7	W153 37 37.0	Infauna/sediment sample	Cores and 1/4m infauna
MPS3	N59 38 35.3	W153 37 38.8	Infauna/sediment sample	1/4 m infauna



PEBBLE PROJECT
ENVIRONMENTAL BASELINE STUDIES
2008 FIELD SAMPLING PLAN

MARINE STUDIES
Cook Inlet

DRAFT

June 2008

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ACRONYMS AND ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
AVS	acid volatile sulfides
CAS	Columbia Analytical Services, Inc.
DI	deionized
FSP	field sampling plan
GERG	Geochemical and Environmental Research Group (Texas A&M)
GPS	global positioning system
HDPE	high density polyethylene
HNO_3	nitric acid
IIE	Iniskin/Iliamna Estuary
mL	milliliter(s)
MS	matrix spike
MSD	matrix spike duplicate
NOAA	National Oceanic and Atmospheric Administration
PAH	polynuclear aromatic hydrocarbons
Pentec	Pentec Environmental
PVC	polyvinyl chloride
QAPP	quality assurance project plan
QA	quality assurance
QC	quality control
SEM	simultaneously extracted metals
Shaw	Shaw Alaska, Inc.
SHC	soluble hydrocarbons
TA	TestAmerica, Inc.
TOC	total organic carbon

2008 FIELD SAMPLING PLAN

MARINE STUDIES, COOK INLET

1. Introduction

This 2008 field sampling plan (FSP) describes the project team organization and protocols for surveys of fish, invertebrates, and intertidal and subtidal benthic assemblages and for collection of marine sediment, water, and plant and animal tissue samples during the 2008 marine studies for the Pebble Project. The objective of the 2008 marine studies is to further characterize the fauna, flora, and habitat conditions in marine areas in the Iniskin/Iliamna Estuary (IIE) and to raise the information base to a level adequate to accomplish the following:

- Establish a full IIE baseline characterization.
- Provide a starting point for long-term monitoring.
- Support permitting (including preparation of the environmental impact statement "Existing Conditions" sections).
- Support engineering design in the areas of the possible port site and access road.

The 2008 study will build on historic information, including the results of the 2004 through 2007 marine surveys. The field sampling effort in 2008 will include intertidal and nearshore areas near the possible port sites (Port Sites 1 and 4) and along shoreline access corridors (Figures 1 and 2). It also will include subtidal studies offshore of those areas.

2. Organization and Responsibilities

Pentec Environmental (Pentec), the natural resources arm of Hart Crowser, Inc., manages the marine environment, benthos, and nearshore fish and invertebrate portions of the marine study program for Pebble Project. Pentec and its subcontractors will conduct the marine studies and collect all field samples for laboratory analyses. Shaw Alaska, Inc. (Shaw), will manage analytical quality assurance (QA) and quality control (QC) for the project in accordance with the quality assurance project plan (QAPP; Pebble Partnership, In press). Table 1 shows the primary and QA analytical laboratories for the marine studies. Key marine studies personnel and their roles are identified in the organizational chart in Figure 3.

3. 2008 Sampling Program Summary

3.1 Field Activities

Field sampling tasks to be conducted for the marine studies in 2008 will include the following:

- Collect samples of water, sediment, and plant and animal tissues for laboratory analysis of metals and hydrocarbon concentrations.
- Collect intertidal and subtidal infauna samples for quantitative analysis.
- Using beach seining, assess fish and invertebrate use of littoral habitat in intertidal and shallow subtidal areas.
- Use otter trawling to collect pelagic and demersal fish and invertebrates in offshore subtidal areas.
- Using gill nets and/or trammel nets, assess fish use of rocky littoral areas.
- Survey for herring-spawn deposition.
- Assess intertidal rocky assemblages using stratified random sampling techniques.
- Assess subtidal rocky and mixed habitats using diver transect surveys.
- Conduct in situ water-quality measurements at fish/invertebrate net-sampling sites.

3.2 Sampling Schedule

Sampling for the marine studies will be conducted by Pentec personnel from March through November 2008 as shown in Table 2. Table 3 summarizes the laboratory analyses to be performed. Table 4 summarizes the number of samples expected to be collected and analyzed during the 2008 marine studies.

3.3 Sample Locations

Stations proposed for sampling for the 2008 marine studies are depicted in Figures 1 and 2. Most of these stations have previously been sampled. A summary of sampling activities to be performed at the sampling stations is provided in Table 5. Appendix A lists the global positioning system (GPS) coordinates for all 2008 marine studies sampling stations.

4. Sampling Methods

For all field sampling, team members will follow the procedures described in this FSP and will abide by the requirements of the Alaska Department of Fish and Game (ADF&G) collection permit (Appendix B). All biological samples must be recorded on the Intertidal Field Form, Fish Catch Record, and Specimen Log (Appendix C).

The sampling program is a component of the study of the nature of the nearshore and intertidal habitats in the project area and their usage by a variety of species. The intertidal studies will include epibiota quantification on hard substrata, infauna quantification in soft substrata, tissue collection, and beach seining, as well as observation and documentation of patterns of herring-spawn deposition in intertidal areas. Subtidal surveys will document infauna, demersal fish presence, and the nature of assemblages using subtidal rock, boulder, and mixed soft-bottom habitats. Background levels of potential contaminants will be established in several media: sediment, water, plants, invertebrates, and fish.

4.1 Intertidal Herring-spawn Deposition

ADF&G herring-spawn survey data from the IIE and adjacent bays, as available, will be gathered to characterize herring spawning activity in the IIE. ADF&G currently surveys the study area by air weekly or every two weeks, weather permitting. ADF&G has already provided Pebble Project with data on surveys conducted between 1978 and 2005 (ADF&G, 2002 and unpublished data).

During field surveys in mid-May and mid-June, crews will seek to minimize the catch of adult herring during net fisheries (Section 4.5), but will document locations along the shoreline where herring schools and spawning are observed. During the May and June surveys, and during a single-purpose survey in early June, additional shoreline surveys will be conducted specifically for herring spawn. A survey crew will cruise the shoreline at minus tidal elevations, when possible, looking for signs of herring spawn (e.g., spawn in the water, bird activity) from Scott Island to North Head, as well as rocky outcrops and reefs inside the north shore of Iniskin Bay. Crews will stop frequently to examine attached and drifting vegetation closely for eggs, walking selected reaches of shore for a more thorough search. GPS coordinates of areas surveyed and of any areas of spawn deposition will be recorded, and algal species receiving spawn deposition will be noted. Where spawn is found it will be classified as “trace,” “low,” “medium,” or “high” using standard criteria.

Mapping will include documentation, with GPS coordinates, of areas and habitats surveyed and locations where eggs were detected for later incorporation into the project geographical information system (GIS) database.

4.2 Intertidal Epibenthic Assemblages

Intertidal epibenthic assemblages on rocky and boulder/cobble substrata will be quantified in fixed quadrats on fixed transects. The sampling program will revisit some sites established in 1978, 1996, 2004, 2005, and 2006 and may establish new sites along Iliamna Bay to fully characterize that area. Key historical sampling locations will be revisited to ensure that markers (e.g., transect head stakes) are well established for future reference, as well as to evaluate trends observed in algae and epibiota on these beaches. Proposed sampling locations are shown on Figure 2 and are listed in Table 5. Intertidal epibiota will be sampled in July only.

With the help of photographs and previously placed markers, intertidal rocky sites and elevations will be resampled as close as possible to the locations (specific quadrats) previously sampled. New sites will be located to be representative of intertidal habitats along previously unsampled shorelines in the IIE. At each intertidal sampling site, one to three elevations representative of the gradient of assemblages present will be sampled. At some sites, there may be significant substrate changes between the upper and lower elevations. For most of the Iliamna Bay sites, only upper and possibly middle elevations will be rocky; many middle and all lower elevations occur on the mudflats and will be sampled as soft-bottom sites.

At each elevation sampled on rocky or boulder/cobble habitat types, a 30-meter-long transect line will be laid out along the tidal elevation contour line. Along each transect, five to ten 0.25-square-meter quadrats will be randomly located, or in the case of previously sampled random quadrats, relocated. In 2008, field teams will seek to re-establish permanent marks with marine epoxy, nails, or rebar to allow precise repositioning of each quadrat in subsequent sampling.

Once a quadrat is positioned, a photograph will be taken of the quadrat and immediate surrounding substrate. A preprinted label showing date, site, elevation, and quadrat number will be included in each photograph. Within each quadrat, the nature of the substrate and the percent cover of all algal species and all sessile animals will be estimated and recorded on the Intertidal Field Form (Appendix C). Areas of coverage less than 0.5 percent will be recorded as 0.5 percent. Counts will be made of all mobile species larger than about 4 millimeters in size. Dominant species will be identified along with less numerically abundant but ecologically important "keystone species." Very abundant organisms may be subsampled by counting the numbers in a randomly selected subsection of the quadrat; data recorded will reflect that subsampling ("=count x 1/fraction of quadrat counted"). Detailed species lists will be compiled for each habitat type and elevation and will be recorded on the Intertidal Field Form (Appendix C). These data will provide a quantitative baseline for comparison with the data available from previous work in the IIE.

4.3 Intertidal Infauna and Sediment Characterization

Intertidal infauna and sediment sampling in soft-bottom habitats (sand or mud) will be conducted to document the type and distribution of infaunal species in soft-bottom intertidal areas (Figure 2). Previously sampled sites will be found using GPS coordinates, previously placed rebar stakes, photographs, and/or other points of reference (e.g., identifiable landmarks). New sites along the east side of Iliamna Bay will be similarly marked; most, if not all, sites will comprise the lowest elevation sampled at sites with rocky upper and/or middle elevation stations. At most soft sites, only a single elevation will be sampled. Intertidal infauna and sediment sampling will be conducted in July at all stations indicated on Table 5.

At each elevation at each site, five replicate samples will be taken along a transect at random distances from the transect head stake. Samples for analysis of macroinfauna will be taken with a 15-centimeter-deep, 80-square-centimeter hand corer. In addition, two scoops of sediment 2 centimeters thick will be taken with a decontaminated stainless steel spoon from undisturbed sediments adjacent to each macroinfauna sampling location. These scoops of sediment will be combined in a zipper-seal bag to form one composite sample for the transect, for chemical. At three locations (MPS1, MPS4, and MBSA1), in addition to the surface sediment sample, a composite sample also will be collected from below the biologically active zone (more than 10 centimeters below ground surface by deeper excavation of the shallow sample holes). Additional sediment samples will be collected at locations where *Macoma* (clams) are collected for tissue analysis (Section 4.4.2).

Macroinfauna samples will be processed in the field by washing and sieving through a 1.0-millimeter mesh screen. The macroinfauna will then be preserved in 10 percent neutral buffered formalin solution with 0.1 percent rose Bengal dye. Each sample will be catalogued on the Taxonomic Sample Log by the sampler (Appendix C), and all sample containers will be clearly labeled as described in Section 6.2. The preserved samples then will be transported to the taxonomic laboratory for identification. At the taxonomic laboratory, the samples will be transferred from the formalin solution to a 50 percent isopropyl alcohol solution for storage until identification is completed.

Visual observations of sediment characteristics at each station sampled and additional required information will be recorded on the Sediment Sample Collection Log (Appendix C). The composite samples will be transferred from the collection bag to the appropriate sample containers for packaging and shipment to the laboratory for chemical analysis (Table 6). The samples will be entered on the

Sample Transfer Log (Appendix C), and containers will be clearly labeled, as described in Section 6.2. Samples will then be packed in coolers and delivered to Shaw personnel in Anchorage, following chain-of-custody procedures. The Sample Transfer Log will accompany each cooler shipment at all times until delivery to Shaw. Shaw personnel will prepare chain-of-custody forms and will pack and ship the samples to the appropriate laboratory.

At selected soft intertidal sites, additional sampling will be conducted to quantify epibiota, including larger mega-infauna such as large clams, polychaetes, and echiurids. Randomly located 0.25-square-meter quadrats first will be photographed in the manner described for rocky sites above. All epibiota will be recorded as described for rocky sites. The quadrat will then be excavated to approximately 25 to 30 centimeters, and the excavated material will be either sieved or visually examined for animals larger than approximately 5 millimeters. Organisms may be identified in the field, when possible, or collected in labeled plastic bags for later identification and enumeration on the support vessel; alternatively, they may be preserved and sent to the analytical or taxonomic laboratory for chemical analysis or identification.

4.4 Intertidal/Subtidal Tissue Collections

In 2004 and 2005, a wide range of biological tissues for trace elements analysis was opportunistically sampled at several times of the year and at various places in the IIE. While these data provide a confidence that existing conditions in the IIE are relatively free of contaminants they do not provide an adequate baseline for post-project comparisons. In 2008, Pentec will systematically collect tissue samples from areas most at risk from project activities and at suitable reference areas. Protocols for sample collection, preparation, handling, and analysis, including labeling and collection of QA/QC samples, are described in the QAPP (Pebble Project, In press) and below.

Four types of tissue sampling are scheduled for the 2008 field season:

- Algal tissue (rockweed, *Fucus distichus ssp. evanescens*).
- Shelled bivalves (mussel, *Mytilus trossulus*, and clam, *Macoma sp.*).
- Whole-body juvenile/subadult fish (yellowfin sole, *Limanda aspera*, and Dolly Varden char, *Salvelinus malma*).
- Muscle tissue (skin-off fillets) of adult fish (Pacific halibut, *Hippoglossus stenolepis*, Dolly Varden char, and chum salmon, *Oncorhynchus keta*, or pink salmon, *O. gorbuscha*, depending on availability).

Target quantities for each primary sample are a minimum of 50 grams for algal tissue and 100 grams each for bivalve and fish tissue; similar additional quantities will be necessary for each QA sample, QC sample, matrix spike (MS) sample, or matrix spike duplicate (MSD) sample.

Fish, invertebrates, and other organisms collected for tissue sampling will be rinsed in clean site seawater upon collection to remove mud, sediment, or other debris from the outer surfaces as needed. Specimens will be placed in a clean, labeled (Section 6.2), zipper-seal plastic bag. Smaller fish or invertebrates that will be composited into a single tissue sample may be placed in the same bag. Larger fish or specimens that will be submitted to the laboratory as separate samples will be segregated in separate bags. All samples will be kept on ice until properly prepared and packaged for shipment to the laboratory. Note: in

accordance with the Mussel Watch protocols from the National Oceanic and Atmospheric Administration (NOAA; Mearns, pers. comm., 2007), bivalves will not be depurated after collection.

4.4.1 Rockweed (Algal Tissue)

Rockweed (*Fucus distichus* ssp. *evanescens*) will be sampled in July 2008 at two stations in each bay within the IIE (Stations MPS1, MPS2, MPS3, and MPS4; Figure 2). At two stations—MPS1 and MPS4—rockweed also will be sampled in May and September to document any seasonal variation in trace element concentrations. Each rockweed sample will be a composite of distal portions of at least 10 individual robust and mature plants. One frond, approximately 10 centimeters long, with conceptacles, will be taken from each plant, and the pieces (sufficient to have a sample size of 50 grams) will be placed in a prelabeled zipper-seal bag in a cooler. Samples will be immediately placed on ice in a sample cooler and will be frozen upon return to the survey vessel. Additional plant material will be collected for QA/QC samples and MS/MSD samples according to the schedule in Table 4.

4.4.2 Bivalve Tissue

Bivalve samples will be prepared by collecting at least 10 individuals per sample (sufficient to produce a sample size of 100 grams), wrapping the group of individuals (shell on) in aluminum foil, and placing them into a prelabeled zipper-seal bag. Samples will be immediately placed on ice in a sample cooler and will be frozen upon return to the survey vessel. The field crew will fill out the Specimen Log (Appendix C). Additional bivalves will be collected for QA/QC samples and MS/MSD samples according to the schedule in Table 4. Note that, for ease of collection, QA/QC samples need not be taken at the same location as MS/MSD samples. Mussels will be collected in May, July, and September; clams, in July only.

Sample identification numbers and other pertinent information will be recorded on the Sample Transfer Log (Appendix C). Samples will remain in the custody of the field crew until being turned over to a carrier for delivery to Shaw personnel in Anchorage (Section 6.1). Chain-of-custody procedures will be followed.

4.4.2.1 Mussels

The mussel *Mytilus trossulus* will constitute the primary species used to make spatial and temporal comparisons of background levels of trace elements and will be a primary indicator species of the general level of potential contaminants in the long-term monitoring program. In July 2008, mussels will be sampled at two stations in each bay in the IIE (Figure 2; Stations MPS1, MPS2, MPS3, and MSP4), which also were sampled in 2004. At two stations (near MPS1 and near MPS4), mussels also will be sampled in May and September to document any seasonal variation in trace element concentrations. Each mussel sample will be a composite of at least 10 individuals, chosen from among the largest cohort (size class) available at each site. Protocols for animal selection and compositing will follow the NOAA Mussel Watch protocols (Mearns, pers. comm., 2007); accordingly, animals will be rinsed in ambient seawater, but depuration will not be done.

4.4.2.2 Clams

A second bivalve, *Macoma* species—most likely *M. obliqua*—will be collected by hand digging from mixed fine sediments near MPS2 and near MPS4, as near as possible to the sites of previous intertidal infauna sampling at those stations. *Macoma* also will be collected from near AC Point (MBSA1). Each *Macoma* sample will be a composite of at least 10 individuals, rinsed in ambient seawater.

4.4.3 Fish Tissue

4.4.3.1 Sample Collection

Demersal Fish

Yellowfin sole, *Limanda aspera*, will be the primary indicator species for the demersal fish assemblage in deeper waters of the study area. A minimum of eight fish will be taken from otter trawls in each bay in July 2008 for trace elements analysis. Each yellowfin sole sample will consist of the whole body of a fish in the 100- to 200-millimeter size range.

Pacific Halibut

Adult Pacific halibut move into the IIE in the spring to feed and are likely the top predator in the demersal habitats of the study area through June. Capture by trawl and/or by hook and line will occur in June to maximize the potential time that captured fish have spent in the study area. Edible tissue (skin-off fillets) will be collected from up to eight fish, if available, in each bay.

Dolly Varden Char

Both subadult (immature fish that have migrated to marine areas) and adult (sexually mature) Dolly Varden are a common component of the nearshore fish assemblage in the study area from May into August and constitute a top predator preying on crustaceans and small fish. This species was selected for monitoring as a surrogate for Pacific salmon that will provide a conservative estimate of possible accumulation of trace elements from the IIE in anadromous salmonids. Two types of samples will be collected:

- Subadult char, approximately 120 to 200 millimeters in fork length will be frozen for whole-body analysis. A minimum of eight fish will be collected from seine hauls in each bay in July.
- Adult char (longer than 250 millimeters) will be collected in May, when they are most abundant, for analysis of edible tissue (skin-off fillets). Up to eight fish, if available, will be collected by net (beach seine, gill net, trammel net) or by hook and line from each bay.

Chum or Pink Salmon

Adult pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) migrate through the IIE to spawn in area streams. Both species are present in some abundance in August and early September. Adult salmon will be captured by net or by hook and line in September. Edible tissue (skin-off fillets) will be collected from up to eight fish, if available, from each bay.

4.4.3.2 Sample Processing

Fish collection procedures will follow many of the methods of Zhang et al. (2001) and Jewett et al. (2003). General procedures include the following:

- Fish length (fork or total length) and sex will be recorded for each specimen in the field, when feasible.
- During warm weather (i.e., greater than 15^{o}C ambient temperature), fish specimens will be placed on ice in the field; care will be taken to avoid freezing of tissues prior to dissection. Preparation of tissue samples will occur on the survey vessel after collection. Prepared samples and whole-fish samples will be immediately frozen.
- Samples will be labeled with the sample identification number and other relevant information (Section 6.2).
- The frozen samples will be packaged in a cooler and delivered by courier to Shaw personnel in Anchorage for packaging and shipment to the laboratory. Chain-of-custody procedures will be followed.

Whole-body fish samples will be prepared by selecting eight representative individuals from trawls or beach seine sets. Each individual will be placed in a prelabeled zipper-seal bag; the sample will be immediately placed on ice in a sample cooler. Where individual fish weigh less than 100 grams, multiple fish may be composited to provide the necessary sample quantity. Additional fish for QC samples, QA samples, and MS/MSD samples will be collected at a frequency of 10 percent (Table 7). These fish will be handled by the same procedures used for primary samples. The primary laboratory (Columbia Analytical Services, Inc. [CAS]) will prepare homogenates and ship the QA samples to QA laboratory (TestAmerica, Inc. [TA]), as required.

Tissue for muscle (skin-off fillet) samples from larger fish will be prepared as follows:

- Immediately upon capture, fish will be placed in clean plastic bags and placed in a cooler with ice.
- Dissection will occur indoors onboard the survey vessel.
- The cutting surface will be washed with laboratory-grade detergent, rinsed with tap water and then 10 percent nitric acid, and double rinsed with laboratory-grade water.
- A high-quality stainless-steel fillet knife will be used for dissection. Any knife with visible rusting will not be used. Knives will be washed with laboratory-grade detergent, rinsed with tap water and then 10-percent nitric acid, and double rinsed with laboratory-grade water before use and between samples. Samplers will wear powder-free gloves.
- An equipment blank will be prepared BEFORE each set of dissections, as described in Section 7.
- Muscle tissue will be collected in approximately equal portions from both sides of the individual fish (left and right sides, or in the case of halibut, from the dark and light sides). An approximately 50-gram sample of muscle tissue (about a 3x3x2-inch piece of tissue) will be extracted from each side of the fish and placed in an individually labeled zipper-seal bag. Tissue samples will be immediately placed in a freezer.

- Triple quantities of muscle tissue will be collected from some individuals to provide sufficient tissue for QA/QC or for MS/MSD purposes. The primary laboratory (CAS) will prepare homogenates, and will ship the QA samples to the QA laboratory (TA), for analysis.

Upon identification of fish specimens for tissue analysis, the individuals will be identified by species and recorded on the Fish Catch Record (Appendix C) for ADF&G collection-permit reporting, as well as on the Specimen Log (Appendix C).

4.5 Nearshore Fish Assemblages

4.5.1 Beach Seining

4.5.1.1 Seining Procedure

An important function of the littoral zone is its role as a nursery for juvenile salmonids and other forage fish, as well as for several important invertebrates. Beach seining will be performed monthly from March though November (weather and ice conditions permitting) at locations identified in Table 5 and shown in Figure 1. Seining will be conducted using a standard 37-meter-long, fine-mesh seine at up to 15 locations along moderate- to low-gradient mud, sand, or gravel beaches in Iniskin and Iliamna Bays. Catch will be identified by species and recorded on the Fish Catch Record (Appendix C). Total lengths of a representative number of each cohort of each species will be measured to determine the dominant size classes using the shallow water habitat at that time; these data also will be recorded on the Fish Catch Record (Appendix C). Selected specimens will be retained for analysis of trace elements in tissues and/or stomach content analysis (Section 4.4 and Section 4.7, respectively). Collection procedures will meet the requirements of the ADF&G collection permit (Appendix B).

A smaller—10-meter-long—fine-mesh seine will be used in selected areas (e.g., AC Point Lagoon) where the larger net cannot be used. The smaller net will be stretched out perpendicular from shore and walked by biologists on either end for 100 feet before pursing to the shore. This net will typically be set into the current if one is detectable.

4.5.1.2 Measurement of Field Parameters

During each sampling event, turbidity, salinity, and temperature will be measured with the appropriate instruments. Temperature and salinity will be measured with a calibrated YSI Model 30 or Model 85 meter. The probe will be placed approximately 1 foot below the water surface, near the shore where the water is 2 or more feet deep. Temperature and salinity will be measured according to the instructions in the manual for the meter. Turbidity will be measured with a calibrated LaMotte Model 2020 turbidimeter. The meter will be field calibrated at the beginning of each day of use with a 1-NTU (nephelometric turbidity unit) standard. To measure turbidity, the sample vial will be completely filled with water from just below the surface (to minimize sampling of the surface microlayer) and in an area that has not been subject to sediment suspension during boat handling or net handling. The vial will be placed in the turbidimeter and a reading will be taken according to the instructions in the manual for the instrument.

4.5.2 Passive Netting

Two types of nets not previously used in the Pebble possible-port-area studies will be deployed to sample fish populations in rocky or boulder/cobble areas where beach seining is not feasible, for example, off rocky headlands adjacent to beach seining sites, and between Knoll Head and North Head. The two types of nets are a variable-mesh gill net and a trammel net. Both were used by Blackburn et al. (1980) in their 1978 Outer Continental Shelf Environmental Assessment Program (OCSEAP) surveys in Iniskin and Iliamna Bays, although they did not set them specifically in rocky-bottom areas.

The monofilament gill net will be 6 feet deep and 100 feet long, consisting of four 25-foot-long panels, each with a different mesh size: 1-inch, 1.5-inch, 2-inch, and 2.5-inch. The net will be set primarily to float at the surface with anchor lines attached to the sides to hold the net in place and vertical in the water column. Additional weight may be added to the lead line if conditions favor a sinking gill net.

The trammel net will be constructed of three adjacent panels (two outer and one inner), each 100 feet by 6 feet. The two outer panels will be 20-inch mesh, with the inner panel being 2-inch mesh. All panels will be monofilament. The lead line will be a 50-pound lead core rope, and the float line will be a 0.5-inch polyfoam core line. The net will be hung to sink with buoyed anchor lines attached to the sides to hold the net in place.

Both nets will initially be anchored over or just offshore of rocky intertidal habitat types. Initially, sets will be of limited duration (e.g., 1 hour) to minimize the potential for killing large numbers of schooling fish or any birds or mammals, although some incidental capture of birds and mammals may be unavoidable. Captured fish will be processed as described above for beach seine samples.

The primary effort to identify the fish fauna over rocky habitats will be conducted in April, June, August, and October; however, additional sampling may be conducted during other sample events.

During each sampling event, turbidity, salinity, and temperature will be measured with the appropriate instruments as described in Section 4.5.1.2.

4.6 Otter Trawling

Trawling with a 10-foot (3-meter) “try net” will be conducted concurrently with beach seining activities (Table 2) to evaluate the use of soft-bottom habitats by both resident and migratory demersal fish and large invertebrates**.** Each month, the try net will be used (weather and ice conditions permitting) at four to six locations each in Iniskin and Iliamna bays. The locations include at least eight sites (Table 5) occupied in previous sampling. Trawling is typically done from an inflatable skiff, but under severe weather or ice conditions, it may be completed from the larger support vessel at deeper stations.

Trawls typically will be run with the tide to ensure progress over the ground. GPS coordinates will be taken as the net initiates contact with the bottom and at the end of the 5-minute trawl when the net will be hauled into the boat. To evaluate catch efficiency, during a minimum of three trawl events, after completion of the haul with the current, a parallel haul will be made into the current for an equivalent time period and with GPS coordinates taken at each end of the trawl run. Upon completion of each trawl, catch will be identified by species and recorded on the Fish Catch Record (for reporting under the ADF&G collection permit), as well as on the Specimen Log (Appendix C). A representative number of

each cohort of each species will be measured to identify the dominant size classes using the habitat. Selected specimens will be retained for analysis of trace elements in tissues and/or stomach content analysis (Section 4.4 and Section 4.7, respectively). Collection procedures will meet the requirements of the ADF&G collection permit (Appendix B). Catch will be standardized to catch per 100 square meters of bottom fished, assuming the width of the trawl while fishing is 2.5 meters and calculating the length of the trawl track assuming a strait path between the trawl start and end GPS coordinates.

During trawling events, turbidity, salinity, and temperature will be measured with the appropriate instruments as described in Section 4.5.1.2, except that all measurements will be made out of the skiff or from a bucket of water hauled to the deck of the larger vessel when that is used as the trawl vessel.

4.7 Fish Stomach Sampling

Stomach samples will be collected from May through September (Table 2) and in the quantities noted in Table 4. Fish will be collected in the IIE by beach seining and trawling and, optionally, with passive netting, or hook and line.

Stomach dissection and sampling methods are modified from Nielson and Johnson (1983). For large fish (i.e., more than 100 millimeters total fork length), the fish stomach will be extracted and preserved in the field. For small fish (less than 100 millimeters total fork length), the fish stomach will remain in the fish.

4.7.1 Removal of the Fish Stomachs

For small fish, the coelom will be opened to ensure proper preservation, but the stomach will be left in the fish to avoid inadvertent loss of stomach contents. Once the coelom has been opened, place each fish in a separate zipper-seal bag for preservation. Stomachs will be removed from fish greater than 100 millimeters total fork length. Before dissection, sampled large fish (i.e., greater than 100 millimeters) will be killed by severing the spinal column or by applying a sharp blow to the head. The coelom will be opened to expose the viscera. To remove the stomach, using blunt scissors, sever the esophagus, the last few millimeters of the intestine, and the mesentery at its dorsal point of attachment. Lift the visceral mass out of the coelom and place it in a plastic zipper-seal bag for immediate preservation.

4.7.2 Fixing and Preserving Stomach Contents

Ten-percent formalin will be used as a fixative. Plastic or rubber gloves will be worn, and work will be conducted in a well-ventilated area to minimize exposure to formaldehyde, a primary component of formalin. Formaldehyde is suspected of being a carcinogen and can cause permanent damage to fingernail growth areas and sinus tissues, so exposure should be limited. (See the Marine Studies Health and Safety Plan [Pentec, 2008] for additional information on the handling of formaldehyde and other chemicals during this field program.)

Sufficient quantity of fixative will be added to the zipper-seal bag to fully bathe the stomach contents or, in the case of small fish, the entire fish. A small incision will be made in the stomachs of large fish or into the coelom for smaller fish to allow the preservative to enter the stomach and bathe the contents as well. Because the fixative rapidly hardens prey tissues, partly digested prey are more likely to stay intact and, thus, will be easier for the taxonomic laboratory to identify.

Prior to sealing the zipper-seal bag, as much air as possible will be removed from the bag so that all areas of the bag are bathed in fixative. An internal label (e.g., plastic tag or DuraRite paper) showing sample identification information (Section 6.2) will be placed in each bag. The bag will then be sealed and placed it into a second zipper-seal bag with the exterior of the second bag clearly labeled in waterproof ink (i.e., Sharpie pen).

The availability of time and facilities usually determines when gut contents are removed and fixed. It is best to remove and fix gut samples, or preserve small fish, immediately after capture. This minimizes post-capture digestion and avoids difficulties associated with dissection of hardened fish tissues. When tens or hundreds of fish are captured at one time, however, it is necessary to fix the gut contents in situ with the least investment of time possible. If air temperatures are warm, fish will be held on ice if more than a few minutes will elapse before fixation. In order to halt post-capture digestion, the coelom will be slit or injected directly with formaldehyde. For larger fish, it is usually more efficient to fix only the digestive tract.

Fish data (length, weight, sex, etc.) will be recorded on the Fish Catch Record and the Specimen Log (Appendix C). Samples will be shipped in coolers at ambient temperature, usually as checked baggage, to the Pentec taxonomic laboratory in Edmonds, Washington. Because samples remain in custody of Pentec personnel chain-of-custody will not be required.

When the samples reach the taxonomic laboratory, they will be examined in detail. Laboratory personnel will remove excess formalin by soaking the samples in several changes of water. After excess formalin is removed, the samples will be preserved in a 45 to 70 percent aqueous solution of alcohol (methanol, ethanol, and isopropanol are all satisfactory).

4.8 Sampling of Marine Water

To obtain a marine water sample, the survey vessel will be positioned so sampling occurs up-current of vessel. Sample collection will occur at high slack water in May, July, and September (Table 2). An additional sampling event will occur at low slack water in September at the stations within the IIE (not at MOPP1).

Marine water will be collected with a 30-liter polyvinyl chloride (PVC) sampling bottle (Niskin bottle). Before water collection begins and between samples, the Niskin bottle will be decontaminated following the procedure described in Section 5.2. Equipment rinsate blanks will be collected at 5 percent frequency before sampling begins.

When cocking the Niskin bottle in preparation for water collection, the handles on the caps must be pulled straight out and then turned over to the side with the arrow (labeled on the outside of the cap) facing inward (to prevent the elastic from slipping out of the groove). No part of the cap should be used as a fulcrum to leverage the tension of the elastic, as this action may adversely affect the O-rings or the cap surface and degrade the seal of the bottle. The eye of plain monofilament line from the top of the bottle goes into the bottle clip actuated by the plunger, and the hook from the bottom monofilament line is clipped around both of the leads in the eye of the top line (held by the plunger clip). The plunger will be activated by the messenger, and before the bottle is cast, care should be taken to ensure that the caps have not moved in a way to interfere with the action of the messenger.

Water will be collected at two depths: 2 meters below the air/water interface (referred to as "surface") and 2 meters above the bottom ("bottom," water depth as measured by the ship's bathymeter minus 2 meters as measured by the sampling line). The Niskin will be lowered to these depths in turn with the air-relief valves at the top closed and with both ends open. The weight on line should not contact the bottom. The messenger will be released to close the bottle. The bottle will then be retrieved and inspected; sampling will be deemed successful if the ends have closed and the bottle is full. Sampling position will be recorded on the Water Sample Collection Log (Appendix C). The bottle will be brought on deck and secured in a rack for sample processing or held in place on the sampling line.

The air-relief valves will be opened to assure smooth flow of water from the bottle. Sample containers will be filled directly from the Niskin bottle using the tube on the bottle. Before the sample containers are filled, some water will be run through the tube to flush it. Also before sample containers are filled, all will be checked for damage, and any damaged containers will be discarded.

Assuming that adequate volume has been collected, sample containers will be filled in order by size, from largest to smallest. The field crew will collect extra volume for QA/QC and MS/MSD samples according to the schedule in Table 4. Note that, for ease of collection, QA/QC samples need not be collected at the same sampling station as MS/MSD samples. Additional water will be run into a 1-liter beaker for shipboard determination of temperature and salinity; this must be accomplished quickly before the water temperature has been affected by the ambient air temperature. An aliquot of the water will be captured for a reading of turbidity.

Sample containers will be labeled with 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 any), sample identification code (Section 6.2), analysis, and sampler's initials. Sample identification numbers and other pertinent information will be recorded on the Sample Transfer Log (Appendix C). Sample containers will be placed on ice in coolers.

Water for analysis of dissolved metals other than mercury will initially be collected from the Niskin bottle into unpreserved sample containers (1 liter plus 500 milliliter per sample). These samples will be filtered within 12 hours of the time they are collected. Two people ("clean hands" and "dirty hands") are required to filter samples, as follows:

1. Put on clean nitrile gloves.
2. Use specially designated clean titanium scissors to cut tubing to length (about 0.6 meters or 2 feet). Attach filter and place in clean zipper-seal bag. Prepare enough filters for at least one day of filtering.
3. Organize the filled, unpreserved dissolved metals sample bottles into pairs with unfilled, preserved (nitric acid) sample bottles of the same size that will receive the filtered samples. Mark the lids of preserved containers with an identifier: "S" for the surface sample or a "B" for the bottom sample. Copy the sample identification information from the unpreserved containers onto the preserved sample containers.
4. Record lot number of filters to be used on the Water Sample Collection Log (Appendix C).
5. One person will be clean hands and the other will be dirty hands; both sample handlers should put on clean nitrile gloves (if already wearing gloves for Steps 1 through 5, put on a new pair).

6. Dirty hands: open one pair of bottles and place inside the plastic filter hood, if available, without touching the insides of the lids or the water.
7. Dirty hands: open the zipper-seal filter bag without touching the filter or tubing. Clean hands: remove filter and tubing. Be sure that the ends of the tubing are not touched by dirty hands and that the ends of the tubing are not resting on an unclean surface.
8. Clean hands: run the silicone tubing through the hole in the hood, if available. Dirty hands: arrange the tubing into the peristaltic pump. Clean hands: place the filter over the empty preserved sample bottle and the other end of the tubing in the full unpreserved sample bottle without touching the bottles themselves.
9. Dirty Hands: turn on peristaltic pump. Clean hands: fill the preserved sample container labeled for dissolved metals analysis, taking care not to touch the outsides of the bottles.
10. *Dirty Hands:* cap and remove the filled preserved sample bottle. Remove and dispose of the now-empty unpreserved bottle.

All samples will remain in the custody of the field crew until turned over to a shipper in Homer or to Shaw personnel in Anchorage. Chain-of-custody procedures will be followed. Upon receiving the samples, Shaw personnel will prepare chain-of-custody forms and will package the samples for transport and ship them to the analytical laboratories.

4.9 Sampling of Marine Subtidal Sediments

Subtidal sediment samples will be collected for chemical and infaunal analyses at three locations (Table 5; Figure 2) in July. A decontaminated (Section 5.2) 0.1-square-meter, stainless steel, van Veen grab sampler, with the appropriate amount of weight for the fineness or coarseness of the sediment, will be lowered gently to the bottom. Upon contact with the bottom, the sampler will be gently but firmly retrieved. The grab sampler will be secured on a sample stand for processing, and the contents will be accessed through the screens on the top. After the sampler is secured on deck, the contents will be inspected carefully. The following acceptability criteria must be satisfied:

- The sampler should not be overfilled (i.e., the sediment surface is not pressed against the top of the sampler).
- Overlying water should be present, indicating minimal leakage.
- The overlying water should not be excessively turbid, indicating minimal sediment disturbance.
- The sediment surface should be relatively flat, indicating minimal sediment disturbance.
- The desired penetration depth should achieved (more than 8 centimeters for a 4-centimeter layer).

If the sampler contents do not meet all of the above criteria, the grab should be rejected and reasons for rejection should be noted on the Sediment Sample Collection Log (Appendix C).

When a satisfactory grab has been obtained, the sediment will be processed as described below to produce samples for chemical analysis. The overlying water will be siphoned off while producing minimal disturbance to the sediment surface (as described in PSEP, 1989), and the following observations will be noted on the collection log:

- Date and time of collection
- Name of person collecting the sample
- Environmental conditions (e.g., weather, wave height)
- Station location
- Water depth
- Gross characteristics of the surface sediment
  - Texture
  - Color
  - Biological structures (shells, tubes, macrophytes)
  - Presence of debris (wood chips, wood fibers, human artifacts)
  - Presence of oily sheen
  - Odor (hydrogen sulfide, oil, creosote)
- Gross characteristics of vertical profile
  - Changes in sediment characteristics
  - Presence and thickness of redox potential discontinuity layer
- Penetration (centimeters)
- Comments related to sample quality
  - Leakage
  - Disturbance

After the sediment has been characterized, unrepresentative material such as identifiable human debris is removed. Then, sediment representing the top 4-centimeter-thick layer will be removed from the grab with a decontaminated spoon without contacting the sides of the collection device. This material will provide a sample for chemical analysis. Additional volume for QA/QC samples and/or MS/MSD samples will be obtained as necessary to achieve the schedule in Table 4. Note that, for ease of collection, QA/QC samples need not be taken at the same sampling station as MS/MSD samples. Equipment rinsate blanks will be collected according to the schedule in Table 4.

If sufficient undisturbed sediment remains following extraction of sufficient material for all chemical analyses, samples for taxonomic analysis of infauna will be prepared from that remaining material. The sediment for infaunal taxonomic analysis will be obtained with a 15-centimeter-deep, 80-square-centimeter-area hand corer and will be taken from an area of the grab with an undisturbed surface area equal to the corer size (80 square centimeters) and at least 10 centimeters deep. If insufficient material remains for infauna samples following extraction of samples for chemical analyses, additional grabs will be taken at the station until five infaunal samples have been obtained. The sediment for taxonomic analysis will be washed through a 1-millimeter sieve, and the residue in the sieve (macroinfauna) will be collected and washed with a minimum amount of seawater into a suitably sized wide-mouth glass jar to which a half volume of 30 percent formalin will be added.

Subsurface samples of sediment for chemical analysis will be taken using the grab collector, by drop corer, or by diver-operated corer and will be composited to provide one subsurface sample from each of the three stations. Unneeded surface material will be discarded, and material from below 10 centimeters below ground surface will be removed from the grab by prepared spoon.

Sediment for either surface or subsurface samples for chemical analysis will be gently deposited into a prepared stainless steel bowl until a sufficient volume is obtained for the analyses listed in Table 6 (about 2 liters for primary samples; about 5 liters if QA/QC or MS/MSD samples need to be prepared). In all cases, care will be taken to ensure that the sample is not taken from sediments that have contacted non-decontaminated surfaces. If necessary to obtain sufficient sample material for a single sample set (primary plus, as applicable, QA/QC and/or MS/MSD), additional drops of the grab or corer will be made.

Material will be transferred from the bowl to the sample containers. The bowl and the spoons or other implements used to do the sample transfer will be prepared according to the decontamination procedure described in Section 5.2 and will be wrapped in aluminum foil (shiny side out) before sampling. Aside from the process of transferring the sediment from the sampler to the bowl and then to the sample containers, the sediment for chemical analysis will otherwise be processed whole with no sieving.

Sediment samples will be transferred to the sample containers in the following order:

1. Polynuclear aromatic hydrocarbons (PAH) and soluble hydrocarbons (SHC)
2. Acid volatile sulfides (AVS)/simultaneously extracted metals (SEM)
3. Mercury
4. Total metals
5. Total organic carbon
6. Grain size
7. Infauna (if sufficient material is available—if not, additional material will be obtained as described above).

At each of the three stations, five sediment samples for chemical analysis and five infauna samples will be taken. Each set of samples (one chemical and one infauna) will be obtained from a separate grab, for a minimum of five grabs per station (more than five grabs may be necessary to obtain sufficient material for both chemical and infauna samples). In addition, one subsurface sediment sample for chemical analysis will be taken from more than 10 centimeters below the sediment/water interface.

Sample containers will be inspected before being filled, and any damaged containers will be discarded. Sample containers will be labeled with 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 any), sample identification code (Section 6.2), analysis, and sampler's initials. Sample identification numbers and other pertinent information will be recorded on the Sample Transfer Log (Appendix C). Sample containers will be placed on ice in coolers.

All samples will remain in the custody of the field crew until turned over to a shipper in Homer or to Shaw personnel in Anchorage. Chain-of-custody procedures will be followed. Upon receiving the

samples, Shaw personnel will prepare chain-of-custody forms and will package the samples for transport and ship them to the analytical laboratories.

4.10 Subtidal Diver Surveys

During the July 2008 cruise, divers will conduct semi-quantitative surveys of demersal and epibenthic macrofauna at a minimum of four stations: MPS1A, MPS1B, MPS4, and White Gull Island (MWGI; Figure 2). These surveys will be conducted as near as possible to locations of similar surveys conducted in 2004. If conditions permit, additional qualitative surveys may be conducted at Black Reef and near MTR1.

In each survey the general nature of the bottom substrata and habitats will be documented with video coverage (visibility permitting). This information will be supplemented by a diving biologist who will compile detailed lists of benthic and demersal species and will characterize benthic assemblages in key habitat types identified. Poor visibility may limit the extent of data recovery possible from the diver surveys.

Subtidal information gathered will include relative abundance of algal, invertebrate, and fish species and descriptions of the seafloor. Information will be derived from direct diver notes and from post-dive review of the video survey record. Two types of diver surveys may be employed.

Quantitative surveys will employ a band-transect methodology to measure primarily kelp and selected macroinvertebrate densities. An underwater measuring tape will be deployed from the origin for 50 or 100 feet over the seafloor. The diving biologist will survey a 1-meter-wide area beside the tape, identifying and counting the kelps and large invertebrates within 10-foot-long plots.

For qualitative surveys, the divers will start at a point on the surface fixed by GPS and proceed along a predetermined azimuth using an underwater compass. The compass heading will be selected to permit examination the habitats and biota in specific areas. Observations will be made within specific depth bands or habitats.

5. Sampling Equipment

5.1 Field Instruments/Equipment

As applicable, makes and models of field instruments to be used for the 2008 marine studies are as follows:

- YSI Model 30 or Model 85 hand-held salinity and temperature meter and standard solutions.
- LaMotte Model 2020 turbidity meter and standard solutions.
- Standard, floating, 37-meter, fine-mesh beach seine.
- Standard, 10-meter, fine-mesh beach seine.
- 10-foot otter trawl (Research Nets, Inc.): four-seam, semi-balloon style, 1/2-inch #9 body, 1-inch #15 cod end, and 1/4-inch knotless nylon liner; headrope—10 feet x 3/8 inch braided

nylon with 2-foot extensions and three 2-1/2-inch x 3-inch floats; footrope—12 feet x 3/8 inch braided nylon with 2-foot extensions and seven 4-ounce rolling leads; treated with latex netcoat (green or black). Otter doors are 12x24-inch plywood with runners and chain bridles. "V" – Bridle is 3/8-inch braided nylon with two 20-foot legs.

- Gill net (6 feet by 100 feet; four 25-foot panels of variable mesh: 1-inch to 2.5-inch; floating).
- Trammel net (three adjacent panels, each 100 feet by 6 feet; two outer panels 20-inch mesh, central panel 2-inch mesh; sinking).
- 30-liter Niskin bottle for sampling marine water.
- 0.1-square meter stainless steel van Veen grab sampler for sampling subtidal marine sediments.
- Cores for sampling intertidal sediments and lower stratum of subtidal sediments.

5.2 Equipment Decontamination

All sample-collection equipment which comes into contact with a sample will be decontaminated by means of the following procedure prior to each sample collection. Sample collections which require multiple attempts or passes to acquire adequate sample volume are considered a single sample collection.

1. Rinse in potable fresh water.
2. Wash with a solution of Alconox, or the equivalent, in potable fresh water or deionized (DI) water.
3. Rinse three times with tap or bottled water.
4. For implements used in tissue sample preparation, rinse with dilute nitric acid.
5. Rinse twice in laboratory-supplied DI water.

5.3 Sample Containers

For all samples collected for chemical analysis, except biological tissues, containers will be provided by the laboratory selected to conduct the analysis. Tables 6 and 8 summarize the required containers, sample volumes, preservation methods, and maximum holding times for all analyses for sediment and water, respectively. Table 9 summarizes similar information for all analyses for tissue samples.

6. Sample Handling

6.1 Sample-handling Protocols

Sample-collection and -handling procedures will be followed to assure achievement of QA/QC objectives. Proper sample handling, including custody procedures, are required in the field, during transport, and in the laboratory. These procedures take into account the nature of the samples, the maximum holding times, and shipping options from the project site to the laboratories.

In the field, the Task Managers are responsible for ensuring that the sample-handling procedures are implemented correctly and will confirm that QA/QC protocols are being followed. All samples for

chemical analysis will be delivered to Shaw personnel in Anchorage for entry into the electronic chain-of-custody system. Shaw will be responsible for packaging and shipping samples to the analytical laboratories.

While in the field, corrective actions will be the responsibility of the Task Managers, in consultation with the Pentec and Pebble Partnership program managers. When a failure in the sampling system occurs, this management team will cooperate to investigate the failure and implement any necessary corrective actions.

6.2 Sample Labeling and Field Documentation

Each sample container will have a waterproof label large enough to contain the information needed to easily identify each sample. The information on each label will include the project name, date, time, preservative (if any), sample identification code, analysis, and sampler's initials. Similar information will be entered onto the Sample Transfer Log (Appendix C), which will be placed in the sample cooler.

The sample identification codes will be formatted to indicate sample date (month and year), location, matrix, and number. The sample identification code for samples for chemical analysis must not exceed 25 characters, including hyphens. An example of sample identification for a fish-tissue sample is as follows:

0708MPS1TF001-DV-a-MU

Where:

0708 is the date as MM/YY

MPS1 is the location code (up to six characters; Table 5 and Figures 1 and 2)

TF is the matrix code for fish tissue (see additional codes below)

001 is a sequential sample number

DV is the species code (tissue samples only) for Dolly Varden (see Table 10 for additional species codes)

a indicates an adult fish; **j** is the code for a juvenile fish (fish tissue only)

MU is the code for muscle tissue; the code for whole body samples is WB (fish tissue only)

The location codes (between the date and the matrix code) for water samples will have an "S" for surface or a "B" for bottom added to the end (e.g., MPS1S, MPS1B). Intertidal sediment samples will have a letter indicating the tidal range ("L" for low, "M" for medium, or "H" for high) added to the end of the location code (e.g., MBSA1M, MPS4L). The location codes for subtidal sediment samples will include a number from 1 through 5 at the end to indicate which of the five replicate samples collected at that sampling station it is (MPS11, MOPP15).

Additional matrix codes are as follows:

WO—marine water

MS—marine sediment

TP—plant tissue

TA—animal tissue

For field duplicates (QC samples), the sequential sample number is 201, and for triplicates (QA samples), 301. The sequential number 401 indicates equipment rinse blanks (for all equipment coming in contact with samples, except filter trains), which will be collected on a 5 percent frequency (minimum of one per sampling event). The sequential number 402 is used for filter rinses, which are collected at a rate of one per filter lot. The sequential number 403 is for equipment rinse blanks for equipment, including filters, coming in contact with the samples for dissolved metals analysis; 403 blanks are collected at a frequency of 5 percent (minimum of one per sampling event). The sequential number 501 indicates DI water blanks for total metals analysis and 502 is for DI water blanks for total organic carbon (TOC) analysis, both of which are collected at a rate of one per event. The suffix 601 is used for trip blanks (one per cooler).

For trip blanks, laboratory codes are used for the location code. Laboratory codes are TAPW for Test America, Portland, Oregon, and CASK for Columbia Analytical Services, Inc., Kelso, WA. An example identification code for a surface water trip blank for Columbia Analytical Services would be 0108CASKWS601 for the first trip blank in January 2008. If more than one trip blank is used in the same event for the same matrix, increase the sequential number to 602 and so on, as needed.

For samples not being submitted for chemical analysis, the following codes describing sample type may be inserted in the sample identification codes immediately after the location code to identify the origin of samples for off-site taxonomic analysis:

Qn = quadrat number (n = 1 to 10); QT = quadrat

HS = herring-spawn survey

IF = infaunal (invertebrates)

BS = beach seine

GN = gill net

TN = trammel net

TR = trawl

SC = stomach contents

Following are examples of sample identification codes for samples collected for taxonomic analysis:

0508MPS1LQ1QT001	May 2008 at station MPS1, low tidal range, quadrat 1, quadrat sample 001 for taxonomic analysis
0708MPS4IF001	July 2008 at station MPS4, subtidal infaunal sample
0708MPSE1MIF001	July 2008 at station MPSE1, mid tidal range, intertidal infaunal sample
0308MBSA1GN001	March 2008 at station MBSA1, gill net sample
0808MTR1ASC001	August 2008 at station MTR1A, stomach content sample

For each water or sediment sample, the field crew will prepare a sample-collection log (Appendix C) noting day and time as well as other conditions of collection. The field crew will assure that all samples are collected and labeled properly prior to moving to the next sampling station.

It is extremely important that the Specimen Log (Appendix C) is filled out for EVERY tissue sample collected. This log includes all the information that will be needed to properly report the animals collected/sacrificed under the 2008 ADF&G collection permit. This sheet must be filled out as completely as possible with all information that is applicable to the sample (even if the sample is not sent to the laboratory, e.g., due to damage.

Note that two sample logs (Appendix C)—the Taxonomic Sample Log and the Sample Transfer Log (in conjunction with the chain-of-custody form)—form the sample tracking system for this project. Each sample produced in the course of this year's field work must be accounted for on one of these forms. Samples for taxonomic analysis, including fish stomach contents and biota collected for more precise identification in the taxonomic laboratory, will be recorded on the Taxonomic Sample Log. Samples of water, sediment, or tissue for chemical analysis will be tracked on the Sample Transfer Log. In addition to providing information for administering the 2008 ADF&G collection permit, the Specimen Log will cross-reference fish samples for taxonomic analysis of stomach contents and fish tissues submitted for chemical analysis.

7. Quality Assurance/Quality Control Samples

Several types of QA/QC samples will be collected to assess possible sample contamination and data quality parameters such as precision and accuracy. Table 7 summarizes the QA/QC samples for the 2008 marine studies program. The types of QA/QC samples are described below:

- **QC Samples**: split samples of material collected in the same manner and at the same time and place as primary samples and analyzed in the primary laboratory to assess both sample matrix variability and variability in sampling and analytical practices.
- **QA Samples**: split samples of material collected in the same manner and at the same time and place as primary samples and QC samples and analyzed at a designated QA laboratory as an independent check of the primary laboratory.
- **Matrix Spike/Matrix Spike Duplicate Samples**: samples used to assess the effect, if any, of the sample matrix on the efficiency of the analytical method as it is employed by the laboratory. MS/MSD samples are collected in the same manner and at the same time and place as primary samples. Unlike other QA/QC samples, MS/MSD samples are treated as part of the primary sample set; the material is placed in separate sample containers, but the samples are not assigned separate sample identification codes. In the laboratory, a known amount of the parameter being analyzed is added to the sample, and the sample is analyzed by the same method as the primary samples.
- **Equipment Rinsate Blanks** (also known as decontamination blanks): used to assess the effectiveness of the decontamination process by detecting any residual chemical constituents remaining on the equipment. When decontamination occurs, field blanks will be prepared by rinsing decontaminated sampling equipment (e.g., grab sampler, dissection knife) with laboratory-purified water before the sample collection or dissection begins. Equipment blanks

also will be prepared for the filter train used in filtering water samples for dissolved metals analysis. The rinsate will be collected in the sample containers prescribed for the relevant analyses and analyzed along with the primary samples. .

- **Deionized Water Blanks**: used to assess potential contamination in laboratory-provided DI water used in equipment decontamination. The water is collected directly into sample containers without coming into contact with field equipment.
- **Trip Blanks**: used to monitor inadvertent contamination that might occur during sample collection or during transport of water samples for low-level mercury analysis. These blanks will typically be a sample of DI water preserved with hydrochloric acid that will be placed in each cooler with the sample bottles prior to their shipment into the field.

All QA/QC samples will be labeled as noted in Section 6.2 and will be handled, packaged, and shipped following the same procedures used for primary samples.

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TABLES

TABLE 1
Primary and Quality Assurance Laboratories for Marine Studies

Media	Primary Laboratory	QA Laboratory
Marine Surface Water	Columbia Analytical Services, Inc., Kelso, WA	Test America, Inc., Tacoma, WA
Marine Sediment	Columbia Analytical Services, Inc., Kelso, WA Texas A&M GERG, College Station, TX [a]	Test America, Inc., Tacoma, WA
Marine Tissue	Columbia Analytical Services, Inc., Kelso, WA Texas A&M GERG, College Station, TX [a]	Test America, Inc., Tacoma, WA

Notes:

a. Analyses for lipid content, PAH, SHC.

GERG = Geochemical and Environmental Research Group.

TABLE 2
Marine Sampling Schedule for 2008

Area	Media (Sample Method)	Analysis	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov
Pelagic	Water (bottle)	Chemical			X		X		2		
Subtidal	Sediment (grab)	Chemical					X				
Subtidal	Sediment Infauna (grab)	Taxonomic					X				
Intertidal, soft bottom	Sediment (core)	Chemical					X				
Inter/subtidal	Tissues: Plant/Invert./ Fish (net, hook/line)	Chemical			X	X	X	X	X		
Intertidal, rocky	Sediment Infauna (core)	Taxonomic					X				
Intertidal, rocky	Epibiota (quadrat)	Taxonomic					X				
Intertidal, rocky	Herring spawn (observation)	Spawn deposition			X	2					
Subtidal, rocky/mixed	Macrofauna (dive transect)	Taxonomic					X				
Inter/subtidal, rock/bolder	Fish assemblages (gill/trammel net)	Taxonomic		X		X		X		X	
Inter/subtidal, soft bottom	Fish/invert. (seine/trawl)	Taxonomic	X	X	X	X	X	X	X	X	X
Inter/subtidal	Fish stomachs	Taxonomic			X	X	X	X	X		

TABLE 3
2008 Marine Studies Analytes and Analytical Methods

Analyte	Methods		
	Marine Water	**Marine Sediment**	**Tissue**
Ammonia as N	SM4500NH_3-G		
AVS/SEM		SW6010 or SW7470A and SW3050/6020	
Cyanide, total		SM4500CN-E	
Metals except mercury	E200.8 or SW6010B [a]	SW3050/E200.8 [b]	PSEP/E200.8 [c]
Low-level mercury	E1631		E1631
Mercury		SW7471	
Grain Size [d]		ASTM D422M	
Total Susp. Solids	E160.2		
Polynuclear Aromatic Hydrocarbons		GERG9733	GERG9733 [e]
Soluble Hydrocarbons		GERG0008	GERG0008 [e]
Lipid Content			GERG9727 [e]
Total Organic Carbon		ASTM D4129-82	

a. Metals = Al, Sb, As, Ba, Be, B, Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, Se, Ag, Tl, Sn, V, Zn. The term "metals" in this field sampling plan refers to analytes that are strictly classed as metals in environmental chemical reactions as well as elements referred to as metalloids (e.g., arsenic, antimony) that may act like metals or nonmetals in environmental chemical reactions.

b. Metals = Al, Sb, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, Ag, Sn, Zn.

c. Metals = Sb, As, Be, B, Cd, Cr, Cu, Pb, Mo, Ni, Se, Ag, Tl, Sn, Zn.

d. Grain size will be measured in φ- (phi-) series (Wentworth scale) with percent passing 32mm, 16mm, 8mm, 4mm, 2mm, 1mm, 500µm, 250µm, 125µm, and 62.5µm, equivalent to US sieve sizes: 1.25in, 0.625in, 0.313in, and sieve numbers 5, 10, 18, 35, 60, 120, and 230, respectively.

e. To be analyzed in bivalve tissue only.

AVS/SEM = acid volatile sulfides/simultaneously extracted metals

E = EPA (1983, 1991, and 2001)

SM = Standard Methods for the Examination of Water and Wastewater

SW = EPA (1993) 20th Edition. 1998.

TABLE 4
2008 Marine Studies Expected Sample Quantities

Medium	Sample Type	Analysis	May	Jun	Jul	Aug	Sep	Total
Water	Primary	All parameters	6		6		12	**24**
	QC/QA	All parameters	2		2		4	**8**
	MS/MSD	All parameters	2		2		2	**6**
	Equipment blank	Metals, total	1		1		1	**3**
	DI water blank	Metals, total	1		1		1	**3**
	Filtration equipment blank	Metals, dissolved	1		1		1	**3**
	Trip blank	Low-level Mercury	1		1		1	**3**
Subtotal			**14**		**14**		**22**	**50**
Sediment	Primary	All parameters			27			**27**
	QC/QA	All parameters, except no QA for organics			6			**6**
	MS/MSD	All parameters			4			**4**
	Equipment blank	Metals, total			2			**2**
	DI water blank	TOC			1			**1**
Subtotal					**40**			**40**
Algal Tissue	Primary	All parameters	2		4		2	**8**
	QC/QA	All parameters	2					**2**
	MS/MSD	All parameters	2					**2**
Bivalve Tissue	Primary	All parameters	4		7		4	**15**
	QC/QA	All parameters, except no QA for organics	2					**2**
	MS/MS	All parameters	2					**2**
Fish Tissue	Primary	All parameters	24	8	32		16	**80**
	QC/QA	All parameters	6		8		4	**18**
	MS/MSD	All parameters	4		4		2	**10**
	Equipment blank	Metals, total	2		2		1	**5**
Subtotal			**50**	**8**	**57**		**29**	**144**
TOTAL			**64**	**8**	**111**		**51**	**234**

Infauna and Fish Stomach Samples (Laboratory = Pentec—Edmonds, WA)

Task	Sample Type	May	Jun	Jul	Aug	Sep	Total
Infauna Species Identification/Quantification	Sediment, intertidal			40			**40**
	Sediment, subtidal			15			**15**
Stomach, Prey Species Identification	Fish stomachs, seining	10	10	10	10	10	**50**
	Fish stomachs, trawling	10	10	10	10	10	**50**

TABLE 5
Summary of Marine Studies Sampling Stations and Activities in Iniskin and Iliamna Bays

Station Name	Station ID	Water, Subtidal Sediment & Infauna	Dive Survey	Intertidal Sediment & Infauna	Intertidal Epibiota	Off-shore Trawls[1]	Beach Seine	Gill/ Trammel Net	Tissue Samples[2]
Beach Seine Site 1	MBS1						X		
Beach Seine Site A1	MBSA1			X	X		X	X	X
Beach Seine Site 3	MBS3						X		
Beach Seine Site 4 (Williamsport)	MBS4						X		
Port Site 1	MPS1	X			X		X		X
Port Site 1 Seine Site A	MPS1A		X		X		X	X	
Port Site 1 Seine Site B	MPS1B		X				X	X	
Port Site 1 Seine Site C	MPS1C						X		
Port Site 1 Trawl Site	MPS1T					X			
Port Site 2	MPS2			X	X				X
Port Site 2 Trawl Site	MPS2T					X			
Port Site 2 Trawl Site A	MPS2TA					X			
Port Site 2 Trawl Site B	MPS2TB					X			
Port Site 3	MPS3			X	X		X		X
Port Site 4	MPS4	X	X	X	X		X	X	X
Port Site Existing	MPSE						X		

Station Name	Station ID	Water, Subtidal Sediment & Infauna	Dive Survey	Intertidal Sediment & Infauna	Intertidal Epibiota	Off-shore Trawls[1]	Beach Seine	Gill/ Trammel Net	Tissue Samples[2]
Port Site Existing Seine Site 1	MPSE1			X			X		
Scott Island	MSI				X				
Blackie Beach	MBB			X			X		
Trawl Site 1	MTR1					X			
Trawl Site 2	MTR2					X			
Trawl Site 3	MTR3					X			
Trawl Site 4	MTR4					X			
Sugarloaf Flats	MSLF						X		
AC Point Lagoon	MACL						X		
White Gull Island	MWGI		X						
Black Reef	MBR							X	
Offshore Reference	MOPP1	X							

1. Note: Trawling will occur only in soft bottom areas without rocky substrates to prevent damage to gear; if unknown, the status of bottom type will first be determined by inspection during low tides or vessel instrumentation.
2. Note: Fish collection for chemical analysis of tissues will be determined by fish availability.

TABLE 6
Sample Container Schedule and Sampling Parameters for Marine Sediment

Container for Primary Lab (CAS/GERG)	Container for QA Lab (TA)	Analysis	Preservative	Holding Time	Required Temp.
4 oz glass	4 oz glass	Mercury	None	28 days	4±2°C
		Metals, total	None	6 months	4±2°C
		Cyanide, Total	None	28 days	4±2°C
		AVS/SEM	None	14 days	4±2°C
		TOC	None	180 days	4±2°C
1 liter in 1-gal zipper-seal bag	1 liter in 1-gal zipper-seal bag	Grain Size	None	not applicable	4±2°C
8 oz glass	none	PAH	None	14 days	4±2°C
		SHC	None	14 days	4±2°C

gal = gallon
oz = ounce

TABLE 7
Summary of Quality Assurance/Quality Control Samples

Type of Field QA/QC Sample	Analysis	Sampling Events	Frequency
QC sample	All parameters (201)	All	10 percent
QA sample	All parameters (301)	All	10 percent
MS/MSD	All parameters (as specified by lab)	All	10 percent each
Equipment blank	Total metals (401)	Marine water, sediment, fish (fillets)	5 percent
	Dissolved metals (402, 403)	Marine water	1 per filter lot (402), 5 percent (403)
Deionized water blank	Total metals (501)	Marine water, sediment, fish (fillets)	1 per sampling event
	Total organic carbon (502)	Marine sediment	1 per sampling event
Trip blank	Low-level mercury (601)	Marine water	1 per cooler

TABLE 8
Sample Container Schedule and Sampling Parameters for Marine Water

Container for Primary Lab (CAS)	**Container for QA Lab (TA)**	**Analysis**	**Preservative**	**Holding Time**	**Required Temp.**	**Comments**
1-liter HDPE + 500-mL HDPE	500-mL HDPE	Total metals (except Hg)	HNO_3	6 months	None	Unfiltered
1-liter HDPE + 500-mL HDPE 1 extra unpreserved 1-liter container + 1 extra unpreserved 500-mL container for collection	500-mL HDPE 1 extra unpreserved container for collection	Dissolved metals (except Hg)	HNO_3	6 months	None	Field Filtered
1-liter HDPE	1-liter HDPE	Total suspended solids	None	7 days	4°C	Unfiltered
500-mL fluoropoly	500-mL fluoropoly	Low-level mercury, total	HCl	90 days	None	Unfiltered
250-mL HDPE	250-mL HDPE	Ammonia as N (NH_3)	$H2_SO_4$	28 days	4°C	Unfiltered

HDPE = high density polyethylene

Hg = mercury

mL = milliliter

TABLE 9
Sample Amounts and Containers and Sampling Parameters for Marine Tissues

Tissue Type	Minimum Sample Amount & Container for Primary Lab (CAS/GERG)	Minimum Sample Amount & Container for QA Lab (TA)	Analysis	Preservative	Holding Time	Required Temp.
Algal Tissue	20 grams in zipper-seal bag	20 grams in zipper-seal bag (prepared by CAS)	Mercury	None	28 days	Freeze < -20˚C; Ship on blue ice; Samples must arrive at the lab within 48 hours of shipment.
			Total metals	None	6 months	
Bivalve Tissue	Whole organisms representing at least 100 grams of tissue, wrapped in aluminum foil	Whole organisms representing at least 20 grams of tissue, wrapped in aluminum foil (prepared by CAS)	Low-level mercury	None	28 days	
			Total metals	None	12 months	
		Not applicable	PAH/SHC	None	14 days	
			Lipid content	None	None	
Fish Tissue	100 grams in zipper-seal bag	100 grams in zipper-seal bag (prepared by CAS)	Low-level Mercury	None	28 days	
			Total metals	None	12 months	

TABLE 10
Species Codes for Marine Studies

Scientific Name	Common name	Species Code
Telemessus cheiragonus	Helmet crab	HC
Hyas lyratus	Lyre crab	PC
Neptunea lyrata	Whelk, Neptune's Lyre	RN
Clinocardium nuttallii	Nuttall's heart cockle	NC
Fusitriton oregonensis	Oregon Hairy Triton	HT
Mytilus trossulus	Blue mussel	MMmt
Macoma obliqua	Oblique macoma	MA
Modiolus modiolus	Northern horsemussel	MMmm
Mactromeris polynyma	Arctic surf clam	AS
Mya arenaria	Softshell clam	SO
Oncorhynchus tshawytscha	Chinook salmon	KS
O. keta	Chum salmon	CH
O. kisutch	Coho salmon	CS
O. nerka	Sockeye salmon	SS
O. gorbuscha	Pink salmon	PS
Salvelinus malma	Dolly Varden	DV
O. mykiss	Steelhead Trout	RT
Cottidae	Sculpin (unidentified)	SC
Leptocottus armatus	Pacific staghorn sculpin	SP
Hexagrammos sp.	Greenling (unidentified)	GX
Hexagrammos stelleri	Whitespotted Greenling	GW
	Flatfish (unidentified)	FX
Platichthys stellatus	Starry flounder	FS
Hippoglossus stenolepis	Pacific halibut	PH
Pleuronectes asper	Yellowfin sole	YS
Spirinchus thaleichthys	Longfin smelt	LS
Clupea pallasi	Herring	HE
Lumpenus sagitta	Snake prickleback	PR
Fucus distichus ssp. Evanescens	Rockweed	RW

FIGURES

1,750,000

2,100,000

MSLF

MTR4

Iniskin Bay

Williamsport

MBS4

MPSE

MPSE1

MBS3

MTR3

Iliamna Bay

MACL

MBSA1

MBSA1

AC Point

MPS3

Diamond Point

Port Site 3

Cottonwood Bay

MBS1

MTR1

MPS4

MPS4

MTR2

Port Site 4

White Gull Island

North Head

MPS2TB

Port Site 2

MPS2TA

MPS1C

MPS2T

MPS1B

Port Site 1

MPS1B

MPS1

MPS1T

MPS1A

MPS1A

Knoll Head

MBR

Black Reef

MBB

Blackie Beach

Scott Island

South Head

Cook Inlet

2,050,000



0 0.5 1 1.5 2 Miles

0 0.5 1 1.5 2 2.5 Kilometers

Scale 1:55,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

Legend

- Beach seine
- Trawl
- Gill/Trammel Net
- Possible Port Site
- Possible Road Corridor

THE pebble PARTNERSHIP

Figure 1
Marine Benthos and Nearshore Beach Seine, Trawl, and Gill/Trammel Net Locations
DRAFT

File: RDI_Pen_Seine_Trawl_Fig1_Pen-2008_11X17P_1of1_D04.mxd	Date: June 13, 2008
Version 4	Author: RDI - LS

THE pebble PARTNERSHIP

Figure 2
Marine Benthos and Nearshore Intertidal and Subtidal Sampling Locations
DRAFT

Williamsport
Iliamna Bay
Y Valley
Iniskin Bay
MPSE1
MBSA1
MBSA1
MBSA1
AC Point
Port Site 2
MPS2
MPS2
MPS2
Port Site 1
MPS1B
MBB
Port Site 3
MPS3
MPS3
MPS3
Diamond Point
MPS1
MPS1
MPS1A
Knoll Head
MPS1
MPS1A
Scott Island
Blackie Beach
MSI
Cottonwood Bay
MPS4
MPS4
MPS4
Port Site 4
MPS4
MPS4
North Head
Black Reef
White Gull Island
MWGI
MOPP1
South Head
Cook Inlet

Legend
- Intertidal Quadrat Sampling
- Intertidal Sediment and Infauna
- Intertidal Tissue Samples
- Water/Subtidal Sediment and Infauna
- Dive Transects
- Possible Port Site
- Possible Road Corridor



0 0.5 1 1.5 2 Miles

0 0.5 1 1.5 2 Kilometers

Scale 1:45,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_Sub_Intertidal_Fig2_11X17L_1of1_D07.mxd	Date: June 13, 2008
Version: 7	Author: RDI-LS

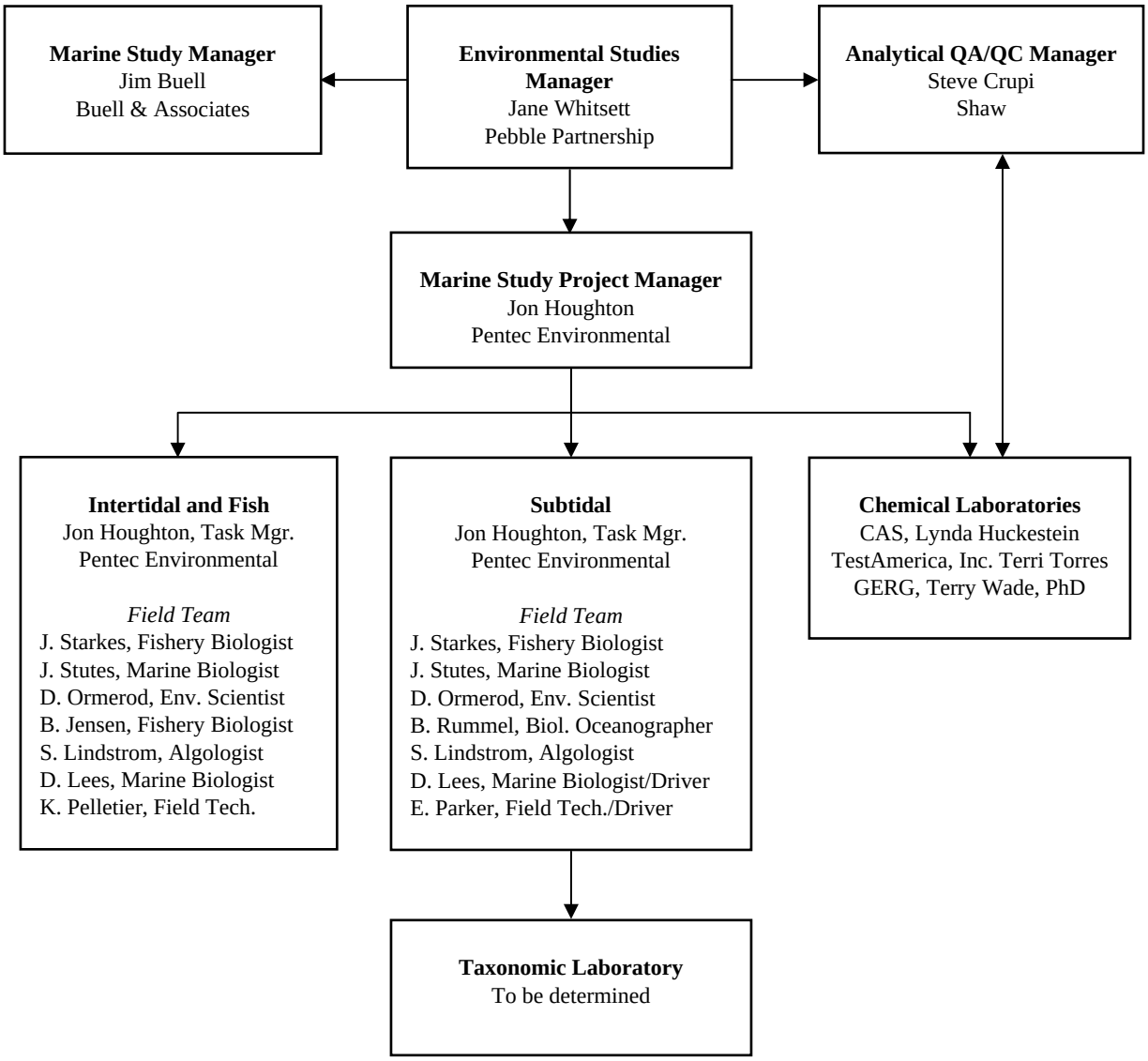


FIGURE 3. Pebble Project Marine Studies Organization Chart

APPENDICES

APPENDIX A

Coordinates of Marine Studies Station Locations in Iniskin and Iliamna Bays

Coordinates of Marine Studies Station Locations in Iniskin and Iliamna Bays

Station Name	Station ID	Sampling Station Coordinates (WGS '84)	
		Latitude (N)	Longitude (W)
Beach Seine Site 1	MBS1	59 deg 38' 36.4"	153 deg 34' 38.5"
Beach Seine Site A1	MBSA1	59 deg 39' 11.6"	153 deg 35' 54.5"
Beach Seine Site 3	MBS3	59 deg 39' 55.3"	153 deg 36' 23.2"
Beach Seine Site 3A	MBS3A	59 deg 40' 03.1"	153 deg 36' 23.7"
Beach Seine Site 4	MBS4	59 deg 40' 56.0"	153 deg 37' 33.5"
Port Site 1	MPS1	59 deg 38' 36.3"	153 deg 28' 44.2"
Port Site 1 Seine Site A	MPS1A	59 deg 38' 16.5"	153 deg 29' 55.1"
Port Site 1 Seine Site B	MPS1B	59 deg 38' 55.1"	153 deg 28' 25.5"
Port Site 1 Seine Site C	MPS1C	59 deg 39' 03.5"	153 deg 28' 10.9"
Port Site 1 Trawl Site	MPS1T	59 deg 38' 36.9"	153 deg 28' 23.9"
Port Site 2	MPS2	59 deg 39' 32.8"	153 deg 27' 49.3"
Port Site 2 Trawl Site	MPS2T	59 deg 39' 02.3"	153 deg 26' 56.5"
Port Site 2 Trawl Site A	MPS2TA	59 deg 39' 42.5"	153 deg 27' 05.5"
Port Site 2 Trawl Site B	MPS2TB	59 deg 40' 54.2"	153 deg 26' 23.4"
Port Site 3	MPS3	59 deg 38' 38.3"	153 deg 38' 15.7"
Port Site 4	MPS4	59 deg 37' 49.2"	153 deg 33' 48.6"
Port Site Existing (Williamsport)	MPSE	59 deg 40' 29.7"	153 deg 37' 24.4"
Port Site Existing Seine Site 1	MPSE1	59 deg 40' 00.9"	153 deg 37' 43.1"
Scott Island	MSI	59 deg 38' 06.2"	153 deg 26' 27.1"
Blackie Beach	MBB	59 deg 38' 53.7"	153 deg 25' 06.8"
Trawl Site 1	MTR1	59 deg 38' 16.7"	153 deg 36' 03.0"
Trawl Site 1A	MTR1A	59 deg 38' 10.2"	153 deg 35' 52.3"
Trawl Site 2	MTR2	59 deg 37' 28.6"	153 deg 34' 15.0"
Trawl Site 3	MTR3	59 deg 38' 53.4"	153 deg 36' 48.5"
Trawl Site 4	MTR4	59 deg 43' 25.5"	153 deg 25' 51.0"
Trawl Site 5	MTR5	59 deg 44' 35.7"	153 deg 25' 54.0"
Sugarloaf Flats	MSLF	59 deg 45' 08.1"	153 deg 26' 23.0"
AC Point Lagoon	MACL	59 deg 39' 14.2"	153 deg 35' 47.0"
White Gull Island	MWGI	59 deg 36' 57.6"	153 deg 34' 23.9"
Black Reef	MBR	59 deg 37' 39.0"	153 deg 30' 32.0"
Offshore Reference	MOPP1	59 deg 36' 26.3"	153 deg 29' 35.9"

APPENDIX B

ADF&G Fish Collection Permit and Sampling Plan

COMMISSIONERS:

CLIFF ATLEO
PORT ALBERNI, B.C.
JAMES BALSIGER
JUNEAU, AK
RALPH G. HOARD
SEATTLE, WA
PHILLIP LESTENKOF
ST. PAUL, AK
LAURA RICHARDS
NANAIMO, B.C.
GARY ROBINSON
VANCOUVER, B.C.

INTERNATIONAL PACIFIC HALIBUT COMMISSION

ESTABLISHED BY A CONVENTION BETWEEN CANADA

AND THE UNITED STATES OF AMERICA

DIRECTOR
BRUCE M. LEAMAN

P.O. BOX 95009
SEATTLE, WA 98145-2009

TELEPHONE
(206) 634-1838

FAX:
(206) 632-2983

March 12, 2008

To Whom It May Concern:

Pentec Environmental - Hart Crowser, Inc. is authorized to capture up to 16 adult halibut (*Hippoglossus stenolepis*) for baseline tissue chemistry and gut content analysis, during the 2008 calendar year. All adult halibut will be captured by hook and line by field personnel with valid Alaska recreational fishing licenses. Daily bag limits will be adhered to. Eight will be captured in Iniskin Bay and eight will be captured in Iliamna Bay. Pentec Environmental - Hart Crowser, Inc. is also authorized to capture, measure, and immediately release 50 juvenile (<200 mm) halibut. The juvenile halibut may be captured by otter trawl or hook and line gear.

Halibut obtained under this permit may not be retained for purposes other than scientific research and may not be sold. Halibut captured in excess of the limits specified in this permit must be returned to the sea with a minimum of delay and injury.

Bruce M. Leaman
Executive Director

STATE OF ALASKA

SARAH PALIN GOVERNOR

DEPARTMENT OF FISH AND GAME

Division of Commercial Fisheries

P.O. BOX 115526
JUNEAU, AK 99811-5526
PHONE: (907) 465-4724
FAX: (907) 465-4168
Sara.larsen@alaska.gov

March 7, 2008

Jim Starkes
Pentec Environmental
120 Third Ave S., Suite 110
Edmonds, WA 98020-8411

Dear Mr. Starkes,

Enclosed you will find your 2008 Fish Resource Permit. Please read over the permit carefully. Make sure that your name, organization that you are representing, address, effective dates, purpose, species, numbers, locations, methods of capture, and disposition are all correct. An annual report is due no later than thirty days after the expiration of the permit. This report is due even if the permitted activities were not undertaken. If there are any further publications from this research, those are required as well when the information is published.

Issuance of this Fish Resource Permit does not constitute endorsement of study plans in terms of project review or permitting, this task belongs with the Large Mine Permitting Team.

Prior to engaging in your first collection activity, Bert Lewis with the Division of Commercial Fisheries in Cordova (907) 424-3212 must be contacted. Mr. Lewis has the authority to specify methods for collecting, as well as limiting the collection of any species and the number of specimens collected by time and area. The activities will conform to the operational plan that was submitted with your application. Any deviations will require a permit amendment. If changes are deemed necessary, Sara Larsen must be contacted at (907)465-4724 or sara.larsen@alaska.gov to request an amendment.

The following are the stipulations that must be followed prior to, during, and after collections have taken place.

1. Permits will indicate the number of specimens that may be taken by species and life stage. Sampling or collecting activities must stop when the maximum allowable number of specimens is obtained. All live fish, shellfish, and aquatic plants collected in excess of the number specified on the permit must be release immediately and unharmed at the capture location.
2. All bycatch incidentally captured during sampling will be identified, recorded, and released unharmed. Bycatch data shall be included in the collection report.
3. All unattended collecting gear must be labeled with the permittee's name, telephone number, and permit number.
4. A valid sport fishing license must be in the possession of each person collecting fish with a hook and line.
5. Halibut may NOT be collected or retained under the authority of this permit. Please contact the International Pacific Halibut Commission at (206)634-1838, P.O. Box 95009, Seattle, WA 98145-2009 to obtain permission for halibut collection.
6. No person may transport, possess, export from the state, or release into the waters of the state, any live fish unless the person holds a valid fish transport permit (FTP), and the person is in compliance with all conditions of the permit and the provisions of 5 AAC 41.005. A fish transport permit may be issued by the Commissioner. A fish transport permit must be obtained prior to any exportation of non-preserved specimens. Please contact Sara Larsen at (907) 465-4724 for more information.

7. Collected fish, shellfish, or aquatic plant specimens may not be sold, bartered, or used as food, and may be used only for the purposes specified in the permit.
8. A copy of the permit, including amendments, must be made available at all field location sites and project sites for inspection upon request by a representative of the department or law enforcement officer.
9. Issuance of this permit does not absolve the permittee from compliance in full with any and all other applicable federal, state, or local laws, regulations, or ordinances.
10. A report of research activities referencing this fish resource permit, must be submitted to the Alaska Department of Fish and Game, Division of Commercial Fisheries, PO Box 115526, Juneau, AK 99811-5526, attention Sara Larsen (465-4724; sara.larsen@alaska.gov), within 30 days after the expiration of the permit. This report must present the research conducted in the format of a scientific paper including the following: introduction (objective of the study plan and hypothesis), methods, and results. The report is ad-hoc and intended to show that the specimens were used in a scientific method, but not as a peer-reviewed scientific paper. A report is required whether or not research activities were undertaken. A report must also be sent to the Biologist(s) listed under number 1 of the Stipulations section.
11. A report of collecting activities referencing this fish resource permit, must be submitted to the Alaska Department of Fish and Game, Division of Commercial Fisheries, PO Box 115526, Juneau, AK 99811-5526, attention Sara Larsen (465-4724, sara.larsen@alaska.gov), within 30 days after the expiration of this permit. This report must summarize the number of specimens captured by location, including latitude and longitude, date, and species, and the fate of those specimens. A report is required whether or not collecting activities were undertaken. A report must also be sent to the Biologist(s) listed under number 1 of the Stipulations section.
12. Permit validation requires the permittee's signature agreeing to abide by permit conditions before beginning collecting activities.
13. Changes to the permit can only be made by Sara Larsen and must be requested prior to engaging in the activitities. If you need to make changes to the permit, please contact Sara at sara.larsen@alaska.gov or (907)465-4724 to request an amendment to your permit. A requested change in permit conditions will not be valid until the amendment has been received by the permit holder.

Failure to comply with the conditions of this permit will result in the loss of future permitting privileges and may result in prosecution.

If you have any questions, please do not hesitate to call me at (907)465-4724, or send me an email at sara.larsen@alaska.gov.

Sara Larsen
Permit Coordinator

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME

P.O. Box 115526
JUNEAU, ALASKA 99811-5526

Permit No. CF-08-036

Expires 11/30/2008

FISH RESOURCE PERMIT
(For Scientific Purposes)

This permit authorizes **Jim Starkes** *(whose signature is required on page 3 for permit validation)*
Person
of **Pentec Environmental** at **120 Third Ave S., Suite 110, Edmonds, WA 98020-8411**
agency or organization address

to conduct the following activities from **February 11, 2008** to **November 30, 2008** in accordance with AS 16.05.930 and AS 16.05.340(b).

Purpose: To characterize marine fish and habitats within two bays to provide baseline information to a level adequate to evaluate potential impacts of a proposed port facility for compliance with NEPA and to support other permitting activities.

Method of Capture: Beach seine, 10-ft otter trawl, 100-ft experimental floating gill net, 100-ft sinking trammel net, hook and line (see **Stipulations** section).

Location: Iniskin and Iliamna Bays, lower west Cook Inlet.

Species Collected and Final Disposition: various species and numbers listed on page 4 (see **Stipulations** section).

REPORT DUE December 30, 2008. The report shall include species, numbers, dates, and locations of collection and disposition, and if applicable, sex, age, and breeding condition, and lengths and weights of fish. The report shall also include other information as may be required under the stipulations section.

GENERAL CONDITIONS, EXCEPTIONS AND RESTRICTIONS

1. This permit must be carried by person(s) specified during approved activities who shall show it on request to persons authorized to enforce Alaska's fish and game laws. This permit is nontransferable and will be revoked or renewal denied by the Commissioner of Fish and Game if the permittee violates any of its conditions, exceptions or restrictions. No redelegation of authority may be allowed under this permit unless specifically noted.
2. No specimens taken under authority hereof may be sold, bartered, or consumed. All specimens must be deposited in a public museum or a public scientific or educational institution unless otherwise stated herein. Subpermittees shall not retain possession of live animals or other specimens.
3. The permittee shall keep records of all activities conducted under authority of this permit, available for inspection at all reasonable hours upon request of any authorized state enforcement officer.
4. Permits will not be renewed until detailed reports, as specified above, have been received by the department.
5. UNLESS SPECIFICALLY STATED HEREIN, THIS PERMIT DOES NOT AUTHORIZE the exportation of specimens or the taking of specimens in areas otherwise closed to hunting and fishing; without appropriate licenses required by state regulations; during closed seasons; or in any manner, by any means, at any time not permitted by those regulations.

Craig Harrington
Division of Commercial Fisheries

Gaven Bruce
Deputy Director
Division of Commercial Fisheries
Alaska Department of Fish and Game

Authorized Personnel: The following personnel may participate in collecting activities under terms of this permit: Jon Houghton, Jim Starkes, Derek Omerod, Jason Stutes, Celina Abercrombie, Dennis Lees, Sandra Lindstrom, Eric Parker, Kathryn Peltier, Bruce Rummel.

Stipulations:

1) **Bert Lewis** (Division of Commercial Fisheries, Cordova, 907-424-3212) must be contacted **prior** to you engaging in collecting activities. Division of Commercial Fisheries Management Biologists have the authority to specify methods for collecting, as well as limiting the collections of any species, and the number of specimens collected by time and area.

2) Permits will indicate the number of specimens that may be taken, by species and life stage. Sampling or collecting activities must stop when the maximum allowable number of specimens is obtained. All live fish, shellfish, and aquatic plants collected in excess of the number specified on the permit must be released immediately and unharmed at the capture location.

3) All bycatch incidentally captured during sampling will be identified, recorded and released unharmed. Bycatch data shall be included in the collection report.

4) All unattended collecting gear must be labeled with the permittee's name, telephone number, and permit number.

5) A valid sport fishing license must be in the possession of each person collecting fish with a hook and line.

6) **Halibut may NOT be collected or retained under the authority of this permit. Please contact the International Pacific Halibut Commission at (206)634-1838, P.O. Box 95009, Seattle, WA 98145-2009 to obtain permission for halibut collection.**

7) No person may transport, posses, export from the state, or release into the waters of the state, any live fish unless the person holds a valid fish transport permit (FTP), and the person is in compliance with all conditions of the permit and the provisions of 5 AAC 41.005. A fish transport permit may be issued by the Commissioner. A fish transport permit must be obtained prior to any exportation of non-preserved specimens. Please contact Sara Larsen at (907) 465-4724 for more information.

8) Collected fish, shellfish, or aquatic plant specimens may not be sold, bartered, or used as food, and may be used only for the purposes specified in the permit.

9) *A copy of this permit, including any amendments, must be made available at all field collection sites and project sites for inspection upon request by a representative of the department or a law enforcement officer.*

10) Issuance of this permit does not absolve the permittee from compliance in full with any and all other applicable federal, state, or local laws regulations, or ordinances.

11) **A report of research activities, referencing this fish resource permit, must be submitted to the Alaska Department of Fish and Game, Division of Commercial Fisheries, PO Box 115526, Juneau, AK 99811-5526, attention Sara Larsen (465-4724; sara.larsen@alaska.gov), within 30 days after the expiration of this permit.** This report must present the research conducted in the format of a scientific paper including the following: introduction (objective of the study plan and hypothesis), methods, and results. The report is ad-hoc and intended to show that the specimens were used in a scientific method, but is not intended to be a full peer-reviewed scientific paper. A report is required whether or not research activities were undertaken. A report must also be sent to the Biologist(s) listed under number 1 in this Stipulations section.

12) **A report of collecting activities, referencing this fish resource permit, must be submitted to the Alaska Department of Fish and Game, Division of Commercial Fisheries, PO Box 115526, Juneau, AK 99811-5526, attention Sara Larsen (465-4724; sara.larsen@alaska.gov), within 30 days after the expiration of this permit.** This report must summarize the number of specimens captured by location, including latitude and longitude, date, and species, and the fate of those specimens. A report is required whether or not collecting activities were undertaken. A report must also be sent to the Biologist(s) listed under number 1 in this Stipulations section.

13) PERMIT VALIDATION requires permittee's signature agreeing to abide by permit conditions before beginning collecting activities:

_____

Signature of Permittee

14) Failure to comply with the conditions of this permit will result in the loss of future permitting privileges.

cc: Bert Lewis
Lee Hammarstrom
CF Division Files
Alaska Wildlife Troopers-Homer

The following species listed will be collected, identified, measured, and release.

Common Name	Life stage	Number
Chum Salmon	Juvenile	2,000
Pink Salmon	Juvenile	3,000
Sockeye Salmon	Juvenile	300
Chinook Salmon	Juvenile	20
Coho Salmon	Juvenile	100
Dolly Varden	Juvenile/Adult	500
Pacific Herring	Juvenile	10,000
Longfin Smelt	Adult	200
Starry Flounder	Juvenile/Adult	300
Yellowfin Sole	Juvenile/Adult	300
Pacific Staghorn Sculpin	Juvenile/Adult	300
Whitespotted Greenling	Juvenile/Adult	100
Snake Prickleback	Juvenile/Adult	300
Pacific Halibut (**IPHC permit required**)	Juvenile	50

The following species listed will be collected and sacrificed for stomach content analysis.

Common Name	Life stage	Number
Chum Salmon	Juvenile	10
Pink Salmon	Juvenile	10
Dolly Varden	Juvenile/Adult	10
Pacific Herring		10
Longfin Smelt	Adult	10
Starry Flounder	Juvenile/Adult	10
Yellowfin Sole	Juvenile/Adult	10
Pacific Staghorn Sculpin	Juvenile/Adult	10
Whitespotted Greenling	Juvenile/Adult	10
Snake Prickleback	Adult	10

The following species will be collected and sacrificed for tissue chemistry.

Common Name	Life stage	Number
Chum Salmon	Adult	8
Dolly Varden	Juvenile/Adult	16
Yellowfin Sole	Adult	16
Blue Mussels	Adult	20
Clams	Adult	10
Rockweed		10

16 Pacific Halibut adults will be colleted and sacrificed for stomach content analysis and tissue chemistry. **Requires an IPHC permit.**

APPENDIX C

Field Data Forms and Logs

INTERTIDAL FIELD FORM

ROCKY / BOULDER-COBBLE

ID No. | Boat code | YYMMDD | Serial No.

Date _____ Location _____ Site: Rock / Boulder-Cobble Elevation LOW / MID / HIGH (circle one)

Time _____ Observer(s) _____ Recorder _____ Time water hits marker _____

Salinity _____ Water temp. _____

Taxon	Observer										
	Quad No.	1	2	3	4	5	6	7	8	9	10
	Ft. marker										
SUBSTRATE (%)	Code No..										
Bedrock	711										
Boulder/Cobble	703										
Gravel/Sand	706										
Mud	707										
Water	715										
Oil Scale (prim.)	709										
Oil Cover (prim.)	710										
Oil Scale (sec.)	722										
Oil Cover (sec.)	723										
Subsurface oil	713										
PLANTS (%)											
Acrosiphonia sp.	11										
Articulated coralline algae	18										
Blue-green algae, crust	22										
Blue-green spheroids	21										
Cladophora sericea	178										
Cryptosiphonia woodii	36										
Elaschista fucicola	43										
Encrusting brown algae	44										
Encrusting green algae	46										
Encrusting red algae	48										
Encrusting coralline algae	45										
Endocladia muricata	49										
Enteromorpha intestinalis	51										
Enteromorpha linza	52										
Enteromorpha prolifera	53										
Filamentous brown algae	56										
Filamentous green algae	57										
Filamentous red algae	58										
Flagelliform brown algae	59										
Fucus gardneri	63										
Fucus gardneri, germlings	64										
Gloiopeltis furcata	65										
Halosaccion glandiforme	68										
Hildenbrandia rubra	70										
Iridaea heterocarpa	71										
Leathesia difformis	77										
Mastocarpus papillatus	80										
Mazzaella sp.	73										
Melanosiphon intestinalis	82										
Monostroma grevillei	165										
Neorhodomela larix	89										
Neorhodomela oregona	114										
Odonthalia floccosa	91										
Odonthalia kamschatica?	90										
Odonthalia sp.	92										
Palmaria callophylloides	94										
Palmaria hecatensis	95										
Palmaria mollis	144										
Petrocelis spp.	97										
Pilayella littoralis	101										
Polysiphonia spp.	102										
Porphyra	103										
Pterosiphonia bipinnata	105										
Ptilota filicina	107										
Ralfsia spp.	111										
Rhodochorton purpureum	112										
Soranthera ulvoidea	120										
Ulothrix spp.	169										
Ulva/Ulvaria spp.	127										
Verrucaria sp.	128										
DEAD PLANTS (%)											
Articulated coralline (dead)	501										
Encrusting coralline (dead)	502										
Fucus gardneri (dead)	503										

Comments:

ROCKY / BOULDER-COBBLE

ID No. | Boat code | YYMMDD | Serial No.

Date _____ Location_____ Site: Rock / Boulder-Cobble Elevation LOW / MID / HIGH (circle one)

Time _____ Observer(s)_____ Recorder _____ Time water hits marker _____

Taxon	Observer / Quad No. / Ft. marker / Code no.	1	2	3	4	5	6	7	8	9	10
ANIMALS											
Anthopleura artemisia	303										
Buccinum baeri	309										
Cancer oregonensis	311										
Cryptobranchia concentrica	320										
Dermasterias imbricata	323										
Evasterias troschelii	330										
Gammaridea	331										
Gnorimosphaeroma oreg.	335										
Hiatella arctica	340										
Lacuna spp.	344										
Leptasterias hexactis	347										
Ligia	452										
Littorina scutulata	349										
Littorina sitkana	350										
Littorina scut., juv.	451										
Littorina sitk., juv.	450										
Lottiidae	356										
Lottiidae, juv.	357										
Lottia digitalis	353										
Lottia pelta	354										
Lottia strigatella	355										
Margarites marginatus	362										
Margarites pupillus (spiral)	363										
Modiolus modiolus	368										
Musculus spp.	371										
Nemertea	379										
Nucella lamellosa	384										
Nucella lima	385										
Onchidella borealis	388										
Pagurus granosimanus	390										
Pagurus hirsutiusculus	391										
Pagurus spp.	392										
Paranemertes peregrina	393										
Pentidotea wosnesenskii	396										
Pholis laeta	399										
Pholis ornata	400										
Pisaster ochraceus	401										
Searlesia dira	413										
Serpula vermicularis	414										
Siphonaria thersites	416										
Tectura persona	422										
Tectura scutum	423										
Tonicella lineata	428										
ANIMAL AREA COVER (%)											
Balanus crenatus (%)	201										
Balanus glandula (%)	202										
Balanus rostratus (%)	203										
Balanus/Semibalanus spp (%)	206										
Balanus/Semibalanus, set (%)	228										
Chthamalus dalli (%)	208										
Chthamalus dalli, set (%)	207										
Encrusting bryozoan (%)	209										
Littorina spp., eggs (%)	232										
Mytilus sp. (%)	213										
Mytilus sp., spat (%)	214										
Porifera, color? (%)											
Rhynchozoon bispinosum (%)	217										
Semibalanus balanoides (%)	219										
Semibalanus balanoides, set (%)	218										
Semibalanus cariosus (%)	221										
Semibalanus cariosus, set (%)	220										
Spirobidae, unid. (%)	222										
DEAD ANIMALS											
Balanus crenatus, dead (%)	600										
Balanus glandula, dead (%)	601										
Balanus/Semibal., dead (%)	602										
Chthamalus dalli, dead (%)	603										
Mytilus sp., dead (#)	606										
Nucella lamellosa, dead (#)	607										
Semibal. balanoides, dead (%)	609										
Semibal. cariosus, dead (%)	612										
Spirobidae, dead (%)	613										

Pentec Environmental/Hart Crowser, Inc.
Pebble Marine Studies
Fish Catch Record

Job Number: _____ Page_____ of_____

Project Name: _____ Date: _____ Recorded by: _____

Station	Sample Type	Time		Rep. #	Species	Length (mm)	Count (if no length taken)	Temp.	Salinity	Turbidity (ntu)	Weather	Tide
		Set	Retrieve									

Fish Catch Codes

Sample Type

0 = 120 ft Beach Seine
1 = Fyke Net
2 = Trawl
3 = Hook and Line
4 = 30 ft Beach Seine
5 = Gill Net
6 = Trammel Net

Weather

S = Sunny
P = Partly Cloudy
C = Overcast
R = Rain
F = Fog

Tide

E = Ebb
F = Flood
L = Low Slack
H = High Slack

Fish	Code
Adult Chinook	1
Juvenile Chinook	2
Adult chum	3
Juvenile chum	4
Adult coho	5
Juvenile coho	6
Adult sockeye	7
Juvenile sockeye	8
Adult pink	9
Juvenile pink	10
Dolly Varden	11
Steelhead trout	12
Cutthroat trout	13
Bering cisco	14
Smelt unid	15
Longfin smelt	16
Surf smelt	17
Pacific herring	18
Threespine stickleback	19
Ninespine stickleback	20
Sculpin unid	21
Pacific staghorn sculpin	22
Buffalo sculpin	23
Calico sculpin	24
Silverspotted sculpin	25
Great sculpin	26
Red Irish lord	27
Perch unid	28
Eulachon (hooligan)	29
Saffron cod	30
Greenling unid	31
Whitespotted greenling	32
Kelp greenling	33
Poacher unid	34
Tubenose poacher	35
Prickleback unid	36
Snake prickleback	37
Pacific sand lance	38
Crescent gunnel	39
gunnel unid	40
Liparid unid	41
Variagated snailfish	42
Pumpkinseed	43
Flatfish unid	44
Starry flounder	45
Arrowtooth flounder	46
Pacific halibut	47
Sand sole	48
Rock sole	49
Yellowfin sole	50
Alaska plaice	51
Longnose skate	52
Spiny dogfish	53
Pacific cod	54
Tomcod	55
Walleye pollock	56
Sturgeon poacher	57
Pacific sandfish	58
Dover sole	59

Macroinvertebrates	Code
Balanus sp.	157
Cancer magister	162
Cancer sp.	164
Chionecetes bairdi	169
Elassochirus tenuimanus	183
Erimacrus isenbecki	184
Eualus fabricii	185
Heptacarpus brevirostris	192
Heptacarpus camtschaticus	193
Hyas lyratus	195
Lebbeus groenlandicus	200
Mysidacea	203
Neomysis czerniavsky	204
Neomysis rayi	206
Neomysis sp.	207
Oregonia gracilis	288
Pagarus berngarus	210
Paguridae	209
Pagurus aleuticus	211
Pagurus ochotensis	215
Pandalus sp.	219
Pugettia gracillis	225
Spirontocaris ochotensis	227
Spirontocaris prionata	228

Pentec Environmental/Hart Crowser, Inc.
Pebble Marine Studies
Specimen Log

Project No. _____ Page ___ of ____

Project Name _____ Date _____ Recorded by: _____

Species	Species Code	Time	Sample Type	Station	Length (mm)	Tissue Type	Disposition	Comments/Sample ID

Pentec Environmental/Hart Crowser, Inc.
Pebble Marine Studies
Sediment Sample Collection Log

Station _____ **Collection Log Date** _____

Crew:	**Weather:**
Water depth (m):	**Marine conditions:**

GRAB ACCEPTABILITY CRITERIA: (for subtidal sediment)	1. Grab is not overfilled 2. Overlying water present	3. Surface is flat 4. Water is not excessively turbid

Attempt Number	Time	Latitude	Longitude	Grab Accepted Y/N	Pene-tration (cm)	Comments

Sediment Characteristics (circle where appropriate)				**Comments**
Surface Layer (oxidized layer for subtidal sediment)				
Texture	Fine/ Smooth	Coarse/ Rough		
Color				
Biological Structures	Shells	Tubes	Macrophytes	
Debris	Wood Chips	Wood Fibers	Human Artifacts	
Sheen	Y	N		
Odor	H_2S	Oil	Creosote	
Thickness of oxidized layer	cm			
Lower Layer (below redox potential discontinuity layer for subtidal sediment)				
Texture	Fine/ Smooth	Coarse/ Rough		
Color				
Biological Structures	Shells	Tubes	Macrophytes	
Debris	Wood Chips	Wood Fibers	Human Artifacts	
Sheen	Y	N		
Odor	H_2S	Oil	Creosote	
SAMPLE NUMBER:				
Notes:				

Pentec Environmental/Hart Crowser, Inc.

Pebble Marine Studies

Taxonomic Sample Log

Station	Collection Date	Collection Time	Sample Identification (MMYYlocationTIDALRANGEtypeSERIAL)	Type of Sample	Number of Containers	Date Analysis Completed	Initials	Date Entered in Database	Initials	Comments

Notes:

Pentec Environmental/Hart Crowser, Inc.
Pebble Marine Studies
Sample Transfer Log

TB (if applicable)	Collection Date	Time	Sample Identification (MMYYlocation)	Matrix	QA/QC	Species (if applicable)	# container	MS / MSD?	Relinquished By	Date	Time	Received By	Date	Time

Notes:

Pentec Environmental/Hart Crowser, Inc.
Pebble Marine Studies
Water Sample Collection Log

Station_____ **Date** _____

Crew:	**Weather:**
Water depth (m):	**Marine conditions:**

	Salinity (o/oo)	**Temperature (C)**	**Turbidity (NTU)**
Surface			
Bottom			

Cast Number	**Time**	**Latitude**	**Longitude**	**Messenger Tripped Y/N**	**Comments**
Surface					
Bottom					

Adequate Volume Obtained	Y	N

Sample Number:

Notes:

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Metal Leaching and Acid Rock Drainage Characterization

Pebble Project

Metal Leaching/Acid Rock Drainage Characterization

DRAFT Sampling and Analysis Plan

Prepared for

Northern Dynasty Mines Inc.
3201 C Street, Suite 604
Anchorage, AK 99503

Prepared by

SRK Consulting
Engineers and Scientists

June 2005

Pebble Project

Metal Leaching/Acid Rock Drainage Characterization

DRAFT Sampling and Analysis Plan

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SRK Project Number 1CN007.000

June 2005

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Appendix D List of Rock Samples Selected for Static Testing (2004 Drilling)

Acronyms

AP	acid potential
ABA	acid-base accounting
ASTM	American Society for Testing and Materials
CEMI	Canadian Environmental and Metallurgical Inc.
cm	centimetres
CUEQ%	copper equivalent grade
kg	kilogram(s)
L	liter(s)
mg	milligram(s)
ML/ARD	metal leaching/acid rock drainage
µg	microgram(s)
µmhos	micromhos
NDM	Northern Dynasty Mines Inc.
NNP	net neutralization potential
NP	neutralization potential
SRK	SRK Consulting Inc.
SAP	sampling and analysis plan

1 Introduction

Geological materials exposed, excavated, and processed during mining of the Pebble Project will have varying potentials for leaching of contained metals, as well as for production of acidic drainage. SRK Consulting (SRK) has been retained by Northern Dynasty Mines Inc. (NDM) to develop and implement a laboratory testing program for metal leaching and acid rock drainage (ML/ARD) to provide input into prediction of water chemistry for the various mine components.

ML/ARD test programs are by nature iterative. Iterations occur as a result of results obtained and changes in the overall project concept. This document describes sample selection and test methods as completed to March 2005.

2 Program Design

2.1 Geological Background

The calc-alkalic porphyry copper-gold-molybdenum deposit occurs in deformed turbiditic sedimentary rocks (siltsone, argillite, greywacke) intruded by diorite and porphyritic granodiorite to tonalite. The porphyry phases occur as dykes, sills and irregular bodies. A large breccia mass is also present. Porphyry mineralization occurs as pyrite with lesser chalcopyrite, bornite, and molybdenite in fractures near the core of the deposit. Pyrite content increases in the periphery. Alteration is dominantly potassic dominantly expressed as biotite with lesser K-feldspar. The host rocks and mineralization are pre-Tertiary in age.

To the east, the pre-Tertiary rocks are overlain by Tertiary cover consisting of sedimentary (conglomerate with lesser siltstone and sandstone) and volcano-sedimentary (andesite, dacite, and latite) rocks. While these rocks were deposited after the porphyry mineralizing event, drill-core from the Tertiary cover rocks indicates that they contain low but locally variable concentrations of pyrite. Calcite is common in the Tertiary cover rocks.

Oxidation of the exposed mineralized pre-Tertiary has occurred, resulting in a thin gossan zone, minor supergene enrichment, and ferricrete zones on surface.

Additional geological background can be found in Bouley et al. (1995).

2.2 Approach to Design

The overall objectives of the ML/ARD characterization are to obtain data that can be used as inputs to:

1. Waste management planning (for example, is the rock./tailings acid-generating and/or metal-leaching?) and
2. Impact assessment (what concentrations of metals and other components might leach from rock/tailings?).

Figure 1 illustrates the general flow of data collection to achieve the above objectives. The bulk geological and geochemical characteristics (indicated by the geological and lithogeochemical block models) are interpreted in the context of release rates and geochemical waste classification criteria, and are input into waste scheduling. The resulting waste composition allows information on release rates to be used in scale-up calculations, which in turn are used to develop water chemistry predictions.

The overall components therefore include the following:

1. Bulk characterization of the rock mass using geological and/or geochemical variables that can be used to model the waste characteristics for the purpose of waste management planning.
2. Correlation of the characteristics used for bulk characterization with relevant ML/ARD variables and development of criteria (e.g., neutralization potential/acid potential, net neutralization potential (NNP), correlation of metal leaching rates with bulk characteristics).
3. Prediction of contaminant release rates on a mass basis from rock and tailings under various disposal scenarios.
4. Determination of water quality controls (e.g., solubility limits, attenuation effects, etc.) for prediction of source term concentrations for individual facilities. Data obtained for this component will be used to adjust water quality predictions obtained from scale-up of laboratory kinetic tests.

All four components are relevant to both objectives, and the process is iterative. For example, the last component may indicate parameters that should be used for classification of waste leading to requirements for waste modelling in the first component (Figure 1). The studies have been designed to collect data for each of these components and for each potential source of water requiring a source term prediction in water quality impact assessment. Currently, the facilities anticipated in the mine plan are an open pit, separate disposal areas for rougher and scavenger tailings, and a construction fill area (primarily tailings dams). The current mine plans do not include sub-aerial waste-rock dumps but instead show underwater co-disposal of waste rock with scavenger tailings.

This sampling and analysis plan (SAP) describes the collection and analysis of samples to provide data on the bulk characteristics of the rock and tailings, and the selection of a sub-set of these samples to provide information on leaching characteristics.

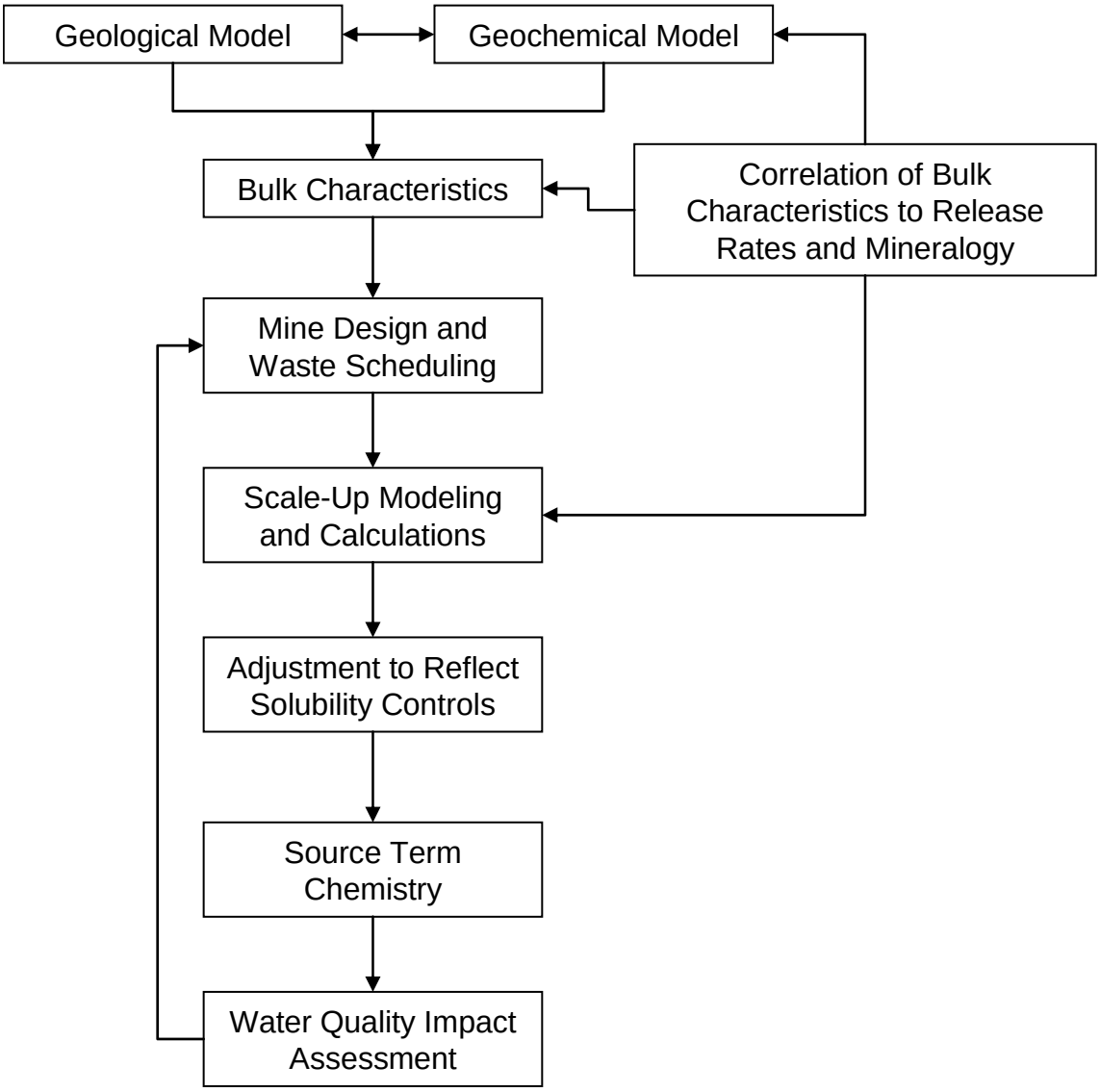


Figure 1. Flow chart showing data collection links.

3 Roles and Responsibilities

Table 1 summarizes roles and responsibilities for implementation of this SAP.

Table 1. Roles and responsibilities

Organization	Lead Person	Responsibilities
Northern Dynasty	Richard Moses	Sample collection and shipping, reject storage.
SRK Consulting	Stephen Day	Program design, SAP preparation, selection of laboratories, sample selection, liaison with testing laboratories, initial interpretation of incoming data and identification of data quality issues based on trends observed, data management.
Canadian Environmental and Metallurgical	Sohan Basra	Sample management, preparation of samples, initial analytical testwork (acid-base accounting), leach testing, data compilation
ALS	Fred Chan	Analysis of metal and sulfur concentrations in solids, analysis of leachates from leach tests
Process Research Associates	Morris Beattie	Scoping-level metallurgical testwork
SGS Lakefield under supervision of AMEC	Tony Lipiec (AMEC)	Detailed metallurgical testwork for feasibility study
EVS Environment Consultants	Robert Harrison	Toxicity testing on process water samples
Shaw Alaska, Inc.	Jane Whitsett	Quality control management

4 Sample Selection and Collection Methods

4.1 Introduction

Exploration drilling has occurred over several phases and provides the majority of candidate drill-core for ML/ARD testing. Cominco Alaska Incorporated initially conducted exploration drilling on the Pebble Deposit from 1989 through 1992. A second round of drilling was undertaken by Cominco in 1997. The most recent round of drilling was carried out by NDM over the period from 2002 to 2003. Additional exploration drilling was completed in 2004 and is ongoing in 2005.

Since the majority of drilling has been conducted on the mineralized core of the deposit, some of the drilling in 2004 was designed specifically by SRK to provide geochemical data on the rock that could potentially form the eventual pit walls. This program was designed based on understanding of pyrite distribution provided by the exploration drilling.

Core from exploration drill programs has been stored on site in wooden core boxes following core logging and sampling for assay and analysis. Stored core has been subject to ambient climatic conditions since drilling. Differences in the degree of weathering between older and newer core is expected to provide insight into material weathering rates under site conditions.

4.2 Mine Rock

Sample selection occurred in two rounds. The first round involved selection of samples from the pre-2004 exploration drill-hole database. In the second round, drill-core from the 2004 program was selected. These selection rounds are described separately below.

4.2.1 Pre-2004 Sample Selection

Database

SRK was supplied with Excel databases containing drill-hole lithological and assay data for the pre-2004 drilling. These databases were reviewed by SRK to select a large suite of samples for static geochemical testwork.

The sample selection was designed to ensure the following components are represented in the testwork:

- All lithologies,
- All alteration types and zones identified in the database, and
- The range of potential contaminant and sulfide values covering typical and extreme values.

As the core available for sampling has been in storage for variable lengths of time, representative samples of the same lithology were collected from old (Cominco) and new (NDM) core. The intent was to allow an assessment of the extent of natural oxidation that has occurred during core storage.

Selection Methodology

Since no previous ML/ARD sampling had been completed at the project, an arbitrary target number of samples was selected based on experience and review of the exploration database (which includes total sulfur analysis for the NDM drilling). The number of samples was 400.

Several iterative steps were followed to determine the drill-core for selection, as described below.

- The database included data from the Pebble Deposit and neighboring prospects. Therefore, all drill-holes located outside of the proposed pit area were eliminated by using the X-Y coordinates of the resource land for the Pebble Deposit.
- Within the resource land (Figure 2), drill-holes were selected to provide adequate spatial

coverage for the 2.5 billion tonne pit outline. Approximately five boreholes per 0.6 acres (2500 square meters) were initially selected. This was achieved by reference to the drill-hole collar plan.

- A catalogue of available core was provided by NDM, and further review of the database was limited to those drill-holes where core was available.
- Simplified lithological codes (the first character of the lithology codes) based on the major rock type identified were then assigned to each logged interval. The database was then sorted according to this simplified lithological code to allow examination of the characteristics of the individual lithologies.
- The lithological changes with depth in each drill-hole were then assessed using the database. From each lithological unit, samples were selected by considering the following parameters:
    - **Copper equivalent grade (CUEQ%, calculated by NDM from Cu + Au)**. This roughly indicates whether rock would be processed to recover commodities or disposed of as waste;
    - **Acid potential (AP) calculated from total S%** (units of kg $CaCO_3$ equivalent). This provides a maximum value for AP because not all sulfur may be in an acid-generating form.
    - **Semi-quantitative estimate of neutralization potential (NP) calculated from Ca%** (units of kg $CaCO_3$ equivalent). The assumption is that calcium concentrations will reflect carbonate content. This may underestimate actual NP if non-calcic carbonates are present but more likely overestimates NP due to the presence of other calcium minerals that will not effectively neutralize acid (sulfates and silicates);
    - **Pyrite content estimated from total sulfur less the sulfur associated with copper, zinc, and molybdenum**; and
    - **Na/K as an indicator of degree of alteration**.
- Each sample was selected to consist of 20 feet of core, which was composed of two 10-foot exploration sample intervals. The wider interval for ML/ARD testing was selected to reduce variability expected from local variations in mineralogy that would not be manageable during mining.
- To ensure samples selected were representative of geochemical variations within each lithology, scatter plots for each lithological type were carefully reviewed. Based on this gap analysis, further samples were selected to ensure all variations observed were represented in the intervals selected.

Table 2 summarizes the number of samples collected by lithology. Figure 2 shows the location of drill-holes selected. Appendix A lists the samples requested.

Table 2. Number of samples of each rock type selected

Stratigraphic Section	Rock Type	Unit Designation	N
Quaternary Deposits	Ferricrete	Fc	2
	Overburden	Ob	8
Tertiary Rocks	Sedimentary Units	TC/TW/TY	24
	Volcanic Units	TA/TB/TD	17
Cretaceous Stratiform and Cross-cutting Plutonic Rocks	Diorite/Gabbro	D	45
	Granodiorite-Quartz-Monzodiorite	G (Gp and Gs)	70
	Monzodiorite	N	39
	Monzonite	F (and X2)	17
	Monzonite (near Stock A)	M	12
	Intrusion Breccia	X	23
	Porphyritic Monzodiorte to Quartz Monzodiorite	P	13
	Skarn	K	5
Jurassic to Cretaceous Sedimentary and Volcano-sedimentary Rocks	Andesitic Bedded Rocks (Argillite, Siltstone)	Y	90
	Andesitic Bedded Rocks (Volcaniclastic Sandstone, Wacke)	W	8
Other		R	17
		Z	9

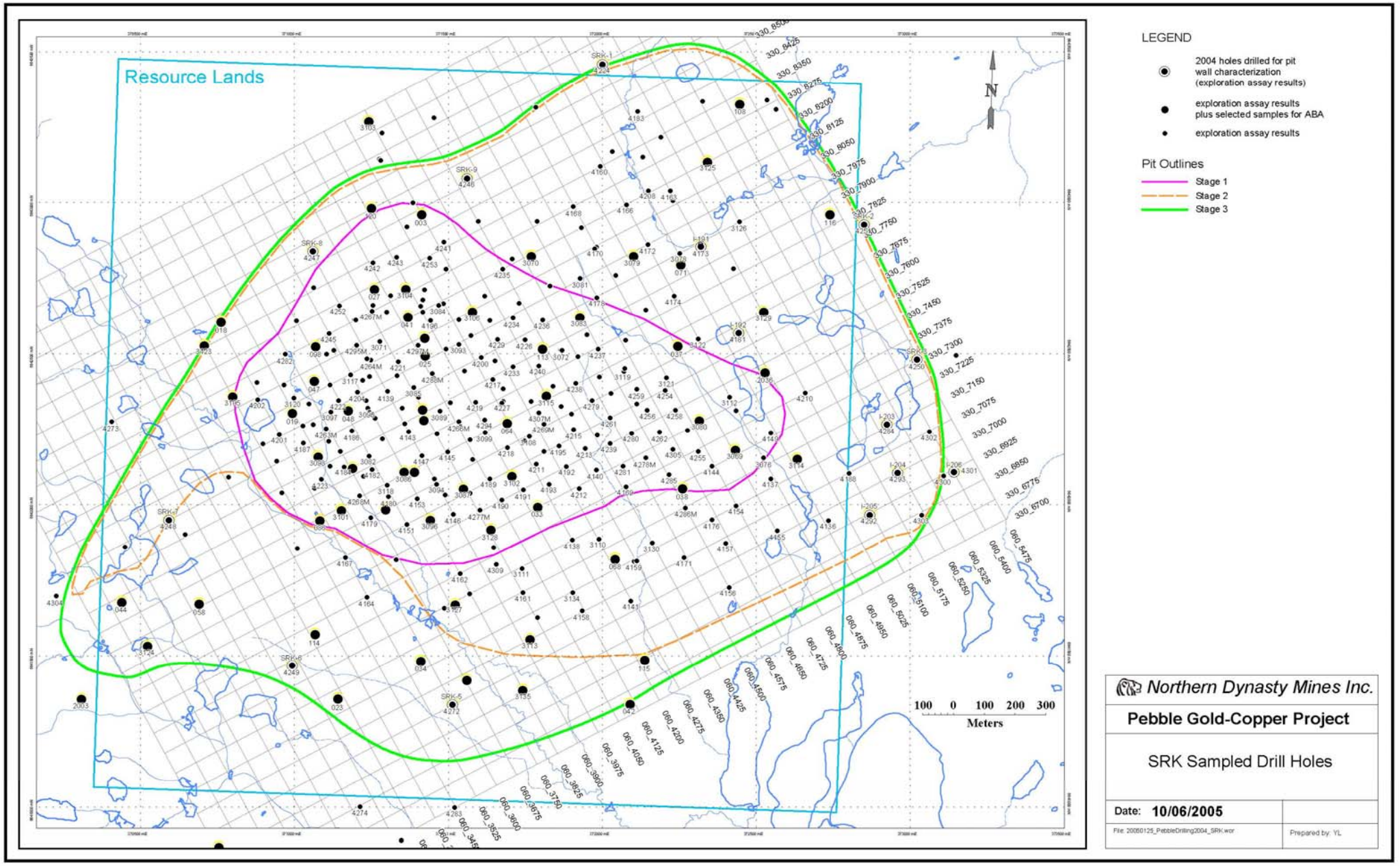


FIGURE 2. Location of Drill-holes Sampled

Collection Methodology

The sample selection list was sent to NDM (Richard Moses) in May 2004 for sample collection from core boxes. All samples were collected as splits or whole core over the intervals requested in June 2004, and bagged and shipped to NDM's warehouse in the Vancouver area. SRK examined the samples primarily to ensure that the selection of 20-foot composite samples would not result in combining lithologically distinctive materials. Examination of the core also increased understanding of the characteristics of the various rock types and allowed oxidation of the older core to be viewed.

Selection of Samples for Shake Flask Extractions and Hydrogen Peroxide Extractions

The objective of shake flask extractions is to evaluate the accumulation and solubility of contaminant load under a range of pH conditions. The distribution of paste pH in the acid-base accounting results was used as a basis for selection of samples. Paste pH tends to overestimate actual pH of rock at low pHs due to the liberation of reactive carbonate and silicate fines by pulverization prior to ABA testing. Experience indicates that paste pHs below 5 are typically 1 pH unit higher than the coarse crushed rock. Therefore, paste pHs were grouped into the following categories for sample selection:

- Group 1 — Paste pH <5.5 (actual pH <~4.5) – Rock pH controlled by soluble aluminum and ferric iron species.
- Group 2 — Paste pH between 5.5 and 7 – Rock with pH controlled by soluble aluminum and copper species.
- Group 3 — Paste pH greater than 7 – Pre-Tertiary rock (elevated S) with pH controlled by carbonate mineral solubility.
- Group 4 — Paste pH greater than 7 – Tertiary rock (low S) with pH controlled by carbonate mineral solubility.

Samples were chosen separately for Groups 3 and 4 to reflect the major differences in the rock types and possible differences in solubility of potential contaminants.

The target number for shake flask extractions for this testing was defined as 30. For Groups 1 and 2, the target number of samples was 10 each. For Groups 3 and 4, the target was five samples each. Selection of actual samples within the group was made using a random number generator. The target proportion of samples in each group was selected based on the proportion of available samples to target (Table 3). Each sample was assigned a random number which was compared to the proportion. If the random number was less than the proportion, the sample was selected. The resulting numbers of samples selected from each pH group are shown in Table 3. Appendix B provides the list of samples selected.

Table 3. Tally of samples selected for shake flask extractions

pH Group	Available Samples	Target	Actual
1	39	10	11
2	72	10	11
3	214	5	4
4	51	5	6

Selection of Samples for Kinetic Testing

Results from the testing of drill-core were used to select samples for kinetic testing. The following primary criteria were considered when selecting humidity cell samples:

- **Age of the Core**. The varying age of the core enables testing of material that has already undergone oxidation and therefore potentially indicates weathering rates beyond the usual time frame for kinetic testing and project permitting.
- **Sulfur Content**. Rates of oxidation are invariably correlated with sulfur content. Testing of materials with a range of sulfur concentrations enables oxidation rates to be interpolated beyond the dataset.
- **Rock Type**. Rock type may be a factor due to differences in style of mineralization and gangue mineralogy. At least 15 different rock types have been identified, though at present the only relationships to rock type are the differences between the mineralized rock and Tertiary cover. For the mineralized rock, the different rock types were grouped into two logical major groups (country rock and intrusion), but the final selections were also checked to ensure that samples were selected from the major intrusive rock types.

Appendix C provides the list of samples selected. Table 4 summarises sample selection by rock type and sulfide content.

Table 4. Sample selection matrix for humidity cells

	Core Age	1. 1989-1992			2. 1997			3. 2002-2003		
Rock Types	**Sulfur as Sulfide Concentration Range, %**	**i. <1.5**	**ii. 1.5 to 2.5**	**iii. >2.5**	**i. <1.5**	**ii. 1.5 to 2.5**	**iii. >2.5**	**i. <1.5**	**ii. 1.5 to 2.5**	**iii. >2.5**
Tertiary Cover	**Sediments**	2								
	Volcano-Sediments	2								
Tertiary Intrusions	**Basalt Dykes**	2								
Intrusions	**A. Plutonic Rocks**	1Ai[1]	1Aii	1Aiii	2Ai	2Aii	2Aiii	3Ai	3Aii	3Aiii
Host Rocks	**B. Sedimentary and Volcano-sedimentary Units**	1Bi	1Bii	1Biii	NS[2]	2Bii	2Biii	3Bi	3Bii	3Biii

Notes:
1. Designation of samples in Appendix C.
2. NS — Dataset contains only one sample. No test proposed.

4.2.2 2004 Sample Selection

In 2004, 16 diamond drill-holes were completed on the periphery of the deposit near the projected ultimate pit walls. Eight of these holes were specifically sited to collect information for the ML/ARD program. The locations of these holes are shown in Figure 2.

A total of 1216 samples from these holes were submitted for analysis on 10-foot intervals. Based on the exploration results, 134 samples were selected for static geochemical analysis. These samples were selected on typically 20-foot intervals evenly spaced along the drill-core. Total proportion of core selected for the additional testing was 20 percent with a greater emphasis on the Tertiary cover materials.

Appendix D provides a list of samples selected.

4.3 Tailings

Geochemical characterization of tailings is closely tied to metallurgical testing. Samples of tailings are generated as a by-product metallurgical testing. The composites used in the metallurgical testing are designed by the project metallurgical consultants.

To date, tailings samples are available from two rounds of metallurgical testing which have each generated two main tailings streams. The majority of tailings report to rougher tailings which are produced by bulk flotation of sulfide minerals. This produces a sulfide mineral concentrate. Commodity minerals are floated from this concentrate resulting in a final pyritic tailings product.

Additional metallurgical testwork is planned for 2005 to refine the processing of ore.

The samples provided for ML/ARD testing are tailings solids and supernatant.

5 Analytical Procedures

5.1 Analytical Contractors

The team of Canadian Environmental and Metallurgical Incorporated (CEMI), ALS Environmental (ALS), and ALS Chemex (Chemex) was selected to carry out the laboratory testing and analysis.

5.2 Static Testing

Seven groups of static tests are used for rock drill-core and samples of tailings produced by metallurgical testwork (Table 5). These include routine acid-base accounting (ABA) tests (MEND, 1991), conventional neutralization potential (Sobek et al., 1978) for comparison with the MEND method, distilled water extraction tests (Price, 1997), Meteoric Water Mobility Procedure tests (NDEP, 1996), hydrogen peroxide shake flask extraction tests (Tran et al., 2003), major and trace metal analysis (EPA standard methods), and grain-size determinations (internal method). Tables 6, 7, and 8 list the analytical methods.

Table 5. Static testing procedures and descriptions

Analysis Group	Method Reference	Brief Description
Routine ABA	MEND (1991)	Total sulfur (0.01%), sulfate sulfur as HCl-soluble sulfate (0.01%), modified neutralization potential, total inorganic carbon (0.02% as C), and paste pH. Detection limits are indicated in brackets.
Neutralization Potential	Sobek et al. (1978)	
Rock Metal Analysis	See Table 6	
Shake Flask Extraction	Price (1997)	Leachate analysis for parameters indicated in Table 7.
Meteoric Water Extraction Procedure	Nevada Department of Environmental Protection (1996)	Leachate analysis for parameters indicated in Table 7.
Hydrogen peroxide shake flask	Tran et al. (2003)	Modification of shake flask extraction test above using mild peroxide solution.
Grain-size analysis	SRK standard operating procedure	Size-fraction analysis using screens at 6.25 mm. 10 mesh, and 20 mesh.

Table 6. Methods for rock analysis

Parameter	Limit of Reporting	Units	Method
Sulfate	100	mg/kg	E300.0
Al	10	mg/kg	E200.8
Sb	0.05	mg/kg	E200.8
As	0.1	mg/kg	E200.8
Ba	10	mg/kg	E200.8
Be	0.05	mg/kg	E200.8
Bi	0.01	mg/kg	E200.8
B	10	mg/kg	E200.7
Cd	0.01	mg/kg	E200.8
Ca	10	mg/kg	E200.7
Cr	1	mg/kg	E200.8
Co	0.1	mg/kg	E200.8
Cu	0.2	mg/kg	E200.8
Fe	10	mg/kg	E200.7
Pb	0.2	mg/kg	E200.8
Mg	10	mg/kg	E200.7
Mn	5	mg/kg	E200.8
Hg	0.01	mg/kg	SW7471
Mo	0.05	mg/kg	E200.8
Ni	0.2	mg/kg	E200.8
K	10	mg/kg	E200.7
Se	0.2	mg/kg	E200.8
Ag	0.01	mg/kg	E200.8
Na	10	mg/kg	E200.7
Tl	0.02	mg/kg	E200.8
Sn	0.2	mg/kg	E200.8
Ti	10	mg/kg	E200.8
U	0.05	mg/kg	E200.8
V	1	mg/kg	E200.8
Zn	2	mg/kg	E200.8

Table 7. Leachate analysis methods

Parameter	Maximum Method Reporting Limit	Units	Method
Inorganics			
pH	0.01	pH units	E150.1
Eh	NA	mV	
Conductivity	2	μmhos/cm	SM 2510B
Acidity	1	mg $CaCO_3$/L	E305.1
Alkalinity	1	mg/L	SM2320B
Chloride	0.2	mg/L	E300.0
Fluoride	0.1	mg/L	E300.0
Hardness	0.5	mg/L	Calculated from Ca and Mg
Sulfate	0.2	mg/L	E300
TDS	10	mg/L	E160.1
Metals (Dissolved)			
Al	1	μg/L	ICPMS (200.8)
Sb	0.05	μg/L	ICPMS (200.8)
As	0.1	μg/L	ICPMS (200.8)
Ba	0.05	μg/L	ICPMS (200.8)
Be	0.2	μg/L	ICPMS (200.8)
Bi	0.5	μg/L	ICPMS (200.8)
B	10	μg/L	ICPMS (200.8)
Ca	50	μg/L	ICPMS (200.8)
Cd	0.05	μg/L	ICPMS (200.8)
Co	0.1	μg/L	ICPMS (200.8)
Cr	0.5	μg/L	ICPMS (200.8)
Cu	0.1	μg/L	ICPMS (200.8)
Fe	30	μg/L	ICPMS (200.8)
Pb	0.05	μg/L	ICPMS (200.8)
Mg	5	μg/L	ICPMS (200.8)
Mn	0.05	μg/L	ICPMS (200.8)
Hg	0.010	μg/L	EPA 1631E (CVAFS)
Mo	0.05	μg/L	ICPMS (200.8)
Ni	0.5	μg/L	ICPMS (200.8)
K	50	μg/L	ICPMS (200.8)
Se	1	μg/L	ICPMS (200.8)
Si	50	μg/L	ICPMS (200.8)
Ag	0.01	μg/L	ICPMS (200.8)
Na	2000	μg/L	ICPMS (200.8)
Tl	0.05	μg/L	ICPMS (200.8)
Sn	0.1	μg/L	ICPMS (200.8)
V	0.5	μg/L	ICPMS (200.8)
Zn	1	μg/L	ICPMS (200.8)

Table 8. Kinetic testing procedures and descriptions

Analysis Group	Method Reference	Brief Description
Waste rock humidity cell	ASTM D5744-96 (modified)	The overall procedure is consistent with the ASTM procedure. Testing will be performed on 5 kg of material crushed to approximately 1". Analyze all leachates for pH, Eh, and Conductivity and every other cycle leachate for all other parameters shown in Table 7.
Tailings humidity cell	ASTM D5744-96 (modified)	The overall procedure is consistent with the ASTM procedure. Testing will be performed on 3 kg of material. Analyze all leachates for pH, Eh, and Conductivity and every other leachate for all other parameters shown in Table 7
Waste rock column	SRK standard operating procedure	Approximately 5 kg crushed to approximately 1". Water will be added as a trickle leach. Volume of water will be determined by volume of rock used for test and will be specified by SRK. Analyze all leachates for pH, Eh, and Conductivity and every other leachate for all other parameters shown in Table 7. Columns are configured so that they can be flooded to simulate subaqueous storage of waste material.
Tailings Column	SRK standard operating procedure	Approximately 3 kg of tailings. Water will be added as a trickle leach. Volume of water will be determined by volume of rock used for test and will be specified by SRK. Analyze all leachates for pH, Eh, and Conductivity and every other leachate for all other parameters shown in Table 7. Columns should be configured so that they can be flooded to simulate subaqueous storage of waste material.

5.3 Kinetic Testing

Two main types of humidity cells are being used.

- Rock and tailings are both being tested in humidity cells modified from ASTM D5744-96. The modification involves a direct scale-up to a larger sample mass of 5 kilograms and 3 kilograms, respectively. Rock is crushed to pass a 1-inch screen rather than a 1/4-inch screen. The volume of leachate is increased in proportion to the sample size increase. The increase for waste rock in particular was needed to address the occurrence of mineralization in veinlets. The coarser particle size allows greater exposure of mineralization on fracture faces as is expected to occur under site conditions during blasting.
- Rock and tailings are also tested in columns either separately or co-mingled to evaluate disposal options. Standard methods are not available for this type of testwork, therefore specific methods were designed.

5.4 Toxicity Testing

Toxicity testing is being performed on tailings supernatant samples by EVS Environment Consultants to predict the toxicity of process water. Samples for this procedure are collected by

the metallurgical testing laboratory in plastic containers and shipped in coolers to EVS without preservation. Procedures used are summarized in Table 9.

Table 9 Toxicity testing procedures and descriptions

Test	Method
96-hour rainbow trout LC50	Environment Canada EPS 1/RM/13, Second Edition, 2000
48-hour *Daphnia magna* LC50	Environment Canada EPS 1/RM/14, Second Edition, 2000

6 Quality Assurance/Quality Control

Quality assurance for the Pebble geochemical characterization program is provided by the systematic sample selection procedures described in Section 3 and by the internal laboratory systems in place at the analytical laboratories. Data quality control is provided through a system of blank and duplicate sample analysis. Data quality on test leachates is reviewed by NDM's quality control manager

6.1 Static Testing

For ABA, metal testing, and shake flask testing, the analytical laboratory tests a duplicate of every tenth ABA sample submitted.

Three duplicate samples were run and one shake flask leachate blank was submitted for the 1989 to 2003 core.

6.2 Kinetic Testing

Quality control measures for kinetic testing includes:

- Humidity cell containing no sample but operated with same procedures (blank test) for both rock and humidity cells tests. This test evaluates potential contamination from cell construction materials and laboratory dust.
- Triplicates on two samples.

This draft report, **1CN007.000 – Metal Leaching/Acid Rock Drainage Characterization, Sampling and Analysis Plan**, has been prepared by:

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7 Bibliography

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Appendices

Appendix A

List of Rock Samples Selected for Static Testing (pre-2004 Database)

APPENDIX A
List of Rock Samples Selected for Static Testing (pre-2004 Database)

Sample ID	DDH	Start m	Finish m	Rock Type
013-0107-0117	13	107	117	G
013-0117-0127	13	117	127	G
018-0074-0095	18	74	95	D
018-0135-0155	18	135	1055	D/D
018-0225-0245	18	225	245	D/D
019-0030-0051	19	30	51	OB
019-0072-0090	19	72	90	WY
019-0200-0220	19	200	220	N.Y
019-0240-0260	19	240	260	Y
019-0390-0410	19	390	410	Gp-Pl
025-0179-0199	25	179	199	Y
025-0453-0473	28	453	473	Y
025-0617-0637	25	617	637	D
027-0070-0090	27	70	90	Y
027-0110-0130	27	110	130	W
027-0200-0220	27	200	220	Y
027-0260-0280	27	260	280	Y
033-0137-0155	33	137	155	Y
033-0304-0323	33	304	323	TBpd
033-0343-0363	33	343	363	G-P
034-0060-0090	34	60	90	OB
034-0100-0117	34	100	117	X.DbGY
037-0062-0093	37	62	93	TC - basalt
037-0122-0161	37	122	161	TC - cng
037-0161-0182	37	161	182	TC - cng
041-0000-0020	41	0	20	Fc
041-0020-0040	41	20	40	Y
041-0094-0114	41	94	114	Y
041-0244-0260	41	244	260	N
041-0280-0300	471	280	300	D
041-0500-0520	41	500	520	Z
041-0538-0558	41	538	558	Y
041-0728-0748	41	728	748	q
042-0060-0075	42	60	75	Y
042-0271-0290	42	271	290	D/G
042-0360-0380	42	360	380	Yb
044-0190-0210	44	190	210	Gp
044-0225-0245	44	225	245	X.HGDN-YxN/D
044-0305-0325	44	305	325	N.H
044-0343-0363	44	343	363	Gp
046-0038-0063	46	38	63	Fc
046-0113-0133	46	113	133	N or Gp-p.YM
046-0195-0215	46	195	215	Y
046-0259-0279	46	259	279	N or Gp.YM
046-0308-0328	46	308	328	G-p
046-0363-0383	46	363	383	N or Gp.YD-M
046-0563-0580	46	563	580	N-p
046-0580-0600	46	580	600	GxN
047-0117-0136	47	117	136	Wy
047-0226-0246	47	226	246	Wy

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Sample ID	DDH	Start m	Finish m	Rock Type
047-0350-0365	47	350	365	Wy
047-0462-0482	47	462	482	Gph
047-0592-0612	47	592	612	Gph
048-0135-0155	48	135	155	Gp
048-0172-0190	48	172	190	Z / Gp
048-0200-220	48	200	220	Gp
048-0760-0780	48	760	780	Gp
058-0058-0078	58	58	78	P-k
058-0348-0368	58	348	368	P
058-0378-0398	58	378	398	N
058-0398-0418	58	398	418	Z.NPY
058-0428-0448	58	428	448	X.DPYxN
064-0000-0030	64	0	30	OB
064-0030-0050	64	30	50	G
064-0132-0147	64	132	147	G
064-0156-0176	64	156	176	Y
064-0499-0519	64	499	519	Y-W
064-0539-0554	64	539	554	D/G
068-0046-0066	68	46	66	Z.Y
068-0095-0115	68	95	115	D
068-0235-0255	68	235	255	D
068-0265-0285	68	265	285	Y-x
068-0500-0520	68	500	520	G
071-0313-0333	71	313	333	R/Db
071-0353-0373	71	353	373	R/Db
071-0423-0443	71	423	443	R/Db
071-0473-0493	71	473	493	R/Db
076-0438-0458	76	438	458	D/N
076-0518-0538	76	518	538	D/N
076-0608-0625	76	608	625	G/N?
086-0000-0067	86	0	67	OB
086-0279-0287	86	279	287	TBd
086-0363-0377	86	363	377	Np
086-0417-0437	86	417	437	Gp-k
086-0467-0487	86	467	487	N.MH
086-0617-0637	86	617	637	X.Db GN
093-0043-0063	93	43	63	G-p
093-0133-0148	93	133	148	G-p
093-0158-0178	93	158	178	Y
093-0248-0268	93	248	268	Y
093-0377-0394	93	377	394	Y
098-0151-0171	98	151	171	Y
098-0191-0211	98	191	211	Z.Y / Y
098-0241-0261	98	241	261	Y
098-0572-0592	98	572	592	Gph
098-0642-0662	98	642	662	Gph
108-0633-0650	108	633	650	Y
108-0770-0790	108	770	790	G
112-0160-0180	112	160	180	N.NM / N.YM
112-0220-0240	112	220	240	N.H

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Sample ID	DDH	Start m	Finish m	Rock Type
112-0300-0320	112	300	320	N.H
112-0400-0420	112	400	420	N.H
112-0460-0480	112	460	480	X.MDbxN
113-0040-0060	113	40	60	Y
113-0090-0110	113	90	110	Y
113-0170-0190	113	170	190	G-p
113-0360-0380	113	360	380	Y
113-0510-0530	113	510	530	Y
114-0055-0062	114	55	62	Pp
114-0090-0104	114	90	104	Pp
114-0180-0200	114	180	200	Ppk / P-k
114-0290-0303	114	290	303	Ppk
114-0310-0330	114	310	330	X.MDxN
114-0400-0420	114	400	420	X.MD#b
114-0460-0481	114	460	481	X.MD#b
115-0014-0024	115	14	24	TC- Oxidized
115-0024-0034	115	24	34	TC- Arkose
115-0041-0054	115	41	54	TC - Cng
115-0054-0066	115	57	66	TC - Slst
115-0104-0123	115	104	123	TC - Slst
115-0142-0163	115	142	163	TC - Arkose
115-0197-0215	115	197	215	TC - Cng
115-0232-0264	115	232	264	TC - Cng/mdst
115-0280-0300	115	280	300	TA pd
115-0300-0320	115	300	320	Y-W
115-410-0430	115	410	430	Y
116-0570-0590	116	570	590	Gp
116-0630-0650	116	630	650	Gp
116-0780-0802	116	780	802	Gp
116-0890-0908	116	890	908	Y
117-0000-0053	117	0	53	OB
117-0070-0090	117	70	90	N.M
117-0160-0174	117	160	174	MpK-N
117-0190-0210	117	190	210	N.YM
117-0233-0250	117	233	250	Mp-K
117-0300-0320	117	300	320	Gp-K
117-0560-0579	117	560	579	GpK
117-0590-0610	117	590	610	Y
117-0630-0650	117	630	650	Y
117-1055-1071	117	1055	71	TBd
118-0150-0170	118	150	170	N-.Y
118-0190-0210	118	190	210	Z.N
118-0220-0240	118	220	240	Y
118-0260-0278	118	260	278	Y
118-0336-0355	118	336	355	TbD
118-0390-0410	118	390	410	TBd
118-0468-0488	118	468	488	Mkp-x
118-0497-0515	118	497	515	N/D.-YM
118-0520-0535	118	520	535	Y
118-0565-0585	118	565	585	Y

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Sample ID	DDH	Start m	Finish m	Rock Type
118-0650-0670	118	650	670	D/N-.#b
118-0710-0730	118	710	730	Np-.#b D?
118-0760-0780	118	760	780	D
118-0890-0910	118	890	910	N/D
118-0980-1000	118	980	1000	N-p-.Y / N-.Y-D
118-1040-1060	118	1040	1060	N.Y-D
118-1220-1238	118	1220	1238	WY
118-1300-1320	118	1300	1320	Y
118-1480-1500	118	1480	1500	X.YxN
120-0075-0095	120	75	95	B
120-0116-0130	120	116	130	R/Db
120-0260-0280	120	260	280	R/Db
120-0380-0400	120	380	400	R/Db
2001-0130-0150	2001	130	150	Kqs
2003-0210-0230	2003	210	230	Kgde
2003-0335-0356	2003	335	356	Kgde
2026-0050-0070	2026	50	70	Kq
2026-0190-0210	2026	190	210	Kq
2028-0055-0076	2028	55	76	G/N
2028-0155-0175	2028	155	175	Y
2028-0310-0330	2028	310	330	G
2028-0430-0450	2028	430	450	Y
2036-0421-0440	2036	421	440	W
2036-0500-0520	2036	500	520	G-p
2036-0540-0564	2036	540	564	Y
2036-0570-0590	2036	570	590	G-p
2036-0660-0682	2036	660	682	G-p
2036-0700-0720	2036	700	720	G-p
3069-0127-0147	3069	127	147	D
3069-0247-0267	3069	247	267	Z
3069-0287-0307	3069	287	307	G
3069-0347-0367	3069	347	367	D
3069-0397-0417	3069	397	417	D
3069-0427-0437	3069	427	437	Y
3069-0487-0507	3069	487	507	Y
3069-0627-0647	3069	627	647	Y
3069-0707-0727	3069	707	727	G
3069-0807-0827	3069	807	827	G
3069-0927-0947	3069	927	947	G
3070-0074-0094	3070	74	94	D
3070-0204-0224	3070	204	224	D
3070-0284-0304	3070	284	304	D
3070-0464-0484	3070	464	484	Y
3070-0594-0614	3070	594	614	G-p
3070-0634-0654	3070	634	654	G-p
3079-0499-0519	3079	499	519	D
3079-0589-0599	3079	589	599	Tad
3080-0075-0095	3080	75	95	D
3080-0129-0149	3080	129	149	G
3080-0179-0199	3080	179	199	G

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List of Rock Samples Selected for Static Testing (pre-2004 Database)

Sample ID	DDH	Start m	Finish m	Rock Type
3080-0375-0394	3080	375	394	D
3080-0394-0419	3080	394	419	Y
3080-0479-0499	3080	479	499	Y
3080-0549-0569	3080	549	569	G^f
3080-0669-0689	3080	669	689	G^f
3083-0599-0619	3083	599	619	Y
3083-0639-0652	3083	639	652	Y
3083-0719-0739	3083	719	739	Y
3086-0949-0969	3086	949	969	N.M
3086-0979-0992	3086	979	992	N.MY/ TBd
3086-1009-1027	3086	1009	1027	P-K
3086-1109-1121	3086	1109	1121	Y
3086-1121-1126	3086	1121	1126	TBd
3086-1236-1255	3086	1236	1255	N
3086-1319-1338	3089	1319	1338	G
3087-0023-0040	3087	23	40	Y
3087-0164-0171	3087	164	171	G
3087-0171-0181	3087	171	181	G
3087-0209-0229	3087	209	229	Y
3087-0359-0379	3087	359	379	Y
3087-0509-0528	3087	509	528	Y
3087-0539-0559	3087	539	559	D
3087-0787-0809	3087	787	809	Dxq/D
3087-0869-0889	3087	869	889	Yxq
3087-0905-0919	3087	905	919	Mk.Y
3087-0979-0999	3087	979	999	M
3087-1047-1067	3087	1047	1067	YxN/N.Y / YXNYxq
3087-1143-1159	3087	1143	1159	X.YP
3096-0000-0058	3096	0	58	OB
3096-0058-0078	3096	58	78	X.YMzN(?) / X.YM-DxN
3096-0108-0128	3096	108	128	X.YM-DxN
3096-0168-0188	3096	168	188	N.DyM
3096-0235-0258	3096	235	258	Y
3096-0318-0338	3096	318	338	Y
3096-0418-0438	3096	418	438	Y
3096-0718-0738	3096	718	738	X
3096-0788-0808	3096	788	808	N
3096-1006-1018	3096	1006	1018	X
3096-1088-1108	3096	1088	1108	TBd
3096-1328-1348	3096	1328	1348	M
3096-1388-1408	3096	1388	1408	P
3096-1518-1538	3096	1518	1538	P
3096-1748-1768	3096	1748	1768	G-q
3098-0138-0158	3098	138	158	N-p
3098-0238-0258	3098	238	258	Mpk / M-k
3098-0353-0371	3098	353	371	M-k
3098-0418-0438	3098	418	438	Y
3098-0488-0508	3098	488	508	Y-xk-pd
3098-0656-0676	3098	656	676	Y-W
3098-0712-0727	3098	712	727	G

APPENDIX A

List of Rock Samples Selected for Static Testing (pre-2004 Database)

Sample ID	DDH	Start m	Finish m	Rock Type
3098-0778-0792	3098	778	792	G
3098-0908-0928	3098	908	928	G
3098-1198-1218	3098	1198	1218	G
3101-0110-0138	3101	110	138	X.M/Mx
3101-0240-0262	3101	240	262	Yxqd
3101-0308-0346	3101	308	346	TD
3101-0378-0398	3101	378	398	Yxq-p
3101-0548-0568	3101	548	568	Yxqp / Yxq-p\
3101-0738-0761	3101	738	761	M.ky/X.mk
3101-0978-0995	3101	978	995	YxP\P/M-k / Y-x
3101-1038-1058	3101	1038	1058	Mp-k
3101-1161-1172	3101	1161	1172	TBd
3101-1201-1208	3101	1201	1208	TBd
3101-1226-1236	3101	1226	1236	TBd
3102-0044-0068	3102	44	68	Y
3102-0088-0098	3102	88	98	G^fp
3102-0254-0276	3102	254	276	TBd
3102-0398-0418	3102	398	418	Y
3102-0568-0588	3102	568	588	Y
3102-0623-0638	3102	623	638	D
3102-0798-0818	3102	798	818	D
3102-0938-0952	3102	938	952	D
3102-0958-0978	3102	958	978	TBd
3102-1074-1078	3102	1074	1078	Y
3103-0036-0056	3103	36	56	R
3103-0129-0143	3103	129	143	R / *qp
3103-0159-0172	3103	159	172	R
3103-0176-0196	3103	176	196	R
3103-0236-0252	3103	236	252	R
3103-0376-0393	3103	376	393	R
3103-0546-0566	3103	546	566	R
3103-0617-0636	3103	617	636	R
3103-0786-0797	3103	786	797	R
3103-0888-0901	3103	888	901	R
3104-000-0018	3104	0	18	O/B
3104-0077-0098	3104	77	98	G^p
3104-0128-0148	3104	128	148	G^p
3104-0238-0258	3104	238	258	G^p
3104-0378-0398	3104	378	398	Y
3104-0458-0480	3104	458	480	M/P
3104-0538-0558	3104	538	558	Y
3104-0588-0608	3104	588	608	N-p
3104-0718-0738	3104	718	738	Y
3104-0848-0868	3104	848	868	P
3104-0978-0998	3104	978	998	Y
3104-1228-1244	3104	1228	1244	D
3104-1328-1346	3104	1328	1346	D
3104-1458-1478	3104	1458	1478	Y
3105-0138-0158	3105	138	158	N
3105-0198-0208	3105	198	208	N

APPENDIX A
List of Rock Samples Selected for Static Testing (pre-2004 Database)

Sample ID	DDH	Start m	Finish m	Rock Type
3105-0268-0278	3105	268	278	G^c
3105-0418-0438	3105	418	438	G^c
3105-0638-0653	3105	638	653	G^c
3105-1008-1028	3105	1008	1028	G^c
3105-1138-1158	3105	1138	1158	G^c
3105-1284-1300	3105	1284	1300	Z
3105-1313-1332	3105	1313	1332	Z.TBd / Z
3105-1332-1369	3105	1332	1369	TBd
3105-1388-1408	3105	1388	1408	G^c
3106-0020-0033	3106	20	33	D
3106-0158-0178	3106	158	178	D
3106-0236-0258	3106	236	258	Y
3106-0548-0568	3106	548	568	D
3106-0758-0778	3106	758	778	Y
3106-0908-0928	3106	908	928	Y
3106-1128-1148	3106	1128	1148	Y
3106-1288-1308	3106	1288	1308	Y
3113-0019-0037	3113	19	37	N / F.FD
3113-0157-0177	3113	157	177	N/F-D.Y
3113-0347-0357	3113	347	357	N.FDZ / N/DX
3113-0787-0807	3113	787	807	F.F-Dy
3113-0981-1002	3113	981	1002	F.H(FDY)
3114-0196-0213	3314	196	213	TC^k - Volc Cng
3114-0266-0283	3314	226	283	TC^k - Volc Cng
3114-0283-0301	3114	283	301	TC^k - Volc Cng
3114-0392-0410	3114	392	410	TC^k - Volc Cng
3114-0410-0427	3114	410	427	TC^k - Basalt
3114-0449-0469	3114	449	469	YW
3114-0609-0629	3114	609	629	Y
3114-0699-0709	3114	699	709	G^m
3114-0779-0799	3114	779	799	G^m
3114-1019-1036	3114	1019	1036	G^m
3114-1059-1079	3114	1059	1079	Y
3115-0678-0698	3115	678	698	D
3115-0768-0788	3115	768	788	D
3115-0838-0858	3115	838	858	D
3115-0988-1008	3115	988	1008	Y
3116-0935-0958	3116	935	958	M?
3116-1018-1038	3116	1018	1038	YxP/M
3116-1248-1268	3116	1248	1268	WC?
3116-1348-1368	3116	1348	1368	G
3123-0148-0168	3123	148	168	X.H(DNNxY)
3123-0178-0198	3123	178	198	X.H(DNNxY)
3123-0248-0268	3123	248	268	Yxbp(l?)
3123-0438-0458	3123	438	458	D? / Dp
3123-0488-0503	3123	488	503	Dp
3123-0648-0668	3123	648	668	D
3123-0744-0766	3123	744	766	X.HxN/X.YxN
3124-0000-0137	3124	0	137	OB
3124-0188-0209	3124	188	209	Y

APPENDIX A
List of Rock Samples Selected for Static Testing (pre-2004 Database)

Sample ID	DDH	Start m	Finish m	Rock Type
3124-0328-0348	1055	328	348	N/P / N
3124-0388-0408	3124	388	408	N/P
3124-0428-0450	3124	428	450	N/P / N
3124-0518-0538	3124	518	538	N/P
3124-0872-0887	3124	872	887	X.HxN^f
3124-1218-1235	3124	1218	1235	TB
3125-0099-0119	3125	99	119	D
3125-0239-0259	3125	239	259	D
3125-0349-0369	3125	349	369	D
3125-0379-0399	3125	379	399	D
3125-0719-0739	3125	719	739	D
3125-0919-0933	3125	919	933	D/R
3125-1049-1069	3125	1049	1069	N
3128-0039-0056	3128	39	56	D
3128-0076-0098	3128	79	98	X.FDM/pxn/p^f
3128-0298-0323	3128	298	323	X.FDM/pxn/p^f
3128-0518-0538	3128	518	538	P/N.DN/p
3128-0658-0678	3128	658	678	X.DFxN/P\P/N.DF
3128-0738-0758	3128	738	758	P.DF
3128-0808-0828	3128	808	828	P.DF
3128-0938-0958	3128	938	958	X.DFxN/P/N/P.DF
3129-0080-0100	3129	80	100	TC - And/Volc cng
3129-0100-0119	3129	100	119	TC - And/Volc cng
3129-0234-0253	3129	234	253	TC - And/Volc cng
3129-0253-0272	3129	253	272	TC - And/Volc cng
3129-0399-0417	3129	388	417	TC - And/Volc cng
3129-0417-0435	3129	417	435	TC - And/Volc cng
3129-0453-0470	3129	453	470	TC - Volc cng
3129-0470-0489	3129	470	489	TC - Volc cng
3129-0550-0574	3129	550	574	Y
3129-0574-0590	3129	574	590	Gp
3129-0610-0630	3129	610	630	Gp
3129-0970-0980	3129	970	980	Y
3129-1200-1220	3129	1200	1220	Y
3129-1220-1240	3129	1220	1240	Y
3129-1300-1320	3129	1300	1320	G
3133-0100-0118	3133	100	118	X2
3133-0348-0368	3133	348	368	X2xx2qpw
3133-0668-0688	3133	668	688	X2
3133-0688-0708	3133	688	708	Fh
3133-0758-0778	3133	758	778	Fh
3133-0808-0828	3133	808	828	X2
3133-1148-1168	3133	1148	1168	X2
3135-0080-0098	3135	80	98	X2
3135-0198-0218	3135	198	218	X2
3135-0388-0408	3135	388	408	X2
3135-0748-0768	3135	748	768	X2
3135-0988-1008	3135	988	1008	X2
3135-1038-1058	3135	1038	1058	Fh
3135-1098-1118	3135	1098	1118	Fh

APPENDIX A
List of Rock Samples Selected for Static Testing (pre-2004 Database)

Sample ID	DDH	Start m	Finish m	Rock Type
3135-1238-1258	3135	1238	1258	Fh

Appendix B

List of Rock Samples Selected for Shake Flask Testing

APPENDIX B
List of Rock Samples Selected for Shake Flask Testing

Sample ID	DDH	Start m	Finish m	Rock Type
018-0135-0155	18	135	1055	D/D
027-0070-0090	27	70	90	Y
034-0060-0090	34	60	90	OB
041-0020-0040	41	20	40	Y
041-0244-0260	41	244	260	N
044-0225-0245	44	225	245	X.HGDN-YxN/D
044-0343-0363	44	343	363	Gp
044-0343-0363 (Duplicate)	44	343	363	Gp
047-0350-0365	47	350	365	Wy
068-0500-0520	68	500	520	G
071-0423-0443	71	423	443	R/Db
086-0000-0067	86	0	67	OB
093-0043-0063	93	43	63	G-p
093-0133-0148	93	133	148	G-p
114-0090-0104	114	90	104	Pp
115-0024-0034	115	24	34	TC- Arkose
2028-0155-0175	2028	155	175	Y
3079-0499-0519	3079	499	519	D
3080-0669-0689	3080	669	689	G^f
3087-0023-0040	3087	23	40	Y
3104-0378-0398	3104	378	398	Y
3105-0198-0208	3105	198	208	N
3113-0019-0037	3113	19	37	N / F.FD
3113-0157-0177	3113	157	177	N/F-D.Y
3114-0392-0410	3114	392	410	TC^k - Volc Cng
3124-0188-0209	3124	188	209	Y
3124-0188-0209 (Duplicate)	3124	188	209	Y
3128-0039-0056	3128	39	56	D
3129-0100-0119	3129	100	119	TC - And/Volc cng
3129-0253-0272	3129	253	272	TC - And/Volc cng
3135-0080-0098	3135	80	98	X2
3135-0388-0408	3135	388	408	X2
3135-0988-1008	3135	988	1008	X2
3135-1038-1058	3135	1038	1058	Fh
3135-1038-1058 (Duplicate)	3135	1038	1058	Fh

Appendix C

List of Rock Samples Selected for Humidity Cell Testing

APPENDIX C
List of Rock Samples Selected for Humidity Cell Testing

Age	Rock Type	Sample ID #	Selection (see Table 4)
Pre-Tertiary	Granodiorite-Quartz-Monzodiorite	046-0580-0600	1Ai
Pre-Tertiary	Monzodiorite	046-0113-0133	1Aii
Pre-Tertiary	Diorite/Gabbro	025-0617-0637	1Aiii
Pre-Tertiary	Monzonite (near Stock A)	118-0468-0488	2Ai
Pre-Tertiary	Monzodiorite	117-0190-0210	2Aii
Pre-Tertiary	Intrusion Breccia	112-0460-0480	2Aiii
Pre-Tertiary	Intrusion Breccia	3124-0872-0887	3Ai
Pre-Tertiary	Granodiorite-Quartz-Monzodiorite	3069-0927-0947	3Aii
Pre-Tertiary	Diorite/Gabbro	3123-0438-0458	3Aiii
Pre-Tertiary	Andesitic Bedded Rocks (Volcaniclastic Sandstone, Wacke)	019-0072-0090	1Bi
Pre-Tertiary	Andesitic Bedded Rocks (Argillite, Siltstone)	033-0137-0155	1Bii
Pre-Tertiary	Andesitic Bedded Rocks (Volcaniclastic Sandstone, Wacke)	047-0350-0365	1Biii
Pre-Tertiary	Andesitic Bedded Rocks (Volcaniclastic Sandstone, Wacke)	118-1220-1238	2Bii
Pre-Tertiary	Andesitic Bedded Rocks (Argillite, Siltstone)	118-0520-0535	2Biii
Pre-Tertiary	Andesitic Bedded Rocks (Argillite, Siltstone)	3115-0988-1008	3Bi
Pre-Tertiary	Andesitic Bedded Rocks (Argillite, Siltstone)	3124-0188-0209	3Bii
Pre-Tertiary	Andesitic Bedded Rocks (Argillite, Siltstone)	3102-0568-0588	3Biii
Tertiary	Sedimentary Units	115-0054-0066	
Tertiary	Sedimentary Units	115-0142-0163	
Tertiary	Volcano-Sedimentary Units	3129-0253-0272	
Tertiary	Volcano-Sedimentary Units	3129-0417-0435	
Tertiary	Intrusive Dykes	117-1055-1071	
Tertiary	Intrusive Dykes	3102-0958-0978	

Appendix D

List of Rock Samples Selected for Static Testing (2004 Drilling)

Appendix D
List of Rock Samples Selected for Static Testing (2004 Drilling)

DDH	From m	To m	Rock Type
4173	0.00	30.48	OB
4173	48.46	50.29	TFf
4173	50.29	53.64	TA
4173	53.64	54.56	TA
4173	54.56	57.61	TA
4173	57.61	57.76	TA
4173	57.76	60.20	TA
4173	60.20	60.66	TF
4173	69.80	72.85	TF
4173	72.85	75.90	TC
4173	85.04	88.09	TW
4173	88.09	91.14	TW
4173	97.23	100.28	TW
4173	100.28	103.63	TW
4173	104.85	106.38	D
4173	106.38	109.42	D
4224	17.98	21.03	Y
4224	21.03	24.08	Y
4224	27.13	30.18	Y
4224	30.18	33.22	Y
4224	45.42	51.51	Y
4246	0.00	0.30	ob
4246	0.30	2.13	Y
4246	2.13	5.79	Y
4246	5.79	8.84	Y
4246	8.84	11.43	Gs?
4246	11.43	14.63	Gs?
4246	14.63	17.68	Gs?
4246	17.68	21.03	Y
4246	21.03	24.08	Y
4246	24.08	26.67	Y
4246	26.67	30.18	Y
4246	30.18	33.22	Y
4246	33.22	36.27	Y
4246	36.27	39.32	Y
4246	39.32	42.37	Y
4246	42.37	45.42	Y
4246	45.42	50.29	Y
4246	50.29	53.34	Y
4246	53.34	56.39	Y
4246	56.39	59.44	Y
4246	59.44	63.70	Y
4246	74.68	77.72	Y
4246	77.72	80.77	Y
4246	88.09	91.14	Y
4246	91.14	94.18	Y
4246	103.33	106.38	Y

Appendix D
List of Rock Samples Selected for Static Testing (2004 Drilling)

DDH	From	To	Rock Type
4246	106.38	109.42	Y
4246	118.57	121.62	Y
4246	121.62	124.66	Y
4246	133.81	136.86	Y
4246	136.86	139.90	Y
4246	149.05	152.10	Y
4246	152.10	155.14	Y
4246	164.29	167.34	Y
4246	167.34	170.38	Y
4246	179.53	182.58	Y
4246	182.58	185.62	Y
4246	194.77	197.82	Y
4246	197.82	200.86	Y
4247	0.00	18.29	ob
4247	18.29	21.03	D
4247	21.03	24.08	D
4247	30.18	33.22	D
4247	33.22	36.27	D
4247	45.42	48.46	D
4247	48.46	51.51	D
4247	60.66	63.70	D
4247	63.70	66.75	D
4247	75.90	78.94	D
4247	78.94	81.99	D
4247	88.09	91.14	D
4247	91.14	94.18	D
4247	103.33	106.38	D
4247	106.38	109.42	D
4247	118.57	121.62	D
4247	121.62	124.66	D
4247	133.81	136.86	D
4247	136.86	139.60	D
4247	149.05	152.10	Y
4247	152.10	155.14	Y
4247	161.24	164.29	Y
4247	164.29	167.34	Y
4248	0.00	31.70	ob
4248	44.20	45.42	TBd-.MY
4248	45.42	48.46	TBd-.MY
4248	57.61	60.66	TBd-.MY
4248	60.66	63.70	TBd-.MY
4248	72.85	75.90	TBd-.MY
4248	75.90	78.94	TBd-.MY
4248	84.58	87.78	M.Y
4248	87.78	89.92	M.Y

Appendix D
List of Rock Samples Selected for Static Testing (2004 Drilling)

DDH	From	To	Rock Type
4248	103.33	106.38	M.YM
4248	106.38	108.20	M.YM
4248	118.57	121.62	TBd
4248	121.62	124.66	TBd
4248	130.76	133.81	TBd
4248	133.81	136.86	TBd
4248	149.05	152.10	X.YM
4248	152.10	155.14	X.YM
4248	161.24	164.29	TBd.M
4248	164.29	167.34	TBd.M
4248	179.53	182.58	M.Y
4248	182.58	185.62	M.Y
4248	194.77	197.82	M.Y
4248	197.82	200.86	M.Y
4249	0.00	10.67	ob
4249	10.67	14.94	N
4249	14.94	17.98	N
4249	17.98	21.03	N
4249	21.03	24.08	N
4249	33.22	36.27	N
4249	36.27	39.32	N
4249	51.51	54.56	X.MD-YxN
4249	54.56	57.61	X.MD-YxN
4249	66.75	69.80	X.MD-YxN
4249	69.80	72.85	X.MD-YxN
4249	81.99	85.04	N
4249	85.04	88.09	N
4249	97.23	100.28	N
4249	100.28	103.33	N
4249	112.47	115.52	N
4249	115.52	118.57	N
4249	127.71	130.76	N
4249	130.76	133.81	N
4249	142.95	146.00	X.MDYxN
4249	146.00	147.52	X.MDYxN
4249	152.10	155.14	TA
4249	155.14	158.50	TA
4249	158.50	161.24	X.MDYxN
4249	161.24	164.29	X.MDYxN
4249	170.38	173.43	X.MDYxN
4249	173.43	176.48	X.MDYxN
4250	0.00	13.56	ob
4250	13.56	15.85	TC
4250	15.85	21.03	TW
4250	45.11	47.09	TF
4250	47.09	49.99	TC

Appendix D
List of Rock Samples Selected for Static Testing (2004 Drilling)

DDH	From	To	Rock Type
4250	68.43	71.02	TW
4250	71.02	76.50	TY
4250	129.08	131.67	TW
4250	219.46	222.50	TC
4250	256.49	258.78	Gs
4250	258.78	261.82	Gs
4250	270.97	274.02	Gs
4250	274.02	277.06	Gs
4250	286.21	289.26	Y
4250	289.26	293.52	Y
4250	297.79	301.60	D
4250	301.60	304.19	Y
4251	0.00	57.76	ob
4251	75.90	78.64	TY
4251	145.39	148.13	TC
4251	182.73	185.32	TD
4251	213.36	215.80	Gs
4251	215.80	218.85	Gs
4251	243.23	246.28	Gs
4251	246.28	249.33	Gs
4251	273.71	276.76	Gs
4251	276.76	279.81	Gs
4251	304.19	307.24	Y
4251	307.24	310.29	Y
4251	333.45	337.72	Y
4251	337.72	340.77	Y
4251	365.15	368.20	Y
4251	368.20	371.25	Y
4251	396.09	398.68	Gs
4251	398.68	401.73	Gs
4251	426.11	429.16	Gs
4251	429.16	432.21	Gs
4251	456.59	459.64	Gs
4251	459.64	462.69	Gs
4251	487.07	490.12	Y
4251	490.12	493.17	Y
4251	517.55	520.60	Gs
4251	520.60	523.65	Gs
4251	548.03	551.08	Y
4251	551.08	554.13	Y
4251	578.51	581.56	Y
4251	581.56	584.61	Y
4251	605.94	608.99	Gs
4251	608.99	612.04	Gs
4272	0.00	33.53	ob

Appendix D
List of Rock Samples Selected for Static Testing (2004 Drilling)

DDH	From	To	Rock Type
4272	33.53	36.27	X2.DYF
4272	36.27	39.32	X2.DYF
4272	45.42	48.46	X2.DYF
4272	48.46	51.51	X2.DYF
4272	60.66	63.70	X2.DYF
4272	63.70	66.75	X2.DYF
4272	75.90	78.94	X2.DYF
4272	78.94	82.30	X2.DYF
4272	91.14	94.18	X2.DYF
4272	94.18	97.23	X2.DYF
4272	106.38	109.42	X2.DYF
4272	109.42	112.47	X2.DYF
4272	121.62	124.66	X2.DYF
4272	124.66	127.71	X2.DYF
4272	136.86	139.90	X2.DYF
4272	139.90	142.95	X2.DYF
4272	152.10	155.14	X2.DYF
4272	155.14	158.19	X2.DYF
4272	167.34	170.38	X2.DYF
4272	170.38	173.43	X2.DYF
4272	182.58	185.62	X2.DYF
4272	185.62	188.67	X2.DYF
4293	0.00	53.64	ob
4293	53.64	56.69	TF
4293	112.47	114.91	TW/TY/TC
4293	200.56	203.61	TC
4293	247.50	249.63	Gs
4293	249.63	252.68	Gs
4293	277.06	280.11	Gs
4293	280.11	283.16	Gs
4293	307.54	310.59	Gs
4293	310.59	313.64	Gs
4293	334.98	337.57	Gs
4293	337.57	341.68	Z.Gs
4293	341.68	347.47	TBd
4293	372.31	374.60	Z.Y
4293	374.60	377.65	Gs
4293	402.03	405.08	Gs
4293	405.08	408.13	Gs
4293	429.46	432.51	Gs
4293	432.51	434.95	Gs
4293	462.99	466.04	Y
4293	466.04	469.09	Y
4293	493.47	496.52	Y
4293	496.52	499.57	Y
4293	520.90	523.95	Y
4293	523.95	527.00	Y
4293	549.86	551.38	D

Appendix D
List of Rock Samples Selected for Static Testing (2004 Drilling)

DDH	From	To	Rock Type
4293	551.38	554.43	D
4293	578.82	581.86	Y
4293	581.86	584.91	Y
4293	609.30	612.34	Y
4293	612.34	615.39	Y
4293	639.78	642.82	D
4293	642.82	645.87	D
4293	670.26	673.30	D
4293	673.30	676.35	D
4293	700.74	703.78	D
4293	703.78	706.83	D

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
FIELD SAMPLING PLAN ADDENDA
2006 FIELD SEASON

METAL LEACHING/ACID ROCK DRAINAGE CHARACTERIZATION

September 2006

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1. Introduction

Geological materials exposed, excavated, and processed during mining of the Pebble Project will have varying potentials for leaching of contained metals, as well as for production of acidic drainage. SRK Consulting (SRK) has been retained by Northern Dynasty Mines Inc. (NDM) to develop and implement a laboratory testing program for metal leaching and acid rock drainage (ML/ARD) to provide input to the prediction of water chemistry for the various mine components.

The 2005 sampling and analysis plan for ML/ARD provided a detailed description of methods used and samples obtained through March 2005.

2. 2006 Program

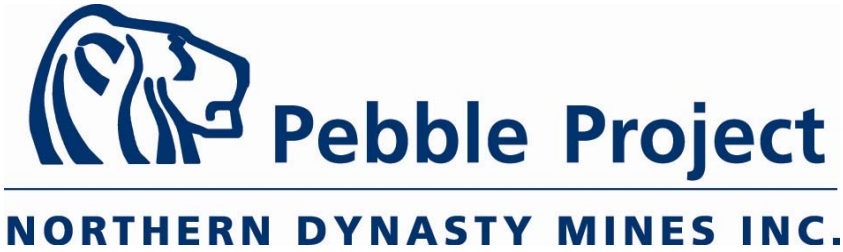
The 2006 program will be a continuation of the program described in the 2005 sampling and analysis plan. The following kinetic testing is ongoing:

- Waste Rock Humidity Cells—13 tests.
- Tailings Humidity Cells—2 tests.
- Waste Rock Subaqueous Columns—6 tests.
- Tailings Subaqueous Columns—6 tests

The data from these tests will be reviewed in June 2006 to determine which tests, if any, can be terminated as a result of stable trends. The balance of the tests will continue through 2006.

In addition to this test work, SRK will continue to liaise with NDM's exploration geologist to include geochemical static testing (ABA) in ongoing drilling programs at the site. ABA testing, as described in the 2005 sampling and analysis plan, will be conducted on selected overburden samples obtained from the 2006 drilling programs.

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Trace Elements and Natural Occurring Constituents



DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

NATURALLY OCCURRING CONSTITUENTS IN SURFACE SOIL, SEDIMENT, VEGETATION, AND FISH

NOVEMBER 2005

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Acronyms

ABR	Alaska Biological Research
°C	degrees Celsius
CAS	Columbia Analytical Services Ltd.
COC	chain of custody
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GIS	geographical information system
GPS	global positioning system
NCA	North Creek Analytical
NDM	Northern Dynasty Mines Inc.
oz	ounce
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
SGS	SGS Environmental Services, Ltd.
Shaw	Shaw Alaska, Inc.
SLR	SLR Alaska
USGS	U.S. Geological Survey

1. Introduction

This field sampling plan (FSP) provides guidance for collection of data on trace elements in soil and vegetation at the Pebble Project mine site. The FSP was prepared by SLR Alaska (SLR) at the direction of Northern Dynasty Mines Inc. (NDM). The purpose of the FSP is to update field procedures for conducting a study of naturally occurring constituents in surface soil and vegetation which was begun in 2004. The field work for this study in 2005 will involve collecting samples of surface soil, subsurface soil, terrestrial vegetation, and aquatic vegetation for analysis of naturally occurring trace elements and petroleum hydrocarbons.

2. Project Background

2.1 Project Purpose and Scope

The scope of the trace elements study allows for analysis of the spatial and temporal variability of trace elements and anions at the mine site. Also, a subset of soil samples will be analyzed for biogenic petroleum hydrocarbons to provide a baseline in the event of any potential petroleum-related releases in the future.

Based on the Bureau of Land Management's cadastral survey system of township-range-section, the mine site encompasses an area of 160 square miles. In 2004, to determine landforms and environmental media common to these landforms, 50 one-square-mile cells were randomly selected from a grid of 160 such cells which represented coverage of the mine-site area. Five landforms were identified, with 10 environmental media common to those land forms.

In 2004, the types and relative abundance of the different habitats was unknown, thus samples sites were located based on landform (e.g., geology, vegetative coverage). For 2005 studies, the approach will be slightly different because the number of samples collected will be based primarily on habitat type rather than on landform. Several locations in 2004 had insufficient vegetation for collection or had only one or two species in sufficient abundance for collection. Therefore, a different approach was developed to ensure the best representative coverage of various plant species of interest. Alaska Biological Research (ABR) has compiled habitat information, and a total of seven broad habitat types have been identified. Based on research and reconnaissance conducted during the 2004 sampling season, the areal extent of the seven habitat types will be considered in light of the 10 environmental media, and the identification of grids used as specific sampling locations will be modified appropriately.

Before soil and vegetation sampling begins, general sample locations in selected sections from the random grid system will be translated into latitude/longitude coordinates and transferred to a navigational global positioning system (GPS) on a helicopter. The majority of sampling locations will be randomly selected while ensuring that adequate coverage is provided for each of the habitat types. Some pre-planning will be required to identify an appropriate number of grids within each habitat type while keeping the total number of samples consistent with those from 2004. Where possible and relevant, the same locations sampled in 2004 will again be sampled in 2005 to provide an indication of annual variability in trace element concentrations in soil and vegetation. Final locations of 2005 sampling sites will be provided to the project team prior to beginning field work.

Defensible documentation and characterization of the existing natural levels of trace elements, anions, and petroleum hydrocarbons present in environmental media prior to mining operations will be generated. These baseline data will be used as part of the evaluation of future potential impacts to these media during operation, closure, and long-term site monitoring for the mine.

Risk aspects related to mine development and operation, including dust generation, will be considered to ensure that the sampling program and data-quality objectives for estimating natural

levels of trace elements and other chemicals in surface soil and vegetation will support a human health and/or ecological risk assessment.

2.2 Project Site Description

The Pebble Project site is located in southwestern Alaska in the headwater areas of the Koktuli River and Upper Talarik Creek. Mine operations will include open-pit mining, construction of earthen impoundment dams, tailings piles, gravel roads, and pads. These developments will traverse archetypical landscapes and ecological habitats. The landforms and associated habitats common to the region are characterized by specific surface soils and vegetation types.

3. Project Scope and Objectives

3.1 Objectives

The objectives of the trace elements study are as follows:

- Continue and update field procedures established in the 2004 study of naturally occurring constituents in surface soil and vegetation.
- Continue collecting baseline data to provide defensible documentation of the natural levels of trace elements and petroleum hydrocarbons in surface soil and vegetation, including their spatial and temporal variability, present prior to mining operations.
- Determine organic content in surface soils to support long-term site-monitoring objectives.

The information to be gathered in this trace elements study is key to understanding current conditions at the mine site and surrounding areas. It will provide a baseline for the evaluation of future, potential environmental impacts to soil and plants during mine operation and closure and will support long-term site-monitoring objectives.

3.2 Sample Analysis Summary

To achieve the objectives outlined above, the baseline study program includes a comprehensive data-collection effort across environmental media. SLR is responsible for collection of surface and subsurface soil, and aquatic and terrestrial vegetation samples at the mine site in 2005.

Soil samples will be appropriately documented and packaged and sent to SGS Environmental Services, Ltd. (SGS) in Anchorage, Alaska. The Columbia Analytical Services (CAS) laboratory in Kelso, Washington, will act as the quality assurance (QA) laboratory for the soil samples.

Vegetation samples will be appropriately documented and packaged and then sent to the CAS laboratory. The North Creek Analytical (NCA) laboratory in Portland, Oregon, will act as the QA laboratory for vegetation samples.

Samples will be analyzed for the trace elements listed in Table 1 by the indicated analysis methods.

TABLE 1. TRACE ELEMENT CONSTITUENTS AND ANALYTICAL METHODS

CONSTITUENT	METHOD
Soil	
Metals[1]	SW6010B/6020
Mercury	SW7471A
Diesel Range/Residual Range Organics	AK102/103
Ammonia as N	SM4500NH3G
Cyanide, Total	SM4500CN
Organic Carbon	E415.1
Vegetation	
Metals[1]	SW6010B/6020/E200.8
Mercury	SW7471A
Ammonia as N	SM4500NH3G
Cyanide, Total	E335.2

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

SW U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third edition, September 1986.

SM Standard Methods for the Examination of Water and Wastewater, 20th Edition.

E Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991.

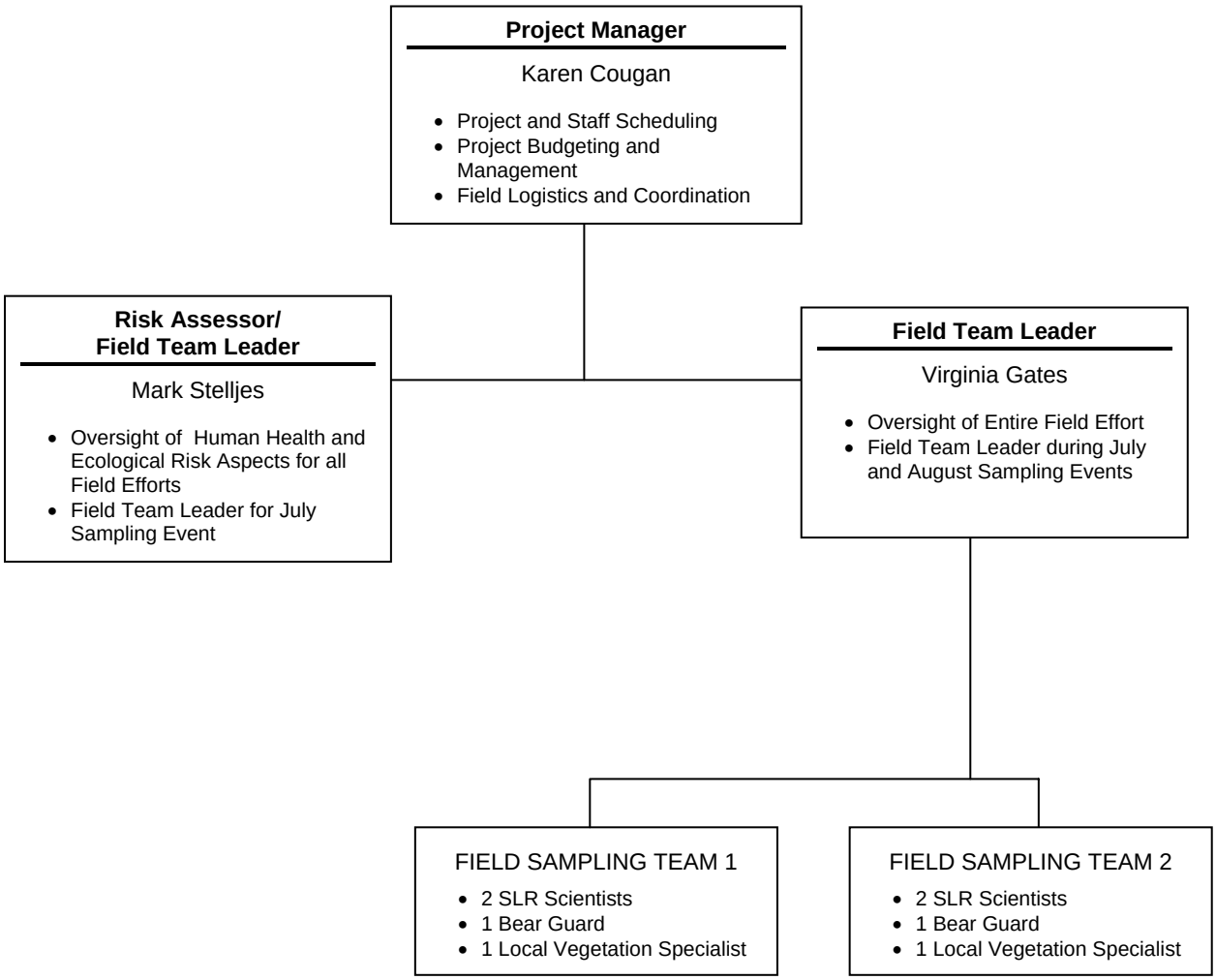
AK Methods for Determination of Aromatic and Aliphatic Hydrocarbons in Diesel and Residual Range Organics. Version 6-30-98.

3.3 Field Activities

As part of the 2005 field season, sampling events at the mine site will occur once in July and once in late August. This will include two soil and terrestrial vegetation sampling events and one aquatic vegetation sampling event (August only). The soil sampling event in August will include only locations that are determined to be necessary for further data evaluation.

4. Project Organization and Responsibility

The soil and vegetation sampling events will be conducted by SLR under direct contract to NDM. The following organizational chart outlines project management roles and responsibilities.



5. 2005 Sampling Program

The 2005 field sampling season will consist of two sampling events. During each sampling event, primary and quality control (QC) samples of soil and vegetation will be collected. In both July and August, approximately 88 soil samples will be collected at the mine site. During July, approximately 78 upland vegetation samples will be collected, while approximately 90 upland vegetation samples will be collected in the August (the additional 20 samples represent berry or fruit samples). During each sampling event, at 10 percent of the locations, duplicate (QC) and triplicate (QA) soil and vegetation samples will be collected. For collection of soil and vegetation samples, equipment blanks will also be prepared at a frequency of 5 percent of the primary samples. The sampling matrix is summarized in Table 2.

TABLE 2. 2005 SAMPLING SUMMARY

Medium	Number of Samples	Sampling Frequency	Number of Primary Samples	Number of Duplicates (QC Samples)	Number of Triplicates (QA Samples)	Total Lab Samples
Surface Soil	80	2	160	9	9	196
Subsurface Soil	8	2	16	1	1	20
Terrestrial Vegetation	78/98[1]	2	176	9	9	212
Aquatic Vegetation	18	1	18	2	2	22

1. Values reflect July and August sampling events without/with the additional 20 samples in August representing berries.

Before sampling begins, general sample locations in sections selected from the random grid system will be translated into longitude/latitude coordinates and transferred to a navigational GPS on the helicopter. Geographic coordinates collected for each sampling location will be recorded in a format compatible with the existing geographical information system (GIS) for the project to allow creation of maps depicting sampling locations.

The field team will use the helicopter to locate each section, where up to three sample locations will be staked, flagged, marked with the sample identification, and recorded by GPS. Field teams will begin sample collection immediately after the locations are recorded.

6. Sample Collection and Handling

These requirements are designed to maximize sample quality and to meet the stated data-quality objectives for the project (e.g., precision, accuracy, comparability, completeness, and representative quality). Sample methodologies and procedures for each type of environmental media to be encountered are described below.

Sampling for this project will be conducted in accordance with U.S. Environmental Protection Agency (EPA) and Alaska Department of Environmental Conservation guidelines for quality assurance and quality control (QA/QC). Procedures for compliance with QA/QC requirements are described in the Pebble Project *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (NDM, 2005).

In all cases, sample collection procedures will be followed to minimize contamination of samples, to prevent cross-contamination between samples, and to ensure sample validity by following proper preservation and storage procedures in the field.

Photo documentation of each sample site will be done.

6.1 Sampling Procedures

6.1.1 Surface Soil Sampling

One surface soil sample will be collected at each sample location during one of the two sampling events. Surface soil samples will be collected to a depth of 0.5 feet using hand tools, such as stainless steel or disposable polyethylene shovels or trowels. If an organic mat occurs at the surface, the mat will be removed before the soil sample is collected. The field sampling team will remove rocks and twigs from the samples. For each sample, an 8-ounce (oz) jar will be filled, if possible, or at least 50 grams will be collected (a minimum of 25 grams is necessary to meet laboratory requirements for data quality objectives [DQOs]). As described in the Pebble Project 2005 quality assurance project plan (QAPP; NDM, 2005), equipment blanks for soil media will be prepared at a frequency of 5 percent (1 for every 20 samples) using a deionized-water rinse after an Alconox wash. This will be done for the total metals analyses only, consistent with the QAPP.

The investigation-derived waste is expected to consist of sampling waste. This waste will be disposed of as follows:

- Sampling waste—which could include used nitrile gloves, plastic baggies, tape, paper towels, plastic wrapping, and aluminum foil—will be transported to and disposed of in Iliamna in approved receptacles.
- Excess sampling media—which could include removed soil—will be returned to the sample location and raked level after sampling.

6.1.2 Subsurface Soil Sampling

All soil sampling will once per sampling location, either in July or August 2005, concurrent with vegetation sampling events. Soil and vegetation samples will be co-located.

At approximately 10 percent of the surface-soil sample locations (eight locations), deeper samples, from the 0.5- to 1.5-foot interval, will be collected using hand tools, such as stainless steel or disposable polyethylene shovels or trowels. The field sampling team will remove rocks and twigs from the soil samples. For each sample, an 8 oz jar will be filled if possible, or at least 50 grams of subsurface soil will be collected (minimum for DQO is 25 grams). Equipment blanks will be prepared as discussed above for surface soils and at the same frequency.

Appropriate numbers of samples will be collected based on the areal extent of the basic habitat types. It is likely that no more than one subsurface sample will be collected from each habitat type.

The investigation-derived waste is expected to consist of sampling and storage devices, including nitrile gloves, plastic baggies, tape, paper towels, plastic wrapping, and aluminum foil. These wastes will be transported to and disposed of in Iliamna in approved receptacles.

Excess sampling media, which could include excavated soil, will be returned to the sample location and raked level after sampling.

6.1.3 Terrestrial Vegetation Sampling

Sampling for vegetation in 2005 will occur in two events, one in July and one in August. These vegetation sampling events will be concurrent with soil sampling events and, during August, will focus mostly on collecting berries not available during the July sampling event. Vegetation samples will be collected from the same locations as soil samples.

At the mine site, plant uptake of trace elements is the mechanism of most interest to the trace-elements characterization program. The purpose of two separate vegetation sampling periods is to address the different browse available in July and in August. For example, in early summer, willow shrubs have new growth and are beginning to flower, while in the fall, fruits have developed on the plants. Trace-element uptake into berries differs from uptake into new growth. As a result, the dietary concentrations of trace elements in edible plant parts is likely different throughout the growing season and can be characterized by the two sampling periods.

At each sample site, a sample plot encompassing a 10-foot radius from the soil sample location will be designated. Within each sample area, the vegetation species present will be documented. Four to eight species at each location will be sampled and may include moss, lichen, grass, shrub, or berry-producing plants, depending on the type and density present.

Both vegetation and berry samples will be collected, where available. It is expected that berry samples will be available only in the August sampling event. Non-woody material will be collected from the plants to ensure that edible portions of the plant species are analyzed (leaves and browsable twigs and shoots will be aggregated, and berries and fruits will be kept separate from vegetative plant material). Material will be collected from the plants using stainless steel clippers and nitrile-gloved hands; the material will be placed into sealed plastic bags.

To evaluate the contribution of metals to the sample from use of stainless steel clippers, an equipment blank of deionized water used to rinse the blade between samples will be collected and analyzed for trace elements. A similar blank will be collected from the blades used to homogenize the plant samples and analyzed by the laboratory. Where possible, each sample will represent a composite of approximately 50 grams within a taxonomic group (genus or species) from at least three plants. The analytical method requires at least 25 grams to meet DQOs.

Each sample will represent a taxonomic group (genus or species) identified at the mine site in 2004 surveys. In 2004, few trees were present at the mine site. Wherever possible, willows will be sampled as representative of tree species. Primary species to be sampled include fireweed (representing forbs), various species of sedges, caribou moss (representing lichens), green terrestrial moss (represent mosses), and bog blueberry and willow (representing shrubs). Selection of these particular species was based on overall dominance, bio-uptake potential, use as wildlife forage, and/or subsistence use.

The investigation-derived waste is expected to consist of sampling and storage devices, including nitrile gloves, plastic baggies, tape, paper towels, plastic wrapping, and aluminum foil. These wastes will be transported to and disposed of in Iliamna in approved receptacles.

Excess sampling media, which could include removed vegetative tissue, will be returned to the sample location and made level with a shovel after sampling.

6.1.4 Aquatic Vegetation Sampling

One aquatic vegetation event is scheduled for 2005. This will occur in August, concurrent with the second soil and terrestrial vegetation sampling events.

Aquatic vegetation samples will be collected from four to six lakes and ponds. Where possible, these lakes and ponds will be the same as those to be sampled by HDR Alaska, Inc., as part of their sediment sampling program. Methods will be similar to those outlined above for terrestrial vegetation, with one major difference. Human subsistence use and moose browse include the roots and tubers of aquatic plants; therefore, where feasible, roots and tubers of aquatic plants will be collected in addition to vegetative portions above the water-line. Vegetative portions above the water-line will be kept separate from roots and tubers for analysis.

Different tools than those used for terrestrial plant collection may be necessary to clip and collect aquatic vegetation, depending on the location of the vegetation (e.g., edge of lake versus deeper areas) and the type of plant (e.g., grasses need to be clipped at the sediment surface, while flowering plants can be clipped above the water surface, if sufficient mass is available). Above-water samples will be collected with nitrile-gloved hands and/or stainless steel clippers. Approximately 100 grams of edible browse above the water-line or sediment layer will be collected at each selected sampling point and placed into sealable plastic bags.

For roots and tubers, either the entire plant will be pulled out of the lake/pond and the roots and tubers collected, or a shovel or similar device will be used to pull out the roots and tubers for collection.

The investigation-derived waste is expected to consist of sampling and storage devices, including nitrile gloves, plastic baggies, tape, paper towels, plastic wrapping, and aluminum foil. These wastes will be transported to and disposed of in Iliamna in approved receptacles.

Excess sampling media, which could include removed vegetative tissue, will be returned to the sample location after sampling.

6.2 Sampling Equipment Decontamination

All non-disposable sample-collection equipment that comes into contact with a sample will be decontaminated by means specified in the 2005 QAPP (NDM, 2005). At a minimum, sampling-equipment decontamination will consist of the following:

1. Rinse in tap water or deionized water.
2. Wash with a solution of Alconox mixed with deionized water.
3. Double rinse in deionized water.

The purpose of the water and Alconox wash is to remove all visible particulate matter. The deionized-water rinse removes the detergent. These procedures will be followed between samples. Gloves will also be changed between samples to prevent possible cross-contamination.

6.3 Sample Handling

During each sampling event, Shaw Alaska Inc. (Shaw) will have one to three field staff stationed in Iliamna. All analytical samples will be delivered to the Shaw field staff, who will pack and ship the samples to the appropriate laboratory in accordance with the procedures outlined in the 2005 QAPP (NDM, 2005). To preserve soil and vegetation sample integrity from collection to receipt by Shaw, all coolers will contain blue ice in accordance with the QAPP.

6.3.1 Sample Volumes, Container Types, and Preservation Requirements

The appropriate number and type of sample bottles/containers will be ordered from the relevant laboratories prior to each sampling event. Surface and subsurface soil samples will be collected in accordance with Table 3, which shows volume, container type, and preservation measures.

TABLE 3. SAMPLE BOTTLE SCHEDULE AND SAMPLING PARAMETERS FOR SOIL COLLECTION

Bottle Type (SGS)	Bottle Type (CAS)	Analysis	Preservative[3]	Hold Time	Required Temp
(1) 8 oz	(1) 8 oz	Diesel/residual range organics	None	14 days to extraction, 40 days to analysis of extract	4°C
(1) 8 oz		Total metals [1]	None	6 Months	None
		Total mercury	None	28 Days	4°C
		Cyanide	None	28 Days[2]	4°C
(1) 4 oz	(1) 4 oz	Ammonia as N	None	28 Days	4°C
(1) 8 oz	(1) 8 oz	Chloride, fluoride, sulfate	None	28 Days	4°C
(1) 4 oz	(1) 4 oz	Total organic carbon	None	180 Days	4°C

oz – ounce: lab weighed and tared

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, Zn

2. As per EPA methods factsheet titled “Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity”

3. Holding time is from the date of preparation.

Aquatic and terrestrial vegetation samples will be collected in accordance with Table 4, which shows volume, container type, and preservation measures.

TABLE 4. SAMPLE BOTTLE SCHEDULE AND SAMPLING PARAMETERS FOR VEGETATION COLLECTION

Tissue Type	Minimum Sample Amount (grams)	Container Type CAS/NCA)	Analysis	Lab Method	Hold Time	Required Temp
Vegetation	25	Sealable plastic bag	Total Metals[1]	SW6010B/6020	6 Months	None
			Total Cyanide	None	28 Days[2]	4°C
			Mercury (total)	SW7471	28 Days	4°C

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

2. As per EPA methods factsheet titled “Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity”

6.3.2 Sample Identification

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 identification code, analysis, and

sampler's initials. Each sampling location also will be identified by the sampler on a field form. The sample identification codes will be formatted to indicate sample date (month and year), location, matrix, and number, as follows:

0105CR199ASL001

Where:

0105 is the date as month/year

CR199A is the location identification

SL is the matrix code for surface soil

001 is a sequential sample number

The matrix codes to be used:

SL – Surface soil

SS – Subsurface soil

TP – Terrestrial plant tissue

AP – Aquatic plant tissue

For field duplicates, the sequential sample number will be 201, and for triplicates it will be 301.

For vegetation samples, a two- or three-letter code for each species will be added as a suffix to the sample identification code—for example, 0804TE12TP001Pm is a sample of *picea mariana* (or black spruce) from location TE12 collected in August 2004. The two- or three-letter suffixes to be used for sample designation are listed in Tables 5 and 6.

TABLE 5. TERRESTRIAL PLANT SPECIES NAMES AND ID SUFFIXES

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Trees		
Black spruce	*Picea mariana*	Pm
White spruce	*Picea glauca*	Pg
Mountain hemlock	*Tsuga mertensiana*	Tm
Quaking aspen	*Populus tremuloides*	Pt
Paper birch (Kenai birch)	*Betula papyrifera*	Bp
Shrub birch	*Betula nana*	Bn
Balsam poplar	*Populus balsamifera*	Pb
Common juniper	*Juniperus communis*	Jc
Mountain alder/Sitka alder	*Alnus crispa*	Ac
Shrub or dwarf birch	*Betula nana*	Bn

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Prickly rose	*Rosa acicularis*	Ra
Tundra rose	*Dasiphora floribunda*	Df
Trailing black currant	*Ribes laxiflorum*	Rl
Northern red currant	*Ribes triste*	Rt
Skunk or northern black currant	*Ribes glandulosum or hudsonianum*	Rg or Rh
Bog blueberry	*Vaccinium uliginosum*	Vu
Early blueberry	*Vaccinium ovalifolium*	Vo
Feltleaf willow	*Salix alaxensis*	Sa
Barren-ground willow	*Salix brachycarpa*	Sb
Diamond-leaf willow	*Salix planifolia*	Sp
Willow (species not identified)	*Salix sp.*	Ssp
Shrubby cinquefoil (tundra rose)	*Dasiphora floribunda*	Df
Red-fruit bearberry	*Arctostaphylos rubra*	Ar
Bog rosemary	*Andromeda polifolia*	Ap
Rusty menzisii	*Menziesia ferruginea*	Mfe
Canadian burnet	*Sanguisorba canadensis*	Sca
Dwarf dogwood	*Cornus canadensis*	Cc
Salmonberry	*Rubus spectabilis*	Rs
Elderberry	*Sambucus racemosa*	Sr
Narrow leaf Labrador tea	*Ledum palustre*	Lp
Sweet gale	*Myrica gale*	Mg
Crowberry	*Empetrum nigrum*	En
Lingonberry (low bush cranberry)	*Vaccinium vitis-idaea*	Vv
Grasses		
Alaska cotton or cotton grass	*Eriophorim scheuchzeri*	Es
Beach rye	*Leymus mollis*	Lm
Sedge (species not identified)	*Carex sp.*	Ss
Short stalk sedge	*Carex microchaeta*	Cm
Northern water sedge	*Carex aquatilis*	Ca
Blue joint grass	*Calamagrostis sp.*	Cs

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Forbs		
Worm wood	*Artemisia tilesii*	At
Fireweed	*Chamerion angustifolium*	Ca
Cloudberry	*Rubus chamaemorus*	Rc
Wild celery (putchkie)	*Angelica genuflexa*	Ag
Iris	*Iris setosa*	Is
Cow parsnip	*Heracleum maximum*	Hm
Lupine	*Lupinus nootkatensis*	Ln
Sour dock	*Rumex arcticus*	Rar
Wild rhubarb	*Polygonum alaskanum*	Pa
False hellebore	*Veratrum viride*	Vvi
Eskimo potato	*Hedysarum alpinum*	Ha
Wild sweet pea	*Hedysarum mackenzii*	Hm
Marsh five finger	*Comarum palustre*	Cp
Beautiful Jacob's ladder	*Polemonium pulcherrimum*	Ppu
Fringed willow herb	*Epilobium ciliatum*	Epc
Monkshood	*Aconitum delphinifolium*	Ad
Partridgefoot	*Luetkea pectinata*	Lpe
Alaska spirea	*Spiraea stevenii*	Sst
Trailing raspberry	*Rubus pedatus*	Rp
Northern yarrow	*Achillea borealis*	Ab
Golden rod	*Solidago decumbens*	Sd
Star flower	*Trientalis europea*	Te
Rose root/stone crop	*Rhiodiola rosea*	Sro
Devil's club	*Opolopanax horridus*	Oh
Beach lovage	*Ligusticum scoticum*	Ls
Horse tail	*Equisetum pratense*	Ep
Ferns and Fern Allies		
Lady fern	*Athyrium filix-femina*	Af
Spreading wood fern	*Dryopteris expansa*	De

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Mosses		
Green terrestrial moss	*Ptelium crista casttensis*	Pcc
Club moss	*Lycopodium annotinum*	La
Stair-step moss	*Hylocomium splendens*	Hs
Lichens		
Reindeer lichen or caribou “moss"	*Cladina rangiferina*	Cr

TABLE 6. AQUATIC PLANT SPECIES NAMES AND SUFFIXES

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Yellow pond lily	*Nuphar polysepalum*	Npo
Water hemlock	*Cicuta douglasii*	Cdo
Mare's tail	*Hippuris vulgaris*	Hvu
Coon's tail or hornwort	*Ceratophyllum demersum*	Cde
Narrow-leaved bur-reed	*Sparganium angustifolium*	San
Giant bur-reed	*Spariganium eurycarpum*	Seu
Common cattail	*Typha latifolia*	Tia
Broad-leaved water plantain	*Alisma plantago-aquatica*	Apa
Arum-leaved arrowhead	*Sagittaria cuneata*	Scu
Water smartweed	*Polygonum amphibium*	Ppe
Clasping-leaf pondweed	*Potamogeton perfoliatus*	Sp
Fries' pondweed	*Potamogeton friesil*	Pfr
Thread-leaved pondweed	*Potamogeton filiformis*	Pfi
Vernal water-starwort	*Callitriche verna*	Cve
Spiked water-milfoil	*Myriophyllum spicatum*	Msp
Large-leaved white water-crowfoot	*Ranunculus aquatilis*	Raq
Yellow water-crowfoot	*Ranunculus gmelinii*	Rgm
Common duckweed	*Lemna minor*	Lmi
Bladderwort	*Utricularia (vulgaris, minor or intermedia)*	Utr

6.4 Sample Custody

Sample custody procedures will be followed in the field, in the laboratory, and during transport. The procedures take into account the nature of the samples, the maximum holding times, and shipping options from Iliamna to the laboratories.

Once collected, the samples will remain within sight of the sampler or will be secured until the samples are handed over to and prepared for shipment by Shaw personnel. Samples collected by SLR will be yielded to Shaw field staff at the end of each sampling day. SLR will have labeled each sample with the following:

- SLR's name.
- Sample or location identification.
- Sample data and time.
- Required analyses.
- Sample type: primary, duplicate (QC), triplicate (QA).

Shaw field staff will prepare the chain-of-custody (COC) form and labels using E-chain (an electronic COC application). They will also be responsible for packaging and shipping samples to the appropriate laboratories. SLR is responsible for providing Shaw with sufficient frozen blue ice and packaging materials to properly transport samples collected during each sampling event.

Each time a sample cooler changes hands, both the sender and the receiver will sign and date the COC form. The laboratory will forward the original to the analytical QA/QC manager. Shaw's field team will verify all COC forms before sample shipment and will make a copy of each to maintain a duplicate set of records. The following information is to be included on the COC form:

- Sample identification code.
- Signature of sampler.
- Date and time of collection.
- Project name.
- Type of sample.
- Number and type of containers.
- Sample preservation method.
- Sample analysis requested.
- Inclusive dates of possession.
- Signature of receiver.

The consulting company's name, addresses, and phone number is required on the COC. Laboratories will be instructed to invoice NDM and to mail reports to:

Jane Whitsett
Shaw Alaska Inc.
2000 West International Airport Road, Suite A-11
Anchorage, AK 99502

Other COC components will include sample labels, field notebooks, sample shipment receipts, and the laboratory logbook.

6.5 Field Quality Control Samples

6.5.1 Field Duplicates

Field duplicate samples will be collected at 10 percent of soil and vegetation sample locations. See Section 5 for specific number of duplicates planned for collection in each medium.

6.5.2 Field Triplicates

Field triplicate samples will be collected at 10 percent of soil and vegetation sample locations. See Section 5 for specific number of triplicates planned for collection in each medium.

7. Measurement of Field Parameters

7.1 Parameters

At each sample site, plants and soil types will be identified and approximate ambient temperature and weather conditions will be recorded.

7.2 Equipment Calibration and Field-Procedures Quality Control

No equipment requiring calibration will be used for the trace elements soil and vegetation sampling program.

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 reviewing field forms for completeness and accuracy. 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.

7.3 Equipment Maintenance and Decontamination

Field team managers are responsible for field equipment testing, inspection, and maintenance decisions. Equipment will be maintained in good operating condition. Sampling equipment will be decontaminated as detailed in Section 6.2.

8. Record Keeping

The field team leader will be responsible for overseeing that adequate detail is recorded on the field forms. The forms will contain sufficient information so that all field activity can be reconstructed without relying on the memory of the field crew.

8.1 Field Logbooks

Field forms will be the primary method of record keeping; however, each sampling team may also keep a separate field logbook for additional notes.

8.2 Field Forms

A modified version of CH2M Hill's 2004 field forms will be used during the 2005 sampling events. 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. Comprehensive information on the sampling site and respective samples collected at each site will be recorded by the field crew. This information includes site and sampling GPS positions, field observations, field measurements, sample identification, sample duplicates, and date and time the samples were collected.

Field forms will be maintained for each task. Field forms will consist of waterproof pages, written in indelible ink, with every appropriate area marked. All corrections will consist of initialed, single-line-out deletions, and blank pages will be marked as such with a diagonal line across the page, when appropriate.

Strict custody procedures will be maintained with the field forms used. No accountable documents will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. While being used in the field, forms will remain with the field team and will be secured on a clip board or, at a minimum, with rubber bands at all times.

The field team leader will review all data before leaving the sampling station. Upon completion of the field effort, forms will be filed in an appropriately secure manner in a notebook labeled "original data." These forms will remain with the task manager. Photocopies of the original data will be used as working documents. Completed field forms will be kept on file for future reference.

9. Field Performance and System Audits

SLR will perform field performance and system audits at a minimum during one soil and one vegetation sampling event. The field performance and system audit will be conducted by a senior-level SLR employee. The audit will evaluate if field procedures are being correctly implemented and will also identify any additional measures that may be taken to improve field data collection, as warranted.

10. References

CH2M Hill. 2004. Baseline Environmental/Impact Assessment Studies for Trace Elements Work Plan. Prepared for Northern Dynasty Mines Inc., by CH2M Hill. October 2004.

Northern Dynasty Mines Inc. (NDM). 2005. Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan.

U.S. Environmental Protection Agency (EPA). 2005. Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity. http://www.epa.gov/reg3hwmd/bfs/regional/analytical/petroleum.htm

Pebble Project

NORTHERN DYNASTY MINES INC.

ENVIRONMENTAL BASELINE STUDIES
FIELD SAMPLING PLAN

NATURALLY OCCURRING CONSTITUENTS IN SURFACE SOIL, SEDIMENT, AND VEGETATION AT THE MINE SITE

JULY 2006

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Acronyms

ABR	Alaska Biological Research
°C	degrees Celsius
CAS	Columbia Analytical Services Ltd.
COC	chain of custody
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GIS	geographical information system
GPS	global positioning system
NCA	North Creek Analytical
NDM	Northern Dynasty Mines Inc.
oz	ounce
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
SGS	SGS Environmental Services, Ltd.
Shaw	Shaw Alaska, Inc.
SLR	SLR Alaska
USGS	U.S. Geological Survey

1. Introduction

This field sampling plan (FSP) provides guidance for collection of data on trace elements in soil and vegetation at the Pebble Project mine site. The FSP was prepared by SLR Alaska (SLR) for Northern Dynasty Mines Inc. (NDM). The purpose of the FSP is to update field procedures for conducting a study of naturally occurring constituents in surface soil and vegetation which began in 2004. The field work to be conducted in 2006 will involve collecting samples of surface soil, terrestrial vegetation, aquatic vegetation, and lake/pond sediments for analysis of naturally occurring trace elements and potential petroleum hydrocarbons.

2. Project Background

2.1 Project Site Description

The Pebble Project site is located in southwestern Alaska in the headwater areas of the Koktuli River and Upper Talarik Creek. Mine operations may include open-pit mining, underground mining, construction of earthen impoundment dams, tailings piles, gravel roads, and pads. These developments will traverse archetypical landscapes and ecological habitats. The landforms and associated habitats common to the region are characterized by specific surface soils and vegetation types.

2.2 Summarized Trace Elements Historical Sampling

Based on the Bureau of Land Management's cadastral survey system of township-range-section, the mine site encompasses an area of 160 square miles. In 2004, to determine landforms and environmental media common to these landforms, 50 one-square-mile cells were randomly selected from a grid of 160 such cells, which represented coverage of the mine-site area. Five landforms were identified, with 10 environmental media common to those land forms.

In 2004, the types and relative abundance of the different habitats were unknown, thus sample site locations were based on landforms (e.g., geology, vegetative coverage). Several locations in 2004 had insufficient vegetation for collection or had only one or two species in sufficient abundance for collection. Therefore, in 2005, a different approach was developed to ensure the best representative coverage of various plant species of interest. Alaska Biological Research (ABR) has compiled habitat information, and a total of seven broad habitat types have been identified. Based on research and reconnaissance conducted during the 2004 sampling season, the aerial extent of the seven habitat types was considered in light of the 10 environmental media, and the identification of grids used as specific sampling locations was modified appropriately.

For the 2005 studies, the approach was slightly different because the number of samples collected was based primarily on habitat type rather than on landform. The majority of sampling locations were randomly selected while ensuring that adequate coverage was provided for each of the habitat types. Some pre-planning was required to identify an appropriate number of grids within each habitat type while keeping the total number of samples consistent with those from 2004. Where possible and relevant, the same locations sampled in 2004 were again sampled in 2005 to provide an indication of annual variability in trace element concentrations in soil and vegetation.

3. Project Scope and Objectives

3.1 Scope

The scope of the trace elements study allows for analysis of the spatial and temporal variability of trace elements and anions at the proposed mine site. Also, a subset of soil samples will be analyzed for biogenic petroleum hydrocarbons to provide a baseline in the event of any potential petroleum-related releases in the future.

Defensible documentation and characterization of the existing natural levels of trace elements, anions, and potential petroleum hydrocarbons present in environmental media prior to mining operations will be generated. These baseline data will be used as part of the evaluation of future potential impacts to these media during operation, closure, and long-term site monitoring of the mine. Risk aspects related to mine development and operation, including dust generation, will be considered to ensure that the sampling program and data-quality objectives for estimating natural levels of trace elements and other chemicals in surface soil and vegetation will support a human health and/or ecological risk assessment.

3.2 Objectives

The objectives of the trace elements study are to:

- Continue and update field procedures established in the 2004 and 2005 studies of naturally occurring constituents in surface soil and vegetation.
- Continue collecting baseline data to provide defensible documentation of the natural levels of trace elements and biogenic hydrocarbons in surface soil and vegetation, including their spatial and temporal variability, present prior to mining operations.
- Determine organic content in surface soils to support long-term site-monitoring objectives.
- Characterize naturally occurring constituents found in vegetation and sediment in different types of ponds/lakes present in the area.

The information to be gathered in this trace elements study is key to understanding current conditions at the mine site and surrounding areas. It will provide a baseline for the evaluation of future potential environmental impacts to soil and plants during mine operation and closure and will support long-term site-monitoring objectives.

3.3 Sample Analysis Summary

To achieve these objectives, the baseline study program includes a comprehensive data-collection effort across environmental media. SLR is responsible for collection of surface soil, aquatic and terrestrial vegetation, and four pond/lake sediment samples in Pebble West, and one pond/lake sediment sample in Pebble East in 2006.

Soil samples will be appropriately documented and packaged and sent to SGS Environmental Services, Ltd. (SGS) in Anchorage, Alaska. The Columbia Analytical Services (CAS) laboratory in Kelso, Washington, will act as the quality assurance (QA) laboratory for the soil and sediment samples.

Sediment samples will be appropriately documented and packaged and then sent to the SGS laboratory. However, the sulfur (total), AVS-SEM samples will be sent to the CAS laboratory. For sulfur (total), AVS-SEM, QA samples will be sent to Severn Trent Laboratory in Seattle, Washington. CAS will act as the QA laboratory for the remaining analyses.

Vegetation samples will be appropriately documented and packaged and then sent to the CAS laboratory. The North Creek Analytical (NCA) laboratory in Portland, Oregon, will act as the QA laboratory for vegetation samples.

Samples will be analyzed for the trace elements listed in Table 1, as shown of the next page, by the indicated analytical methods.

TABLE 1. TRACE ELEMENT CONSTITUENTS AND ANALYTICAL METHODS

CONSTITUENT	METHOD
Soil	
Metals[1]	SW6010B/6020
Mercury	SW7471A
Diesel Range/Residual Range Organics	AK102/103
Ammonia as N	SM4500NH3G
Cyanide, Total	SM4500CN
Organic Carbon	E415.1
Vegetation	
Metals[1]	SW6010B/6020/E200.8
Mercury	SW7471A
Cyanide, Total	E335.2
Sediments	
Metals[1]	E200.7/200.8
Mercury	SW7471A
Ammonia as N	SM4500NH3G
Cyanide, Total	SM4500CN-E or E335.2
Chloride, Fluoride, Sulfate	E300.0
Sulfur, total	EPA 300M
AVS (acid volatile sulfide)	Draft E1991
SEM (simultaneously extracted metals)	6010B

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

SW U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third edition, September 1986.

SM Standard Methods for the Examination of Water and Wastewater, 20th Edition.

E Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991.

AK Methods for Determination of Aromatic and Aliphatic Hydrocarbons in Diesel and Residual Range Organics. Version 6-30-98.

3.4 Field Activities

As part of the 2006 field season, sampling events at the mine site will occur once in July and once in August. Activities for SLR will include one soil sampling event in July, two terrestrial vegetation sampling events (one in July and one in August) and one sediment sampling event (August only) from the four pond/lakes sampled in August 2005 in Pebble West, and the new pond/lake in Pebble East.

Aquatic vegetation sampling will be conducted in coordination with HDR. The Pebble West ponds/lakes sampled during August 2005 and the new pond/lake in Pebble East will be sampled in the August 2006 sampling event. Sampling of the additional ponds included in this year's Scope of Work will be divided into the two sampling events, depending on the location and presence of vegetation at each pond. SLR will collect aquatic vegetation at these ponds/lakes in conjunction with surface water and sediment sample collection by HDR.

For the 2006 studies at the mine site, subsurface soil samples will not be collected because review of data from the 2004 and 2005 sampling programs indicated that the results from samples collected at depth were equal or less than the concentrations from surface samples.

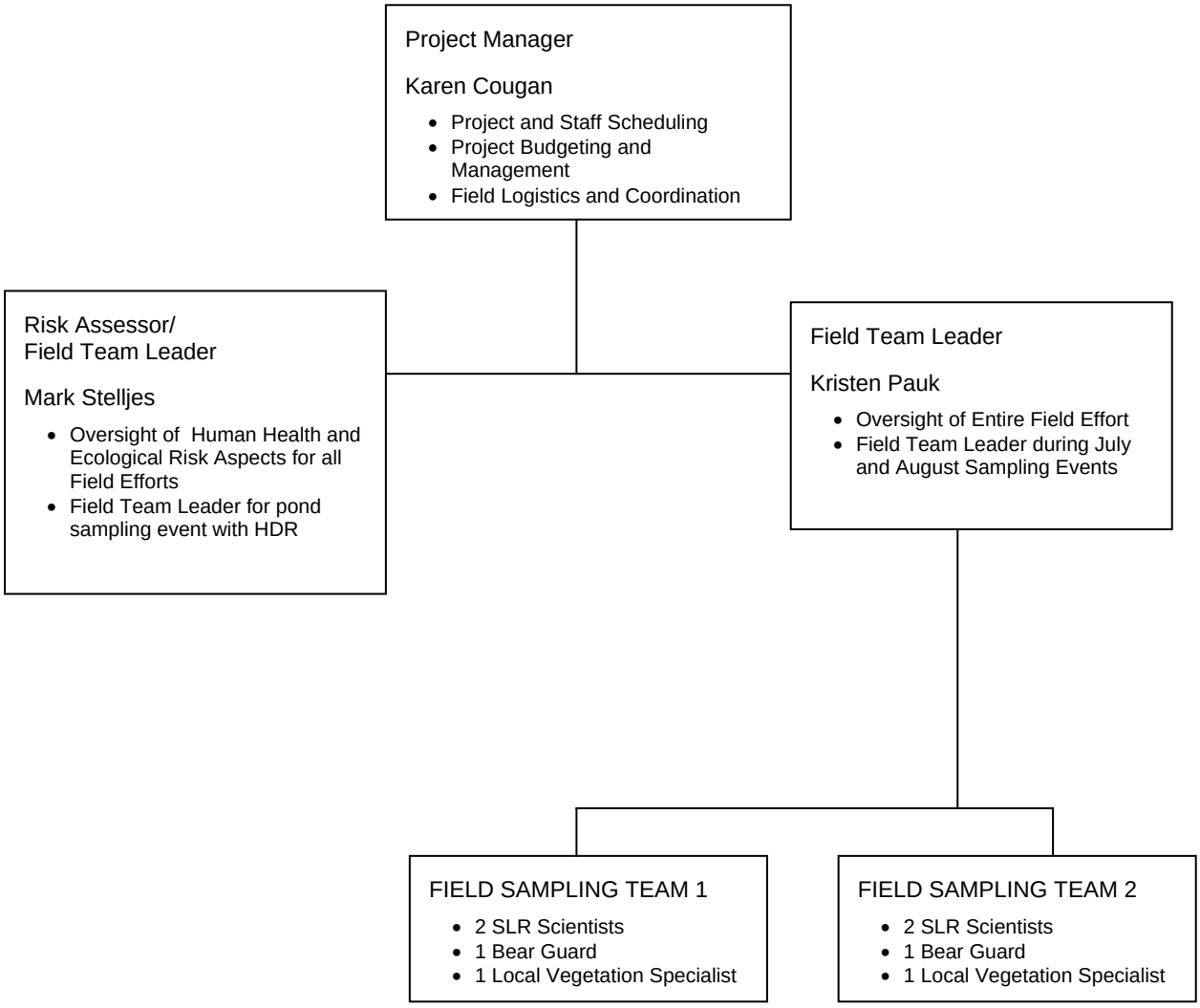
In 2006, fewer samples will be collected in the area of Pebble West, where extensive sampling has already occurred. Additional samples will be collected in the area of Pebble East, where little trace element sampling has been historically performed. The number of samples to be collected in 2006 is summarized by area and study on Table 7.1-3 of the 2006 Study Plan (NDM, 2006). Two sampling events will be conducted for terrestrial vegetation, consistent with the 2005 Study Plan. The rationale for the modifications to the sampling in 2006 is threefold:

- The short-term goal of the program is to collect data from two years at each location. Since some locations were only added last year, an additional round of sampling is needed at these new locations. This is a subset of the locations sampled in the mine site area in 2005.
- Identification of the new eastern deposit (Pebble East) requires characterization of baseline conditions in the watershed in the vicinity of this new deposit. Surface soil samples, vegetation samples, pond and lake water samples, and pond and lake sediment samples will be collected from sample sites in Pebble East.
- Suggestions for focused sampling of specific moss and lichen were discussed at the agency meetings conducted after the 2005 field sampling season. Specifically, the agencies suggested that mosses and lichen that have exhibited increased uptake of trace elements from other studies should be considered.

Pond sediment sampling will be conducted as outlined in Section 7.1.2.2 of the 2005 study plan (NDM, 2006b), with an additional chemical analysis included. This new analysis, which involves total sulfur and acid volatile sulfide/simultaneously extracted metals (AVS-SEM), is designed to evaluate the bioavailability of trace elements in sediment. Pond sampling is intended to be conducted in coordination with HDR so that water, sediment, and aquatic vegetation samples are temporally collocated.

4. Project Organization and Responsibility

The soil, pond/lake sediment and vegetation sampling events will be conducted by SLR under direct contract to NDM. The following organizational chart outlines project management roles and responsibilities.



5. 2006 Sampling Program

The 2006 field sampling program for the Mine site study area (Pebble West and Pebble East) will consist of two sampling events, July and August. In July 2006, approximately 36 primary soil, 64 primary terrestrial vegetation, 24 primary aquatic vegetation, and 9 primary pond/lake sediment samples will be collected at the proposed mine study area. During the August 2006 sampling event approximately 96 primary terrestrial vegetation (the additional 32 samples represent berry or fruit samples), 44 aquatic vegetation samples, and 24 pond/lake sediments will be collected.

One sample event will be conducted in the transportation corridor by BEESC in 2006. The sample event that is scheduled to occur in August 2006 includes approximately 72 terrestrial vegetation samples (included two berry samples per location).

Before soil and vegetation sampling begins, sample locations will be translated into latitude/longitude coordinates and transferred to a navigational global positioning system (GPS). Where relevant, the same locations sampled in 2005 will again be sampled in 2006 to provide an indication of annual variability in trace element concentrations in soil and vegetation.

During each sampling event, primary and quality control (QC) samples of soil, pond/lake and creek sediments, creek surface water and vegetation will be collected. Duplicate QC and triplicate quality assurance (QA) soil, sediment, surface water and vegetation samples will be collected at 10 percent of the locations for each event. For collection of soil, sediment, surface water and vegetation samples, equipment blanks will also be prepared at a frequency of 5 percent of the primary samples. The sampling matrix is summarized in Table 2.

TABLE 2. 2006 SAMPLING SUMMARY

Medium	Number of Samples	Sampling Frequency	Number of Primary Samples	Number of Duplicates (QC Samples)	Number of Triplicates (QA Samples)	Total Lab Samples
Mine Studies Area (SLR)						
Surface Soil	36	1	36	4	4	44
Terrestrial Vegetation	64/96[1]	2	160	15	15	190
Aquatic Vegetation	68[2]	1	68	9	9	86
Pond/Lake Sediment Samples	33	1	33	4	44	41
Transportation Corridor (BEESC)						
Surface Soil	12	1	12	2	2	16
Terrestrial Vegetation	72	1	72	7	7	86
Aquatic Vegetation	4	1	4	1	1	6
Pond and Creek Sediment	10	1	10	2	2	14
Creek Surface Water	7	1	7	1	1	9

1. Values reflect July and August sampling events without/with the additional 32 samples in August representing berries.

2. Includes pond study samples.

Geographic coordinates collected for each sampling location will be recorded in a format compatible with the existing geographical information system (GIS) for the project to allow creation of maps depicting sampling locations.

The field team will use the helicopter to locate each section, where up to three sample locations will be staked, flagged, marked with the sample identification, and recorded by GPS. Field teams will begin sample collection after the locations are recorded.

6. Sample Collection and Handling

These requirements are designed to maximize sample quality and to meet the stated data-quality objectives for the project (e.g., precision, accuracy, comparability, completeness, and representative quality). Sample methodologies and procedures for each type of environmental media to be encountered are described below.

Sampling for this project will be conducted in accordance with U.S. Environmental Protection Agency (EPA) and Alaska Department of Environmental Conservation guidelines for quality assurance and quality control (QA/QC). Procedures for compliance with QA/QC requirements are described in the Pebble Project *Draft Environmental Baseline Studies, Draft 2006 Final Quality Assurance Project Plan* (QAPP) (NDM, 2006).

In all cases, sample collection procedures will be followed to minimize contamination of samples, to prevent cross-contamination between samples, and to ensure sample validity by following proper preservation and storage procedures in the field.

Photo documentation will be performed for each sample site.

6.1 Sampling Procedures

6.1.1 Surface Soil Sampling

One surface soil sample will be collected at each sample location during one of the two sampling events. Surface soil samples will be collected at a depth of approximately 0.5 feet using hand tools, such as stainless steel or disposable polyethylene shovels or trowels. If an organic mat occurs at the surface, the mat will be removed before the soil sample is collected. The field sampling team will remove large rocks and twigs from the samples. For each sample, an 8-ounce (oz) jar will be filled with approximately 50 grams of soil (a minimum of 25 grams is necessary to meet laboratory requirements for data quality objectives [DQOs]). As described in the Pebble Project Draft 2006 Final QAPP (NDM, 2006), equipment blanks for soil media will be prepared at a frequency of 5 percent (1 for every 20 samples) using a deionized-water rinse after an Alconox wash. This will be done for the total metals analyses only, consistent with the QAPP.

6.1.2 Terrestrial Vegetation Sampling

Sampling for vegetation in 2006 will occur in two events, one in July and one in August. The August vegetation sampling event will focus mostly on collecting berries not available during the July sampling event. Vegetation samples will be collected from the same locations as soil samples.

At the mine site, plant uptake of trace elements is the mechanism of most interest to the trace-elements characterization program. The purpose of two separate vegetation sampling periods is to address the different browse available in July and in August. For example, in early summer, willow shrubs have new growth and are beginning to flower, while in the fall, fruits have developed on the plants. Trace-element uptake into berries differs from uptake into new growth. As a result, the dietary concentrations of trace elements in edible plant parts is likely different throughout the growing season and can be characterized by the two sampling periods.

At each sample site, a sample plot encompassing a 10-foot radius from the soil sample location will be designated. Within each sample area, the vegetation species present will be documented. Four to eight species at each location (depending on the type and density present) will be sampled and may include moss, lichen, grass, shrub, or berry-producing plants.

Both vegetation and berry samples will be collected, where available. It is expected that berry samples will be available only in the August sampling event. Non-woody material will be collected from the plants to ensure that edible portions of the plant species are analyzed (leaves and browsable twigs and shoots will be aggregated, and berries and fruits will be kept separate from vegetative plant material). Material will be collected from the plants using stainless steel clippers and nitrile-gloved hands; the material will be placed into sealed plastic bags.

To evaluate the contribution of metals to the sample from use of stainless steel clippers, an equipment blank of deionized water used to rinse the blade between samples will be collected and analyzed for trace elements. A similar blank will be collected from the blades used to homogenize the plant samples and will be analyzed by the laboratory. Where possible, each sample will represent a composite of approximately 50 grams within a taxonomic group (genus or species) from at least three plants. The analytical method requires at least 25 grams to meet DQOs.

Each sample will represent a taxonomic group (genus or species) identified at the mine site in the 2004 and 2005 surveys. In 2004, few trees were present at the mine site. Wherever possible, willows will be sampled as representative of tree species. Primary species to be sampled include equisetum (representing forbs), various species of sedges, reindeer lichen (representing lichens), various species of mosses, and bog blueberry. Selection of these particular species was based on overall dominance, bio-uptake potential, use as wildlife forage, and/or subsistence use.

6.1.3 Aquatic Vegetation Sampling

Aquatic vegetation samples will be collected from five lakes and ponds and will occur in August. Four of these lakes and ponds in Pebble West will be the same as those sampled in 2005, and one new pond/lake located within the Pebble East deposit area in 2006.

Methods will be similar to those outlined above for terrestrial vegetation, with one major difference. Human subsistence use and moose browse include the roots and tubers of aquatic plants; therefore, where feasible, roots and tubers of aquatic plants will be collected in addition to vegetative portions above the water-line. Vegetative portions above the water-line will be kept separate from roots and tubers for analysis.

Different tools than those used for terrestrial plant collection may be necessary to clip and collect aquatic vegetation, depending on the location of the vegetation (e.g., edge of lake versus deeper areas) and the type of plant (e.g., grasses need to be clipped at the sediment surface, while flowering plants can be clipped above the water surface, if sufficient mass is available). Above-water samples will be collected with nitrile-gloved hands and/or stainless steel clippers. Approximately 100 grams of edible browse above the water-line or sediment layer will be collected at each selected sampling point and placed into sealable plastic bags.

For roots and tubers, either the entire plant will be removed of the lake/pond and the roots and tubers collected, or a shovel or similar device will be used to remove the roots and tubers for collection.

6.1.4 Pond Sediment Sampling

New to the SLR Trace Elements Program in 2006 is the addition of sediments collected from all lakes or ponds where water and aquatic vegetation samples are collected. In August 2006, SLR will collect sediment from the four Pebble West ponds/lakes that were sampled for aquatic vegetation in August 2005 and one new pond/lake in Pebble East. These sample locations will be consistent with 2005 SLR aquatic vegetation sample sites, and HDR water sample collection sites, and will include the twelve new ponds to be sampled in coordination with the Small Pond Study.

6.1.5 Investigation Derived Waste

The investigation-derived waste will be disposed of as follows:

- Sampling waste—which could include used nitrile gloves, plastic baggies, tape, paper towels, plastic wrapping, and aluminum foil—will be transported to and disposed of in Iliamna in approved receptacles.
- Excess sampling media—which could include removed soil—will be returned to the sample location and raked level after sampling.

6.2 Sampling Equipment Decontamination

All non-disposable sample-collection equipment that comes into contact with a sample will be decontaminated by means specified in the Draft 2006 Final QAPP (NDM, 2006). At a minimum, sampling-equipment decontamination will consist of the following:

Rinse in tap water or deionized water.

Wash with a solution of Alconox mixed with deionized water.

Double rinse in copious amounts of deionized water.

The purpose of the water and Alconox wash is to remove all visible particulate matter. The deionized-water rinse removes the detergent. These procedures will be followed between samples. Gloves will also be changed between samples to prevent possible cross-contamination.

6.3 Sample Handling

During each sampling event, Shaw Alaska Inc. (Shaw) will have one to three field staff stationed in Iliamna. All analytical samples will be delivered to the Shaw field staff, who will pack and ship the samples to the appropriate laboratory in accordance with the procedures outlined in the Draft 2006 Final QAPP (NDM, 2006). To preserve soil and vegetation sample integrity from collection to receipt by Shaw, all coolers will contain blue ice in accordance with the QAPP.

6.3.1 Sample Volumes, Container Types, and Preservation Requirements

The appropriate number and type of sample bottles/containers will be ordered from the relevant laboratories prior to each sampling event. Surface soil samples will be collected in accordance with Table 3, which shows volume, container type, and preservation measures.

TABLE 3. SAMPLE BOTTLE SCHEDULE AND SAMPLING PARAMETERS FOR SOIL COLLECTION

Bottle Type (SGS)	Bottle Type (CAS)	Analysis	Preservative[3]	Hold Time	Required Temp
(1) 8 oz	(1) 8 oz	Diesel/residual range organics	None	14 days to extraction, 40 days to analysis of extract	4°C
(1) 8 oz		Total metals [1]	None	6 Months	None
		Total mercury	None	28 Days	4°C
		Cyanide	None	28 Days[2]	4°C
(1) 8 oz	(1) 8 oz	Ammonia as N	None	28 Days	4°C
(1) 8 oz	(1) 8 oz	Chloride, fluoride, sulfate	None	28 Days	4°C
(1) 4 oz	(1) 4 oz	Total organic carbon	None	180 Days	4°C

oz – ounce: lab weighed and tared

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, Zn

2. As per EPA methods factsheet titled “Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity”

3. Holding time is from the date of preparation.

Aquatic and terrestrial vegetation samples will be collected in accordance with Table 4, which shows volume, container type, and preservation measures.

TABLE 4. SAMPLE BOTTLE SCHEDULE AND SAMPLING PARAMETERS FOR VEGETATION COLLECTION

Tissue Type	Minimum Sample Amount (grams)	Container Type CAS/NCA)	Analysis	Lab Method	Hold Time	Required Temp
Vegetation	25	Sealable plastic bag	Total Metals[1]	SW6010B/6020	6 Months	None
			Total Cyanide	None	14 Days[2]	4°C
			Mercury (total)	SW7471	28 Days	4°C

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

2. As per EPA methods factsheet titled “Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity”

Sediment samples collected from lakes and ponds will be collected in accordance with Table 5, which shows volume, container type, and preservation measures.

TABLE 5. SAMPLE BOTTLE SCHEDULE AND SAMPLING PARAMETERS FOR SEDIMENT COLLECTION

Bottle Type (SGS)	Bottle Type (CAS)	Bottle Type (STL)	Analysis	Preservative	Hold Time	Required Temp
(1) 8 oz.	(1) 8 oz.		Total Metals[1]	None	6 Months	None
			Mercury (total)	None	28 Days	4°C
			Total Cyanide	None	28 Days[2]	4°C
(1) 8 oz.			Chloride, Fluoride, Sulfate	None	28 Days	4°C
(1) 8 oz.	(1) 8 oz.		Ammonia	None	28 Days	4°C
	(1) 2 oz. (zero headspace)	(1) 2 oz. (zero headspace)	Sulfur, total	None	28 Days	4°C
		(1) 4 oz. (zero headspace)	AVS	None	14 Days	4°C
			SEM	None	6 months (SW6010B) 28 Days (SW7470A)	4°C

1. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

2. As per EPA methods factsheet titled “Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity”

6.3.2 Sample Identification

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 identification code, analysis, and sampler's initials. Each sampling location also will be identified by the sampler on a field form. The sample identification codes will be formatted to indicate sample date (month and year), location, matrix, and number, as follows:

0105CR199ASL001

Where:

0105 is the date as month/year

CR199A is the location identification

SL is the matrix code for surface soil

001 is a sequential sample number

The matrix codes to be used:

SL – Surface soil

SE – Sediment

TP – Terrestrial plant tissue

AP – Aquatic plant tissue

For field duplicates, the sequential sample number will be 201, for triplicates it will be 301, and for equipment rinsates it will be 401.

For vegetation samples, a two- or three-letter code for each species will be added as a suffix to the sample identification code—for example, 0804TE12TP001Pm is a sample of *picea mariana* (or black spruce) from location TE12 collected in August 2004. The two- or three-letter suffixes to be used for sample designation are listed in Tables 6 and 7.

TABLE 6. TERRESTRIAL PLANT SPECIES NAMES AND ID SUFFIXES

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Trees		
Black spruce	Picea mariana	Pm
White spruce	Picea glauca	Pg
Mountain hemlock	Tsuga mertensiana	Tm
Quaking aspen	Populus tremuloides	Pt
Paper birch (Kenai birch)	Betula papyrifera	Bp
Swamp/Shrub birch	Betula nana	Bn
Balsam poplar	Populus balsamifera	Pb
Shrubs		
Common juniper	Juniperus communis	Jc
Mountain alder/Sitka alder	Alnus Virida ssp. Sinuata	Avssps
Shrub or dwarf birch	Betula nana	Bn
Prickly rose	Rosa acicularis	Ra
Trailing black currant	Ribes laxiflorum	Rl
Northern red currant	Ribes triste	Rt
Skunk or northern black currant	Ribes glandulosum or hudsonianum	Rg or Rh
Bog blueberry	Vaccinium uliginosum	Vu
Early blueberry	Vaccinium pallidum	Vp
Net leaf willow	Salix reticulate	Srt
Feltleaf willow	Salix alaxensis	Sa
Gray leaf willow	Salix glauca	Sg
Barren-ground willow	Salix brachycarpa	Sb
Diamond-leaf willow	Salix planifolia	Sp
Sitka willow	Salix sitchensis	Ss
Barclay willow	Salix barclayi	Sb
Willow (species not identified)	Salix sp.	Ssp
Shrubby cinquefoil (tundra rose)	Dasiphora floribunda	Df
Red-fruit bearberry	Arctostaphylos rubra	Ar
Bog rosemary	Andromeda polifolia	Ap
Rusty menzisii	Menziesia ferruginea	Mfe

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Canadian burnet	Sanguisorba canadensis	Sca
Dwarf dogwood	Cornus canadensis	Cc
Salmonberry	Rubus spectabilis	Rs
Elderberry	Sambucus racemosa	Sr
Narrow leaf Labrador tea	Ledum palustre	Lp
Cranberry (bog)	Vaccinium oxyoccus	Vo
Cranberry (highbush)	Viburnum edule	Ve
Sweet gale	Myrica gale	Mg
Crowberry	Empetrum nigrum	En
Labrador tea (Eskimo tea)	Ledum decubens	Ld
Lingonberry (low bush cranberry)	Vaccinium vitis-idaea	Vv
Grasses		
Alaska cotton or cotton grass	Eriophorim scheuchzeri	Es
Beach rye	Leymus mollis	Lm
Sedge (species not identified)	Carex sp.	Csp
Short stalk sedge	Carex microchaeta	Cm
Northern water sedge	Carex aquatilis	Ca
Blue joint wheat grass	Calamagrostis species	Csp
Forbs		
Worm wood	Artemisia tilesii	At
Fireweed	Chamerion angustifolium	Ca
Cloudberry	Rubus chamaemorus	Rc
Kneeling Angelica (wild Celery)	Angelica genuflexa	Ag
Iris	Iris setosa	Is
Cow parsnip	Heracleum lanatum (Umbelliferae)	Hi or Hu
Common Cow parsnip (Putchkie) (wild celery)	Heracleum maximum	Hm
Wild Celery	Angelica lucida	Al
Lupine	Lupinus nootkatensis	Ln
Sour dock	Rumex arcticus	Rar
Wild rhubarb	Polygonum alaskanum	Pa
False hellebore	Veratrum viride	Vvi
Eskimo potato	Hedysarum alpinum	Ha

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Wild sweet pea	Hedysarum boreale ssp. mackenzii	Hvsspm
Marsh five finger	Comarum palustre	Cp
Beautiful Jacob's ladder	Polemonium pulcherrimum	Ppu
Fringed willow herb	Epilobium ciliatum	Ec
Monkshood	Aconitum delphinifolium	Ad
Partridgefoot	Luetkea pectinata	Lpe
Alaska spirea	Spiraea stevenii	Sst
Trailing raspberry	Rubus pedatus	Rp
Northern yarrow	Achillea borealis	Ab
Golden rod	Solidago decumbens	Sd
Coltsfoot	Petasites frigidus	Pf
Star flower	Trientalis europea	Te
Rose root/stone crop	Rhiodiola rosea	Sro
Devil's club	Opolopanax horridus	Oh
Beach loveage	Ligusticum scoticum	Ls
Horse Tail (meadow)	Equisetum pratense	Epr
Horse Tail (field)	Equisetum arvense	Ea
Horse Tail (water)	Equisetum fluviatile	Ef
Horse tail (marsh)	Equisetum palustre	Ep
Ferns and Fern Allies		
Lady fern	Athyrium filix-femina	Af
Spreading wood fern	Dryopteris expansa	De
Mosses		
Green terrestrial moss (feather moss)	Ptelium crista casttensis	Pcc
Club moss	Lycopodium annotinum	La
Stair-step moss	Hylocomium splendens	Hs
Moss (Schreber's Big Red stem Moss)	Pleurozium schreberi	Ps
Moss (Sphagnum) (Species not identified)	Sphagnum sp.	Spsp
Lichens		
Reindeer lichen or caribou "moss"	Cladina rangiferina	Cr

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Whiteworm Lichen (Species not identified)	Thamnolia sp.	Tsp.

TABLE 7. AQUATIC PLANT SPECIES NAMES AND SUFFIXES

COMMON NAME	SPECIES NAME	SAMPLE ID SUFFIX
Yellow pond lily	Nuphar polysepalum	Npo
Water hemlock	Cicuta douglasii	Cdo
Mare's tail	Hippuris vulgaris	Hvu
Coon's tail or hornwort	Ceratophyllum demersum	Cde
Narrow-leaved bur-reed	Sparganium angustifolium	San
Giant bur-reed	Spariganium eurycarpum	Seu
Common cattail	Typha latifolia	Tia
Broad-leaved water plantain	Alisma plantago-aquatica	Apa
Arum-leaved arrowhead	Sagittaria cuneata	Scu
Water smartweed	Polygonum amphibium	Pam
Clasping-leaf pondweed	Potamogeton perfoliatus	Ppe
Fries' pondweed	Potamogeton friesil	Pfr
Thread-leaved pondweed	Potamogeton filiformis	Pfi
Vernal water-starwort	Callitriche verna	Cve
Spiked water-milfoil	Myriophyllum spicatum	Msp
Large-leaved white water-crowfoot	Ranunculus aquatilis	Raq
Yellow water-crowfoot	Ranunculus gmelinii	Rgm
Common duckweed	Lemna minor	Lmi
Bladderwort	Utricularia (vulgaris, minor or intermedia)	Utr

6.4 Sample Custody

Sample custody procedures will be followed in the field, during transport, and in the laboratory. The procedures take into account the nature of the samples, the maximum holding times, and shipping options from Iliamna to the laboratories.

Once collected, the samples will remain within sight of the sampler or will be secured until the samples are handed over to and prepared for shipment by Shaw personnel. Samples collected by SLR will be yielded to Shaw field staff at the end of each sampling day. SLR will have labeled each sample with the following:

- SLR's name.
- Sample or location identification.
- Sample data and time.
- Required analyses.
- Sample type: primary, duplicate (QC), triplicate (QA).

Shaw field staff will prepare the chain-of-custody (COC) form and labels using E-chain (an electronic COC application). They will also be responsible for packaging and shipping samples to the appropriate laboratories. SLR is responsible for providing Shaw with sufficient frozen blue ice and packaging materials to properly transport samples collected during each sampling event.

Each time a sample cooler changes hands, both the sender and the receiver will sign and date the COC form. The laboratory will forward the original to the analytical QA/QC manager. Shaw's field team will verify all COC forms before sample shipment and will make a copy of each to maintain a duplicate set of records. The following information is to be included on the COC form:

- Sample identification code.
- Signature of sampler.
- Date and time of collection.
- Project name.
- Type of sample.
- Number and type of containers.
- Sample preservation method.
- Sample analysis requested.
- Inclusive dates of possession.
- Signature of receiver.

The consulting company's name, addresses, and phone number is required on the COC. Laboratories will be instructed to invoice NDM and to mail reports to:

Jane Whitsett
Shaw Alaska Inc.
2000 West International Airport Road, Suite A-11
Anchorage, AK 99502

Other COC components will include sample labels, field notebooks, sample shipment receipts, and the laboratory logbook.

6.5 Field Quality Control Samples

6.5.1 Field Duplicates

Field duplicate samples will be collected at 10 percent of soil and vegetation sample locations. See Section 5 for specific number of duplicates planned for collection in each medium.

6.5.2 Field Triplicates

Field triplicate samples will be collected at 10 percent of soil, pond/lake and creek sediment, surface water and vegetation sample locations. See Section 5 for specific number of triplicates planned for collection in each medium.

7. Measurement of Field Parameters

7.1 Parameters

At each sample site, plants and soil types will be identified and approximate ambient temperature and weather conditions will be recorded.

7.2 Equipment Calibration and Field-Procedures Quality Control

No equipment requiring calibration will be used for the trace elements soil and vegetation sampling program.

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 reviewing field forms for completeness and accuracy. 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.

7.3 Equipment Maintenance and Decontamination

Field team managers are responsible for field equipment testing, inspection, and maintenance decisions. Equipment will be maintained in good operating condition. Sampling equipment will be decontaminated as detailed in Section 6.2.

8. Record Keeping

The field team leader will be responsible for overseeing that adequate detail is recorded on the field forms. The forms will contain sufficient information so that all field activity can be reconstructed without relying on the memory of the field crew.

8.1 Field Logbooks

Field forms will be the primary method of record keeping; however, each sampling team may also keep a separate field logbook for additional notes.

8.2 Field Forms

A modified version of SLR's 2005 field forms will be used during the 2006 sampling events. 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. Comprehensive information on the sampling site and respective samples collected at each site will be recorded by the field crew. This information includes site and sampling GPS positions, field observations, field measurements, sample identification, sample duplicates, and date and time the samples were collected.

Field forms will be maintained for each task. Field forms will consist of waterproof pages, written in indelible ink, with every appropriate area marked. All corrections will consist of initialed, single-line-out deletions, and blank pages will be marked as such with a diagonal line across the page, when appropriate.

Strict custody procedures will be maintained with the field forms used. No accountable documents will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. While being used in the field, forms will remain with the field team and will be secured on a clip board or, at a minimum, with rubber bands at all times.

The field team leader will review all data before leaving the sampling station. Upon completion of the field effort, forms will be filed in an appropriately secure manner in a notebook labeled "original data." These forms will remain with the task manager. Photocopies of the original data will be used as working documents. Completed field forms will be kept on file for future reference.

8.3 Photograph Logs

At least one photograph will be taken at each sampling location to document the site conditions at the time of sample collection. All photographs will be compiled and displayed in a photograph log that will be used in the Environmental Baseline Document. A photograph log will be created for the photographs collected in 2006.

9. Field Performance and System Audits

SLR will perform field performance and system audits at a minimum during one soil and one vegetation sampling event. The field performance and system audit will be conducted by a senior-level SLR employee. The audit will evaluate if field procedures are being correctly implemented and will also identify any additional measures that may be taken to improve field data collection, as warranted.

10. References

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Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES 2007 FIELD SAMPLING PLANS

NATURALLY OCCURRING CONSTITUENTS IN SURFACE SOIL, SEDIMENT, AND VEGETATION

DRAFT

SEPTEMBER 2007

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ACRONYMS AND ABBREVIATIONS

ACZ	ACZ Laboratories, Inc.
BEESC	Bristol Environmental and Engineering Services Corporation
°C	degrees Celsius
CAS	Columbia Analytical Services Ltd.
COC	chain-of-custody
DQOs	data-quality objectives
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GIS	geographical information system
GPS	global positioning system
HDR	HDR Alaska, Inc.
NOC	naturally occurring constituents
oz	ounce
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
Shaw	Shaw Alaska, Inc.
SLR	SLR Alaska

NATURALLY OCCURRING CONSTITUENTS

2007 FIELD SAMPLING PLAN

1. Introduction

This field sampling plan (FSP) provides guidance for the collection of data on trace elements in soil, sediment, and vegetation at the Pebble Project mine study area and along the transportation corridor. The study is being conducted by SLR Alaska (SLR) in the mine study area and Bristol Environmental and Engineering Services Corporation (BEESC) along the transportation corridor. This FSP was prepared by SLR. The purpose of the FSP is to update field procedures for conducting a study of naturally occurring constituents in surface soil, sediment, and vegetation begun in 2004.

The term "trace elements" refers to naturally occurring elements (mostly metals) for which various matrices (soil, vegetation, etc.) are analyzed. In Pebble Project documents, the term "trace elements" also is used to refer to the trace elements program. The trace elements program examines not only elements, but also naturally occurring compounds such as anions, cations, and biogenic hydrocarbons; the term "naturally occurring constituents" (NOC) is commonly used in this document to refer collectively to the analytical parameters included in the trace elements program.

The field work for this study in 2007 will involve collecting samples of surface soil, terrestrial vegetation, aquatic vegetation, and lake/pond sediments for analysis of NOC. The 2007 field season also will introduce new soil sampling for analysis of bacteria present in various soil types.

In addition to the trace elements work conducted by SLR, other consultants will collect surface water, sediment, and fish and mussel tissues for analysis for NOC. HDR Alaska, Inc. (HDR), will collect surface water-quality and sediment samples from streams and lakes/ponds in the mine study area. The details of this water-quality program are described in Section 6.1 of the 2007 study plan (NDM, In press1) and in the FSP for surface water quality, hydrology, and sediment (NDM, In press4). In addition to the water-quality program, HDR also is conducting fish surveys and collecting fish tissue for analysis. Details of the fish study program are described in Chapter 11 of the 2007 study plan (NDM, In press1) and in the 2007 FSP for the fish-tissue study (NDM, In press3). HDR also will collect freshwater mussels in June 2007 from three lakes in the mine study area, as described in the FSP for macroinvertebrates and periphyton (NDM, In press2).

2. Project Background

The scope of the trace elements study allows for analysis of the spatial and temporal variability of NOC in the mine study area and transportation corridor.

In 2004, to determine landforms and environmental media common to these landforms, 50 one-square-mile cells were randomly selected from a grid of 160 such cells, which represented the mine study area. Five landforms were identified, with 10 environmental media common to those land forms. The types and relative abundance of the different habitats were unknown; therefore, sample sites were located based on landforms (e.g., geology, vegetative coverage).

For 2005 and subsequent years, the approach was slightly different because the number of samples collected was based primarily on habitat type rather than on landform. Several locations in 2004 had insufficient vegetation for collection or had only one or two species in sufficient abundance for collection. A different approach was therefore developed to ensure the best representative coverage of various plant species of interest. Habitat information was compiled, and a total of seven broad habitat types were identified. Based on research and reconnaissance conducted during the 2004 sampling season, the aerial extent of the seven habitat types was considered in light of the 10 environmental media, and the identification of grids used as specific sampling locations was modified appropriately. The sampling in 2005 and 2006 incorporated these modifications, as will the sampling in 2007.

For the 2006 studies in the mine study area, subsurface-soil samples were not collected because review of data from the 2004 and 2005 sampling programs indicated that the results from samples collected at depth were similar to or less than the concentrations found in surface samples. Subsurface-soil samples will not be collected in 2007.

A subset of surface-soil samples will be analyzed in 2007 for total organic carbon (also referred to as fraction organic carbon), as outlined in Section 7.1.2.1 of the 2005 study plan (NDM, 2005).

In 2006, fewer samples than in previous years were collected in the area of Pebble West deposit, where extensive sampling had already been conducted. Additional samples were collected in the area of Pebble East deposit, where little trace element sampling had been done. Soil and plants at almost all upland locations in Pebble West have been sampled for two consecutive years. The short-term goal of the program is to collect data from two years at each location. Therefore, in 2007, soil and plant samples will be collected only from the three upland locations in Pebble West that were first sampled in 2006. For Pebble East, only one year of sampling has been conducted. Second year samples will be collected at Pebble East, consistent with the 2007 study plan (NDM, In press1).

Sampling for terrestrial vegetation will be conducted twice in 2007: once in early summer during the primary vegetative growth season and once in late summer when berries are present. Soil and plant samples will be collocated, and the same locations sampled in 2006 will be sampled in 2007. In the mine area, plant uptake of trace elements is the mechanism of most interest to the characterization of naturally occurring constituents. The purpose of two separate vegetation sampling periods is to address the different browse available in July and in August. For example, in early summer, willow shrubs have new growth and are beginning to flower, while in the fall, fruits have developed on the plants. Naturally occurring constituent uptake into berries differs from uptake into new vegetative growth. As a result, the dietary concentrations of trace elements in edible plant parts may be different throughout the growing season and can be characterized by the two sampling periods.

A new bacteriological study is being added in 2007 to address the hypothesis of cyanogenic bacteria as a cyanide source in soil. Soil samples will be collected for bacteriological analysis, focusing on identification of the types of bacteria present in native soils. Samples will be collected at up to 11

locations representative of the range of detected cyanide concentrations in soil. This will include some locations where two years of data have already been collected, to take full advantage of the currently available data. At each location where a soil sample is collected for the bacteriological study, a surface-soil sample also will be collected for trace element analyses. Vascular plants and moss/lichen samples also will be collected at the bacteriological soil-sampling sites to allow comparison of cyanide concentrations in plants with cyanide concentrations in soil and bacteria.

A review of data from other mine projects indicates that uptake of trace elements in specific mosses and lichens is significant. Only one year of sampling has been conducted for these vegetation types; therefore, additional sampling will be conducted in 2007 at select sites at Pebble East and at the three Pebble West locations to obtain two consecutive years of data for these species.

In 2005, sampling of aquatic plants by SLR was initiated at four lakes in the mine study area. Both aquatic plants and sediment were sampled at these four lakes in 2006. This effort was expanded in 2006 to include 12 additional lakes/ponds. Lake/pond sediment and surface-water sampling at the latter locations was conducted by HDR. Second-year aquatic-vegetation sampling at these 12 ponds will be coordination with HDR so that surface water, sediment, and aquatic-vegetation samples will be collected at the same time. Since only one event of sediment sampling has been conducted at the four lakes/ponds in Pebble West, an additional round of sampling will be conducted at these locations. Aquatic vegetation also will be collected by SLR. Finally, the one pond in Pebble East added to the program in 2006 will be sampled in 2007 to obtain a second year of data. BEESC is not collecting aquatic vegetation in the transportation corridor.

Sample analyses will be consistent with analyses conducted in 2006. Before soil and vegetation sampling begins, latitude and longitude of any new sampling locations will be determined and transferred to a global positioning system (GPS) so the sample sites can be accurately located in the future. Sampling conducted in 2007 at existing sampling sites will be done at the same GPS coordinates used in previous years to provide an indication of annual variability in NOC concentrations.

In the transportation corridor, the sampling of soil, terrestrial vegetation, pond and stream sediment, surface water, and aquatic vegetation conducted in 2006 will be repeated in 2007 to obtain two years of data.

3. Study Area

The Pebble Project is located in southwestern Alaska in the headwater areas of the Koktuli River and Upper Talarik Creek. The landforms and associated habitats common to the region are characterized by specific surface soils and vegetation types.

For the transportation corridor, the study area includes a one-mile wide corridor centered on the possible road corridor between the mine site and Cook Inlet, and the area surrounding the port site. At the time the initial field studies were conducted in 2004, the port location and configuration of upland facilities had not been determined. Sampling during this event focused on possible Port Site 1 and an upland area to the west where flat land suitable for upland development could be reasonably expected.

4. Project Organization and Responsibilities

The soil (including soil for bacterial analysis), vegetation, and sediment sampling events will be conducted by SLR. The organizational chart in Figure 1 outlines project management roles and responsibilities.

SLR will provide oversight of the sampling in the transportation corridor to be implemented by BEESC. Patricia Curl will lead the BEESC team.

5. 2007 Sampling Program

The 2007 field sampling program for the mine study area (Pebble West and Pebble East) will consist of two sampling events. In July, approximately 30 primary surface-soil samples and 11 primary bacteriology soil samples will be collected, and approximately 108 primary terrestrial-vegetation samples will be collected from the same locations as the soil samples. In August, approximately 140 primary terrestrial-vegetation samples will be collected (including 32 samples of berries or fruit). In August only, approximately 18 primary aquatic-vegetation samples will be collected from tundra ponds/lakes, along with approximately five pond/lake sediment samples. Figure 2 shows the proposed 2007 sampling locations for the mine study area.

New in 2007, SLR will collect approximately 11 bacteriology soil samples at existing soil sampling locations in Pebble West. The purpose of the bacteriology study is to test a hypothesis that cyanogenic bacteria in area soils are contributing to the naturally occurring cyanide concentrations at the mine study area. A surface-soil sample to be analyzed for NOC also will be collected from these locations, and approximately 56 terrestrial-vegetation samples will be collected from these locations, based on the number of vegetation samples collected between 2005 and 2006. In addition to vascular plants, the terrestrial-vegetation samples will include a minimum of one moss or lichen sample at each of these locations.

Second year sampling of the 12 small ponds will entail collecting approximately 28 aquatic-vegetation samples in coordination with HDR as they concurrently collect surface water and sediments at these locations.

One sample event will be conducted in the transportation corridor by BEESC in 2007. The sample event, which will occur in August, entails collection of approximately 42 primary terrestrial-vegetation samples (including two berry samples per location) and approximately seven primary soil samples, to be collocated with vegetation samples wherever possible. In addition, sediment will be collected from one tundra pond, and surface water and sediment will be collected from approximately four creeks in the Cook Inlet drainages. Figure 3 shows the proposed sampling locations for 2007 in the transportation corridor.

In addition to the primary samples just described, during each sampling event, duplicate quality control (QC) and triplicate quality assurance (QA) samples of soil, pond/lake and creek sediments, surface water, and vegetation will be collected at a frequency of 10 percent. Equipment blanks will also be prepared at a

frequency of 5 percent of the primary samples. The 2007 sampling for the trace elements program is summarized in Table 1.

Geographic coordinates for each sampling location will be recorded in a format compatible with the existing geographical information system (GIS) for the project to allow creation of maps depicting sampling locations.

The field team will use the helicopter to locate each section, where up to three sample locations will be staked, flagged, marked with the sample identification, and recorded by GPS. Field teams will begin sample collection immediately after the locations are recorded.

5.1 Sample Collection

Sampling methods and procedures for each type of environmental media to be encountered are described below. These protocols are designed to maximize sample quality and to meet the stated data-quality objectives (DQOs) for the project (e.g., precision, accuracy, comparability, completeness, and representative quality).

Sampling for this project will be conducted in accordance with U.S. Environmental Protection Agency (EPA) and Alaska Department of Environmental Conservation guidelines for quality assurance and quality control. QA/QC procedures are described in the 2007 quality assurance project plan (QAPP; NDM, In press5). In all cases, sample-collection procedures will be followed to minimize contamination of samples, to prevent cross-contamination between samples, and to ensure sample validity by following proper preservation and storage procedures in the field.

Photographic documentation will be done for each sample site.

5.1.1 Surface-soil Sampling

One surface-soil sample will be collected at each sample location during the July sampling event. Surface-soil samples will be collected to a depth of 0.5 feet using hand tools, such as stainless steel or disposable polyethylene shovels or trowels. If an organic mat occurs at the surface, the mat will be removed before the soil sample is collected. The field sampling team will remove rocks and twigs from the samples. For each sample, a 16-ounce jar will be filled, if possible, or at least 50 grams will be collected (a minimum of 25 grams is necessary to meet laboratory requirements for DQOs. As described in the 2007 QAPP (NDM, In press5), equipment blanks for soil media will be prepared at a frequency of 5 percent (1 for every 20 samples) using a deionized-water rinse after an Alconox wash. The equipment blanks will be analyzed only for total metals, consistent with the QAPP.

The investigation-derived waste is expected to consist of sampling waste. This waste will be disposed of as follows:

- Sampling waste—which could include used nitrile gloves, plastic bags, tape, paper towels, plastic wrapping, and aluminum foil—will be transported to and disposed of in Iliamna in approved receptacles.

- Excess sampling media—which could include removed soil—will be returned to the sample location and leveled after sampling.

5.1.2 Soil Bacteriology Sampling

Sampling of soil for bacteriology analysis will occur in July. One bacteriological soil sample will be collected at each of the 11 predetermined sample locations. These locations will be the same as those sampled in previous years and where results exhibited a range of detected cyanide concentrations. Samples will be collected to a depth of 0.5 feet using hand tools, such as stainless steel or disposable polyethylene shovels or trowels. If an organic mat occurs at the surface, the mat will be removed before the soil sample is collected. The sampling team will remove rocks and twigs from the samples. For each sample, a 4-ounce sterilized jar will be filled. Samples will be submitted for an HCN (cyanide) colorimetric detection. An equipment rinse is not required, but one may be collected in accordance with the QAPP (NDM, In press5) based on field sampling conditions and further discussions between SLR and the data-quality managers.

The investigation-derived waste is expected to consist of sampling waste. This waste will be disposed of as follows:

- Sampling waste—which could include used nitrile gloves, plastic bags, tape, paper towels, plastic wrapping, and aluminum foil—will be transported to and disposed of in Iliamna in approved receptacles.
- Excess sampling media—which could include removed soil—will be returned to the sample location and leveled after sampling.

5.1.3 Terrestrial-vegetation Sampling

Sampling for vegetation in 2007 will occur in two events, one in July and one in August. The July vegetation sampling event will be concurrent with soil sampling, and during August, vegetation sampling will include the collection of berries not available earlier in the season.

Vegetation samples will be collected from the same locations as soil samples. At each sample site, a sample plot encompassing an approximate 10-foot radius from the soil sample location will be designated. Within each sample plot, the vegetation species present will be documented. Four to eight species at each location will be sampled and may include moss, lichen, grass, shrub, or berry-producing plants, depending on the type and density present.

Both vegetation and berry samples will be collected, where available. It is expected that berry samples will be available only in the August sampling event. Non-woody material will be collected from the plants to ensure that edible portions of the plant species are analyzed (leaves and browsable twigs and shoots will be aggregated, and berries and fruits will be kept separate from vegetative plant material). Material will be collected using stainless steel clippers, and samplers will wear nitrile gloves. The material will be placed into sealable plastic bags. Where possible, each sample will represent a composite of approximately 50 grams from at least three plants within a taxonomic group (genus or species). The analytical method requires at least 25 grams to meet DQOs.

Each sample will represent a taxonomic group (genus or species) identified in the mine study area in 2004 surveys. Few trees were present in the mine study area at that time. Wherever possible, willows will be sampled as representative of shrub species. Primary species to be sampled include equisetum (representing forbs), various species of sedges, caribou moss (representing lichens), knights plume moss (representing mosses), and bog blueberry. Selection of these particular species was based on overall dominance, bio-uptake potential, use as wildlife forage, and/or subsistence use.

The investigation-derived waste is expected to consist of sampling and storage devices, including nitrile gloves, plastic bags, tape, paper towels, plastic wrapping, and aluminum foil. These wastes will be transported to and disposed of in Iliamna in approved receptacles. Excess sampling media, which could include removed vegetative tissue, will be returned to the sample location and made level with a shovel after sampling.

5.1.4 Aquatic-vegetation Sampling

Aquatic-vegetation samples will be collected from five lakes and ponds sampled in 2005 and 2006. Sampling will occur in August, concurrent with the second terrestrial-vegetation event. Additionally, aquatic-vegetation samples will be collected from twelve ponds/lakes in coordination with HDR, who will collect water and sediment samples at the same locations. Sampling will occur in areas near the shore that can be reached by wading, and life jackets will be worn for safety.

Methods will be similar to those outlined above for terrestrial vegetation, with one major difference. Human subsistence use and moose browse include the roots and tubers of aquatic plants; therefore, where feasible, roots and tubers of aquatic plants will be collected in addition to vegetative portions above the water-line. Vegetative portions above the water-line will be kept separate from roots and tubers for analysis.

Different tools than those used for terrestrial plant collection may be necessary to clip and collect aquatic vegetation, depending on the location of the vegetation (e.g., edge of lake versus deeper areas) and the type of plant (e.g., grasses need to be clipped at the sediment surface, while flowering plants can be clipped above the water surface, if sufficient mass is available). Above-water samples will be collected with nitrile-gloved hands and/or stainless steel clippers. Approximately 100 grams of edible browse above the water-line or the sediment layer will be collected at each sampling point and placed into sealable plastic bags.

For roots and tubers, either the entire plant will be pulled out of the lake/pond and the roots or tubers will be collected, or a shovel or similar device will be used to pull out the roots or tubers for collection.

The investigation-derived waste is expected to consist of sampling and storage devices, including nitrile gloves, plastic bags, tape, paper towels, plastic wrapping, and aluminum foil. These wastes will be transported to and disposed of in Iliamna in approved receptacles. Excess sampling media, which could include removed vegetative tissue, will be returned to the sample location after sampling.

5.1.5 Lake/Pond Sediment Sampling

During the August vegetation sampling event, SLR will collect sediments from the same five pond/lake locations where aquatic-vegetation samples are collected. These sample locations will be consistent with

2006 SLR aquatic-vegetation sample sites and HDR water-quality sample sites. (HDR will collect the sediment samples at the twelve ponds added to the study in 2006.)

One sediment sample will be collected at each sample location during the August vegetation sampling event. Sediment samples will be collected using a stainless steel dredge. If organic material with no mineral content is collected in the dredge bucket, the mat will be removed, and additional dredges will be attempted. The sampling team will remove rocks and twigs from the samples. For each sample, an 8-ounce jar will be filled, if possible, or at least 50 grams will be collected. As described in the 2007 QAPP (NDM, In press5), equipment blanks for sediment will be prepared at a frequency of 5 percent (1 for every 20 samples) using a deionized-water rinse after an Alconox wash. The equipment blanks will be analyzed only for total metals, consistent with the QAPP. All investigation-derived waste will be disposed of similar to surface-soil sampling wastes.

5.2 Sampling Equipment Decontamination

All non-disposable sample-collection equipment that comes into contact with a sample will be decontaminated as specified in the 2007 QAPP (NDM, In press5). At a minimum, sampling-equipment decontamination will consist of the following:

1. Rinse in tap water or deionized water.
2. Wash with a solution of Alconox mixed with deionized water.
3. Double rinse in deionized water.

The purpose of the water and Alconox wash is to remove all visible particulate matter. The deionized-water rinse removes the detergent. These procedures will be followed between samples. Gloves will also be changed between samples to prevent possible cross-contamination.

5.3 Sample Handling

During each sampling event, Shaw Alaska, Inc. (Shaw), will have one to three field staff stationed in Iliamna. All analytical samples will be delivered to the Shaw field staff, who will pack and ship the samples to the appropriate laboratory in accordance with the procedures outlined in the 2007 QAPP (NDM, In press5). To preserve sample integrity from collection to receipt by Shaw, all samples will be placed in coolers with gel ice after collection, in accordance with the QAPP.

5.3.1 Sample Volumes, Container Types, and Preservation Requirements

The appropriate number and type of sample bottles/containers will be ordered from the relevant laboratories prior to each sampling event. Sample containers and preservation requirements for surface-soil, bacteriological soil, and sediment samples are provided in Table 2. Sample containers and preservation requirements for aquatic and terrestrial-vegetation samples are provided in Table 3.

5.3.2 Sample Identification

Each sample container will have a waterproof label large enough to contain the information needed to easily identify each sample. The information to be recorded on each label will include the project name, date, time, sample identification code, analysis, and sampler's initials. Each sampling location also will be identified by the sampler on a field form. The sample identification codes will be formatted to indicate sample date (month and year), location, matrix, and number, as shown with the following example:

0105CR199ASL001

Where:

0105 is the date as month/year

CR199A is the location identification

SL is the matrix code for surface soil

001 is a sequential sample number

The matrix codes used for the trace elements program are as follows:

SL = Surface soil

SE = Sediment

TP = Plant tissue (for both terrestrial and aquatic vegetation)

For field duplicates, the sequential sample numbers are the 200 series (201, 202, etc.); for triplicates, the sequential numbers are in the 300 series (301, 302, etc.); and for sampling-equipment rinsates, the sequential number is 401.

For vegetation samples, a species code will be added to the end of the sample identification code—for example, 0804TE12TP001Pm is a sample of *Picea mariana* (or black spruce) collected in August 2004 from location TE12. The species codes for terrestrial and aquatic plants are listed in Tables 4 and 5, respectively.

5.3.3 Sample Custody

Sample custody procedures will be followed in the field, in the laboratory, and during transport. The procedures take into account the nature of the samples, the maximum holding times, and shipping options from Iliamna to the laboratories.

Once collected, the samples will remain within sight of the sampler or will be secured until the samples are handed over to and prepared for shipment by Shaw personnel. Samples collected by SLR will be yielded to Shaw field staff at the end of each sampling day. SLR will have labeled each sample with the following:

- SLR company name.
- Sample or location identification.

- Sample date and time.
- Required analyses.
- Sample type: primary, duplicate (QC), triplicate (QA), equipment blank.

Shaw field staff will prepare the chain-of-custody (COC) form and labels using E-chain (an electronic COC application). They will be responsible for packaging and shipping samples to the appropriate laboratories. SLR is responsible for providing Shaw with sufficient frozen gel ice and packaging materials to properly transport samples collected during each sampling event.

Each time a sample cooler changes hands, both the sender and the receiver will sign and date the COC form. The laboratory will forward the original form to the analytical QA/QC manager. Shaw's field team will verify all COC forms before sample shipment and will make a copy of each to maintain a duplicate set of records. The following information will be included on the COC form:

- Sample identification code.
- Signature of sampler.
- Date and time of collection.
- Project name.
- Sample type.
- Number and type of containers.
- Sample preservation method.
- Sample analysis requested.
- Inclusive dates of possession.
- Signature of receiver.

The consulting company's name, address, and phone number are required on the COC form. Laboratories will be instructed to invoice Northern Dynasty Mines Inc. and to mail reports to:

Steve Crupi
Shaw Alaska Inc.
2000 West International Airport Road, Suite C-1
Anchorage, AK 99502

Other COC components will include sample labels, field notebooks, sample shipment receipts, and the laboratory logbook.

6. Sample Analysis Summary

Primary and duplicate (QC) surface-soil and sediment samples will be appropriately documented, and packaged and sent to ACZ Laboratories, Inc. (ACZ) in Steamboat Springs, Colorado. Columbia

Analytical Services (CAS) in Kelso, Washington, will act as the QA laboratory for the soil samples. Bacteriology soil samples will be submitted to Shaw for HCN colorimetric detection.

Primary and QC vegetation samples will be appropriately documented, and packaged and sent to the CAS laboratory. Severn Trent Laboratories in Tacoma, Washington, will act as the QA laboratory for vegetation samples.

Samples will be analyzed for the NOCs listed in Table 6 by the indicated analytical methods.

7. Record Keeping

At each sample site, plants and soil types will be identified and recorded, and approximate ambient temperature and weather conditions will be recorded.

7.1 Field Forms

A modified version of SLR's 2006 field forms will be used during the 2007 sampling events. All pertinent field survey and sampling information will be recorded on field forms during each day of the field effort and at each sampling site. Comprehensive information on the sampling site and the samples collected at each site will be recorded by the field crew. This information includes sample-site GPS coordinates, field observations, sample identification, sample duplicates, and date and time the samples were collected.

Field forms will be maintained for each task. Field forms will be printed on waterproof pages, with every appropriate field completed in indelible ink. Any corrections will be made by crossing out incorrect information with a single line (so the original entry remains legible), adding correct information, and initialing the correction. Blank pages, when appropriate, will be marked as such with a diagonal line across the page.

Strict custody procedures will be maintained with the field forms used. No accountable documents will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. While being used in the field, forms will remain with the field team and will be secured on a clip board or, at a minimum, with rubber bands at all times.

The field team leader will be responsible for ensuring that adequate detail is recorded on the field forms. The forms will contain sufficient information so that all field activity can be reconstructed without relying on the memory of the field crew.

The field team leader will review all data before leaving a sampling station. Upon completion of the field effort, forms will be filed in an appropriately secure manner in a notebook labeled "original data." These forms will remain with the task manager. Photocopies of the original data will be used as working documents. Completed field forms will be kept on file for future reference.

7.2 Field Logbooks

Field forms will be the primary method of record keeping; however, each sampling team will also keep a separate field logbook for additional notes.

7.3 Photographic Logs

At least one photograph will be taken at each sampling location to document the site conditions at the time of sample collection. All photographs will be compiled and displayed in a photograph log that will be included in the environmental baseline document.

8. Field Performance and System Audits

SLR will perform field performance and system audits during at least one soil and one vegetation sampling event. 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 any additional measures that may be taken to improve field data collection, as warranted.

9. References

Northern Dynasty Mines Inc. (NDM). In press1. Draft Environmental Baseline Studies, Proposed 2007 Study Plans.

———. In press2. Draft Environmental Baseline Studies, 2007 Field Sampling Plans, Macroinvertebrates and Periphyton, Mine Study Area.

———. In press3. Draft Environmental Baseline Studies, 2007 Field Sampling Plans, Fish Tissue Study, Mine Study Area.

———. In press4. Draft Environmental Baseline Studies; 2007 Field Sampling Plans; Surface Water Quality, Hydrology, and Sediment; Mine Study Area.

———. In press5. Draft Environmental Baseline Studies, 2007 Quality Assurance Project Plan.

———. 2006. Draft Environmental Baseline Studies, Proposed 2006 Study Plan. July.

———. 2005. Draft Environmental Baseline Studies, 2005 Study Plans. November

TABLES

TABLE 1
2007 Sampling Summary

Media	Number of Primary Samples	Number of Sampling Events	Total Primary Samples	Number of Duplicate (QC) Samples	Number of Triplicate (QA) Samples	Total Lab Samples
Mine Studies Area (SLR)						
Surface Soil	30	1	30	3	3	36
Bacteriologic Soil	11	1	11	2	2	15
Terrestrial Vegetation	108/140[a]	2	248	25	25	298
Aquatic Vegetation	46[b]	1	46	5	5	58
Pond/Lake Sediment	5	1	5	1	1	7
Transportation Corridor (BEESC)						
Surface Soil	7	1	7	1	1	9
Terrestrial Vegetation	42[c]	1	42	5	5	50
Pond and Creek Sediment	5	1	5	1	1	5
Creek Surface Water	4	1	4	1	1	6

a. Values reflect July and August sampling events; second value includes 32 berry samples to be collected in August

b. Includes small pond samples

c. Includes berry samples

TABLE 2
Sample Containers and Preservation for Soil and Sediment

Bottle Type (ACZ, prim.)	Bottle Type (CAS, QA)	Analysis	Preservative	Hold Time	Required Temp
(1) 8 oz	(2) 8 oz	Total organic carbon (Soil Only)	None	180 Days	4°C
(1) 8 oz	(1) 8 oz	Total metals[a]	None	6 Months	4°C
		Total mercury	None	28 Days	4°C
		Cyanide	None	28 Days[b]	4°C
		Ammonia as N	None	28 Days	4°C
		Chloride, fluoride, sulfate	None	28 Days	4°C

oz = ounce, lab weighed and tared

a. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, Zn

b. From EPA fact sheet titled “Total Petroleum Hydrocarbons, Reactive Cyanide, Reactive Sulfide, Ignitability, and Corrosivity” found at http://www.epa.gov/reg3hwmd/bfs/regional/analytical/petroleum.htm

TABLE 3
Sample Containers and Preservation for Vegetation

Tissue Type	Minimum Sample Amount (grams)	Container Type	Analysis	Lab Method	Hold Time	Required Temp
Vegetation	25	Sealable plastic bag	Total Metals[a]	SW6010B/6020	6 Months	None
			Total Cyanide	SM4500CN-E	14 Days	4°C
			Mercury (total)	SW7471	28 Days	4°C

a. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

TABLE 4
Terrestrial Plant Species Names and Identification Codes

Common Name	Species Name	Species ID Code
Trees		
Black spruce	*Picea mariana*	Pm
White spruce	*Picea glauca*	Pg
Mountain hemlock	*Tsuga mertensiana*	Tm
Quaking aspen	*Populus tremuloides*	Pt
Paper birch (Kenai birch)	*Betula papyrifera*	Bp
Balsam poplar	*Populus balsamifera*	Pb
Shrubs		
Alpine Asalea	*Loiseleuria procumbens*	Lpr
Lapland diapensia	*Diapensia lapponicum*	Dl
Common juniper	*Juniperus communis*	Jc
Mountain alder/Sitka alder	*Alnus crispa*	Ac
Dwarf birch	*Betula nana*	Bn
Scrub birch	*Betula glandulosa*	Bg
Prickly rose	*Rosa acicularis*	Ra
Trailing black currant	*Ribes laxiflorum*	Rl
Northern red currant	*Ribes triste*	Rt
Skunk or northern black currant	*Ribes glandulosum or hudsonianum*	Rg or Rh
Bog blueberry	*Vaccinium uliginosum*	Vu
Early blueberry	*Vaccinium ovalifolium*	Vov
Least willow	*Salix rotundifolia*	Saro
Feltleaf willow	*Salix alaxensis*	Sa
Barren-ground willow	*Salix brachycarpa*	Sbr
Diamond-leaf willow	*Salix planifolia*	Sp
Net-leaf willow	*Salix reticulate*	Srt

Common Name	Species Name	Species ID Code
Gray leaf willow	*Salix glauca*	Sg
Barclay willow	*Salix barclayi*	Sb
Alaska bog willow	*Salix fuscescens*	Sf
Sitka willow	*Salix sitchensis*	Ss
Willow (species not identified)	*Salix* species	Ssp
Shrubby cinquefoil (tundra rose)	*Dasiphora floribunda*	Df
Red-fruit bearberry	*Arctostaphylos rubra*	Ar
Bog rosemary	*Andromeda polifolia*	Ap
Rusty menzisii	*Menziesia ferruginea*	Mfe
Alaska spirea	*Spiraea stevenii*	Sst
Dwarf dogwood	*Cornus canadensis*	Cc
Salmonberry	*Rubus spectabilis*	Rs
Elderberry	*Sambucus racemosa*	Sr
Labrador tea (Eskimo tea)	*Ledum decumbens*	Ld
Sweet gale	*Myrica gale*	Mg
Crowberry	*Empetrum nigrum*	En
Lingonberry (low bush cranberry)	*Vaccinium vitis-idaea*	Vv
Cranberry (high bush)	*Viburnum edule*	Ve
Cranberry (bog)	*Vaccinium oxyoccus*	Vo
Grasses		
Alaska cotton or cotton grass	*Eriophorum* species	Esp
Beach rye	*Leymus mollis*	Lm
American dune grass	*Leymus arenarius*	La
Sedge (species not identified)	*Carex* sp.	Ss
Short stalk sedge	*Carex microchaeta*	Cm
Northern water sedge	*Carex aquatilis*	Ca
Blue joint grass	*Calamagrostis* sp.	Cs
Forbs		
Worm wood	*Artemisia tilesii*	At
Fireweed	*Chamerion angustifolium*	Ca
Cloudberry	*Rubus chamaemorus*	Rc
Wild celery (putchkie)	*Angelica genuflexa*	Ag
Wild celery	*Angelica lucida*	Al
Iris	*Iris setosa*	Is
Cow parsnip	*Heracleum lanatum (Umbelliferae)*	Hl (Hu)
Lupine	*Lupinus nootkatensis*	Ln
Sour dock	*Rumex arcticus*	Rar
Wild rhubarb	*Polygonum alaskanum*	Pa
False hellebore	*Veratrum viride*	Vvi
Eskimo potato	*Hedysarum alpinum*	Ha

Common Name	Species Name	Species ID Code
Wild sweet pea	*Hedysarum mackenzii*	Hm
Marsh five finger	*Comarum palustre*	Cp
Beautiful Jacob's ladder	*Polemonium pulcherrimum*	Ppu
Fringed willowherb	*Epilobium ciliatum*	Epc
Marsh willowherb	*Epilobium palustre*	Epa
Monkshood	*Aconitum delphinifolium*	Ad
Partridgefoot	*Luetkea pectinata*	Lpe
Canadian burnet	*Sanguisorba canadensis*	Sca
Trailing raspberry	*Rubus pedatus*	Rp
Northern yarrow	*Achillea borealis*	Ab
Goldenrod	*Solidago decumbens*	Sd
Starflower	*Trientalis europea*	Te
Rose root/stone crop	*Rhodiola rosea*	Sro
Devil's club	*Opolopanax horridus*	Oh
Coltsfoot	*Petasites* species	Psp
Beach lovage	*Ligusticum scoticum*	Ls
Horsetail (meadow)	*Equisetum pratense*	Epr
Horsetail (field)	*Equisetum arvense*	Ea
Horsetail (water)	*Equisetum fluvitile*	Ef
Horsetail (marsh)	*Equisetum palustre*	Ep
Ferns and Fern Allies		
Lady fern	*Athyrium filix-femina*	Af
Spreading wood fern	*Dryopteris expansa*	De
Mosses		
Hair cap moss	*Polytrichum* species	Posp
Green terrestrial moss	*Ptilium crista-castrensis*	Pcc
Club moss	*Lycopodium* species	Lsp
Stair-step moss	*Hylocomium splendens*	Hs
Schreber's big red stem moss	*Pleurozium schreberi*	Ps
Sphagnum (species not identified)	*Sphagnum* sp.	Spsp
Lichens		
Reindeer lichen or caribou "moss"	*Cladina* species	Csp
Whiteworm lichen (species not identified)	*Thamnolia* species	Tsp
Curled snow lichen	*Flavocetraria cucullata*	Fc

TABLE 5
Aquatic Plant Species Names and Identification Codes

Common Name	Species Name	Species ID Code
Yellow pond lily	*Nuphar polysepalum*	Npo
Water hemlock	*Cicuta douglasii*	Cdo
Mare's tail	*Hippuris vulgaris*	Hvu
Coon's tail or hornwort	*Ceratophyllum demersum*	Cde
Narrow-leaved bur-reed	*Sparganium angustifolium*	San
Giant bur-reed	*Sparganium eurycarpum*	Seu
Common cattail	*Typha latifolia*	Tla
Broad-leaved water plantain	*Alisma plantago-aquatica*	Apa
Arum-leaved arrowhead	*Sagittaria cuneata*	Scu
Water smartweed	*Polygonum amphibium*	Pam
Clasping-leaf pondweed	*Potamogeton perfoliatus*	Spe
Fries' pondweed	*Potamogeton friesil*	Pfr
Thread-leaved pondweed	*Potamogeton filiformis*	Pfi
Vernal water-starwort	*Callitriche verna*	Cve
Spiked water-milfoil	*Myriophyllum spicatum*	Msp
Large-leaved white water-crowfoot	*Ranunculus aquatilis*	Raq
Yellow water-crowfoot	*Ranunculus gmelinii*	Rgm
Common duckweed	*Lemna minor*	Lmi
Bladderwort	*Utricularia (vulgaris, minor,* or *intermedia)*	Utr

TABLE 6
Analytes and Analytical Methods

Analyte	Method
Soil	
Metals[a]	SW6010B/6020
Mercury	SW7471A
Ammonia as N	SM4500NH3G
Cyanide, Total	SM4500CN
Chloride, Fluoride, Sulfate	E300.0
Total Organic Carbon	ASTM D4129-82M
pH	
Bacteriological Soil	
Bacteria	HCN colorimetric detection
Vegetation	
Metals[a]	SW6010B/6020/E200.8
Mercury	SW7471A
Cyanide, Total	E335.2
Sediments	
Metals[a]	E200.7/200.8
Mercury	SW7471A
Ammonia as N	SM4500NH3G
Cyanide, Total	SM4500CN-E or E335.2
Chloride, Fluoride, Sulfate	E300.0

a. Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Pb, K, Mg, Mn, Mo, Na, Ni, Sb, Se, Sn, Tl, V, Zn

SW = U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third Edition, September 1986

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition

E = Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991

FIGURES

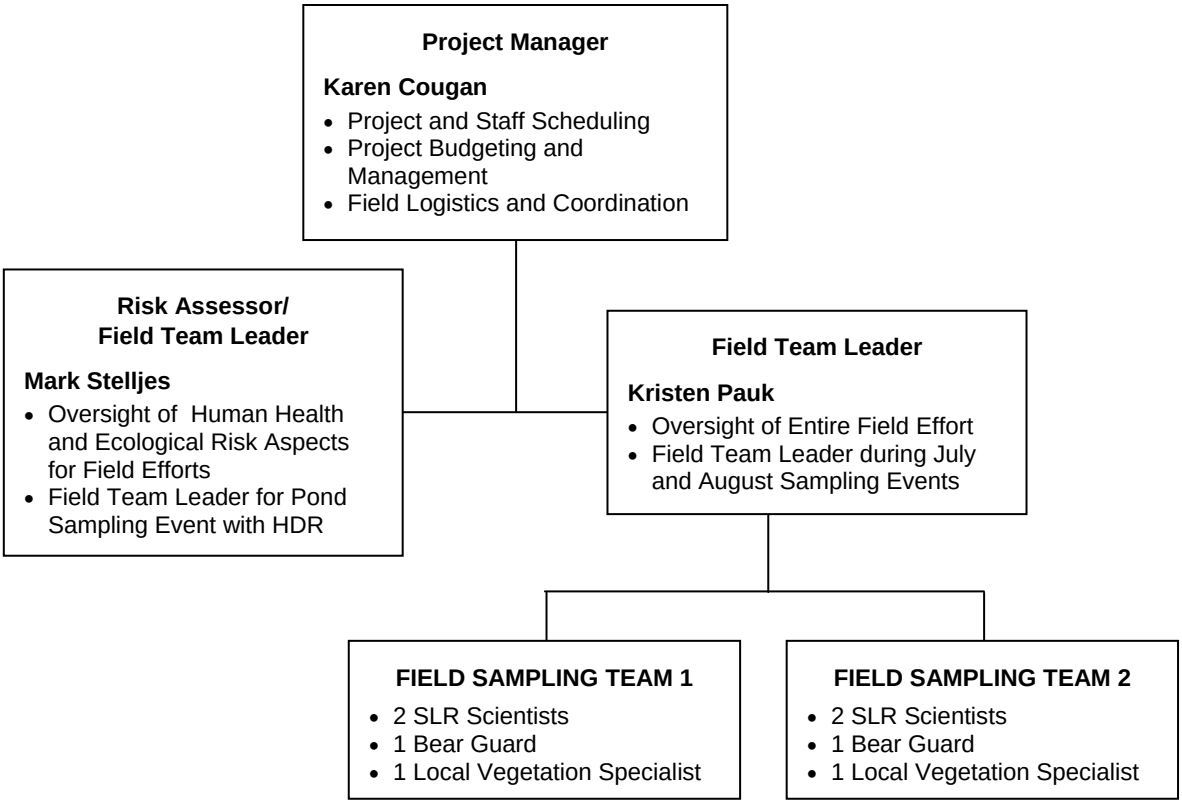
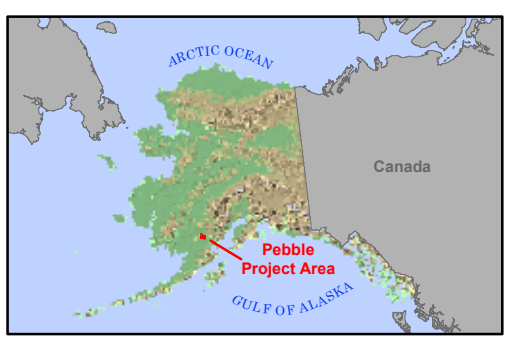


FIGURE 1
Trace Elements Program Organization Chart

155°24'0"W 155°18'0"W 155°12'0"W

59°57'0"N 59°54'0"N 59°51'0"N 59°48'0"N

236221 235282 235271 TPS4 235361 236353 335051 336011 TPS3 TPS1 335011 335081 TPS2 335144 335132 335141 335142 335245 335246 335143 335145 335133 335131 335235 335233 335242 335243 335234 335241 335244 336131 336231 WL-P01 336261 28B2 28B1 336362 TPS7 436041 335101 TPS5 WL-S04D TPS6 TPS8 436221 435301 536051



Miles 0 1 2 3

Kilometers 0 1 2 3

N

Scale 1:80,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

Legend

- **Bacteriology Soil, Surface Soil, and Terrestrial Vegetation Sample Locations**
- **Surface Soil and Terrestrial Vegetation Sample Locations**
- **Surface Soil Sample Locations**
- **Aquatic Vegetation and Sediment Sample Locations**
- **Aquatic Vegetation (Small Pond Study) Sample Locations**
- Study Boundary
- General Pit Outline

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Figure 2
2007 Field Sampling Plan;
Naturally Occurring Constituents;
Proposed 2007 Sampling Locations for Soil, Sediment, and Vegetation;
Mine Study Area

RDI_SLR_2007_FSP_Mine_TE_Fig2_11x17P_v01.mxd	Date: August 30, 2007
Version: 1	Author: RDI-LS

153°55'0"W 153°50'0"W 153°45'0"W 153°40'0"W 153°35'0"W 153°30'0"W 153°25'0"W

59°45'0"N

59°40'0"N

59°35'0"N

Iniskin Bay

Summit Lakes

TE18

SWQ-1

Williamsport

TE24

SWQ-2

TE19

Iliamna Bay

TE23

Pond6

SWQ-3

Cottonwood Bay

TE22

TE21

TE20

SWQ-4

Cook Inlet

153°55'0"W 153°50'0"W 153°45'0"W 153°40'0"W 153°35'0"W 153°30'0"W 153°25'0"W

Pebble Project

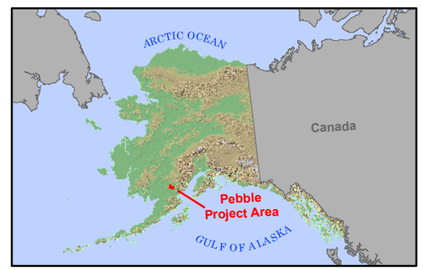
NORTHERN DYNASTY MINES INC.

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Figure 3
2007 Field Sampling Plan;
Naturally Occurring Constituents;
Proposed 2007 Sampling Locations for Soil, Sediment, and Vegetation;
Transportation Corridor

Legend

- Surface Soil and Terrestrial Vegetation Sample Locations
- Sediment Sample Locations
- Creek Water and Sediment Sample Locations
- Possible Road Corridor



0 1 2 3 4 Miles

0 1 2 3 4 5 Kilometers

N

Scale 1:100,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_SLR_FSP_TransCorr_TE_Fig2_11X17L_D01.mxd	August 27, 2007
Version: 1	Author: RDI-MRA, LS

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Groundwater Quality and Hydrology

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

DRINKING WATER CHARACTERIZATION

TRANSPORTATION CORRIDOR

NOVEMBER 2005

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ACRONYMS AND ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation
BEESC	Bristol Environmental & Engineering Services Corporation
C	Celsius
CAS	Columbia Analytical Services
COC	chain of custody
DI	deionized
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
µg/L	micrograms per liter
µm	micrometer(s)
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate
NCA	North Creek Analytical
NDM	Northern Dynasty Mines, Inc.
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
TDS	total dissolved solids
TSS	total suspended solids

1.0 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 is to detail tasks and to establish field procedures for conducting a study of groundwater chemistry in the road and port areas. The field work for this study will involve collecting and analyzing groundwater samples from existing wells along the proposed road corridor. This Field Sampling Plan also provides the basis for appropriate quality assurance (QA) and quality control (QC) measures to be instituted and monitored during data-collection activities.

The groundwater studies field work for the road/port will be conducted by Bristol Environmental & Engineering Services Corporation (BEESC) under direct contract to Northern Dynasty Mines Inc. (NDM).

2.0 PROJECT SCOPE AND OBJECTIVES

2.1 OBJECTIVES

The objective of the groundwater-quality studies is to define the chemical characteristics of groundwater used for drinking water along the proposed road corridor between the Newhalen River and Cook Inlet. Establishment of this baseline and regular, ongoing monitoring will give local residents confidence that their health is being considered and protected. At the port site, where ore concentrates may be temporarily stored and handled, there is potential for environmental impact to groundwater. The objective at the port site is to establish background concentrations of naturally occurring constituents in groundwater.

2.2 SAMPLE LOCATION SUMMARY

Groundwater samples will be collected from existing water-supply wells along the road corridor. Upon selection of the port site, a program involving installation of groundwater monitoring wells may be required. This aspect of the program will be evaluated after the port site configuration is finalized.

The following four wells, shown on Figure 1, will be sampled on a quarterly basis in 2005:

- Nondalton City Well
- Newhalen Public Well #2
- Iliamna Weathered Inn
- Pedro Bay Tribal Council Well

The groundwater analysis methods are detailed in the *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (QAPP; NDM, 2005).

3.0 GROUNDWATER ANALYTICAL SAMPLING

3.1 SAMPLE COLLECTION

The basic requirements for sampling groundwater from existing community drinking-water wells are designed to maximize sample quality and facilitate the permitting process. For each sample, water will be collected from a tap after running the water for several minutes. For the Nondalton and Newhalen wells, the water will be sampled from where it first leaves the wellhead, prior to chlorination. Water from the Iliamna and Pedro Bay wells is not treated. Groundwater will be tested for the same laboratory parameters and field parameters as for surface water (Table 1). QA/QC protocols will follow procedures outlined in Section 3.3 and in the QAPP (NDM, 2005).

Table 1. Groundwater Analytes for Laboratory Determination

Analyte	Method	Method Reporting Limit (µg/L)
Aluminum, total and dissolved	E200.8	1.0
Antimony, total and dissolved	E200.8	0.05
Arsenic, total and dissolved	E200.8	0.5
Barium, total and dissolved	E200.8	0.05
Beryllium, total and dissolved	E200.8	0.02
Bismuth	E200.8	0.1
Boron	E200.8	0.5
Cadmium, total and dissolved	E200.8	0.02
Calcium, total and dissolved	200.7	50
Chromium, total and dissolved	E200.8	0.2
Cobalt, total and dissolved	E200.8	0.02
Copper, total and dissolved	E200.8	0.1
Iron, total and dissolved	E200.7/200.8	20
Lead, total and dissolved	E200.8	0.02
Magnesium, total and dissolved	E200.7/200.8	20
Manganese, total and dissolved	E200.8	0.05
Mercury, total and dissolved	E245.1	0.2
Molybdenum, total and dissolved	E200.8	0.05
Nickel, total and dissolved	E200.8	0.2
Potassium, total and dissolved	E200.7/200.8	50

Analyte	Method	Method Reporting Limit (µg/L)
Selenium, total and dissolved	E200.8	1
Silver, total and dissolved	E200.8	0.02
Sodium, total and dissolved	E200.7/200.8	100
Thallium, total and dissolved	E200.8	0.01
Tin, total and dissolved	E200.8	1
Vanadium, total and dissolved	E200.8	0.2
Zinc, total and dissolved	E200.8	0.5
pH	E150.1	N/A
Specific Conductance	SM20 2510B	2 (µS/cm)
Alkalinity	SM20 2320B	10 (mg/L)
Acidity	E305.2	10 (mg/L)
Ammonia	SM20 4500NH3 G	0.1 (mg/L)
Chloride	E300.0	0.2 (mg/L)
Cyanide-total	SM20 4500	0.01 (mg/L)
Cyanide-WAD	SM20 4500	0.01 (mg/L)
Fluoride	E300.0	0.1 (mg/L)
Nitrate + Nitrite	E300.0	0.1 (mg/L)
Phosphorus-total	E365.2	0.1 (mg/L)
Sulfate	E300.0	0.01 (mg/L)
TDS	E160.1	10 (mg/L)
TSS	E160.2	5 (mg/L)
Thiocyanate	Lab SOP	1 (mg/L)
Hardness	SM20 2340 B	N/A

Notes:

µg/L = micrograms per liter

µS/cm = microSiemens per centimeter

mg/L = milligrams per liter

E – Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991.

SM – Standard Methods for the Examination of Water and Wastewater, 20th Edition.

Before a water sample is collected, the following field parameters will be measured and recorded in the field logbook:

- Dissolved oxygen.
- Conductivity.

- Temperature.
- pH.
- Turbidity.

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

1. Total metals.
2. Dissolved metals.
3. Total suspended solids (TSS), Total dissolved solids (TDS), etc.
4. Cyanide.
5. Miscellaneous parameters (e.g., ammonia, phosphorus).

Samples collected for dissolved metals analyses will be filtered using disposable 0.45 micrometer, 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.

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.

Because the water samples will be collected directly from the tap at each well, no non-disposable sampling equipment will be used; therefore, no decontamination procedures are required.

3.2 SAMPLE HANDLING

Samples will be packed to prevent breakage and will be kept chilled during field operations by packing the samples with frozen gel ice.

3.2.1 Sample Containers

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

3.2.2 Sample Identification

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 identification, analysis, and sampler's initials. Sample identification will be formatted to indicate sample date (month

and year), location, matrix, and number. Each sampling location will be identified by the sampler on the field form. An example of a sample identification is as follows:

0105ILIWIWG001

Where:

- 0105 is the date as month/year
- ILIWI is the location ID
- WG is the matrix code for groundwater
- 001 is a sequential sample number

For field duplicates, the sequential sample number will be 201, and triplicates will be 301.

3.2.3 Sample Custody

Chain-of-custody (COC) forms will be used for all samples and will be prepared by the field sample-handling person at Iliamna. Once collected, samples will remain within sight of the sampler or will be secured until the samples are turned over to the sample-handling person at Iliamna for transport to Anchorage. The field sample-handling person will be responsible for shipping and laboratory notification.

3.3 FIELD QUALITY CONTROL SAMPLES

To aid in evaluating the accuracy and precision of the analytical data, QC (duplicate) samples, and QA (triplicate) samples will be collected and subjected to the same analyses as identified for task samples. Equipment (also known as field) blanks will not be collected during this program because groundwater samples are being collected directly from the wells and sample-collection equipment is not used. The field QA/QC samples to be collected are summarized in the QAPP (NDM, 2005).

4.0 MEASUREMENT OF FIELD PARAMETERS

4.1 COLLECTION OF MEASUREMENTS

Portable instruments will be used for the in situ measurement of pH, temperature, dissolved oxygen, conductivity, and turbidity. The field measurements of water levels, pH, temperature, dissolved oxygen, conductivity, and turbidity will be recorded in the field logbook or on field sampling sheets, as appropriate.

4.2 EQUIPMENT CALIBRATION AND QUALITY CONTROL

Field equipment used for collection, measurement, and testing will be 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 and will be checked before sampling at each

station with reference to standard calibration solution. The standards of calibration are in accordance with the equipment manufacturer's handbook of specifications. All calibration activities will be documented on appropriate field-calibration forms.

The field-crew 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 documented and corrective action may be required. Field-sampling corrective actions 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 corrective actions will be recorded in the field book.

Equipment will be maintained in good operating condition.

5.0 RECORD KEEPING

Field observations, field equipment-calibration information, field measurements, and sample documentation—including sample identification, sample duplicates and triplicates, and date and time of sample collection—will be the responsibility of the entire sampling team. Record keeping will be accomplished with field logbooks, 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 crew.

5.1 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. 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 conditions, 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. Calibration logbooks will be maintained for each field-parameter meter used for the entire sampling season. The data in the calibration logbooks will include the name of the person doing the calibration, date and time, calibration solution and expiration date, and reading versus calibration value.

5.2 CORRECTIONS TO DOCUMENTATION

Unless weather conditions prevent it, all original data will be recorded using waterproof ink. No records 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 a record assigned to one person, that person 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 subsequent error discovered on a document will be corrected by the person who made the entry. All such subsequent corrections will be initialed and dated.

6.0 REFERENCES

Northern Dynasty Mines (NDM). In press. Draft Environmental Baseline Studies, Proposed 2005 Study Plan.

———. 2005. Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan.

FIGURE

1,400,000 1,450,000 1,500,000 1,550,000 1,600,000 1,650,000 1,700,000 1,750,000

2,250,000 2,200,000 2,150,000 2,100,000 2,050,000 2,000,000

Nondalton

Iliamna

Newhalen

Pedro Bay

Northern Dynasty Mines Inc.

Pebble Project

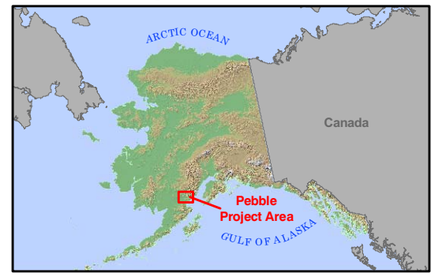
Groundwater Well Sample Locations

Figure 1.

Legend

- Groundwater Well Sample Location
- Port Site 1
- ADOT&PF Preferred Road Corridor

Privileged and Confidential



0 16,000 32,000 48,000 64,000 Feet

0 4,700 9,400 14,100 18,800 Meters

Scale 1:361,929

N

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: WaterGrnd_V02.mxd	Date: Sept. 2, 2005
Version: 2	Author: BEESC-ME

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

GROUNDWATER HYDROLOGY AND WATER QUALITY

MINE AREA

NOVEMBER 2005

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Table 2, 2005 Proposed Boreholes

Appendices

Appendix A, Field Forms

Appendix B, Example Well Construction Logs

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).

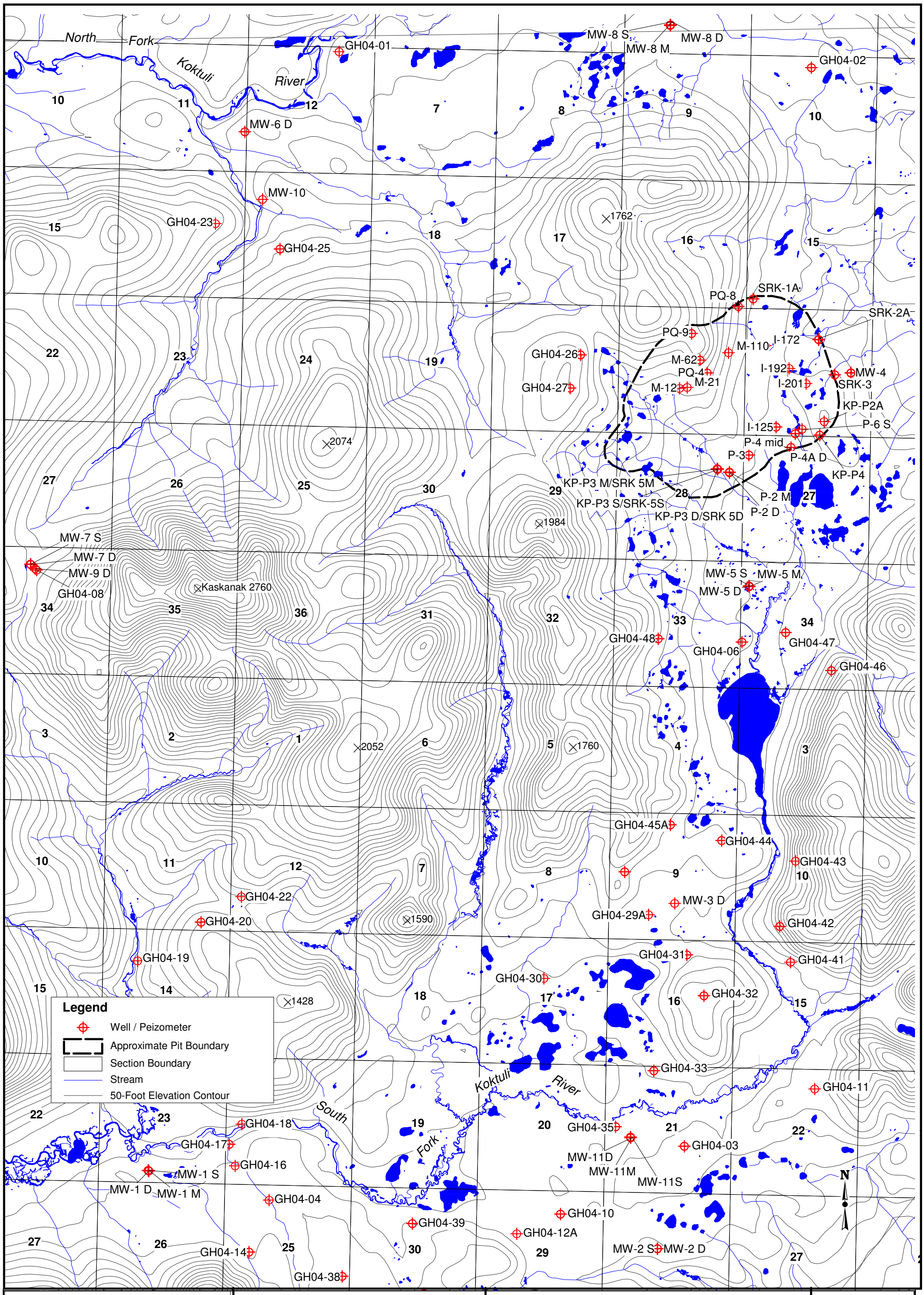
———. 2004. Method D 5092-04e1, Standard Practice for Design and Installation of Groundwater Monitoring Wells.

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

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

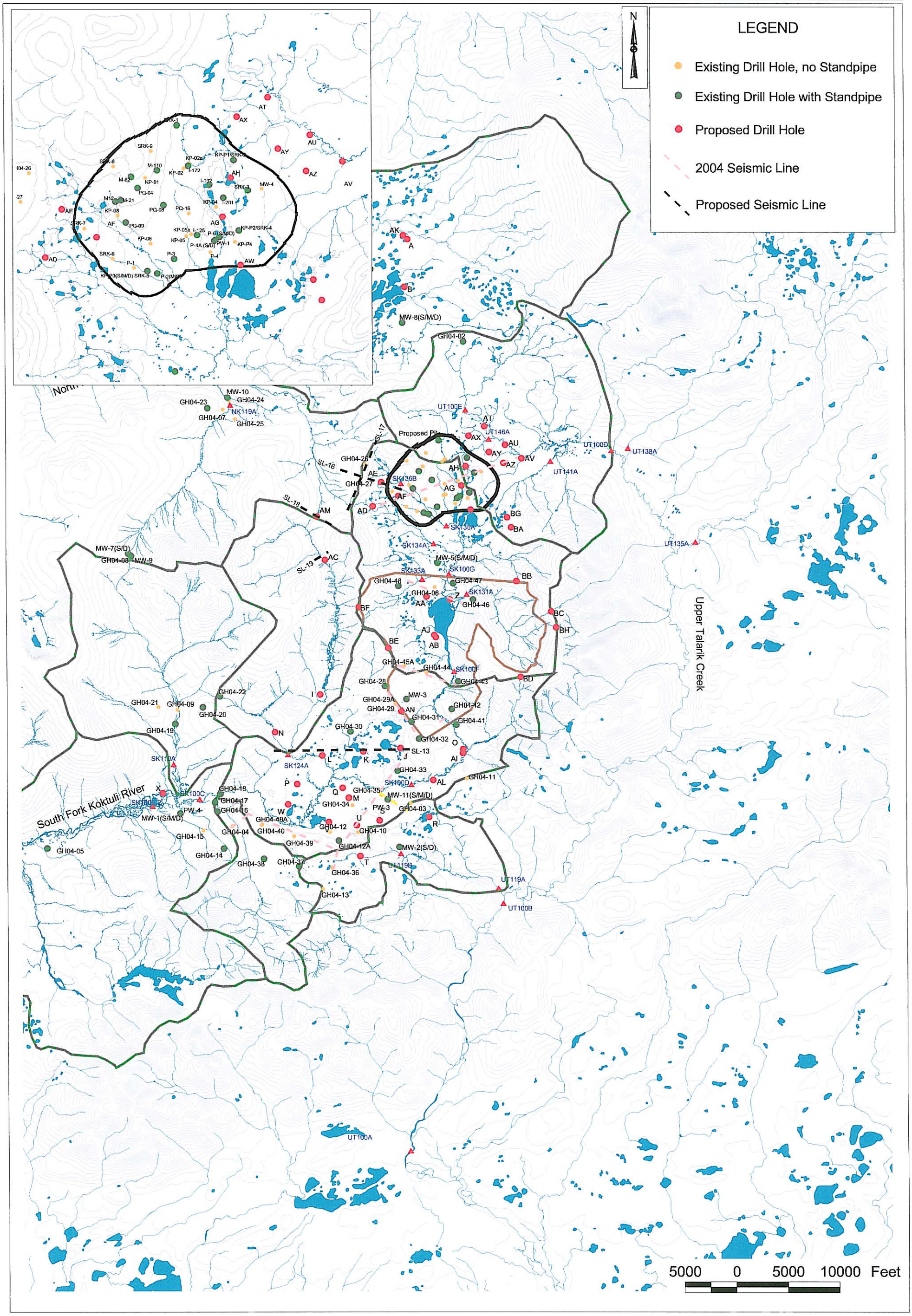
3522 International Street
Fairbanks, AK 99701
(907) 455-9005 Fax (907) 455-9015

Northern Dynasty Mines, Inc.
Existing Mine Site
Well Locations

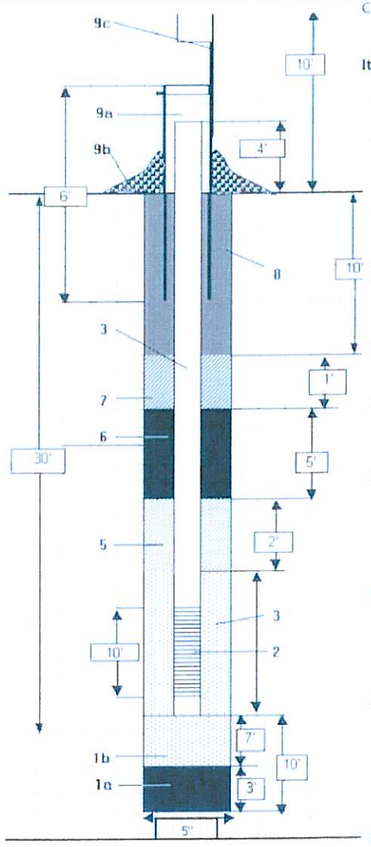
Figure

1

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



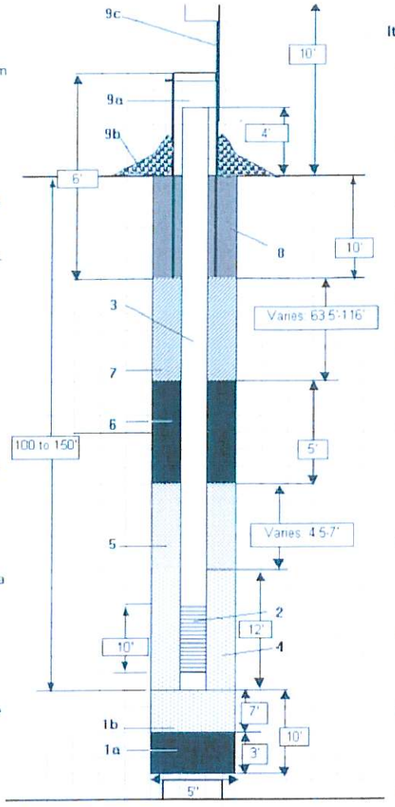
SHALLOW WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specifiction/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	CSSI 10-20 silica sand, placed to least 3 feet above rathole bentonite plug
1	b) Type of transition sand	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.
2	Type/slot size of screen	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
3	Dia./type of riser well casing	CSSI 10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
4	Type screen filter pack	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)
5	Type of transition sand	PureGold medium bentonite chips, (where possible) placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
6	Type of 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.
7	Type seal overlying plug	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
8	Type near-surface completion	
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

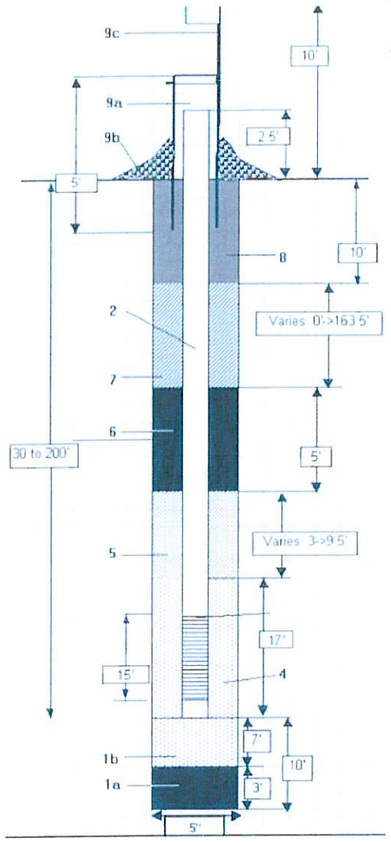
INTERMEDIATE (100 to 150 ft.) WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specifiction/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	CSSI 10-20 silica sand, placed at least 7 feet above rathole bentonite plug
1	b) Type of transition sand	2-inch/Schedule 80 PVC Pre-pack (or Insta-pack), 0.020-inch, machine-slotted PVC pipe, capable of retaining filter sand
2	Type/slot size of screen	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
3	Dia./type of riser well casing	CSSI 10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
4	Type screen filter pack	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)
5	Type of transition sand	PureGold medium bentonite chips, placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
6	Type of plug	PureGold grout, >30%solids by weight bentonite; place by tremie pipe from bottom up
7	Type seal overlying plug	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
8	Type near-surface completion	
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	Specifiction/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	CSSI 10-20 silica sand, placed at least 7 feet above rathole bentonite plug
1	b) Type of transition sand	2-inch/Schedule 80 PVC Pre-pack (or Insta-pack), 0.020-inch, machine-slotted PVC pipe, capable of retaining filter sand
2	Type/slot size of screen	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
3	Dia./type of riser well casing	10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
4	Type screen filter pack	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)
5	Type of transition sand	PureGold medium bentonite chips, placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
6	Type of plug	PureGold grout, >30%solids by weight bentonite; place by tremie pipe from bottom up
7	Type seal overlying plug	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
8	Type near-surface completion	
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

E:\2004\04ANC (Ver)\wells @ 07/08/04 rds

TABLES

Table 1. Existing Well Locations and Completions

Drillhole	NAD 1927 Coordinates Northing (m)	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)	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:

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

Comments:

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: _____

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.

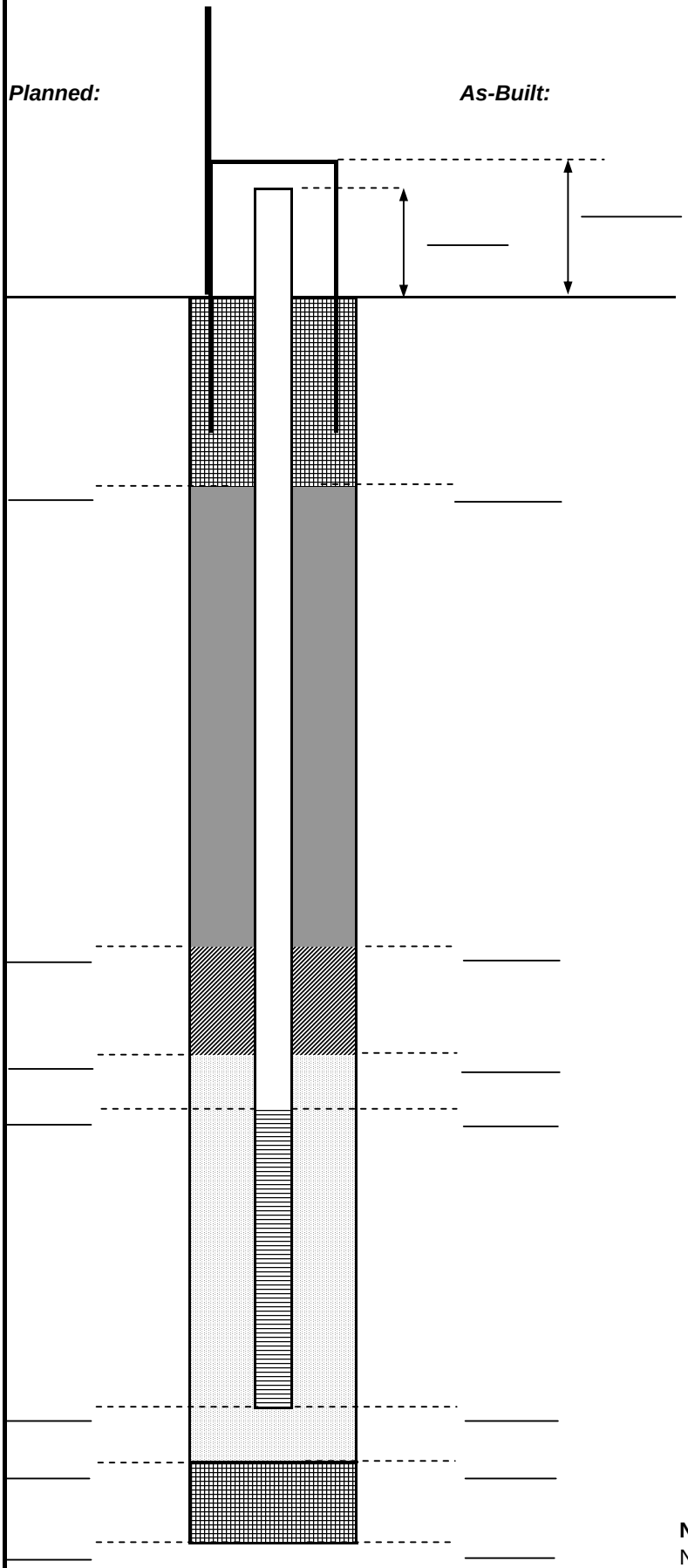
Construction Method:
refers to drill type, e.g. solid stem auger, hollow stem auger, mud rotary, air rotary, reverse air, etc.

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:** _____

Bottle Inventory:	AS1	AS2	AS3	AS4	AS5		AS6	AS7
	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	**Schedule 40**		**Schedule 80**	
Diameter (inches)	(gal/ft casing)	(liters /ft casing)	(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										

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	
GH04-01	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										

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

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
0					**Peat (PT)** Brown, moist, soft.	
					3.0 **Well-graded sand w/ trace gravel to 3/8" (SW)** Brown, moist, fine to medium sand.	
					6.0 **Poorly-graded sand (SP)** Brown, moist, medium to fine sand, trace gravel to 3/8".	
10					Wet at 11-12'	
					13.0 **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: _____

NORTHERN DYNASTY PEBBLE.GPJ GINT US.GDT 1/24/05

(Continued Next Page)

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
40					**Sandy well-graded gravel (GW)** Brown, wet, sub-angular to rounded gravel to 1", medium sand.	Flow YES/OUT
					Sandy well-graded gravel (GW) Brown, wet, sub-angular to rounded gravel to 1", medium sand.	Cond=0-1, pH=6.1 Flow YES/OUT
					70% gravel, 30% sand	
50					Sand content increasing. 60% gravel, 40% sand.	
					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						Collect water at 65'. Specific Condition=5.7, pH=6.55
					Same as above.	
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,

NORTHERN DYNASTY PEBBLE.GPJ GINT US.GDT 1/24/05

(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
100					45% sand and 55% gravel	pH=6.04 Collect water at 95'. Flow YES/OUT
					105.0 Same	
110					**Silty gravel with sand (GM)** Tan/brown, saturated. 20% silt, 30% sand, 50% gravel	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	
130					**Bedrock** White/green, wet, calcified rock with pyrite. HCl test confirmed.	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.	

Pebble Project

Groundwater Studies for Mine Area

2006 Addendum to Field Sampling Plan

Prepared for



Northern Dynasty Mines Inc.

3201 C Street
Anchorage, Alaska 99503

SLR Alaska

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(907)-222-1112

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Figure 1, Existing Well Locations

Figure 2, Proposed Well Locations

Tables (following figures)

Table 1, Existing Well Locations and Completions

Table 2, 2006 Proposed Borehole Schedule

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 Study Plan (Northern Dynasty Mines, 2005). This addendum should be read with the Pebble Project Ground Water Studies Field Sampling Plan (FSP).

The purpose of this addendum to the Field Sampling Plan (FSP) is to detail changes to the tasks and field procedures for conducting a study of groundwater hydrology and chemistry in the Pebble Project mine area. Specifically, this 2006 addendum adds wells and piezometers completed in 2005 to the monitoring tables and describes other work planned for 2006 that was not completed in 2005. The fieldwork for this study will involve drilling and installing additional groundwater monitoring wells and piezometers and collecting and analyzing groundwater samples. The FSP provided the basis for appropriate quality assurance (QA) and quality control (QC) measures to be instituted and monitored during data collection activities.

2 Project Background

No changes to project background.

3 Project Scope and Objectives

3.1 Objectives

No change.

3.2 Sample Analysis Summary

The only change to groundwater analysis methods is for mercury, which has been changed to a low-level analysis. Other analytical methods are the same as the 2005 FSP. The updated locations of 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.

3.3 Field Activities

The field work, which consists of drilling, installing, and developing monitoring wells and piezometers; aquifer testing; groundwater level measurement; and groundwater sampling, is scheduled to begin by January 2006 and to be completed in December 2006. Each of these activities is described in the following paragraphs.

3.3.1 Water-level Monitoring

Water levels will be measured in selected monitoring wells and piezometers monthly during 2006. (see Table 1).

3.3.2 Install and Sample Piezometers and Monitoring Wells

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 (see Table 2). The number of wells at each site and the actual depths will vary depending on site conditions encountered during drilling. The drilling system will be a helicopter-portable ODEX drilling rig with a 5-inch inner diameter (ID) temporary drill casing. The rig will be equipped with rotary and coring capability.

3.3.3 Install Pumping Wells and Perform Pumping Tests

No pumping tests are planned for 2006.

3.3.4 Westbay System Installation

A multi level piezometer is planned for installation in a resource drillhole in the Upper Talarik watershed. The planned installation will provide instrumentation that allows measurement of piezometric level and screening-level hydraulic conductivity testing in 50 zones at depths up to

4,200 ft. More detailed hydraulic conductivity testing and collection of groundwater samples will be possible from 25 of the 50 zones.

4 Project Organization and Responsibility

No change to the FSP.

5 Groundwater Analytical Sampling Methods

The following sections outline addendum to the basic requirements for drilling, installing, sampling, and measuring monitoring wells, pumping wells, and piezometers.

5.1 Surveying and Identifying Well/Piezometer Locations

No change to the FSP.

5.2 Groundwater Monitoring Wells

5.2.1.1 Drilling

No change.

5.2.1.2 Monitoring Well Design

No change in the monitoring well design. The proposed monitoring well depths and drilling methods for 2006 are summarized in Table 2, and the proposed locations are shown on Figure 2.

5.3 Piezometers

5.3.1 Piezometer Installation

No change with respect to design or field installation methods. The proposed locations for 2006 are summarized in Table 2 and the proposed locations are shown on Figure 2.

5.3.2 Development and Sampling

No change.

5.3.3 Response Testing

No change.

5.4 Pumping Test Wells

No pumping tests are planned for 2006.

5.5 Water-level Measurements

No change to the FSP.

5.6 Sampling Procedures

No change to the FSP.

5.7 Sampling Equipment Decontamination

No change to the FSP.

5.8 Sample Handling

No change to the FSP.

5.9 Sample Custody

No change to the FSP.

5.10 Field Quality Control Samples

No change to the FSP.

5.11 Westbay System Installation

5.11.1 General

A Westbay System Installation is planned for a resource hole cored in the Upper Talarik watershed in the Pebble East Zone. The drilling will include installation of a surface casing, drilling as far as possible with HQ coring equipment and stepping down to complete the hole with NQ coring equipment. The planned depth of the hole is a minimum of 4,200 ft. The Westbay well is planned to include 50 measurement ports, 50 water inflated packers, and 25 hydraulically operated pumping ports.

Selection of monitoring zones will be recommended in the field by WMC, with assistance by KP and Westbay. The system will be installed by the drill contractor under the advice of Westbay. Assistance will be provided by KP, WMC and SLR. Westbay will train SLR in the use of monitoring and testing tools to supplement the information provided in the respective Operators Manuals supplied with the Westbay monitoring equipment. In particular, the equipment

operating procedures for the Model 2532 MOSDAX Sampler Probe includes step-by step instructions for typical monitoring and testing tasks such as pressure profile measurements, groundwater sample collection, and operation of the Model 0706 Hydraulic Pumping Port. Special procedures will be developed as required in consultation with SLR, WMC and Westbay for the performance and documentation of other tests as described in the following sections. SLR will be responsible for completion of monitoring and testing.

5.11.2 Installation

The installation will generally include the following.

- The installation will be designed to isolate zones that will define hydrostratigraphic conditions. Drill core logging and drilling conditions will be the data used to select packer locations.
- The casing components will be laid out in order prior to lowering in the hole.
- After completion of drilling, drilling fluid in the hole will be replaced with clean water.
- Drill rods will be removed, but N casing will be left in the drillhole.
- The MP components will be assembled and lowered into the drillhole. Each assembled joint will be pressure tested to reduce the potential for leakage.
- Water will be added to the Westbay casing as it is assembled to sink the Westbay casing string into the drillhole. As the Westbay casing string length increases, the string will need to be supported and the volume of water inside the MP casing adjusted to meet design strength constraints.
- Packers in the unlined portion (NQ drillhole) will be inflated with a packer inflation tool from the bottom up. N casing will be removed in sections so as to minimize standing time on unstable borehole sections prior to packer inflation.
- The MP casing string tension will be adjusted during inflation to keep the casing straight, yet prevent unacceptable tensile loads from locking into the couplings.

5.11.3 Initial Testing

Two pressure profiles will be completed following installation. Piezometric pressures will be measured with a downhole probe at each measurement port for each profile. Pressures will be measured at each port for a sufficient period of time (up to 10 min) to verify that transient response to measurement port activation is complete.

Following the pressure profiles, screening level hydraulic conductivity testing will be completed for all 50 measurement ports. The tests will be carried out by parking the downhole tool at each port, allowing pressure stabilization, while adjusting the water level inside the MP casing, allowing flow from the monitored interval into the casing, and then measuring the pressure recovery to the flow test. For those zones where the test response is constrained by the head

drop across the measurement port, tests will be carried out using the pumping port (if installed in the zone).

5.11.4 Hydraulic Conductivity Testing

When a pumping port is opened, the Westbay casing acts as a conventional monitoring well. A piezometer response test will be carried out using each of the selected zones. First, the water level inside the MP casing will be drawn down several meters below the piezometric level in the test zone. A high capacity Waterra pump will be used to draw the water level down. The opening tool will then be lowered to the opening location, and the port opened. The water level recovery inside the MP casing will be monitored until stable or for 20 minutes. The probe will then be removed from the hole re-configured and re-deployed for closing. The port will then be closed and the next test will start. A suitable record of the testing will be collected according to the agreed test procedure, including a paper record for each test, plus datalogging of pressure responses by means of the MAGI datalogger unit purchased from Westbay Instruments.

5.11.5 Initial Groundwater Samples

Ground water samples will be collected from measurement ports installed within relatively permeable zones. As the installation has only recently been completed, sampling will be limited to documentation of field parameters (electrical conductivity and pH). The Westbay sample bottle will be rinsed with deionized water as a decontamination step.. The Westbay sampling equipment will be deployed and operated as described in the Equipment Operators Manual. The retrieved sample will be extracted and the electrical conductivity and pH measured. This initial sampling round should provide SLR with the field experience and background required to integrate the Westbay sampling with the remainder of the sampling program.

5.11.6 Piezometric Pressure Profiles

A piezometric pressure profile will be completed at the end of the initial testing and each month coincident with water level monitoring of piezometers and monitoring wells. The Westbay equipment will be deployed and operated as described in the Equipment Operators Manual

5.11.7 Groundwater Sampling

Groundwater samples will be collected from selected measurement ports coincident with a groundwater sampling event in late 2006. Actual protocols will be developed by SLR following installation and initial testing.

6 Field Measurements

No change to the FSP.

7 Record Keeping

No change to the FSP.

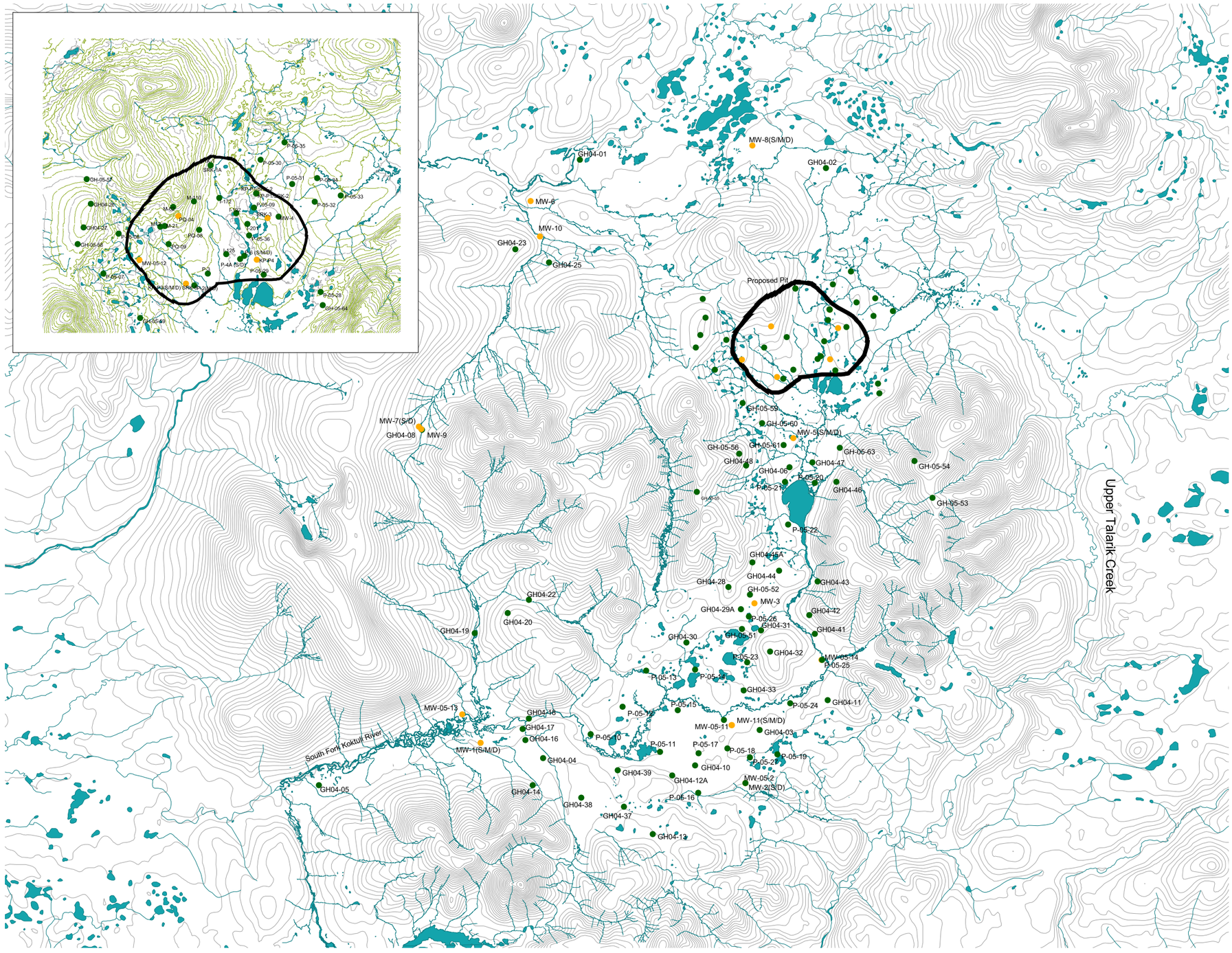
8 Field Performance and System Audits

No change to the FSP.

9 References

No change to the FSP.

FIGURES



Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 1
Exising Welll Locations

- Piezometer
- Monitoring Well



0 4000 8000 12000 16000 20000 Feet

0 1000 2000 3000 4000 5000 Meters

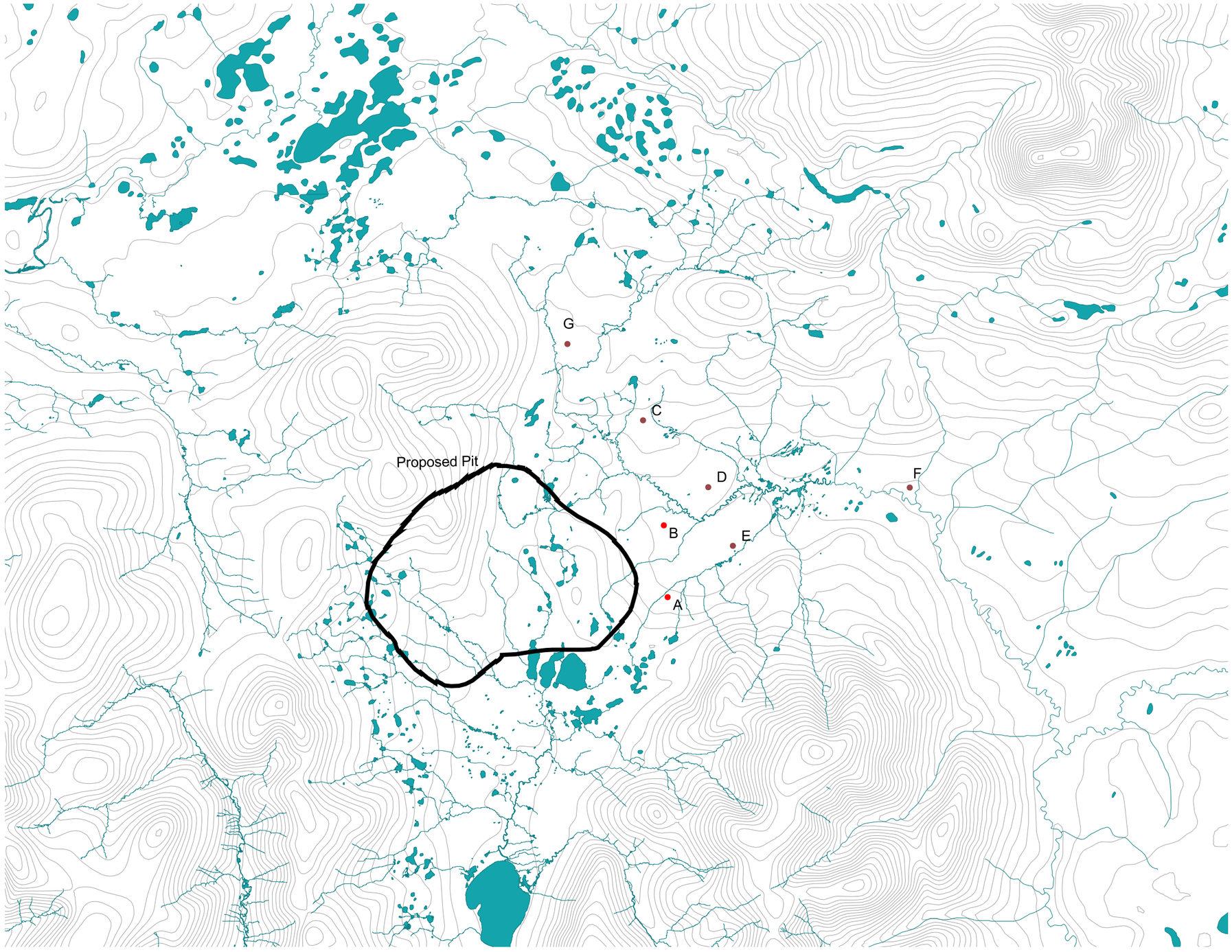
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File: Fig1-2006 Addendum to FSP	Date: July 27, 2006
Version: 1	Author: WMC-RS

Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 2
Proposed Welll Locations



- Proposed Piezometer
- Proposed Monitoring Well



0 2000 4000 6000 8000 10000 Feet

0 500 1000 1500 2000 2500 Meters

N

File: Fig2-2006 Addendum to FSP	Date: July 27, 2006
Version: 1	Author: WMC-RS

TABLES

Table 1: Existing Well Locations and Completions

Drillhole	Alaska State Plane 5 NAD 83		NAD 1927 Coordinates		PVC elevation		Ground elevation		PVC stickup			Total Depth	Depth to pump	Screen Interval	Monthly Water Levels	Quarterly Water Sampling	Notes
	Easting (ft)	Northing (ft)	Easting (m)	Northing (m)	(m)	(ft)	(m)	(ft)	(m)	(ft)[1]	(ft)[2]	(ft, FTOC)	(ft)	(ft, BGS)			
GH04-01	1,386,180	2,171,584	366,784	6,646,682	325.065	1066.49	324.88	1065.89			0.6	33.50		23-33	X (1)		
GH04-02	1,405,882	2,170,918	372,785	6,646,388	350.859	1151.11	350.52	1150.01			1.1	26.10		15-25	X (2)		
GH04-03	1,400,583	2,125,932	370,963	6,632,704	285.206	935.72	285.11	935.42			0.3	60.30		50-60	X (3)		
GH04-04	1,383,250	2,123,686	365,671	6,632,099	281.628	923.98	281.54	923.68			0.3	73.30		63-73	X (4)		
GH04-05	1,365,296	2,121,512	360,190	6,631,520	235.396	772.30	235.24	771.80			0.5	36.50		26-36	X (5)		
GH04-06	1,402,986	2,146,959	371,792	6,639,100	294.974	967.76	294.82	967.26			0.5	35.30		23-35	X (6)		
GH04-08	1,373,556	2,149,963	362,838	6,640,151	465.266	1526.46	464.96	1525.46			1	42.00		31-41	X (7)		
GH04-10	1,395,412	2,123,101	369,374	6,631,865	276.751	907.98	276.45	906.98			1	57.00		46-56	X (8)		
GH04-11	1,406,017	2,128,321	372,630	6,633,407	297.865	977.25	297.83	977.15			0.1	25.10		16-25	X (9)		
GH04-12A	1,393,590	2,122,286	368,815	6,631,625	269.536	884.30	269.38	883.80			0.5	62.80		52-62	X (10)		
GH04-13	1,392,021	2,117,580	368,315	6,630,199	321.703	1055.46	321.46	1054.66			0.8	43.80		33-43	X (11)		
GH04-14	1,382,419	2,121,520	365,408	6,631,443	283.19	929.10	282.98	928.40			0.7	73.90		63-73	X (12)		
GH04-16	1,381,837	2,125,117	365,247	6,632,542	271.455	890.60	271.30	890.10			0.5	101.50		91-101	X (13)		
GH04-17	1,381,594	2,126,017	365,177	6,632,817	256.827	842.61	256.67	842.11			0.5	39.50		29-39	X (14)		
GH04-18	1,382,120	2,126,850	365,341	6,633,069	253.957	833.19	253.80	832.69			0.5	54.50		44-54	X (15)		
GH04-19	1,377,773	2,133,668	364,048	6,635,166	268.95	882.38	268.80	881.88			0.5	15.50		5-15	X (16)		
GH04-20	1,380,421	2,135,284	364,862	6,635,647	373.545	1225.54	373.39	1225.04			0.5	13.50		3-13	X (17)		
GH04-22	1,382,100	2,136,338	365,379	6,635,960	345.547	1133.68	345.39	1133.18			0.5	16.50		8-16	X (18)		
GH04-23	1,381,015	2,164,417	365,177	6,644,521	416.64	1366.93	416.49	1366.43			0.5	20.50		10-20	X (19)		
GH04-25	1,383,712	2,163,357	365,994	6,644,186	401.057	1315.80	400.90	1315.30			0.5	76.00		65.5-75.5	X (20)		
GH04-26	1,396,246	2,158,941	369,793	6,642,783	475.075	1558.65	474.92	1558.15			0.5	27.50		17-27	X (21)		
GH04-27	1,395,818	2,157,549	369,657	6,642,361	473.417	1553.21	473.26	1552.71			0.5	31.50		21-31	X (22)		
GH04-28	1,398,091	2,137,379	370,256	6,636,204	352.912	1157.85	352.79	1157.45			0.4	57.40		47-57	X (23)		
GH04-29A	1,399,086	2,135,590	370,551	6,635,654	313.97	1030.09	313.82	1029.59			0.5	60.50		50-60	X (24)		
GH04-30	1,394,724	2,132,937	369,210	6,634,866	286.308	939.33	286.16	938.83			0.5	77.5		67-77	X (25)		
GH04-31	1,400,682	2,133,911	371,030	6,635,135	308.292	1011.46	308.14	1010.96			0.5	63.5		53-63	X (26)		
GH04-32	1,401,402	2,132,207	371,241	6,634,613	370.038	1214.04	369.89	1213.54			0.5	41.5		31-41	X (27)		
GH04-33	1,399,309	2,129,087	370,589	6,633,671	275.986	905.47	275.83	904.97			0.5	57.5		47-57	X (28)		
GH04-35	1,397,715	2,126,742	370,093	6,632,964	271.409	890.45	271.26	889.95			0.5	66.3		56-66	X (29)		
GH04-37	1,389,715	2,119,791	367,623	6,630,883	297.997	977.68	298.00	977.68			0	148.3		138-148	X (30)		
GH04-38	1,386,308	2,120,502	366,588	6,631,115	287.69	943.86	287.69	943.86			0	60.4		50-60	X (31)		
GH04-39	1,389,233	2,122,703	367,490	6,631,772	277.889	911.71	277.74	911.21			0.5	35.5		25-35	X (32)		
GH04-41	1,405,013	2,133,609	372,348	6,635,023	287.643	943.71	287.41	942.96			0.75	92.8		82-92	X (33)		
GH04-42	1,404,563	2,135,111	372,218	6,635,483	325.075	1066.52	325.04	1066.42			0.1	90.8		81-91	X (34)		
GH04-43	1,405,221	2,137,825	372,431	6,636,307	342.257	1122.89	342.10	1122.39			0.5	100.7		90-100	X (35)		
GH04-44	1,402,137	2,138,681	371,495	6,636,582	335.306	1100.09	335.15	1099.59			0.5	97.6		87-97	X (36)		
GH04-45A	1,399,997	2,139,335	370,846	6,636,791	342.15	1122.54	342.00	1122.04			0.5	84.5		74-84	X (37)		
GH04-46	1,406,716	2,145,777	372,923	6,638,723	348.629	1143.80	348.48	1143.30			0.5	84.2		74-84	X (38)		
GH04-47	1,404,802	2,147,359	372,347	6,639,214	296.944	974.23	296.64	973.23			1	42.3		31-41	X (39)		
GH04-48	1,399,489	2,147,095	370,727	6,639,158	361.113	1184.75	360.96	1184.25			0.5	50.3		40-50	X (40)		
GH05-51	1,399,172	2,133,996	370,570	6,635,168	305.332	1001.75	305.027	1000.74	0.305	1.00		256.0		215-255	X (41)		
GH05-52	1,399,790	2,136,769	370,771	6,636,010	312.172	1024.19	311.701	1022.64	0.471	1.55		121.5		110-120	X (42)		
GH05-53	1,414,414	2,144,518	375,263	6,638,304	592.837	1945.00	592.4385	1943.70	0.399	1.31		31.3		20-30	X (43)		
GH05-54	1,412,985	2,147,460	374,841	6,639,207	609.629	2000.10	609.465	1999.56	0.164	0.54		35.5		25-35	X (44)		
GH05-55	1,395,554	2,144,994	369,518	6,638,536	485.116	1591.59	484.900	1590.88	0.216	0.71		13.7		3-13	X (45)		
GH05-56	1,398,947	2,148,042	370,566	6,639,449	414.313	1359.29	414.058	1358.46	0.255	0.84		45.8		35-45	X (46)		
GH05-57	1,396,013	2,160,439	369,729	6,643,240	429.456	1408.98	429.211	1408.17	0.245	0.80		37.8		27-37	X (47)		
GH05-58	1,395,458	2,156,535	369,542	6,642,053	459.044	1506.05	458.784	1505.20	0.260	0.85		38.9		28-38	X (48)		
GH05-59	1,399,207	2,152,099	370,664	6,640,684	361.388	1185.66	360.965	1184.27	0.423	1.39		79.4		68-78	X (49)		
GH05-60	1,400,784	2,150,475	371,137	6,640,182	337.757	1108.13	337.494	1107.26	0.263	0.86		100.0		89-99	X (50)		
GH05-61	1,402,487	2,148,722	371,648	6,639,640	297.685	976.66	297.470	975.95	0.215	0.71		170.7		160-170	X (51)		
GH05-63	1,406,996	2,148,518	373,021	6,639,557	317.602	1042.00	317.448	1041.50	0.154	0.51		60.5		50-60	X (52)		
GH05-64	1,410,179	2,152,865	374,011	6,640,867	310.875	1019.93	310.773	1019.60	0.102	0.33		60.3		50-60	X (53)		
MW-1D	1,378,226	2,124,912	364,146	6,632,496	249.484	818.52	248.748	816.10	0.736	2.41		136.9		124.5-134.5	X (54)	X (1)	
MW-1M	1,378,238	2,124,905	364,149	6,632,494	249.327	818.00	248.862	816.48	0.465	1.53		96.5		62-72	X (55)	X (2)	
MW-1S	1,378,207	2,124,919	364,140	6,632,499	249.697	819.22	248.621	815.69	1.076	3.53		26.5		15-25	X (56)	X (3)	
MW-2D	1,378,226	2,124,912	364,146	6,632,496	254.493	834.95	253.805	832.69	0.688	2.26	2.5	137.5	127.60	120-135	X (57)	X (4)	Kerry's 2005 survey data different
MW-05-2M	1,399,438	2,121,667	370,594	6,631,410	254.548	835.13	254.020	833.40	0.528	1.73		20.2		13.5-18.5	X (58)	X (5)	
MW-2S	1,399,461	2,121,654	370,601	6,631,406	254.352	834.49	253.663	832.23	0.689	2.26	2.4	77.4	0.00	65-75	X (59)		
MW-05-2SR	1,399,446	2,121,654	370,597	6,631,406	254.624	835.38	253.767	832.57	0.857	2.81		65.5		52.7-62.7	X (60)	X (6)	
MW-3D	1,400,178	2,136,063	370,886	6,635,793	313.733	1029.31	312.825	1026.33	0.908	2.98	3	197.0	183.00	179-194	X (61)	X (7)	
MW-5D	1,403,274	2,149,287	371,890	6,639,808	299.394	982.26	298.718	980.05	0.676	2.22	2.4	107.4	91.15	90-105	X (62)	X (8)	
MW-5M	1,403,292	2,149,284	371,896	6,639,808	299.733	983.38	299.681	983.21	0.052	0.17	2.5	67.5	57.30	55-65	X (63)	X (9)	
MW-5S	1,403,287	2,149,303	371,894	6,639,813	299.592	982.91	298.535	979.45	1.057	3.47	2.9	44.0	33.20	31-41	X (64)	X (10)	
MW-6D	1,382,244	2,168,254	365,569	6,645,685	342.370	1123.26	341.592	1120.71	0.778	2.55	2.7	93.7	86.30	81-91	X (65)	X (11)	
MW-7D	1,373,318	2,150,204	362,766	6,640,226	471.867	1548.12	470.92	1545.02			3.1	74.1	65.73	61-71	X (66)	X (12)	
MW-7S	1,373,299	2,150,209	362,760	6,640,227	472.387	1549.83	471.53	1547.03			2.8	33.0	30.30	20-30	X (67)	X (13)	
MW-8D	1,400,007	2,172,701	371,003	6,646,958	341.498	1120.40	340.74	1117.90			2.5	99.5	90.82	87-97	X (68)	X (14)	
MW-8M	1,399,993	2,172,687	370,998	6,646,954	341.474	1120.32	340.71	1117.82			2.5	49.5	34.14	32-47	X (69)	X (15)	
MW-8S	1,399,990	2,172,705	370,997	6,646,959	341.536	1120.52	340.65	1117.62			2.9	21.0	18.76	8-18	X (70)	X (16)	
MW-9D	1,373,502	2,150,022	362,822	6,640,169	466.672	1531.08	465.79	1528.18			2.9	77.0	67.19	58-74	X (71)	X (17)	**Extension on well**
MW-10	1,383,020	2,163,359	365,783	6,644,190	339.229	1112.96	338.295	1109.89	0.934	3.06	3	43.0		30-40	X (72)	X (18)	
MW-11D	1,398,335	2,126,319	370,280	6,632,832	270.279	886.74	269.287	883.49	0.992	3.25	2.9	139.0		126-136	X (73)	X (19)	
MW-11M	1,398,338	2,126,303	370,281	6,632,828	270.427	887.23	268.652	881.40	1.775	5.82	3.2	115.2		102-112	X (74)	X (20)	
MW-11S	1,398,344	2,126,290	370,282	6,632,824	270.332	886.92	268.840	882.02	1.492	4.90	2.9	74.0		51-71	X (75)	X (21)	
MW-05-11SS	1,398,358	2,126,297	370,286	6,632,826	269.818	885.23	269.027	882.63	0.791	2.60		32.1		19.5-29.5	X (76)	X (22)	
MW-05-12D	1,399,176	2,155,571	370,671	6,641,742	375.153	1230.82	374.480	1228.61	0.673	2.21		124.2		102-122	X (77)	X (23)	
MW-05-12S	1,399,196	2,155,584	370,677	6,641,746	375.085	1230.59	374.380	1228.28	0.705	2.31		43.3		36-41	X (78)	X (24)	
MW-05-13D	1,376,783	2,127,181	363,716	6,633,194	248.538	815.41	247.817	813.05	0.721	2.37		112.4		94.5-110	X (79)	X (25)	

Table 1: Existing Well Locations and Completions

Drillhole	Alaska State Plane 5 NAD 83		NAD 1927 Coordinates		PVC elevation		Ground elevation		PVC stickup			Total Depth	Depth to pump	Screen Interval	Monthly Water Levels	Quarterly Water Sampling	Notes
	Easting (ft)	Northing (ft)	Easting (m)	Northing (m)	(m)	(ft)	(m)	(ft)	(m)	(ft)[1]	(ft)[2]	(ft, FTOC)	(ft)	(ft, BGS)			
MW-05-13S	1,376,800	2,127,166	363,721	6,633,190	248.522	815.36	247.926	813.41	0.596	1.96		34.0		16-32	X (80)	X (26)	
MW-05-14D	1,405,521	2,131,540	372,493	6,634,390	282.720	927.56	281.928	924.96	0.792	2.60		103.6		90-101	X (81)	X (27)	
MW-05-14S	1,405,504	2,131,550	372,488	6,634,393	282.526	926.92	281.906	924.89	0.620	2.03		48.0		41-46	X (82)	X (28)	
P-2D	1,402,466	2,154,026	371,666	6,641,256	312.994	1026.88	312.268	1024.50	0.726	2.38		86.4		76-86	X (83)		
P-2M	1,402,464	2,154,048	371,665	6,641,263	313.067	1027.12	312.376	1024.86	0.691	2.27		70.3		58-68	X (84)		
P-3	1,403,275	2,154,762	371,916	6,641,477	312.334	1024.72	311.551	1022.15	0.783	2.57		25.1		12.5-22.5	X (85)		
P-4AD	1,405,205	2,155,654	372,508	6,641,740	305.878	1003.54	304.918	1000.39	0.960	3.15		93.1		80-90	X (86)		
P-4AS	1,405,222	2,155,638	372,513	6,641,735	305.994	1003.92	304.894	1000.31	1.100	3.61		53.6		40-50	X (87)	X (29)	
P-4Mid	1,405,028	2,155,079	372,452	6,641,565	303.672	996.30	302.745	993.26	0.927	3.04		58.0		45-55	X (88)		
P-6D	1,405,474	2,155,849	372,591	6,641,798	305.049	1000.82	304.183	997.98	0.866	2.84		114.8		102-112	X (89)		
P-6M	1,405,474	2,155,835	372,591	6,641,794	305.162	1001.19	304.246	998.18	0.916	3.01		89.0		81-86	X (90)		
P-6S	1,405,490	2,155,839	372,596	6,641,795	305.135	1001.10	304.289	998.32	0.846	2.78		38.0		25-35	X (91)		
P-05-07D	1,397,004	2,154,758	370,005	6,641,504	395.220	1296.65	394.541	1294.43	0.679	2.23		199.2		187-197	X (92)		
P-05-07S	1,397,026	2,154,737	370,011	6,641,498	394.662	1294.82	393.966	1292.54	0.696	2.28		77.3		65-75	X (93)		
P-05-08	1,397,921	2,157,152	370,295	6,642,230	403.899	1325.13	403.198	1322.83	0.701	2.30		73.3		61-71	X (94)		
P-05-09D	1,406,042	2,158,727	372,777	6,642,672	305.465	1002.18	304.733	999.78	0.732	2.40		99.0		81-96.5	X (95)		
P-05-09S	1,406,042	2,158,727	372,777	6,642,672	305.465	1002.18	304.733	999.78	0.732	2.40		22.4		17-20	X (96)		
P-05-10D	1,387,052	2,125,582	366,838	6,632,660	257.546	844.97	257.011	843.21	0.535	1.76		137.8		126-136	X (97)		
P-05-10S	1,387,029	2,125,596	366,831	6,632,664	257.681	845.41	256.940	842.98	0.741	2.43		32.0		19-29.5	X (98)		
P-05-11D	1,392,613	2,124,160	368,526	6,632,201	258.705	848.77	257.989	846.42	0.716	2.35		164.4		146-162	X (99)		
P-05-11M	1,392,628	2,124,149	368,531	6,632,198	258.655	848.61	257.941	846.26	0.714	2.34		77.3		65-75	X (100)		
P-05-11S	1,392,612	2,124,148	368,526	6,632,197	258.419	847.83	257.856	845.98	0.563	1.85		23.7		17-22	X (101)		
P-05-12	1,389,593	2,127,784	367,622	6,633,319	265.858	872.24	265.163	869.96	0.695	2.28		84.3		62-82	X (102)		
P-05-13	1,391,482	2,130,681	368,212	6,634,193	268.778	881.82	268.098	879.59	0.680	2.23		115.2		103-113	X (103)		
P-05-14D	1,395,412	2,130,750	369,409	6,634,196	270.941	888.91	270.273	886.72	0.668	2.19		116.2		104-114	X (104)		
P-05-14S	1,395,392	2,130,774	369,403	6,634,203	270.938	888.90	270.259	886.68	0.679	2.23		36.3		23-38	X (105)		
P-05-15D	1,394,031	2,127,495	368,973	6,633,211	264.093	866.45	263.441	864.31	0.652	2.14		125.1		108-123	X (106)		
P-05-15S	1,394,025	2,127,476	368,971	6,633,205	264.014	866.19	263.389	864.14	0.625	2.05		81.0		69-79	X (107)		
P-05-16D	1,395,663	2,120,883	369,440	6,631,188	262.829	862.30	262.029	859.68	0.800	2.62		136.6		124-134	X (108)		
P-05-16M	1,395,682	2,120,877	369,446	6,631,186	262.639	861.68	261.891	859.22	0.748	2.45		86.5		79-84	X (109)		
P-05-16S	1,395,666	2,120,862	369,441	6,631,182	262.142	860.05	261.480	857.87	0.662	2.17		55.6		48-53	X (110)		
P-05-16SS	1,395,646	2,120,869	369,435	6,631,184	262.437	861.01	261.640	858.40	0.797	2.61		18.6		11-16	X (111)		
P-05-17D	1,395,677	2,124,064	369,459	6,632,158	277.782	911.36	277.048	908.95	0.734	2.41		136.4		129-134	X (112)		
P-05-17S	1,395,670	2,124,025	369,457	6,632,146	277.796	911.40	277.071	909.03	0.725	2.38		61.4		49-59	X (113)		
P-05-18	1,397,983	2,124,460	370,164	6,632,268	279.420	916.73	278.832	914.80	0.588	1.93		63.7		52-62	X (114)		
P-05-19M	1,401,988	2,123,990	371,382	6,632,106	269.844	885.31	269.168	883.10	0.676	2.22		88.2		76-86	X (115)		
P-05-19S	1,402,019	2,123,966	371,391	6,632,098	269.881	885.44	269.276	883.45	0.605	1.98		41.8		30-40	X (116)		
P-05-20D	1,405,011	2,145,705	372,403	6,638,709	297.140	974.87	296.409	972.47	0.731	2.40		65.4		58-93	X (117)		
P-05-20S	1,405,014	2,145,729	372,404	6,638,716	297.180	975.00	296.469	972.67	0.711	2.33		28.8		22-27	X (118)		
P-05-21D	1,402,602	2,145,774	371,669	6,638,741	294.749	967.02	294.052	964.74	0.697	2.29		175.3		253-173	X (119)		
P-05-21M	1,402,612	2,145,797	371,672	6,638,748	294.604	966.55	293.944	964.38	0.660	2.17		90.2		78-88	X (120)		
P-05-21S	1,402,618	2,145,817	371,675	6,638,754	294.600	966.54	294.019	964.63	0.581	1.91		20.4		14-19	X (121)		
P-05-22D	1,402,870	2,142,370	371,735	6,637,703	303.606	996.08	303.016	994.15	0.590	1.94		234.0		212-232	X (122)		
P-05-23	1,399,577	2,131,334	370,681	6,634,355	291.088	955.01	290.602	953.42	0.486	1.59		59.6		48-58	X (123)		
P-05-24D	1,403,035	2,128,064	371,720	6,633,343	276.238	906.29	275.677	904.45	0.561	1.84		142.5		130-140	X (124)		
P-05-24S	1,403,045	2,128,089	371,723	6,633,350	276.149	906.00	275.541	904.01	0.608	1.99		39.0		32-37	X (125)		
P-05-25	1,405,576	2,131,539	372,510	6,634,390	282.708	927.52	282.062	925.40	0.646	2.12		61.7		52-62	X (126)		
P-05-26D	1,399,728	2,135,000	370,744	6,635,471	309.160	1014.30	308.592	1012.44	0.568	1.86		180.0		163-178	X (127)		
P-05-26M	1,399,711	2,135,007	370,739	6,635,474	309.553	1015.59	308.703	1012.81	0.850	2.79		102.8		90-10	X (128)		
P-05-26S	1,399,728	2,134,986	370,744	6,635,467	309.058	1013.97	308.268	1011.38	0.790	2.59		32.1		20-30	X (129)		
P-05-27D	1,399,814	2,123,738	370,718	6,632,039	267.040	876.12	266.198	873.35	0.842	2.76		146.8		134-144	X (130)		
P-05-27M	1,399,828	2,123,724	370,723	6,632,035	266.757	875.19	265.995	872.69	0.762	2.50		71.5		64-69	X (131)		
P-05-27S	1,399,815	2,123,723	370,719	6,632,035	266.894	875.64	266.202	873.37	0.692	2.27		39.3		27-37	X (132)		
P-05-28D	1,410,047	2,153,654	373,974	6,641,108	315.540	1035.24	314.929	1033.23	0.611	2.00		162.5		141-161	X (133)		
P-05-28S	1,410,032	2,153,663	373,970	6,641,111	315.745	1035.91	314.784	1032.76	0.961	3.15		75.7		63-73	X (134)		
P-05-29D	1,406,635	2,154,704	372,939	6,641,444	304.960	1000.52	303.946	997.20	1.014	3.33		125.8		113-123	X (135)		
P-05-29D2	1,406,663	2,154,697	372,948	6,641,441	305.212	1001.35	304.566	999.23	0.646	2.12		126.6		114-124	X (136)		
P-05-29M	1,406,677	2,154,712	372,952	6,641,446	305.610	1002.66	304.886	1000.28	0.724	2.38		60.4		48-58	X (137)		
P-05-29S	1,406,639	2,154,722	372,941	6,641,449	305.380	1001.90	304.367	998.58	1.013	3.32		30.0		23-28	X (138)		
P-05-30D	1,406,448	2,161,592	372,914	6,643,543	297.630	976.48	296.848	973.91	0.782	2.57		107.6		95-105	X (139)		
P-05-30S	1,406,458	2,161,605	372,917	6,643,547	297.635	976.49	296.903	974.09	0.732	2.40		74.9		70-73	X (140)		
P-05-31D	1,408,341	2,160,140	373,484	6,643,092	281.900	924.87	281.126	922.33	0.774	2.54		151.8		134-149	X (141)		
P-05-31S	1,408,355	2,160,159	373,489	6,643,098	281.558	923.75	281.042	922.05	0.516	1.69		26.8		19-24	X (142)		
P-05-32D	1,409,691	2,159,074	373,891	6,642,761	272.044	892.53	271.435	890.53	0.609	2.00		101.0		84-99	X (143)		
P-05-33D	1,411,248	2,159,456	374,367	6,642,870	256.668	842.09	256.089	840.19	0.579	1.90		46.4		35-45	X (144)		
P-05-34D	1,409,831	2,160,495	373,940	6,643,194	260.874	855.89	260.265	853.89	0.609	2.00		96.0		84-94	X (145)		
P-05-35D	1,407,882	2,162,627	373,356	6,643,852	286.135	938.76	285.519	936.74	0.616	2.02		60.0		53-58	X (146)		
P-05-36D	1,405,756	2,157,046	372,682	6,642,161	309.199	1014.43	308.499	1012.14	0.700	2.30		150.3		138-148	X (147)		
P-05-36M	1,405,765	2,157,031	372,685	6,642,157	309.379	1015.02	308.435	1011.93	0.944	3.10		93.1		80-90	X (148)		
P-05-36S	1,405,747	2,157,061	372,680	6,642,166	309.119	1014.17	308.335	1011.60	0.784	2.57		36.1		24-34	X (149)		
PQ-4 (4270M)	1,401,056	2,157,430	371,252	6,642,300	392.8	1288.71		0.00				138.1		123.8-133.8	X (150)	X (30)	
PQ-8	1,402,895	2,157,343	371,812	6,642,265	318.8	1045.93		0.00				102.0		88.9-98.9	X (151)		
PQ-9	1,400,938	2,156,539	371,212	6,642,029	349.9	1147.97		0.00				94.8		--	X (152)		
SRK-1A	1,403,453	2,161,276	372,000	6,643,461	326.65	1071.69		0.00				73.1		--	X (153)		
SRK-2 (AKA 4251)	1,406,189	2,159,582	372,826	6,642,932	303.495	995.72	303.40	995.42			0.3	205.7		--	X (154)		
SRK-2A	1,406,175	2,159,587	372,822	6,642,934	305.127	1001.07	304.24	998.17			2.9	75.8		70-80	X (155)		
SRK-3 (AKA 4250)	1,406,854	2,158,115	373,022	6,642,482	313.161	1027.43		0.00				75.9		--	X (156)	X (31)	

Table 1: Existing Well Locations and Completions

Drillhole	Alaska State Plane 5 NAD 83		NAD 1927 Coordinates		PVC elevation		Ground elevation		PVC stickup			Total Depth (ft, FTOC)	Depth to pump (ft)	Screen Interval (ft, BGS)	Monthly Water Levels	Quarterly Water Sampling	Notes
	Easting (ft)	Northing (ft)	Easting (m)	Northing (m)	(m)	(ft)	(m)	(ft)	(m)	(ft)[1]	(ft)[2]						
I-125	1,404,406	2,155,932	372,266	6,641,828	307.3	1008.20		0.00				80.0			X (157)		
I-172	1,403,968	2,159,322	372,148	6,642,863	312.9	1026.57		0.00				128.2			X (158)		
I-192	1,404,947	2,158,375	372,442	6,642,570	307.7	1009.51		0.00				139.1			X (159)		Extension on well
I-201	1,405,666	2,157,739	372,658	6,642,373	321.7	1055.45		0.00				156.2			X (160)		
KP-P1/SRK-2	1,406,189	2,159,581	372,826	6,642,932	304.956	1000.51	304.016	997.43			2.9	137.0		124-134	X (161)	X (32)	
KP-P3D /SRK-5D	1,401,943	2,154,181	371,507	6,641,306	320.408	1051.21	318.691	1045.57	1.717	5.63		83.6		68-78	X (162)	X (33)	Extension on well
KP-P3M /SRK-5M	1,401,952	2,154,193	371,510	6,641,309	319.616	1048.61	318.700	1045.60	0.916	3.01		55.0		41-51	X (163)	X (34)	
KP-P3S /SRK-5S	1,401,973	2,154,169	371,517	6,641,302	319.417	1047.96	318.556	1045.13	0.861	2.82		24.8		8-18	X (164)	X (35)	
KP-P4	1,406,224	2,155,592	372,818	6,641,716	306.406	1005.27	305.55	1002.47			2.8	44.8		32-42	X (165)	X (36)	
M-110	1,402,420	2,159,036	371,675	6,642,783	360.3	1182.09		0.00				98.8		--	X (166)		
M-12	1,400,378	2,157,544	371,046	6,642,338	367.1	1204.40		0.00				63.3		--	X (167)		
M-21	1,400,693	2,157,582	371,142	6,642,348	371.6	1219.16		0.00				91.9		--	X (168)		
M-62	1,401,233	2,158,729	371,312	6,642,695	403.5	1323.82		0.00				149.6		--	X (169)		

Notes: Kerry Adler data (October 19, 2005)

1 Calculated

2 Observed

Table 2: 2006 Proposed Borehole Schedule

Drillhole	Alaska State Plane 5 NAD 83		Contractor	Method	Installation
	Easting (ft)	Northing (ft)			
C	1,409,465	2,163,587	Foundex	Odex	dual P
D	1,412,085	2,160,917	Foundex	Odex	dual P
E	1,413,042	2,158,549	Foundex	Odex	dual P
F	1,420,146	2,160,867	Foundex	Odex	dual P
G	1,406,416	2,166,636	Foundex	Odex	dual P

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2007 FIELD SAMPLING PLANS

GROUNDWATER STUDIES
Mine Study Area

DRAFT

SEPTEMBER 2007

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ACRONYMS AND ABBREVIATIONS

ASPCS	Alaska State Plane Coordinate System
ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
DO	dissolved oxygen
GPS	global positioning system
ID	inner diameter
KP	Knight Piésold Ltd.
NAD	North American Datum
NAVD	North American Vertical Datum
NDM	Northern Dynasty Mines Inc.
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Shaw	Shaw Alaska Inc.
SLR	SLR Alaska
WMC	Water Management Consultants, Inc.

GROUNDWATER STUDIES, MINE STUDY AREA

2007 FIELD SAMPLING PLAN

1. Introduction

The purpose of this field sampling plan is to describe tasks and to establish field procedures for conducting a study of groundwater hydrology and chemistry in the Pebble Project mine study 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 field sampling plan also provides the basis for appropriate quality assurance (QA) and quality control (QC) measures to be instituted and monitored during data-collection activities.

2. Study Area and 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 infill 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, thus allowing an assessment of existing conditions. The mine 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 infill deposits, so that certain sectors of the pit wall may 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 assessed to evaluate 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 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 study area.
- Support the permitting process by characterizing 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 aid in project design.
- Establish a long-term monitoring plan.

4. Project Organization and Responsibilities

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 Pebble Project *Draft Environmental Baseline Studies, 2007 Quality Assurance Project Plan* (QAPP; NDM, In press) 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 Piésold (KP). Before installing a monitoring well, SLR personnel will communicate with WMC personnel to confirm well completion details, most likely via a satellite phone from the drill site.

Groundwater samples will be submitted to Shaw Alaska, Inc. (Shaw), 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 to analytical laboratories under proper chain-of-custody procedures.

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

5. 2007 Project Overview

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 2007 and to be completed in December 2007.

5.1 Installation and Sampling of Piezometers and Monitoring Wells

Piezometers and monitoring wells are used to collect information on stratigraphy, hydraulic conductivity, groundwater levels, and groundwater quality. Collection of data from existing wells and piezometers (Table 1; Figure 1) will continue in 2007. In addition, new wells and piezometers (Table 2; Figure 2) will be installed and data will be collected from them. 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. The locations of some wells/piezometers will be determined in the field at the time of drilling.

5.1.1 Groundwater Sampling and Analysis

Groundwater samples will be collected from selected monitoring wells and will be submitted for laboratory analyses. The analytical methods for groundwater are detailed in the QAPP (NDM, In press).

5.1.2 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 2007.

5.2 Installation of Pumping Wells and Performing Pumping Tests

Pumping tests may be conducted to define hydraulic properties. 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 samples and to measure the pumping rate and water levels in piezometers.

In addition to existing pumping wells, new installations will be added in 2007. Each pumping site will consist of one or two pumping wells installed in proximity to one another for each of the overburden pumping tests. These wells and related piezometers will be installed using the ODEX drilling rig.

5.3 Installation and Monitoring of Westbay System

The existing Westbay System is a multi-zone well completion with 50 separate zone completions within the 4,050-foot-deep drill-hole, with surface equipment to allow lowering and raising of specialized tools in the well. A second Westbay installation to a similar depth and with a similar number of monitoring zones in planned for 2007.

Monthly monitoring of the pressure profile in the existing Westbay System installed at drill-hole NDM-6349 will be conducted during 2007. Once the second system is completed, monthly monitoring of the pressure profile also will be carried out on that hole. Hydraulic testing and water sampling will be performed in both holes.

Monitoring of the Westbay System is performed by SLR under the direction of WMC. The operational

procedures for the Westbay system are detailed in the Westbay operator training manual (Schlumberger, n.d.), and are not repeated here.

6. Field Activities

The following sections outline basic requirements for drilling, installing, sampling, and collecting measurements from monitoring wells and piezometers, pumping wells, and Westbay systems. These requirements are designed to maximize sample quality and to assist in the permitting process.

6.1 Installation of Monitoring Wells and Piezometers

6.1.1 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 then will 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 moved safely without causing harm to human health or 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 survey personnel designated by NDM.

The ASPCS coordinates and elevations of all newly installed monitoring wells will be surveyed. Well elevations will be surveyed at the top of the 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.

6.1.2 Identification

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

- MW, P, or PW = abbreviation for monitoring well, piezometer, or pumping well, respectively.
- Year = two digit number representing the last two digits of the year.
- Well or piezometer site number = two digit sequential number from 01 to 99. Numbers will be assigned sequentially by completion.
- 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

Several examples are provided below:

- MW-05-20S denotes a shallow monitoring well at the 20th well site or array drilled in the year 2005.
- MW-06-10M and MW-06-10D denote an intermediate and a deep monitoring well at the 10th well site or array drilled in the year 2006.
- P-05-25S identifies a shallow piezometer at the 25th piezometer site or array drilled in the year 2005.

6.1.3 Groundwater Monitoring Wells

Drilling and installation 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).

6.1.3.1 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-size drill-rod system. The rotary rig will be used to collect bulk samples in the pit area and to install monitoring wells and piezometers in that area whenever possible. Use of the rotary method or the ODEX method in other areas will depend on the relative efficiency, availability, and effectiveness of each rig, as determined in the field.

Past drilling in the mine 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 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.
- Photos of cuttings at five-foot intervals.

6.1.3.2 Monitoring Well Design

Proposed depths and drilling methods for the monitoring wells to be installed in 2007 are summarized in Table 2, and the proposed locations are shown on Figure 2. Locations of some wells will be determined in the field at the time of drilling; not all locations are listed in the table and shown on the figure. An example of a well-construction log is presented in Appendix B.

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 rat-hole. Well-screen placement will be determined after the rat-hole 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.

6.1.3.3 Well Construction

Subsurface well construction will include (from the bottom up) the following 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 riser pipe is placed in the casing.
- Monitoring wells will be constructed of 2-inch-diameter, Schedule 80, flush-joint threaded, polyvinyl chloride (PVC) riser pipe with O-rings, extending at least 3 feet above surface grade.
- Well screens will be constructed of prepacked or non-prepacked Schedule 80, 0.02-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 the 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 placement of the bentonite plug 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 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.

6.1.3.4 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 also will 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 (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.
- Specific conductance and pH of water.
- Comments on well yield and results of development.

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

- Measure and 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 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 pump 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 four hours.
- After stabilization (or four hours of surging and pumping), pass development water through a 0.45-micometer 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.

6.1.3.5 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. The groundwater level as a function of time will be monitored with the pressure transducer and field computer 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. Water levels will be measured using a well sounder prior to and after the response test to correlate the pressure-transducer reading to water-level elevations. 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).

6.1.4 Piezometers

6.1.4.1 Piezometer Installation

Piezometers will be designed, drilled, installed, constructed, and documented in the same manner as monitoring wells (Figure 3 and Section 6.4.3). Piezometers will be used to measure piezometric levels and aquifer response to pumping tests. The proposed piezometers are summarized in Table 2.

6.1.4.2 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.

6.1.4.3 Response Testing

Piezometers will be response tested in the same manner as for monitoring wells.

6.2 Collecting 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 will be measured within the shortest time practical. 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.
- Electronic sounders will be kept clean and will be maintained in accordance with manufacturer's instructions. Before the sounder is used on wells that are sampled for water quality, the probe will be rinsed with deionized water.
- 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.

6.3 Groundwater Sampling from Monitoring Wells

6.3.1 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 using non-dedicated 3/8-inch-diameter polyethylene tubing connected to the dedicated tubing at the well cap. New tubing between the well cap and the sample container will be used for each sample. The tubing will allow the use of in-line filters, as needed, for specific analyses. All required field measurements will be collected as described below. Purge water will be disposed of on site.

The proposed number of samples and sample types, as well as container types, holding times, and preservatives, are described in the QAPP (NDM, In press);.

6.3.2 Monitoring Well Purging and Measuring of Field Parameters

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

Measurement data and the makes 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. The suggested maximum drawdown is 25 percent of the height of the water column above the pump intake. Readings of water-level elevation and the determined drawdown will be recorded approximately every five minutes. Priority will be given to ensuring that two volumes are purged and especially that the water level is stable or rising when field parameters are recorded and samples are collected.

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

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

Turbidity will be monitored visually and qualitative comments will be included on the field sampling form. Care will be taken to ensure that the pump's tubing is free of air bubbles along its entire length. If necessary, a turbidity meter may be used to collect turbidity measurements. If the turbidity meter is used, the sample for the turbidity analysis will be drawn from a "T" fitted with a valve located upstream of the flow-through cell. When drawing the turbidity samples, care will be taken to not introduce air into the

sampling tubing and to draw the sample at a sufficiently low rate as to not significantly disrupt flow to the flow-through cell.

Once the minimum purge volume (two times the combined volume from drawdown and from below the pump) has been removed, 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.
- Volume of purged-water 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.

6.3.3 Sample Collection

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

1. Total metals (including total mercury).
2. Dissolved metals (including dissolved mercury).
3. Total suspended solids and total dissolved solids.
4. Cyanide.
5. Miscellaneous water-quality parameters (e.g., ammonia, phosphorus).
6. Field method for ferrous iron.

Samples will be collected with the pump and tubing used to purge the well. Samples collected for dissolved metals analyses will be filtered in the field with disposable, inline filters. The filter lot number will be recorded in the field form for each sampled well.

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 (including those for duplicate samples, if any) will be filled sequentially before bottles designated for the next analysis are filled. Care will be taken not to touch the tubing to the sample container during sample collection.

After the collection of the samples for laboratory analysis, water will be collected and analyzed for ferrous iron using a Hach colorimetric meter. The results will be recorded on the well purging and sampling field sheet.

6.3.4 Sample Handling

Samples will be packed to prevent breakage and will be kept chilled in coolers with frozen gel ice during field operations and transport. 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.

6.3.4.1 Sample Containers

Sample container requirements are provided in the QAPP (NDM, In press). 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.

6.3.4.2 Sample Volumes, Container Types, and Preservation Requirements

Sample volumes, container types, and preservation requirements are described in the QAPP (NDM, In press). 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.

6.3.4.3 Sample Identification

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

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 code is as follows:

0107MW1DWG001

Where:

0107 is the date as month/year

MW1D is the location identification

WG 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 equipment-rinse blanks, which are collected at a frequency of 5 percent. The number 402 represents an equipment-rinse blank specifically for the groundwater filter. The number 501 is used for deionized water blanks, which are collected once per sample event. The sequential number 601 will be used to designate trip blanks.

6.3.4.4 Sample Custody

Chain-of-custody forms will be used for all samples and will be prepared by the designated 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 sample-handling person at Iliamna, who will be responsible for shipping the samples and for laboratory notifications.

Other chain-of-custody components, which SLR will provide copies of, include the field logbook and the field sampling sheets.

6.3.5 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. Calibrations will be performed before each day's sampling. Calibration for conductivity will be checked with standard calibration solution before sampling at each well array. Calibration for pH will be checked with standard calibration solution before sampling at each well. The meter will be recalibrated if the following criteria are not met:

- Plus or minus 0.10 for pH calibration solution.
- Plus or minus 10 percent for the conductivity calibration solution.

These standards of calibration follow applicable criteria such as those of the National Institute of Standards and Technology, ASTM standards, or other accepted procedures outlined in the manufacturer's handbook of specifications. Certification of maintenance of calibration standards will be acquired from the vendor or manufacturer. 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.

6.3.6 Equipment Maintenance and Decontamination

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

All nondisposable or nondedicated sample-collection equipment that comes into contact with a sample will be decontaminated as follows:

- Rinse in water.
- Double rinse in deionized water.

The purpose of the deionized water rinse is to remove all visible particulate matter. Because sample equipment and supplies are either precleaned and disposable (e.g., filters) or dedicated to the well (e.g., pumps and tubing), this decontamination procedure is generally only necessary for decontaminating new sample pumps prior to installation.

6.3.7 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 project samples. Equipment blanks (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. The laboratory will provide the deionized water for equipment blanks and the deionized water blanks. The laboratory-designated lot number and date for deioinized water containers will be noted on the appropriate sample forms. 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, In press). The field-team leader will review the QAPP prior to field activities to ensure that the correct field QA/QC samples are collected.

6.4 Installation of Pumping Test Wells

6.4.1 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. Selection of pumping-well locations and design will be based on the information gained during installation of nearby piezometers. The locations and the depths will be selected in the field and approved by project personnel from 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.

6.4.2 Installation and Construction

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-size drill-rod system, depending on rig availability. 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.

6.4.3 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.

6.5 Pumping Test Procedures

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 drilling contractor or with submersible pumps. The actual pumping method will be determined in the field based on field conditions. Therefore, the 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 pressure transducer for monitoring background groundwater levels at least two days before the test starts.
- Install pressure 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 barometric logger in a nearby piezometer simultaneously with installation of the first pressure transducer.
- During the full testing period, measure the water level manually at regular intervals to confirm the pressure transducer readings and to relate the pressure 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 depth for the pipe for the constant-rate test.
- Monitor the recovery from the step test.
- Start the constant-rate pumping 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 pumping 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 pumping test is terminated, monitor recovery for a period equal to the duration of the pumping test and the pretest monitoring.

All field data collected during the 24 hour pump test will be recorded in a field notebook while the test is being conducted.

6.6 Installation of Westbay Multi-level Piezometers

6.6.1 Drilling

The drilling will include installation of a surface casing, drilling as far as possible with HQ-size coring equipment and stepping down to complete the hole with NQ-size coring equipment, if necessary. The planned depth of the hole is a minimum of 4,200 feet. The hole will be drilled with a wireline coring rig to the final depth. Drilling to final depth of approximately 4,200 feet with HQ drill size is preferred.

6.6.2 Well Design

Selection of monitoring zones will be recommended by WMC, with assistance from KP and Westbay. Locations of packers, measurement ports, and pumping ports will be selected following review of

available geologic, geotechnical, and geophysical logs of the drill-hole. The installation design will emphasize isolating zones that will define hydrostratigraphic conditions.

6.6.3 Well Construction

The installation will be carried out by the drilling contractor, with advice from Westbay. Assistance will be provided by KP, WMC, and SLR.

The installation will generally include the following.

- The casing components will be laid out in order prior to being lowered into the hole.
- After completion of drilling, drilling fluid in the hole will be replaced with clean water.
- Drill rods will be removed, but N casing (HQ rods) will be left in the drill-hole.
- The MP components will be assembled and lowered into the drill-hole. Each assembled joint will be pressure tested to reduce the potential for leakage.
- Water will be added to the Westbay casing as it is assembled to sink the Westbay casing string into the drill-hole. As the length of the Westbay casing string increases, the string will need to be supported and the volume of water inside the MP casing adjusted to meet design strength constraints.
- Pre-inflation pressures will be measured.
- Packers in the unlined portion (NQ drill-hole, if used) will be inflated from the bottom up using a packer inflation tool. N casing will be removed in sections so as to minimize standing time on unstable borehole sections prior to packer inflation.
- The tension of the MP casing string will be adjusted during inflation to keep the casing straight, yet prevent unacceptable tensile loads from locking into the couplings.

Two pressure profiles will be completed following installation. Piezometric pressures will be measured with a down-hole probe at each measurement port for each profile. Pressures will be measured at each port for a sufficient period of time (up to 10 minutes) to verify that transient response to activation of the measurement port is complete.

6.7 Westbay System Testing, Sampling, and Pressure Profiles from

Westbay trained SLR in 2006 in the use of monitoring and testing tools to supplement the information provided in the operators manuals supplied with the Westbay monitoring equipment. The equipment operating procedures for the Model 2532 MOSDAX Sampler Probe include step-by step instructions for typical monitoring and testing tasks such as pressure-profile measurements, groundwater sample collection, and operation of the Model 0706 Hydraulic Pumping Port. As necessary, special procedures will be developed, in consultation among SLR, WMC, and Westbay, for the performance and documentation of other tasks as described below. SLR will be responsible for completion of monitoring and testing.

6.7.1 Well Testing

Screening-level hydraulic conductivity testing will be completed for all 50 measurement ports in both the existing and the new holes. The tests will be carried out by parking the down-hole tool at each port, allowing pressure stabilization while adjusting the water level inside the MP casing, allowing flow from the monitored interval into the casing, and then measuring the pressure recovery to the flow test. Those zones where the test response is constrained by the head drop across the measurement port will be identified.

Zones for well testing through pumping ports will be selected based on pressure profiles and the screening-level hydraulic conductivity testing. When a pumping port is opened, the Westbay casing acts as a conventional monitoring well. First, the water level inside the MP casing will be drawn down several meters below the piezometric level in the test zone. A high capacity Waterra pump will be used to draw the water level down. The opening tool will then be lowered to the opening location, and the port will be opened. The water level recovery inside the MP casing will be monitored until it is stable or for 20 minutes. The probe will then be removed from the hole, reconfigured, and redeployed for closing. The port will then be closed, and the next test will start. A suitable record of the testing will be collected according to the agreed test procedure, including a paper record for each test, plus datalogging of pressure responses by means of the MAGI datalogger unit.

6.7.2 Groundwater Sampling from Westbay System

Groundwater samples will be collected from the Westbay Systems from measurement ports installed within relatively permeable zones. Preliminary sampling will be limited to documentation of field parameters (electrical conductivity and pH), as follows:

- The sample bottle will be rinsed with deionized water as a decontamination step.
- The sampling equipment will be deployed and operated as described in the system operator manual (Schlumberger, n.d.).
- The retrieved sample will be extracted, and the electrical conductivity and pH will be measured.

This initial sampling round is expected to provide the information required to integrate the Westbay sampling with the remainder of the sampling program. Groundwater samples will be collected from selected measurement ports coincident with groundwater sampling events. Protocols will be developed by SLR following installation and initial testing.

6.7.3 Piezometric Pressure Profiles from Westbay System

6.7.3.1 Monthly Profiles

A piezometric pressure profile will be completed at the end of the initial testing and each month coincident with water-level monitoring of piezometers and monitoring wells. The Westbay equipment will be deployed and operated as described in the system operator manual (Schlumberger, n.d.).

6.7.3.2 Continuous Profile

Continuous datalogging is planned for the Westbay system in NDM 6349 while the new system is being installed in 2007. This will provide several weeks of data that can be analyzed for barometric and earth-tide effects, allowing further assessment of the interconnectivity of the monitoring zones and transmissivity. If any drilling is occurring nearby, hydraulic responses can be used for later scoping of a pumping test in 2008. A string of five probes on a 1,000-foot string will be installed in NDM 6349, to permit hand-lowering.

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, the records 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 or pencil. 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 locations.
- 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:

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

Examples of the field forms are provided 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. 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 a sampling station.

Strict chain-of-custody 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 forms 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 or pencil. No accountable documents—original notes of field observations or conditions, including field logbooks 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 also will identify additional measures, if any, that may be taken to improve 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

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TABLES

TABLE 1
Existing Wells

Drill-hole	Alaska State Plane Zone 5		Monthly Water Levels	Quarterly Water Sampling	Notes
	X (ft)	Y (ft)			
GH04-01	1386180	2171584	X		
GH04-02	1405882	2170918	X		
GH04-03	1400583	2125932	X		
GH04-04	1383250	2123686	X		
GH04-05	1365296	2121512	X		
GH04-06	1402986	2146959	X		
GH04-08	1373556	2149963	X		
GH04-10	1395412	2123101	X		
GH04-11	1406017	2128321	X		
GH04-12A	1393590	2122286	X		
GH04-13	1392021	2117580	X		
GH04-14	1382419	2121520	X		
GH04-16	1381837	2125117	X		
GH04-17	1381594	2126017	X		
GH04-18	1382120	2126850	X		
GH04-19	1377773	2133668	X		
GH04-20	1380421	2135284	X		
GH04-22	1382100	2136338	X		
GH04-23	1381015	2164417	X		
GH04-25	1383712	2163357	X		
GH04-26	1396246	2158941	X		
GH04-27	1395818	2157549	X		
GH04-28	1398091	2137379	X		
GH04-29A	1399086	2135590	X		
GH04-30	1394724	2132937	X		
GH04-31	1400682	2133911	X		
GH04-32	1401402	2132207	X		
GH04-33	1399309	2129087	X		
GH04-35	1397715	2126742	X		
GH04-37	1389715	2119791	X		
GH04-38	1386308	2120503	X		
GH04-39	1389233	2122703	X		
GH04-41	1405013	2133609	X		
GH04-42	1404563	2135111	X		
GH04-43	1405221	2137825	X		
GH04-44	1402137	2138681	X		
GH04-45A	1399997	2139335	X		
GH04-46	1406716	2145777	X		
GH04-47	1404802	2147359	X		
GH04-48	1399489	2147095	X		
GH05-51	1399173	2133996	X		
GH05-52	1399789	2136767	X		
GH05-53	1414414	2144518	X		
GH05-54	1412983	2147460	X		
GH05-55	1395553	2144993	X		
GH05-56	1398947	2148042	X		
GH05-57	1396013	2160439	X		
GH05-58	1395457	2156534	X		
GH05-59	1399206	2152099	X		
GH05-60	1400785	2150474	X		
GH05-61	1402486	2148724	X		
GH05-63	1406997	2148517	X		
GH05-64	1410178	2152866	X		
GH06-65	1372647	2149020	X		

Drill-hole	Alaska State Plane Zone 5		Monthly Water Levels	Quarterly Water Sampling	Notes
	X (ft)	Y (ft)			
GH06-66	1376039	2163510	X		
GH06-67	1379185	2163945	X		
GH06-68	1380641	2162370	X		
GH06-69	1384085	2160944	X		
GH06-70	1400211	2147906	X		
GH06-71	1401484	2147080	X		
GH06-71A	1401454	2147087	X		
GH06-72	1403789	2147129	X		
GH06-73	1406063	2146876	X		
GH06-74	1407904	2147514	X		
GH06-75	1400526	2136598	X		
GH06-76	1401319	2135578	X		
GH06-77	1400130	2135459	X		
GH06-78	1409794	2155947	X		
GH06-79	1410562	2155394	X		
GH06-80	1406799	2154864	X		
I-125	1404406	2155932	X		
I-172	1403968	2159322	X		
I-192	1404947	2158375	X		
I-201	1405666	2157739	X		
KP-P1/SRK-2	1406189	2159582	X	X	
KP-P3D /SRK-5D	1401943	2154181	X	X	
KP-P3M /SRK-5M	1401952	2154193	X	X	
KP-P3S /SRK-5S	1401973	2154169	X	X	
KP-P4	1406224	2155592	X	X	
M-110	1402420	2159036	X		
M-12	1400378	2157544	X		
M-21	1400693	2157582	X		
M-62	1401233	2158729	X		
MW-1D	1378226	2124912	X	X	
MW-1M	1378238	2124905	X	X	
MW-1S	1378207	2124919	X	X	
MW-2D	1399455	2121671	X	X	
MW-05-2M	1399438	2121667	X		Cannot be sampled
MW-2S	1399461	2121654	X		Cannot be sampled
MW-05-2SR	1399446	2121654	X		Cannot be sampled
MW-3D	1400178	2136063	X	X	
MW-4	1407534	2158182	X		Cannot be sampled
MW-5D	1403274	2149287	X	X	
MW-5M	1403292	2149284	X	X	
MW-5S	1403287	2149303	X	X	
MW-6D	1382244	2168254	X	X	
MW-7D	1373318	2150204	X	X	
MW-7S	1373299	2150209	X	X	
MW-8D	1400007	2172701	X	X	
MW-8M	1399993	2172687	X	X	
MW-8S	1399990	2172705	X	X	
MW-9D	1373502	2150022	X	X	
MW-10	1382989	2165426	X	X	
MW-11D	1398344	2126290	X	X	
MW-11M	1398338	2126303	X	X	
MW-11S	1398335	2126319	X	X	
MW-05-11SS	1398358	2126297	X	X	
MW-05-12D	1399176	2155571	X	X	
MW-05-12S	1399196	2155584	X	X	
MW-05-13D	1376783	2127181	X	X	
MW-05-13S	1376800	2127166	X	X	

Drill-hole	Alaska State Plane Zone 5		Monthly Water Levels	Quarterly Water Sampling	Notes
	X (ft)	Y (ft)			
MW-05-14D	1405521	2131540	X	X	
MW-05-14S	1405504	2131550	X	X	
P-2D	1402466	2154026	X		
P-2M	1402464	2154048	X		
P-3	1403275	2154762	X		
P-4AD	1405205	2155654	X		
P-4AS	1405222	2155638	X	X	
P-4Mid					Piezometer currently blocked at surface
P-6D	1405474	2155849	X		
P-6M	1405474	2155835	X		
P-6S	1405490	2155839	X		
P-05-07D	1397004	2154758	X		
P-05-07S	1397026	2154737	X		
P-05-08	1397921	2157152	X		
P-05-09D	1406042	2158727	X		
P-05-09S	1406042	2158727	X		
P-05-10D	1387052	2125582	X		
P-05-10S	1387029	2125596	X		
P-05-11D	1392613	2124160	X		
P-05-11M	1392628	2124149	X		
P-05-11S	1392612	2124148	X		
P-05-12	1389593	2127784	X		
P-05-13	1391482	2130681	X		
P-05-14D	1395412	2130750	X		
P-05-14S	1395392	2130774	X		
P-05-15D	1394031	2127495	X		
P-05-15S	1394025	2127476	X		
P-05-16D	1395663	2120883	X		
P-05-16M	1395682	2120877	X		
P-05-16S	1395666	2120862	X		
P-05-16SS	1395646	2120869	X		
P-05-17D	1395677	2124064	X		
P-05-17S	1395670	2124025	X		
P-05-18	1397983	2124460	X		
P-05-19D	1401988	2123990	X		
P-05-19S	1402019	2123966	X		
P-05-20D	1405011	2145705	X		
P-05-20S	1405014	2145729	X		
P-05-21D	1402602	2145774	X		
P-05-21M	1402612	2145797	X		
P-05-21S	1402618	2145817	X		
P-05-22D	1402870	2142370	X		
P-05-23	1399577	2131334	X		
P-05-24D	1403035	2128064	X		
P-05-24S	1403045	2128089	X		
P-05-25	1405576	2131539	X		
P-05-26D	1399728	2135000	X		
P-05-26M	1399711	2135007	X		
P-05-26S	1399728	2134986	X		
P-05-27D	1399814	2123738	X		
P-05-27M	1399828	2123724	X		
P-05-27S	1399815	2123723	X		
P-05-28D	1410047	2153654	X		
P-05-28S	1410032	2153663	X		
P-05-29D	1406635	2154704	X		
P-05-29D2	1406663	2154697	X		
P-05-29M	1406677	2154712	X		

Drill-hole	Alaska State Plane Zone 5		Monthly Water Levels	Quarterly Water Sampling	Notes
	X (ft)	Y (ft)			
P-05-29S	1406639	2154722	X		
P-05-30D	1406448	2161592	X		
P-05-30S	1406458	2161605	X		
P-05-31D	1408341	2160140	X		
P-05-31S	1408355	2160159	X		
P-05-32D	1409691	2159074	X		
P-05-33D	1411248	2159456	X		
P-05-34D	1409831	2160495	X		
P-05-35D	1407882	2162627	X		
P-05-36D	1405756	2157046	X		
P-05-36M	1405765	2157031	X		
P-05-36S	1405747	2157061	X		
P-06-37D	1409444	2163540	X	X	
P-06-37M	1409436	2163524	X	X	
P-06-37S	1409431	2163508	X	X	
P-06-38D	1406578	2166680	X	X	
P-06-38M	1406562	2166691	X		
P-06-39D	1412117	2160792	X		
P-06-39S	1412125	2160810	X		
P-06-40D	1412908	2158572	X		
P-06-40M	1412942	2158593	X		
P-06-40S	1412926	2158585	X		
P-06-41D	1420118	2160961	X		
P-06-41M	1420136	2160971	X		
P-06-41S	1420151	2160983	X		
PQ-4	1401056	2157430	X	X	
PQ-8	1402895	2157343	X		
PQ-9	1400938	2156539	X		
SRK-1A	1403453	2161276	X		
SRK-2	1406189	2159581	X		
SRK-2A	1406175	2159587	X		
SRK-3	1406854	2158115	X	X	
WL-P01D	1399220	2154559	X		
WL-P01S	1399205	2154539	X		
WL-P02D	1399639	2154297	X		
WL-P02S	1399639	2154297	X		
WL-P03D	1400199	2153981	X		
WL-P03S	1400209	2153991	X		
WL-P04D	1400399	2133809	X		
WL-P04S	1400405	2133809	X		
WL-P05D	1400110	2134434	X		
WL-P05S	1400120	2134424	X		
WL-P06D	1399786	2134857	X		
WL-P06S	1399786	2134857	X		
WL-P07D	1399781	2123179	X		
WL-P07S	1399776	2123169	X		
WL-P08D	1400183	2123303	X		
WL-P08S	1400178	2123313	X		
WL-P09D	1400682	2122948	X		
WL-P09S	1400684	2122796	X		
WL-P10D	1401268	2122804	X		
WL-P10S	1401253	2122815	X		
WL-P11D	1401561	2122636	X		
WL-P11S	1401561	2122626	X		
WL-S01D	1400052	2154319	X		
WL-S01G	1400052	2154319	X		
WL-S01S	1400047	2154319	X		

Drill-hole	Alaska State Plane Zone 5		Monthly Water Levels	Quarterly Water Sampling	Notes
	X (ft)	Y (ft)			
WL-S02D	1399555	2154461	X		
WL-S02G	1399555	2154461	X		
WL-S02S	1399555	2154461	X		
WL-S03D	1399910	2134672	X		
WL-S03G	1399910	2134672	X		
WL-S03S	1399905	2134662	X		
WL-S04D	1400143	2134281	X		
WL-S04G	1400143	2134281	X		
WL-S04S	1400158	2134281	X		
WL-S05D	1400000	2123104	X		
WL-S05G					No water level data
WL-S05S	1399995	2123114	X		
WL-S06D	1400153	2123090	X		
WL-S06G	1400153	2123090	X		
WL-S06S	1400183	2123080	X		
WL-S07D	1401401	2122792	X		
WL-S07G	1401401	2122792	X		
WL-S07S	1401400	2122761	X		
PW-5					
PW-6					
PW-7					
PW-8					

KEY:

GH = Geotechnical Hole
MW = Monitoring Well
P = Piezometer
PW = Pumping Well
WL = Wetlands Location

TABLE 2
Proposed Geotechnical and Hydrogeological Drill-holes, 2007

Drill-hole ID[(a)]	NAD83 Coordinates		Estimated Total Depth (in feet, maximum 250)	Method
	Easting (X)	Northing (Y)		
Geotechnical Drill-holes				
GH07-01	1,379,561	2,162,940	230	Rotary
GH07-02	1,382,524	2,161,396	230	Rotary
GH07-03	1,374,774	2,163,537	200	Rotary
GH07-04	1,372,853	2,161,159	200	Rotary
GH07-05	1,373,636	2,149,046	220	Rotary
GH07-06	1,374,649	2,148,883	220	Rotary
GH07-07	1,369,115	2,153,555	220	Rotary
GH07-08	1,384,902	2,152,976	230	Rotary
GH07-09	1,377,703	2,163,916	220	Rotary
GH07-10	1,385,451	2,159,829	230	Rotary
GH07-11	1,408,668	2,153,098	250	Rotary
GH07-12	1,406,696	2,152,503	250	Rotary
GH07-13	1,384,390	2,166,958	250	Rotary
GH07-14	1,387,518	2,166,764	250	Rotary
GH07-15	1,379,826	2,155,391	180	Rotary
GH07-16	1,381,712	2,156,228	180	Rotary
GH07-17	1,370,723	2,149,480	220	Rotary
GH07-18	1,367,770	2,151,076	220	Rotary
GH07-19	1,373,297	2,162,360	200	Rotary
GH07-20	1,382,635	2,154,750	180	Rotary
GH07-21	1,383,755	2,168,714	250	Rotary
GH07-22	1,386,306	2,165,176	250	Rotary
GH07-23	1,406,552	2,150,617	250	Rotary
GH07-24	1,410,824	2,147,451	200	Rotary
GH07-25	1,408,299	2,146,586	200	Rotary
GH07-26	1,368,777	2,149,807	220	Rotary
GH07-27	1,372,316	2,159,288	230	Rotary
GH07-28	1,375,606	2,164,963	250	Rotary
GH07-29	1,386,126	2,157,507	230	Rotary
GH07-30	1,385,505	2,154,320	230	Rotary
GH07-31	1,384,363	2,151,898	230	Rotary
GH07-32	1,388,153	2,155,547	250	Rotary
GH07-33	1,390,797	2,154,228	250	Rotary
GH07-34	1,393,920	2,152,694	250	Rotary
GH07-35	1,393,987	2,151,152	250	Rotary
GH07-36	1,394,009	2,148,777	250	Rotary
GH07-37	1,391,302	2,148,432	250	Rotary
GH07-38	1,389,393	2,145,900	250	Rotary
GH07-39	1,388,521	2,144,497	250	Rotary
GH07-40	1,386,979	2,144,179	250	Rotary

Drill-hole ID[(a)]	NAD83 Coordinates		Estimated Total Depth (in feet, maximum 250)		Method
	Easting (X)	Northing (Y)			
GH07-41	1,385,398	2,144,941	250		Rotary
GH07-42	1,373,966	2,158,369	180		Rotary
GH07-43	1,377,451	2,159,019	180		Rotary
GH07-44	1,408,688	2,147,257	200		Rotary
GH07-45	1,411,234	2,147,410	200		Rotary
GH07-46	1,380,054	2,161,360	250		Rotary
TOTAL DEPTH			10,430		
Hydrogeological Drill-holes (two piezometers to be installed per drill-hole)			**Deep (D)**	**Shallow (S)**	
HH07-06	1,418,139	2,157,997	200	70	Odex
HH07-07	1,418,373	2,160,342	200	70	Odex
HH07-08	1,419,041	2,163,654	200	70	Odex
HH07-09	1,418,550	2,169,520	200	70	Odex
HH07-10	1412789	2174366	200	70	Odex
HH07-11	1,408,617	2,171,511	200	70	Odex
HH07-12	1,404,375	2,171,801	200	70	Odex
HH07-13	1,379,479	2,170,083	200	70	Odex
HH07-14	1,379,920	2,171,519	200	70	Odex
HH07-15	1,380,016	2,172,797	200	70	Odex
HH07-17	1,372,236	2,162,175	100	50	Odex
HH07-18	1,368,200	2,152,272	100	50	Odex
HH07-19	1,372,964	2,147,402	100	50	Odex
HH07-20	1,385,929	2,152,189	100	50	Odex
HH07-21	1,395,717	2,130,878	400	n/a	Rotary
HH07-22	1,396,223	2,128,124	100	50	Odex
HH07-23	1,400,448	2,127,566	100	50	Odex
HH07-24	1,404,359	2,129,706	100	50	Odex
HH07-25	1,379,611	2,171,846	200	70	Odex
HH07-26	1,393,473	2,146,504	75	30	Odex
HH07-29	1,392,252	2,155,342	75	30	Odex
HH07-30	1,384,762	2,143,495	75	30	Odex
HH07-31	1,385,866	2,126,396	200	70	Odex
HH07-32	1,389,059	2,124,187	200	70	Odex
HH07-33	1,392,581	2,127,380	200	70	Odex
TOTAL DEPTH			4,125	1,120	
Pumping Wells					
PW07-02	1,379,929	2,171,854	100		Odex
TOTAL DEPTH			100		

Notes:

a. Drill-hole ID naming convention is preliminary and will change.

FIGURES

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Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 1
Existing Well and Piezometer Locations

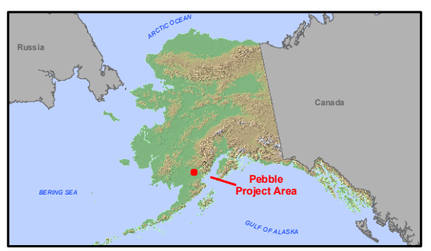
2007 Field Sampling Plan
Groundwater Studies
Mine Study Area

Legend

- Monitoring Well
- Piezometer (P, GH, I, M)
- Pumping Well (PW)
- Wetlands Piezometer (WL)
- General Pit Outline
- Lakes
- Rivers
- 50-ft Contour Interval

Watershed

- North Fork Koktuli River
- South Fork Koktuli River
- Upper Talarik Creek



0 4,000 8,000 12,000 16,000 Feet

0 1,000 2,000 3,000 4,000 Meters

N

Scale 1:72,219

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

Project No: 7126	Date: July 31, 2007
Version: 6	Author: WMC-LC

File: \\Manu\projects\Pebble\scope schedule & budget\2007\Field Sampling Plan\Figure 1 Existing Well Locations.mxd

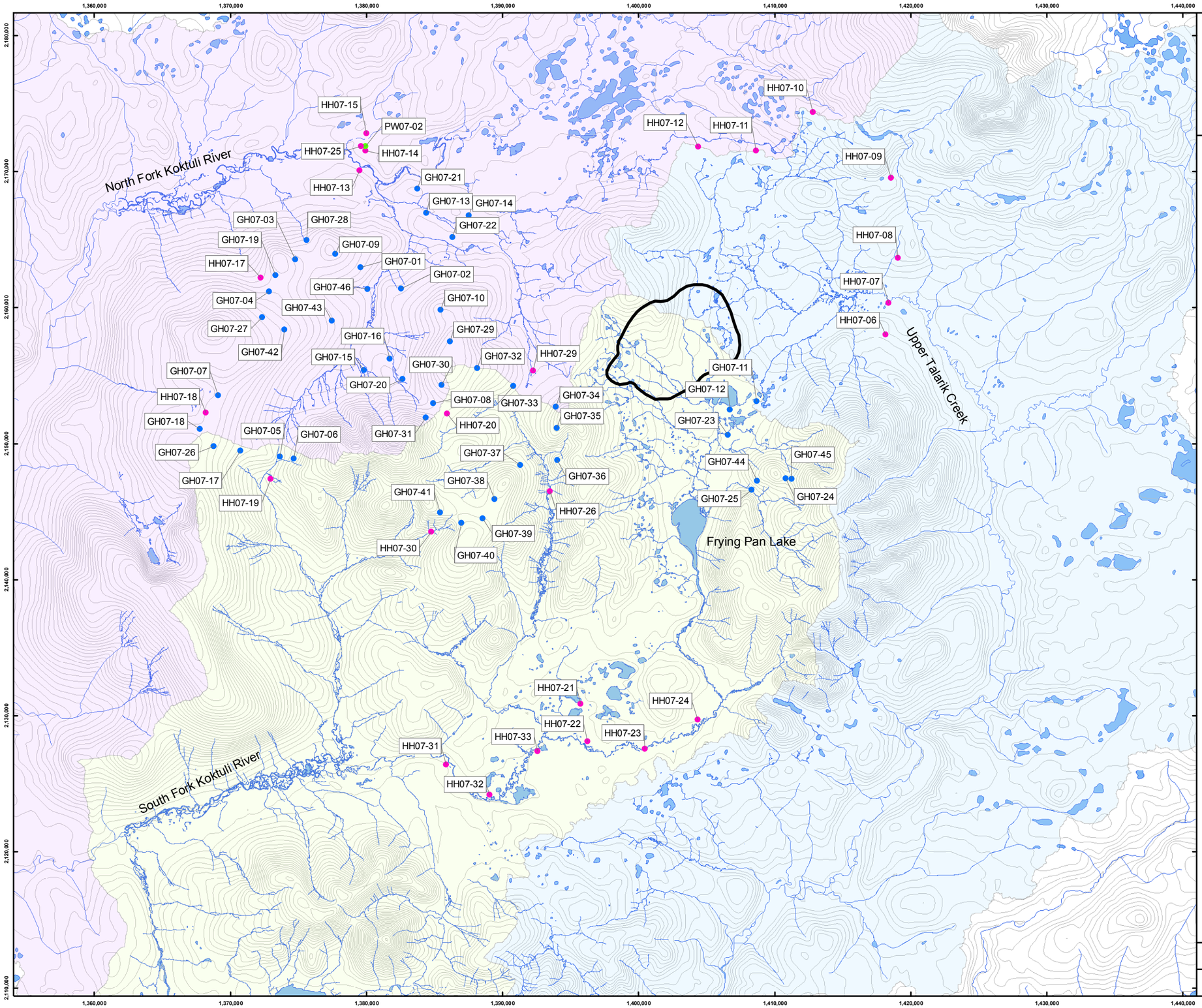
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Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 2
Proposed Well and Piezometer Locations

2007 Field Sampling Plan
Groundwater Studies
Mine Study Area

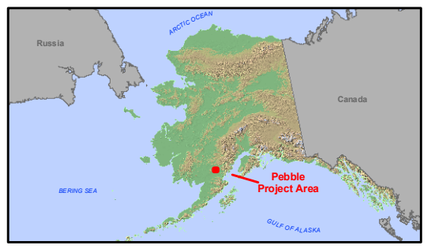


Legend

- GH07 - Geotechnical Hole
- HH07 - Hydrogeology Hole
- PW07 - Pumping Well
- Lakes
- General Pit Outline
- Rivers
- 50-ft Contour Interval

Watershed

- North Fork Koktuli River
- South Fork Koktuli River
- Upper Talarik Creek



0 4,000 8,000 12,000 16,000 Feet

0 1,000 2,000 3,000 4,000 Meters

N

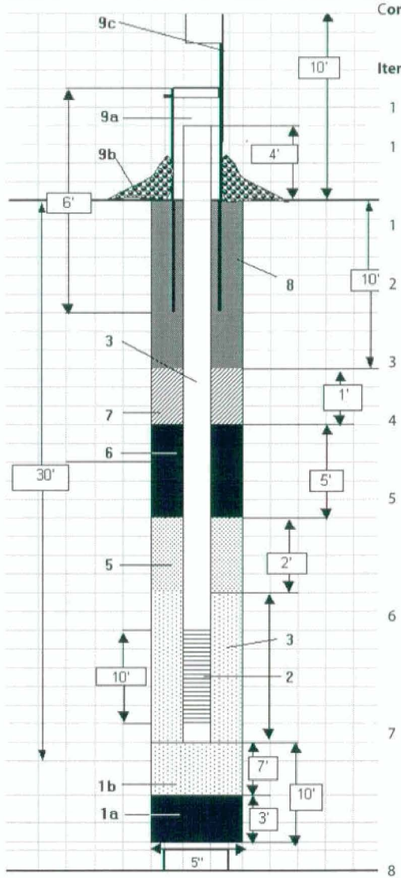
Scale 1:87,189

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

Project No: 7126	Date: July 31, 2007
Version: 6	Author: WMC-LC

File: \\Manu\projects\Pebble\scope schedule & budget\2007\study plan\Figure 5.1-3 Proposed Well Locations.mxd

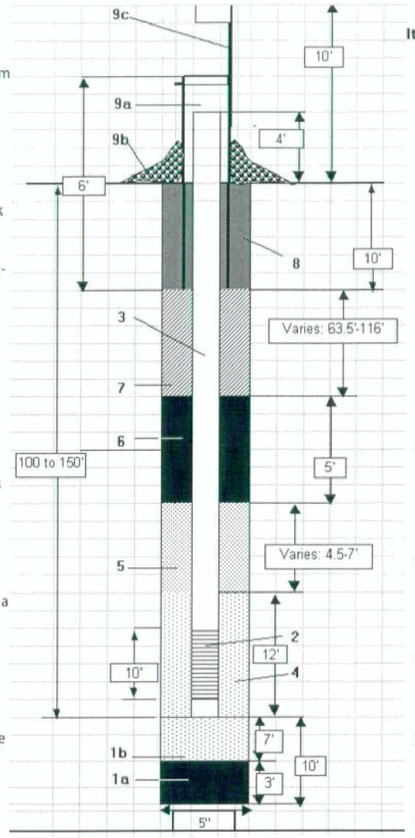
SHALLOW WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specifiction/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	CSSI 10-20 silica sand, placed to least 3 feet above rathole bentonite plug
1	b) Type of transition sand	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.
2	Type/slot size of screen	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
3	Dia./type of riser well casing	CSSI 10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
4	Type screen filter pack	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)
5	Type of transition sand	PureGold medium bentonite chips, (where possible) placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
6	Type of 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.
7	Type seal overlying plug	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
8	Type near-surface completion	8-inch dia. by 5 feet/Stainless Steel with weep hole with locking cap
9	Wellhead protection	Mound 10 inches around well casing, using drill cuttings if possible
9	a) Wellhead protective casing	1-inch dia. PVC pole attached to protective casing with flag
9	b) Gravel blanket	Inscribed in locking cap
9	c) Reflector	
9	d) Well tag	
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

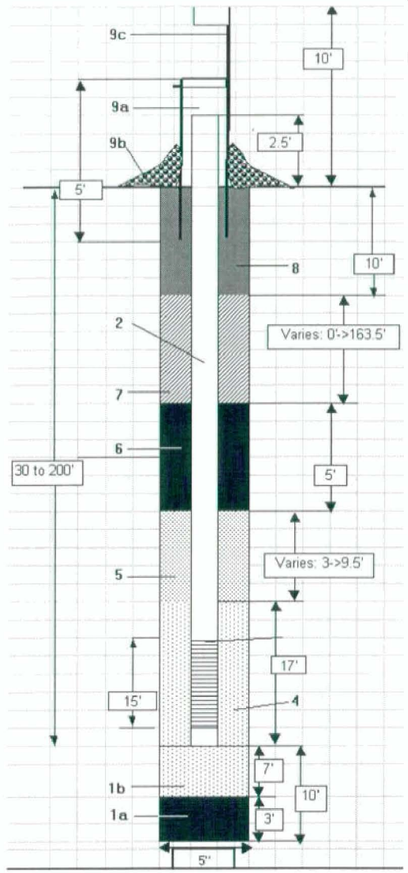
INTERMEDIATE (100 to 150 ft.) WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

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

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



Construction (Bottom Up)

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

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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

APPENDICES

APPENDIX A

FIELD FORMS

SLR Alaska
4601 Business Park Boulevard
Suite K42
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

DRILLING BORING LOG

Sheet ____ of ____

Boring/Well Number: _____

Client: Northern Dynasty Mines		Project:	
Site Name:		Boring Total Depth (feet):	
SLR Project #		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:

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

Comments:

SLR Alaska
4601 Business Park Boulevard
Suite K42
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

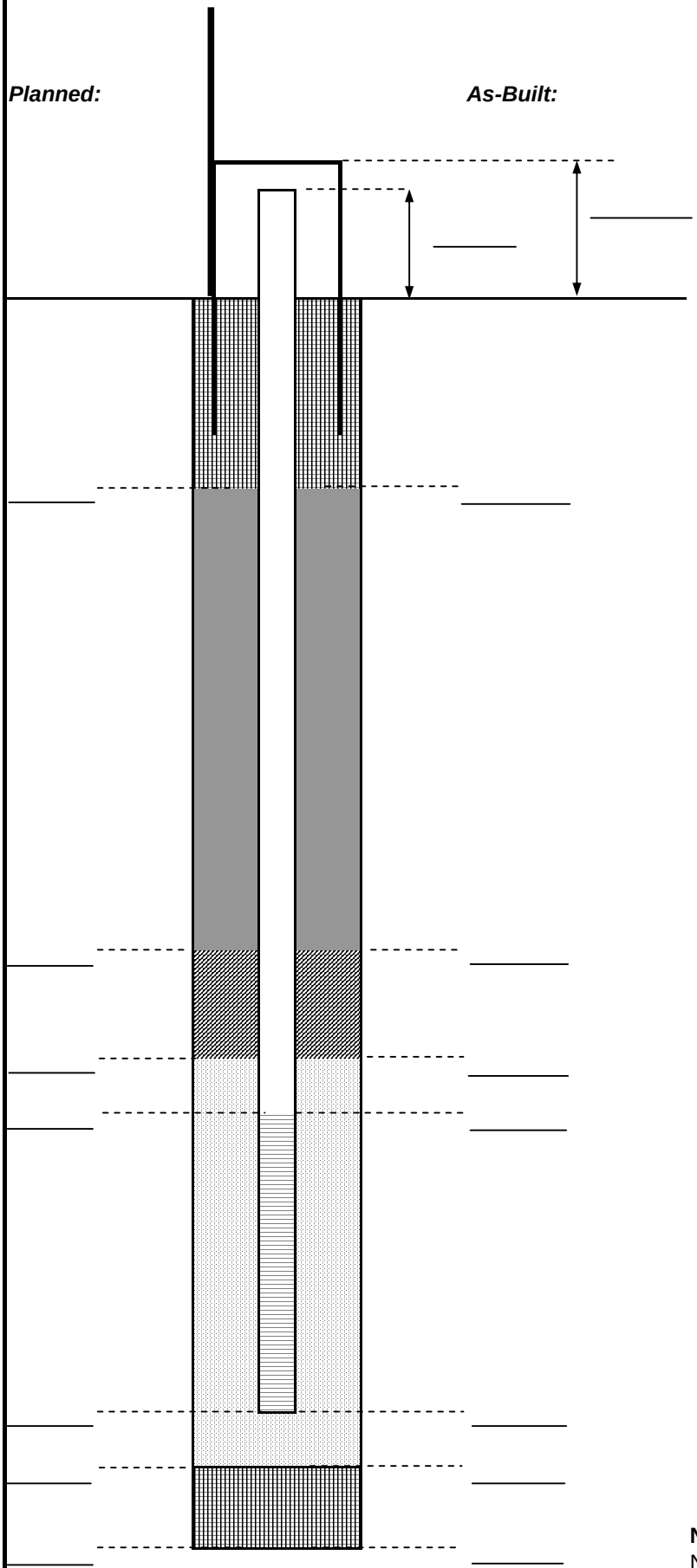
FIELD LOG OF SOIL BORING Sheet ____ of ____

Boring/Well Number: _____

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

Comments:

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.

Volume of Annulus Between Casing and Borehole

Hole Diameter (inches)	Nominal Casing Diameter	Volume of Annulus (cu ft)	(gal per lf)	(gal per lf)
6.0	2.0	0.17	1.47	1.27
	Linear Foot			
	1	0.17	1.47	1.27
	2	0.34	2.94	2.54
	3	0.51	4.41	3.81
	4	0.68	5.88	5.08
	5	0.85	7.35	6.35
	6	1.02	8.82	7.62
	7	1.19	10.29	8.89
	8	1.36	11.76	10.16
	9	1.53	13.23	11.43
	10	1.7	14.7	12.7
	11	1.87	16.17	13.97
	12	2.04	17.64	15.24
	13	2.21	19.11	16.51
	14	2.38	20.58	17.78
	15	2.55	22.05	19.05
	16	2.72	23.52	20.32
	17	2.89	24.99	21.59
	18	3.06	26.46	22.86
	19	3.23	27.93	24.13
	20	3.4	29.4	25.4
	21	3.57	30.87	26.67
	22	3.74	32.34	27.94
	23	3.91	33.81	29.21
	24	4.08	35.28	30.48
	25	4.25	36.75	31.75
	26	4.42	38.22	33.02
	27	4.59	39.69	34.29
	28	4.76	41.16	35.56
	29	4.93	42.63	36.83
	30	5.1	44.1	38.1
	31	5.27	45.57	39.37
	32	5.44	47.04	40.64
	33	5.61	48.51	41.91
	34	5.78	49.98	43.18
	35	5.95	51.45	44.45
	36	6.12	52.92	45.72
	37	6.29	54.39	46.99

NOTES:
Volume of annular space = volume of hole - volume of casing (O.D.)
1 cubic foot = 7.481 gallons = 28.32 liters

Cementing & Grouting Volume Information

Material	cu ft	liters	gallons
3/8 HOLEPLUG® (50 lb. Sack)	0.69	19.54	5.16
3/4 HOLEPLUG® (50 lb. Sack)	0.73	20.67	5.46
BENSEAL® (50 lb. Sack)	0.70	19.82	5.24
EZ SEAL™ (50 lb. Sack)	0.70	19.82	5.24
1/4" BAROID®Bentonite Pellets(50 lb. Bkt.)	0.70	19.82	5.24
3/8" BAROID® Bentonite Pellets (50 lb. Bkt.)	0.70	19.82	5.24
1/2" BAROID® Bentonite Pellets (50 lb. Bkt.)	0.74	20.96	5.54
94 lb. Sack of Cement	1.00	28.32	7.48

WELL DEVELOPMENT LOG

Well ID: _____
Date: _____

Project: _____ Project #: _____

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)	Sp Cond (mS/cm)	Turbidity (NTU)	Temp (deg C)	Sediment (grain size, color, quantity)
Surge block on								
Surge block off								

RESPONSE TEST LOG

Date: _____ Well ID: _____

Project: _____ Project #: _____

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			

PUMPING TEST
Pumping Well Log

Date: _____ Well ID: _____

Project: _____ Project #: _____

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)
Sp Cond	0.447		
(mS/cm)	1.413		

Observation Wells

_____ _____

_____ _____

_____ _____

Field Instrument Readings

	Date	Time	Volume (gal)	Elapsed Time*	Flow (gpm)	Sp 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										

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

PUMPING TEST
Observation Well Log

Date: _____ Well ID: _____

Project: _____ Project #: _____

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

TRANSDUCER CONTROL LOG

Date: _____ Well ID: _____

Project: _____ Project #: _____

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 _____

Manual water level readings

	Year	Date	Time	DTW (ft, _____)		Year	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				

WATER LEVEL MEASUREMENT LOG

SLR Alaska

Water Level Meter
Make:
SN:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:

Date start
Date finish

Water Level Measurements

Well	Oct DTW				Current Reading					Comments
	Feb WL	Ref	Feb TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
GH04-01		FTOC		FTOC						
GH04-02		FTOC		FTOC						
GH04-03		FTOC		FTOC						
GH04-04		FTOC		FTOC						
GH04-05		FTOC		FTOC						
GH04-06		FTOC		FTOC						
GH04-08		FTOC		FTOC						
GH04-10		FTOC		FTOC						
GH04-11		FTOC		FTOC						
GH04-12A		FTOC		FTOC						
GH04-13		FTOC		FTOC						
GH04-14		FTOC		FTOC						
GH04-16		FTOC		FTOC						
GH04-17		FTOC		FTOC						
GH04-18		FTOC		FTOC						
GH04-19		FTOC		FTOC						
GH04-20		FTOC		FTOC						
GH04-22		FTOC		FTOC						
GH04-23		FTOC		FTOC						
GH04-25		FTOC		FTOC						
GH04-26		FTOC		FTOC						
GH04-27		FTOC		FTOC						
GH04-28		FTOC		FTOC						
GH04-29A		FTOC		FTOC						
GH04-30		FTOC		FTOC						
GH04-31		FTOC		FTOC						
GH04-32		FTOC		FTOC						
GH04-33		FTOC		FTOC						
GH04-35		FTOC		FTOC						
GH04-37		FTOC		FTOC						
GH04-38		FTOC		FTOC						
GH04-39		FTOC		FTOC						
GH04-41		FTOC		FTOC						
GH04-42		FTOC		FTOC						
GH04-43		FTOC		FTOC						

ABBREVIATIONS:
FTOC - from top of casing
FTOP - from top of sample port
FAS - frozen at surface

SLR Water Parameter Meter
Calibration Log

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

WELL PURGING AND SAMPLING FIELD CONTROL LOG

Date: _____ **Well ID:** _____

Project: _____ **Project #** _____

Samplers: _____

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: _____

Filter Lot Number: _____

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: _____

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

Bottle Inventory:		AS1	AS2	AS5		AS6	AS3	AS4	AS7
	Hg (NF, F)	Metals	Metals (F)	TSS	TDS+	Anions	Cn	P, Am, N	Thiocyanate
	HCl	HNO_3	HNO_3	--	--	--	NaOH	H_2SO_4	HNO_3
	2 x 500mL	1 x 500mL	1 x 500mL	1 x 1L	1 x 1L	1 x 120mL	1 x 250mL	1 X 500mL	1 X 250mL
MS/MSD Volume:	no	extra	extra	extra	extra	extra	no	no	no
CAS Volume:	2 x 500mL	1 x 1L	1 x 1L	1 x 1L		no	1 x 1L	1 x 1L	(same as metals)
Sample Order:	1	2	3	4	5	6	7	8	9
Bottle Count:	____	____	____	____	____	____	____	____	____

Casing Diameter (inches)	**Schedule 40** (gal/ft casing)	**Schedule 40** (liters /ft casing)	**Schedule 80** (gal/ft casing)	**Schedule 80** (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										

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: _____

APPENDIX B

EXAMPLE WELL CONSTRUCTION LOGS

SLR Alaska
4601 Business Park Boulevard
Suite K42
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

DRILLING BORING LOG

Sheet ____ of ____

Boring/Well Number: _____

Client: Northern Dynasty Mines		Project:	
Site Name:		Boring Total Depth (feet):	
SLR Project #		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:

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

Comments:

SLR Alaska
4601 Business Park Boulevard
Suite K42
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

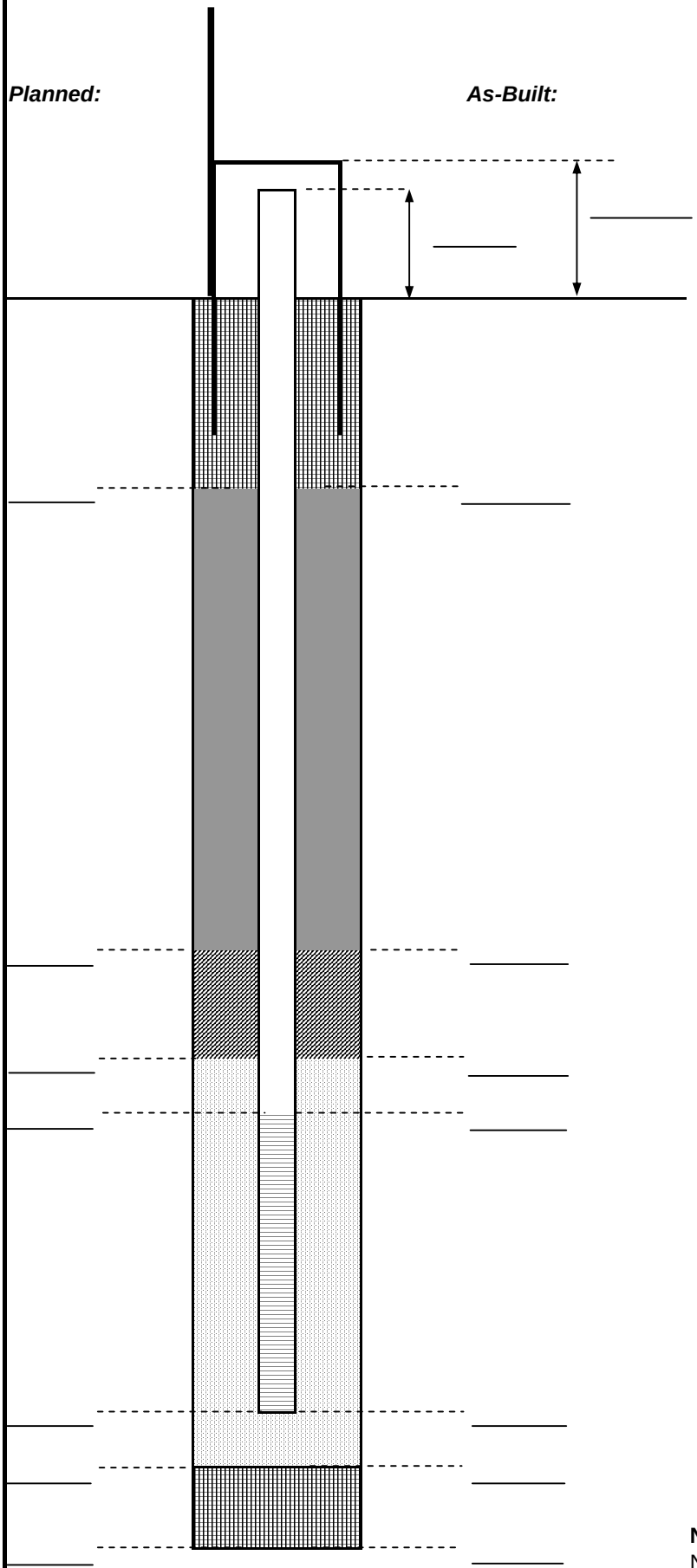
FIELD LOG OF SOIL BORING Sheet ____ of ____

Boring/Well Number: _____

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

Comments:

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.

Volume of Annulus Between Casing and Borehole

Hole Diameter (inches)	Nominal Casing Diameter	Volume of Annulus (cu ft)	(gal per lf)	(gal per lf)
6.0	2.0	0.17	1.47	1.27
	Linear Foot			
	1	0.17	1.47	1.27
	2	0.34	2.94	2.54
	3	0.51	4.41	3.81
	4	0.68	5.88	5.08
	5	0.85	7.35	6.35
	6	1.02	8.82	7.62
	7	1.19	10.29	8.89
	8	1.36	11.76	10.16
	9	1.53	13.23	11.43
	10	1.7	14.7	12.7
	11	1.87	16.17	13.97
	12	2.04	17.64	15.24
	13	2.21	19.11	16.51
	14	2.38	20.58	17.78
	15	2.55	22.05	19.05
	16	2.72	23.52	20.32
	17	2.89	24.99	21.59
	18	3.06	26.46	22.86
	19	3.23	27.93	24.13
	20	3.4	29.4	25.4
	21	3.57	30.87	26.67
	22	3.74	32.34	27.94
	23	3.91	33.81	29.21
	24	4.08	35.28	30.48
	25	4.25	36.75	31.75
	26	4.42	38.22	33.02
	27	4.59	39.69	34.29
	28	4.76	41.16	35.56
	29	4.93	42.63	36.83
	30	5.1	44.1	38.1
	31	5.27	45.57	39.37
	32	5.44	47.04	40.64
	33	5.61	48.51	41.91
	34	5.78	49.98	43.18
	35	5.95	51.45	44.45
	36	6.12	52.92	45.72
	37	6.29	54.39	46.99

NOTES:
Volume of annular space = volume of hole - volume of casing (O.D.)
1 cubic foot = 7.481 gallons = 28.32 liters

Cementing & Grouting Volume Information

Material	cu ft	liters	gallons
3/8 HOLEPLUG® (50 lb. Sack)	0.69	19.54	5.16
3/4 HOLEPLUG® (50 lb. Sack)	0.73	20.67	5.46
BENSEAL® (50 lb. Sack)	0.70	19.82	5.24
EZ SEAL™ (50 lb. Sack)	0.70	19.82	5.24
1/4" BAROID®Bentonite Pellets(50 lb. Bkt.)	0.70	19.82	5.24
3/8" BAROID® Bentonite Pellets (50 lb. Bkt.)	0.70	19.82	5.24
1/2" BAROID® Bentonite Pellets (50 lb. Bkt.)	0.74	20.96	5.54
94 lb. Sack of Cement	1.00	28.32	7.48

WELL DEVELOPMENT LOG

Well ID: _____
Date: _____

Project: _____ Project #: _____

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)	Sp Cond (mS/cm)	Turbidity (NTU)	Temp (deg C)	Sediment (grain size, color, quantity)
Surge block on								
Surge block off								

RESPONSE TEST LOG

Date: _____ Well ID: _____

Project: _____ Project #: _____

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			

PUMPING TEST
Pumping Well Log

Date: _____ Well ID: _____

Project: _____ Project #: _____

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)
Sp Cond	0.447		
(mS/cm)	1.413		

Observation Wells

_____ _____

_____ _____

_____ _____

Field Instrument Readings

	Date	Time	Volume (gal)	Elapsed Time*	Flow (gpm)	Sp 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										

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

PUMPING TEST
Observation Well Log

Date: _____ Well ID: _____

Project: _____ Project #: _____

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

TRANSDUCER CONTROL LOG

Date: _____ Well ID: _____

Project: _____ Project #: _____

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 _____

Manual water level readings

	Year	Date	Time	DTW (ft, _____)		Year	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				

WATER LEVEL MEASUREMENT LOG

SLR Alaska

Water Level Meter
Make:
SN:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:

Date start
Date finish

Water Level Measurements

Well	Oct DTW				Current Reading					Comments
	Feb WL	Ref	Feb TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
GH04-01		FTOC		FTOC						
GH04-02		FTOC		FTOC						
GH04-03		FTOC		FTOC						
GH04-04		FTOC		FTOC						
GH04-05		FTOC		FTOC						
GH04-06		FTOC		FTOC						
GH04-08		FTOC		FTOC						
GH04-10		FTOC		FTOC						
GH04-11		FTOC		FTOC						
GH04-12A		FTOC		FTOC						
GH04-13		FTOC		FTOC						
GH04-14		FTOC		FTOC						
GH04-16		FTOC		FTOC						
GH04-17		FTOC		FTOC						
GH04-18		FTOC		FTOC						
GH04-19		FTOC		FTOC						
GH04-20		FTOC		FTOC						
GH04-22		FTOC		FTOC						
GH04-23		FTOC		FTOC						
GH04-25		FTOC		FTOC						
GH04-26		FTOC		FTOC						
GH04-27		FTOC		FTOC						
GH04-28		FTOC		FTOC						
GH04-29A		FTOC		FTOC						
GH04-30		FTOC		FTOC						
GH04-31		FTOC		FTOC						
GH04-32		FTOC		FTOC						
GH04-33		FTOC		FTOC						
GH04-35		FTOC		FTOC						
GH04-37		FTOC		FTOC						
GH04-38		FTOC		FTOC						
GH04-39		FTOC		FTOC						
GH04-41		FTOC		FTOC						
GH04-42		FTOC		FTOC						
GH04-43		FTOC		FTOC						

ABBREVIATIONS:
FTOC - from top of casing
FTOP - from top of sample port
FAS - frozen at surface

SLR Water Parameter Meter
Calibration Log

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

WELL PURGING AND SAMPLING FIELD CONTROL LOG

Date: _____ **Well ID:** _____

Project: _____ **Project #** _____

Samplers: _____

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: _____

Filter Lot Number: _____

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: _____

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

Bottle Inventory:		AS1	AS2	AS5		AS6	AS3	AS4	AS7
	Hg (NF, F)	Metals	Metals (F)	TSS	TDS+	Anions	Cn	P, Am, N	Thiocyanate
	HCl	HNO_3	HNO_3	--	--	--	NaOH	H_2SO_4	HNO_3
	2 x 500mL	1 x 500mL	1 x 500mL	1 x 1L	1 x 1L	1 x 120mL	1 x 250mL	1 X 500mL	1 X 250mL
MS/MSD Volume:	no	extra	extra	extra	extra	extra	no	no	no
CAS Volume:	2 x 500mL	1 x 1L	1 x 1L	1 x 1L		no	1 x 1L	1 x 1L	(same as metals)
Sample Order:	1	2	3	4	5	6	7	8	9
Bottle Count:	____	____	____	____	____	____	____	____	____

Casing Diameter (inches)	**Schedule 40** (gal/ft casing)	**Schedule 40** (liters /ft casing)	**Schedule 80** (gal/ft casing)	**Schedule 80** (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										

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: _____



PEBBLE PROJECT
ENVIRONMENTAL BASELINE STUDIES
2008 FIELD SAMPLING PLAN

GROUNDWATER HYDROLOGY AND WATER QUALITY
Mine Study Area

DRAFT

April 2008

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ACRONYMS AND ABBREVIATIONS

ASPCS	Alaska State Plane Coordinate System
ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
DO	dissolved oxygen
DOC	dissolved organic carbon
GPS	global positioning system
ID	inner diameter
NAD	North American Datum
NAVD	North American Vertical Datum
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Shaw	Shaw Alaska Inc.
SLR	SLR International Corporation
TOC	total organic carbon
WMC	Water Management Consultants, Inc.

2008 FIELD SAMPLING PLAN

GROUNDWATER HYDROLOGY AND WATER QUALITY, MINE STUDY AREA

1. Introduction

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

2. Study Area and Project Background

The Pebble Deposit is located in the headwater areas of the Koktuli River and Upper Talarik Creek. The main stems of the river and the creek flow primarily in flood-plain channels eroded into widespread glacial deposits. The valley's glacial infill is bounded by bedrock mantled with glacial deposits. Existing groundwater levels, flow, and chemistry will be defined within major bedrock units and within the overburden, thus allowing an assessment of baseline conditions. The mine study area encompasses local and regional groundwater that might be affected by the proposed project or that could affect the surface water system.

The projected location of the open pit of the mine is along the margins of the valley infill deposits, such that certain sectors of the pit wall may 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 mining activities.

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 assessed to evaluate 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 Objectives

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

- Characterize the existing groundwater flow regime within the study area.
- Support the permitting process by characterizing 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 aid in project design.
- Establish a long-term monitoring plan.

4. Project Organization and Responsibilities

The field work for the groundwater studies will be conducted by SLR International Corporation (SLR). SLR will conduct groundwater sampling and field work according to guidelines in the Pebble Project *2008 Quality Assurance Project Plan* (QAPP; PLP, In press) and this field sampling plan.

While in the field, SLR will e-mail brief daily updates to Water Management Consultants (WMC) and Pebble Project management and will transmit daily field logs of drilling and testing to WMC. Before installing a monitoring well, SLR personnel will communicate lithology information and planned well completion details to WMC personnel, most likely via a satellite phone from the drill site.

Groundwater samples will be delivered to Shaw Alaska, Inc. (Shaw), personnel in Iliamna on the same day as the samples are collected. If no Shaw representatives are in Iliamna, the samples will be shipped priority to Shaw in Anchorage. Shaw personnel will log the samples and ship them to the analytical laboratories under proper chain-of-custody procedures.

SLR will coordinate field efforts with other companies, including drillers and helicopter contractors.

5. 2008 Project Overview

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 will consist of drilling, installing, and developing monitoring wells; aquifer testing; groundwater-level measurement; and groundwater sampling and is scheduled to begin in January 2008 and to be completed in December 2008. Field activities are summarized below, and detailed methods are discussed in Section 6.

5.1 Installation and Sampling of Piezometers and Monitoring Wells

Piezometers and monitoring wells are used to collect information on stratigraphy, hydraulic conductivity, groundwater levels, and groundwater quality. Collection of data from existing wells and piezometers (Table 1, Figure 1) will continue in 2008. In addition, new wells and piezometers will be installed and data will be collected from them. The locations of the new wells and piezometers have not yet been determined.

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 throughout 2008.

Groundwater samples will be collected from selected monitoring wells and will be submitted for laboratory analyses. The analytical methods for the groundwater samples are detailed in the QAPP (PLP, In press).

5.2 Installation of Pumping Wells and Performing Pumping Tests

Pumping tests may be conducted to define hydraulic properties. The wells will be pumped using 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. SLR will be equipped to collect groundwater samples and to measure the water levels in piezometers. The drilling contractor will provide appropriate equipment to measure the pumping rate.

In addition to existing pumping wells, new installations may be added in 2008. Each pumping site will consist of one or two pumping wells installed in proximity to one another for each of the overburden pumping tests. These wells and related piezometers will be installed using the ODEX drilling rig.

5.3 Installation and Monitoring of Westbay System

The existing Westbay System is a multi-zone well completion with 50 separate zone completions within the 4,050-foot-deep drillhole, with surface equipment to allow lowering and raising of specialized tools in the well. One additional Westbay installation with a similar number of monitoring zones will be completed during 2008.

Monthly monitoring of the pressure profile in the existing Westbay System installed at drillhole NDM-6349 will be conducted during 2008. If an additional Westbay System is installed, monthly monitoring of the pressure profile will be carried out at that location also. Hydraulic testing and water sampling may be performed in existing or new holes in 2008.

Monitoring of the Westbay System is performed by SLR under the direction of WMC. The operational procedures for the Westbay System are detailed in the Westbay operator training manual (Schlumberger, n.d.), and are not repeated here.

6. Field Activities

The following sections outline basic requirements for drilling, installing, sampling, and collecting measurements from monitoring wells and piezometers, pumping wells, and Westbay System(s). These requirements are designed to maximize sample quality and to assist in the permitting process.

6.1 Installation of Monitoring Wells and Piezometers

Wells may be installed in clusters, and each well-cluster location may include up to three wells installed at nominal depths of approximately 30 to 50 feet, 70 to 100 feet, and 150 to 200 feet. The number of wells at each site and the actual depths will vary depending on site conditions. The locations of some wells/piezometers will be determined in the field at the time of drilling.

6.1.1 Locating and Surveying

Before drilling begins, SLR field-team members and drilling contractors will locate the site of each well and piezometer using cadastral survey and global positioning system (GPS) coordinates and then will visit the sites with WMC personnel. No intrusive action will begin until SLR, The Pebble Partnership, and the drilling contractor agree that drilling rigs can be moved safely without causing harm to human health or the environment.

After wells and piezometers are installed, a surveyor 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).

The ASPCS coordinates and elevations of all newly installed monitoring wells will be surveyed. Well elevations will be surveyed at the top of the riser pipe and at the ground surface. All surveying data will be recorded in a bound field logbook. SLR and WMC will be provided with a table summarizing survey locations of all newly installed monitoring wells and piezometers.

6.1.2 Identification

Wells and piezometers will be identified using an alphanumeric identification system composed of the following components in the order shown below:

- MW, P, or PW = abbreviation for monitoring well, piezometer, or pumping well, respectively.
- Year = two digit number representing the last two digits of the year the location was drilled.
- Well or piezometer site number = two- or three-digit sequential number from 01 to 999. Numbers are assigned sequentially by completion and are carried over from year to year. The first number used in 2008 will be 54.
- Well type (if in a cluster) = single alpha character denoting general well depth, as follows:

  SS = super shallow: less than 30 feet deep.

S = shallow: 30 to 50 feet deep.

M = intermediate: 70 to 100 feet deep.

D = deep: 150 to 200 feet deep.

Several examples are provided below:

- MW-05-20S denotes a shallow monitoring well drilled in the year 2005 at the 20th well site or array.
- MW-06-40D denotes a deep monitoring well drilled in the year 2006 at the 40th well site or array.
- P-07-43M identifies an intermediate piezometer drilled in the year 2007 at the 43rd well site or array.

6.1.3 Groundwater Monitoring Wells

Drilling and installation 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).

6.1.3.1 Drilling

Well borings will be drilled either with an ODEX drilling system that employs a down-hole hammer and a 5- or 6-inch-inner-diameter (ID) continuous casing or with a rotary rig with HQ- or NQ-size drill-rod system. Use of the rotary method or the ODEX method will depend on the relative efficiency, availability, and effectiveness of each rig, as determined in the field.

Previous drilling in the mine 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 riser after the casing has been pulled back.

Field personnel will collect cuttings from borings in order to prepare soil descriptions. Cuttings will be photographed, bagged, and labeled at 5-foot intervals and stored for future reference. The bagged samples will be stored in plastic 5-gallon buckets labeled with the drillhole number and dates 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 logs (Appendix A). Boring logs will be prepared in accordance with ASTM Method D 2488-00 (ASTM, 2000). Other observations to be documented include the following:

- Drill-rig behavior, such as rate and chatter, plugging of return hose, and driller's observations.
- Addition of water into hole (if any).

- Rate of water flow out of hole.

6.1.3.2 Well Design

The proposed locations, drilling methods, and depths for the monitoring wells to be installed in 2008 have not yet been determined. An example of a hole lithology log with well-construction information is presented in Appendix B.

In well arrays (or clusters), each well will be installed in a separate hole, with approximately 15 to 20 feet of horizontal separation between holes. These borings will be drilled to predetermined depths. If the drilling equipment used requires the drive shoe to be left in the boring for a well completion, the boring will be over-drilled by about 10 feet before the drive shoe is knocked off to create a rat-hole. Well-screen placement will be determined after the rat-hole 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), 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 at the 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 drilling may extend into bedrock, if the supervising hydrogeologist finds it necessary. 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.

6.1.3.3 Well Construction

Subsurface well construction will include (from the bottom up) the following features (Figure 2):

- If necessary, the casing shoe will be sealed at the bottom of the drillhole beneath at least 3 feet of bentonite pellets and 3 feet of transition sand before the riser pipe is placed in the casing.
- Monitoring wells will be constructed of 2-inch-diameter, Schedule 40 or Schedule 80, flush-joint threaded, polyvinyl chloride (PVC) riser pipe with O-rings, extending approximately 3 feet above surface grade.
- Well screens will be constructed of Schedule 40 or Schedule 80, 0.020-inch machine-slotted PVC pipe capable of retaining filter sand.
- Filter sand packs will be 10-20 sieve 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 the casing. Filter sand will not be required if sands are heaving after the screen is placed.

- A 5-foot bentonite pellet plug will be placed above the sand to seal the annulus above the 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 placement of the bentonite plug is not feasible, the grout will be placed directly on top of the 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 approximately 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 to 25 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, as follows. Lay the PVC pipe to be installed out on the ground, double-check and record the lengths, and record the number of pipe sections.
  - 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. The steel casing will be painted safety yellow or orange for increased visibility.

6.1.3.4 Well Development

Before they are sampled, newly constructed monitoring wells will be developed 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 inertial pump fitted with a surge block and operated by an electric or gasoline-powered actuator. This method will be used to maximize the sediment drawn in from the filter pack during development. A gasoline-powered suction pump may be used in some cases to polish the well. Piezometers also will be developed, but for a shorter period of time in order to verify that the piezometers are responding to aquifer piezometric level changes.

The following parameters will be monitored during development:

- Volume of water pumped.

- Quantity, color, and size of sediment removed.
- pH, temperature, specific conductance, and turbidity of water.
- Comments on well yield and results of development.

Water-level measurements will be collected before and after development. All development data will be recorded on a well development log (Appendix A).

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

1. Measure and 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.
2. Lower the pump tubing with surge block to the bottom of the screen, and start the actuator. After one or two minutes, collect a water sample for filtration.
3. Filter the water sample through a 0.45-micrometer filter, and take a "before" picture of the filter.
4. Continue development until a noticeable decrease in sediment yield has been observed, to a maximum of 45 to 60 minutes.
5. Move the surge block approximately 2 feet up the screen and repeat the process.
6. Continue moving the surge block up the screen until the full screen has been developed.
7. 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.
8. The well will be considered adequately developed if the water discharged by the pump 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.
9. After stabilization (or 4 hours of surging and pumping), pass development water through a 0.45-micrometer filter and take an "after" picture of the filter. Measure the pH, temperature, specific conductance, and turbidity of the final developed water.
10. 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.

6.1.3.5 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. The groundwater level as a function of time will be monitored with the pressure transducer and field computer 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. Water levels will be measured using a well sounder before and after the response test to correlate the pressure-transducer reading to water-level

elevations. 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 1-inch-diameter tubing (of the same type used for the well development pump) 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 (a test is a slug in/slug out cycle) with enough recovery data for analysis 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) per test, and only one test (slug in/slug out cycle) would be conducted in this circumstance.

6.1.4 Piezometers

6.1.4.1 Piezometer Installation

Piezometers will be designed, drilled, installed, constructed, and documented in the same manner as monitoring wells (Figure 2 and Section 6.1.3). Piezometers will be used to measure piezometric levels and aquifer response to pumping tests. The locations of the piezometers proposed for installation in 2008 have not yet been determined.

6.1.4.2 Development and Sampling

Sampling from piezometers is not planned. Piezometers will be developed using procedures similar to those for monitoring wells (Section 6.1.3.4.), but for a shorter duration, as development is necessary to improve response to piezometric-level changes rather than to remove sample turbidity.

6.1.4.3 Response Testing

Piezometers will be response tested in the same manner as for monitoring wells (Section 6.1.3.5).

6.2 Collecting Water-level Measurements

Water levels in wells and piezometers will be measured with an electric sounder. Water levels will be documented on water-level measurement logs (Appendix A). For the water-level survey, all water levels will be measured within the shortest time practical. The following protocol will be employed while collecting water-level data:

- An electric sounder will be used to measure water levels and total depths in all wells and groundwater piezometers.
- Electric sounders will be kept clean and will be maintained in accordance with manufacturer's instructions. Before the sounder is used on wells that are sampled for water quality, the probe will be rinsed with deionized water.

- 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.

6.3 Groundwater Sampling from Monitoring Wells

6.3.1 General Techniques

As described below, the groundwater monitoring wells will be purged and sampled with dedicated submersible pumps. Dedicated 3/4-inch-diameter polyethylene (or equivalent) tubing will be permanently installed between the well cap and the pump at each well. Samples will be collected using nondedicated 3/8-inch-diameter polyethylene tubing connected to the dedicated tubing at the well cap. For each sample, new tubing will be used between the well cap and the sample container. The tubing will allow the use of in-line filters, as needed for specific analyses. All required field measurements will be collected as described below. Purge water will be disposed of on site.

The proposed number of samples and sample types, as well as container types, holding times, and preservatives, are described in the QAPP (PLP, In press).

6.3.2 Monitoring Well Purging and Measuring of Field Parameters

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

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

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

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

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

Turbidity will be monitored visually, and qualitative comments will be entered on the well purging and sampling form. Care will be taken to ensure that the pump's tubing is free of air bubbles along its entire length. If necessary, a turbidity meter may be used to collect turbidity measurements. If the turbidity meter is used, the sample for the turbidity analysis will be drawn from a "T" fitted with a valve located upstream of the flow-through cell. When drawing the turbidity samples, care will be taken to not introduce air into the sampling tubing and to draw the sample at a sufficiently low rate as to not significantly disrupt flow to the flow-through cell.

Once the minimum purge volume (two times the combined volume from drawdown and from below the pump) has been removed, 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 1.0 degree Celsius (ºC).
- pH varies by less than 0.2 pH units.
- Turbidity is observed to be minimal.

If the readings will not stabilize, 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. The field instrument probe will be rinsed off after sample collection is complete to ensure that calibration solutions used for calibration checks at every well or well array are not contaminated by site groundwater.

6.3.3 Sample Collection

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

1. Total metals (including total mercury).
2. Dissolved metals (including dissolved mercury).
3. Parameters not requiring chemical preservation.
4. Cyanide.
5. Other water-quality parameters (ammonia, phosphorus, nitrate-nitrite, total dissolved solids, total suspended solids, alkalinity, acidity, specific conductance, pH, chloride, fluoride, sulfate, thiocyanate, and dissolved organic carbon [DOC]).

Samples will be collected with the pump and tubing used to purge the well. Sample will be collected from dedicated tubing upstream of the flow-through cell. Samples collected for dissolved metals analyses will be filtered in the field with disposable, in-line filters. The filter lot number will be recorded on the log for each sampled well.

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. The low-level-mercury trip blank will be removed from the cooler during sampling at each location.

At each sampling location, all bottles designated for a particular analysis (including those for duplicate, triplicate, and matrix spike/matrix spike duplicate samples, if any) will be filled sequentially before bottles designated for the next analysis are filled. Care will be taken not to touch the tubing to the sample container during sample collection.

After the collection of the samples for laboratory analysis, water will be collected and analyzed for ferrous iron using a Hach colorimetric meter. The results will be recorded on the well purging and sampling log.

6.3.4 Field Quality Control Samples

To aid in evaluating the accuracy of the analytical data, sample blanks and duplicate/triplicate samples will be collected and subjected to the same analyses as project samples.

Three types of equipment banks will be collected: sample-collection equipment blanks, dissolved metals filter blanks, and DOC filter blanks, as described below:

- Sample-collection equipment blanks for total metals analysis (401) will be collected at a frequency of 5 percent of each set of newly installed dedicated pump assemblies from a single manufacturer, or a minimum of one equipment blank for each new dedicated equipment delivery. These equipment blanks will be collected by passing deionized water through the sample-collection equipment into a sample-collection bottle.
- Dissolved metals filter blanks (402) are collected at a frequency of once per filter lot per event for dissolved metals. The blank is prepared by collecting one-half liter of laboratory-provided deionized water that has been run through the filter prior to filling the sample bottle.
- DOC filter blanks (404) are collected at a frequency of once per filter lot per event for DOC. The filter is pre-rinsed with one liter of lab water and the rinsate is discarded. The blank is then prepared by collecting one-half liter of laboratory-provided deionized water that has passed through the filter prior to filling the sample bottle.

The 402 and 404 samples may use the same filter; however, the dissolved metals filter blank (402) should be prepared before the DOC filter blank (404). After collection of the 402 blank, another one-half liter of lab water must be filtered and discarded prior to filtering a portion for the 404 blank.

Deionized water blanks for total metals analysis (501) and for total organic carbon (TOC) analysis (502; supports DOC sampling) will be collected once per field sampling event.

The laboratory will provide the deionized water for filter and equipment blanks and deionized water blanks. The laboratory-designated lot number and date for deioinized water containers will be noted on the appropriate sample forms. Blanks will be analyzed along with the regular project samples.

Each team will carry one SGS Environmental Services, Inc., trip blank per cooler in the field during collection of primary and duplicate samples and one Columbia Analytical Services, Inc., trip blank per cooler during collection of triplicate samples. The trip blanks will be removed from the cooler and will be present during collection of samples. The trip blanks will follow the respective sample bottles wherever they go and will never be left in the field or sent back from the field independent of the samples.

Field duplicates and field triplicates will be collected at a frequency of 10 percent at the same time as the primary sample is collected.

The QA/QC samples to be collected are summarized in the QAPP (PLP, In press). The field-team leader will review the QAPP prior to field activities to ensure that the correct QA/QC samples are collected.

6.3.5 Sample Handling

Samples will be packed to prevent breakage and will be kept chilled in coolers with frozen gel-ice during field operations and transport. Samples and sample transfer forms will be delivered to the Shaw representative in Iliamna at the end of each day. Samples will be packed for shipment to the laboratories by the Shaw representative in Iliamna.

6.3.5.1 Sample Volumes, Container Types, and Preservation Requirements

Sample volumes, container types, and preservation requirements are described in the QAPP (PLP, In press). 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.

6.3.5.2 Sample Identification

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

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 identification code, analysis, and sampler's initials. The sample identification code will be formatted to indicate sample date (month and year), location, matrix, and sequential number.

The sample identification code will be entered by the sampler on the well purging and sampling log (Appendix A). An example of sample identification code is as follows:

0108P0637DWG001

Where:

0108 is the date as month/year

P0637D is the location identification

WG 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 equipment blanks (except filters). The number 402 represents an equipment blank specifically for the groundwater filter. The number 404 reflects a filter rinse associated with DOC sampling. The number 501 is used for deionized water blanks for metals analysis. The number 502 indicates an unfiltered deionized water blank for TOC analysis (supports DOC sampling). The number 601 will be used to designate trip blanks. If there is more than one trip blank, sequential numbers starting with 601 will be used.

The location for sample identifications ending in 401, 402, and 404 will be the well where the equipment-rinse blank was collected. Sample identifications ending in 501 and 502 (deionized water blanks) typically will reflect the location of the first sample collected that day. The location code for sample identifications ending in 601 (or other numbers in the 600 series) will indicate the laboratory that provided the blank: SGSA indicates SGS Environmental Services, Inc., and CASK indicates Columbia Analytical Services, Inc.

6.3.5.3 Sample Custody

Once collected, samples will remain within sight of the sampler or will be secured until the samples are signed over to the Shaw representative in Iliamna, who will be responsible for shipping the samples and for laboratory notifications. Chain-of-custody forms will be used for all samples and will be prepared by the Shaw representative in Iliamna.

Other chain-of-custody components, which SLR will provide, are copies of the field logbook, field sampling sheets, and the sample transfer log.

6.3.6 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. All equipment calibration will be done according to the instructions in the respective manufacturer's manual. Calibrations will be performed before each day's sampling. Calibration solutions will accompany the meter throughout the sampling day to allow recalibration at sampling locations, as necessary. Calibration for conductivity will be checked with standard calibration solution before sampling at each well array. Calibration for pH will be checked with standard calibration solution (pH 7) before sampling at each well. The meter will be recalibrated if the results of the calibration checks do not meet the following criteria:

- Plus or minus 0.10 for pH calibration solution.
- Plus or minus 10 percent for the conductivity calibration solution.

These standards of calibration follow applicable criteria such as those of the National Institute of Standards and Technology, ASTM standards, or other accepted procedures outlined in the manufacturer's handbook of specifications. Certification of calibration standards will be acquired from the vendor or manufacturer. All calibration activities will be documented on appropriate calibration logs (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.

6.3.7 Equipment Maintenance and Decontamination

Equipment will be maintained in good operating condition. Sampling equipment will be decontaminated as described below, except in a case where more minimal decontamination would be adequate, such as for the flow-through cell and water-quality meters where rinsing alone may be adequate during field operations. All nondisposable or nondedicated sample-collection equipment that comes into contact with a sample will be decontaminated as follows:

- Rinse in water.
- Double rinse in deionized water.

The purpose of the deionized water rinse is to remove all visible particulate matter and trace level contamination. Because groundwater sampling equipment and supplies are either precleaned and disposable (e.g., filters) or dedicated to the well (e.g., pumps and tubing), this decontamination procedure is generally necessary only for decontaminating new sample pumps prior to installation.

6.4 Installation of Pumping Wells

6.4.1 Well Design

Five-inch-ID pumping wells with 4-inch-ID screen will be installed for the pumping tests. Selection of pumping-well locations and design will be based on the information gained during installation of nearby piezometers. The locations and the depths will be selected in the field and approved by project personnel from SLR and WMC.

3. Install a barometric logger in a nearby piezometer simultaneously with installation of the first pressure transducer.
4. Measure the water level in the piezometers manually at regular intervals during the step test and pumping test to confirm the pressure-transducer readings and to relate the pressure-transducer data to surveyed elevations.
5. Conduct a step test in the pumping well by adjusting the submergence depth of the pipe used for injecting compressed air. Note the water-flow rate and air pressure at each step. The duration of the step test will be one to four hours.
6. Based on the results of the step test, choose a submergence depth for the pipe for the constant-rate test.
7. Monitor the recovery from the step test in the pumping well and piezometers.
8. Start the constant-rate pumping test at the chosen rate after the water levels have fully recovered.
9. Transmit the water-level data to WMC at the end of the first day.
10. Continue pumping 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 have passed.
11. After the pumping is terminated, monitor recovery for a minimum of 24 hours or until full recovery has occurred.

Information gathered during the pumping test will be recorded on field forms (Appendix A) and in the field logbook.

6.6 Installation of Westbay Multi-level Piezometers

One additional Westbay System will be installed in 2008.

6.6.1 Drilling

The drilling will include installation of a surface casing, drilling as far as possible with HQ-size coring equipment, and stepping down to complete the hole with NQ-size coring equipment, if necessary. The hole will be drilled with a wireline coring rig to the final depth; HQ drill size is preferred.

6.6.2 Well Design

WMC, with assistance from Westbay, will select appropriate bedrock zones to monitor. Locations of packers, measurement ports, and pumping ports will be selected following review of available geologic, geotechnical, and geophysical logs of the drillhole. The installation design will emphasize isolating zones that will define hydrostratigraphic conditions.

6.6.3 Well Construction

The installation will be carried out by the drilling contractor, with advice from Westbay. Assistance will be provided by Knight Piésold, WMC, and SLR.

The installation will generally include the following.

- The casing components will be laid out in order before being lowered into the hole.
- After completion of drilling, drilling fluid in the hole will be replaced with clean water.
- Drill rods will be removed, but N casing (HQ rods) will be left in the drillhole.
- The Westbay Model MP-38 components will be assembled and lowered into the drillhole. Each assembled joint will be pressure tested to reduce the potential for leakage.
- Water will be added to the Westbay casing as it is assembled to sink the Westbay casing string into the drillhole. As the length of the Westbay casing string increases, the string will need to be supported and the volume of water inside the MP-38 casing adjusted to meet design strength constraints.
- Pre-inflation pressures will be measured.
- Packers in the unlined portion (NQ drillhole) will be inflated from the bottom up using a packer inflation tool. N casing will be removed in sections so as to minimize standing time on unstable borehole sections prior to packer inflation.
- The tension of the MP-38 casing string will be adjusted during inflation to keep the casing straight, yet prevent unacceptable tensile loads from locking into the couplings.

Two pressure profiles will be completed following installation. Piezometric pressures at each measurement port for each profile will be measured with a down-hole probe. Pressures will be measured at each port for a sufficient period of time (up to 10 minutes) to verify that transient response to activation of the measurement port is complete.

6.7 Westbay System Testing, Sampling, and Pressure Profiles

In 2006 Westbay trained SLR personnel in the use of monitoring and testing tools to supplement the information provided in the operator's manuals supplied with the Westbay monitoring equipment. The equipment operating procedures for the Model 2532 MOSDAX Sampler Probe include step-by-step instructions for typical monitoring and testing tasks such as pressure-profile measurements, groundwater sample collection, and operation of the Model 0706 Hydraulic Pumping Port. As necessary, special procedures will be developed, through consultation among SLR, WMC, and Westbay, for the performance and documentation of other tasks as described below. SLR will be responsible for monitoring and testing.

6.7.1 Hydraulic Testing

Screening-level hydraulic conductivity testing (pulse tests) will be completed for all 50 measurement ports in all Westbay System holes. The tests will be carried out by parking the down-hole tool at each

port, allowing pressure stabilization while adjusting the water level inside the MP-38 casing, allowing flow from the monitored interval into the casing, and then measuring the pressure recovery to the flow test. Those zones where the test response is constrained by the head drop across the measurement port will be identified.

Zones for well testing through pumping ports (pumping tests) will be selected based on pressure profiles and the screening-level hydraulic conductivity testing. When a pumping port is opened, the Westbay casing acts as a conventional monitoring well. First, the water level inside the MP-38 casing will be drawn down several meters below the piezometric level in the test zone. A high-capacity Waterra pump will be used to draw the water level down. The opening tool will then be lowered to the opening location, and the port will be opened. The water-level recovery inside the MP-38 casing will be monitored until it is stable or for 20 minutes. The probe will then be removed from the hole, reconfigured, and redeployed for closing. The port will then be closed, and the next test will start. A suitable record of the testing will be created according to the agreed test procedure. The record will include a paper record for each test, plus datalogging of pressure responses using a MAGI datalogger controller unit and a computer.

6.7.2 Groundwater Sampling from Westbay System

Groundwater samples will be collected from the Westbay Systems from measurement ports installed within relatively permeable zones. Preliminary sampling will be limited to documentation of field parameters (conductivity and pH), as follows:

1. The sample bottle will be rinsed with deionized water as a decontamination step.
2. The sampling equipment will be deployed and operated as described in the system operator's manual (Schlumberger, n.d.).
3. The retrieved sample will be extracted, and the conductivity and pH will be measured.

This initial sampling round is expected to provide the information required to integrate the Westbay sampling with the remainder of the sampling program. Groundwater samples will be collected from selected measurement ports coincidently with other groundwater sampling events. Protocols for collection of samples from the Westbay Systems will be developed by SLR following installation and initial testing.

6.7.3 Piezometric Pressure Profiles from Westbay System

6.7.3.1 Monthly Profiles

A piezometric pressure profile will be completed at the end of the initial testing and monthly coincidently with water-level monitoring of piezometers and monitoring wells. The Westbay equipment will be deployed and operated as described in the system operator's manual (Schlumberger, n.d.).

6.7.3.2 Continuous Profile

Continuous datalogging for one or more months at selected ports is planned for 2008. This will provide several weeks of data that can be analyzed for barometric and earth-tide effects, allowing further assessment of the interconnectivity of the monitoring zones and transmissivity. If any drilling is occurring nearby, hydraulic responses can be used for later scoping of a pumping test.

7. Record Keeping

Field observations, field-equipment calibration information, field measurements, and sample documentation—including sample identifications, 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, the records 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 (loose-leaf field forms, described in Section 7.2, are also used). The field logbook will be bound. All field notes will be entered in indelible ink or pencil. 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 conditions, field instrument readings).
- Number and type of samples collected and sample identification numbers.
- Sample locations.
- 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:

- Drilling Boring Log.

- Well Completion Diagram.
- Well Development Log.
- Sample Transfer Log.
- Well Purging and Sampling Field Control Log.
- Water Level Measurement Log.
- Calibration Log.
- Pumping Test Pumping Well Log.
- Pumping Test Observation Well Log.
- Response Test Log.
- Transducer Control Log.
- Westbay Field Data and Calculation Sheet.

Examples of the field forms are provided 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. 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 a sampling station.

Strict chain-of-custody 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 forms 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 or pencil. No documents necessary for accountability—original notes of field observations or conditions, including field logbooks 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 accountability 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 accountability 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 a 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 also will identify additional measures, if any, that may be taken to improve data collection.

WMC personnel will be present for the following activities:

- Initial siting of drillholes.
- Drilling and installation of the first monitoring well or piezometer.

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

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

———. 1996. Method D 4044-96, Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers.

Pebble Limited Partnership (PLP). In press. Environmental Baseline Studies, 2008 Quality Assurance Project Plan.

Schlumberger Water Services (Schlumberger). n.d. Westbay System Operator Training Manual, Pressure Profile, Sampling, Purging.

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

TABLE

TABLE 1
Existing Well Locations and Data To Be Collected

Drillhole	Alaska State Plane Zone 5 NAD83 (ft) X	Y	Monthly Water Levels	Quarterly Water Sampling	Notes
GH04-01	1386180	2171584			Not currently monitored
GH04-02	1405882	2170918	X		
GH04-03	1400583	2125932			Not currently monitored
GH04-04	1383250	2123686			Not currently monitored
GH04-05	1365296	2121512	X		
GH04-06	1402986	2146959	X		
GH04-08	1373556	2149963	X		
GH04-10	1395412	2123101			Not currently monitored
GH04-11	1406017	2128321			Not currently monitored
GH04-12A	1393590	2122286	X		
GH04-13	1392021	2117580			Not currently monitored
GH04-14	1382419	2121520	X		
GH04-16	1381837	2125117	X		
GH04-17	1381594	2126017	X		
GH04-18	1382120	2126850	X		
GH04-19	1377773	2133668	X		
GH04-20	1380421	2135284	X		
GH04-22	1382100	2136338	X		
GH04-23	1381015	2164417	X		
GH04-25	1383712	2163357	X		
GH04-26	1396246	2158941			Not currently monitored
GH04-27	1395818	2157549	X		
GH04-28	1398091	2137379	X		
GH04-29A	1399086	2135590			Not currently monitored
GH04-30	1394724	2132937	X		
GH04-31	1400682	2133911			Not currently monitored
GH04-32	1401402	2132207			Not currently monitored
GH04-33	1399309	2129087	X		
GH04-35	1397715	2126742	X		
GH04-37	1389715	2119791	X		
GH04-38	1386308	2120503	X		
GH04-39	1389233	2122703			Not currently monitored
GH04-41	1405013	2133609			Not currently monitored
GH04-42	1404563	2135111			Not currently monitored
GH04-43	1405221	2137825	X		
GH04-44	1402137	2138681			Not currently monitored
GH04-45A	1399997	2139335	X		
GH04-46	1406716	2145777	X		
GH04-47	1404802	2147359	X		
GH04-48	1399489	2147095	X		
GH05-51	1399173	2133996			Not currently monitored
GH05-52	1399789	2136767			Not currently monitored
GH05-53	1414414	2144518	X		
GH05-54	1412983	2147460			Not currently monitored
GH05-55	1395553	2144993			Not currently monitored
GH05-56	1398947	2148042			Not currently monitored
GH05-57	1396013	2160439	X		
GH05-58	1395457	2156534	X		
GH05-59	1399206	2152099	X		
GH05-60	1400785	2150474	X		
GH05-61	1402486	2148724	X		
GH05-63	1406997	2148517	X		
GH05-64	1410178	2152866	X		
GH06-65	1372647	2149020	X		
GH06-66	1376039	2163510	X		
GH06-67	1379185	2163945	X		

Drillhole	Alaska State Plane Zone 5 NAD83 (ft) X	Y	Monthly Water Levels	Quarterly Water Sampling	Notes
GH06-68	1380641	2162370	X		
GH06-69	1384085	2160944	X		
GH06-70D	1400211	2147906	X		
GH06-70S	1400211	2147906	X		
GH06-71	1401484	2147080			Not currently monitored
GH06-71A	1401454	2147087	X		
GH06-72	1403789	2147129	X		
GH06-73	1406063	2146876			Not currently monitored
GH06-74	1407904	2147514	X		
GH06-75	1400526	2136598	X		
GH06-76	1401319	2135578	X		
GH06-77	1400130	2135459	X		
GH06-78	1409794	2155947			Not currently monitored
GH06-79	1410562	2155394			Not currently monitored
GH06-80	1406799	2154864	X		
GH07-81	1382565	2161333	X		
GH07-82D	1379582	2162942	X		
GH07-82S	1379582	2162942	X		
GH07-83D	1374823	2163510	X		
GH07-83S	1374823	2163510	X		
GH07-84	1375761	2164988	X		
GH07-85	1377731	2163904	X		
GH07-86	1372867	2161121	X		
GH07-87D	1372352	2159296	X		
GH07-87S	1372352	2159296	X		
GH07-88	1372729	2162437	X		
GH07-89D	1367909	2153619	X		
GH07-89S	1367909	2153619	X		
GH07-90D	1367771	2151061	X		
GH07-90S	1367771	2151061	X		
GH07-91	1368764	2149767	X		
GH07-92D	1370764	2149447	X		
GH07-92S	1370764	2149447	X		
GH07-93	1373639	2149129	X		
GH07-94	1374742	2148733	X		
GH07-95	1379809	2155440	X		
GH07-96D	1381751	2156211	X		
GH07-96S	1381751	2156211	X		
GH07-97D	1382607	2154726	X		
GH07-97S	1382607	2154726	X		
GH07-98D	1384911	2152902	X		
GH07-98S	1384911	2152902	X		
GH07-99	1385450	2154210	X		
GH07-100	1384517	2151718	X		
GH07-101	1387532	2166749	X		
GH07-102D	1383762	2168707	X		
GH07-102S	1383762	2168707	X		
GH07-103D	1386315	2165174	X		
GH07-103S	1386315	2165174	X		
GH07-104	1408701	2153137	X		
GH07-105	1406896	2152552	X		
GH07-106	1406499	2150671	X		
I-125	1404406	2155932	X		
I-172	1403968	2159322	X		
I-192	1404947	2158375	X		
I-201	1405666	2157739	X		
KP-P1/SRK-2	1406189	2159582	X	X	
KP-P3D /SRK-5D	1401943	2154181	X	X	

Drillhole	Alaska State Plane Zone 5 NAD83 (ft) X	Y	Monthly Water Levels	Quarterly Water Sampling	Notes
KP-P3M /SRK-5M	1401952	2154193	X	X	
KP-P3S /SRK-5S	1401973	2154169	X	X	
KP-P4	1406224	2155592	X	X	
M-110	1402420	2159036	X		
M-12	1400378	2157544	X		
M-21	1400693	2157582	X		
M-62	1401233	2158729	X		
MW-1D	1378226	2124912	X	X	
MW-1M	1378238	2124905	X	X	
MW-1S	1378207	2124919	X	X	
MW-2D	1399455	2121671	X	X	
MW-05-2M	1399438	2121667	X		Not sampled
MW-2S	1399461	2121654	X		Not sampled
MW-05-2SR	1399446	2121654	X		Not sampled
MW-3D	1400178	2136063	X	X	
MW-4	1407534	2158182			Not currently monitored
MW-5D	1403274	2149287	X	X	
MW-5M	1403292	2149284	X	X	
MW-5S	1403287	2149303	X	X	
MW-6D	1382244	2168254	X	X	
MW-7D	1373318	2150204	X	X	
MW-7S	1373299	2150209	X	X	
MW-8D	1400007	2172701	X	X	
MW-8M	1399993	2172687	X	X	
MW-8S	1399990	2172705	X	X	
MW-9D	1373502	2150022	X	X	
MW-10	1382989	2165426	X	X	
MW-11D	1398344	2126290	X	X	
MW-11M	1398338	2126303	X	X	
MW-11S	1398335	2126319	X	X	
MW-05-11SS	1398358	2126297	X	X	
MW-05-12D	1399176	2155571	X	X	
MW-05-12S	1399196	2155584	X	X	
MW-05-13D	1376783	2127181	X	X	
MW-05-13S	1376800	2127166	X	X	
MW-05-14D	1405521	2131540	X	X	
MW-05-14S	1405504	2131550	X	X	
P-2D	1402466	2154026	X		
P-2M	1402464	2154048	X		
P-3	1403275	2154762	X		
P-4AD	1405205	2155654	X		
P-4AS	1405222	2155638	X	X	
P-4Mid	1405023	2155082			Not currently monitored
P-6D	1405474	2155849	X		
P-6M	1405474	2155835	X		
P-6S	1405490	2155839	X		
P-05-07D	1397004	2154758	X		
P-05-07S	1397026	2154737	X		
P-05-08	1397921	2157152	X		
P-05-09D	1406042	2158727	X		
P-05-09S	1406042	2158727	X		
P-05-10D	1387052	2125582	X		
P-05-10S	1387029	2125596	X		
P-05-11D	1392613	2124160	X		
P-05-11M	1392628	2124149	X		
P-05-11S	1392612	2124148	X		
P-05-12	1389593	2127784	X		
P-05-13	1391482	2130681	X		

Drillhole	Alaska State Plane Zone 5 NAD83 (ft) X	Y	Monthly Water Levels	Quarterly Water Sampling	Notes
P-05-14D	1395412	2130750	X		
P-05-14S	1395392	2130774	X		
P-05-15D	1394031	2127495	X		
P-05-15S	1394025	2127476	X		
P-05-16D	1395663	2120883	X		
P-05-16M	1395682	2120877	X		
P-05-16S	1395666	2120862	X		
P-05-16SS	1395646	2120869	X		
P-05-17D	1395677	2124064	X		
P-05-17S	1395670	2124025	X		
P-05-18	1397983	2124460	X		
P-05-19M	1401988	2123990	X		
P-05-19S	1402019	2123966	X		
P-05-20D	1405011	2145705	X		
P-05-20S	1405014	2145729	X		
P-05-21D	1402602	2145774	X		
P-05-21M	1402612	2145797	X		
P-05-21S	1402618	2145817	X		
P-05-22D	1402870	2142370	X		
P-05-23	1399577	2131334	X		
P-05-24D	1403035	2128064	X		
P-05-24S	1403045	2128089	X		
P-05-25	1405576	2131539	X		
P-05-26D	1399728	2135000	X		
P-05-26M	1399711	2135007	X		
P-05-26S	1399728	2134986	X		
P-05-27D	1399814	2123738	X		
P-05-27M	1399828	2123724	X		
P-05-27S	1399815	2123723	X		
P-05-28D	1410047	2153654	X		
P-05-28S	1410032	2153663	X		
P-05-29D	1406635	2154704	X		
P-05-29D2	1406663	2154697	X		
P-05-29M	1406677	2154712	X		
P-05-29S	1406639	2154722	X		
P-05-30D	1406448	2161592	X		
P-05-30S	1406458	2161605	X		
P-05-31D	1408341	2160140	X		
P-05-31S	1408355	2160159	X		
P-05-32D	1409691	2159074	X		
P-05-33D	1411248	2159456	X		
P-05-34D	1409831	2160495			Not currently monitored
P-05-35D	1407882	2162627	X		
P-05-36D	1405756	2157046	X		
P-05-36M	1405765	2157031	X		
P-05-36S	1405747	2157061	X		
P-06-37D	1409444	2163540	X	X	
P-06-37M	1409436	2163524	X	X	
P-06-37S	1409431	2163508	X	X	
P-06-38D	1406578	2166680	X	X	
P-06-38M	1406562	2166691	X	X	May be removed from the sample list
P-06-39D	1412117	2160792	X		
P-06-39S	1412125	2160810	X		
P-06-40D	1412908	2158572	X		
P-06-40M	1412942	2158593	X		
P-06-40S	1412926	2158585	X		
P-06-41D	1420118	2160961	X		
P-06-41M	1420136	2160971	X		

Drillhole	Alaska State Plane Zone 5 NAD83 (ft) X	Y	Monthly Water Levels	Quarterly Water Sampling	Notes
P-06-41S	1420151	2160983	X		
P-07-42D	1404363	2171817	X		
P-07-42S	1404364	2171795	X		
P-07-43D	1408689	2171790	X		
P-07-43M	1408706	2171783	X		
P-07-43S	1408701	2171767	X		
P-07-44D	1411817	2174231	X		
P-07-44S	1411807	2174242	X		
P-07-45D	1418782	2169420	X		
P-07-46D	1419003	2163586	X		
P-07-47D	1418171	2158453	X		
P-07-48D	1380043	2172841	X		
P-07-48S	1380029	2172825	X		
P-07-49D	1384394	2167007	X		
P-07-49S	1384409	2167025	X		
P-07-50D	1379658	2171915	X		
P-07-50S	1379684	2171909	X		
P-07-50SS	1379683	2171931	X		
P-07-51D	1372609	2162375	X		
P-07-51S	1372627	2162387	X		
P-07-52D	1367487	2153681	X		
P-07-52S	1367475	2153676	X		
P-07-53D	1379645	2171900	X		
P-07-53S	1379651	2171885	X		
PQ-4 (4270M)	1401056	2157430	X	X	
PQ-8	1402895	2157343	X		
PQ-9	1400938	2156539	X		
SRK-1A	1403453	2161276	X		
SRK-2 (AKA 4251)	1406189	2159581	X		
SRK-2A	1406175	2159587	X		
SRK-3 (AKA 4250)	1406854	2158115	X	X	
WL-P01D	1399220	2154559	X		
WL-P01S	1399205	2154539	X		
WL-P02D	1399639	2154297	X		
WL-P02S	1399639	2154297	X		
WL-P03D	1400199	2153981	X		
WL-P03S	1400209	2153991	X		
WL-P04D	1400399	2133809	X		
WL-P04S	1400405	2133809	X		
WL-P05D	1400110	2134434	X		
WL-P05S	1400120	2134424	X		
WL-P06D	1399786	2134857	X		
WL-P06S	1399786	2134857	X		
WL-P07D	1399781	2123179	X		
WL-P07S	1399776	2123169	X		
WL-P08D	1400183	2123303	X		
WL-P08S	1400178	2123313	X		
WL-P09D	1400682	2122948	X		
WL-P09S	1400684	2122796	X		
WL-P10D	1401268	2122804	X		
WL-P10S	1401253	2122815	X		
WL-P11D	1401561	2122636	X		
WL-P11S	1401561	2122626	X		
WL-P15D	N/A	N/A	X		
WL-P15G (NF3G)	N/A	N/A	X		
WL-P15S	N/A	N/A	X		
WL-P16D	N/A	N/A	X		
WL-P16G (NF2G)	N/A	N/A	X		

Drillhole	Alaska State Plane Zone 5 NAD83 (ft) X	Y	Monthly Water Levels	Quarterly Water Sampling	Notes
WL-P16S	N/A	N/A	X		
WL-P17D	N/A	N/A	X		
WL-P17S	N/A	N/A	X		
WL-P18D	N/A	N/A	X		
WL-P18G (NF1G)	N/A	N/A	X		
WL-P18S	N/A	N/A	X		
WL-P19D	N/A	N/A	X		
WL-P19S	N/A	N/A	X		
WL-P20D	N/A	N/A	X		
WL-P20G (UTM2G)	N/A	N/A	X		
WL-P20S	N/A	N/A	X		
WL-P21D	N/A	N/A	X		
WL-P21G (UTM1G)	N/A	N/A	X		
WL-P21S	N/A	N/A	X		
WL-P22D	N/A	N/A	X		
WL-P22S	N/A	N/A	X		
WL-P23D	N/A	N/A	X		
WL-P23S	N/A	N/A	X		
WL-P24D	N/A	N/A	X		
WL-P24S	N/A	N/A	X		
WL-P25D	N/A	N/A	X		
WL-P25S	N/A	N/A	X		
WL-P26D	N/A	N/A	X		
WL-P26S	N/A	N/A	X		
WL-S01D	1400052	2154319	X		
WL-S01G	1400052	2154319	X		
WL-S01S	1400047	2154319	X		
WL-S02D	1399555	2154461	X		
WL-S02G	1399555	2154461	X		
WL-S02S	1399555	2154461	X		
WL-S03D	1399910	2134672	X		
WL-S03G	1399910	2134672	X		
WL-S03S	1399905	2134662	X		
WL-S04D	1400143	2134281	X		
WL-S04G	1400143	2134281	X		
WL-S04S	1400158	2134281	X		
WL-S05D	1400000	2123104	X		
WL-S05G	1400000	2123104	X		
WL-S05S	1399995	2123114	X		
WL-S06D	1400153	2123090	X		
WL-S06G	1400153	2123090	X		
WL-S06S	1400183	2123080	X		
WL-S07D	1401401	2122792	X		
WL-S07G	1401401	2122792	X		
WL-S07S	1401400	2122761	X		

Notes:

D = deep (typically 150 to 200 feet deep)
G = staff gauge, stage (feet)
GH = geotechnical hole
I = piezometer
KP/SRK = piezometer/monitoring well
M (following a number) = medium depth (typically 70 to 100 feet deep)
M (followed by number) = piezometer
MW = monitoring well
N/A = not available at this time
P = piezometer
PQ = piezometer/monitoring well
PW = pumping well
S = shallow depth (typically 30 to 50 feet deep)
SS = super shallow depth (typically <30 feet deep)
WL = wetlands location

FIGURES

155°30'0"W 155°24'0"W 155°18'0"W 155°12'0"W

59°54'0"N 59°51'0"N 59°48'0"N

North Fork Koktuli River

South Fork Koktuli River

Upper Talarik Creek

P-07-48 (S-D) P-07-53 (S-D) P-07-50 (S-D) GH04-01 MW-6D GH07-102 (S-D) P-07-49 (S-D) GH07-101 MW-10 GH07-103 (S-D) GH04-23 GH07-84 GH07-85 GH07-83 (S-D) GH06-66 GH06-67 GH04-25 P-07-51 (S-D) GH07-88 GH07-82 (S-D) GH06-68 GH07-81 GH07-86 GH06-69 GH07-87 (S-D) GH07-96 (S-D) GH07-95 GH07-97 (S-D) GH07-99 GH07-98 (S-D) GH07-100 P-07-52 (S-D) GH07-89 (S-D) GH07-90 (S-D) GH07-91 MW-7 (S-D) MW-9D GH07-93 GH04-08 GH07-92 (S-D) GH06-65 GH07-94 MW-8 (S-M-D) P-07-42 (S-D) P-07-44 (S-D) P-07-43 (S-M-D) GH04-02 P-07-45D P-06-38 (M-D) P-05-30 (S-D) SRK-2A P-05-35D SRK-2 4251 SRK-2 KP-P1 SRK-3 P-06-37 (S-M-D) P-07-46D P-05-09 (S-D) SRK-1A P-05-31 (S-D) P-05-34D M-110 I-172 P-05-32D P-06-41 (S-M-D) M-62 GH05-57 P-06-39 (S-D) GH04-26 PQ-4 P-05-33D P-05-08 M-21 MW-4 P-07-47D GH04-27 M-12 I-192 P-06-40 (S-M-D) GH05-58 I-201 P-05-36 (S-M-D) P-6 (S-M-D) PQ-9 PQ-8 KP-P4 GH06-78 MW-05-12 (S-D) GH06-79 P-05-07 (S-D) I-125 GH06-80 WL-P01S P-3 P-05-28S WL-S02 (G-S-D) P-2 (M-D) GH05-64 WL-P02D GH07-105 GH07-104 WL-S01D GH05-60 GH07-106 P-05-29 (S-M) GH05-59 SRK-5 (S-M-D) P-05-29D2 WL-P03S MW-5 (S-M-D) GH05-63 P-4A (S-D) GH05-56 GH06-70 (S-D) GH06-74 GH05-54 GH04-48 GH06-71A GH06-73 GH06-71 GH04-46 GH05-55 GH05-61 GH04-47 GH05-53 GH06-72 P-05-22D GH04-06 P-05-20 (S-D) P-05-21 (S-M-D) GH04-45A GH04-44 GH05-52 GH04-43 GH04-28 GH06-75 GH04-29A MW-3D P-05-26S GH06-77 GH04-22 WL-P06 (S-D) GH06-76 GH04-42 GH04-20 WL-P05 (S-D) GH04-41 GH05-51 GH04-19 GH04-30 WL-S04 (G-S-D) GH04-31 MW-05-14 (S-D) WL-P04 (S-D) GH04-32 P-05-13 P-05-14 (S-D) P-05-25 P-05-23 GH04-33 GH04-11 P-05-12 MW-05-13 (S-D) P-05-15 (S-D) P-05-24 (S-D) GH04-18 GH04-35 GH04-03 GH04-17 MW-05-11 (SS-S-M-D) P-05-27 (S-D-M) P-05-10 (S-D) GH04-16 P-05-17 (S-D) P-05-18 P-05-19 (S-D) P-05-11 (S-M-D) GH04-04 WL-P07 (S-D) WL-P08 (S-D) MW-1 (S-M-D) GH04-39 GH04-10 GH04-14 WL-S05 (G-S-D) GH04-05 GH04-12A WL-S07 (G-S-D) GH04-38 WL-P11 (S-D) GH04-37 P-05-16 (SS-S-M-D) MW-05-2M MW-05-2SR MW-2 (S-D) WL-P09 (S-D) GH04-13

THE pebble PARTNERSHIP

Figure 1, 2008 Field Sampling Plan, Groundwater Studies, Existing Wells and Piezometers for 2008 Data Collection

DRAFT

Legend

- General Deposit Location
- Monitoring Well
- Geotechnical Hole
- Exploration Hole with Piezometer
- Piezometer
- Wetland Piezometer



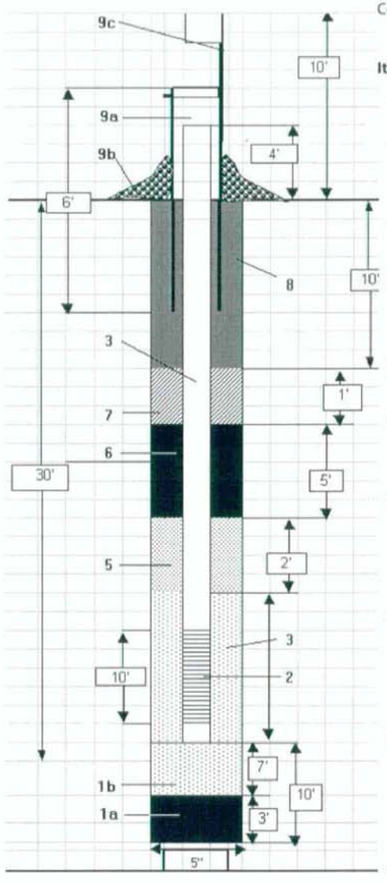
0 0.5 1 1.5 2 2.5 Miles

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

RDI_SLR_2008_Water_Level_Locs_11x17_1of1_D01.mxd	Date: April 8, 2008
Version: 1	Author: RDI- MRA, LS

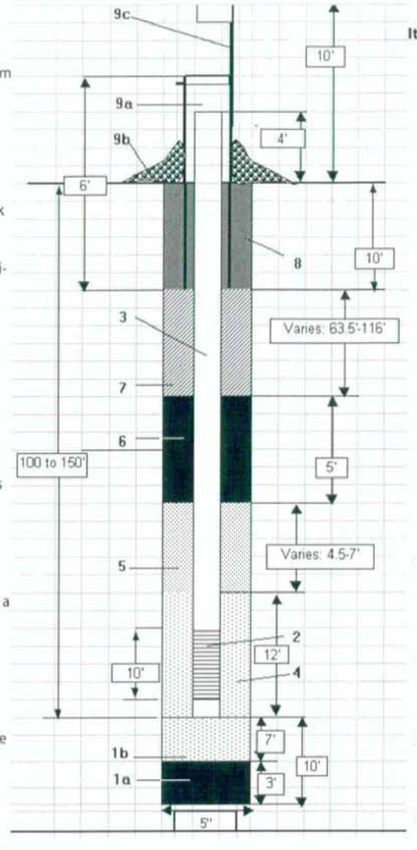
SHALLOW WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

Item	Description	Specifiction/Type
1	Rathole backfill	PureGold medium bentonite chips, placed as a 3-foot plug from bottom of hole
1	a) Type of Plug	CSSI 10-20 silica sand, placed to least 3 feet above rathole bentonite plug
1	b) Type of transition sand	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.
2	Type/slot size of screen	2-inch/Schedule 80, flush-joint threaded, PVC pipe with O-rings
3	Dia./type of riser well casing	CSSI 10-20 silica sand, placed to least 2 feet above top of screen before casing is pulled.
4	Type screen filter pack	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)
5	Type of transition sand	PureGold medium bentonite chips, (where possible) placed as a 5-foot plug above the transition sand to seal the annulus within aquitards.
6	Type of 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.
7	Type seal overlying plug	10 lbs PureGold bentonite grout to 100 lbs Portland cement to 10 gallons water for top 10 feet.
8	Type near-surface completion	
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

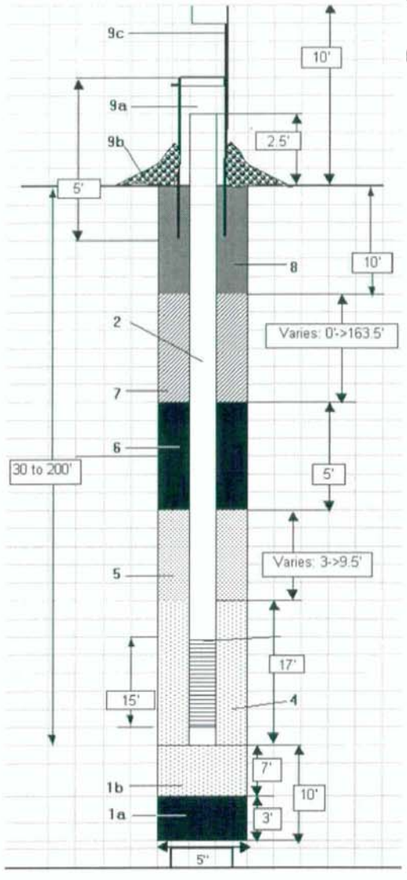
INTERMEDIATE (100 to 150 ft.) WELL and PIEZOMETER CONSTRUCTION



Construction (Bottom Up)

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

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



Construction (Bottom Up)

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

E042004004ANC WellDepths.ai 07/08/04 cts

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 2
Groundwater Monitoring Well Construction Details

APPENDICES

APPENDIX A

Field Forms

SLR
4601 Business Park Boulevard,
Suite K42
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

DRILLING BORING LOG

Sheet ____ of ____

Boring/Well Number: _____

Client:	Project:	
Site Name:	Boring Total Depth (feet):	
SLR Project #	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:

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

Comments:

SLR
4601 Business Park Boulevard,
Suite K42
Anchorage, Alaska 99503
office: (907) 222-1112
fax: (907) 222-1113

DRILLING BORING LOG **Sheet ____ of ____**

Boring/Well Number: _____

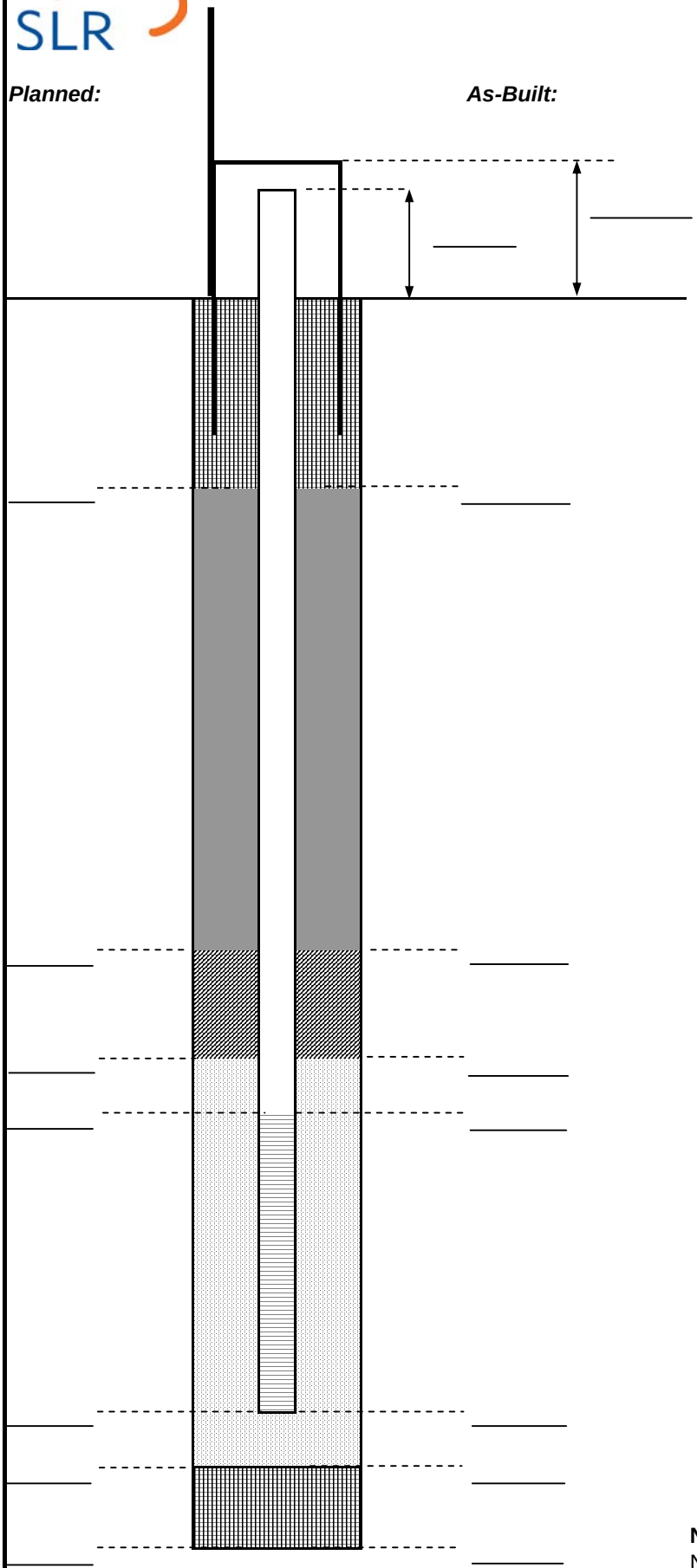
DEPTH (FEET)	SAMPLE	TIME	FLOW TEST	SOIL DESCRIPTION	DRILLERS COMMENTS
6					
7					
8					
9					
0					
1					
2					
3					
4					
5					

Comments:

WELL COMPLETION DIAGRAM

SLR

Planned: ***As-Built:***



WELL ID: _____

Date: _____
Logger: _____

Installation time
Start: _____
Finish: _____

Stickup
before pulling casing: _____
after pulling casing: _____

PVC Casing
type: _____
diameter: _____
lengths: _____
_____
_____

Screen
type: _____
slot size: _____
length: _____

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: _____

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

WELL DEVELOPMENT LOG

Well ID: _____
Date: _____

Project: _____

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)	Sp Cond (mS/cm)	Turbidity (NTU)	Temp (deg C)	Sediment (grain size, color, quantity)
Surge block on								
Surge block off								

SLR

Pebble Project Sample Transfer Log:

TB (if applicable)	Collection Date	Time	Sample Identification (MMYYlocation)	Matrix	QA/QC	species (if applicable)	#container	MS / MSD?	Relinquished By	Date	Time	Received By	Date	Time

Comments:

WELL PURGING AND SAMPLING FIELD CONTROL LOG

Date: _____ **Well ID:** _____

Project: _____ **Project #** _____

Samplers: _____

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: _____

Filter Lot Number: _____

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: _____

See Calibration log for Calibration Lot Numbers

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

Bottle Inventory:		AS1	AS2	AS5		AS6	AS3	AS4	AS7
	Hg (NF, F)	Metals	Metals (F)	TSS	TDS+	Anions	Cn	P, Am, N	Thiocyanate
	HCl	HNO_3	HNO_3	--	--	--	NaOH	H_2SO_4	HNO_3
SGS Volume:	2 x 500mL	1 x 500mL	1 x 500mL	1 x 1L	1 x 1L	1 x 120mL	1 x 250mL	1 X 500mL	1 X 250mL
MS/MSD Volume:	no	extra	extra	extra	extra	extra	no	no	no
CAS Volume:	2 x 500mL	1 x 1L	1 x 1L	1 x 1L		no	1 x 1L	1 x 1L	(same as metals)
Sample Order:	1	2	3	4	5	6	7	8	9
Bottle Count:	____	____	____	____	____	____	____	____	____

Casing Diameter (inches)	Schedule 40 (gal/ft casing)	Schedule 40 (liters /ft casing)	Schedule 80 (gal/ft casing)	Schedule 80 (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										

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
GH04-02		FTOC		FTOC						
GH04-05		FTOC		FTOC						
GH04-06		FTOC		FTOC						
GH04-08		--		--						
GH04-12A		FTOC		FTOC						
GH04-14		FTOC		FTOC						
GH04-16		--		--						
GH04-17		FTOC		FTOC						
GH04-18		FTOC		FTOC						
GH04-19		FTOC		FTOC						
GH04-20		--		--						
GH04-22		FTOC		FTOC						
GH04-23		FTOC		FTOC						
GH04-25		FTOC		FTOC						
GH04-27		FTOC		FTOC						
GH04-28		FTOC		FTOC						
GH04-30		FTOC		FTOC						
GH04-33		FTOC		FTOC						
GH04-35		FTOC		FTOC						
GH04-37		FTOC		FTOC						
GH04-38		FTOC		FTOC						
GH04-43		FTOC		FTOC						
GH04-45A		FTOC		FTOC						
GH04-46		FTOC		FTOC						
GH04-47		FTOC		FTOC						
GH04-48		FTOC		FTOC						
I-125		--		--						
I-172		FTOC		FTOC						
I-192		--		--						
I-201		FTOC		FTOC						
KP-P1 / SRK-2		FTOP		FTOP						
KP-P3D / SRK-5D		--		--						
KP-P3M / SRK-5M		FTOP		FTOP						
KP-P3S / SRK 5S		FTOP		FTOP						
KP-P4		FTOP		FTOP						

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

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter

Make: _____
Model: _____
Cutoff: _____
Units: _____
Res: _____

Project: _____
Project #: _____
Logger: _____

Date start _____
Date finish _____

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
M-110		FTOC		FTOC						
M-12		FTOC		FTOC						
M-21		FTOC		FTOC						
M-62		FTOC		FTOC						
MW-1D		FTOP		FTOP						
MW-1M		FTOP		FTOP						
MW-1S		FTOP		FTOP						
MW-2D		FTOP		FTOP						
MW-05-2M		FTOC		FTOC						
MW-2S		FTOP		FTOP						
MW-05-2SR		FTOC		FTOC						
MW-3D		FTOC		FTOC						
MW-5D		FTOP		FTOP						
MW-5M		FTOP		FTOP						
MW-5S		FTOP		FTOP						
MW-6D		FTOP		FTOP						
MW-7D		FTOP		FTOP						
MW-7S		FTOP		FTOP						
MW-8D		FTOP		FTOP						
MW-8M		FTOP		FTOP						
MW-8S		FTOP		FTOP						
MW-9D		--		--						
MW-10		FTOP		FTOP						
MW-11D		FTOP		FTOP						
MW-11M		FTOP		FTOP						
MW-11S		FTOP		FTOP						
MW-05-11SS		FTOP		FTOP						
MW-05-12D		FTOP		FTOP						
MW-05-12S		FTOP		FTOP						
MW-05-13D		FTOC		FTOC						
MW-05-13S		FTOC		FTOC						
MW-05-14D		FTOP		FTOP						
MW-05-14S		FTOP		FTOP						
P-2D		FTOC		FTOC						
P-2M		FTOC		FTOC						
P-3		FTOC		FTOC						
P-4AD		FTOC		FTOC						
P-4AS		FTOP		FTOP						

ABBREVIATIONS:

FTOC - from top of casing
FTOP - from top of sample port
FAS - frozen at surface

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
P-6D		FTOC		FTOC						
P-6M		FTOC		FTOC						
P-6S		FTOC		FTOC						
P-05-07D		FTOC		FTOC						
P-05-07S		FTOC		FTOC						
P-05-08		FTOC		FTOC						
P-05-09D		FTOC		FTOC						
P-05-09S		FTOC		FTOC						
P-05-10D		FTOC		FTOC						
P-05-10S		FTOC		FTOC						
P-05-11D		FTOC		FTOC						
P-05-11M		FTOC		FTOC						
P-05-11S		FTOC		FTOC						
P-05-12		FTOC		FTOC						
P-05-13		FTOC		FTOC						
P-05-14D		FTOC		FTOC						
P-05-14S		FTOC		FTOC						
P-05-15D		FTOC		FTOC						
P-05-15S		FTOC		FTOC						
P-05-16D		FTOC		FTOC						
P-05-16M		FTOC		FTOC						
P-05-16S		FTOC		FTOC						
P-05-16SS		FTOC		FTOC						
P-05-17D		FTOC		FTOC						
P-05-17S		FTOC		FTOC						
P-05-19M		FTOC		FTOC						
P-05-19S		FTOC		FTOC						
P-05-20D		--		--						
P-05-20S		FTOC		FTOC						
P-05-21D		--		--						
P-05-21M		--		--						
P-05-21S		FTOC		FTOC						
P-05-22D		FTOC		FTOC						
P-05-23		FTOC		FTOC						
P-05-24D		FTOC		FTOC						
P-05-24S		FTOC		FTOC						
P-05-25		FTOC		FTOC						
P-05-18		FTOC		FTOC						

ABBREVIATIONS:
FTOC - from top of casing
FTOP - from top of sample port
FAS - frozen at surface

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
P-05-26D		FTOC		FTOC						
P-05-26M		FTOC		FTOC						
P-05-26S		FTOC		FTOC						
P-05-27D		FTOC		FTOC						
P-05-27M		FTOC		FTOC						
P-05-27S		FTOC		FTOC						
P-05-28D		FTOC		FTOC						
P-05-28S		FTOC		FTOC						
P-05-29D		FTOC		FTOC						
P-05-29D2		FTOC		FTOC						
P-05-29M		FTOC		FTOC						
P-05-29S		FTOC		FTOC						
P-05-30D		FTOC		FTOC						
P-05-30S		FTOC		FTOC						
P-05-31D		FTOC		FTOC						
P-05-31S		FTOC		FTOC						
P-05-32D		FTOC		FTOC						
P-05-33D		FTOC		FTOC						
P-05-35D		FTOC		FTOC						
P-05-36D		FTOC		FTOC						
P-05-36S		FTOC		FTOC						
P-06-37D		--		--						
P-06-37M		FTOP		FTOP						
P-06-37S		FTOP		FTOP						
P-06-38D		FTOC		FTOC						
P-06-38M		FTOC		FTOC						
P-06-39D		FTOC		FTOC						
P-06-39S		FTOC		FTOC						
P-06-40D		--		--						
P-06-40M		--		--						
P-06-40S		--		--						
P-06-41D		FTOC		FTOC						
P-06-41M		FTOC		FTOC						
P-06-41S		FTOC		FTOC						
PQ-4 (4270M)		FTOP		FTOP						
PQ-8		--		--						
PQ-9		FTOC		FTOC						
SRK-1A		--		--						
P-05-36M		FTOC		FTOC						

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

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
SRK-2 (AKA 4251)		FTOC		FTOC						
SRK-2A		FTOC		FTOC						
SRK-3 (AKA 4250)		FTOP		FTOP						
GH05-53		FTOC		FTOC						
GH05-57		FTOC		FTOC						
GH05-58		FTOC		FTOC						
GH05-59		FTOC		FTOC						
GH05-60		--		--						
GH05-61		FTOC		FTOC						
GH05-63		FTOC		FTOC						
GH05-64		FTOC		FTOC						
GH06-65		FTOC		FTOC						
GH06-66		FTOC		FTOC						
GH06-67		FTOC		FTOC						
GH06-68		FTOC		FTOC						
GH06-69		FTOC		FTOC						
GH06-70D		--		--						
GH06-70S		--		--						
GH06-71A		--		--						
GH06-72		--		--						
GH06-74		FTOC		FTOC						
GH06-75		FTOC		FTOC						
GH06-76		FTOC		FTOC						
GH06-77		FTOC		FTOC						
GH06-80		FTOC		FTOC						
Northern Wetland Group (Order = NE to SW)										
WL-P01D		FTOC		FTOC						
WL-P01S		--		--						
WL-S02D		FTOC		FTOC						
WL-S02G		FTOC		FTOC						
WL-S02S		FTOC		FTOC						
WL-P02D		FTOC		FTOC						
WL-P02S		FTOC		FTOC						
WL-S01D		FTOC		FTOC						
WL-S01G		--		--						
WL-S01S		FTOC		FTOC						
WL-P03D		FTOC		FTOC						
WL-P03S		FTOC		FTOC						

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

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
Middle Wetland Group (Order = NE to SW)										
WL-P06D		FTOC		FTOC						
WL-P06S		FTOC		FTOC						
WL-S03D		--		--						
WL-S03G		FTOC		FTOC						
WL-S03S		--		--						
WL-P05D		FTOC		FTOC						
WL-P05S		FTOC		FTOC						
WL-S04D		--		--						
WL-S04G		--		--						
WL-S04S		--		--						
WL-P04D		FTOC		FTOC						
WL-P04S		FTOC		FTOC						
Southern Wetland Group (Order = NE to SW)										
WL-P07D		FTOC		FTOC						
WL-P07S		FTOC		FTOC						
WL-P08D		FTOC		FTOC						
WL-P08S		FTOC		FTOC						
WL-S05D		FTOC		FTOC						
WL-S05G		--		--						
WL-S05S		FTOC		FTOC						
WL-S06D		--		--						
WL-S06G		--		--						
WL-S06S		--		--						
WL-P09D		FTOC		FTOC						
WL-P09S		FTOC		FTOC						
WL-P10D		FTOC		FTOC						
WL-P10S		FTOC		FTOC						
WL-S07D		FTOC		FTOC						
WL-S07G		--		--						
WL-S07S		FTOC		FTOC						
WL-P11D		FTOC		FTOC						
WL-P11S		FTOC		FTOC						
2007 Wetland Wells										
WL-P15D		FTOC		FTOC						
WL-P15G (NF3G)		--		--						
WL-P15S		FTOC		FTOC						

ABBREVIATIONS:
FTOC - from top of casing
FTOP - from top of sample port
FAS - frozen at surface

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
2007 Wetland Wells										
WL-P16D		FTOC		FTOC						
WL-P16G (NF2G)		--		--						
WL-P16S		FTOC		FTOC						
WL-P17D		FTOC		FTOC						
WL-P17S		FTOC		FTOC						
WL-P18D		FTOC		FTOC						
WL-P18G (NF1G)		--		--						
WL-P18S		FTOC		FTOC						
WL-P19D		FTOC		FTOC						
WL-P19S		FTOC		FTOC						
WL-P20D		FTOC		FTOC						
WL-P20G (UTM2G)		--		--						
WL-P20S		FTOC		FTOC						
WL-P21D		FTOC		FTOC						
WL-P21G (UTM1G)		--		--						
WL-P21S		FTOC		FTOC						
WL-P22D		FTOC		FTOC						
WL-P22S		FTOC		FTOC						
WL-P23D		FTOC		FTOC						
WL-P23S		FTOC		FTOC						
WL-P24D		FTOC		FTOC						
WL-P24S		FTOC		FTOC						
WL-P25D		FTOC		FTOC						
WL-P25S		FTOC		FTOC						
WL-P26D		FTOC		FTOC						
WL-P26S		FTOC		FTOC						
2007 Wells										
GH07-81		FTOC		FTOC						
GH07-82D		FTOC		FTOC						
GH07-82S		--		--						
GH07-83D		FTOC		FTOC						
GH07-83S		--		--						
GH07-84		FTOC		FTOC						
GH07-85		FTOC		FTOC						
GH07-86		FTOC		FTOC						

ABBREVIATIONS:
FTOC - from top of casing
FTOP - from top of sample port
FAS - frozen at surface

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter
Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:
Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
2007 Wells										
GH07-87D		FTOC		FTOC						
GH07-87S		FTOC		FTOC						
GH07-88		FTOC		FTOC						
GH07-89D		FTOC		FTOC						
GH07-89S		--		--						
GH07-90		--		--						
GH07-91		--		--						
GH07-92D		FTOC		FTOC						
GH07-92S		FTOC		FTOC						
GH07-93		FTOC		FTOC						
GH07-94		FTOC		FTOC						
GH07-95		FTOC		FTOC						
GH07-96D		FTOC		FTOC						
GH07-96S		FTOC		FTOC						
GH07-97D		FTOC		FTOC						
GH07-97S		FTOC		FTOC						
GH07-98D		FTOC		FTOC						
GH07-98S		FTOC		FTOC						
GH07-99		--		--						
GH07-100		FTOC		FTOC						
GH07-101		FTOC		FTOC						
GH07-102D		FTOC		FTOC						
GH07-102S		FTOC		FTOC						
GH07-103D		FTOC		FTOC						
GH07-103S		FTOC		FTOC						
GH07-104		FTOC		FTOC						
GH07-105		FTOC		FTOC						
GH07-106		--		--						
P-07-42D		FTOC		FTOC						
P-07-42S		FTOC		FTOC						
P-07-43D		FTOC		FTOC						
P-07-43M		FTOC		FTOC						
P-07-43S		FTOC		FTOC						
P-07-44D		FTOC		FTOC						
P-07-44S		FTOC		FTOC						
P-07-45D		FTOC		FTOC						
P-07-46D		FTOC		FTOC						
P-07-47D		FTOC		FTOC						

ABBREVIATIONS:

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

GROUND WATER LEVEL MEASUREMENTS

Water Level Meter

Make:
Model:
Cutoff:
Units:
Res:

Project:
Project #:
Logger:

Date start
Date finish

Water Level Measurements

Well	Previous Readings				Current Reading					Comments
	Previous Month WL	Ref	Previous Month TD	Ref	Date	DTW1	DTW2	Total Depth	Ref	
2007 Wells										
P-07-48D		FTOC		FTOC						
P-07-48S		FTOC		FTOC						
P-07-49D		FTOC		FTOC						
P-07-49S		FTOC		FTOC						
P-07-50D		FTOC		FTOC						
P-07-50S		FTOC		FTOC						
P-07-50SS		FTOC		FTOC						
P-07-51D		FTOC		FTOC						
P-07-51S		FTOC		FTOC						
P-07-52D		FTOC		FTOC						
P-07-52S		FTOC		FTOC						
P-07-53D		FTOC		FTOC						
P-07-53S		FTOC		FTOC						

ABBREVIATIONS:

FTOC - from top of casing

FTOP - from top of sample port

SLR Water Parameter Meter
Calibration Log

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

Date: _____
Meter: _____
Lot #: _____

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

PUMPING TEST
Pumping Well Log

Date: _____ Well ID: _____

Project: _____ Project #: _____

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)
Sp Cond	0.447		
(mS/cm)	1.413		

Observation Wells

_____ _____

_____ _____

_____ _____

Field Instrument Readings

	Date	Time	Volume (gal)	Elapsed Time*	Flow (gpm)	Sp 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										

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

PUMPING TEST
Observation Well Log

Date: _____ Well ID: _____

Project: _____ Project #: _____

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

RESPONSE TEST LOG

Date: _____ Well ID: _____

Project: _____ Project #: _____

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 LOG

Date: _____ Well ID: _____

Project: _____ Project #: _____

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 _____

Manual water level readings

	Year	Date	Time	DTW (ft, _____)		Year	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				

Westbay Piezometric Pressures/Levels

Field Data and Calculation Sheet

Well No.: _____ Probe Type: _____ Date: _____

Datum: _____ Serial No.: _____ Client: _____

Elev. G.S.: _____ Probe Range: _____ Job No.: _____

Height of Westbay above G.S.: _____ Westbay Casing Type: _____ Location: _____

Elev. top of Westbay Casing: _____ Initial DTW: _____ Weather: _____

Reference Elevation: _____ Final DTW: _____ Operator: _____

Borehole Angle: _____

Note: "Port position" in angled boreholes refer to position along drillhole True depth (Dp) needs to be calculated using borehole angle and deviation data to calculate zone piezometric level (Dz).

Ambient Readings:

Initial P_{atm} _____ **psi** **Initial Temp** _____ ***C** **Final P_{atm}** _____ **psi** **Final Temp** _____ ***C**

Start Date: _____ **Time:** _____ **Finish Date:** _____ **Time:** _____

Port No.	Port Position From Log (ft)	Port Position From Cable (ft)	True Port Depth "Dp"	Fluid Pressure Readings			Probe Temp. (°C)	Time H:M:S	Pressure Head Outside Port H = (P2-Patm)/w	Piez. Level Outside Port Dz = Log PP - H	DTW FTOC	Comments
				Inside Casing (P1)	Outside Casing (P2)	Inside Casing (P1)						
1	4034		--									
2	3997		--									
3	3952		--									
4	3837		--									
5	3727		--									
6	3682		--									
7	3495		--									
8	3440		--									
9	3345		--									
10	3290		--									
11	3125		--									
12	3050		--									
13	2960		--									
14	2835		--									
15	2790		--									

Notes: w = 0.433 psi/ ft (1.422psi/m) of H_2O Dz = piezometric level in zone Patm = atmospheric pressure

H = pressure head of water in zone Dp = true depth of measurement port

Westbay Piezometric Pressures/Levels

Field Data and Calculation Sheet

Well No.: _____ Probe Type: _____ Date: _____

Datum: _____ Serial No.: _____ Client: _____

Elev. G.S.: _____ Probe Range: _____ Job No.: _____

Height of Westbay above G.S.: _____ Westbay Casing Type: _____ Location: _____

Elev. top of Westbay Casing: _____ Initial DTW: _____ Weather: _____

Reference Elevation: _____ Final DTW: _____ Operator: _____

Borehole Angle: _____

Note: "Port position" in angled boreholes refer to position along drillhole True depth (Dp) needs to be calculated using borehole angle and deviation data to calculate zone piezometric level (Dz).

Ambient Readings:

Initial P_{atm} _____ **psi** **Initial Temp** _____ ***C** **Final P_{atm}** _____ **psi** **Final Temp** _____ ***C**

Start Date: _____ **Time:** _____ **Finish Date:** _____ **Time:** _____

Port No.	Port Position From Log (ft)	Port Position From Cable (ft)	True Port Depth "Dp"	Fluid Pressure Readings			Probe Temp. (°C)	Time H:M:S	Pressure Head Outside Port H = (P2-Patm)/w	Piez. Level Outside Port Dz = Log PP - H	DTW FTOC	Comments
				Inside Casing (P1)	Outside Casing (P2)	Inside Casing (P1)						
16	2698		--									
17	2629		--									
18	2584		--									
19	2475		--									
20	2375		--									
21	2320		--									
22	2130		--									
23	2085		--									
24	1980		--									
25	1935		--									
26	1755		--									
27	1695		--									
28	1625		--									
29	1580		--									
30	1485		--									

Notes: w = 0.433 psi/ ft (1.422psi/m) of H_2O Dz = piezometric level in zone Patm = atmospheric pressure

H = pressure head of water in zone Dp = true depth of measurement port

Westbay Piezometric Pressures/Levels

Field Data and Calculation Sheet

Well No.: _____ Probe Type: _____ Date: _____

Datum: _____ Serial No.: _____ Client: _____

Elev. G.S.: _____ Probe Range: _____ Job No.: _____

Height of Westbay above G.S.: _____ Westbay Casing Type: _____ Location: _____

Elev. top of Westbay Casing: _____ Initial DTW: _____ Weather: _____

Reference Elevation: _____ Final DTW: _____ Operator: _____

Borehole Angle: _____

Note: "Port position" in angled boreholes refer to position along drillhole True depth (Dp) needs to be calculated using borehole angle and deviation data to calculate zone piezometric level (Dz).

Ambient Readings:

Initial P_{atm} _____ **psi** **Initial Temp** _____ ***C** **Final** P_{atm} _____ **psi** **Final Temp** _____ ***C**

Start Date: _____ **Time:** _____ **Finish Date:** _____ **Time:** _____

Port No.	Port Position From Log (ft)	Port Position From Cable (ft)	True Port Depth "Dp"	Fluid Pressure Readings			Probe Temp. (°C)	Time H:M:S	Pressure Head Outside Port H = (P2-Patm)/w	Piez. Level Outside Port Dz = Log PP - H	DTW FTOC	Comments
				Inside Casing (P1)	Outside Casing (P2)	Inside Casing (P1)						
31	1440		--									
32	1300		--									
33	1235		--									
34	1180		--									
35	1105		--									
36	1070		--									
37	1025		--									
38	930		--									No Collar
39	825		--									
40	750		--									
41	730		--									No Collar
42	695		--									
43	570		--									
44	495		--									
45	445		--									

Notes: w = 0.433 psi/ ft (1.422psi/m) of H_2O Dz = piezometric level in zone Patm = atmospheric pressure

H = pressure head of water in zone Dp = true depth of measurement port

Westbay Piezometric Pressures/Levels

Field Data and Calculation Sheet

Well No.: _____ Probe Type: _____ Date: _____

Datum: _____ Serial No.: _____ Client: _____

Elev. G.S.: _____ Probe Range: _____ Job No.: _____

Height of Westbay above G.S.: _____ Westbay Casing Type: _____ Location: _____

Elev. top of Westbay Casing: _____ Initial DTW: _____ Weather: _____

Reference Elevation: _____ Final DTW: _____ Operator: _____

Borehole Angle: _____

Note: "Port position" in angled boreholes refer to position along drillhole True depth (Dp) needs to be calculated using borehole angle and deviation data to calculate zone piezometric level (Dz).

Ambient Readings:

Initial P_{atm} _____ **psi** **Initial Temp** _____ ***C** **Final** P_{atm} _____ **psi** **Final Temp** _____ ***C**

Start Date: _____ **Time:** _____ **Finish Date:** _____ **Time:** _____

Port No.	Port Position From Log (ft)	Port Position From Cable (ft)	True Port Depth "Dp"	Fluid Pressure Readings			Probe Temp. (°C)	Time H:M:S	Pressure Head Outside Port H = (P2-Patm)/w	Piez. Level Outside Port Dz = Log PP - H	DTW FTOC	Comments
				Inside Casing (P1)	Outside Casing (P2)	Inside Casing (P1)						
46	338		--									
47	293		--									
48	268		--									
49	208		--									
50	158		--									
			--									
			--									
			--									
			--									
			--									
			--									
			--									
			--									
			--									

Notes: w = 0.433 psi/ ft (1.422psi/m) of H_2O Dz = piezometric level in zone Patm = atmospheric pressure

H = pressure head of water in zone Dp = true depth of measurement port

APPENDIX B

Example Lithology Log with Well Construction Information

P-07-42S

PROJECT LOCATION Iliamna, Alaska
DRILL SITE P-07-42S
DATE STARTED 8/27/07 **COMPLETED** 8/27/07
GROUND ELEVATION 1160.5 feet **TOC ELEVATION** 1162.8 feet
DRILLING CONTRACTOR Foundex **NORTHING** 2171795.2 **EASTING** 1404364.7
DRILLING METHOD Air Percussion **EQUIPMENT** ODEX/HT700 **LOGGER** C. Bentz, S. O'Neill, M. Rieser

DEPTH BELOW SURFACE (ft)	SAMPLE TYPE	DEPTH TO WATER (ft bgs)	FLOW TEST (gpm)	GRAPHIC LOG	SOIL DESCRIPTION	WELL DIAGRAM / COMMENTS
0						No recovery, 0-2 feet
					2.0 ML **Sandy Silt with Gravel** brown, moist	
					3.0	No recovery, 3-4 feet
					4.0 SM **Sandy Silt with Gravel** brown, dry to moist	
5						More gravel present, 6-8 feet
					8.0 GM **Gravel with Sandy Silt** brown, subangular to subrouned gravel, well graded sand, dry	
10					11.0	
					12.0 GM **Gravel with Sand and Silt** brown, subangular to subrounded gravel, well graded fine to coarse grained sand, dry	
					14.0 GP **Sandy Gravel** brown, subangular to rounded gravel, well graded fine to coarse grained sand, trace silt, dry	Gravel more rounded, 13-14 feet
15					15.0 GM **Gravel with Sandy Silt** brown, dry	
					17.0	
					18.0 SW **Gravelly Sand** brown, well graded sand, trace silt, dry	
					19.0 GP **Sandy Gravel** brown, subrounded to rounded gravel, trace silt, dry	
20					20.0 GP **Gravel and Sand** brown, subangular to	

WELL COMPLETION INFORMATION

WELLHEAD PROTECTION
Type: Steel
Diameter: 6"

WELL CASING
Stickup: 2.3'
Type: Schedule 80 PVC
Diameter: 2"

SURFACE SEAL
Mix Used: 10# grout, 100# cement, 10 gal H2O

GROUT
Type: Volclay Bentonite Grout
Method of Placement: Tremie

PLUG
Type: 1/4" Coated Bentonite Pellets

SCREEN FILTER
Type: 10/20 Colorado Silica Sand

SCREEN
Type: Schedule 80 PVC
Slot Size: 0.020 inch

RATHOLE
Type: Bentonite Pellets

DEVELOPMENT
Method: Waterra Pump (w/ and w/out surge block)
Date: 10/23/07
Purge Volume: 586 gallons

RESPONSE TEST
Response Method: N/A
Date: N/A

Comments: Static Water Level is denoted by solid triangle (measured from top of casing): 8/28/07 at 820 AM

2007 PEBBLE LOGS 2007 PEBBLE.GPJ PEBBLE2.GPJ 3/3/08

THE pebble PARTNERSHIP

PROJECT LOCATION Iliamna, Alaska **DRILL SITE** P-07-42S

DATE STARTED 8/27/07 **COMPLETED** 8/27/07 **GROUND ELEVATION** 1160.5 feet **TOC ELEVATION** 1162.8 feet

DRILLING CONTRACTOR Foundex **NORTHING** 2171795.2 **EASTING** 1404364.7

DRILLING METHOD Air Percussion **EQUIPMENT** ODEX/HT700 **LOGGER** C. Bentz, S. O'Neill, M. Rieser

DEPTH BELOW SURFACE (ft)	SAMPLE TYPE	DEPTH TO WATER (ft bgs)	FLOW TEST (gpm)	GRAPHIC LOG	SOIL DESCRIPTION	WELL DIAGRAM / COMMENTS
20					subrounded gravel, trace silt, dry	
					21.0 GM **Gravel with Silt and Sand** brown, dry	
					GM **Gravel with Sand and Silt** brown, subangular to subrounded gravel, some silt, dry	
					23.0 GP **Sandy Gravel** brown, subangular to subrounded gravel, well graded sand, trace silt, dry	
25					25.0 GP **Sandy Gravel** brown, trace silt, dry	
30	GB				32.0 GM **Gravel with Silty Sand** yellowish brown, subrounded gravel, moist	
					33.0 GP **Gravel with Sand and Silt** brown to yellowish brown, subrounded gravel, trace to some silt, moist	
35	GB	▼			34.0 SP **Gravelly Sand** brown, well graded poorly sorted sand, moist	
					35.0 SW **Gravelly Sand** reddish brown, subrounded gravel, up to 1/2"; well graded sand, trace silt, moist	
					37.5 GW **Sandy Gravel** gravel up to 1/4", moist	
					38.0 GP **Sandy Gravel** reddish brown, subrounded gravel, up to 1/2", moist	
40	GB				41.0 GP **Gravel** subangular to subrounded gravel, trace poorly sorted sand, moist	
					42.0 GM **Gravel** reddish brown, subrounded gravel, up to 5/8"; trace silt, moist	
					44.0 GM **Sandy Gravel** reddish brown, subrounded gravel, up to 5/8"; coarse grained sand, trace silt, moist	
45	GB				45.0 GM **Gravel** reddish brown, subrounded gravel, up to 5/8"; 10% silt, moist	
					46.0 GP **Sandy Gravel** subangular to subrounded gravel, up to 5/8"; coarse grained sand, moist	
					47.0 GP **Gravel** yellowish brown, subangular gravel, <1/2"; trace silt, wet	Water encountered, 48.5 feet Adding water while drilling, 49-52 feet

THE pebble PARTNERSHIP

PROJECT LOCATION Iliamna, Alaska **DRILL SITE** P-07-42S

DATE STARTED 8/27/07 **COMPLETED** 8/27/07 **GROUND ELEVATION** 1160.5 feet **TOC ELEVATION** 1162.8 feet

DRILLING CONTRACTOR Foundex **NORTHING** 2171795.2 **EASTING** 1404364.7

DRILLING METHOD Air Percussion **EQUIPMENT** ODEX/HT700 **LOGGER** C. Bentz, S. O'Neill, M. Rieser

DEPTH BELOW SURFACE (ft)	SAMPLE TYPE	DEPTH TO WATER (ft bgs)	FLOW TEST (gpm)	GRAPHIC LOG	SOIL DESCRIPTION	WELL DIAGRAM / COMMENTS
50	GB	49			GP **Gravel** yellowish brown, subangular gravel, <1/2"; trace silt, wet	Water level rising
					52.0 Bottom of hole at 52.5 feet.	

Pebble Project Environmental Baseline Studies
Field Sampling Plans
Surface Water Quality and Hydrology

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

SURFACE WATER - MINE AREA

NOVEMBER 2005

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Figure 1. 2005 Surface-water-quality and hydrology baseline site map

APPENDICES

Appendix A. Surface-water-quality and Hydrology Field Form

ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation
BP	barometric pressure
BTEX	benzene, toluene, ethylbenzene, xylene
°C	degrees Celsius
CAS	Columbia Analytical Services
COC	chain of custody
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
ft/sec	feet per second
GPS	global positioning system
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
ml	milliliter(s)
mm	millimeter(s)
MRL	method reporting limit
ng/L	nanograms per liter
MS	matrix spike
MSD	matrix spike duplicate
NCA	North Creek Analytical
NDM	Northern Dynasty Mines Inc.
NK	North Fork of Koktuli River
NTU	nephelometric turbidity units
ORP	oxidation-reduction potential
PCB	polychlorinated biphenyl
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
SK	South Fork of Koktuli River
SOP	standard operating procedure
SVOC	semivolatile organic compound

TDS	total dissolved solid
TSS	total suspended solid
USGS	U.S. Geological Survey
UT	Upper Talarik Creek
VOC	volatile organic compound
WAD	weak acid dissociable
WMC	Water Management Consultants

1. INTRODUCTION

This field sampling plan includes the protocols for the hydrology, sediment, and water-quality baseline studies to be performed in 2005 for the Pebble Project, a proposed gold-copper-molybdenum mine located in southwestern Alaska. The program results will be used in a feasibility study and applications for construction, operation, and closure of the open-pit mine and related infrastructure. U.S. Environmental Protection Agency (EPA) guidance (EPA, 2003) was considered when developing this field sampling plan at the start of the program in April 2004.

2. PROJECT BACKGROUND

2.1 Project Purpose and Scope

Northern Dynasty Mines Inc. is proposing to develop the Pebble Project; therefore a series of environmental studies is being conducted to provide background information necessary for mine planning, permitting, and development. This field sampling plan includes the methodology for the collection of hydrology, sediment, and water-quality data for the baseline studies.

2.2 Project Site Description

The project area is shown on Figure 1 and includes the mineralized area and potential mine, mill, and tailings-disposal facilities. The project area is drained by the north and south forks of the Koktuli River, Upper Talarik Creek, and tributaries of these waterbodies. The Kaskanak Creek watershed is located to the southwest of the project area and will be studied to identify potential interbasin transfer from the South Fork Koktuli River. Thirty-one surface-water stations are being sampled for hydrology and water quality in the north and south forks of Koktuli River, Upper Talarik Creek, and Kaskanak Creek in 2005. Sediments will be collected in sixteen streams, six lakes, and approximately ten seeps near the mine site for the trace elements baseline program.

3. PROJECT SCOPE AND OBJECTIVES

3.1 Objectives

Objectives of the baseline surface-water hydrology portion of this program include the following:

- Characterization of current site conditions and site resources.
- Collection of surface-water baseline data for comparison to future conditions (construction, operations, and closure).

- Collection of data for design of facilities including water-management and water-supply structures.

The main objectives of the surface-water-quality portion of this study are as follows:

- Collect baseline data to provide defensible documentation of the naturally occurring levels and variability of trace elements in surface water.
- Evaluate alternative water-supply sources.
- Provide a database for the site surface-water-chemistry and site-loading models for project design and environmental impact assessment.
- Develop the baseline for the evaluation of potential environmental impacts during construction, operation, and closure.
- Support project permitting.

Baseline studies will provide physical flow information and water-quality data for surface-water systems in the vicinity of the proposed mine, mill, and tailings-disposal facilities. Surface-water baseline conditions will be documented to provide information on hydrologic interaction and on how they change throughout the year. Surface-water flow and quality data will be linked to provide estimates of baseline surface-water load from the mineralized area to downgradient surface-water systems. This information will be used to understand current conditions and to provide a baseline for the evaluation of potential future impacts during operation and closure.

3.2 Sample Analysis Summary

The list of laboratory analyses that will be performed in the baseline water-quality program in 2005 is in Table 1. Quality assurance (QA) samples will be shipped to Columbia Analytical Services in Kelso, Washington. Primary and duplicate, or quality control (QC), samples tested for metals and low-level mercury samples are shipped to North Creek Analytical in Beaverton, Oregon, and the inorganic, organic, and cyanide samples are being analyzed at SGS Laboratory in Anchorage, Alaska.

TABLE 1. Surface-water and sediment parameters for laboratory determination.

Analyte	Method	Method Reporting Limit
Aluminum, total and dissolved	EPA 200.8	1.0 µg/L
Antimony, total and dissolved	EPA 200.8	0.05 µg/L
Arsenic, total and dissolved	EPA 200.8	0.5 µg/L
Barium, total and dissolved	EPA 200.8	0.05 µg/L
Beryllium, total and dissolved	EPA 200.8	0.02 µg/L
Bismuth, total and dissolved	EPA 200.8	0.1 µg/L
Boron, total and dissolved	EPA 200.8	0.5 µg/L
Cadmium, total and dissolved	EPA 200.8	0.02 µg/L
Calcium, total and dissolved	EPA 200.7/200.8	50 µg/L
Chromium, total and dissolved	EPA 200.8	0.2 µg/L
Cobalt, total and dissolved	EPA 200.8	0.02 µg/L
Copper, total and dissolved	EPA 200.8	0.1 µg/L
Iron, total and dissolved	EPA 200.7	20 µg/L
Lead, total and dissolved	EPA 200.8	0.02 µg/L
Magnesium, total and dissolved	EPA 200.7/200.8	20 µg/L
Manganese, total and dissolved	EPA 200.8	0.05 µg/L
Mercury, total	EPA 1631	0.005 µg/L
Molybdenum, total and dissolved	EPA 200.8	0.05 µg/L
Nickel, total and dissolved	EPA 200.8	0.2 µg/L
Potassium, total and dissolved	EPA 200.7/200.8	50 µg/L
Selenium, total and dissolved	EPA 200.8	1 µg/L
Silicon, dissolved	EPA 200.8	100 µg/L
Silver, total and dissolved	EPA 200.8	0.02 µg/L
Sodium, total and dissolved	EPA 200.7/200.8	100 µg/L
Thallium, total and dissolved	EPA 200.8	0.01 µg/L
Tin, total and dissolved	EPA 200.8	1 µg/L
Vanadium, total and dissolved	EPA 200.8	0.2 µg/L
Zinc, total and dissolved	EPA 200.8	0.5 µg/L
pH	EPA 150.1	NA
Specific Conductance	SM 2510B	2 µS/cm
Alkalinity	SM 2320B	10 mg/L
Acidity	EPA 305.2	NA
Ammonia	SM 4500NH3G	0.1 mg/L
Chloride	EPA 300.0	0.2 mg/L
Cyanide—total	SM 4500-CN E	0.01 mg/L
Cyanide—WAD	SM 4500-CN I	0.01 mg/L
Fluoride	EPA 300.0	0.1 mg/L
Nitrate + nitrite	EPA 300.0	0.1 mg/L
Phosphorus, total	EPA 365.3	0.1 mg/L

Analyte	Method	Method Reporting Limit
Sulfate	EPA 300.0	0.01 mg/L
Total dissolved solids	EPA 160.1	10 mg/L
Total suspended solids	EPA 160.2	5 mg/L
Thiocyanate	Laboratory SOP	1 mg/L
Pesticides, SVOCs, VOCS	various	See 2005 NDM QAPP (NDM, 2005) for MRL
Sediments		
Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mo, Mn, Ni, K, Se, Ag, Na, Tl, Sn, V, Zn	SW3050/6020	See Table 1-12 in 2005 NDM QAPP (NDM, 2005) for MRL
Hg	SW 3050/7471	0.02 mg/kg
Total Cyanide	SM 4500CN-E	0.2 mg/kg
Chloride	EPA 300.0	1 mg/kg
Fluoride	EPA 300.0	2 mg/kg
Sulfate	EPA 300.0	2 mg/kg
Ammonia as N	SM 4500NH3	0.2 mg/kg

EPA = Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition

SW = U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third edition, September 1986

µg/L = micrograms per liter

µS/cm = microsiemens per centimeter

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

MRL = method reporting limit

NA = not applicable

SOP = standard operating procedure

SVOC = semivolatile organic compound

VOC = volatile organic compound

WAD = weak acid dissociable

% = percent

3.3 Field Activities

Detailed procedures for the surface-water hydrology, sediment, and water-quality field activities are included in Sections 5 and 6. Appropriate QA/QC procedures will be used, and QA/QC samples will be collected at a 10 percent frequency, which is based on the schedule set up by the analytical laboratories and the laboratory QA manager at Shaw Environmental.

The surface-water sampling program will quantify the water chemistry throughout the year and under a range of different hydrologic conditions at key surface-water locations. The sampling program is designed to occur during breakup and to catch high flow in summer (which may take more than one sampling event), low flow in summer, a fall storm event, and a couple of low-flow events in winter. As hydrologic conditions change (for example, variation of flows because of breakup and storm events), there is greater potential for varying water chemistry. The sampling program consists of nine planned surface-water events for a 12-month period.

Organic samples will be collected to identify baseline conditions and develop site-specific cleanup standards. Site specific standards will be considered only in the event of a future petroleum release. Seasonal variation in organic concentrations will not be a factor in determining cleanup standards, and samples will be collected once in July 2005.

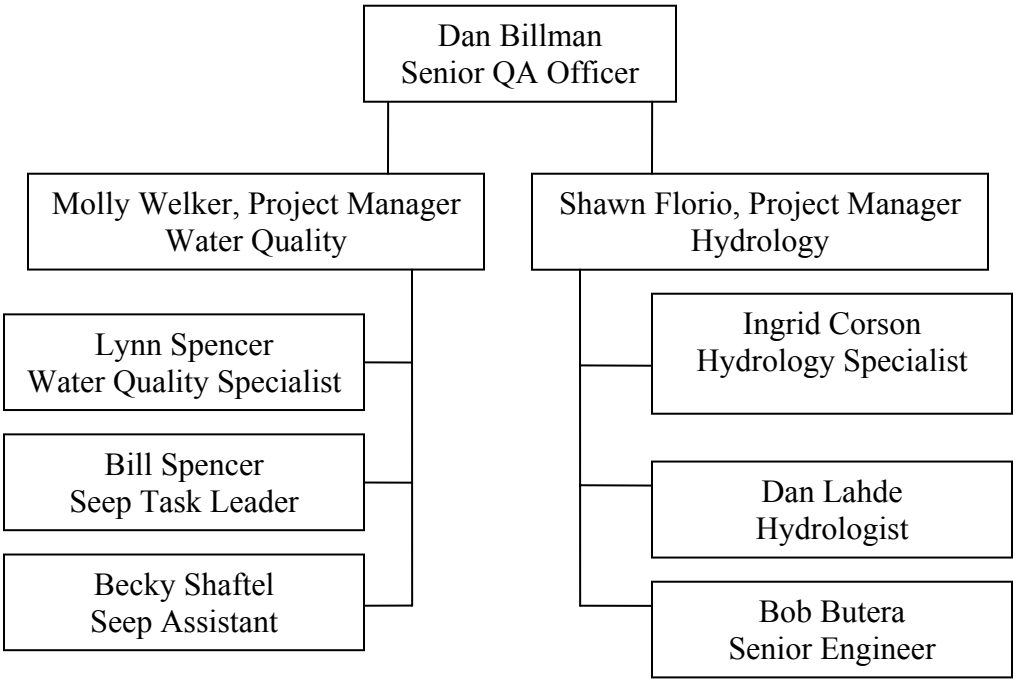
In all cases, field-collection procedures are performed so as to minimize contamination of samples, prevent cross-contamination between samples, and ensure sample validity by conducting proper preservation and storage in the field according to the requirements in the *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (NDM, 2005).

Part of the surface-water baseline program includes sampling seeps for flow and water quality in March, July, August, and October in of 2005. The objective of the seep sampling program is to document the amount and chemistry of water discharging from seeps or springs in the vicinity of the ore deposit. Discharge at each seep will be measured by directing flow over a 60° V-notch weir, where possible. If flows are too large to use the weir, measurements will be made along a cross-section using a top-setting wading rod and current meter. Flows may be estimated based on visual observations if the above methods cannot be used. Water-chemistry parameters to be analyzed for the seep samples are exactly the same as those analyzed for the surface-water samples (Table 1). Field parameters that will be measured at the seep locations are the same as those measured at the surface-water sites: pH, dissolved oxygen, specific conductance, temperature, turbidity, and oxidation-reduction potential. YSI Multiprobe 556 and Hach turbidity meters will be deported directly at the seep discharge for measurement of field parameters.

Sediment data will also be collected from streams, lakes, and seeps in the proposed mine site to be incorporated into the trace elements program of the baseline environmental studies. Sediments will be collected from 16 stream locations in June, July, and September and will be co-located at a subset of the water-quality, hydrology, fish-tissue, and macroinvertebrate sampling stations. Sediments will be collected in approximately ten seeps in June and October and in six lakes in July.

4. PROJECT ORGANIZATION AND RESPONSIBILITY

Molly Welker and Shawn Florio will coordinate the field work and report-writing for the hydrology, sediment, and surface-water-quality programs. The field teams will consist of two water-quality specialists working with two hydrologists to collect the flow data, and sediment and water-quality samples. A variety of HDR Alaska Inc. (HDR) employees and local hires will help with the field work when needed. An organization chart depicting the main HDR staff managing and assisting on the hydrology, sediment, and water-quality programs is provided below.



4.1 Subcontractors

Two subcontractors (Denise Herzog of Apex North Consulting and Tony Yeo of the University of Alaska-Anchorage) are involved in the project. Their involvement includes technical review of the reports and advice on statistical procedures to be used for data analysis.

5. HYDROLOGY MONITORING AND SEDIMENT SAMPLING

Field activities will include several tasks described below for the hydrology program and sediment program. Water-chemistry field activities are included in Section 6. Activities for measuring field parameters are described in Section 7. The hydrology and surface-water baseline stations and the hydrology data to be collected are listed in Table 2.

TABLE 2. Hydrology and surface-water baseline sites and hydrology data type.

Location ID	Operator	Data Type	Rationale	Period of Continuous Record
North Fork Koktuli River				
NK100C	HDR	Continuous stage and discharge	NK "basin" integrator for NK headwaters	Jul-Oct 2004
NK119A	HDR	Continuous stage and discharge	Downstream of G tailings site	Jul-Oct 2004
NK119B	HDR	Instantaneous discharge only	Drains northwest side of mineralized area	
NK100A	USGS	Continuous stage and discharge	Lower main stem NK near SK confluence	Aug 2004-Current
NK100B	HDR	Instantaneous discharge only	Integrates NK 100C and NK 100A.	
South Fork Koktuli River				
SK136B	HDR	Instantaneous discharge only	Drains mineralized area	
SK136A	HDR	Instantaneous discharge only	Drains mineralized area	
SK134A	HDR	Instantaneous discharge only	South of mineralized area	
SK133A	HDR	Instantaneous discharge only	South of mineralized area	
SK100G	HDR	Continuous stage and discharge	Upper main stem; upstream of Frying Pan Lake; same reach as Cominco Stations 6 and 14	Jul-Oct 2004
SK131A	HDR	Instantaneous discharge only	Drains Koktuli Mountain	
SK100F	HDR	Continuous stage and discharge	Main stem downstream of Frying Pan Lake (poss. sink); same reach as Cominco CQ Station 17	Aug, Sep 1991; Jun – Oct 1992; Jul-Oct 2004
SK100D	HDR	Instantaneous discharge only	Main stem downstream of flow loss; Cominco Station 5	

Location ID	Operator	Data Type	Rationale	Period of Continuous Record
SK100C	HDR	Continuous stage and discharge	Main stem and upstream of flow gain; Cominco CQ Station 16	Jul-Oct 1993; Jul-Oct 2004
SK119A	HDR	Continuous stage and discharge	Tributary and flows to "aquifer recharge-discharge" area; Cominco Stations 18 and 20	Jul-Oct 2004
SK124A	HDR	Continuous stage and discharge	Provides flow data for Bear Valley	
SK100B	USGS	Continuous stage and discharge	Main stem downstream of flow gain	Aug 2004-Current
SK100A	HDR	Continuous stage and discharge	Lower main stem SK near confluence with NK	Jul-Oct 2004
			Upper Talarik Creek	
UT100E	HDR	Continuous stage and discharge	Upper reach of UT; downstream of potential flow gain from NK; upstream of drainage from ore body; same reach as Cominco Station 8	Jul-Oct 2004
UT146A	HDR	Instantaneous discharge only	Drains mineralized area; headwaters in mineralized zone	
UT141A	HDR	Instantaneous discharge only	"Low point" for new drainage north of mine area; added Q to UT	
UT100D	HDR	Continuous stage and discharge	Integrates all UT from MDC; Cominco CQ Station 13	Aug-Sep 1991; Jun-Oct 1992; Sep-Oct 1993; Jul-Oct 2004
UT138A	HDR	Instantaneous discharge only	Drains locally named Pig Mountain	
UT135A	HDR	Instantaneous discharge only	Major UT tributary near confluence with main stem of UT; winter flow contribution; Cominco CQ Station 19	Aug-Oct 1993; May-Sep 1994
UT119B	HDR	Instantaneous discharge only	Downstream of flow gain from SK	
UT119A	HDR	Continuous stage and discharge	Integrates mine/mill groundwater effects on UT from reduced flow from SK and WQ and biological sampling.	Jul-Oct 2004
UT100B	USGS	Continuous stage and discharge	Lower reach of UT; downstream of UT-1.190 effects; downstream of mineralized zone	Aug 2004-Current
UT100A	HDR	Instantaneous discharge only	Downstream of mineralized zone; integrates all of UT	
			Kaskanak Creek	
KC100A	HDR	Continuous stage and discharge	Evaluate potential interbasin transfer of water from SK	Jul-Oct 2004

Location ID	Operator	Data Type	Rationale	Period of Continuous Record
Main Stem Koktuli River				
KR100A	HDR	Instantaneous discharge only	Integrates NK and SK; lowest watershed site	

Notes:

Continuous-stage data collected when ice is present are suspect because of a continuously changing cross-section and other variables.

CQ = continuous discharge

MDC = mine development concept

NK = North Fork of the Koktuli River

Q = flow or discharge

SK = South Fork of the Koktuli River

USGS = U.S. Geological Survey

UT = Upper Talarik Creek

WQ = water quality

Sediment will be collected from a total of six lake locations in July. Samples will be collected from the following lake locations:

- Frying Pan Lake and Big Wiggly Lake.
- Two new lake sites in the southern portion of the mine site area and co-located with newly proposed fish-monitoring sites. Final locations to be determined.
- Two lake sites considered prime moose pond habitat and co-located with aquatic-vegetation sampling sites. Final locations to be determined.

Lake samples will be collected from a boat in a location which is most likely to accumulate sediment. Sediment will be collected using a dredge or core sampling techniques.

Sediment samples will be collected from up to ten seep locations in July and October. Sediment samples will be located at a subset of the seeps where water-quality samples are collected in 2005.

5.1 Datalogger Installation and Monitoring

Dataloggers used for this project are MiniTROLL units manufactured by In-Situ, Inc. Each datalogger is designed to record water depth and water temperature. A 5-pound-per-square-inch (psi) pressure transducer within the MiniTROLL unit records changes in water-surface elevation and has an accuracy rating to 0.01 feet. The units are set to observe water depth and temperature on a one-minute interval. One-minute observations are recorded only for changes in water depth of 0.01 foot or greater; however, observations are recorded every 10 minutes, regardless of changes in water depth. Temperature is recorded for every depth recording.

Dataloggers will be re-installed in April and May 2005 at twelve locations. The timing of installations may be specific to each site depending on conditions. The units will be installed by driving a steel angle iron into the streambed until the angle is solidly anchored. Where possible, the angle iron that was

installed in 2004 will be used again in 2005. A prefabricated polyvinyl chloride (PVC) housing shell is connected to the angle iron at the channel bottom with steel clamps. PVC conduit is then installed above the housing, and the MiniTROLL unit is placed in the housing with the cable secured in the conduit. A junction box to protect the cable connection is installed at the top of conduit. The top of the PVC housing remains open, and holes are drilled in the sides of the PVC to allow free water pressure over the sensors.

A channel cross-section is surveyed at each datalogger upon re-installation. Two or three temporary benchmarks, which were established in 2004 at each site, will provide local data for vertical control. A minimum of one temporary benchmark on each bank will define the cross-section to be established. Cross-section distances are measured with a survey tape, and a survey level is used for vertical measurements. The datalogger is tied to the surveyed cross-section by surveying the elevation of the top of the angle iron post and the water-surface elevation at the angle iron post.

Data from the dataloggers are scheduled to be downloaded monthly from installation in the spring through October 2005.

5.2 Instantaneous Discharge Measurements

Field procedures defined by the USGS (Rantz et al., 1982) and in the *Draft Environmental Baseline Studies, 2005 FInal Quality Assurance Project Plan* (NDM, 2005) are used to obtain instantaneous discharge measurements. Price AA, Pygmy, and Marsh McBirney current meters will be used, depending on stream depths and velocities. According to the USGS (Rickman, pers. comm., 2005) Pygmy meters will be used when the depth of the water is <1.5 feet (ft) and the flow is <3.5 feet per second (ft/sec); Price AA meters will be used when the depth is >1.5 ft and the flow is >3.5 ft/sec. The Marsh McBirney meter can be used when the depth of water is greater than 4 to 6 inches and the velocities are >0.5 ft/sec.

Instantaneous discharge measurements will be collected at each sampling location during each field event. Measurements will be taken using top-setting wading rods. If the water is too deep or swift to wade in 2005, a boat will be employed to obtain discharge measurements. A sounding weight may also be used with the boat to help stabilize the current meter. Backup current meters will be kept on hand in 2005 for use in the event of equipment malfunctions. Procedures for discharge measurements defined by the USGS are outlined below:

1. Visually check wading rod, current meter (Marsh McBirney, Pygmy, or AA type), and headsets for damage. Repair damage to equipment and replace batteries as necessary.
2. Evaluate reach of stream to determine type of meter necessary to make flow measurement. For shallow, low-velocity streams, use a Pygmy or Marsh McBirney current meter; for relatively deep, higher velocity streams, use a Marsh McBirney or a standard AA-type meter.
3. Perform spin test on selected meter if appropriate; the cups on the Pygmy meter should spin continuously for at least 30 seconds; on the AA meter, the cups should spin for at least 2 minutes. If the current meter fails the spin test, lubricate and adjust as necessary to achieve desired results.
4. Attach current meter and head set, or electric recorder, to wading rod. Check the electric connection between the current meter and headset or recorder by spinning cups on the current meter. Adjust equipment as necessary such that a clear signal is received upon every revolution of the cups.

5. Anchor surveyor's tape tautly across the stream perpendicular to the direction of streamflow and attach on either side of the stream. Attempt to provide at least 1 foot of clearance between the water surface and surveyor's tape.
6. Determine the spacing of the vertical partial sections, generally using 25 to 35 partial sections. The number of sections shall be based on an estimated distribution of the discharge across the entire cross-section. With a smooth cross-section and even velocity distribution, fewer cross-sections may be used. Space the partial sections to meet the USGS objective, which is that no partial section should have more than 10 percent of the total discharge in it. A more ideal measurement is one in which no partial section has more than 5 percent of the total discharge in it. However, the USGS recognizes this is not always practical and is seldom accomplished when 25 partial sections (or fewer) are used. Equal widths of partial sections across the entire cross-section are not recommended unless the discharge is well distributed. Make the width of the partial sections less as depths and velocities become greater (USDOI, 1969).
7. Person wading in stream calls out to data recorder on shore the location of the first measuring point with respect to the surveyor's tape. Person in stream measures water depth at that vertical, using wading rod, to the nearest 0.05 foot.
8. Data recorder calls out height(s) above the streambed at which velocity measurements are to be made. If the water is more than 2.5 feet deep, measurements will be made at 20 and 80 percent of the water column height. For water columns less than 2.5 feet deep, a single measurement of velocity at 60 percent of the water-column height will suffice. Person wading adjusts height of current meter on the wading rod accordingly.
9. Person wading stands downstream of the surveyor's tape, facing upstream, holding the wading rod vertical in the water with the current meter facing directly into the current. Person should not stand directly behind the meter but either to the left or right so as not to influence velocity readings.
10. Person wading counts clicks or observes visual output at each vertical for a minimum of 40 seconds and calls final tally of both number of clicks and time to data recorder. Click count should correlate with velocity chart provided with each meter.
11. Repeat procedure at each vertical.
12. Data recorder records other appropriate information on the field form.

5.3 Upper Hyporheic Zone Measurements

Changes potentially resulting from the proposed mine include altered hydraulic exchange between the groundwater and streams. Temperatures within the hyporheic zone—the saturated zone under a river or stream comprising substrate with the interstices filled with water—are important to the spawning success of salmonids (Rubin, 1995). Since a change to the hydraulic exchange rates could affect the temperature regime within the hyporheic zone, baseline data of temperatures in the hyporheic zone are being collected. Comparison of temperatures in the hyporheic zone to those in the adjacent groundwater and the above in-stream water column may also be used to better understand the hydraulic connections between these systems.

Temperature will be measured at four locations within the mine area. These locations, determined in concert among HDR's fisheries group, Water Management Consultants (WMC), and the Alaska Department of Natural Resources (DNR), include:

- The spring and salmon-spawning area on the main stem of South Fork Koktuli just downstream of the confluence with Tributary 1.190,
- Upper Talarik close to surface-water station UT100B,
- Upper Talarik in the general vicinity of surface-water station UT146A, and,
- North Fork Koktuli, a little downstream of NK100B.

Installation of the hyporheic monitoring stations is planned for June 2005. Continuously logged thermistors will be installed at each station to measure hyporheic temperatures at multiple depths down to a total depth of 10 feet below the stream bottom. Thermistor strings will be constructed and installed to measure temperatures every 6 inches to a depth of 3 feet; then every 12 inches to the total depth of 10 feet. One thermistor will be placed at the sediment/water interface and another will be placed about 6 inches (less in shallow streams) above the stream bottom. The thermistor strings will likely be installed through a 3/4-inch steel pipe. HDR plans to install the steel pipe using an electric jackhammer. Once the thermistor string is placed inside the steel pipe, the pipe will be removed, leaving the thermistors in place.

The thermistors will be connected to a datalogger mounted to an angle iron installed immediately adjacent to the thermistor string. After the stations have been installed, HDR will download the thermistor data according to the same schedule as for the surface-water hydrology-monitoring program. The stations will be capable of data collection throughout the year.

5.4 Low-Flow Stream Profiling

An evaluation of baseline hydrology, as well as potential changes to watersheds from the proposed mine, requires characterization of the hydraulic connections between surface-water and groundwater resources. To aid the hydrogeology study, a series of low-flow stream-flow profiles will be completed. These profiles will consist of 10 to 15 instantaneous discharge measurements along the North Fork of Koktuli River, South Fork of Koktuli River, Upper Talarik Creek, and tributaries for a total of up to 45 measurements. The measurements will be collected during the low-flow periods in March and following spring runoff (planned for late June or early July). Measurements will be collected using the same field methods described above for the monthly discharge measurements. HDR will provide the resulting data to WMC following each of the two field efforts. The specific stream reaches to be measured during the summer low-flow period are being determined in consultation with WMC.

5.5 Groundwater/Surface-water Exchange Measurements

In conjunction with the studies described in Sections 5.3 and 5.4, which target the exchange of groundwater and surface water, mini-piezometers and seepage meters also are planned for 12 locations within the mine-site drainages. HDR, with input from WMC, will install a pair of mini-piezometers at each station following breakup in 2005 to evaluate the direction of groundwater flow (gaining or losing) during low-flow conditions. Two drive-point mini-piezometers will be driven into the hyporheic zone at

each station. One each will be installed at three and 10 feet below the stream bottom using a vibrating hammer.

Differential water elevations will be collected using an electronic water-level indicator from each pair of mini-piezometers on the same schedule as the surface-water hydrology field program.

Seepage-meter measurements will also be recorded at these locations to document the quantity of groundwater flux into or out of the streambed. Seepage meters will be constructed in Anchorage from 55-gallon drums, as described by Lee and Cherry (1978).

The data collected during these studies will be provided to WMC for use with other groundwater and surface-water data to interpret groundwater recharge and discharge patterns.

5.6 Lake and Seep Sediment Sampling

Lake sediment samples will be collected from the top 0.5 feet of sediment by using Lexan tubes, Ponar dredge, Eckman dredge, or hand troweling. The seep- and lake-sediment sampling will be coordinated between the trace elements program and aquatic biological program. Sampling for lake sediments will occur once in six lakes in July 2005, and sediment sampling will occur in approximately 10 seeps in July and October 2005.

The exact device used at each location will be recorded in the field logbook and on the field data sheets. For all sampling methods, the individual collecting the sample will stand downstream (i.e., facing the current) when collecting the samples, to avoid disturbance of the sampling area.

The following steps will be used during the sediment sampling and compositing:

1. All samples and sampling equipment will be handled with gloved hands.
2. All non-disposable sampling equipment will be decontaminated prior to and between sampling areas.
3. Grab samples will be collected along a transect perpendicular to surface-water flow at each location. The outermost samples will be collected just below watermark with one sample collected within the stream channel. If feasible, samples will be collected at approximately equal intervals. Sampling plan will be sufficiently flexible to allow alternate locations (e.g., behind boulders, etc.)
4. Grab samples will be composited (i.e., three samples along a transect) and thoroughly mixed in a large stainless-steel bowl using gloved hands prior to filling the sample containers. The bowl can be placed within plastic garbage bags to eliminate the need for decontamination between samples.
5. Large debris (e.g., rocks, gravel, and sticks) will be hand picked and removed in the field during homogenization of the transect samples.
6. Place the composited sediment into sampling bottles; 25 grams of sediment is required by the laboratory for their sediment analyses.
7. At stations where field duplicate samples are obtained, each sample will be collected, homogenized, and sampled as if it were an entirely new sample, with complete cross-

contamination prevention efforts used. Triplicate samples will come from the same composited sample.

8. Fill out appropriate field form(s) documenting sampling-location description and coordinates, time, sampling device(s) used, and other pertinent information before leaving sampling site. Additionally, photo documentation and a GPS (global positioning system) location of the sample site will be taken.

Samples may be screened at the analytical laboratory to remove material greater than 2 millimeters. Analyses will be run on the sample that passes the 2-millimeter sieve. Sufficient fine-grained material (25 grams) must be present in sample jar for laboratory analysis. Coarse material should not be sent to the lab. Additional volume of sample will be sent to the laboratory if there is a question about providing adequate material.

5.7 Stream Sediment Sampling

The frequency for stream sediment sampling is different than for lake sediment sampling due to the dynamic changes expected from variation in streamflow. Stream sediment sampling will be carried out in close coordination with groundwater baseline hydrology and surface-water-quality work. Specifically, stream sediment samples will be collected concurrent with surface-water samples at 16 surface-water stations in June, July, and September 2005 (Table 4).

TABLE 4. Sediment sampling sites in sixteen streams at the Mine Site.

Stream	Sampling Location
Upper Talarik Creek	UT100B, UT100C, UT100D, UT100E, UT119A
North Fork Koktuli River	NK100A, NK100B, NK100C, NK119A
South Fork Koktuli River	SK100A, SK100B, SK100C, SK100F, SK100G, SK119A
Kaskanak Creek	KC100A

Sediment sampling sites are co-located with fish and macroinvertebrate sites.

Sediment samples will be analyzed for the parameters listed in Table 5.

TABLE 5. Summary of sediment analyses.

Analysis	Analytical Method
Total Metals	SW 3050/6020
Hg	SW 3050/7471
Total Cyanide	SM 4500CN-E
Chloride	EPA 300.0
Fluoride	EPA 300.0
Sulfate	EPA 300.0
Ammonia as N	SM 4500NH3

EPA — Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993 and Methods for the Determination of metals in Environmental samples, EPA/600/4-91-010, June 1991.

SM — Standard Methods for the Examination of Water and Wastewater, 20th Edition.

SW — U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third edition, September 1986.

6. WATER-CHEMISTRY SAMPLING

6.1 Surface-water Sampling

6.1.1 DH-81 Depth-Integrated Sampling

Analytical samples will be collected using an equal-discharge, depth-integrated technique. Depth-integration collection will be conducted using a DH-81 depth-integrated sampler where adequate depths permit its use. Depth-integration in shallow streams will be completed with a grab sample that is depth-integrated by hand. Equal-discharge collection will be conducted by dividing the stream into segments based on percent discharge. A minimum of eight depth-integrated sample collections is required at each site to fill all the sample bottles required for analyses. Iindividual depth-integrated samples will be composited in a 5-gallon plastic bucket. By taking the eight or more depth-integrated samples at estimated spacing and combining these before filling sample bottles, a complete discharge and depth-integrated sample will be collected. The only exception will be the collection of low-level mercury with a grab sample. Methods for depth-integrated sampling are described below:

1. Label sample bottles with sample site, analysis, date, time, sampler, and “HDR Pebble Project.”
2. Visually check DH-81 suspended sediment sampler for damage.
3. Decontaminate all parts of sediment sampler used including nozzle, body, gasket, and sample bottle. Spray with an Alconox solution and rinse several times with lots of deionized water.
4. Locate sampling sites by dividing the stream into areas with equal discharge. A minimum of four subsections should be sampled. If more sample volume is required, more subsamples will be taken by dividing the stream into more areas of equal discharge.

5. At the selected stream location, lower the sediment sampler into the stream with one continuous motion, making sure the sampler handle is vertical. Lower the sediment sampler to the streambed at a rate based on the rating curve for the nozzle size used and the velocity of the stream. The sample bottle should be just under half full upon encountering the streambed. Raise the sampler at a rate similar to the descent rate. The collection bottle should not be completely full upon removal from the stream. Pour contents of collection bottle into the clean 5-gallon bucket.
6. Repeat procedure until at least eight bottles have been collected.
7. Put on nitrile gloves and collect analytical samples from composite sample in 5-gallon bucket using a decontaminated dipper to pour water into the bottles. Do not allow bottle to fill completely such that preservative is not lost.
8. Fill out appropriate field form documenting sampling location, time, and other pertinent information before leaving sampling site.

6.1.2 Grab Sampling

Decontaminate sampling collection container if employed. After decontamination, put the double rinse collection container in stream water at a location downstream of the sampling point. In many cases, grab samples will be taken directly into the sample bottles and no decontamination will be necessary. Procedures for collecting grab samples are outlined below:

1. Label sample bottles with sample site, analysis, date, time, sampler, and ”HDR Pebble Project.”
2. Locate sampling site at a point in the stream exhibiting greatest flow and/or highest velocity.
3. Put on nitrile gloves and submerge sample collection container or sample bottle at sampling point such that mouth of container is 2 to 3 inches below the surface of the stream. Uncap bottle while below the surface of the water and fill slowly. If filling sample bottle directly, do not allow bottle to fill completely such that preservative is not lost.
4. Pour sample into sampling bottles if sampling collection container is used.
5. Fill out appropriate field form(s) documenting sampling location, time, and other pertinent information before leaving sampling site.

6.1.3 Sample Filtration

All dissolved metals samples will be filtered within 12 hours of the time they are collected. Samples will be filtered at the base camp after each field day. Sample filtration procedures are outlined below:

1. Label the dissolved metals sample bottle into which the filtered sample will be collected. Include sample site, analysis, date, time, sampler, and ”HDR Pebble Project.”
2. Put on nitrile gloves. Run silicone tubing through the peristaltic pump and attach a 0.45 micron filter cartridge to the end of the tubing. Place the other end of the tubing in the total metals sample bottle.
3. Fill the dissolved metals sample container.

4. If extremely turbid sample water is obtained, use same procedure using pre-filter (usually 3.0 micron) followed by 0.45 micron filtration.
5. Put dissolved metals sample bottle with other bottles from same site to be packaged for shipping.

6.2 Sampling Equipment Decontamination

Sampling equipment that will be decontaminated prior to collecting samples includes the DH-81 collection bottle, cap, and nozzle and the 5-gallon bucket used for compositing samples. Methods for decontaminating sampling equipment are outlined below:

1. Spray all parts of the equipment using a pre-mixed Alconox and Global deionized water solution. If there is obvious sediment or biological material on the equipment, use a brush to remove material.
2. Rinse the equipment using deionized water several times, and ensure that all traces of the Alconox solution and other materials are removed.
3. Immerse the equipment downstream of the sampling location, and rinse completely prior to collecting a sample.

During winter sampling events, below-freezing conditions prevent using spray bottles. In these conditions, the following methodology will be used:

1. Pour warm deionized water into the bucket or DH-81 sample bottle and scrub thoroughly with a clean brush.
2. Rinse the equipment using warm deionized water several times, and ensure that all traces of material are removed.
3. Immerse the equipment downstream of the sampling location, and rinse completely prior to collecting a sample.

6.3 Sample Handling

Samples will be stored in the field in coolers with frozen gel-ice at the method-required range of 4°C (+/- 2°C). If the sample coolers approach the warm end of the temperature range, coolers will be shipped via helicopter to Shaw staff at base camp to ensure that sample temperatures are maintained. The appropriate chain-of-custody procedures will be maintained in the event that samples are shipped via helicopter without the sampler present. During winter sampling events, samples are kept in plastic bags until transfer to Shaw staff at base camp at the end of each day.

Table 6 lists the sample containers, sample volumes, container types, and preservation requirements.

TABLE 6. Sample containers, sample volumes, container types, and preservation requirements.

Analytical Set	Bottle Type (SGS/NCA)	Bottle Type (CAS)	Analysis	Lab Method	Preservative	Hold Time	Req. Temp.	Comments
1	(1) 1L HDPE 1 extra volume for MS/MSD	(1) 1L HDPE no extra volume for MS/MSD	Total Hg	E1631	HNO_3	28 days	4°C	Unfiltered
			Total Metals (1)	E200.8/200.7	HNO_3	6 months	None	
2	(1) 1L HDPE 1 extra volume for MS/MSD	(1) 1L HDPE no extra volume for MS/MSD	Dissolved Metals (2)	E200.8/200.7	HNO_3	6 months	None	Filtered
3	(2) 250 ml HDPE no extra volume for MS/MSD	(1) 1L HDPE no extra volume for MS/MSD	Cyanide Total	4500CN-E	NaOH	14 days	4°C	Unfiltered
			Cyanide (weak acid dissociable)	4500CN-I				
4	500 ml HDPE no extra volume for MS/MSD	(1) 1L HDPE no extra volume for MS/MSD	Ammonia as N	SM4500-NH3-G	H_2SO_4	28 days	4°C	Unfiltered
			Phosphorus total	E365.3				
			Nitrate-nitrite total	E300.0, E353.2				
5	(2) 1L HDPE 2 extra volumes for TDS/TSS lab duplicates 60 ml Nalgene* (*Cl, F, SO_4 only) 1 extra volume for MS and 1 extra volume for lab duplicate	(2) 1L HDPE no extra volume for MS/MSD	TDS	E160.1 or SM2540C	None	7 days	4°C	Unfiltered
			TSS	E160.2		7 days		
			Alkalinity	2320B		14 days		
			Acidity	305.2		14 days		
			Specific conductance	SM2510B		28 days		
			pH	E150.1		24 hours		
			Chloride	E300.0		28 days		
			Fluoride	E300.0		28 days		
			Sulfate	E300.0		28 days		

Analytical Set	Bottle Type (SGS/NCA)	Bottle Type (CAS)	Analysis	Lab Method	Preservative	Hold Time	Req. Temp.	Comments
6	250 ml HDPE no extra volume for MS/MSD	250 ml HDPE no extra volume for MS/MSD	Thiocyanate	Lab SOP	HNO_3	28 days	4°C	Unfiltered
7	500 ml Fluoropoly no extra volume for MS/MSD	500 ml Fluoropoly no extra volume for MS/MSD	Low-level Hg	E1631	HCl	90 days	None	Unfiltered
8	See analytical set 4 above	1L HDPE Same bottle as analytical set 4	Nitrate-nitrite total	E353.2	H_2SO_4	28 days	4°C	Unfiltered
9	(3) 40 ml VOA vial with Teflon septum lid 6 extra VOA vials for MS/MSD	(3) 40 ml VOA vial with Teflon septum lid 6 extra VOA vials for MS/MSD	VOCs (or BTEX)	SW8260B	HCl	14 days	4°C	Unfiltered
10	(2) 1L amber glass jar with Teflon cap 4 extra volumes for MS/MSD	(2) 1L amber glass jar with Teflon cap 4 extra volumes for MS/MSD	SVOCs	SW8270C	None	7 days to extraction; 40 days to analysis of extract	4°C	Unfiltered
11	(2) 1L amber glass jar with Teflon cap 4 extra volumes for MS/MSD	(2) 1L amber glass jar with Teflon cap 4 extra volumes for MS/MSD	Pesticides/PCBs	SW508	None	7 days to extraction; 40 days to analysis of extract	4°C	Unfiltered

1 - Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl, Hardness, B

2 - Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, K, Ag, Na, Sb, V, Zn, As, Pb, Se, Sn, Tl, B, Si

BTEX = benzene, toluene, ethylbenzene, xylene

MS/MSD = matrix spike/matrix spike duplicate

PCB = polychlorinated biphenyl

TDS = total dissolved solid

TSS = total suspended solid

6.3.1 Sample Identification

Sampling locations will be identified on the field forms and in the log books. Sample identification will follow the methodology described below:

0105CR199ASW001

Where 0105 is the month and year (January 2005),
CR199A is the location ID (see Figure 1),
SW is the matrix code for surface water, and
001 is a sequential sample number.

Additional matrix codes to be used under this field sampling plan include:

SP for seeps

Additional sequential sample numbers are as follows:

201 – field duplicates,
301 – field triplicates,
401 – field equipment rinse blanks,
501 – deionized water blanks, and
601 – trip blanks.

For trip blanks, laboratory codes are used for the station ID. The only trip blanks included under this field sampling plan are for low-level mercury analyses that will be submitted to Columbia Analytical Services and North Creek Analytical. Sample identification for a mercury trip blank collected in January 2005 is 0105CASKTBSW601 for CAS and 0105NCAPTBSW601 for NCA. If additional trip blanks are used on the same date, increase the sequential sample number to 602, etc.

6.4 Sample Custody

Samples will be kept with field staff during the day unless warm conditions or excess weight on the helicopter become an issue, at which point they will be sent back to Shaw staff at base camp. The appropriate sample custody procedures—which include signatures, dates, and times by both the person in possession of the samples and the receiver of the samples—will always be followed during sample transfer. This may include transfers between samplers and Shaw staff. HDR will enter samples in the Shaw Transfer Log at the end of each day.

Chain-of-custody (COC) forms will accompany each cooler shipped to analytical laboratories. The e-Chain program will be used to generate electronic COC forms by a Shaw Environmental Sample Custodian. Once the COC form is completed, insert the COC form in a ziplock bag and seal the bag. Tape the ziplock bag with the COC form to the inside of the cooler lid. Other chain-of-custody components will include sample labels, custody seals, field notebook, cooler tracking log, sample shipment receipts, and the laboratory logbook.

Sample coolers will be packed by a Shaw Environmental Sample Custodian according to the following procedures:

1. Place a layer of bubble wrap in the bottom of the cooler and around the sides.
2. Place glass containers in individual bubble-wrap sleeves. Place sample containers and temperature blank on the bubble wrap.
3. Secure containers from tipping over by placing packing material in/around containers; frozen gel-ice will also be used where possible.
4. Place a minimum of two layers of frozen gel-ice over the containers. Pack coolers with 50 percent gel-ice and 50 percent samples.
5. Place bubble wrap over the gel-ice and fill remaining void space to secure containers from vertical movement.
6. Close cooler and secure the lid with strapping tape by wrapping tape around the entire cooler and back onto itself. Press tape to secure it to cooler, especially on the bottom to prevent tape from ripping when coolers are slid across a surface.
7. Attach two signed, dated, and timed custody seals onto cooler lid, one on the front and one on the back of the cooler.
8. Attach shipping label that includes the chain-of-custody ID to the top of cooler.
9. Complete the Anchorage to Iliamna columns in the Cooler Tracking Form.

Sample coolers will be shipped from Iliamna, to Anchorage via Iliamna Air Taxi (or other airport-to-airport service) where a Shaw Environmental Cooler Custodian will receive them, packs the coolers, and arranges delivery to one of three analytical laboratories. Coolers designated to go to SGS will be hand delivered, and coolers designated to go to Columbia Analytical Services (CAS) and North Creek Analytical (NCA) will be shipped by Alaska Airlines Gold Streak (or other airport-to-airport equivalent). The following procedures provide shipping protocol for shipping laboratory samples from Iliamna to analytical laboratories.

1. Complete and place the following shipping information on the coolers for shipment from Iliamna to Anchorage:

   Shaw Environmental, Inc.
   Anchorage Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   COOLER Identification Number:

2. Place "Keep Chilled" labels on the coolers.
3. Deliver the samples to Iliamna Air Taxi (or other airport-to-airport service) and complete the airbill information for shipment. Write on the airbill:

   Shaw Environmental, Inc.
   Anchorage Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   "KEEP COOL"

4. Complete the Cooler Tracking Log for Iliamna to Anchorage shipping and convey the information to the Shaw Environmental Cooler Custodian in Anchorage as soon as possible.

After the coolers arrive in Anchorage, the Shaw Environmental Cooler Custodian will immediately take possession of the coolers and will use the following protocol to deliver the coolers to the appropriate laboratory.

1. Complete the time and date received and custody seal time and date columns in the Cooler Tracking Log.
2. Verify all coolers that were shipped have been received.
3. Evaluate necessity for gel-ice change-out. For coolers shipped to CAS and NCA, evaluate if the time and date recorded on the custody seal is recent enough (within 12 hours) to ship the coolers to the destination laboratory and keep the samples at 4^{o}C or less. Take into account the following information for the time required for coolers to arrive at the destination laboratory:
    a. CAS has courier service available to pick up samples at the Portland Airport Monday through Friday. Delivery to the lab is a minimum of one hour depending on other pickups in the Portland area. CAS sample receiving hours are from 8AM to 5PM Monday through Friday and from 8AM to 2PM on Saturday. CAS does have swing-shift staff working to receive samples and put them into cold storage if they arrive after normal business hours. On the day before a Saturday delivery, the Shaw Environmental Sample Custodian will contact CAS and notify them of all sample shipments and airbill numbers and arrange for Saturday delivery.
    b. NCA has courier service to pick up samples from the Portland airport for delivery to their lab. NCA will be notified of the shipment, its airbill number, and its arrival. NCA sample receiving will be notified on weekdays. NCA sample receiving is from 7AM to 6PM, Monday through Friday. NCA is typically closed on weekends, and arrangements need to be made the previous Friday for weekend receiving.
    c. SGS sample receiving is Monday through Friday 8AM to 6PM and sometimes on Saturday from 9AM to noon by prior arrangement. Saturday delivery will be coordinated the previous day.
4. Ship the coolers going to CAS and NCA via Alaska Airlines Gold Streak (or other airport-to-airport equivalent) as soon as possible. Samples shipped to CAS and NCA need to be shipped to the Portland airport. Shipping samples from Anchorage to Portland can take from 5 to 9 hours to arrive. During normal business hours, samples shipped from Anchorage at noon will be available for pickup in Portland the following morning. Thus, any shipments on Friday will not be picked up until Monday unless special arrangements are made. In this situation, the Cooler Custodian will emphasize to the shipper that the coolers must be kept chilled and that they have sufficient gel-ice. If coolers cannot be chilled, the Cooler Custodian will store the samples over the weekend in a refrigerator. For samples that are held in the Shaw Environmental office, COC procedures will be adhered to. The samples that are held over will be repacked with frozen gel-ice and shipped as soon as possible. Write the following information on the airbill:

    "By Way of Portland" for samples shipped to CAS.
    "KEEP CHILLED"

"Notify On Arrival:" (enter respective name and number of lab contact from information provided below)

5. Hand deliver the coolers going to SGS in Anchorage.
6. Complete the date and time shipped, shipping method, airbill number, and shipped to columns on the Cooler Tracking Log.
7. Contact the respective lab and inform them of cooler shipment, airbill number, and anticipated arrival time. Complete the contact date and time column in the Cooler Tracking Log.
8. Continue tracking the shipped coolers until the laboratory receives them and takes custody. Complete laboratory time and date columns in the Cooler Tracking Log.

Laboratory Contacts: The following are the addresses and contacts for the respective laboratories.

COLUMBIA ANALYTICAL SERVICES, INC.
1317 S. 13th Ave
Kelso, WA 98626-284
Phone: (360) 577-7222
Fax: (360) 636-1068
Project Chemist: Lynda Huckestein
LHuckestein@kelso.caslab.com
Direct: (360) 501-3358

NORTH CREEK ANALYTICAL
9405 SW Nimbus Avenue
Beaverton, OR 97008-7132
Phone: (503) 906-9200
Fax: (503) 906-9210
Project Chemist: Crystal Jones
CJones@ncalabs.com
Direct: (503) 906-9234

SGS/CT&E ENVIRONMENTAL SERVICES
200 W Potter Dr
Anchorage, AK 99518-1605
Phone (907) 562-2343
Fax (907) 561-5301
Project Chemist: Steven R. Crupi
steve_crupi@sgs.com

6.5 Field Quality Control Samples

6.5.1 Deionized Water Blank

One deionized water blank will be collected for each sampling event for total metals. The deionized water used for decontamination will be collected in an empty total metals analysis bottle and submitted to the primary laboratory. The water for the deionized blank is provided by the laboratory conducting the analysis. Deionized water blanks are required for primary and QA laboratories.

6.5.2 Equipment Blank

Equipment blanks will be collected at a frequency of 5 percent and submitted for dissolved metals analysis. The procedure for collected the equipment blank is outlined below:

1. Decontaminate the DH-81 and 5-gallon bucket as described in Section 6.2 after sampling at a site.
2. Pour deionized water into the DH-81 sample bottle and dispense through the nozzle into the 5-gallon bucket.
3. Label the dissolved metals bottle with "equipment blank," the sample site previous to collection, analysis, date, time, sampler. and "HDR Pebble Project."
4. Collect the dissolved metals sample from the 5-gallon bucket.

6.5.3 Trip Blank

Trip blanks will be provided for the low-level mercury and VOCs analyses and will accompany the field staff into the field for each field day. The trip blank that accompanies the field team at each sampling site will be noted on the sampling form. At the end of each field day, the trip blank will be provided to Shaw staff and will be packaged and sent with the samples that it accompanied during the field day.

6.5.4 Field Duplicates

Field duplicates are the quality control sample and will be collected at a frequency of 10 percent during all sampling events for all parameters and will be analyzed by the primary laboratory.

6.5.5 Field Triplicates

Field triplicates are the quality assurance sample and will be collected at a frequency of 10 percent during all sampling events for all parameters and will be analyzed by the QA laboratory.

6.5.6 Matrix Spikes

Matrix spikes will be collected at a frequency of 10 percent during all sampling events for analysis by the primary laboratory. Matrix spikes are not required for QA samples.

7. MEASUREMENT OF FIELD PARAMETERS

7.1 Parameters

Two field meters (YSI 556 and Hach 2100P) will be used to measure the following parameters: specific conductance, temperature, pH, dissolved oxygen, oxidation-reduction potential, and turbidity. The procedure for collecting field measurements is outlined in Section 7.4.

7.2 Equipment Calibration and Quality Control

7.2.1 YSI 556

The YSI 556 meters will be calibrated for four parameters: dissolved oxygen, pH, specific conductance, and oxidation-reduction potential (ORP). Procedures for calibrating for each parameter are provided below. Prior to calibrating the instrument, clean the sensors with an Alconox solution and rinse several times with deionized water. Shake off excess water prior to immersing the probe in the calibration cup with solution. Make sure that the sensors are covered when running the calibration. Used calibration solution can be used to rinse the sensors prior to calibration to provide an extra level of accuracy.

To enter calibration mode:

1. Press the on/off key to display the run screen.
2. Press the escape key to display the main menu screen.
3. Use the arrow keys to highlight the calibrate selection.
4. Press the enter key. The calibrate screen is displayed.

Conductivity:

1. On the calibrate screen, select conductivity and press enter.
2. Select specific conductance and press enter. Note that calibrating to specific conductance will also calibrate conductivity and salinity.
3. Place 55 ml of the 1.413 µS/cm conductivity solution in the clean, dry calibration cup and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the conductivity cell. Make sure that the conductivity sensor is completely immersed past the vent hole.
5. Tighten the calibration cup onto the probe module.
6. Enter the calibration value: 1.413 µS/cm. Note that the value for specific conductivity is always in µS/cm at 25°C.
7. Press enter and allow at least one minute for the temperature to stabilize. Note the temperature of the calibration solution for the pH and ORP calibrations.

8. When the specific conductivity reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
9. Press escape to return to the calibrate screen.
10. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

Dissolved Oxygen:

1. On the calibrate screen, select dissolved oxygen and press enter.
2. Select DO% and press enter. Note that calibrating to DO% will also calibrate dissolved oxygen (DO) mg/L.
3. Place 1/8 inch of water into the calibration cup, and place the probe module into the cup making sure that the DO and temperature sensors are NOT immersed in the water.
4. Secure the cup to the module by securing only 1 or 2 threads to ensure that the DO sensor is vented to the atmosphere.
5. Use the keypad to enter the local barometric pressure. Barometric pressure (BP) readings from the Iliamna airport can be obtained at http://weather.noaa.gov/weather/current/PAIL.html. Note that these readings have been adjusted for sea level and must be corrected to obtain the pressure at the correct altitude. The following calculation must be performed to convert the units from inches Hg to millimeters (mm) Hg and to adjust for the local elevation in the mine area:
    a. Corrected BP (inches Hg) x 25.4 = Corrected BP (mm Hg)
    b. True BP = Corrected BP (mm Hg) – (2.5 * (altitude/100))
6. Allow 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate. When the DO% reading shows no significant change for 30 seconds, press enter. Press enter again to accept the calibration.
7. Press escape to return to the calibration menu.

pH:

1. On the calibrate screen, select pH and press enter.
2. Select 3 point and press enter. A 3 point calibration is used to correctly read surface waters that are both basic and acidic.
3. Place 30 ml of the first pH buffer in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the pH sensor. Make sure that the sensor is completely immersed.
5. Tighten the calibration cup onto the probe module.
6. Enter the value of the pH buffer at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration for the pH and ORP.

7. Press enter and allow at least one minute for the temperature to stabilize.
8. When the pH reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
9. Press enter to return to the specified pH calibration screen.
10. Rinse the probe module, calibration cup, and sensors in deionized water and dry.
11. Repeat steps 3 through10 for the second and third buffer solutions.
12. Press escape to return to the calibrate screen.
13. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

ORP:

1. On the calibrate screen, select ORP and press enter.
2. Place 30 ml of the ORP solution in the clean, dry calibration cup, and immerse the sensors in the solution.
3. Rotate or move the probe module up and down to remove any bubbles from the ORP sensor. Make sure that the sensor is completely immersed.
4. Tighten the calibration cup onto the probe module.
5. Enter the value of the ORP solution at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration for the pH and ORP.
6. Press enter and allow at least one minute for the temperature to stabilize.
7. When the ORP reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
8. Press escape to return to the calibrate screen.
9. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

7.2.2 Hach 2100P Turbidimeter

Routine calibration checks will be performed on the 2100P Turbidimeter using the Gelex secondary turbidity standards. The Gelex standards must have values assigned to them immediately after calibration has been performed with formazin in order to be used for checking the calibration in the future. These standards will be used as a calibration check prior to every field day. If the readings are outside 5 percent accuracy, the instrument will be recalibrated using the StablCal stabilized formazin standards. A recalibration will be performed at a minimum of once every three months. Methods for calibrating the turbidimeter using the formazin standards, assigning values to the Gelex secondary standards, and checking the calibration are outlined below.

Calibration:

1. If the StablCal standards have been sitting for longer than one month, they must be shaken to break the condensed suspension into its original particle size. If the standards are used on a weekly interval, start at step 2 below. Standards <0.1 nephelometric turbidity units (NTU) should not be shaken.
    a. Shake the standard vigorously for 2 to 3 minutes to resuspend any particles.
    b. Allow the standard to stand undisturbed for 5 minutes.
2. Gently invert the bottle 5 to 7 times.
3. Prepare the sample cell.
    a. Clean the cell using an Alconox solution and a deionized water rinse.
    b. Allow the cell to air dry. Handle the cell by the top to avoid scratching or contaminating the glass surface.
    c. Apply a small bead of silicone oil to the surface of the cell and rub with a lint-free cloth. Note that the cloth will absorb oil, and after a few applications, it will suffice to simply rub the cloth over the cell. Avoid using too much oil; the cell should appear dry with little or no visible oil.
4. Turn on the instrument by pressing I/O.
5. Press CAL. The CAL and SO icons will display indicating that it is calibrating the first standard at 0 NTU.
6. Rinse the sample cell one time with the standard and discard the rinse.
7. Fill the cell with the first standard. Cap the cell and let stand for one minute.
8. Insert the cell in the compartment by aligning the orientation mark on the cell with the mark on the front of the compartment.
9. Close the lid.
10. Press → to get a numerical display.
11. Press READ. The instrument will count from 60 to 0 and then switch to the next standard.
12. Repeat steps 6 through 11 for the three remaining standards.
13. When the last standard is done, the display will increment back to S0. Press CAL to accept the calibration and the instrument will return to measurement mode.
14. If E1, E2, or CAL? are flashing after the CAL button is pressed, check the standards and repeat the calibration. Refer to the instrument manual for troubleshooting guidelines.

Assigning values to the Gelex secondary standards:

1. Only assign values to Gelex standards after completing a calibration using formazin standards. Select automatic range mode using the RANGE key.

2. Thoroughly clean the outside of the Gelex vials and apply a thin coating of silicone oil. See step 3 above for instructions on preparing a sample cell.
3. Place the 0-10 NTU Gelex standard in the cell compartment and align the diamond on the vial with the orientation mark on the instrument. Close the lid and press READ.
4. Mark the value on the band near the top of the vial.
5. Repeat steps 2 through 4 for each Gelex standard.

Checking calibration:

1. Check the instrument calibration using the Gelex standards.
2. If the readings are not with 5 percent of the previously established values, recalibrate using the StablCal stabilized formazin standard.

7.3 Equipment Maintenance and Decontamination

Field meters will be decontaminated prior to calibration or if there is visible sediment or biological material on the probe or sensors. Decontamination procedures are outlined below:

1. Spray all parts of the equipment using a pre-mixed Alconox and deionized water solution. If there is obvious sediment or biological material on the equipment, lightly brush to remove material.
2. Rinse the equipment using deionized water several times and ensure that all traces of the Alconox solution and other materials are removed.

Maintenance procedures for the Hach 2100P that will be performed in the field include cleaning and battery and lamp replacement. Maintenance for the YSI 556 includes cleaning of sensors and replacement of the dissolved oxygen membrane. Complete descriptions of these procedures can be found in the instrument manuals, which will be kept with the instruments at all times. If maintenance and troubleshooting procedures in the instrument manuals are insufficient, the instruments will be sent to their respective manufacturers for repair.

7.4 Collection of Field Measurements

YSI 556

1. Turn the YSI 556 on and place the probe module in the YSI confidence solution and check the readings. If the pH does not agree within 0.1 units or the other parameters are not within 5 percent, recalibrate the instrument.
2. Place the probe in the stream and allow it to equilibrate at least 5 minutes or until the dissolved oxygen is steady prior to recording the readings for pH, specific conductance, dissolved oxygen, and ORP.

Hach 2100p

1. Decontaminate the sample cell using an Alconox solution and several rinses with deionized water. Be careful to handle the cell by the top to avoid smudging or scratching the glass.
2. Collect the sample from the stream or seep in a clean container, transfer to the sample cell, and cap the sample cell.
3. Wipe the cell with a clean, lint-free cloth to remove fingerprints and water.
4. Apply a thin film of silicone oil. Wipe with a clean, lint-free cloth to create an even film on the surface of the cell.
5. Turn on the instrument and place on a flat, sturdy surface.
6. Place the sample cell in the instrument compartment making sure that the mark on the cell aligns with the mark on the compartment. Close the lid.
7. Hit the RANGE key until AUTO RNG is displayed.
8. Press READ, the final measurement will display after approximately 13 seconds. If the reading is very unstable, press the SIGNAL AVERAGE key to average 10 measurements; this takes approximately 20 seconds.
9. Record the reading on the data sheet for turbidity.

8. RECORD KEEPING

All records will be made in waterproof ink unless weather conditions prevent its use. Corrections will be made by drawing a line through the corrected entry and initialing and dating the line. All corrections will remain legible.

8.1 Field Log Books

Field log books will be used to record any deviations from the sampling methods and additional notes which are not recorded on the field forms. Calibration log books will be maintained for each field parameter meter used for the entire sampling season. The data in the calibration log books will include the name of the person doing the calibration, date and time, calibration solution and expiration date, and the reading versus the calibration value.

8.2 Field Forms

Field forms will be used to record all field data, including the location of the sampling station (Table 7 and Figure 1), recorded measurements, and primary and quality control samples collected at the site (see Appendix A). Improvements to field forms may be made throughout the year as needed.

TABLE 7. 2005 hydrology and surface-water-quality site locations.

Site ID	Degrees, Decimal Minutes WGS 84		Decimal Degrees WGS 84	
	Longitude	Latitude	Longitude	Latitude
KC100A	W155.°42.129'	N59.°43.402'	-155.702150	59.723367
KR100A	W155.°50.262'	N59.°52.660'	-155.837700	59.877667
NK100A	W155.°43.136'	N59.°50.584'	-155.718933	59.843067
NK100B	W155.°25.541'	N59.°26.073'	-155.425700	59.934550
NK100C	W155.°24.595'	N59.°55.822'	-155.409917	59.930367
NK119A	W155.°24.104'	N59.°55.088'	-155.401700	59.918130
NK119B	W155.°24.703'	N59.°55.633'	-155.411717	59.927217
SK100A	W155.°46.545'	N59.°50.010'	-155.775750	59.833500
SK100B	W155.°31.452'	N59.°47.591'	-155.524200	59.793183
SK100B2	W155.°48.652'	N59.°26.329'	-155.43881	59.81086
SK100C	W155.°24.857'	N59.°48.777'	-155.414283	59.812950
SK100D	W155.°18.159'	N59.°49.084'	-155.302650	59.818067
SK100F	W155.°16.877'	N59.°50.909'	-155.281283	59.848483
SK100G	W155.°17.083'	N59.°52.457'	-155.284717	59.874283
SK119A	W155.°25.693'	N59.°49.326'	-155.428217	59.822100
SK124A	W155.°22.009'	N59.°41.523'	-155.366816	59.692200
SK131A	W155.°16.503'	N59.°52.146'	-155.275050	59.869100
SK133A	W155.°17.917'	N59.°52.369'	-155.298617	59.872817
SK134A	W155.°17.577'	N59.°52.937'	-155.292950	59.882283
SK136A	W155.°17.182'	N59.°53.222'	-155.286367	59.887033
SK136B	W155.°18.639'	N59.°53.887'	-155.310650	59.898117
UT100A	W155.°18.013'	N59.°43.241'	-155.300217	59.720683
UT100B	W155.°15.215'	N59.°47.215'	-155.253583	59.786917
UT100D	W155.°11.995'	N59.°54.481'	-155.199917	59.908017
UT100E	W155.°16.637'	N59.°55.090'	-155.277283	59.918167
UT119A	W155.°15.372'	N59.°47.461'	-155.250600	59.791020
UT119B	W155.°18.466'	N59.°47.977'	-155.307767	59.799617
UT135A	W155.°09.289'	N59.°53.042'	-155.154817	59.884033
UT138A	W155.°11.430'	N59.°54.510'	-155.190500	59.908500
UT141A	W155.°13.913'	N59.°54.295'	-155.231883	59.904917
UT146A	W155.°15.884'	N59.°54.625'	-155.264733	59.910417

9. FIELD PERFORMANCE AND SYSTEM AUDITS

During the March 2005 sampling event, Shaw Environmental, Inc., performed a field performance and system audit based on the 2004 sampling plan. A Shaw employee accompanied each field team to the field to audit compliance with the protocols for both hydrology and water-quality monitoring. Sample handling and equipment calibration and maintenance procedures also were reviewed at base camp. The audit results were provided by Shaw staff to HDR field members and reviewed to ensure that field sampling protocols are being followed or modified appropriately when necessary in order to meet the data quality objectives. Based on the methods provided in this 2005 field sampling plan, a second audit will be performed during one field event in the summer.

10. REFERENCES

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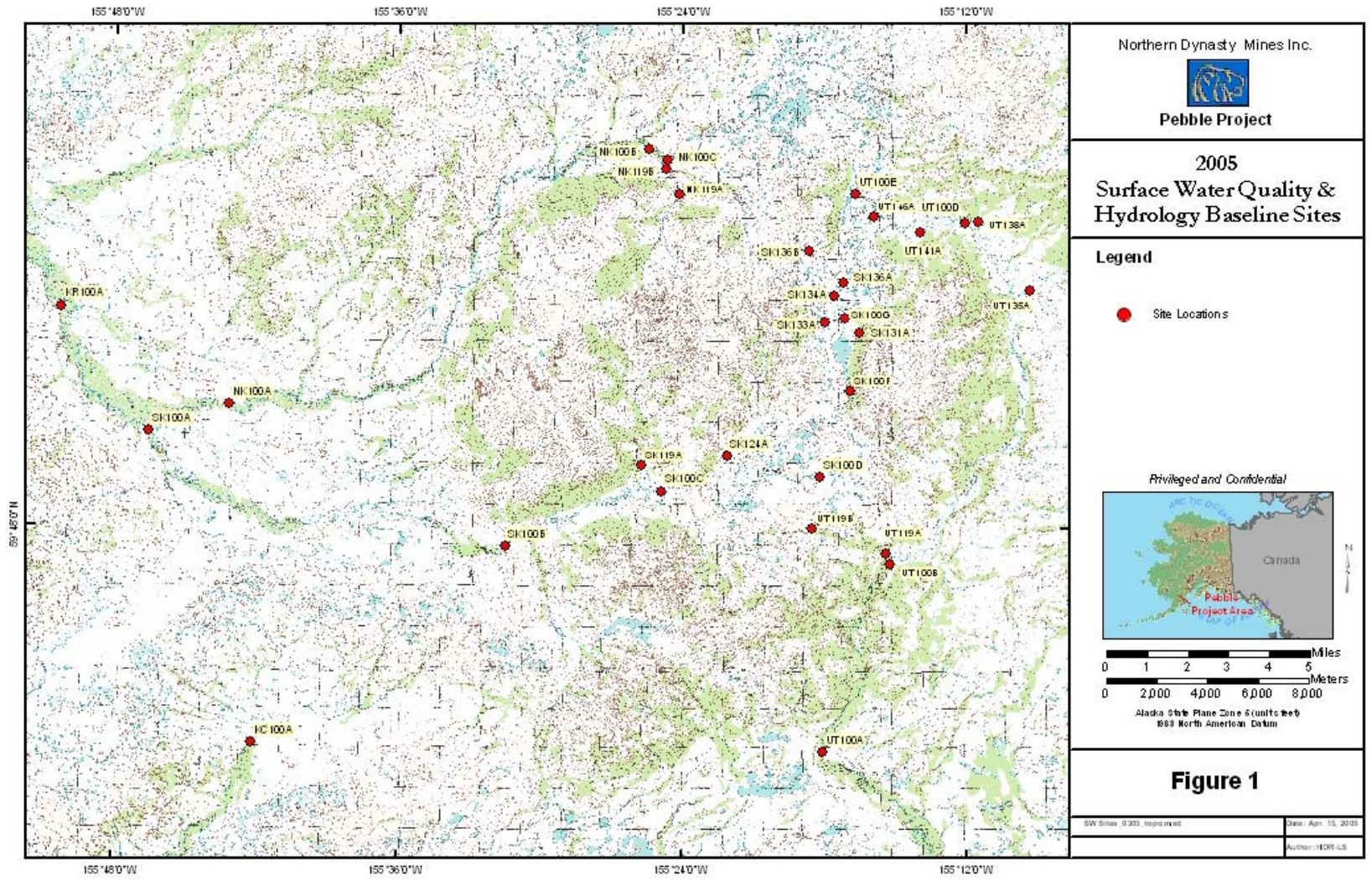
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155°48'0"W
155°36'0"W
155°24'0"W
155°12'0"W
59°48'0"N
NK100B
NK100C
NK119B
NK119A
UT100E
UT146A
UT100D
UT138A
UT141A
SK136B
SK136A
SK134A
UT135A
SK100G
SK133A
SK131A
SK100F
KR100A
NK100A
SK100A
SK124A
SK119A
SK100C
SK100D
UT119B
UT119A
SK100B
UT100B
MC100A
UT100A
Northern Dynasty Mines Inc.
Pebble Project
2005
Surface Water Quality & Hydrology Baseline Sites
Legend
Site Locations
Privileged and Confidential
Canada
Pebble Project Area
Miles
0 1 2 3 4 5
Meters
0 2,000 4,000 6,000 8,000
Alaska State Plane Zone 5 (units feet)
1983 North American Datum
Figure 1

Appendix A:

Surface-water Quality and Hydrology Field Form

June 2005
Discharge/ Water Quality Measurements
Pebble Project - Mine Site

Station ID:	**Date:**	**Start Time :** **End Time:**	**GPS - Lat:**
Team:		**Site Observer/ Bear Guard:**	**Long:**
Photos:	**Camera:**	**Weather: Air** **º (F) (C)** **Wind:**	**Precip:**
Sample Matrix: (SW) (Seeps)		**(Sediments): Streams Lakes Seeps**	
Seep Measurement Method: (Weir) (Direct catch estimate) (Flow channel estimate)			**Estimated % Capture:**

HYDROLOGY

Method: (Wade) (Ice) (Boat)	**Type of meter: (M. McBirney) (AA) (Pygmy)**	**Meter #:**	**Spin test: (Y) (N)**
Gage Height: **Time:**	Measurement estimated error: (Excellent) (Good) (Fair) (Poor)		
	Based on following conditions:		

WATER QUALITY

In-situ Field Parameters

Meter Make and Model: _____
Meter Make and Model: _____
Meter Number: _____

Sample Type

Duplicate: Y N
Triplicate: Y N
MS/MSD: Y N

Meter Readings

Temperature: _____ ℃
Conductivity: _____ mS/cm
DO: _____ % saturation
DO: _____ mg/L
pH _____ STD units
ORP: _____ mV
Turbidity: NTU

Additional Comments:

Sketch, Notes and Remarks

June 2005
Instantaneous Flow Measurements
Pebble Project - Mine Site

Site: _____ **Type of meter: (M. McBirney) (AA) (Pygmy)** **Measurement No.: 2005 - 5**

Date: _____ **Meter #:** _____

Time: _____

Team:

Angle Coef. (deg)	Notes	Section #	Dist. (ft)	Depth (ft)	VELOCITY At Depth .6 (fps)	VELOCITY At Depth .2 (fps)	VELOCITY At Depth .8 (fps)	Time (sec)	Revo-lutions	Adjust for Angle Coef.	Adjusted Velocity (fps)	Area (s.f.)	Discharge (cfs)	Description
	Bank	0												
		1												
		2												
		3												
		4												
		5												
		6												
		7												
		8												
		9												
		10												
		11												
		12												
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		27												
		28												
		29												
		30												
		31												
		32												
		33												
		34												
		35												
TOTAL														**Page 2 of 2**

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES

FIELD SAMPLING PLAN

SURFACE WATER - ROAD / PORT

NOVEMBER 2005

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APPENDIX

Field Forms:

Sample Transfer Log
Field Notes (Example)
Surface-Water Field Form (Blank and Example)
Field Discharge Measurements (Blank and Example)
Field Observer Form
Field Sampling Plan Acknowledgement Form

ACRONYMS AND ABBREVIATIONS

ADOT&PF	Alaska Department of Transportation and Public Facilities
BEESC	Bristol Environmental and Engineering Services Corporation
BP	barometric pressure
°C	degrees Celsius
CAS	Columbia Analytical Services
cm	centimeter(s)
COC	chain of custody
DI	deionized
DM	discharge measurement
DO	dissolved oxygen
FSP	field sampling plan
GS	gauge station
HDPE	high density polyethylene
kg	kilogram(s)
L	liter(s)
µg	microgram(s)
µS	microsiemen(s)
mg	milligram(s)
ml	milliliter(s)
mS	millisiemen(s)
mV	millivolts
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NCA	North Creek Analytical
NDM	Northern Dynasty Mines, Inc.
NTU	nephelometric turbidity unit(s)
ORP	oxidation reduction potential
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
SD	sediment sample
SGS	SGS Laboratories

SOP	standard operating procedure
TDS	total dissolved solids
TSS	total suspended solids
USGS	U.S. Geological Survey
WAD	weak acid dissociable
WS	surface water-chemistry sample

1.0 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 Baseline Environmental Studies, Proposed 2005 Study Plan* (NDM, in press).

The purpose of this field sampling plan (FSP) is to detail tasks and establish field procedures for conducting a study of surface-water hydrology and chemistry, and sediment chemistry. The field work for this study will involve collecting and analyzing surface-water samples from waterways along the proposed road corridor and collecting sediment samples from ponds and waterways along the proposed road corridor. 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.

The surface-water studies for the road/port will be conducted by Bristol Environmental and Engineering Services Corporation (BEESC) under direct contract to Northern Dynasty Mines Inc. (NDM). The study area includes the preferred road corridor, as identified by the Alaska Department of Transportation and Public Facilities (ADOT&PF), between the mine site and Cook Inlet and will also include the area surrounding the proposed port site as shown in Figure 1. The corridor will be one mile in width along the defined alignment.

Sampling is intended to characterize baseline concentrations of naturally occurring compounds in surface water along the road corridor and at the port site for evaluation of potential environmental impacts associated with development of the project and for evaluation of potential future ecological risks associated with dust migration.

2.0 PROJECT SCOPE AND OBJECTIVES

2.1 OBJECTIVES

The objectives of the baseline surface-water hydrology portion of this program include the following:

- Characterize stream drainage basins based on size, slope, vegetative cover, and other factors.
- Collect streamflow data to be used in predicting potential peak- and low-flow conditions.
- Collect data for evaluation of proposed facilities including water-management and water-supply structures.

The main objectives of the water-quality portion of this study are as follows:

- Collect baseline data to provide defensible documentation of the naturally occurring levels and variability of trace elements in surface water.
- Provide a database for the site water chemistry and site loading models for project design and environmental impact assessment.
- Develop the baseline for the evaluation of potential environmental impacts during construction, operation, and closure of the road and port facilities.

Sediments will be collected within the road corridor and at the port facility. The objectives of the trace elements study are as follows:

- Collect baseline data to provide defensible documentation of the naturally occurring levels and variability of trace elements in sediments including their spatial and temporal variability, prior to mining operations.
- Provide a database for the site sediment chemistry and site loading models for project design and environmental impact assessment.
- Develop the baseline for the evaluation of potential environmental impacts during construction, operation, and closure of the road and port facilities.

The information to be gathered in the water-quality and sediment studies is key to understanding current conditions along the road corridor and at the port site and will provide a baseline for the evaluation of future potential environmental impacts to surface water and sediments along the road corridor and at the port site.

2.2 SAMPLE ANALYSIS SUMMARY

Surface-water and sediment samples will be collected from fresh water streams along the preferred road corridor—identified by ADOT&PF—between the Newhalen River and Cook

Inlet, including the area surrounding the port site (ADOT&PF, 2005). Sediment samples will also be collected from the deposition areas of five ponds along the road corridor.

The surface-water (Table 1) and sediment (Table 2) analyses methods and method reporting limits are detailed in the *Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (QAPP; NDM, 2005).

Table 1. Surface-water Analytes for Laboratory and Field Determination

Analyte	Method	Method Reporting Limit, µg/L
Aluminum, total and dissolved	E200.8	1.0
Antimony, total and dissolved	E200.8	0.05
Arsenic, total and dissolved	E200.8	0.5
Barium, total and dissolved	E200.8	0.05
Beryllium, total and dissolved	E200.8	0.02
Bismuth, total and dissolved	E200.8	0.1
Boron, total and dissolved	E200.7/200.8	0.5
Cadmium, total and dissolved	E200.8	0.02
Calcium, total and dissolved	200.7	50
Chromium, total and dissolved	E200.8	0.2
Cobalt, total and dissolved	E200.8	0.02
Copper, total and dissolved	E200.8	0.1
Iron, total and dissolved	E200.7/200.8	20
Lead, total and dissolved	E200.8	0.02
Magnesium, total and dissolved	E200.7/200.8	20
Manganese, total and dissolved	E200.8	0.05
Mercury, total	E1631	0.005
Molybdenum, total and dissolved	E200.8	0.05
Nickel, total and dissolved	E200.8	0.2
Potassium, total and dissolved	E200.7/200.8	50
Selenium, total and dissolved	E200.8	1
Silicon, dissolved	E200.8	100
Silver, total and dissolved	E200.8	0.02
Sodium, total and dissolved	E200.7/200.8	100
Thallium, total and dissolved	E200.8	0.01
Tin, total and dissolved	E200.8	0.1
Vanadium, total and dissolved	E200.8	0.2
Zinc, total and dissolved	E200.8	0.5
pH	E150.1	N/A
Specific conductance	SM20 2510B	2 (µS/cm)

Analyte	Method	Method Reporting Limit, µg/L
Alkalinity	SM20 2320B	10 (mg/L)
Acidity	E305.2	10 (mg/L)
Ammonia	SM20 4500NH3-G	0.1 (mg/L)
Chloride	E300.0	0.2 (mg/L)
Cyanide-total	SM20 4500CN-E	0.01 (mg/L)
Cyanide-WAD	SM20 4500CN-I	0.01 (mg/L)
Fluoride	E300.0	0.1 (mg/L)
Hardness (total)	SM20 2340B	N/A
Nitrate + Nitrite	E300.0	0.1 (mg/L)
Phosphorus-total	E365.3	0.01 (mg/L)
Sulfate	E300.0	0.2 (mg/L)
Total dissolved solids	E160.1	10 (mg/L)
Total suspended solids	E160.2	5 (mg/L)
Thiocyanate	Lab SOP	1 (mg/L)
Field Parameters	**Units**	**Sensitivity**
Temperature	Degrees Celsius	0.01
Dissolved Oxygen	mg/L	0.01
Dissolved Oxygen	%	0.1
Specific Conductance	mS/cm	0.001
pH	Standard Units	0.01
Turbidity	NTU	0.01
Oxidation reduction potential	mV	0.1

Notes:

E – Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991.

SM – Standard Methods for the Examination of Water and Wastewater, 20th Edition.

SOP = standard operating procedure

WAD = weak acid dissociable

µg/L = micrograms per liter

µS/cm = microsiemens per centimeter

mg/L = milligrams per liter

mS/cm = millisiemens per centimeter

NTU = nephelometric turbidity unit

mV = millivolts

N/A = not applicable

Table 2. Sediment Analytes for Laboratory Determination

Analyte	Method	Method Reporting Limit, mg/kg
Aluminum	SW3050/6020	2.0
Antimony	SW3050/6020	0.05
Arsenic	SW3050/6020	0.5
Barium	SW3050/6020	0.05
Beryllium	SW3050/6020	0.02
Bismuth	SW3050/6020	0.05
Boron	SW3050/6010B	20
Cadmium	SW3050/6020	0.05
Calcium	SW3050/6020	10
Chromium	SW3050/6020	0.2
Cobalt	SW3050/6020	0.02
Copper	SW3050/6020	0.1
Iron	SW3050/6020	4.0
Lead	SW3050/6020	0.05
Magnesium	SW3050/6020	4
Manganese	SW3050/6020	0.05
Mercury	SW3050/7471	0.02
Molybdenum	SW3050/6020	0.05
Nickel	SW3050/6020	0.2
Potassium	SW3050/6020	400
Selenium	SW3050/6020	1.0
Silver	SW3050/6020	0.02
Sodium	SW3050/6020	20
Thallium	SW3050/6020	0.02
Tin	SW3050/6020	1
Vanadium	SW3050/6020	0.2
Zinc	SW3050/6020	0.5
Ammonia	SM20 4500NH3	0.2
Chloride	E300.0	1
Cyanide-total	SM20 4500CN-E	0.2
Fluoride	E300.0	2
Sulfate	E300.0	2

Notes:

E – Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991.

SW – Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.

SM – Standard Methods for the Examination of Water and Wastewater, 20th Edition.

mg/kg = milligrams per kilogram

2.3 FIELD ACTIVITIES

Detailed procedures for the surface-water hydrology studies, water-quality field activities, and sediment collection are included in Section 4. Appropriate QA/QC procedures will be used, and QA/QC samples will be collected based on the schedule set up by the analytical laboratories.

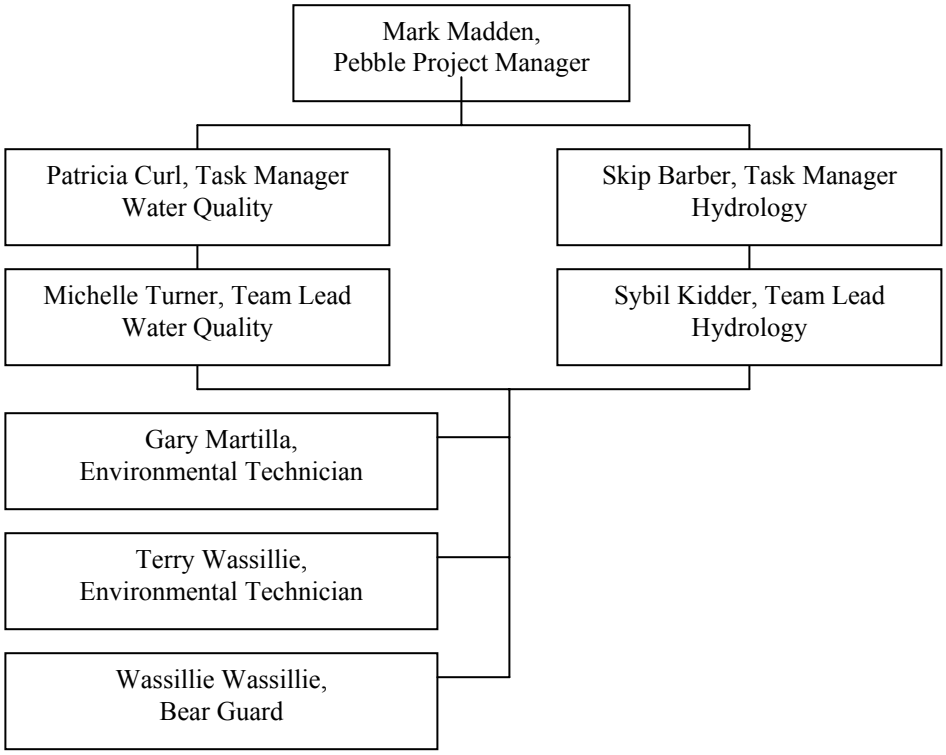
The surface-water sampling program will quantify the water chemistry throughout the year and under a range of different hydrologic conditions at key surface-water locations. The sampling program is designed to occur during breakup and to catch high flow in summer (which may take more than one sampling event), low flow in summer, a fall storm event, and a low flow in winter. As hydrologic conditions change (for example, variation of flows because of breakup and storm events), there is greater potential for varying water chemistry. Therefore, the sampling program consists of eight planned surface-water baseline events for a 12-month period.

The sediment-sampling program will quantify the metals and anions in sediments collected in surface-water streams and five ponds along the road corridor. Sediments from streams and tundra ponds will be collected in May, July, and September. Stream sediments will be collected at the same times and locations as surface-water samples.

In all cases, field collection procedures will be performed so as to minimize contamination of samples, to prevent cross-contamination between samples, and to ensure sample validity by conducting proper preservation and storage in the field according to the requirements in the *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (NDM, 2005).

3.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The project manager maintains overall responsibility for all aspects of the project. The water-quality task manager is responsible for and coordinates the field work and report writing for the surface water-quality and sediment sampling programs. The field team consists of a team lead working with three locally hired environmental technicians to collect the water-quality samples and flow data at each sampling station. An organizational chart depicting the BEESC staff managing and assisting on the water-quality and hydrology programs is provided below.



4.0 FIELD ACTIVITIES

Field activities will include several tasks for the hydrology program and collection of analytical samples and field-parameter measurements for the water-quality program. A list of the surface-water and hydrology baseline stations and the data to be collected are listed in Table 3. Monitoring sites are depicted on Figure 1. Activities related to measurements of field parameters are included in Section 6.

Table 3. Surface-water Monitoring Sites and Data Collection

Location ID	Location Name	2005 Sampling to be Performed							
		Feb	Mar	May	Jun	Jul	Aug	Sep	Oct
GS11A	Canyon Creek	DM, WS	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS
GS14B	unnamed creek	DM, WS	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS
GS17A	Tributary of Eagle Bay Creek	DM, WS	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS
GS21	unnamed creek	DM, WS	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS
GS3A	Iliamna River	WS	WS	WS, SD	WS	WS, SD	WS	WS, SD	WS
GS4A	Pile River	DM, WS	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS
GS8A	Knutson Creek	DM, WS	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS	DM, WS, SD	DM, WS
NHRIV	Newhalen River	WS	WS	WS, SD	WS	WS, SD	WS	WS, SD	WS
Pond1	tundra pond			SD		SD		SD	
Pond2	tundra pond			SD		SD		SD	
Pond3	tundra pond			SD		SD		SD	
Pond4	tundra pond			SD		SD		SD	
Pond5	tundra pond			SD		SD		SD	

Notes: GS – Gauge station
DM – Discharge measurement
WS – Surface water-quality sample
SD – Sediment sample

A list of field equipment used for sampling operations is presented in Table 4. The list provides information on where equipment and supplies are normally kept and sources for replacement materials.

Table 4. Field Equipment Schedule

Equipment	Source
YSI 556 Multiparameter Meter	BEESC
Hach 2100 P Turbidity Meter	BEESC
Boat and Motor	BEESC* / locally hired
DH-81 Depth-Integrated Sampler/Rod	BEESC*
Digital Camera	BEESC
Satellite Phone	SatComm Alaska
Calibration Solutions for YSI and Hach Meters	TTT Environmental*
Peristaltic Pump	BEESC
Marsh McBirney Flow Meter	BEESC*
Computer	BEESC
Printer	BEESC*
Consumables: nitrile gloves, paper towels, deionized (DI) water (provided by the laboratory), dipper/measuring cup, buckets, garbage bags, insect repellant	BEESC Inventory*—various suppliers
Filtering Supplies: 0.45-micron disposable filters, surgical silicon tubing, polyethylene tubing	TTT Environmental*
Rite-in-the-Rain Books and Forms	BEESC inventory
Sample Shipping Supplies: Ziploc bags, markers, printer cartridges, paper for COC forms, custody seals, clear tape, labels	Various suppliers*

* Items maintained in inventory in Iliamna.

5.0 SAMPLING PROCEDURES

5.1 DISCHARGE MEASUREMENTS

Instantaneous-discharge measurements will be collected at each established gauge station during each field event. Measurements are typically taken using top-setting wading rods. If the water is too deep or swift to wade, a boat will be employed to obtain discharge measurements. A moving boat may require a sounding weight attached to the electromagnetic sensor to stabilize the sensor in the current.

Field procedures defined by the U. S. Geological Survey (USGS; Rantz et al., 1982) and the *Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan* (NDM, 2005) will be used to obtain instantaneous-discharge measurements. A Marsh-McBirney Model 2000 FlowMate current meter will be used to measure stream depths and velocities. Procedures for discharge measurements defined by the USGS are outlined below:

1. Visually check wading rod and current meter for damage. Repair damage to equipment and replace batteries as necessary.
2. Attach the electronic sensor to the wading rod. Check the electric connection between the sensing unit on the wading rod and the recorder. Adjust the velocity output to read feet/second.
3. Anchor surveyor's tape tautly across the stream perpendicular to the direction of stream flow and attach on either side of the stream. Provide at least one foot of clearance between the water surface and the surveyor's tape. For large streams when boat measurements are used, a heavy-duty, premeasured tag-line or rope will be anchored across the stream channel.
4. Divide the cross-section of the stream into one-foot or two-foot intervals based on the width of the stream. Narrower stream widths will be sectioned into one-foot intervals and wider stream widths will be sectioned into two-foot intervals.
5. Person wading in stream calls out to onshore data recorder the location of the first measuring point with respect to the surveyor's tape. Person in stream measures water depth at that vertical, using wading rod, to the nearest 0.05 foot, if possible.
6. Data recorder calls out height(s) above the streambed at which velocity measurements are to be made. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water-column height. For water columns less than 2.5 feet deep, a single measurement of velocity at 60 percent of the water-column height will suffice. Person wading adjusts height of current meter on the wading rod accordingly.
7. Person wading stands downstream of the surveyor's tape, facing upstream, holding the wading rod vertical in the water with the current meter facing directly into the current. Person should not stand directly behind the meter but either to the left or right so as not to influence velocity readings.
8. Person wading observes visual output at each vertical for a minimum of 40 seconds or until the electronic reading stabilizes.
9. Repeat procedure at each vertical.
10. Data recorder records all appropriate information on the field form.

5.2 SURFACE-WATER SAMPLING

Water-chemistry samples are collected using the depth-integrated sampling method unless otherwise noted. Samples for low-level mercury analyses will be collected as a grab sample.

5.2.1 DH-81 Depth-Integrated Sampling

Analytical samples are collected using an equal-discharge, depth-integrated technique. Depth-integrated collection is conducted using a DH-81 depth-integrated sampler where adequate depths permit its use. Depth integration in shallow streams is completed with a grab sample that is depth-integrated by hand (Section 5.2.2). Equal-discharge collection is conducted by dividing the stream into segments based on percent discharge. A minimum of eight depth-integrated sample collections is required at each site to fill all the sample bottles required for analyses. All depth-integrated samples collected at a site are poured into a five-gallon plastic bucket. By taking the eight or more depth-integrated samples at estimated spacing and combining these before filling sample bottles, a complete discharge and depth-integrated sample is collected. Methods for depth-integrated sampling are described below:

1. Label sample bottles (Table 5) with sample site, analysis, date, time, and "BEESC" and "Pebble Project."
2. Visually check DH-81 sampler for damage.
3. Using the decontamination procedure detailed in Section 5.4, decontaminate all parts of sampler to be used (including nozzle, body, gasket, and sample bottle) and all other sampling equipment that will come into direct contact with the sample, such as the five-gallon bucket and the measuring cup/dipper.
4. Locate sampling sites by dividing the stream into areas with equal discharge. A minimum of 4 subsections should be sampled. If more sample volume is required, more subsamples can be taken by dividing the stream into more areas of equal discharge.
5. Put on new nitrile gloves before collecting samples using the DH-81.
6. At the selected stream location, lower the sampler into the stream with one continuous motion, making sure the sampler handle is vertical. Lower the sampler to the streambed at a rate based on the rating curve for the nozzle size used and the velocity of the stream. The sample bottle should be just under half full upon encountering the streambed. Raise the sampler at a rate similar to the descent rate. The collection bottle should not be completely full upon removal from the stream. Pour contents of collection bottle into the clean five-gallon bucket.
7. Repeat procedure until at least eight bottles have been collected. If collecting QA/QC and matrix spike/matrix spike duplicate (MS/MSD) samples, collect at least 25 bottles to make sure that enough sample volume has been collected.
8. Collect analytical samples from the composite sample in the five-gallon bucket using a decontaminated measuring cup to pour water into the bottles. Do not allow bottles to fill completely such that preservative is not lost. Be sure to hold bottles over the ground and not over the bucket as they are filled to reduce chances of preservative from a bottle contaminating the main sample.
9. Fill out appropriate field forms (see appendix) documenting sampling location, time, and other pertinent information before leaving sampling site.

Table 5. Sample Bottles for Surface-water Collection

Parameter	Bottle Type	Number of Bottles	Preservative	Comments
Primary and QC samples				
Low-level mercury	250 ml fluoropoly	1	HCl	Collect as a grab sample
Total metals, hardness	500 ml HDPE	1	HNO_3	
Dissolved metals	500 ml HDPE	1	HNO_3	Collect in 500 ml unpreserved container and field filter into HNO_3-preserved container.
Cyanide (total and WAD)	250 ml HDPE	1	NaOH	
Thiocyanate	250 ml HDPE	1	HNO_3	
TSS, TDS, alkalinity, acidity, specific conductance, pH	1- L HDPE	2	none	
Ammonia, phosphorus, nitrate and nitrite	250 ml HDPE	1	H_2SO_4	
Anions	120 ml nalgene	1	none	
QA Samples				
Low-level mercury	500 ml fluoropoly	1	HCl	Collect as a grab sample
Total metals, hardness	1-L HDPE	1	HNO_3	
Dissolved metals	1-L HDPE	1	HNO_3	Collect in 1-L unpreserved container and field filter into HNO_3-preserved container.
Cyanide (total and WAD)	1-L HDPE	1	NaOH	
Thiocyanate	500 ml HDPE	1	HNO_3	
TSS, TDS, alkalinity, acidity, specific conductance, pH, anions	1- L HDPE	2	none	
Ammonia, phosphorus, nitrate and nitrite	1-L HDPE	1	H_2SO_4	
MS/MSD samples				
TSS, TDS, alkalinity, acidity, specific conductance, pH	1- L HDPE	2	none	
Anions	120 ml nalgene	1	none	

Notes: HCl = hydrochloric acid; HDPE = high density polyethylene; HNO_3 = nitric acid; H_2SO_4 = sulfuric acid; ml = milliliters; NaOH = sodium hydroxide; TDS = total dissolved solids; TSS = total suspended solids

5.2.2 Grab Sampling

This procedure is to be used only when sample collection conditions do not allow integrated sampling. This may include winter conditions when only a single boring through ice is feasible.

Decontaminate sample-collection container(s) if employed. After decontamination, double rinse collection container(s) in stream water at a location downstream of the sampling point. In some cases, grab samples will be taken directly into the sample bottles and no decontamination or rinse will be necessary. Procedures for collecting grab samples are outlined below:

1. Label sample bottles with sample site, analysis, date, time, sampler, and "BEESC Pebble Project."
2. Locate sampling site at an accessible point in the stream exhibiting greatest flow and/or highest velocity.
3. Put on new nitrile gloves
4. If using a sample-collection container, submerge the container so that the mouth of the container is two to three inches below the surface of the stream. Pour the contents of the collection container into a clean five-gallon bucket. Repeat the procedure until the bucket is at least half full. If collecting QA/QC and MS/MSD samples, collect at least two full buckets. Pour sample into sampling bottles.
5. If collecting using the sample bottles, submerge the sample bottle at the sampling point such that mouth of container is two to three inches below the surface of the stream. Uncap bottle while below the surface of the water, and fill slowly. Do not allow bottle to fill completely such that preservative is lost.
6. Fill out appropriate field forms (see appendix) documenting sampling location, time, and other pertinent information before leaving sampling site.

5.2.3 Low-level Mercury Grab Sampling

This procedure is to be used when collecting water samples for ultra-low mercury analysis. Minimum exposure of sampling equipment and bottles is required to eliminate contaminates from air, particulates, equipment, or sampling operations. The sample is allowed no contact with metallic equipment. Low-level mercury samples are collected as grab samples directly into the sample bottles and no decontamination or rinse will be necessary. Procedures for collecting grab samples are outlined below:

1. Remove the bottle from the doubled Ziploc bags.
2. Label sample bottles with sample site, analysis, date, time, sampler, and "BEESC Pebble Project."
3. Put on a new set of nitrile gloves. If the sampler already is wearing gloves for sampling of other parameters, these must be replaced with a new set of nitrile gloves.
4. Locate sampling site at a point in the stream exhibiting greatest flow and/or highest velocity.
5. Submerge the sample bottle at sampling point such that mouth of container is two to three inches below the surface of the stream. Uncap bottle while below the surface of

the water, and fill slowly. If filling sample bottle directly, do not allow bottle to fill completely such that preservative is lost.
6. Completely fill the bottle using the cap to dip water from the stream.
7. Cap the bottle and double bag with Ziploc bags.
8. Fill out appropriate field forms (see appendix) documenting sampling location, time, and other pertinent information before leaving sampling site.

5.2.4 Sample Filtration

All dissolved-metals samples will be filtered within 12 hours of the time that they are collected. Samples will be filtered at the base camp after each field day. Sample filtration procedures are outlined below:

1. Label the dissolved metals sample bottle into which the filtered sample will be collected. Include sample site, analysis, date, time, sampler, and "BEESC Pebble Project."
2. Put on nitrile gloves.
3. Cut two small pieces of silicon tubing (approximately 4 inches long) and two longer pieces of Teflon tubing (approximately 12 inches long). Run one piece of silicone tubing through the peristaltic pump and attach a piece of Teflon tubing to each end. On the effluent side of the pump attach the second piece of silicon tubing and a 0.45-micron filter cartridge to the end of the tubing, making sure it is oriented correctly. Place the influent end of the tubing in the sample bottle.
4. Turn on the peristaltic pump, and fill the dissolved metals sample container.
5. If extremely turbid sample water is obtained, use the same procedure using a pre-filter (usually 3.0 microns) followed by 0.45-micron filtration.
6. Put dissolved-metals sample bottle with other bottles from same site to be packaged for shipping.

5.3 SEDIMENT SAMPLING

Sediment samples will be collected from streams and ponds along the road corridor.

Sediment samples collected from streams will be co-located with the surface-water sample-collection sites. If possible, a composite will be collected from three points within the streambed: near each bank and from the bottom of the streambed near mid-channel. In cases of fast-flowing or rocky streams it may be difficult to obtain sediment from the bottom of the stream, in which case the sample will be composited from the bank samples.

Pond-sediment samples will be collected from the deposition side (west side) of ponds along the road corridor. A composite sample will be collected from three locations spread along the deposition side of the pond identified for sediment sampling.

Methods for sediment sampling are described below:

1. Label sample bottles (Table 6) with sample site, analysis, date, time, and "BEESC" and "Pebble Project."

2. Decontaminate all equipment to be used in sampling (spoons, trowels, bowl, etc.) using the decontamination procedure detailed in Section 5.4.
3. Locate sampling sites. A minimum of three sites is required.
4. Put on long sediment-sampling gloves.
5. Put on nitrile gloves over the sediment-sampling gloves.
6. Stand downstream when collecting the sample to avoid disturbing the sample collection area.
7. Collect roughly equal amounts of sediment from each of the selected locations. Collect enough sample to fill a minimum of two to three bottles. Collect additional sample volume if QA/QC will be performed on the sample.
8. Composite the sample in a large stainless steel bowl by mixing with a spoon or trowel.
9. Remove any vegetation or pebbles or rocks larger than one-half inch in size.
10. Allow the sample to sit to let water come to the top, then decant off water.
11. Fill the sample container with sediment. Once the container is full, gently tap it on a rock or hard surface to compact it and encourage water to rise to the top of the bottle. Decant off water and repeat until the bottle is completely full with sediment with a minimum amount of water.
12. Using clean stream or pond water and a gloved hand, carefully rinse sediment off the threads of the container. When the container threads are clean, screw on the cap. Rinse the container with stream or pond water.
10. If collecting QA/QC and MS/MSD samples, collect at least four bottles to make sure that enough sample has been collected.
11. Fill out appropriate field form (see appendix) documenting sampling location, time, and other pertinent information before leaving sampling site.

Table 6. Sample Bottles for Sediment Collection

Parameter	Bottle Type	Number of Bottles	Preservative	Comments
Primary and QC samples				
Total metals, total cyanide, ammonia, anions	8 oz HDPE	1	none	
QA Samples				
Total metals, total cyanide, ammonia, anions	8 oz HDPE	1	none	
MS/MSD samples				
Total metals, total cyanide, ammonia, anions	8 oz HDPE	1	none	

Notes: Anions = chloride, fluoride, and sulfate
oz = ounce

5.4 SAMPLING EQUIPMENT DECONTAMINATION

Sampling equipment that should be decontaminated prior to collecting samples include the DH-81 collection bottle, cap and nozzle; the five-gallon bucket used for compositing samples;

sample-collection containers, if any, for grab samples; and implements used in sediment sampling. Methods for decontaminating sampling equipment are outlined below:

1. Spray all parts of the equipment using a pre-mixed Alconox and DI water solution. If there is obvious sediment or biological material on the equipment, use a brush to remove material. DI water will be provided by the laboratory which is performing metals analyses.
2. Rinse the equipment using DI water several times and ensure that all traces of the Alconox solution and other materials are removed.
3. Immerse the equipment downstream of the sampling location and rinse completely prior to collecting a sample.

During winter sampling events, below-freezing conditions prevent using spray bottles. In these conditions, the following methodology should be used:

1. Pour warm DI water into the bucket or DH-81 sample bottle and scrub thoroughly with a clean brush. The DI water should be kept in a small ice chest with a heat source (heating pads) to keep it warm.
2. Rinse the equipment using warm DI water several times and ensure that all traces of material are removed.
3. Immerse the equipment downstream of the sampling location and rinse completely prior to collecting a sample.

5.5 FIELD QUALITY-CONTROL SAMPLES

To aid in evaluating the accuracy of the analytical data, trip blanks, QC (duplicate) samples, QA (triplicate) samples, matrix spike samples, and matrix spike duplicate samples are collected and subjected to the same analyses as identified for task samples. Equipment (also known as field) blanks and DI water blanks also are collected. The field QA/QC samples are summarized below and in the QAPP (NDM, 2005).

5.5.1 Trip Blank

A trip blank will be provided for the low-level mercury analysis and should accompany the field staff into the field for each field day. The trip blank that accompanies the field team at each sampling site should be labeled as a trip blank with the effective date noted. Trip blanks should be included as a separate line item in the Sample Transfer Log (see appendix). At the end of each field day, the trip blank should be provided to Shaw Environmental, Inc. (Shaw), staff. The sample will be packaged and sent with the samples that it accompanied during the field day. If QA low-level mercury samples are collected, a QA trip blank must accompany the field staff into the field in addition to the primary laboratory trip blank.

5.5.2 Field Duplicates

QC samples are collected at a frequency of 10 percent during all sampling events for all parameters.

5.5.3 Field Triplicates

QA samples are collected at a frequency of 10 percent during all sampling events for all parameters.

5.5.4 MS/MSDs

MS/MSDs are collected at a frequency of 10 percent during all sampling events from the same locations as QA/QC samples. MS/MSDs are collected only for primary laboratories. The additional bottle requirements for MS/MSDs are provided in the QAPP.

5.5.5 Equipment Blank

An equipment blank is collected at a frequency of five percent—or a minimum of once per sampling event—and submitted for dissolved-metals analysis. If possible, the equipment blank is collected during the first day's sampling. The procedure for collecting the equipment blank is outlined below:

1. After sampling at a site, decontaminate the DH-81, five-gallon bucket, and any other sampling equipment used, as described in Section 5.4.
2. Pour DI into the DH-81 sample bottle and dispense through the nozzle into the five-gallon bucket, and thoroughly rinse all other sampling equipment
3. Filter the sample as described in Section 5.2.4.
4. Collect the filtered sample in a dissolved-metals bottle labeled "equipment blank."

5.5.6 DI Water Blank

A DI water blank is collected once per sampling event and is submitted for total metals analysis. The laboratory-provided DI water used for decontamination will be collected in an empty total-metals analysis bottle and submitted to the primary laboratory for total-metals analysis. If possible, the DI-water blank is collected during the first day's sampling.

5.6 SAMPLE CUSTODY

Once collected, samples will remain within sight of the sampler or in a secured location until the samples are transferred to Shaw personnel. Shaw personnel at Iliamna will be responsible for labeling and creating chain-of-custody (COC) forms, shipping samples, and laboratory notification. COC forms, based on the Sample Transfer Log (see appendix), will be used for all samples.

5.6.1 Sample Handling

Samples will be packed to prevent breakage and will be kept chilled during field operations by transporting the samples with frozen gel ice. A daily trip blank will accompany all samples to be analyzed for mercury.

5.6.2 Sample Containers

Sample container requirements are described in Tables 5 and 6 and in the QAPP (NDM, 2005). The field team leader should review the bottle order received from the laboratory against the QAPP prior to departing for Iliamna to verify that the necessary sample containers and container types have been obtained and that preservation requirements have been met.

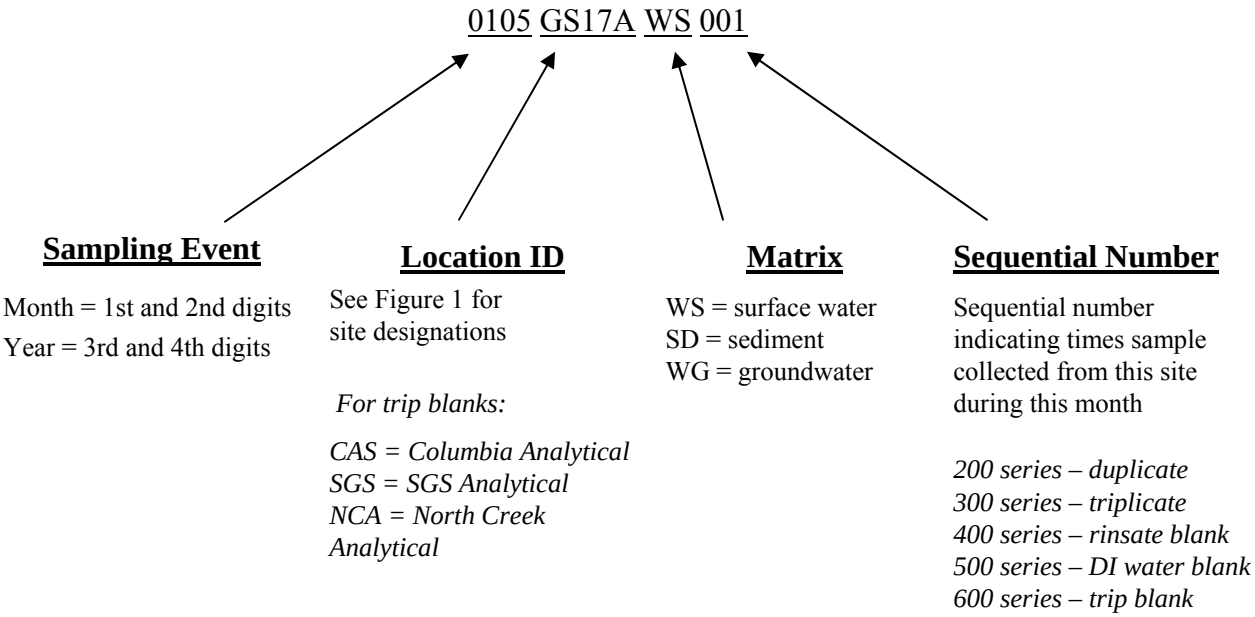
5.6.3 Sample Relinquishing

All samples will be relinquished to Shaw personnel for packing and shipment to laboratories following the procedures outlined below:

1. Verify that all sample containers have been removed from coolers and organized with all bottles from a single location together so that Shaw personnel can label them.
2. Verify that all sample containers have been clearly identified. All sample containers will be labeled at a minimum with "BEESC," "Pebble," the location ID, date, and time of sample collection.
3. Complete the Sample Transfer Log for all samples including trip blanks (see appendix). Note any items of interest, such as collection of QA/QC samples and/or MS/MSD samples, on the bottom of the form.
4. Notify Shaw personnel that samples are ready for transfer and where they are located. Verify whether or not samples should be placed in a refrigerator.

5.6.4 Sample Identification

Shaw is responsible for labeling and shipping analytical samples. Each sample container will be identified with 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 identification, analysis, and sampler's initials. Sample identification (ID) will be formatted to indicate sample event (month and year), location, matrix, and number. Sample IDs for a sampling event that begins in one month and is completed in the following month will contain the month and year during which the event began. Each sampling location will be identified on the field form. These samples IDs are defined to facilitate data management for the life of this project. An example of a sample ID is shown below:



Laboratory codes are used for the Location ID for trip blanks. Laboratory codes are SGS for SGS Environmental Services, Inc., CAS for Columbia Analytical Services, Inc., and NCA for North Creek Analytical Services, Inc. A sample ID for a surface-water trip blank for NCA might be 0105NCATBSW601 for the first trip blank in January 2005. If more than one trip blank were submitted on the same COC form for the same matrix, the Sequential Number would be increased to 602.

The Sequential Number for field duplicates will be in the 200 series, and triplicates will be the 300 series. The 400 series is used for field equipment rinse blanks, the 500 series is used for DI-water blanks, and 600 series is used for trip blanks.

6.0 FIELD MEASUREMENTS

6.1 PARAMETERS

Portable water-quality testing instruments will be used for the in situ measurement of pH, temperature, dissolved oxygen, conductivity, oxidation reduction potential (ORP), and turbidity.

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. A calibration check will be performed before each day's sampling. All calibration activities will be documented on appropriate field calibration forms.

The field crew 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 documented, and 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 field corrective actions when deemed necessary. All field corrective actions will be recorded in the field book.

Equipment will be maintained in good operating condition.

6.2.1 YSI 556 Calibration Check

The calibration of the YSI 556 meter is checked or verified for three parameters: specific conductivity, ORP, and pH based on temperature readings. Calibration check procedures are detailed below:

1. Prior to checking the calibration, verify that the instrument is clean.
2. Make sure the YSI 5580 confidence solution is not too cold (close to freezing) as this will affect the calibration check. Confidence solution is best stored indoors.

3. Rinse the instrument with confidence solution by placing a small amount in the calibration cup, screwing the cup into the meter base, and gently tipping the base so that all meters have been coated with confidence solution.
4. Discard the used confidence solution.
5. Fill the calibration cup with confidence solution so that all meters are covered. Place the meter probe into the solution and allow readings to stabilize.
6. Record readings in the calibration notebook.
7. Compare the readings to those on the YSI 5580 confidence solution bottle. If all readings are within acceptable parameters, the YSI 556 calibration is good and the instrument does not need to be calibrated. If one or more of the readings is not within acceptable parameters, the YSI 556 calibration is not good and the instrument must be recalibrated for those parameters following the procedure in Section 6.2.2.

6.2.2 YSI 556 Calibration

The YSI 556 meters can be calibrated for four parameters: dissolved oxygen, pH, conductivity, and ORP. Procedures for calibrating for each parameter are provided below. Prior to calibrating the instrument, clean the sensors with an Alconox solution and rinse several times with DI water. Shake off excess water prior to immersing the probe in the calibration cup with solution. Make sure that the sensors are covered when running the calibration. Used calibration solution can be used to rinse the sensors prior to calibration to provide an extra level of accuracy.

To enter calibration mode:

1. Press the on/off key to display the run screen.
2. Press the escape key to display the main menu screen.
3. Use the arrow keys to highlight the calibrate selection.
4. Press the enter key. The calibrate screen is displayed.

6.2.2.1 Conductivity

1. On the calibrate screen, select conductivity and press enter.
2. Select specific conductance and press enter. Note that calibrating for specific conductance will also calibrate for conductivity and salinity.
3. Place 55 ml of the 1.413 mS/cm conductivity solution in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the conductivity cell. Make sure that the conductivity sensor is completely immersed past the vent hole.
5. Tighten the calibration cup onto the probe module.
6. Enter the calibration value: 1.413 mS/cm. Note that the value for specific conductivity is always in mS/cm at 25°C.
7. Press enter and allow at least one minute for the temperature to stabilize. Note the temperature of the calibration solution for the pH and ORP calibrations.
8. When the specific conductivity reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.

9. Press escape to return to the calibrate screen.
10. Rinse the sensors and calibration cup and save the solution for a pre-rinse prior to the next calibration.

6.2.2.2 Dissolved Oxygen

1. On the calibrate screen, select dissolved oxygen (DO) and press enter.
2. Select DO% and press enter. Note that calibrating for DO% will also calibrate for DO mg/L.
3. Place 1/8 inch of water into the calibration cup, and place the probe module into the cup making sure that the DO and temperature sensors are NOT immersed in the water.
4. Secure the cup to the module by securing only 1 or 2 threads to ensure that the DO sensor is vented to the atmosphere.
5. Use the keypad to enter the local barometric pressure (BP). Barometric-pressure readings from the Iliamna airport can be obtained at http://weather.noaa.gov/weather/current/PAIL.html. Note that these readings have been adjusted for sea level and must be corrected to obtain the pressure at the correct altitude. The following calculation must be performed to convert the units from inches mercury (Hg) to millimeters (mm) Hg and to adjust for the local elevation:
    a. Corrected BP (inches Hg) x 25.4 = Corrected BP (mm Hg)
    b. True BP = Corrected BP (mm Hg) – (2.5 x (altitude/100))
6. Allow 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate. When the DO% reading shows no significant change for 30 seconds, press enter. Press enter again to accept the calibration.
7. Press escape to return to the calibration menu.

6.2.2.3 pH

1. On the calibrate screen, select pH and press enter.
2. Select 3 point and press enter. A 3 point calibration is used to correctly read surface waters that are both basic and acidic.
3. Place 30 ml of the first pH buffer in the clean, dry calibration cup and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the pH sensor. Make sure that the sensor is completely immersed.
5. Tighten the calibration cup onto the probe module.
6. Enter the value of the pH buffer at the current temperature. The temperature of the stored calibration solution for the pH and ORP should have been recorded during the conductivity calibration.
7. Press enter and allow at least one minute for the temperature to stabilize.
8. When the pH reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
9. Press enter to return to the specified pH calibration screen.
10. Rinse the probe module, calibration cup, and sensors in DI water and dry.
11. Repeat steps 3 through 10 for the second and third buffer solutions.
12. Press escape to return to the calibrate screen.

13. Rinse the sensors and calibration cup and save the solution for a pre-rinse prior to the next calibration.

6.2.2.4 Oxidation Reduction Potential

1. On the calibrate screen, select ORP and press enter.
2. Place 30 ml of the ORP solution in the clean, dry calibration cup, and immerse the sensors in the solution.
3. Rotate or move the probe module up and down to remove any bubbles from the ORP sensor. Make sure that the sensor is completely immersed.
4. Tighten the calibration cup onto the probe module.
5. Enter the value of the ORP solution at the current temperature. The temperature of the stored calibration solution for the pH and ORP should have been recorded during the conductivity calibration.
6. Press enter and allow at least one minute for the temperature to stabilize.
7. When the ORP reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
8. Press escape to return to the calibrate screen.
9. Rinse the sensors and calibration cup and save the solution for a pre-rinse prior to the next calibration.

6.2.3 Hach 2100P Turbidimeter Calibration Check

Routine calibration checks should be performed on the 2100P Turbidimeter using the Gelex secondary turbidity standards. In order to be used for checking the calibration in the future, the Gelex standards must have values assigned to them immediately after calibration has been performed with Formazin. These standards should be used as a calibration check prior to every field day. If the readings are outside 5 percent accuracy, the instrument should be recalibrated using StablCal stabilized Formazin standards.

6.2.4 Hach 2100P Turbidimeter Calibration

A recalibration should be performed at a minimum of once every three months. Methods for calibrating the Turbidimeter using the Formazin standards, for assigning values to the Gelex secondary standards, and for checking the calibration are outlined below.

6.2.4.1 Calibration

1. If the StablCal standards have been sitting for longer than one month, they must be shaken to break the condensed suspension into its original particle size. If the standards are used on a weekly interval, start at step 2 below. Standards with <0.1 NTU (nephelometric turbidity unit) should not be shaken.
    a. Shake the standard vigorously for two to three minutes to resuspend any particles.
    b. Allow the standard to stand undisturbed for five minutes.
2. Gently invert the bottle five to seven times.
3. Prepare the sample cell.

a. Clean the cell using an Alconox solution and a DI water rinse.
b. Allow the cell to air dry. Handle the cell by the top to avoid scratching or contaminating the glass surface.
c. Apply a small bead of silicone oil to the surface of the cell and rub with a lint-free cloth. Note that the cloth will absorb oil and after a few applications, it will suffice to simply rub the cloth over the cell. Avoid using too much oil; the cell should appear dry with little or no visible oil.

4. Turn on the instrument by pressing I/O.
5. Press CAL. The CAL and SO icons will display, indicating that the instrument is calibrating the first standard at 0 NTU.
6. Rinse the sample cell one time with the standard and discard the rinsate.
7. Fill the cell with the first standard. Cap the cell and let stand for one minute.
8. Insert the cell in the compartment by aligning the orientation mark on the cell with the mark on the front of the compartment.
9. Close the lid.
10. Press → to get a numerical display.
11. Press READ. The instrument will count from 60 to 0 and then switch to the next standard.
12. Repeat steps 6 through 11 for the three remaining standards.
13. When the last standard is done, the display will increment back to S0. Press CAL to accept the calibration, and the instrument will return to measurement mode.
14. If E1, E2 or CAL? are flashing after the CAL button is pressed, check the standards and repeat the calibration. Refer to the instrument manual for troubleshooting guidelines.

6.2.4.2 Assigning values to the Gelex secondary standards

1. Only assign values to Gelex standards after completing a calibration using Formazin standards. Select automatic range mode using the RANGE key.
2. Thoroughly clean the outside of the Gelex vials, and apply a thin coating of silicone oil. See Step 3 under Calibration (above) for instructions on preparing a sample cell.
3. Place the 0-10 NTU Gelex standard in the cell compartment, and align the diamond on the vial with the orientation mark on the instrument. Close the lid and press READ.
4. Mark the value on the band near the top of the vial.
5. Repeat steps 2 through 4 for each Gelex standard.

6.2.4.3 Checking calibration

1. Check the instrument calibration using the Gelex standards.
2. If the readings are not within five percent of the previously established values, recalibrate using the StablCal stabilized Formazin standard.

6.3 EQUIPMENT MAINTENANCE AND DECONTAMINATION

Field meters should be decontaminated prior to calibration, prior to calibration check, between samples, or if there is visible sediment or biological material on the probe or sensors. Decontamination procedures for the YSI 556 are outlined below:

1. Spray all parts of the equipment using a pre-mixed Alconox and DI water solution. If there is obvious sediment or biological material on the equipment, lightly brush to remove material.
2. Rinse the equipment using DI water several times, and ensure that all traces of the Alconox solution and other materials are removed.

To decontaminate the Hach 2100P, rinse the equipment using DI water several times and ensure that all traces of the Alconox solution and other materials are removed.

Maintenance for the YSI 556 may include cleaning of sensors and replacement of the dissolved oxygen membrane. Maintenance procedures for the Hach 2100P that may be performed in the field include cleaning, and battery and lamp replacement. Complete descriptions of these procedures can be found in the instrument manuals, which will be kept with the instruments at all times. If maintenance and troubleshooting procedures in the instrument manuals do not fix the instruments, they will be sent to their respective manufacturer for repair.

The FlowMate velocity meter should be equipped with fresh batteries. Alkaline or nickel-cadmium (NiCad) batteries are recommended. Remove batteries from equipment between monitoring events. Sensors should be cleaned periodically to remove any oil or grease. Spray the sensors with an Alconox solution and rinse with fresh water.

6.4 FIELD MEASUREMENT PROCEDURES

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

6.4.1 YSI 556

1. Replace the calibration cup with the protective sampling cup.
2. Turn the instrument on, and place the probe in the stream and allow it to equilibrate until readings are steady prior to recording the readings.
3. Record the readings.
4. pH readings for sites where the water temperature is cooler than 1.0°C are often biased low, possibly due to ice formation around the pH bulb. Note the pH reading, and if it is unusually low (pH of 4.0 or less), note this in the field notebook. Measurements for questionable results may be re-collected from samples' dissolved-metals containers by decanting an aliquot into the calibration cup prior to performing field filtration.
5. In cases where the ambient temperature is very low and ice forms on the meters, readings may be collected by filling the calibration cup with sample water, screwing the cup onto the probe, then placing the cup into a secondary container filled with warm water (such as an insulated coffee cup). All parameters, with the exception of temperature, can be collected.
6. All field parameter results, including those that are questionable and any other relevant information, are recorded and maintained in field notebooks or field forms.

6.4.2 Hach 2100p

1. Decontaminate the sample cell using several rinses of DI water. Be careful to handle the cell by the top to avoid smudging or scratching the glass.
2. Rinse the sample cell several times with sample water.
3. Fill the cell with sample water, cap the sample cell, and dry it with ChemWipes or a clean, lint-free cloth.
4. Apply a thin film of silicone oil. Wipe with a clean, lint-free cloth to create an even film on the surface of the cell.
5. Turn on the instrument and place on a flat, sturdy surface.
6. Place the sample cell in the instrument compartment making sure that the mark on the cell aligns with the mark on the compartment. Close the lid.
7. Hit the RANGE key until AUTO RNG is displayed.
8. Press READ. The final measurement will display after approximately 13 seconds. If the reading is very unstable, press the SIGNAL AVERAGE key to average 10 measurements; this takes approximately 20 seconds.
9. Record the reading on the data sheet.

6.4.3 FlowMate Flow Meter

1. Press the ON/C button to turn the on the power.
2. After displaying the software version and segment test display, select the units of measure. Press the ON/C and OFF buttons simultaneously to cycle through measurement and beeper options. Select a mode which will display in FT/S.
3. Once the sensor is immersed in current facing upstream, allow 45 to 60 seconds for the flow velocity reading to stabilize.
4. Record velocity data.

7.0 RECORD KEEPING

Field observations, field equipment-calibration information, field measurements, and sample documentation (including sample identification, sample duplicates and triplicates, 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 crew. When in doubt, record more information rather than less.

7.1 FIELD LOGBOOKS AND FIELD FORMS

Field logbooks will be used to record any deviations from the sampling methods and additional notes which are not recorded on the field forms. Calibration logbooks are maintained for each field-parameter meter and are used for the entire sampling season. The data in the calibration logbooks include the name of the person doing the calibration, date and time, calibration solution and expiration date, and the reading versus calibration value.

A field logbook and field forms will be maintained on a daily basis to document field activities, including the collection of every sample. The field logbook will be bound, with consecutively numbered pages. An example of a completed field logbook entry is included in the appendix. Field forms (see appendix), including Surface-Water Field Forms and Field Discharge Measurement Forms, will be used for recording specific information about water flows and sample collection. All field notes will be entered into the field notebook or field forms in indelible ink unless conditions prohibit. 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 or field forms 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 conditions, 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 OBSERVER FORMS

Field observer forms will be used to record when observers were used on native lands. At a minimum the forms must record the dates and times observers were used, the name and affiliation of the observer, the types of sampling they observed (sediment or surface water), and at which sample locations they were present. An example of a field observer form is included in the appendix.

7.3 CORRECTIONS TO DOCUMENTATION

Unless weather conditions prevent it, all original data will be recorded using waterproof ink. No documents will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. If an error is made, the author 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 corrections made after the initial information is recorded will be initialed and dated.

8.0 FIELD PERFORMANCE AND SYSTEM AUDITS

Shaw will perform periodic field performance and system audits based on this Sampling Plan. Each field team will be accompanied into the field for compliance with both the hydrology and water-quality monitoring protocols. Audit results will be provided to BEESC by Shaw personnel and will be reviewed to ensure that field-sampling protocols are being followed or modified appropriately when necessary to meet the data-quality objectives.

9.0 REFERENCES

Alaska Department of Transportation and Public Facilities (ADOT&PF). 2005. Iliamna Regional Transportation Corridor Analysis. Prepared by PN&D. July.

Northern Dynasty Mines (NDM). In press. Draft Environmental Baseline Studies, Proposed 2005 Study Plan.

———. 2005. Draft Environmental Baseline Studies, 2005 Final Quality Assurance Project Plan.

Rantz, S.E., et al. 1982. Measurement and Computation of Stage and Discharge. U.S. Geological Survey Water Supply Paper 2175.

FIGURES

1,400,000 1,450,000 1,500,000 1,550,000 1,600,000 1,650,000 1,700,000 1,750,000

2,250,000 2,200,000 2,150,000 2,100,000 2,050,000 2,000,000

LAKE CLARK A-7 LAKE CLARK A-6 LAKE CLARK A-5 LAKE CLARK A-4 LAKE CLARK A-3 LAKE CLARK A-2

ILIAMNA D-7 ILIAMNA D-6 ILIAMNA D-5 ILIAMNA D-4 ILIAMNA D-3 ILIAMNA D-2

ILIAMNA C-7 ILIAMNA C-6 ILIAMNA C-5 ILIAMNA C-4 ILIAMNA C-3 ILIAMNA C-2

ILIAMNA B-7 ILIAMNA B-6 ILIAMNA B-5 ILIAMNA B-4 ILIAMNA B-3 ILIAMNA B-2

Nondalton
Iliamna
Newhalen
Kokhanok
Pedro Bay

NHRIV
Pond 1
Pond 2
Pond 3
Pond 4
Pond 5

GS17a
GS14b
GS11a
GS8a
GS4a
GS3a
GS21

Northern Dynasty Mines Inc.

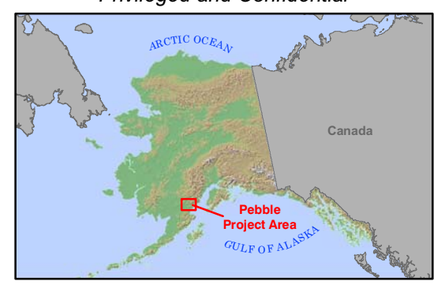
Pebble Project

Surface Water and Sediment Sampling Figure 1.

Legend

- Towns
- 2005 Surface Water Quality and Sediment Sampling Locations
- Tundra Ponds
- Potential Port Sites
- Road Corridor
- Quadrangle 63360
- Anadromous Fish Stream
- Stream

Privileged and Confidential



0 16,000 32,000 48,000 64,000 Feet

0 4,600 9,200 13,800 18,400 Meters

Scale 1:361,929

N

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Sample_Map_20050601.mxd	Date: June 1, 2005
Version: 1	Author: BEESC-ME

APPENDIX

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: _____

2 May 2005

Get ready for travel to Uiamna. Checked calibration for the YSI. Dropped off car @ my place. Arrived @ Uiamna @ 2pm. Met Joannie and Terry, Wassillie, and Gary. Will have to share vehicle w/ other people staying @ Uiasta Inn.

Terry mentioned that weather at the post site would be deteriorating.

Spoke w/ Kelli and asked if we could change to PB lands. Could not get an observer so decided to do 6521, then come back to Uiamna lands. Set up equipment and gathered stuff for the next day. End of day @ 7pm.

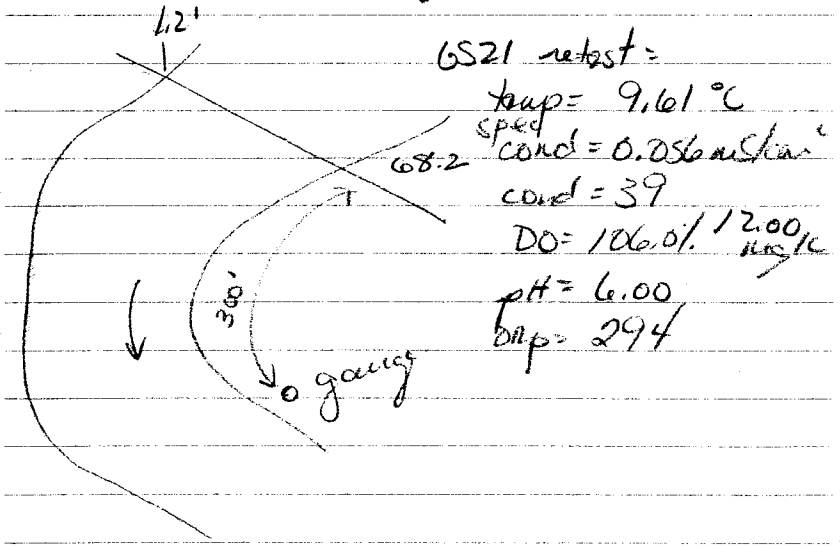
3 May 2005.

Start work @ 7:00. Gather material. Had to calibrate YSI and borrow item.

8:00 ready to go. Dave + Ty are pilots. Head out to 6521 arrive @ 6521 9:30.

Water is high. Slight breeze + overcast. Temp = 40°F.

Gage was empty.



6521 retest:
temp = 9.61 °C
spec cond = 0.056 mS/cm
cond = 39
DO = 106.0% / 12.00 mg/L
pH = 6.00
bar = 294

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ENVIRONMENTAL & ENGINEERING
SERVICES CORPORATION

2000 W. International Airport Road, #C-1
Anchorage, AK 99502-1117
907-563-0013 Phone
907-563-6713 Fax

SURFACE WATER FIELD FORM
Pebble Gold Copper Project

Station No.: _____ Date: _____
GPS coordinates _____ Start Time: _____
_____ End Time: _____

Team:
Team Leader: _____ **Site Observer:** N/A
Team Members: _____
_____
_____

Flow:
Type of Flow Meter: _____
Total Flow = _____
Measurement Rating: Excellent, Good, Fair, Poor
Additional Information:
(e.g., ice thickness) _____
Stream Width: _____
Stream Depth: _____

In-situ Field Parameters:
Meter Make and Model YSI 556 MPS
Meter Number: 05A 2014 AB

Calibration Check:
Calibration Solution: _____
Expiration Date: _____
pH = _____
Cond = _____
Turb = _____
Recalibrate: Y/N _____

Stream Meter Readings:
pH = _____
Spec Cond = _____
Cond = _____
Turb = _____
DO = _____
Temp = _____
ORP =

Sample No.:
Time:
Number of Bottles
Filtration: Y/N _____

Additional Comments:

Analyses Requested:
Total Metals _____
Diss. Metals _____
Etc. _____
QA/QC _____

Weather: _____
Air Temperature _____
Precipitation _____
Wind _____

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SURFACE WATER FIELD FORM
Pebble Gold Copper Project

Station No.: GS21
GPS coordinates Lat. N 59° 38.5294
Long. W 153° 31,4267

Date: 5-3-05
Start Time: 0930
End Time: 1045

Team:
Team Leader: Michelle Turner
Team Members: Sybil Kidder
Terry Wassillie
Wassillie Wassillie
Gary Martilla

Site Observer: N/A
(Shaw) Bryan Cherry

Flow:
Type of Flow Meter: Marsh McBirney
Total Flow =
Measurement Rating: **Excellent**, Good, Fair, Poor
Additional Information:
(e.g., ice thickness) upstream from gauge
Stream Width: 68.10 feet
Stream Depth: 1.90 feet (average)

Water Surface Elevation: 98.92

In-situ Field Parameters:
Meter Make and Model YSI 556 MPS
Meter Number: 05A 2014 AB

Calibration Check:
Calibration Solution:
Expiration Date:
pH =
Cond =
Turb =
Recalibrate: Y/N

Stream Meter Readings:

pH =	4.79 (6.00)
Spec.Cond =	0.053 mS/cm (0.56)
Cond =	30 uS/cm (39)
Turb =	0.26 NTU
DO =	14.62 mg/L (12.00)
Temp =	2.99 Degrees C
ORP =	286.0 (294)
DO% =	107% (106.0%)

Sample No.: 0505GS21WS001
Time: 1000

Number of Bottles 10
Filtration: Y/N Yes

Analyses Requested:
Total Metals Yes
Diss. Metals Yes
Etc.
QA/QC

Weather: Clear, sunny
Air Temperature 40 °F.
Precipitation None
Wind Slight wind

Additional Comments:
Flow and samples collected upstream from gauge pole at shallower area. Sediment sample was collected at 1030 at three spots along the east bank and middle.

Field reading were confirmed at hanger. Hanger readings included in parentheses.

FIELD DISCHARGE MEASUREMENTS

Name of stream: _____

Location: N_____**W**_____

Gage #:_____ **Date:** _____ **Time:** _____

Gage Reading: _____ **Water Surface Elev:**_____

Water temp: _____°F **Air temp:** _____°F **Slope:** _____ **ft/ft**

Skew	Distance	Depth	2/10 V	6/10 V	8/10 V

Note: If the depth of water is 3' or greater then take velocity measurements @ 2/10 & 8/10 of the depth of water. Otherwise velocity measurements will be taken at 6/10 of the depth.

Notes taken by:_____

FIELD DISCHARGE MEASUREMENTS

Name of stream: CANYON CREEK – WEST CHANNEL

Location: N 59° 50.418' W 154° 21.952'

Gage #: 11a **Date:** 5/03/05 **Time:** 11:45

Gage Reading: 0 **Water Surface Elev:** 93.86

Water temp: ____ °F **Air temp:** 55 °F **Slope:** SEE FILES ft/ft

Skew	Distance	Depth	2/10 V	6/10 V	8/10 V	
	~~3/2~~	0		0		TOB
	37.5"	0.3		0.86		EOW
	37	0.4		1.86		
	35	0.7		2.77		
	33	1.0		4.68		
	31	1.0		4.71		
	29	1.3		5.22		
	27	1.5		5.16		
	25	1.3		5.21		
	23	1.6		4.70		
	21	1.7		4.82		
	19	1.5		4.36		
	17	1.5		4.82		
	15	1.7		4.48		
	13	1.5		5.03		
	11	1.3		4.26		
	9	1.3		3.47		
	7	1.2		3.40		
	5	0.5		2.03		EOW
	4.7	0		0		TOB

Note: If the depth of water is 3' or greater then take velocity measurements @ 2/10 & 8/10 of the depth of water. Otherwise velocity measurements will be taken at 6/10 of the depth.

Notes taken by: S. KIDDER

Survey notes: GS-11a – CANYON CRK - WEST CHANNEL

HI = 5.18 **+ bolt on gage 100** 105.18 **= instrument HI**

Instrument HI = 105.18 **- Rod** 11.32 **WS =** 93.86

Cross section notes:

TOB	**Elev.**				
	Rod	10.02			
	Distance	1.18			
	Elev.				
EOW	**Rod**	10.18			
	Distance				
	Elev.				
TOB	**Rod**	9.48			
	Distance				
	Elev.				
EOW	**Rod**	11.32			
	Distance				
	Elev.				
GS BOLT	**Rod**	5.18			
	Distance				
	Elev.				
	Rod	8.24			
	Distance				
	Elev.				
	Rod				
	Distance				

Slope Computations

Elev.		**Elev.**	
Rod		**Rod**	
Upstream Distance		**Downstream Distance**	

Pebble Project Gold Copper Field Observer Form

NDM Consultant Company Name	Bristol Environmental & Engineering Services Corporation	
Team Leader		
Land Access Location		
Native Corporation		
Date and Duration Observer Required (hours)		
Reason for Access (type of monitoring)		
Observer Confirmed	☐ Yes	☐ No
Observer Name		
Date Confirmed		
Dates and Hours Observer Used		
Comments:		
Verified by:	Richard Moses	Date

Pebble Project
Northern Dynasty Mines Inc.

Field Sampling Plan Acknowledgment Form

Disciplines: Hydrology, Surface Water Quality and Sediment Trace Elements
Consultant: Bristol Environmental and Engineering Services Corp

I understand and agree to abide by the procedures as detailed in this Field Sampling Plan (FSP). Should conditions prevent compliance with the FSP I will clearly document actual procedures conducted and explain the rationale for deviation from the plan.

Printed Name	Company	Signature	Date

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2006 FIELD SAMPLING PLAN

SMALL POOLS STUDY

JULY 2006

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SLR 2005 Wetlands Well Locations

ACRONYMS AND ABBREVIATIONS

BP	barometric pressure
°C	degrees Celsius
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
µg/L	microgram(s) per liter
µS/cm	microsiemen(s) per centimeter
mg/L	milligram(s) per liter
mm	millimeter(s)
ORP	oxidation-reduction potential
QA	quality assurance
QC	quality control
SOP	standard operating procedure

1. INTRODUCTION

This field sampling plan includes the protocols for the physical and chemical hydrology studies to be performed in 2006 for the Pebble Project, a proposed gold-copper-molybdenum mine located in southwestern Alaska. The study results will be used primarily to determine the hydrology of the pools in the mine study area.

2. PROJECT BACKGROUND

2.1 Project Purpose and Scope

Northern Dynasty Mines Inc. is proposing to develop the Pebble Project; therefore a series of environmental studies is being conducted to provide background information necessary for mine planning, permitting, and development. This field sampling plan includes the methodology for collection of water samples that will be used to determine the hydrology of the pools present in the mine study area. The source of surface water will be determined, as will the connectivity of the pools with the local aquifer systems.

2.2 Project Site Description

The project will look at three separate study areas (see attached figure). The first area, North Site, is representative of the proposed pit area and the northern part of the proposed spoils area. There are two groundwater flow-through pools located close to one another in this area. The second site, Middle Site, is representative of the southern part of the proposed spoils area and a potential mitigation area. This area has two perched precipitation pools. The final study area, South Site, is also representative of the southern proposed spoils area, but has one perched precipitation pool in close proximity to two groundwater flow-through pools.

3. PROJECT SCOPE AND OBJECTIVES

3.1 Objectives

Objectives of this study include the following:

- Characterization of two proposed pool types: perched precipitation pools and groundwater flow-through pools.
- Collection of stage and hydraulic head measurements to evaluate pool hydrodynamics.
- Collection of surface and groundwater samples for analysis of chemical composition, including stable isotopes and major ions.

The main objectives of the water sampling are as follows:

- Collect data to characterize major cations and anions in surface water, groundwater, and precipitation at the three proposed sites.
- Collect samples to characterize stable isotopes of hydrogen and oxygen in surface water, groundwater, and precipitation at the three proposed sites.
- Use the geochemical data to determine the source of surface water in each type of pool.

The main objective of the study is to verify the hypothesis that there are two types of pools present in the study area—perched precipitation pools and groundwater flow-through pools. The primary sources of water to each of the pools will be determined by comparing the geochemical characteristics of the surface waters to those of the precipitation and groundwater in the surrounding area. The local precipitation and groundwater each have very different geochemical signatures, and the resulting surface water signature should reflect these variances. The hydrodynamic studies (monitoring stage and hydraulic heads in the deposits on which the pools occur) will be used to determine whether the pools are perched on the surface, connected to a shallow perched aquifer, or connected to a deep regional aquifer.

3.2 Sample Analysis Summary

The laboratory analyses that will be performed in the on the water samples are listed in Table 1. The samples collected for major cation and anion analyses will be shipped to SGS for primary analysis and Columbia Analytical Services for quality assurance analysis. The samples collected for stable isotope analyses will be shipped to the Stable Isotope Laboratory at the University of California—Davis.

TABLE 1. Parameters for laboratory determination

Analyte	Method	Method Reporting Limit
Sodium	EPA 200.7 or 200.8	100 µg/L
Potassium	EPA 200.7 or 200.8	50 µg/L
Calcium	EPA 200.7 or 200.8	50 µg/L
Magnesium	EPA 200.7 or 200.8	20 µg/L
Chloride	EPA 300.0 or 325.3	0.2 mg/L
Sulfate	EPA 300.0 or 375.2	0.2 mg/L
Silicon, dissolved	EPA 200.8	100 µg/L
Hydrogen Isotope Ratio	Stable Isotope Laboratory SOP	± 1.0‰
Oxygen Isotope Ratio	Stable Isotope Laboratory SOP	± 0.05‰

EPA = Methods for Chemical Analysis of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993, and Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91-010, June 1991

µg/L = micrograms per liter

mg/L = milligrams per liter

SOP = standard operating procedure

‰ = per mil

3.3 Field Activities

Detailed procedures for the surface-hydrology and water-chemistry field activities are described in Sections 5 and 6. Activities for measuring field parameters are described in Section 7. Appropriate quality assurance/quality control (QA/QC) procedures will be used, and QA/QC samples will be collected at a 10 percent frequency. The sampling program will quantify the water chemistry at two separate sampling times: once in late spring and once in late summer.

4. PROJECT ORGANIZATION AND RESPONSIBILITY

Mark Rains of Coshow Environmental will coordinate the field work and report-writing. The field team will consist of Dr. Rains and Chris Love of Three Parameters Plus, Inc.

5. HYDRODYNAMIC STUDIES

Stage gages were installed by SLR Alaska in October 2005. Seven stage gages were installed. Piezometers also were installed by the SLR in October 2005. Eighteen well nests were installed, each with two piezometers reaching 2-meter and 4-meter depths. Stage in all seven pools and head in four piezometers will be recorded hourly with pressure transducers and dataloggers (Levelogger Gold Model 3001, Solinst Inc.). Head in the remaining piezometers will be measured periodically with an electronic water-level indicator (Water Level Meter Model 101, Solinst Inc.).

Rainfall also will be monitored using manual and tipping-bucket rain gages (Onset Data Logging Rain Gage, Onset Computer Corporation Inc.) placed at each study location. Manual rain gages will be read periodically, while tipping-bucket rain gages will be set to log a reading whenever 1/100th of an inch of rainfall accumulates.

6. WATER-CHEMISTRY SAMPLING

6.1 Surface-water Sampling

Samples will be collected using a peristaltic pump and tubing. Water will be obtained from approximately half-depth at each sampling location. The sample will be pumped through a 0.45-micrometer capsule filter before the sample bottles are filled directly. Each sample will consist of three bottles—an unacidified sample for anions, an acidified sample for cations, and another small bottle for isotope analyses. The acidified sample will be pumped into a bottle containing 1 milliliter HNO_3. The acid will be distributed to the bottles in the laboratory prior to the field trip. The isotope bottle will be sealed with parafilm before capping to prevent exchange with the air. The tubing will be rinsed between samplings with a mild detergent and copious deionized water.

6.2 Groundwater Sampling

Samples will be collected using a peristaltic pump and tubing. The piezometers will be purged by pumping three volumes of the water contained within the well casing. After purging, samples will be drawn from just above the bottom of the casing. Each sample will consist of three bottles, as described above.

6.3 Precipitation Sampling

Precipitation samples will be obtained from the manual rain gages installed at each study site. The sample will be drawn into a 50-milliliter plastic syringe, pushed through a 0.45-micrometer disc filter, and then dispensed into the three bottle set, as described above. Precipitation samples will be collected as soon as possible after the event throughout each field trip. Each sample will consist of three bottles, as described above.

6.4 Sample Handling

Samples will be stored in the field in coolers with frozen gel-ice at the method-required range of 4°C (+/- 2°C) before shipment to the analytical facilities. Sampling locations and identifications will be recorded in the log books.

6.5 Field Quality Control/Quality Assurance Samples

Field duplicates and field triplicates are the quality control samples and quality assurance samples, respectively. They will be collected at a frequency of 10 percent during all sampling events. Quality control will be analyzed by the primary laboratory. Quality assurance will be analyzed by the QA laboratory.

6.6 Field Sample Locations

The potential field-sample location identifications are listed in Table 2. Samples will be collected in the early and late growing season.

TABLE 2. Field sample locations

Location ID	June 2006	August 2006
XXXXNPOOL1WSXXX	X	X
XXXXNPOOL2WSXXX	X	X
XXXXMPOOL1WSXXX	X	X
XXXXMPOOL2WSXXX	X	X
XXXXSPOOL1WSXXX	X	X
XXXXSPOOL2WSXXX	X	X
XXXXSPOOL3WSXXX	X	X
XXXXWLS01SWGXXX	X	X
XXXXWLS01DWGXXX	X	X

Location ID	June 2006	August 2006
XXXXWLS02SWGXXX	X	X
XXXXWLS02DWGXXX	X	X
XXXXWLP01SWGXXX	X	X
XXXXWLP01DWGXXX	X	X
XXXXWLP02SWGXXX	X	X
XXXXWLP02DWGXXX	X	X
XXXXWLP03SWGXXX	X	X
XXXXWLP03DWGXXX	X	X
XXXXWLS03SWGXXX	X	X
XXXXWLS03DWGXXX	X	X
XXXXWLS04SWGXXX	X	X
XXXXWLS04DWGXXX	X	X
XXXXWLP04SWGXXX	X	X
XXXXWLP04DWGXXX	X	X
XXXXWLP05SWGXXX	X	X
XXXXWLP05DWGXXX	X	X
XXXXWLP06SWGXXX	X	X
XXXXWLP06DWGXXX	X	X
XXXXWLS05SWGXXX	X	X
XXXXWLS05DWGXXX	X	X
XXXXWLS06SWGXXX	X	X
XXXXWLS06DWGXXX	X	X
XXXXWLS07SWGXXX	X	X
XXXXWLS07DWGXXX	X	X
XXXXWLP07SWGXXX	X	X
XXXXWLP07DWGXXX	X	X
XXXXWLP08SWGXXX	X	X
XXXXWLP08DWGXXX	X	X
XXXXWLP09SWGXXX	X	X
XXXXWLP09DWGXXX	X	X
XXXXWLP10SWGXXX	X	X
XXXXWLP10DWGXXX	X	X
XXXXWLP11SWGXXX	X	X
XXXXWLP11DWGXXX	X	X
XXXXNSNOW1WSXXX	X	X
XXXXMSNOW1WSXXX	X	X
XXXXSSNOW1WSXXX	X	X
XXXXNPRECPWSXXX		X
XXXXMPRECPWSXXX		X
XXXXSPRECPWSXXX		X

7. MEASUREMENT OF FIELD PARAMETERS

7.1 Parameters

One field meter (YSI 556 Multi-Parameter Handheld Meter, YSI Inc.) will be used to measure the following parameters: specific conductance, temperature, pH, dissolved oxygen, and oxidation-reduction potential.

7.2 Equipment Calibration and Quality Control

The YSI 556 meter will be calibrated for four parameters: dissolved oxygen, pH, specific conductance, and oxidation-reduction potential (ORP). Procedures for calibrating for each parameter are provided below. Prior to calibrating the instrument, clean the sensors with an Alconox solution and rinse several times with deionized water. Shake off excess water prior to immersing the probe in the calibration cup with solution. Make sure that the sensors are covered when running the calibration. Used calibration solution can be used to rinse the sensors prior to calibration to provide an extra level of accuracy.

To enter calibration mode:

1. Press the on/off key to display the run screen.
2. Press the escape key to display the main menu screen.
3. Use the arrow keys to highlight the calibrate selection.
4. Press the enter key. The calibrate screen is displayed.

7.2.1 Conductivity

1. On the calibrate screen, select *conductivity* and press enter.
2. Select *specific conductance* and press enter. Note that calibrating to specific conductance will also calibrate conductivity and salinity.
3. Place 55 milliliters of the 1.413-microsiemens-per-centimeter (µS/cm) conductivity solution in the clean, dry calibration cup and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the conductivity cell. Make sure that the conductivity sensor is completely immersed past the vent hole.
5. Tighten the calibration cup onto the probe module.
6. Enter the calibration value: 1.413 µS/cm. Note that the value for specific conductivity is always in µS/cm at 25°C.
7. Press enter and allow at least one minute for the temperature to stabilize. Note the temperature of the calibration solution for the pH and ORP calibrations.
8. When the specific conductivity reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.

9. Press escape to return to the calibrate screen.
10. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

7.2.2 Dissolved Oxygen

1. On the calibrate screen, select *dissolved oxygen* (DO) and press enter.
2. Select *DO%* and press enter. Note that calibrating to DO% will also calibrate dissolved oxygen in milligrams per liter.
3. Place 1/8 inch of water into the calibration cup, and place the probe module into the cup, making sure that the DO and temperature sensors are NOT immersed in the water.
4. Secure the cup to the module by only 1 or 2 threads to ensure that the DO sensor is vented to the atmosphere.
5. Use the keypad to enter the local barometric pressure. Barometric pressure (BP) readings from the Iliamna airport can be obtained at http://weather.noaa.gov/weather/current/PAIL.html. Note that these readings have been adjusted for sea level and must be corrected to obtain the pressure at the correct altitude. The following calculation must be performed to convert the units from inches mercury (Hg) to millimeters (mm) Hg and to adjust for the local elevation in the mine area:
   a. Corrected BP (inches Hg) x 25.4 = Corrected BP (mm Hg)
   b. True BP = Corrected BP (mm Hg) – (2.5 * (altitude/100))
6. Allow 10 minutes for the air in the calibration cup to become water-saturated and for the temperature to equilibrate. When the DO% reading shows no significant change for 30 seconds, press enter. Press enter again to accept the calibration.
7. Press escape to return to the calibration menu.

7.2.3 pH

1. On the calibrate screen, select *pH* and press enter.
2. Select *3 point* and press enter. A 3-point calibration is used to correctly read surface waters that are both basic and acidic.
3. Place 30 milliliters of the first pH buffer in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the pH sensor. Make sure that the sensor is completely immersed.
5. Tighten the calibration cup onto the probe module.
6. Enter the value of the pH buffer at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.

7. Press enter and allow at least one minute for the temperature to stabilize.
8. When the pH reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
9. Press enter to return to the specified pH calibration screen.
10. Rinse the probe module, calibration cup, and sensors in deionized water and dry.
11. Repeat steps 3 through10 for the second and third buffer solutions.
12. Press escape to return to the calibrate screen.
13. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

7.2.4 ORP

1. On the calibrate screen, select *ORP* and press enter.
2. Place 30 milliliters of the ORP solution in the clean, dry calibration cup, and immerse the sensors in the solution.
3. Rotate or move the probe module up and down to remove any bubbles from the ORP sensor. Make sure that the sensor is completely immersed.
4. Tighten the calibration cup onto the probe module.
5. Enter the value of the ORP solution at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.
6. Press enter and allow at least one minute for the temperature to stabilize.
7. When the ORP reading is stable for 30 seconds, press enter. Press enter again to accept the calibration.
8. Press escape to return to the calibrate screen.
9. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

7.3 Collection of Field Measurements

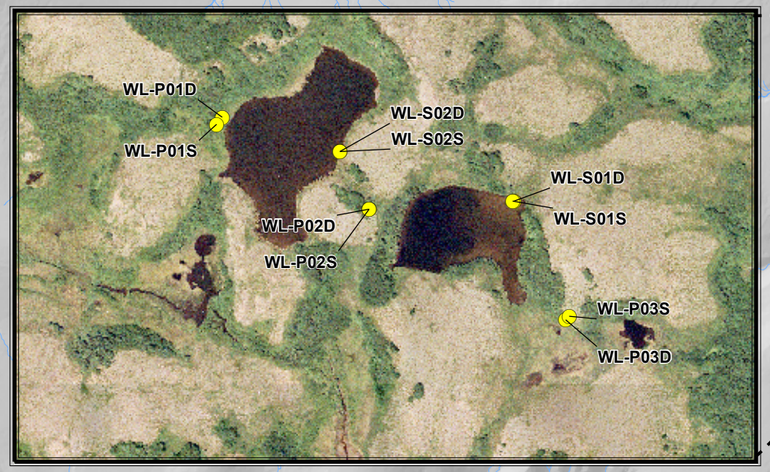
1. Turn the YSI 556 on, and place the probe module in the YSI confidence solution and check the readings. If the pH does not agree within 0.1 units or the other parameters are not within 5 percent, recalibrate the instrument.
2. Place the probe in the stream and allow it to equilibrate at least 5 minutes or until the dissolved oxygen is steady prior to recording the readings for pH, specific conductance, dissolved oxygen, and ORP.

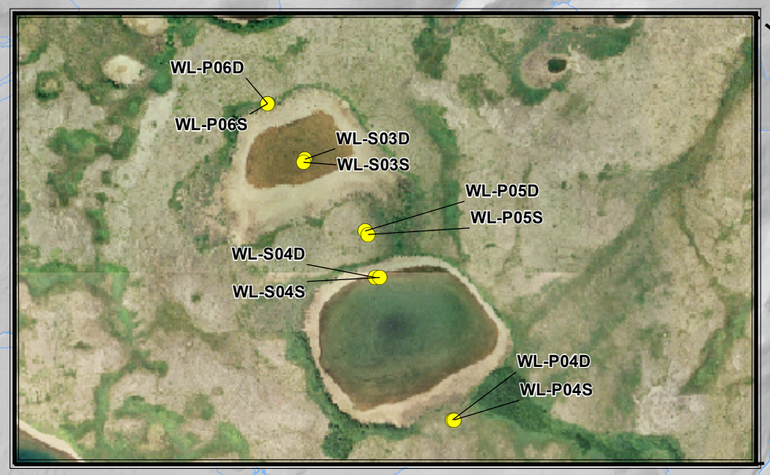
8. RECORD KEEPING

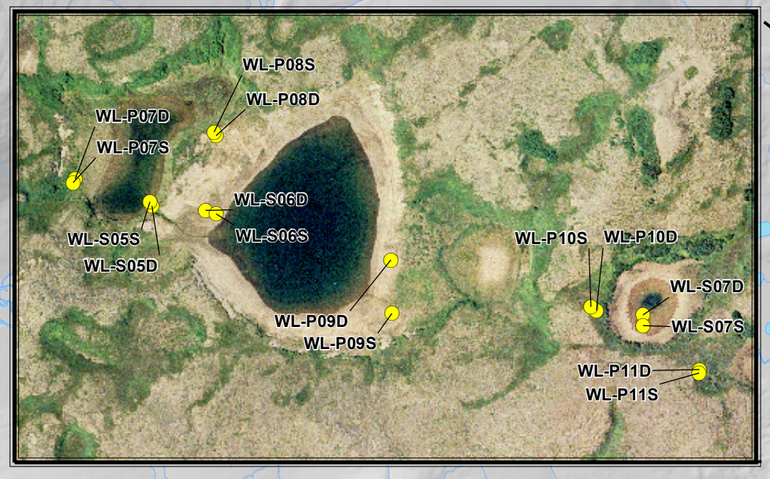
All records will be made in waterproof ink unless weather conditions prevent its use. Corrections will be made by drawing a line through the corrected entry and initialing and dating the line. All corrections will remain legible. Field log books will be used to record any deviations from the sampling methods and any additional, important notes. All sampling information—date, time, station ID, sample ID, and all field measurements— also will be recorded neatly in the log books.

1,380,000 1,390,000 1,400,000 1,410,000

2,150,000 2,140,000 2,130,000







Ore Body

Frying Pan Lake

South Fork Koktuli River

Pebble Project

NORTHERN DYNASTY MINES INC.

SLR 2005 Wetlands Well Locations

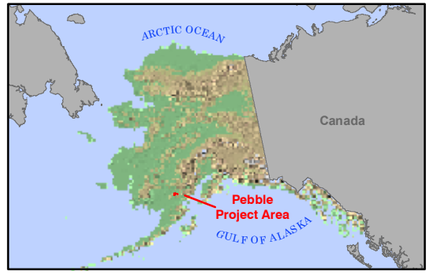
DRAFT

Legend

- SLR Wetlands Well

Notes:
Received Excel file from SLR containing Shallow Well locations.

File: SLR Wetlands Well InstallationTable.xls



0 2,000 4,000 6,000 8,000 Feet

0 500 1,000 1,500 2,000 Meters

Scale 1:42,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_SLR2005Wells_11x17_D02.mxd	Date: August 28, 2006
Version: 2	Author: RDI-DWR, LS

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
FIELD SAMPLING PLAN ADDENDA
2006 FIELD SEASON

MINE STUDY AREA

SURFACE WATER

JUNE 2006

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1. SURFACE WATER—MINE STUDY AREA

Northern Dynasty Mines Inc. is proposing to develop the Pebble Project; therefore a series of environmental studies is being conducted to provide background information necessary for mine permitting, planning, and development. This chapter updates the field sampling plan methodology for the collection of hydrology, water quality, seep, and sediment data for baseline studies within the mine study area during 2006. Although the protocols for 2006 are predominantly consistent with those detailed in the 2005 field sampling plan for these same disciplines, changes and additions to the 2005 protocols and sampling schedule are described here.

1.1 Surface Hydrology

Objectives/Study Area/Methods

The 2006 surface hydrology program for the mine studies has predominantly the same objectives, study area, and methods and approach as stated in the 2005 field sampling plan. Table 1 and Figure 1 detail the schedule and locations, respectively, for surface hydrology field work in 2006. Key changes to the surface hydrology program at the mine study area in 2006 include the addition of a tracer (salt) dilution method to measure discharge at certain sites and reduction in the number of stations that collect only instantaneous discharges following the completion of a two-year period-of-record at those sites. Details of these and other changes are provided below.

2006 Changes

Tracer (Salt) Dilution Method

Although the current-meter method is often a preferred method of measuring instantaneous stream discharge, it can be difficult to obtain good velocity readings in small steep streams due to turbulent flow. In addition, the logistics of measuring very shallow flows under ice-covered streams in winter and during bank-full conditions during breakup necessitated that alternative methods such as tracer (e.g., salt) dilution be integrated into the Pebble Project for improving instantaneous discharge measurements.

Tracer dilution is a standard U.S. Geological Service (USGS) method used to measure stream discharge. The basic method is to introduce a known amount of salt at one point in the stream, and measure the concentration wave as it passes a point downstream where it is completely mixed in the flow. Streamflow is calculated from the area under the resulting conductivity curve. The salt dilution method uses common table salt (NaCl) as a tracer to measure discharge without the use of a current meter. Salt is preferred as a tracer over other known tracers because it is non-toxic to aquatic organisms at the concentrations and exposure times associated with the measurements. It is also inexpensive, easily obtained, and convenient to work with. Field measurements can be made with a conductivity meter read by a datalogger.

Section 5.2 of the 2005 field sampling plan for surface water in the mine study area provides the formal methodology for instantaneous discharge measurements in the mine area. This section has been amended to include the salt dilution methodology. The amended version of Section 5.2 is attached to this document.

In 2006, the salt dilution method will be used at stations where the field hydrologist determines—based on the aforementioned field conditions—that the method will likely provide a more reliable discharge measurement.

Schedule

Baseline data collection for the 2006 surface hydrology program is primarily designed to increase the period-of-record and the reliability of the database. One new continuously gaged station (SK100B1) has been added to the 2006 surface hydrology program. This station is located downstream of the springs on the South Fork of the Koktuli River. The warming influence of the groundwater entering the river above this station tends to keep the station mostly ice free (relative to other stations) throughout the winter season. Data collection at the 16 continuously gaged stations (Table 1 and Figure 1) will continue through 2006 in a manner similar to the past two years.

Data collection at the 16 ungaged stations provides the water quality program with discharge data for mass-flow calculations. Instantaneous discharge measurements are expected to be collected at these stations in 2006 until the completion of a two-year period-of-record. The period-of-record and the 2006 schedule for these stations are detailed in Table 1.

Upper Hyporheic Zone Measurements

Monitoring stations to measure and record temperature in the upper 10 feet of the hyporheic zone at four stream locations were installed in 2005 as planned. The station that was installed on the main stem of the South Fork Koktuli downstream of the confluence with Tributary 1.190 was washed out during the fall freshet. The station installed below the USGS gaging station on Upper Talarik Creek (UT100B) appears to have been removed and lost by icing during winter 2005-2006. The two remaining stations are located on Upper Talarik Creek near UT146A and the North Fork Koktuli downstream of NK100B, respectively. Temperature data will continue to be collected from these two remaining stations throughout 2006. There are no plans to replace the two stations lost during the fall of 2005 and winter 2005-2006.

It is important to note that this is not the only program measuring temperatures in the hyporheic zone. The fisheries program has installed 44 temperature data loggers at 11 separate locations in the South Fork Koktuli River to measure intragravel temperatures.

Ground Water/Surface Water Exchange Measurements

This program will not be conducted during the 2006 field season.

1.2 Water Quality

Objectives/Study Area/Methods

The 2006 surface water quality, seep, and sediment program for the mine studies has predominantly the same objectives, study area, and methods and approach as stated in the 2005 field sampling plan. Table 1 and Figure 1 detail the schedule and locations, respectively, for surface water quality field work in 2006. Key changes to the surface water quality program at the mine study area in 2006 include the completion of a two-year period-of-record at 32 stations and then a reduction of sampling sites for a preconstruction monitoring phase at 17 locations. Details of these and other changes are provided below.

2006 Changes

Three new stream stations were added in 2005 and will be sampled through 2006 to complete the 2-year baseline water-quality sampling record: SK124A, a major tributary of the South Fork Koktuli River; and SK100B1 and SK100B2 in the springs area on the South Fork Koktuli River. To complete the 2-year baseline data set, water quality samples will be collected from 28 stations through the spring break-up event in May 2006. NK100B needs to be sampled through August 2006 for a two-year baseline record.

After the 2006 spring break-up event the surface water-quality program will go into a preconstruction monitoring phase at 17 locations (Table 2). Two issues that mine permit applicants are required to address during the National Environmental Protection Act review and the Clean Water Act permitting processes are whether the proposed project is expected to lead to a discharge of wastewater and whether the proposed project would create short- or long-term impacts to surface water quality. Therefore the 17 stations selected either are above or below a proposed mine site based on Mine Development Concept 25 and/or are collocated with fish tissue and macroinvertebrate monitoring sites.

Table 2. Station Locations for Preconstruction Monitoring of Water Quality

North Fork Koktuli River	South Fork Koktuli River	Upper Talarik Creek
NK100A	SK100A	UT100B
NK100B	SK100B	UT100D
NK100C	SK100B1	UT100E
NK119A	SK100C	UT119A
	SK100D	UT119B
	SK119A	UT141A
	SK124A	

Orthophosphate and separate analyses for nitrate and nitrite will be done by the analytical laboratory for all surface water quality samples and seep samples starting in May 2006.

Frying Pan Lake will be sampled at the inlets, outlet, and the deepest part of the lake for water quality once in the summer of 2006. No samples will be collected in 2006 for volatile organic compounds, semivolatile organic compounds, and pesticides.

1.3 Seeps

2006 Changes

Twenty-four seeps throughout the mine study area were selected by Water Management Consultants for HDR to sample in 2005. HDR will continue to sample the seeps for water quality and discharge in March (winter low-flow event), June (summer high-flow event), July or August (summer low-flow event), and during a high-precipitation event in the fall. Other 2006 seep activities include the following:

- Seeps will be measured for total and ferrous iron using a Hach colorimeter 890 to provide an estimate of redox conditions.
- The seep reconnaissance effort will be continued to locate seeps in areas of concern such as the mineralized area, South Fork Koktuli springs area near SK100B1 and SK100B2, and NK1.190/Option G. From the reconnaissance effort, additional seeps may be identified and added to the seep water quality and discharge sampling program.
- A seep reconnaissance to survey seeps that are persistent and flowing when groundwater levels are low prior to spring break-up will also be completed in May 2006.
- A one-time precipitate sampling protocol for seeps will be established with SRK in June 2006. Precipitate samples will be analyzed to determine their elemental and mineralogical composition.
- Field parameters will be measured in seeps in the mineralized area to identify low pH and high conductivity seeps.
- A reconnaissance of seeps near well sites, especially old Cominco well sites, will be performed to identify whether the wells have created unnatural seeps.

1.4 Sediment

2006 Changes

Sediment samples will be collected from twelve locations in June 2006. The 2006 sediment samples will also be analyzed for total sulfur and acid volatile sulfide. Sediment sites are NK100A, NK100B, NK100C, SK100A, SK100B, SK100C, SK119A, UT100B, UT100D, UT100E, UT119A, and UT141A.

No lake, seep, or pond sediments will be collected in 2006.

Table 1 Pebble Project
Site Period-Of-Record Index
Surface Water - Mine Study Area

Sample Location	Year[1]	Period Of Record By Discipline																																					
		Hydrology[2]													Water Quality												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
KC100A	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F						
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q																				
KR100A	2004				I		I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q										F						
	2005			I			I	I	I	I	I						Q			Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
NK100A (USGS)	2004						I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F						
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
NK100B	2004								I	I	I											Q	Q	Q																
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q									F	F		F				
	2006	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q									F							
NK100C	2004				I	I		I	C	C	C							Q	Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I		C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F		F				
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
NK119A	2004				I		I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q																
	2005	I		I		C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q																
NK119B	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q									F	F						
	2006	I		I		I									Q		Q		Q																				
SK100A	2004				I		I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q									F							
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F						
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
SK100B (USGS)	2004				I		I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F						
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
SK100B1	2004																																						
	2005									I	I	C	C									Q	Q																
	2006	C	C	C	C	C	C	C	C	C	C	C	C		Q		Q		Q	Q	Q	Q	Q	Q																
SK100B2	2004																																						
	2005					I	I	I	I	I	I									Q	Q	Q	Q	Q															
	2006	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q																
SK100C	2004						I	I	C	C	C							Q	Q	Q	Q			Q											F		F			
	2005	I		I		C	C	C	C	C	C				Q				Q	Q	Q		Q	Q									F	F						
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
SK100D	2004						I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q												F				
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
SK100F	2004					I	I	I	C	C	C								Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I		C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q																				
SK100G	2004				I	I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q										F	F	F				
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F						
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q																				
SK119A	2004				I	I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
SK124A	2004																																						
	2005	I		I		C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q																
SK131A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q										F		F				
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
SK133A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q																
	2005			I		I	I	I	I	I	I								Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
SK134A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q																
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
SK136A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q																
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
SK136B	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q																
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
UT100A	2004					I			I	I	I							Q	Q			Q	Q	Q												F				
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q		Q																
	2006	I		I		I									Q		Q		Q															F						
UT100B (USGS)	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q											F	F	F			
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F		F				
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
UT100D	2004				I	I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005	I		I		C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F	F		F				
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
UT100E	2004				I	I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
UT119A	2004				I	I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
	2006	I		I	C	C	C	C	C	C	C				Q		Q		Q	Q	Q	Q	Q	Q									F							
UT119B	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q																
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q											F						
	2006	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
UT135A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q																
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
UT138A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				
UT141A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005			I		I	I	I	I	I	I						Q		Q	Q	Q	Q	Q	Q												F				
	2006	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q									F							
UT146A	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q											F		F			
	2005	I		I		I	I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q																
	2006	I		I		I									Q		Q		Q																				

KEY:

C	Continuous stage/discharge hydrometric data collected in streams (gaged stations with dataloggers).
D	Macroinvertebrate sites were sampled with drift nets AND ASCI methods; periphyton was collected with RBP and diatoms were assessed.
F	Sediment samples collected. Seep sediment samples show number of seeps sampled in 2005. Sediment symbol not shown on associated map.
I	Instantaneous stream discharge measurements taken each month coincident with water quality (ungaged stations without dataloggers).
M	Macroinvertebrate samples from lakes were collected with a modified ASCI approach.
P	Plankton tows .
Q	Surface water quality samples collected for field and laboratory analyses.
S	Macroinvertebrate sites were sampled with Surber Sampler AND ASCI methods; periphyton was collected with DNR methods and chlorophyll a was assessed.
T	Fish tissue sample consisted of discrete muscle and liver samples from adult nothern pike.
W	Fish tissue sample consisted of discrete whole-body juvenile fish .
X	Seep measurements/samples collected as described in notes.

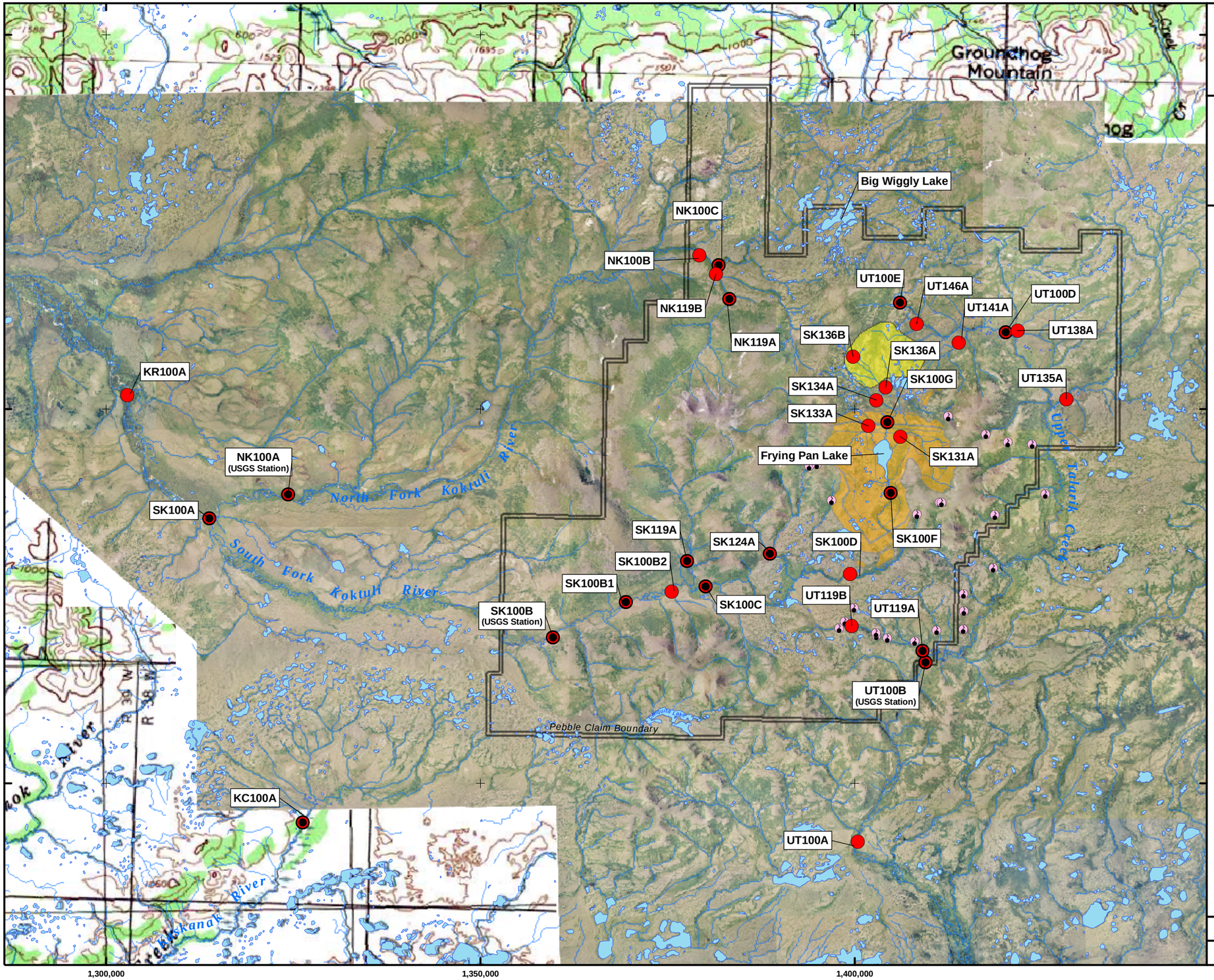
NOTES:

1 Work for 2006 is shown as planned.

2 At stations where continuous hydrometric data are collected, continuous hydrographs will be estimated throughout winter months using standard hydrometric methods.Stream gages are reinstalled each spring as early as breakup.

1,300,000 1,350,000 1,400,000

2,200,000 2,150,000 2,100,000



ASP 5 NAD 83

Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 1
Water Quality and Hydrology 2006 Field Sampling Sites

DRAFT

Legend

Type of Sample Site

- Hydrology & Water Quality site with data logger
- Hydrology & Water Quality site without data logger
- Seep Water Quality/ Hydrology Sampling Site

- Mine Development Concept Plan
- Ore Body
- Claim Boundary



N

Miles
0 1 2 3 4 5

Kilometers
0 1 2 3 4 5

Scale 1:160,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: 2006wqsamplingplan.mxd	Date:June 5, 2006
Version 1	Author: HDR-LS, DW

Z:\200847 Northern Dynasty Minerals\Water Quality Mine\GIS\MXD\2006wqsamplingplan.mxd

5.2 Instantaneous Discharge Measurements

Field procedures defined by the USGS (Rantz et al., 1982) and the *Draft Environmental Baseline Studies Proposed 2005 Quality Assurance Project Plan* (NDM, 2005) are used to obtain instantaneous discharge measurements. Current meters and/or a tracer (salt) dilution method will be used to obtain discharge estimates depending upon stream conditions. Instantaneous discharge measurements are collected at each sampling location during each field event as site conditions permit.

5.2.1 Current Meter Methodology

The current meter method is most appropriate in streams of adequate depth and that have laminar (non-turbulent flow) flow characteristics. When the current meter method is selected Price AA, Pygmy, and Marsh McBirney current meters will be used, depending on stream depths and velocities. According to the USGS (Rickman, pers. comm., 2005) Pygmy meters should be used when the depth of the water is <1.5 feet (ft) and the flow is <3.5 feet per second (ft/sec); Price AA meters should be used when the depth is >1.5 ft and the flow is >3.5 ft/sec. The Marsh McBirney meter can be used when the depth of water is greater than 4 to 6 inches and the velocities are >0.5 ft/sec. Both the Marsh-McBirney and the Pygmy meters may have some ground effects in very shallow depths.

Current meter measurements are taken by using top-setting wading rods. If the water is too deep or swift to wade, a boat will be employed to obtain discharge measurements. A sounding weight may also be used with the boat to help stabilize the current meter. Backup current meters will be kept on hand in the event of equipment malfunctions. Procedures for discharge measurements using the current meter method are outlined below:

1. Visually check wading rod, current meter (Marsh McBirney, Pygmy, or AA type), and headsets for damage. Repair damage to equipment and replace batteries as necessary.
2. Evaluate reach of stream to determine type of meter necessary to make flow measurement. For shallow, low-velocity streams, use a Pygmy current meter or Marsh McBirney; for relatively deep, higher velocity streams, use a Marsh McBirney or a standard AA-type meter.
3. Perform spin test on selected meter if appropriate; the cups on the Pygmy meter should spin continuously for at least 30 seconds; on the AA meter, the cups should spin for at least 2 minutes. If the current meter fails the spin test, lubricate and adjust as necessary to achieve desired results. Calibrate the Marsh McBirney FlowMates at the start of each field event.
4. Attach current meter and head set, or electric recorder, to wading rod. Check the electric connection between the current meter and headset or recorder by spinning cups on the current meter. Adjust equipment as necessary such that a clear signal is received upon every revolution of the cups.

5. Anchor surveyor's tape tautly across the stream perpendicular to the direction of streamflow and attach on either side of the stream. Attempt to provide at least 1 foot of clearance between the water surface and surveyor's tape.
6. Determine the spacing of the vertical partial sections, generally using 25 to 35 partial sections. The number of sections shall be based on an estimated distribution of the discharge across the entire cross-section. With a smooth cross-section and even velocity distribution, fewer cross-sections may be used. Space the partial sections to meet the USGS objective, which is that no partial section should have more than 10 percent of the total discharge in it. The ideal measurement is one in which no partial section has more than 5 percent of the total discharge in it, but this is very seldom accomplished when 25 partial sections (or fewer) are used. Equal widths of partial sections across the entire cross-section are not recommended unless the discharge is well distributed. Make the width of the partial sections less as depths and velocities become greater (USDOI, 1969).
7. Person wading in stream calls out to data recorder on shore the location of the first measuring point with respect to the surveyor's tape. Person in stream measures water depth at that vertical, using wading rod, to the nearest 0.05 foot, if possible.
8. Data recorder calls out height(s) above the streambed at which velocity measurements are to be made. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water column height. For water columns less than 2.5 feet deep, a single measurement of velocity at 60 percent of the water column height will suffice. Person wading adjusts height of current meter on the wading rod accordingly.
9. Person wading stands downstream of the surveyor's tape, facing upstream, holding the wading rod vertical in the water with the current meter facing directly into the current. Person should not stand directly behind the meter but either to the left or right so as not to influence velocity readings.
10. Person wading counts clicks or observes visual output at each vertical for a minimum of 40 seconds if using a Pygmy or Price AA meter and at least 30 seconds if using a Marsh McBirney meter. The person wading calls the final tally of both number of clicks and time to data recorder. Click count should correlate with velocity chart provided with each meter.
11. Repeat above procedure at each vertical.
12. Data recorder records other appropriate information on the field form.

5.2.2 Salt Dilution Method

Although the current-meter method is often a preferred method of measuring instantaneous stream discharge, it can be difficult to obtain good velocity readings in small steep streams due to turbulent flow. In addition, the logistics of measuring very shallow flows under ice-covered streams in winter and during bank-full conditions during breakup, necessitated that alternative methods such as tracer (e.g. salt) dilution be integrated into the Pebble Project for improving instantaneous discharge measurements.

Tracer dilution is a standard USGS method used to measure stream discharge (Rantz et al., 1982). The salt dilution method uses common table salt (NaCl) as a tracer to measure discharge

without the use of a current meter. Salt is preferred as a tracer over other known tracers because it is non-toxic to aquatic organisms at the concentrations and exposure times associated with the measurements (concentrations will not exceed 400 µS/cm). It is also inexpensive, easily obtained, and convenient to work with. Field measurements will be made with a conductivity meter read by a datalogger.

The mass balance method, which uses a slug injection of a known mass and is further described by Hudson and Fraser (2005), will be used for the Pebble Project for stream discharge at the mine area. The basic method is to introduce a known amount of salt at one point in the stream and measure the conductivity wave as it passes a point downstream where it is completely mixed in the flow. Streamflow is calculated from the area under the resulting conductivity curve.

The salt dilution method will be used at stations where hydrologists determine—based on the field conditions—that the method will likely provide a more reliable discharge measurement. Procedures for discharge measurements using the salt dilution method are outlined below:

1. **Determine Mixing Length**

   The method requires that the salt be fully mixed with the stream water so the salt concentration is uniform across the channel at the conductivity measurement point. Salt is added as a slug and is advected downstream by the streamflow. At the same time, it disperses longitudinally, vertically, and horizontally in the channel.

   In highly turbulent mountain streams, full mixing occurs in approximately 10 to 20 channel widths. For the stream sections at Pebble that are relatively low gradient, mixing lengths may be significantly longer than 20 channel widths. The actual mixing length may be determined for each site by deploying multiple conductivity probes at different downstream distances as described in Hudson and Fraser (2005) and/or by deploying more than one probe at each cross-section. It is recommended that the mixing length be verified at least once at each of these gaging sites.

2. **Determine Mass of Salt for Injection**

   The accuracy of the method is partly a function of the accuracy of the conductivity probe and the level to which conductivity is increased above the background conductivity. Background conductivity varies depending on geologic and catchment conditions, and the proportion of groundwater to surface water runoff (Moore, 2004b); therefore, conductivity may vary between sites and between flows at the same site. Conductivity should be increased up to 500 percent in low background-conductivity conditions, but approximately 50 percent is suitable for high background conditions. For background conductivities between 50 and 100 µs/cm, (typical of the Pebble Project mine area), Moore (2004b) suggests a maximum observed conductivity should be 100 to 200 percent greater than background conductivity.

   The mass of salt required to achieve the necessary increase in conductivity depends on the discharge and mixing conditions. In highly turbulent streams, mixing occurs rapidly, and the salt wave does not disperse significantly in the longitudinal direction by the time the salt is fully mixed across the channel. Consequently, conductivity is high and the salt wave passes quickly. In less turbulent conditions, a greater quantity of salt is required for an equivalent peak conductivity recording, and the salt wave takes longer to pass because

the salt plume disperses longitudinally more than in highly turbulent conditions. Figure 1 exemplifies the contrast of the varied turbulent conditions.

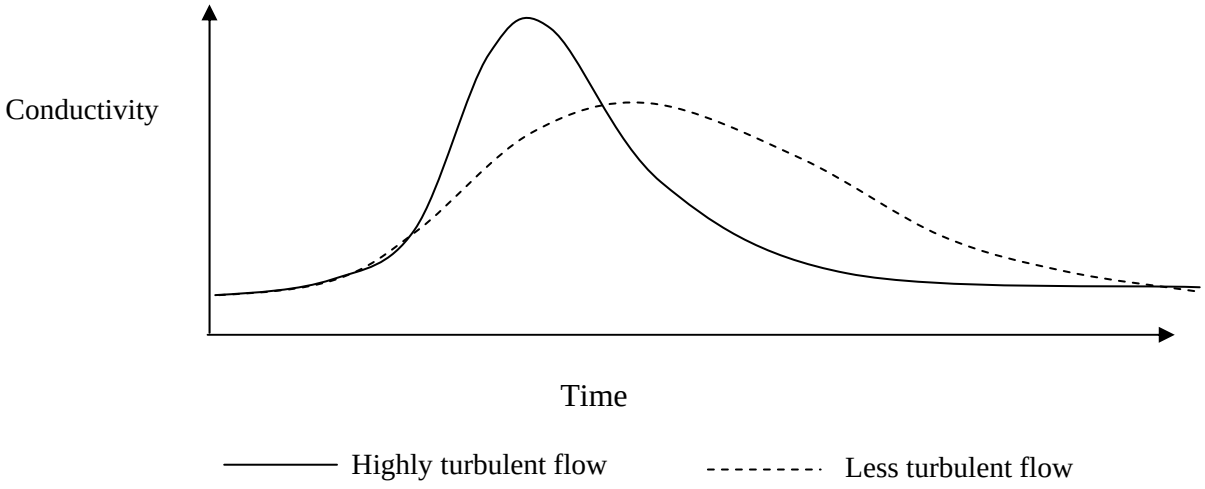


Figure 1. Conductivity recorded at the point where salt is fully mixed across the channel

The quantity of salt required at the Pebble Project depends on channel mixing length and the background conductivity. Moore (2004b) presents a range of salt quantities used by various authors. Based on this information, approximately 1 to 2 kg/m^3 (2 to 4 lb per 35 cfs) of estimated flow will be used as a reasonable starting point. The field hydrologist will visually estimate the stream discharge on site in order to determine the amount of salt tracer to inject for measurement. The final mass may be adjusted as needed to achieve an appropriate increase in conductivity levels at the measure point.

The mass of salt may be injected as dry salt or dissolved in a bucket of stream water prior to injection. This does not alter the method as long as the salt mass is known and completely dissolved prior to injection. When practical, it is recommended that this step be used to assist in rapid dissolution of the tracer. Dry injection may be used; however, the primary disadvantage of dry salt injection is that dry salt may not mix rapidly and completely when added to the stream.

This method uses a mass balance to calculate discharge. Consequently, the mass of salt added must be known accurately (± 1% is recommended). Salt may be weighed on site with an electronic scale, although pre-weighed bags (0.5 kg or greater) also work well.

3. **Place conductivity probes in the channel and start logging.**

Unitdata Starlog conductivity probes and data loggers (or equivalent) will be used to measure and record stream conductivity. The conductivity probes will be placed 10 to 20 stream widths (or further if determined necessary by the field hydrologist) downstream of the injection point. Background stream conductivity and temperature will be measured and recorded prior to injection of the salt tracer. Stream conductivity will be recorded every five seconds throughout the entire discharge measurement event.

4. Inject Salt Slug

As noted in Step 2 above, the salt may be dissolved in a bucket of stream water prior to injection. Dump the salt solution or dry salt mass into the stream. The injection location should preferably be a point that aids in mixing.

5. Monitor Conductivity Meter

The conductivity of the stream will be monitored and recorded until the stream conductivity has returned to the background level.

6. Calculate the Conductivity Curve

Measuring conductivity is a convenient surrogate for measuring the salt concentration. However, the relationship between conductivity and salt concentration depends on stream chemistry and temperature. To account for these effects, an on-site calibration is required. The conductivity curve (CF) procedure is as follows:

1) Collect 1 liter of stream water in a clean calibration container. Place the container in the stream water so that the temperature in the container remains the same as the stream temperature.
2) Record the temperature and conductivity of the stream water in the calibration container. If it is not the same as the stream water, rinse the container and collect another sample.
3) Pipette 5 ml of calibration solution into the calibration container and record the temperature and conductivity.

   Note: A calibration solution of known concentration must be prepared. The accuracy of the calibration solution is important for correctly calculating CF, hence the salt should be weighted to 0.01 g and water should be measured in an accurate volumetric flask. Laboratory-prepared solutions also may be purchased and are acceptable.
4) Repeat Step 3 until the conductivity in the calibration container is above the maximum conductivity observed as the salt wave passed. The objective is to get 4 to 5 points between background conductivity and maximum observed conductivity, to define a conductivity/concentration relationship. If the temperature in the calibration container is constant, it should be a linear relationship.

   Note: The initial volume of stream water, the volume pipetted, and the concentration of the calibration solution may be varied to achieve the above objective, although the volumes described have been found to be practical in the field.

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2007 FIELD SAMPLING PLANS

SMALL POOLS STUDY

DRAFT

SEPTEMBER 2007

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Figure 1, 2007 Field Sampling Plan, Small Pools Sampling Locations, South Fork Koktuli Basin

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
EPA	U.S. Environmental Protection Agency
µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
NDM	Northern Dynasty Mines, Inc.
QA	quality assurance
QC	quality control
SOP	standard operating procedures

SMALL POOLS STUDY

2007 FIELD SAMPLING PLAN

1. Introduction

This field sampling plan describes the methodology for collection of water samples that will be used to determine the hydrology of the pools present in the mine study area. There are three integrated tasks described in this field sampling plan. In the first task, detailed physical and chemical hydrological data will be collected at three sampling areas which are representative of the range of conditions found in the South Fork Koktuli basin (Figure 1). In the second task, detailed physical and chemical data will be collected at four sampling areas which are representative of the range of conditions found in the North Fork Koktuli and Upper Talarik basins. These four areas have been selected, but may or may not be instrumented in time for the latter part of the 2007 field season; therefore, field sampling procedures cannot be explicitly stated in this field sampling plan. In the third task, chemical hydrological data will be collected at a large number of pools throughout the South Fork Koktuli, North Fork Koktuli, and Upper Talarik basins. These pools will be selected in August 2007.

2. Project Organization and Responsibilities

Mark Rains of Coshow Environmental, Inc., will coordinate the field work and report-writing. The field team will consist of Dr. Rains, along with numerous employees and subcontractors of Three Parameters Plus, Inc.

3. Study Area

The small pools study in 2007 will continue to look at three separate areas within the South Fork Koktuli basin (Figure 1). The most northern area, the North Site, is representative of the proposed pit area and the northern part of the possible spoils area. Two groundwater flow-through pools are located close to one another in this area. The next site to the south, the Middle Site, is representative of the southern part of the possible spoils area and a potential mitigation area. This area has two perched precipitation pools. The most southern area, the South Site, is also representative of the southern portion of the possible spoils area and a potential mitigation area, but has one perched precipitation pool in close proximity to two groundwater flow-through pools.

The project is being expanded in 2007 to include sites in the North Fork Koktuli and Upper Talarik basins, in addition to the sites previously studied in the South Fork Koktuli basin. As many as two sites in each basin will be established. The exact location of these sites will be determined during the field work scheduled for May 2007. A landscape-scale study also will be completed by examining surface waters at numerous pools in each of the three basins. As many as 33 pools will be sampled in each basin. The pools to be sampled will be identified during field work scheduled for August 2007.

4. Methods and Procedures

4.1 Hydrodynamic Studies

Field activities for the hydrodynamic studies are described below.

Stage gages and piezometers were installed in the three sampling areas in the South Fork Koktuli basin by SLR Alaska in October 2005 (Figure 1). Stage gages were installed in each of seven small pools. Eighteen piezometer nests were installed, each with two piezometers reaching depths of 2 meters and 4 meters. Manual and tipping-bucket rain gages (Onset Data Logging Rain Gauge, Onset Computer Corporation, Inc.) at the three areas in the South Fork Koktuli basin were installed in June 2006 by personnel from Coshow Environmental, Inc., and Three Parameters Plus, Inc.

Stage gages and piezometer nests at the four sampling areas in the North Fork Koktuli and Upper Talarik basins will be installed by SLR Alaska sometime during summer 2007. These sites may or may not be instrumented in time for the latter part of the 2007 field season. Tipping-bucket rain gages will be installed in the sampling areas in the North Fork Koktuli and Upper Talarik basins in May 2007 by personnel from Coshow Environmental, Inc., and Three Parameters Plus, Inc.

Stage in representative pools and hydraulic head in representative piezometers will be recorded hourly with pressure transducers and dataloggers (Levelogger Gold Model 3001, Solinst, Inc.). Head in the remaining piezometers will be measured periodically with an electronic water-level indicator (Water Level Meter Model 101, Solinst Inc.). Tipping-bucket rain gages will be set to log a reading whenever 1/100th of an inch of rainfall accumulates. Manual rain gages will not be read; however, manual rain gages will be used to collect rainfall for geochemical analyses.

4.2 Water Chemistry Sampling

Precipitation, surface water, and groundwater samples will be collected in August 2007. In total, there will be approximately 14 precipitation samples, approximately 114 surface water samples, and approximately 78 groundwater samples.

4.2.1 Field Sample Locations

The precise locations of the majority of the sample sites cannot be known until field work takes place because most of the sample sites will be selected during the May and August 2007 field visits and because groundwater samples will come from small-diameter, shallow piezometers that frequently have no water or have so little water that adequate sample volumes cannot be recovered.

The potential sample locations can be categorized by task.

- The first task is to continue the detailed sampling at the three sampling areas in the South Fork Koktuli basin (Figure 1). Depending on water availability, as many as six rainfall samples, as many as seven surface water samples, and as many as 36 groundwater samples will be collected. The location identifications (IDs) of the potential sample sites for this task are listed in Table 1.

- The second task is to complete detailed sampling in the four sampling areas to be established in the North Fork Koktuli and Upper Talarik basins. These four sites may or may not be instrumented in time for the latter part of the 2007 field season. If they are, and depending on water availability, as many as eight rainfall samples, as many as eight surface water samples, and as many as 42 groundwater samples will be collected. Because these sites are not instrumented at this time, it is not feasible to provide location IDs at this time.
- The third task is the expansion of the study to the landscape scale. Surface water samples will be collected at approximately 33 pools in each basin (i.e., South Fork Koktuli, North Fork Koktuli, and Upper Talarik basins). Because these sites have not yet been selected, it is not feasible to provide location IDs at this time.

All samples for each task will be collected during the field trip scheduled for August 2007.

4.2.2 Sample Collection

4.2.2.1 Surface Water Sampling

Surface water samples will be collected using a peristaltic pump and tubing. Water will be obtained from approximately half-depth at each sampling location. The sample will be pumped through a 0.45-micrometer capsule filter before being placed in the sample bottles. Each sample will comprise three bottles: an unacidified sample to be analyzed for anions, an acidified sample to be analyzed for cations, and another small bottle for isotope analyses. The acidified sample will be pumped into a bottle containing 1 milliliter of nitric acid. The acid will be distributed to the bottles in the laboratory prior to the field trip. The isotope bottle will be sealed with parafilm before capping to prevent exchange with the air. The tubing will be rinsed between samplings with a mild detergent and copious deionized water.

4.2.2.2 Groundwater Sampling

Groundwater samples also will be collected using a peristaltic pump and tubing. The piezometers will be purged by pumping three volumes of the water contained within the well casing. After purging, samples will be drawn from just above the bottom of the casing. The sample will be pumped through a 0.45-micrometer capsule filter before being placed in the sample bottles. Each sample will comprise three bottles: an unacidified sample to be analyzed for anions, an acidified sample to be analyzed for cations, and another small bottle for isotope analyses. The acidified sample will be pumped into a bottle containing 1 milliliter of nitric acid. The acid will be distributed to the bottles in the laboratory prior to the field trip. The isotope bottle will be sealed with parafilm before capping to prevent exchange with the air. The tubing will be rinsed between samplings with a mild detergent and copious deionized water.

4.2.2.3 Precipitation Sampling

Precipitation samples will be obtained from the manual rain gages installed throughout the study area. Samples will be collected at the start of the August field trip and immediately after any significant rainfall event during the August field trip. The samples will be drawn into a 50-milliliter plastic syringe and pushed through a 0.45-micrometer disc filter before the sample bottles are filled. Each sample will comprise three bottles: an unacidified sample to be analyzed for anions, an acidified sample to be analyzed for cations, and another small bottle for isotope analyses. The acidified sample will be pumped

into a bottle containing 1 milliliter of nitric acid. The acid will be distributed to the bottles in the laboratory prior to the field trip. The isotope bottle will be sealed with parafilm before capping to prevent exchange with the air. The tubing will be rinsed between samplings with a mild detergent and copious deionized water.

4.2.3 Sample Handling

Sample identification numbers, GPS coordinates, date, time, and any special notes will be recorded in field logbooks. Sampling personnel and weather conditions will be recorded in field logbooks at the beginning of each day and after any change during the day. Sample containers will be labeled following the procedures provided in the 2007 quality assurance project plan (NDM, In press). Samples will be stored in the field in coolers with frozen gel ice at the method-required range of 4°C +/-2°C before transfer to Shaw Alaska, Inc., in Iliamna and subsequent shipment to the analytical laboratories.

4.2.4 Field Quality Control/Quality Assurance Samples

Field duplicates and field triplicates are the quality control (QC) samples and quality assurance (QA) samples, respectively. They will be collected at a frequency of 10 percent during all sampling events. QC samples will be analyzed by the primary laboratory. QA samples will be analyzed by the QA laboratory.

4.2.5 Sample Analysis Summary

The laboratory analyses that will be performed on the water samples are listed in Table 2. SGS Environmental Services, Inc., will be the primary laboratory for major cation and anion analyses, and Columbia Analytical Services will be the QA laboratory. Stable Isotope Laboratory at the University of California—Davis will conduct the stable isotope analyses.

4.3 Measurement of Field Parameters

4.3.1 Collecting Measurements

Field meters (YSI 556 Multi-Parameter Handheld Meter, YSI, Inc. or the equivalent) will be used to measure the following parameters: temperature, specific conductance, and pH. Detailed instructions for measuring parameters with the YSI 556 are as follows:

1. Turn the YSI 556 on and place the probe module in the YSI confidence solution and check the readings. If the pH does not agree within 0.1 units or the other parameters are not within 5 percent, recalibrate the instrument.
2. Place a surface water or groundwater sample in a re-usable sample cup.
3. Place the probe in the sample and allow the meter to equilibrate until the temperature, pH, and specific conductance readings are steady.
4. Record the readings for temperature, pH, and specific conductance.

4.3.2 Equipment Calibration

The YSI 556 meter will be calibrated for pH and specific conductance. Procedures for calibrating for each parameter are provided below. Prior to calibrating the instrument, clean the sensors with an Alconox solution and rinse several times with deionized water. Shake off excess water prior to immersing the probe in the calibration cup with solution. Make sure that the sensors are covered when running the calibration. Used calibration solution can be used to rinse the sensors prior to calibration to provide an extra level of accuracy.

To enter calibration mode:

1. Press the On/Off key to display the Run screen.
2. Press the Escape key to display the Main Menu.
3. Use the arrow keys to highlight the Calibrate selection.
4. Press the Enter key. The Calibrate screen is displayed.

4.3.2.1 Conductivity Calibration

1. On the Calibrate screen, select Conductivity and press Enter.
2. Select Specific Conductance and press Enter. Note that calibrating to specific conductance will also calibrate conductivity and salinity.
3. Place 55 milliliters of the 1.413-microSiemens/centimeter (µS/cm) conductivity solution in the clean, dry calibration cup and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the conductivity cell. Make sure that the conductivity sensor is completely immersed past the vent hole.
5. Tighten the calibration cup onto the probe module.
6. Enter the calibration value: 1.413 µS/cm. (Note that the value for specific conductivity is always in µS/cm at 25°C.)
7. Press Enter and allow at least one minute for the temperature to stabilize. Note the temperature of the calibration solution for the pH calibration.
8. When the Specific Conductivity reading is stable for 30 seconds, press Enter. Press Enter again to accept the calibration.
9. Press Escape to return to the Calibrate screen.
10. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

4.3.2.2 pH

1. On the Calibrate screen, select pH and press Enter.
2. Select 3 point and press Enter. A 3-point calibration is used to correctly read surface waters that are both basic and acidic.

3. Place 30 milliliters of the first pH buffer in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the pH sensor. Make sure that the sensor is completely immersed.
5. Tighten the calibration cup onto the probe module.
6. Enter the value of the pH buffer at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.
7. Press Enter and allow at least one minute for the temperature to stabilize.
8. When the pH reading is stable for 30 seconds, press Enter. Press Enter again to accept the calibration.
9. Press Enter to return to the specified pH calibration screen.
10. Rinse the probe module, calibration cup, and sensors in deionized water and dry.
11. Repeat steps 3 through10 for the second and third buffer solutions.
12. Press Escape to return to the calibrate screen.
13. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

4.4 Record Keeping

All records will be made in waterproof ink unless weather conditions prevent its use. Corrections will be made by drawing a line through the corrected entry and initialing and dating the line. All corrections will remain legible. Field logbooks will be used to record any deviations from the sampling methods and any additional, important notes. All sampling information (date, time, station identifications, sample identifications, all field measurements) also will be recorded neatly in the logbooks.

5. References

Northern Dynasty Mines, Inc. (NDM). In press. Draft Environmental Baseline Studies, 2007 Quality Assurance Project Plan.

TABLES

TABLE 1
Sample-location Identifications in the South Fork Koktuli Basin

Location ID	Description	Location ID	Description
NPOOL1	North Pool No. 1	WLP06S	Upland Piezometer No. 6 Shallow
NPOOL2	North Pool No. 2	WLP06D	Upland Piezometer No. 6 Deep
MPOOL1	Middle Pool No. 1	WLS05S	Pool Piezometer No. 5 Shallow
MPOOL2	Middle Pool No. 2	WLS05D	Pool Piezometer No. 5 Deep
SPOOL1	South Pool No. 1	WLS06S	Pool Piezometer No. 6 Shallow
SPOOL2	South Pool No. 2	WLS06D	Pool Piezometer No. 6 Deep
SPOOL3	South Pool No. 3	WLS07S	Pool Piezometer No. 7 Shallow
WLS01S	Pool Piezometer No. 1 Shallow	WLS07D	Pool Piezometer No. 7 Deep
WLS01D	Pool Piezometer No. 1 Deep	WLP07S	Upland Piezometer No. 7 Shallow
WLS02S	Pool Piezometer No. 2 Shallow	WLP07D	Upland Piezometer No. 7 Deep
WLS02D	Pool Piezometer No. 2 Deep	WLP08S	Upland Piezometer No. 8 Shallow
WLP01S	Upland Piezometer No. 1 Shallow	WLP08D	Upland Piezometer No. 8 Deep
WLP01D	Upland Piezometer No. 1 Deep	WLP09S	Upland Piezometer No. 9 Shallow
WLP02S	Upland Piezometer No. 2 Shallow	WLP09D	Upland Piezometer No. 9 Deep
WLP02D	Upland Piezometer No. 2 Deep	WLP10S	Upland Piezometer No. 10 Shallow
WLP03S	Upland Piezometer No. 3 Shallow	WLP10D	Upland Piezometer No. 10 Deep
WLP03D	Upland Piezometer No. 3 Deep	WLP11S	Upland Piezometer No. 11 Shallow
WLS03S	Pool Piezometer No. 3 Shallow	WLP11D	Upland Piezometer No. 11 Deep
WLS03D	Pool Piezometer No. 3 Deep	NPRCP1	North Pool Precipitation No. 1
WLS04S	Pool Piezometer No. 4 Shallow	MPRCP1	Middle Pool Precipitation No. 1
WLS04D	Pool Piezometer No. 4 Deep	SPRCP1	South Pool Precipitation No. 1
WLP04S	Upland Piezometer No. 4 Shallow	NPRCP2	North Pool Precipitation No. 2
WLP04D	Upland Piezometer No. 4 Deep	MPRCP2	Middle Pool Precipitation No. 2
WLP05S	Upland Piezometer No. 5 Shallow	SPRCP2	South Pool Precipitation No. 2
WLP05D	Upland Piezometer No. 5 Deep		

TABLE 2
Laboratory Analyses for Water Samples

Analyte	Method
Sodium, dissolved	EPA 200.7 or 200.8
Potassium, dissolved	EPA 200.7 or 200.8
Calcium, dissolved	EPA 200.7 or 200.8
Magnesium, dissolved	EPA 200.7 or 200.8
Chloride, dissolved	EPA 300.0 or 325.3
Sulfate, dissolved	EPA 300.0 or 375.2
Silicon, dissolved	EPA 200.8
Hydrogen Isotope Ratio	Stable Isotope Laboratory SOP
Oxygen Isotope Ratio	Stable Isotope Laboratory SOP

EPA = EPA methods from *Methods for Chemical Analysis of Inorganic Substances in Environmental Samples*, EPA/600/R-93-100, August 1993, and *Methods for the Determination of Metals in Environmental Samples*, EPA/600/4-91-010, June 1991

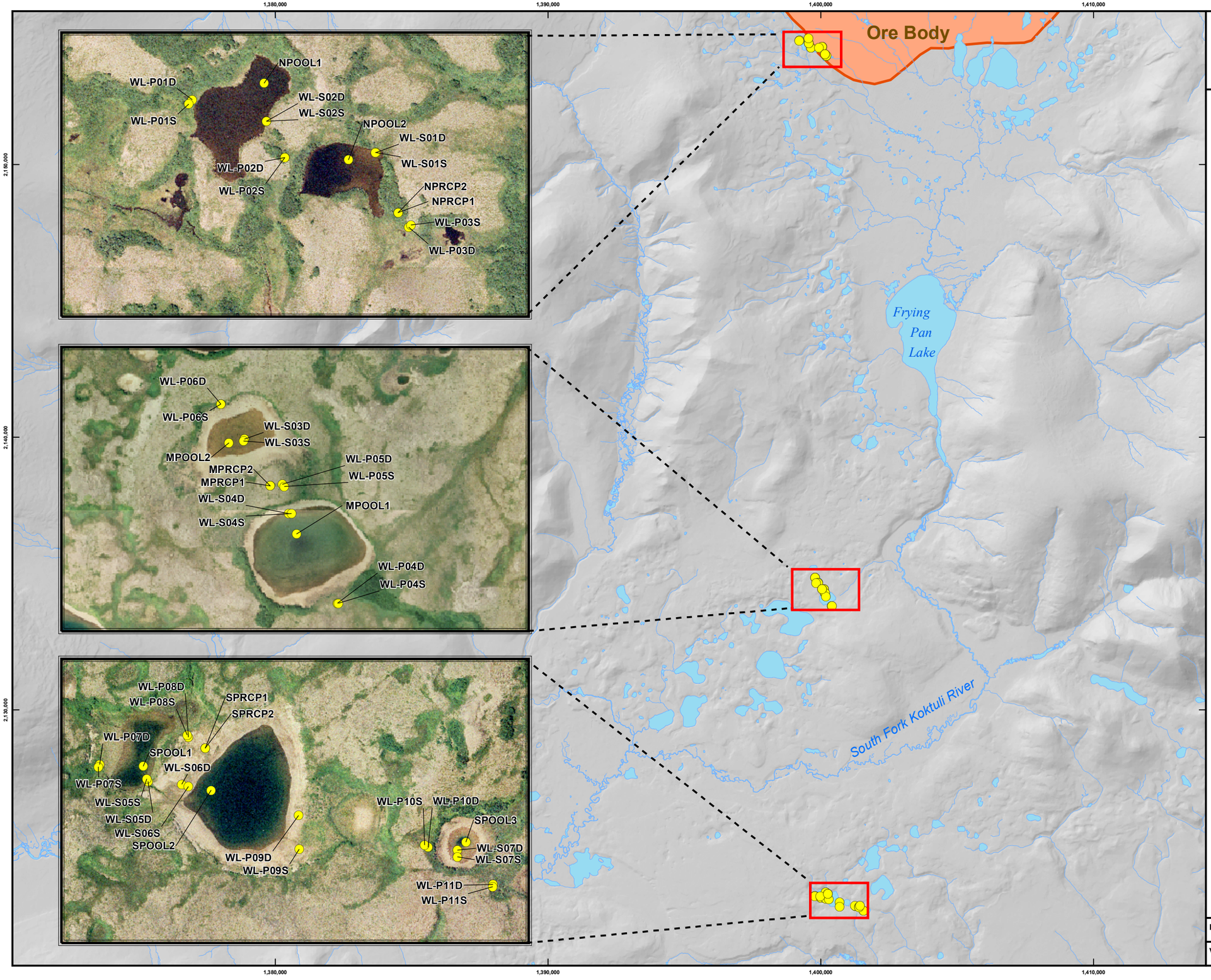
µg/L = micrograms per liter

mg/L = milligrams per liter

SOP = standard operating procedure

‰ = per mil

FIGURE



Pebble Project

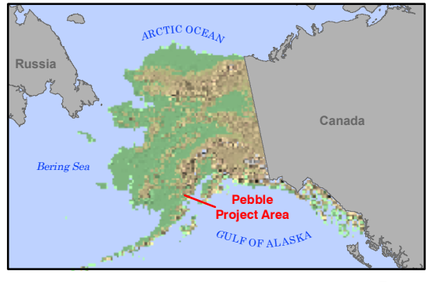
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Figure 1
2007 Field Sampling Plan,
Small Pools Sampling Locations,
South Fork Koktuli Basin

Legend

- Small Pools Sampling Location



0 2,000 4,000 6,000 8,000 Feet

0 500 1,000 1,500 2,000 Meters

Scale 1:42,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_SLR2005Wells_11x17_D04.mxd	Date: July 18, 2007
Version: 4	Author: RDI-DWR, LS

Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2007 FIELD SAMPLING PLANS

SURFACE WATER QUALITY, HYDROLOGY, AND SEDIMENT
Mine Study Area

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SEPTEMBER 2007

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ACRONYMS AND ABBREVIATIONS

ACZ	ACZ Laboratories, Inc.
°C	degrees Celsius
CAS	Columbia Analytical Services, Inc.
COC	chain-of-custody
CQ	continuous discharge
DI	deionized
DO	dissolved oxygen
DOC	dissolved organic carbon
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GPS	global positioning system
Hg	mercury
HDR	HDR Alaska, Inc.
IQ	instantaneous discharge
KC	Kaskanak Creek
KR	mainstem Koktuli River
µS/cm	microSiemens per centimeter
mL	milliliter(s)
NDM	Northern Dynasty Mines Inc.
NK	North Fork Koktuli River
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
SGS	SGS Environmental Services, Inc.
Shaw	Shaw Alaska, Inc.
SK	South Fork Koktuli River
TBM	temporary benchmark
USGS	U.S. Geological Survey
UT	Upper Talarik Creek

SURFACE WATER QUALITY, HYDROLOGY, AND SEDIMENT Mine Study Area

2007 FIELD SAMPLING PLAN

1. Introduction

This field sampling plan (FSP) includes the protocols for baseline studies of surface hydrology, fluvial geomorphology, stream and seep water quality, ponds, and sediment to be performed in the mine study area during 2007 for the Pebble Project. U.S. Environmental Protection Agency (EPA) guidance (EPA, 2003) was considered at the start of the program in April 2004 when study programs were being developed. Changes in the programs from 2004 through 2007 are summarized in Appendix A. Additional information on the 2007 surface water program is provided in the *Draft Environmental Baseline Studies, Proposed 2007 Study Plans* (NDM, In press1), Chapter 4 (surface water hydrology) and Section 6.1 (surface water quality).

2. Project Organization and Responsibility

Andra Love and Shawn Florio of HDR Alaska, Inc. (HDR), will coordinate the field work and report writing for the hydrology, fluvial geomorphology, surface water quality, and sediment programs. Figure 1 is an organizational chart showing key HDR staff who are managing and assisting in the surface water studies.

One subcontractor, Inter-Fluve, Inc., is involved with the hydrology program. Inter-Fluve's involvement may include field sampling, technical review of the reports, and advice on procedures to be used in data analysis.

3. Field Activities

The stream-sampling program will consist of monthly measurements and sampling for surface hydrology and surface water quality. The program is designed to quantify the amount of flow and seasonal flow patterns and to describe and characterize the water chemistry throughout the year under a range of different hydrologic conditions at key locations. Hydrologically significant events such as winter low flow and spring breakup will be targeted. The number and sizes of field teams will depend on site conditions, but teams will generally consist of one water-quality specialist working with one hydrologist to collect flow data and water-quality and sediment samples. Stream sediments will be sampled once during June 2007 from a subset of the surface water-quality stations. Stream sediment sampling will be conducted in conjunction with the stream-sampling events and will be incorporated into the trace elements program of the baseline environmental studies.

The field sampling program for fluvial geomorphology will consist of two summer events, one each in mid-July and in August. During these field events, fluvial geomorphic conditions will be measured and recorded.

The 2007 surface water program will include sampling seeps for flow and for water quality in March, May, July, September, and October and continuation of the seep inventory. The surface water program will also include sampling a selection of small ponds in the vicinity of the proposed mine area for water quality and sediment analysis. These samples will be collected in August in conjunction with collection of vegetation samples by SLR Alaska. The water-quality data will be shared with the small pools study being conducted by Dr. Mark Rains as part of the wetlands program.

4. Hydrology Monitoring and Fluvial Geomorphology

Field activities for hydrology and fluvial geomorphology will include several tasks, described below. The hydrology/surface water stations and the hydrology data to be collected are listed in Table 1, and the sampling stations are depicted on Figure 2.

4.1 Datalogger Installation and Monitoring

The 36 stations identified in Table 1 include the following:

- 13 stations where instantaneous discharge (IQ) measurements will be collected.
- 20 continuously gaged (continuous discharge or CQ) stations operated by HDR. These include the 13 operated in 2006 plus seven new stations (NK100A1, NK100B, NK119B, UT100C, UT100C1, UT100C2, and UT135A).
- Three CQ stations that will continue to be operated by the U.S. Geological Survey (USGS; NK100A, SK100B, and UT100B).

Dataloggers used for this project are either MiniTROLL or Level TROLL 500 units manufactured by In-Situ, Inc. Each datalogger is designed to record water depth and water temperature. A 5-pound-per-square-inch pressure transducer within the datalogger unit records changes in water-surface elevation and has an accuracy rating to 0.012 feet. The units are set to record water depth and temperature at 15-minute intervals.

Dataloggers will be installed or reinstalled as necessary in April through June 2007 at each of the 20 CQ stations operated by HDR. The schedule for these installations is dependent on individual site conditions (e.g., ice-cover and water level). The dataloggers will be housed in a polyvinyl chloride (PVC) sleeve that will be attached to an angle iron anchored in the streambed. The datalogger housing will be installed by driving an angle iron into the streambed until the angle iron is solidly anchored. Where possible, the angle iron that was installed in previous years will be used again in 2007. A prefabricated PVC housing will be connected to the angle iron at the channel bottom with steel clamps. Holes will be drilled in the PVC housing to allow unrestricted water pressure over the sensors. The datalogger will be fixed in place within the housing. An additional PVC conduit will be installed above the housing. This conduit protects the communications cable that is permanently connected to the submerged datalogger. The communications

cable, which is secured to the angle iron/fence post and extends above the estimated high-water elevation, allows data to be downloaded without disturbing the datalogger.

Staff gages also are installed at each CQ station as a quality assurance measure. During monthly field visits, manual readings of the staff gages will be compared with the electronic stage values provided by the electronic CQ gage. If either of the gages physically moves, the movement will be detected by comparing the two gage readings in the field. If movement is indicated, the gage(s) may be reset with a differential (elevation) survey and a mathematical adjustment will be applied to the data.

An independent differential survey will be performed for each of the HDR-operated CQ gages and associated staff gages following installation in the spring and prior to removal in the fall. Cross-sections also will be surveyed once per year at each CQ station. As noted above, an additional differential survey may be performed if elevation movement is observed while the CQ monitors are in place (i.e., during ice-free months). Multiple temporary benchmarks (TBMs) at each CQ station provide differential vertical datum checks for the gage equipment to monitor movement. Therefore, CQ station elevations are assumed local datums and are not interconnected with other CQ station TBMs.

Data from the dataloggers are scheduled to be downloaded monthly from installation in the spring through October 2007.

4.2 Instantaneous Discharge Measurements

Field procedures defined by the USGS (Rantz and others, 1982) will be used to obtain IQ measurements. Depending on stream conditions, a current meter, a tracer (salt)-dilution method, or both will be used to obtain discharge estimates. Instantaneous discharge measurements will be collected at each sampling location during each field event, as site conditions permit.

4.2.1 Current-meter Method

Use of a current meter is most appropriate in streams of adequate depth and that have laminar flow characteristics. (The salt-dilution method, which is detailed below in Section 4.2.2, is an alternative method that may be applicable in turbulent or shallow flow conditions.) When a current meter is to be used, Price AA, Pygmy, or Marsh McBirney meters will be used, depending on stream depths and velocities. According to the USGS (Rickman, pers. comm., 2005), Pygmy meters are appropriate when the depth of the water is less than 1.5 feet and the flow is less than 3.5 feet per second (ft/sec); Price AA meters are appropriate when the depth is more than 1.5 feet and the flow is more than 3.5 ft/sec. The Marsh McBirney meter is appropriate when the depth of water is equal to or greater than 0.2 feet. Both the Marsh-McBirney and the Pygmy meters may be negatively affected by very shallow depths.

When a current meter is used, measurements will be taken by using top-setting wading rods. If the water is too deep or swift to wade, a boat may be employed to obtain discharge measurements. A sounding weight may be used with the boat to help stabilize the current meter. Backup current meters will be kept on hand in the event of equipment malfunctions.

Procedures for taking discharge measurements using a current meter in ice-free conditions are outlined below.

1. Visually check wading rod, current meter (Marsh McBirney, Pygmy, or AA type), and headsets for damage. Repair damage to equipment and replace batteries as necessary.
2. Evaluate reach of stream to determine type of meter necessary to make flow measurement. For shallow, low-velocity streams use a Pygmy or Marsh McBirney current meter; for relatively deep, higher-velocity streams, use a Marsh McBirney or a standard AA-type meter.
3. Perform spin test on selected meter, if appropriate. The cups on the Pygmy meter should spin continuously for at least 30 seconds; on the AA meter, the cups should spin for at least 2 minutes. If the current meter fails the spin test, lubricate and adjust as necessary to achieve desired results. Calibrate the Marsh McBirney FlowMates at the start of each field event by placing them in a 5-gallon bucket of water and letting them stand for 5 minutes. Re-zero if needed.
4. Attach the current meter, and if using a Price AA or Pygmy meter, either a headset or electric recorder to the wading rod. Check the electrical connection between the current meter and the headset or recorder by spinning the cups on the current meter. Adjust equipment as necessary so that a clear signal is received upon every revolution of the cups.
5. Anchor surveyor's measuring tape tautly across the stream perpendicular to the direction of stream flow and attach on either side of the stream. Calculate the width of the entire stream cross-section.
6. Determine the spacing of the vertical partial sections (referred to as "verticals") by splitting the entire stream cross-section into 25 to 35 verticals. The number of verticals will be based on an estimated distribution of the discharge across the entire cross-section. With a smooth cross-section and even velocity distribution, fewer verticals may be used. Space the verticals to meet the USGS objective that no vertical partial section should contain more than 10 percent of the total discharge. The ideal measurement is one in which no partial section contains more than 5 percent of the total discharge; however, this design is very seldom accomplished when 25 verticals (or fewer) are used. Equal widths of verticals across the entire cross-section are not recommended unless the discharge is well distributed. Widths of the vertical partial sections should become less as depths and velocities become greater (USDOI, 1969). Vertical water-column readings will be taken at each vertical.
7. Person wading in stream will call out the location of the first vertical with respect to the surveyor's tape to the person on shore who is recording data (data recorder).
8. Using the wading rod, person wading in stream will measure water depth at that vertical to the nearest 0.05 foot, if possible. Call out this depth reading to data recorder, and adjust the height of the current meter on the top-set wading rod according to the depth at that vertical. For water columns less than or equal to 2.5 feet deep, a single measurement of velocity at 60 percent of the water-column height will suffice. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water-column height from the stream bottom.
9. Person wading in stream: Stand downstream of the surveyor's tape, facing upstream and holding the wading rod vertical in the water with the current meter facing directly into the current. Stand to the side, rather than directly behind the meter, to avoid influencing velocity readings. Occasionally flow at a vertical may not be perpendicular to the tape due to a rock upstream or other flow restrictions. If the obstruction cannot be cleared and the flow is more than 20 degrees off perpendicular, the person in the stream should orient the meter directly into the flow and call

out the angle of flow with respect to perpendicular. A correction will be applied to the velocity measurement from the vertical when calculating the discharge.

10. Person wading in stream: Count clicks or observe visual output of velocity measurements at each vertical, depending on the meter used. If using a Pygmy or Price AA meter, velocity measurements will be made for at least 40 seconds, and both time and number of revolutions (clicks) will be recorded. These data will be used to determine the velocity at the vertical, based on the meter's equation. Click-count should correlate with the velocity chart provided with each meter. If using a Marsh McBirney meter, velocity measurements will be made for 30 seconds, and velocity will be recorded. The time interval will be noted on the data sheet. In the event of extreme weather or flow conditions, a minimum of 20 seconds may be used for velocity measurements made with a Marsh McBirney meter. Call out the final tally of both number of clicks and time to the data recorder.
11. The person recording data will record this and other appropriate information on the field form.
12. Repeat above procedure at each vertical.

Winter conditions present additional challenges for collecting instantaneous discharge measurements. When ice is present in the channel, the following changes to the above will be adopted:

1. Assess the condition of the ice. If the ice is determined to be safe enough to work on, then proceed with site preparations. If the ice and or ice/flow conditions are unsafe, do not attempt a measurement at that location. Ice and flow conditions a short distance upstream or downstream of the station may be different and may be suitable for taking a measurement.
2. Site preparations include auguring holes and/or chopping ice across the channel perpendicular to the flow with spacing that allows for 25 to 30 partial sections. In some channels it may not be possible to auger this many holes. If it is not possible to auger 25 to 30 holes due to narrow flow, auger as many holes as feasible to achieve as many velocity measurements as practicable. Note that the closest spacing for any velocity measurement will be 0.20 feet, so it is possible to take two measurements in one hole, recording one measurement on each side of the hole. If flow is narrow, consider using the salt-dilution method described in Section 4.2.2.
3. The effective depth is the depth of the water below the ice when there is ice/water contact. Once all holes are drilled through to water or substrate note whether or not there is contact between the flowing water and the ice cover. For each vertical where there is ice/water contact, measure the effective depth; otherwise, measure the depth of the water at verticals where there is no ice/water contact as described above for ice-free conditions. If there is contact between the water and the ice cover, an ice-cover multiplier of 0.92 will be applied to each velocity measurement to adjust the flow for the increased friction supplied by the ice cover.
4. Make velocity measurements as described above. Note that the person taking measurements may be standing on top of the ice and not in the stream.
5. In some cases flow under ice will be pressurized and will flow upwards out of an augured hole. If pressurized water is encountered, wait 15 minutes after the hole is complete and asses the situation. If the water is no longer flowing up out of the augered hole(s), proceed with site preparations and velocity measurements. If the water is still coming through the hole(s), it may be possible to create a temporary snow dam that will allow the water to pool up, creating a pressure

head that will equilibrate and stop water flowing out of the hole. If the upward flow is contained, the hydrographer may continue site preparations and make velocity measurements. Measurement may not be practicable if the upward flow is not contained.

4.2.2 Salt-dilution Method

Although the current-meter method is often a preferred method of measuring instantaneous stream discharge, it can be difficult to obtain good velocity readings in small steep streams because of turbulent (non-laminar) flow. In addition, measuring very shallow flows, flows under ice cover in winter, and flows during bankfull conditions that characterize breakup may require alternative methods, such as tracer dilution, to improve instantaneous discharge estimates.

Tracer dilution is a standard USGS method used to measure stream discharge (Rantz and others, 1982). The salt-dilution method uses common table salt (NaCl) as a tracer to measure discharge without the use of a current meter. Salt is preferred as a tracer over other known tracers because it is nontoxic to aquatic organisms at the concentrations and exposure times associated with the measurements. Salt is also inexpensive, easily obtained, and convenient to work with.

The salt-dilution method will be used at stations where hydrologists determine, based on field conditions, that the method will likely provide a more reliable discharge measurement. Measurements will be made with a conductivity meter read by a datalogger (adding salt changes the conductivity of water).

The mass balance method of salt dilution involves injection of a slug of a known mass and is further described by Hudson and Fraser (2005). This is the salt-dilution method that will be used for stream discharge measurement in the mine study area. As described below, a known amount of salt will be introduced at one point in the stream, and as it passes a point downstream where it is expected to have completely mixed in the flow, the conductivity at that point will be measured. Stream flow is calculated from the area under the resulting conductivity curve.

- Determine mixing length required.

  This method requires that the salt be fully mixed with the stream water so the salt concentration is uniform across the channel at the conductivity measurement point. Salt is added as a slug and is conveyed downstream by the stream flow. At the same time, it disperses longitudinally, vertically, and horizontally in the channel.

  In highly turbulent mountain streams, full mixing occurs in approximately 10 to 20 channel widths. For stream sections that are relatively low gradient, mixing lengths may be significantly longer than 20 channel widths. The actual mixing length may be determined for each station by deploying multiple conductivity probes at different downstream distances as described in Hudson and Fraser (2005), deploying more than one probe at each cross-section, or a combination of these approaches. It is recommended that the mixing length be verified at least once at each of the gaging stations.

- Determine mass of salt for injection.

  The accuracy of the method is partly a function of the accuracy of the conductivity probe and the level to which conductivity is increased above the background conductivity. Background conductivity varies depending on geologic and catchment conditions and the proportion of

groundwater to surface water runoff (Moore, 2004); therefore, background conductivity may vary between stations and between flows at the same station. For purposes of discharge estimation, conductivity should be increased as much as 500 percent in conditions of low background conductivity, but approximately 50 percent is suitable for high background conditions. For background conductivities between 50 and 100 microSiemens per centimeter (µS/cm; typical of the mine study area), Moore (2004) suggests that the maximum observed conductivity should be 100 to 200 percent greater than background conductivity.

The mass of salt required to achieve the necessary increase in conductivity depends on the discharge and mixing conditions. In highly turbulent streams, mixing occurs rapidly and the salt wave does not disperse significantly longitudinally (downstream) by the time the salt is fully mixed laterally across the channel. Consequently, conductivity is high and the salt wave passes quickly. In less turbulent conditions, a greater quantity of salt is required for an equivalent peak conductivity recording and the salt wave takes longer to pass because the salt plume disperses longitudinally more than in highly turbulent conditions. Figure 3 illustrates the contrast between conductivity in high turbulence and in lower turbulence.

The quantity of salt required for effective measurement at each station depends on channel mixing length and the background conductivity. Moore (2004) presents a range of salt quantities used by various authors. Based on this information, approximately 2 kilograms (kg) for each 1 cubic meter per second (35.3 cubic feet per second) of estimated flow will be used as a reasonable starting point. The hydrographer will visually estimate the stream discharge on site to determine the amount of salt tracer to inject for measurement. The final mass may be adjusted as needed to achieve an appropriate increase in conductivity at the measurement point.

- Inject known mass of salt.

  Since the salt-dilution method uses a mass balance to calculate discharge, the mass of salt added must be known accurately (±1 percent is recommended). The salt may be weighed on site with an electronic scale; however, use of preweighed bags (0.25 kg or greater) is recommended.

  The mass of salt may be injected as dry salt or may be dissolved in a bucket of stream water before it is injected. Pre-dissolution does not alter the method as long as the salt mass is known and the salt is completely dissolved before injection. When practical, pre-dissolution is recommended to assist in rapid dispersal of the tracer. Dry injection may be used; however, the primary disadvantage of dry injection is that dry salt may not mix as rapidly when added to the stream.

- Place conductivity probes in the channel and start logging.

  Unitdata Starlog conductivity probes and dataloggers (or equivalent) will be used to measure and record stream conductivity. The conductivity probes will be placed 10 to 20 stream widths (or farther, if determined necessary by the hydrologist) downstream of the injection point. Background stream conductivity and temperature will be measured and recorded before injection of the salt tracer. Stream conductivity will be recorded every five seconds throughout the entire discharge-measurement event.

4.3 Baseflow Measurements

The objective of baseflow measurements is to characterize stream flows under low-flow conditions. These data will provide information about gaining and losing aspects of the study area drainages, which will be used in the development of hydrogeologic models.

To measure baseflow conditions, a series of stream low-flow profiles will be completed in late March or early April 2007. No data collection is planned for summer 2007, because past efforts to collect baseflow data during the summer have been unsuccessful. The low-flow profiles will involve measuring instantaneous discharge at multiple (approximately eight to ten) stations each in the north and south forks of the Koktuli River and in Upper Talarik Creek. Specific measurement locations will be determined from data collected in previous years from existing baseflow stations and based on current site conditions. Discharge measurements will be collected with the same methods used during the monthly instantaneous discharge measurements described above. Water-quality field parameters (specific conductance, relative conductance, temperature, pH, dissolved oxygen, and oxidation-reduction potential) will also be measured at each station using a YSI 556 multi-probe (Section 7.3.4).

4.4 Fluvial Geomorphology

The objective of the fluvial geomorphic task is to support the ongoing instream flow studies. The fluvial geomorphic study will characterize baseline geomorphic conditions and develop regime equations to understand the sensitivity of the geomorphology of the North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek to variable hydrologic conditions.

HDR and its subconsultant, Inter-Fluve, Inc. will begin the characterization of baseline fluvial geomorphic conditions on the north and south forks of Koktuli River and on Upper Talarik Creek by conducting an analysis of fluvial geomorphology data collected in 2005. These results will be used to finalize a strategy for the 2007 field sampling effort. At this time, two field sampling events are proposed: one each in mid-July and in August.

The data collection for the 2007 fluvial geomorphology study will use standard methods described in the literature (e.g., Kondolf and Piegay, 2003; Rosgen, 1996; Sanders, 1998, Wolman, 1954). Specific data-collection efforts expected in 2007 include cross-sectional and longitudinal surveys, Wolman pebble counts, and station photo documentation (upstream, downstream, and cross-sectional photos). Station documentation will also include noting channel characteristics such as bankfull indicators and site observations such as vegetation patterns, bank stability, and habitat use. Additional methods may be added after the analysis of the 2005 data.

4.4.1 Station Selection and Survey

The number of stations and their locations will be determined after an evaluation of the 2005 data. Stations will be located to best represent channel geometry conditions, hydraulics, and geomorphic indicators that identify the channel-forming flow for that reach of river. At each station, three to four representative cross-sections and a longitudinal profile will be surveyed and tied to local TBMs providing a differential vertical datum.

4.4.2 Wolman Pebble Count

A Wolman pebble count is a sampling of a predetermined number of grains (commonly 100) selected from the streambed in a random manner to characterize the bed grain-size at a given station. The general procedure is as follows:

1. Decide on sampling feature (bar, riffle, pool, or bank) and pattern (grid, line, or area).
2. Randomly select a grain at the sampling point by closing or averting the eyes while placing a finger on the streambed and selecting a grain. (Other methods for randomly selecting a grain may be used, e.g., always selecting the grain at the tip of the left boot.)
3. Measure the grain by fitting it through the smallest possible opening on the gravelometer.
4. Record the size of the grain on the data sheet.
5. Repeat sampling procedure until the desired sampling number is reached.

5. Seep Flow Measurements

Instantaneous flow measurements are planned at each seep sampling site (Figure 4) five times per year to capture winter baseflow (March), spring breakup (May), summer low flow (July), a fall storm event (September), and late fall low flow (late October). Water-quality samples will be collected at the same time that instantaneous flow measurements are taken.

On the initial visit to a sampling station, a GPS (global positioning system) point is recorded, a fiberglass stake is placed, and the station is developed, beginning with selecting a location that will capture the maximum percentage of the seep flow while maintaining repeatability and consistency of the flow measurement. Often several smaller flows are channelized to a location with suitable characteristics for capturing the flow. Any channeling of flows is documented with sketches and photographs. The sampling station itself is smoothed and reshaped to accept the portable weir or to create a free over-fall for direct catch (see below). Large rocks and other obstructions are removed. On return visits, collection ditches are maintained for repeatability of the flow measurement. During spring events, snowdrifts occasionally necessitate sampling at locations that are near, but not exactly the same as, the original location.

Due to the variability in the size of seeps, two methods and/or apparatus are used to measure discharge:

- **Direct Catch**: This method is used for seeps with small flows and as a supplementary method on mid-sized seeps to calibrate the weir flow data. This method is limited to locations where the flow path is steep enough to allow the container to be positioned under an over-fall and is limited to flows that can be captured in a 5-gallon bucket in two to three seconds. A V-notch weir or a small rubber skirt is used to create a free over-fall. Direct flow is captured over a timed period in a calibrated container. The quantity and the time interval are recorded a minimum of three times and then averaged. This method is quick and repeatable. It is the preferred method where applicable.
- **Portable Weirs**: Portable weirs are used at locations where direct catch isn't feasible. Four portable weirs are used on this project: 60º, 90º, and 120º V-notch weirs and a 3-foot rectangular weir. The size of the weir depends on the amount of seep flow. All of the weirs are fitted with a

rubber skirt that conforms to the bottom of the flow channel. Sediments, mud, moss, and/or rocks are used to seal the skirt along its upstream edge, and static water pressure holds the weir and skirt in place. The seal is fitted to the ground surface, and the size of the quiescent pool behind the weir is adjusted until the best approximation of ideal weir conditions is achieved. The weir is leveled laterally, and the level of the detention pool is allowed to stabilize. The height of the water head above the crest of the weir is then recorded. All weirs are marked on the upstream side with water head scales for rapid, accurate readings. The percentage of the total flow being captured is estimated and recorded. Conditions that affect this percentage are the shape and slope of the channel, the coarseness and gradation of the substrate, and the availability of sealing materials (mud, moss, sand, etc.). Once a station is established, the percentage of capture remains approximately equal for successive sampling events.

The flow measurement methods outlined above are intended to give relative and repeatable flow values in order to compare flows at different times of the year and in different weather, groundwater, and precipitation regimes.

6. Seep Inventory

The seep inventory program documents the location and relative size of seeps in the mine study area. The definition of a seep as defined by HDR for the purposes of this task is as follows:

- To be recorded and mapped, a seep must exhibit a distinct groundwater point source and a distinct flow path extending downslope approximately 30 feet or until it enters a larger drainage feature.
- Large diffuse seep areas that coalesce into a distinct flow path with dry ground up-gradient also are recorded.

Features that are ***not*** mapped include the following:

- Small features that appear to be directly reabsorbed downslope.
- Small drainages with accumulating surface runoff.
- Meltwater features that coalesced below snow fields.
- Marshy areas and ponds with no distinct flow path below the feature.

The seep inventories are conducted using aerial surveys with helicopter support. Field personnel fly over all inventory areas in a helicopter (typically an R-44 for optimal visibility) at altitudes ranging from 50 to 150 feet above ground level. Initially, inventory areas are canvassed at higher altitude and speed to reconnoiter the seeps. A more detailed inventory is then flown at a lower altitude. Inventory altitude varies depending on the terrain and vegetation. In open areas with less topographic detail and/or fewer seeps, inventories are conducted at a higher altitude to allow for wider visibility and faster inventory. In areas with thick brush, more complex topography, or more seeps, inventories are conducted at lower altitudes.

The helicopter pilot helps to ensure complete coverage of the target areas. A navigator sits in the copilot seat and has primary responsibility for identifying seeps, determining relative size, logging GPS

waypoints and waypoint numbers, relaying size and waypoint numbers to the recorder/photographer, keeping track of area coverage, and directing the pilot. A recorder/photographer in the rear seat maintains the field logbooks; records waypoints, seep size, and photo numbers; and takes photos.

Areas are flown in a manner intended to achieve 100 percent coverage. The track-log feature on the GPS unit is used to ensure that all areas were canvassed completely. A goal of the inventory is to obtain an accurate location with the GPS waypoint feature so seeps can be found again easily. Because of the variables of altitude, viewing angle, GPS location update rates, helicopter speed, maneuverability in high winds, and pilot and observer limitations, each seep point has an estimated accuracy of +/-100 feet.

Depending on the terrain and the general layout of the seep areas, each pass is flown across the slope contours (especially when the seeps were located in bands of similar altitudes) or upslope in individual drainages when seeps are scattered randomly in smaller drainage basins. In high-wind situations, the helicopter makes a slow inventory pass upwind over the area and returns downwind to start a new pass.

7. Surface Water Quality and Sediment

HDR's 2007 surface water-quality program includes collection of water samples from streams, seeps, ponds, and lakes and of sediments from streams, ponds, and lakes in the mine study area.

7.1 Sampling for Surface Water Quality

The sampling program for stream surface-water quality is designed to characterize the water chemistry throughout the year and under different hydrologic conditions at key stream locations. Water-quality sampling of stream surface water will occur monthly to document how water chemistry changes as flow increases with breakup and with precipitation events. Late-winter sampling of stream surface water is also important because the conditions represent minimum flows, which are most representative of baseflow from groundwater discharge.

Stream water sampling will occur at 36 stations (Table 1 and Figure 2) on the North Fork Koktuli River (NK), South Fork Koktuli River (SK), mainstem of the Koktuli River (KR), Upper Talarik Creek (UT), and Kaskanak Creek (KC). Stream water-sampling events will occur monthly from January to December.

Six lakes (Big Wiggly, Black, Frying Pan, Chiquita, and Mud lakes and Lake No. 2) were selected for sampling in 2005 based on geographic representation. These sites will be sampled for water by HDR and for sediments and vegetation by SLR Alaska in August of 2007.

7.1.1 Depth-integrated Stream Sampling

Analytical samples will be collected in accordance with the USGS's protocol for equal discharge increment sampling (Shelton, 1994) and will incorporate depth-integrated techniques. Depth-integrated sampling will be conducted by using a DH-81 sampler where adequate depths permit its use. Depth-integrated sampling in shallow streams will be accomplished with grab samples as described in Section 7.5.2.

The areas along a cross-section where depth-integrated samples will be collected are determined by dividing the stream width into segments based on visually estimated percent discharge. Individual depth-integrated samples from a cross-section will be composited in a 5-gallon plastic bucket. By combining the samples before filling the sample bottles, a complete cross-sectional and depth-integrated sample will be collected. The only exceptions will be samples collected for analysis for low-level mercury and for dissolved organic carbon (DOC), which will be grab samples. Methods for depth-integrated sampling are described below:

1. Label sample bottles with sample location code (Section 7.9.1), analysis, date, time, sampler's initials, and "HDR Pebble Project."
2. Visually check DH-81 sampler for damage.
3. Decontaminate all parts of the water sampler used, including nozzle, body, gasket, and sample bottle, as described in Section 7.1.
4. Locate sampling stations by dividing the stream cross-section into segments with visually estimated equal discharge. A minimum of four segments should be sampled at each cross-section. If more sample volume is required to fill all sample bottles, more subsamples will be taken with the DH-81 by dividing the stream width into more segments of equal discharge.
5. At a selected stream segment, lower the DH-81 sampler into the stream all the way to the streambed at a steady rate making sure the sampler handle is vertical. The sample bottle should be just less than half-full upon encountering the streambed. Raise the sampler at a rate similar to the descent rate. The collection bottle should not be completely full upon removal from the stream. Pour contents of collection bottle into the clean 5-gallon bucket.
6. Repeat Step 5 in all segments along the cross-section until the appropriate amount of water has been collected.
7. Put on nitrile gloves, and collect analytical samples from the composite sample in the 5-gallon bucket by pouring directly from the bucket into the sample bottles (requires two people). Do not fill bottles completely, so the preservative will not overflow the bottle neck and be lost.
8. Fill out appropriate field forms documenting sampling location, time, and other pertinent information before leaving the sampling station.

7.1.2 Grab Sampling

Grab sampling will be performed at ponds and lakes and at stream stations where the use of the DH-81 sampler is not possible due to low flow. In below-freezing conditions, grab samples will be collected to prevent the water freezing while in the 5-gallon bucket. In addition, grab sampling will always be used for the collection of samples for low-level mercury and DOC analyses. At each sampling site, the mercury samples will be collected first, then the DOC samples, and then the other samples.

Procedures for collecting grab samples are outlined below:

1. Label sample bottles with sample location code (Section 7.9.1), analysis, date, time, sampler's initials, and "HDR Pebble Project."

2. Locate sampling station at a point in the stream, pond, or lake where water is deep enough to avoid introducing substrate sediments into the sample. In the event that the necessary depth of water is not available at the site, do not collect a sample.
3. Put on nitrile gloves.
4. Low-level mercury bottles must be filled direct from the stream and not taken out of their double zipper-seal bagging. Submerge the capped bottle so that the mouth of the bottle is about 2 to 3 inches below the surface of the stream. Uncap the bottle while it is below the surface of the water, and fill it slowly. To prevent loss of preservative, do not overfill the bottle. Cap the sample bottle, and empty excess water from the zipper-seal bags. Seal both zipper-seal bags.
5. DOC sample bottles should be completely submerged and capped while under water to remove all empty headspace from the bottle.
6. For all other samples, submerge an unpreserved sample bottle so the mouth of the container is about 2 to 3 inches below the surface of the stream, whenever possible. Pour the sample from collection bottle into the other sample bottles until all bottles are full. Do not overfill bottles with preservative.
7. Fill out appropriate field forms documenting sampling location, time, and other pertinent information before leaving the sampling station.

7.1.3 Under-ice Sampling

During winter months, the water-quality stations are frequently frozen over. Sampling protocols have been designed to accommodate these conditions. Because sample bottles and a sampling pole are the only equipment used, no decontamination is necessary. The procedures for sampling under ice cover are described below.

1. Drill a hole at least 15 feet upstream from the instantaneous flow cross-section to prevent contamination from the auger while drilling.
2. Surge the hole vigorously using the plunger pole, and allow water to flush for10 to 15 minutes to ensure that the water is uncontaminated.
3. Label sample bottles with sample location code (Section 7.9.1), analysis, date, time, sampler's initials, and "HDR Pebble Project."
4. Affix an unpreserved sample bottle to the sampling pole.
5. Insert the sample bottle into auger hole below the level of the ice, taking care to capture as little ice as possible.
6. Fill the sample bottle for low-level mercury analysis first, the bottle for DOC analysis second, and then fill the remaining sample bottles.

7.1.4 Measurement of Field Parameters

A YSI 556 multi-probe meter will be used at each site to measure the following field parameters: specific conductance, relative conductance, temperature, pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP). A Hach 2100P meter will used to measure turbidity. Section 7.11 outlines the calibration

and maintenance procedures for these two meters. The procedures for using these instruments are described below.

7.1.4.1 YSI 556 Multi-probe Meter

1. Turn the YSI 556 on.
2. Place the probe in the stream, upstream of the sampling area, and allow it to equilibrate. Once the temperature reading has stabilized, read the other parameters within five minutes.

7.1.4.2 Hach 2100P Meter

1. Turn on the instrument and place on a flat, sturdy surface.
2. Clean the sample cell using a KimWipe and several rinses with deionized (DI) water. Be careful to handle the cell by the top to avoid smudging or scratching the glass. Do not use paper towels on cells.
3. Read the cell with DI water to find the best orientation for the sample cell (this may not be the factory mark). This should be done by taking several readings with a cell containing DI and rotating slightly between each reading. When the lowest reading is found, make a mark near the top of the cell where it aligns with the raised mark on the meter. This will be the orientation mark, and the cell should be placed in the meter with this mark aligned with the mark on the meter for all samples.
4. Collect the sample from the stream or seep in a clean container (amber glass vial) and keep cool in a dark cooler until it is transferred to the sample cell. Avoid introducing bubbles because they will cause interference. Wipe away any condensation, which also interferes with accurate readings.
5. Invert the collection vial once and then transfer the sample to the testing cell.
6. Wipe the cell with a clean, lint-free cloth to remove fingerprints and water.
7. Apply a thin film of silicone oil to the outside of the cell. Wipe with a clean, lint-free cloth to create an even film on the surface of the cell. Avoid excess oil.
8. Place the sample cell in the instrument compartment making sure that the orientation mark on the cell aligns with the raised mark on the meter. Close the lid.
9. Hit the **Range** key until AUTO RNG is displayed.
10. Press **Read.** The final measurement will display after approximately 13 seconds. If the reading is very unstable, press **Signal Average** to average 10 measurements. This action takes approximately 20 seconds.
11. Record the reading on the turbidity log sheet and on the stream-sampling field form.

7.1.5 Sample Filtration

All dissolved metals samples and DOC samples will be filtered within 12 hours of the time they are collected. Samples will be filtered at the base camp after each field day. Two people ("clean hands" and "dirty hands") are required to filter samples. Sample filtration procedures are outlined below:

1. Put on clean nitrile gloves.
2. Use specially-designated clean titanium scissors to cut tubing to length. Attach filter and place in clean zipper-seal bag. Prepare enough filters for at least one day of filtering.
3. Mark the lids of pairs of a field sample-collection bottle for dissolved metals (500 milliliter unpreserved HDPE) and a filtered-sample bottle (500 milliliter with HNO_3) with the same number to prevent confusion during transfer of bottle labels.
4. Transfer bottle labels from the dissolved metals collection bottles (unpreserved) onto the filtered-sample bottles (preserved with HNO_3), and tape them on.
5. On the field form, record the lot number of filters to be used.
6. Both sample handlers will put on clean nitrile gloves; one person will be clean hands and the other will be dirty hands.
7. *Dirty hands:* open one pair of bottles and place inside the plastic filter hood without touching the inside of the lids or the water.
8. *Dirty hands:* open the zipper-seal bag without touching the filter or tubing. *Clean hands:* remove filter and tubing. Be sure that the ends of the tubing are not touched by dirty hands and that the ends of the tubing do not rest on an unclean surface.
9. *Clean hands:* run the silicone tubing through the hole in the hood. *Dirty hands*: arrange the tubing into the peristaltic pump. *Clean hands:* place the filter over the metals-sample bottle with preservative and the other end of the tubing in the sample-collection bottle without touching the bottles.
10. *Dirty Hands:* turn on the peristaltic pump. *Clean hands:* fill the sample container (HNO_3) labeled for dissolved metals, taking care not to touch the outside of the bottles. *Dirty Hands:* cap and remove the dissolved metals bottle now containing the filtered sample.
11. Repeat Steps 3 through 10 until all samples for dissolved metals analysis are filtered.
12. Once all dissolved metals samples are filtered, arrange and number the lids of pairs of a DOC field-collection bottle (unpreserved 250 mL amber glass jar) and a filtered-sample bottle (250 mL amber glass jar with HCl) with the same number to prevent confusion during transfer of bottle labels.
13. Transfer bottle labels from the DOC sample-collection bottles (unpreserved) onto the filtered-sample bottles (preserved with HCl), and tape them on.
14. *Dirty Hands*: uncap and place a 1-liter bottle of DI water supplied for DOC filtration and a wastewater container under the hood. *Clean Hands*: place filter and tubing into the DI bottle, and filter the entire liter into the waste container. Next, filter approximately 50 to 100 milliliters of sample from a 250 milliliter field-collection bottle to the waste container. *Clean Hands:* remove tubing from the field-collection bottle and keep pump running until no more water comes out. Then filter the remaining sample into the labeled HCl-preserved DOC sample container.
15. *Dirty hands:* cap and remove the DOC bottle, then remove and empty the wastewater container and empty bottles. C*lean hands*: remove the tubing and discard the filter train.
16. Repeat Steps 12 through 15 until all the samples for DOC analysis have been filtered.

17. Put the DOC filtered-sample bottles with other bottles from same station to be packaged for shipping.

7.2 Sediment Sampling in Streams, Ponds, and Lakes

Stream sediment sampling will be closely coordinated with field work for the hydrology and surface water-quality studies. Specifically, stream sediment samples will be collected concurrently with surface water samples in June 2007. Sediment will be collected at 14 surface water stations in the north and south forks of Koktuli River and in Upper Talarik Creek (Table 2) when fine-grain sediments are present. Sediment samples will be analyzed for the parameters listed in the 2007 quality assurance project plan (QAPP; NDM, In press2).

Sediment samples will be collected using a decontaminated plastic spoon and decontaminated elbow-length gloves or clean nitrile gloves. The sampler will find an area within the stream where fine-grain material is abundant enough to fill a 250 milliliter amber glass jar. The sampler will stand downstream of the sampling area while removing the top layers of sediment using a plastic spoon or gloved hand. Large rocks and organic matter will be removed from the sample. Sediment will be placed in the jar, and as much water as possible will be decanted from the jar. Sediment will be collected until the jar is completely full.

Small pond and lake sediments will be sampled in conjunction with vegetation sampling for the trace elements program. Sediment will be collected using either the grab technique used for streams or using a stainless steel dredge. One sediment sample will be collected at each sample location during the August vegetation sampling event. If organic material with no mineral content is collected in the dredge bucket, the mat will be removed, and additional dredges will be attempted. Rocks and twigs will be removed from the samples. For each sample, an 8-ounce jar will be filled, if possible, or at least 50 grams will be collected. As described in the 2007 QAPP (NDM, In press2), equipment blanks for sediment media will be prepared at a frequency of 5 percent (one for every 20 samples) using a DI water rinse after an Alconox wash. This will be done for the total metals analyses only, consistent with the QAPP.

7.3 Water-quality Sampling for Organics

Water samples will be collected for analysis for a variety of organic parameters, including gasoline-range organics (GRO), diesel-range organics (DRO), and residual-range organics (RRO).Water samples for organics analyses will be collected at the stations noted in Table 2 twice during the year: once in June and once after the streams freeze (November or December). The two sampling events will be compared to examine possible effects of the different sampling equipment used under the differing weather conditions.

All organics samples will be collected in amber glass containers using the grab sample technique to prevent possible contamination from plastic sampling equipment. Each sample container will be filled completely so no headspace is left in the container.

7.4 Field Quality Control Samples

7.4.1 Deionized Water Blank

For each sampling event for total metals, one DI water blank will be collected from DI water supplied by each laboratory for equipment decontamination. A sample of the DI water will be collected in an empty total metals analysis bottle and submitted to the primary laboratory. The water for the DI blank will be provided by the primary laboratory conducting the analysis.

7.4.2 Equipment Blank

Equipment blanks will be collected and submitted for dissolved and total metals analysis. The equipment blanks are prepared at the field lab and are designated by the location identification for the first or last sample station of the day. The procedure for collecting equipment blanks is outlined below:

An equipment blank designated by sample number 401 (Section 7.9.1, Sample Identification) is a sample of equipment rinse water intended to capture possible contamination from the DH-81 water sampler and bucket. The 401 samples are collected at a 5 percent frequency and are prepared as follows:

1. Decontaminate the DH-81 and 5-gallon bucket as described in Section 7.10.
2. Pour DI water into the DH-81 sample bottle and dispense through the nozzle into the 5-gallon bucket.
3. Label a total metals and a dissolved metals bottle with "equipment blank," the identification number of the last station sampled, analysis, date, time, sampler's initials, and "HDR Pebble Project." Record the DI water lot number on the data sheet.
4. Pour the water from the 5-gallon bucket into the sample bottles.
5. Filter the equipment blank in the same manner as for all dissolved metal samples (Section 7.5.5).

An equipment blank designated by sample number 402 (Section 7.9.1, Sample Identification) is a sample of equipment rinse water intended to capture possible contamination from the filter and tubing. The 402 samples are collected once per sampling event for each filter lot used and are prepared as follows:

1. Label the dissolved metals bottle with "equipment blank," the identification number of last station sampled that day, analysis, date, time, sampler's initials, and "HDR Pebble Project."
2. Fill a dissolved metals bottle directly from the DI water jug provided by the laboratory. Record the water lot number on the data sheet.
3. Filter this equipment blank in the same manner as for all dissolved metal samples (Section 7.5.5).

7.4.3 Trip Blank

Trip blanks will be provided by the laboratories for low-level mercury and for gasoline-range organics analyses. Each field team will take a trip blank in the field with them every day. The same trip blanks will accompany the field teams each day until half (18) of the sites have been sampled. The evening after the eighteenth site is sampled, all trip blanks will be turned over to Shaw Alaska, Inc. (Shaw), personnel. A

new trip blank will then be given to each team for the remainder of the trip and will be labeled accordingly (e.g., the fourth, fifth, and sixth trip blanks will be designated 604, 605, and 606). The trip blank identification number will be written on the appropriate line of the field form. At the end of the field event these trip blanks will be turned over to Shaw or included with the last shipment of sample bottles to the laboratories if a Shaw representative is not present.

7.4.4 Field Duplicates

Field duplicates are quality control (QC) samples and will be collected at a frequency of 10 percent of all samples collected during the year for all parameters. They are collected in the same way as primary samples and will be analyzed by the primary laboratories.

7.4.5 Field Triplicates

Field triplicates are quality assurance (QA) samples and will be collected at a frequency of 10 percent of all samples collected during the year for all parameters. They are collected in the same way as primary samples and will be analyzed by the QA laboratory.

7.4.6 Matrix Spikes

Matrix spike samples are QC samples and will be collected at a frequency of 5 percent during each sampling event for analysis by the primary laboratory. Matrix spikes are not required for QA samples.

7.5 Sample Handling

Table 3 lists the sample container types and volumes typically used for surface water samples, as well as any preservation required. Sediment samples will be collected in 8-ounce amber glass jars.

In the field during warm weather, samples will be stored in coolers with frozen gel ice at a temperature of approximately 4°C (±2°C). If the sample coolers approach the warm end of the temperature range, coolers will be shipped by helicopter to an HDR sample handler at base camp to ensure that proper sample temperatures are maintained.

During winter sampling events, samples will be kept in coolers without gel ice until transfer to Shaw personnel at base camp at the end of each day.

Occasionally full sample coolers will be sent to base camp before the end of the day. When coolers are sent before than the end of the day, the sampling team will radio base camp and request that a Shaw or HDR staff member be on hand to receive any coolers directly from the pilot.

7.5.1 Sample Identification

Sampling locations will be identified on the field forms and in the logbooks. Samples will be identified with a sample code, as demonstrated with the example below:

0507SK100AWS001

Where:

0507 signifies the month and year (MMYY).

SK100A is the location identification.

WS is the matrix code for surface water (SE is the matrix code for sediment).

001 is a sequential sample number.

Sequential sample numbers are coded as follows:

001 through 199 signify primary samples.

201 is the code for a field duplicate.

301 is the code for a field triplicate.

401 signifies an equipment rinse blank for total metals analysis (sampling equipment only).

402 signifies an equipment rinse blank for dissolved metals analysis (filter only).

403 signifies an equipment rinse blank for dissolved metals analysis (sampling equipment and filter).

404 signifies an equipment rinse blank for dissolved organic carbon analysis (filter only).

501 is the code for a field DI water blank for total metals analysis.

502 is the code for a field DI water blank for dissolved organic carbon analysis.

600 series sequential numbers (601, 602, etc.) are the codes for field trip blank.

Sample identification codes for trip blanks use laboratory codes instead of location identification codes. The only trip blanks included in this field sampling plan are those for GRO and low-level mercury analyses. The codes for the laboratories performing that analysis are as follows:

CASK— Columbia Analytical Services, Inc.

TAPO—Test America, Inc.

ACZ—ACZ Laboratories, Inc.

Summer stream sampling involves sampling equipment (5-gallon bucket and DH-81), as well as the filters used for filtering dissolved metals and dissolved organic carbon. Two sets of equipment blanks will be generated for each summer stream event. During winter stream sampling, no sampling equipment other than the sample bottles will come in contact with the sample water; therefore, no 401 or 403 equipment rinse blanks will be collected. A 402 and 404 filter rinse blank will be collected during each sampling event for each filter lot.

7.5.2 Sample Custody

Samples will be kept in coolers with field staff during the day unless warm conditions, freezing conditions, or weight or space limitations on the helicopter become a concern. If those issues do become a concern, sample coolers will be sent to an HDR or Shaw personnel at base camp. The appropriate sample

custody procedures—such as dates and times entered and signed by both the person in possession of the samples and the receiver of the samples—will be followed using a sample transfer log. HDR personnel will enter samples in the Shaw transfer log by the end of each day.

Chain-of-custody will be maintained following the procedures outlined in the 2007 QAPP (NDM, In press2). Chain-of-custody (COC) forms will accompany each cooler shipped from Iliamna to analytical laboratories. Electronic COC forms will be generated by Shaw personnel at base camp. After the COC form is completed, the form will be inserted in a zipper-seal bag which will be sealed and taped to the inside of the cooler lid.

Sample coolers for shipment to the laboratories will be packed by Shaw personnel. If no Shaw personnel are available, coolers will be packed by HDR personnel according to the following procedure:

1. Line the cooler with cardboard and then line with a large trash bag.
2. Pack individual sample sets together in large zipper-seal bags.
3. Place zipper-seal bags into the trash bag, then place frozen gel ice outside trash bag, and close the bag tightly.
4. Insert bubble wrap to fill remaining space in the cooler to secure the sample sets.
5. Tape COC form to inside of cooler lid.
6. Close cooler and secure the lid with strapping tape by wrapping tape around the entire cooler and back onto itself. Press tape to secure it to cooler, especially on the bottom to prevent tape from ripping when coolers slide across a surface.
7. Attach two signed, dated, and timed custody seals onto cooler lid, one on the front and one on the back opposite corner, and tape over with clear tape.
8. Attach shipping label that includes the COC identification to the top of cooler, and tape over completely with clear tape.

Sample coolers will be shipped from Iliamna to Anchorage on Iliamna Air Taxi. Below is the procedure, typically performed by Shaw, for shipping laboratory samples from Iliamna to Anchorage:

1. Place the following shipping information on the coolers:

   Shaw Environmental, Inc.
   Anchorage, Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   COOLER Identification Number:

2. Place "Keep Chilled" labels on the coolers.
3. Deliver the samples to Iliamna Air Taxi (or other airport-to-airport service) and complete the airbill information for shipment. Write the following information on the airbill:

   Shaw Environmental, Inc.
   Anchorage, Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   "KEEP COOL"

4. Complete a cooler tracking log for shipping from Iliamna to Anchorage, and convey the information to Shaw personnel in Anchorage as soon as possible.

In Anchorage, Shaw personnel will receive the coolers and arrange delivery to the appropriate analytical laboratories. Coolers designated to go to SGS Environmental Services, Inc., will be hand-delivered, and coolers designated to go to other laboratories will be shipped by Alaska Airlines Gold Streak (or other equivalent airport-to-airport service).

Laboratory Contacts: The addresses and other contact information for the respective laboratories are provided below.

Columbia Analytical Services, Inc.
1317 S. 13th Ave.
Kelso, WA 98626-284
Phone: (360) 577-7222 Fax: (360) 636-1068
Project Chemist: Lynda Huckestein
LHuckestein@kelso.caslab.com
Direct phone: (360) 501-3358

Test America, Inc.
9405 SW Nimbus Avenue
Beaverton, OR 97008-7132
Phone: (503) 906-9200 Fax: (503) 906-9210
Project Chemist: Crystal Jones
CrystalA.Jones@testamericainc.com
Direct phone: (503) 906-9234

SGS Environmental Services, Inc.
200 W Potter Dr
Anchorage, AK 99518-1605
Phone (907) 562-2343 Fax (907) 561-5301
Project Chemist: Karen Waak
karen.waak@sgs.com

ACZ Laboratories, Inc.
2773 Downhill Drive
Steamboat Springs, CO 80487
Phone (800) 334-5493
Project Chemist: Sue Webber
suew@acz.com

7.6 Sampling Equipment Decontamination

Sampling equipment that will be decontaminated before sample collection is the DH-81 collection bottle, cap, and nozzle and the 5-gallon bucket used for compositing samples. Methods for decontaminating sampling equipment are outlined below.

1. Spray all parts of the equipment with a premixed Alconox and DI water solution. Use a brush to spread the solution and scrub the equipment. If there is obvious sediment or biological material on the equipment, use the brush to remove the material.
2. Rinse the equipment several times using DI water, and ensure that all traces of the Alconox solution and other materials are removed.
3. Rinse the equipment three times in ambient stream water downstream of the sampling location before collecting a sample.

During winter sampling events, water samples will be collected by taking grab samples with an unpreserved sample bottle and filling the remaining bottles so that decontamination is not necessary.

7.7 Maintenance and Calibration of Field Meters

Two types of field meters (YSI 556 and Hach 2100P) will be used to measure the following parameters: specific conductance, relative conductance, temperature, pH, dissolved oxygen, oxidation-reduction potential, and turbidity. The procedure for collecting field measurements is outlined in Section 7.3.4. Maintenance, decontamination, and calibration of the meters are described below.

7.7.1 Equipment Maintenance and Decontamination

Field meters will be decontaminated before calibration or if there is visible sediment or biological material on the probe or sensors. Decontamination procedures are as follows:

1. Spray all parts of the equipment with a premixed Alconox and DI water solution. If there is obvious sediment or biological material on the equipment, lightly brush the equipment to remove the material.
2. Rinse the equipment several times using DI water. and ensure that all traces of the Alconox solution and other materials are removed.

Maintenance for the Hach 2100P that will be performed in Anchorage (typically by TTT Environmental) includes cleaning, battery replacement, and lamp replacement. Maintenance for the YSI 556 includes cleaning of sensors and replacement of the DO membrane (typically performed in Anchorage by TTT Environmental). Complete descriptions of these procedures can be found in the instrument manuals, which will be kept with the instruments at all times. If the maintenance and troubleshooting procedures in the instrument manuals are insufficient, the instruments will be sent to their respective manufacturers for repair.

7.7.2 Equipment Calibration and Quality Control

7.7.2.1 YSI 556 Meters

The YSI 556 meters will be calibrated for four parameters: DO, pH, specific conductance, and ORP. Calibration procedures are provided below.

1. Before calibrating the instruments, clean the sensors with an Alconox solution and rinse several times with DI water.
2. Shake off excess water before immersing the probe in the calibration cup with solution. Make sure that the sensors are covered when running the calibration. Used calibration solution can be used to rinse the sensors before calibration to provide an extra level of accuracy.

The steps for entering the calibration mode are as follows:

1. Press the **On/Off** key to display the Run screen.
2. Press **Escape** to display the main menu.
3. Use the arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.

Conductivity Calibration

1. On the Calibration screen, select Conductivity and press **Enter**.
2. Select Specific Conductance and press **Enter**. (Calibrating for specific conductance will also calibrate conductivity and salinity.)
3. Place 55 milliliters (mL) of the 1.413-microSiemens-per-centimeter (µS/cm) conductivity solution in the clean, dry calibration cup and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the conductivity cell. Make sure that the conductivity sensor is completely immersed past the vent hole.
5. Tighten the calibration cup onto the probe module.
6. Enter the calibration value: 1.413 µS/cm. (The value for specific conductivity is always in µS/cm at 25°C.)
7. Press **Enter** and allow at least 1 minute for the temperature to stabilize. Note the temperature of the calibration solution for the pH and ORP calibrations.
8. When the specific conductivity reading is stable for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
9. Press **Escape** to return to the calibrate screen.
10. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

Dissolved Oxygen Calibration

Before calibrating for DO, place the probe in water which is at a temperature similar to field temperatures (it may be necessary to add ice to the water, especially in winter).

1. On the Calibration screen, select Dissolved Oxygen and press **Enter**.
2. Select DO% and press **Enter**. (Calibrating for DO% will also calibrate DO in milligrams per liter).
3. Place 1/8 inch of water into the calibration cup, and place the probe module into the cup, making sure that the DO and temperature sensors are NOT immersed in the water.
4. Secure the cup to the module by only one or two threads to ensure that the DO sensor is vented to the atmosphere.
5. Use the keypad to accept the internal barometric pressure reading.
6. Allow 10 minutes for the air in the calibration cup to become saturated with water and for the temperature to equilibrate. When the DO% reading shows no significant change for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
7. Press **Escape** to return to the Calibration menu.

pH Calibration

1. On the Calibration screen, select pH and press **Enter**.
2. Select 3 point and press **Enter**. A 3-point calibration is used to calibrate for surface water measurements that are both basic and acidic.
3. Place 30 mL of the first pH buffer in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the pH sensor. Make sure that the sensor is completely immersed.
5. Tighten the calibration cup onto the probe module.
6. Enter the value of the pH buffer at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.
7. Press enter and allow at least 1 minute for the temperature to stabilize.
8. When the pH reading is stable for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
9. Press **Enter** to return to the specified pH calibration screen.
10. Rinse the probe module, calibration cup, and sensors in DI water and dry.
11. Repeat steps 3 through10 for the second and third buffer solutions.
12. Press **Escape** to return to the Calibration screen.
13. Rinse the sensors and calibration cup, and save the solution for a pre-rinse before the next calibration.

Oxidation-reduction Potential Calibration

1. On the Calibration screen, select ORP and press **Enter**.
2. Place 30 mL of the ORP solution in the clean, dry calibration cup, and immerse the sensors in the solution.
3. Rotate or move the probe module up and down to remove any bubbles from the ORP sensor. Make sure that the sensor is completely immersed.
4. Tighten the calibration cup onto the probe module.
5. Enter the value of the ORP solution at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.
6. Press **Enter** and allow at least 1 minute for the temperature to stabilize.
7. When the ORP reading is stable for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
8. Press **Escape** to return to the Calibration screen.
9. Rinse the sensors and calibration cup, and save the solution for a pre-rinse before the next calibration.

7.7.2.2 Hach 2100P Turbidimeter

Routine calibration checks will be performed on the 2100P turbidimeter by using Gelex secondary turbidity standards. The Gelex standards must have values assigned to them by TTT Environmental (TTT) immediately after calibration has been performed with formazin. These standards will be used as a calibration check before every field day. If the readings are outside 5 percent accuracy, the instrument will be recalibrated using StablCal stabilized formazin standards before being used for recorded measurements. A recalibration will be performed at a minimum of once every three months by TTT. Methods for checking the calibration are outlined below.

Calibration

1. If the StablCal standards have been sitting for longer than one month, shake them to break the condensed suspension into its original particle size. If the standards are used weekly, start at Step 2, below. Standards of less than 0.1 nephelometric turbidity units (NTU) should not be shaken.
   a. Shake the standard vigorously for 2 to 3 minutes to resuspend any particles.
   b. Allow the standard to stand undisturbed for 5 minutes.
2. Gently invert the bottle 5 to 7 times.
3. Prepare the standard vial.
   a. Clean the cell with a KimWipe (outside) and a DI water rinse. Do not using paper towels on cell.
   b. Allow the cell to air dry. Handle the cell by the top to avoid scratching or contaminating the glass surface.
   c. Apply a small bead of silicone oil to the surface of the cell, and rub with a lint-free cloth. The cloth will absorb oil, and after a few applications, it will be sufficient to rub the cloth over the cell. Avoid using too much oil; the cell should appear dry with little or no visible oil.
4. Turn on the instrument by pressing I/O.
5. Press CAL. The CAL and SO icons will display, indicating that it is calibrating the first standard at 0 NTU.
6. Rinse the sample cell one time with the standard and discard the rinse.
7. Fill the cell with the first standard. Cap the cell and let it stand for 1 minute.
8. Insert the cell in the compartment by aligning the orientation mark on the cell with the mark on the front of the compartment.
9. Close the lid.
10. Press the → arrow key to get a numerical display.
11. Press Read. The instrument will count from 60 to 0 and then switch to the next standard.
12. Repeat Steps 6 through 11 for the three remaining standards.
13. When the last standard is done, the display will increment back to S0. Press CAL to accept the calibration, and the instrument will return to measurement mode.

14. If E1, E2, or CAL? is flashing after the CAL button is pressed, check the standards and repeat the calibration. Refer to the instrument manual for troubleshooting guidelines.

Checking Calibration

1. Check the instrument calibration using the Gelex standards.
2. If the readings are not within 5 percent of the previously established values, recalibrate using the StablCal stabilized formazin standard.

7.8 Sample Laboratory Analysis

The 2007 QAPP (NDM, In press2) lists the laboratory analyses that will be performed for the 2007 program for water quality and sediment. Primary and duplicate (quality control) samples of stream water and sediment samples will be shipped to SGS Environmental Services, Inc., in Anchorage, Alaska, with the exception of low-level mercury samples, which will go to Test America, Inc., (formerly North Creek Analytical, Inc.) in Beaverton, Oregon (Portland area). Primary and duplicate samples of seep water will be shipped to ACZ Laboratories, Inc., in Steamboat Springs, Colorado. Triplicate (quality assurance) samples of stream and seep water and sediment samples will be shipped to Columbia Analytical Services, Inc., in Kelso, Washington.

8. Record Keeping

All records will be made in waterproof ink or pencil. Corrections will be made by drawing a single line through the corrected entry. Corrections will be initialed and dated. All corrected entries will remain legible.

8.1 Field Logbooks

Field logbooks will be used to record any deviations from the sampling methods, as well as any additional notes that are not recorded on the field forms. Calibration logbooks will be maintained for each field parameter meter. The data in the calibration logbooks will include the name of the person doing the calibration, date and time, calibration solution and expiration date, and the pre-calibration and post-calibration readings and the "true" value for comparison.

8.2 Field Forms

Field forms (Appendices B and C) will be used to record all field data including the location of the sampling station (Table 4 and Figure 2), recorded measurements, and primary and QC and QA samples collected at the station. Improvements to field forms may be made throughout the year as needed.

9. Field Performance and System Audits

During the March 2007 sampling event, Shaw will conduct a field performance and system audit of stream and seep sampling based on the 2006 sampling plan. A Shaw employee will accompany each field team to the field to audit compliance with the protocols for both hydrology and water-quality monitoring.

Sample handling and equipment calibration and maintenance procedures also will be reviewed at base camp. The audit results will be provided by Shaw personnel to HDR field personnel and will be reviewed to ensure that field sampling protocols are being followed or are modified appropriately when necessary to meet the data-quality objectives. A second audit based on this 2007 field sampling plan will be performed during one field event in the summer.

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TABLES

TABLE 1
Hydrology and Surface Water Stations and Hydrology Data Types

Location Identification	Operator	Data Type	Rationale
			Upper Talarik Creek
UT100A	HDR	IQ	Downstream of mineralized zone; integrates all of UT
UT100B	USGS	CQ	Lower reach of UT; downstream of UT-1.190 effects; downstream of mineralized zone
UT100C	HDR	CQ	Mainstem UT, up stream of UT1.190
UT100C1	HDR	CQ	Mainstem UT, suspected loosing reach
UT100C2	HDR	CQ	Mainstem UT, integrates UT100E and UT135A
UT100D	HDR	CQ	Integrates all UT from proposed mine area; Cominco CQ Station 13
UT100E	HDR	CQ	Upper reach of UT; downstream of potential flow gain from NK; upstream of drainage from ore body; same reach as Cominco Station 8
UT119A	HDR	CQ	Integrates mine/mill groundwater effects on UT from reduced flow from SK and WQ and biological sampling.
UT119B	HDR	IQ	Downstream of flow gain from SK
UT135A	HDR	CQ	Major UT tributary near confluence with mainstem of UT; winter flow contribution; Cominco CQ Station 19
UT138A	HDR	IQ	Drains locally-named Pig Mountain
UT141A	HDR	IQ	"Low point" for new drainage north of mine study area; added discharge to UT
UT146A	HDR	IQ	Drains mineralized area; headwaters in mineralized zone
			Mainstem of the Koktuli River
KR100A	HDR	IQ	Integrates NK and SK; lowest sampling station in study drainage area
			South Fork of the Koktuli River
SK100A	HDR	CQ	Lower mainstem SK near confluence with NK
SK100B	USGS	CQ	Mainstem downstream of flow gain
SK100B1	HDR	CQ	Mainstem downstream of flow gain
SK100B2	HDR	IQ	Mainstem downstream of flow gain
SK100C	HDR	CQ	Mainstem and upstream of flow gain; Cominco CQ Station 16
SK100D	HDR	IQ	Mainstem downstream of flow loss; Cominco Station 5
SK100F	HDR	CQ	Mainstem downstream of Frying Pan Lake (possible sink); same reach as Cominco CQ Station 17
SK100G	HDR	CQ	Upper mainstem; upstream of Frying Pan Lake; same reach as Cominco Stations 6 and 14
SK119A	HDR	CQ	Tributary and flows to "aquifer recharge-discharge" area; Cominco Stations 18 and 20
SK124A	HDR	CQ	Provides flow data for Bear Valley
SK131A	HDR	IQ	Drains Koktuli Mountain
SK133A	HDR	IQ	South of mineralized area
SK134A	HDR	IQ	South of mineralized area
SK136A	HDR	IQ	Drains mineralized area
SK136B	HDR	IQ	Drains mineralized area

Location Identification	Operator	Data Type	Rationale
North Fork of the Koktuli River			
NK100A	USGS	CQ	Lower mainstem NK near SK confluence
NK100A1	HDR	CQ	Mid-mainstem NK, point transition of valley type
NK100B	HDR	CQ	Integrates NK100C and NK100A
NK100C	HDR	CQ	Downstream of Big Wiggly Lake
NK119A	HDR	CQ	Downstream of “G” tailings site
NK119B	HDR	CQ	Drains northwest side of mineralized area
Kaskanak Creek			
KC100A	HDR	CQ	Potential interbasin transfer of water from SK

Notes:

CQ = continuous discharge

IQ = instantaneous discharge

KC = Kaskanak Creek

KR = mainstem Koktuli River

NK = North Fork of the Koktuli River

SK = South Fork of the Koktuli River

USGS = U.S. Geological Survey

UT = Upper Talarik Creek

WQ = water quality

TABLE 2
Sampling Stations for Stream Sediment and for Organics in Surface Water

Station ID	Sediments[a]	Organics[b]
SK100A	X	X
SK100B	X	
SK100C	X	
SK100F	X	
SK100G	X	X
NK100A	X	X
NK100B	X	
NK100C	X	X
NK119A	X	
UT100A		X
UT100B	X	
UT100D	X	X
UT100E	X	
UT119A	X	
UT141A	X	

Notes:

a. Sediments will be collected in June.

b. Water samples for organics analysis will be collected in June and when the streams freeze (November or December).

TABLE 3
Water Sample Container Types, Sample Volumes, and Preservation Requirements

Bottle Type (SGS)	Bottle Type (ACZ)	Bottle Type (CAS/Test America)	Analysis	Preservative	Hold Time	Req. Temp.
(1) 1 L HDPE	(1) 250 mL HDPE	(1) 1 L HDPE	Total metals	HNO_3	6 months	None
(1) 500 mL HDPE (1) extra unpreserved for dissolved metals collection	(1) 250 mL HDPE (1) extra unpreserved container for dissolved metals collection	(1) 1 L HDPE (1) extra unpreserved container for dissolved metals collection	Dissolved metals	HNO_3	6 months	None
(1) 250 mL HDPE	(1) 500 mL HDPE	(1) 1 L HDPE	Cyanide total	NaOH	14 days	4°C
			Cyanide (weak acid dissociable)	NaOH	14 days	4°C
			Cyanide, available (low level confirmation)	NaOH	14 days	4°C
(1) 500 mL HDPE	(1) 250 mL HDPE	(1) 1 L HDPE	Ammonia as N	H_2SO_4	28 days	4°C
			Phosphorus total	H_2SO_4	28 days	4°C
			Nitrate-nitrite total	H_2SO_4	28 days	4°C
(2) 1 L HDPE (2) 1 L extra volumes needed for MS/MSD	(2) 500 mL HDPE (TDS, TSS, acidity) (1) 50 mL HDPE (alk., cond., pH)	(1) 1 L HDPE	TDS	None	7 days	4°C
			TSS	None	7 days	4°C
			Alkalinity	None	14 days	4°C
			Acidity	None	14 days	4°C
			Specific conductance	None	28 days	4°C
			pH	None	24 hours	4°C
(1) 120 mL HDPE (1) 120 mL HDPE extra volume for MS/MSD	No separate bottle needed	No separate bottle needed	Chloride	None	28 days	4°C
			Fluoride	None	28 days	4°C
			Sulfate	None	28 days	4°C

Bottle Type (SGS)	Bottle Type (ACZ)	Bottle Type (CAS/Test America)	Analysis	Preservative	Hold Time	Req. Temp.
(1) 250 mL HDPE	(1) 125 mL HDPE	No separate bottle needed – analyzed from sample set 1	Thiocyanate	HNO_3	28 days	4°C
NA	(1) 500 mL glass	(1) 500 mL fluoropoly (CAS) (1) 250 mL fluoropoly (Test America) no extra volume for MS/MSD	Low-level mercury	HCl	90 days	None
(1) 250 mL amber glass jar (1) 250 mL amber glass jar, unpreserved for field collection	n/a	(1) 250 mL plastic bottle (1) 250 mL plastic bottle unpreserved for field collection	Dissolved organic carbon	HCl (SGS) H_2SO_4 (CAS)	14 days	4°C

Notes:

°C = degrees Celsius
CAS = Columbia Analytical Services, Inc.
HCl = hydrochloric acid
HDPE = high-density polyethylene
HNO_3 = nitric acid
H_2SO_4 = sulfuric acid
MS/MSD = matrix spike/matrix spike duplicate
mL = milliliter
L = liter
NA = not applicable
NaOH = sodium hydroxide
SGS = SGS Environmental Services, Inc.
TDS = total dissolved solids
TSS = total suspended solids

TABLE 4
Hydrology and Surface Water-Quality Station Locations, 2007

Station Identification	Degrees, Decimal Minutes[a]		Decimal Degrees[a]	
	Longitude	Latitude	Longitude	Latitude
KC100A	W155.°42.129'	N59.°43.402'	-155.702150	59.723367
KR100A	W155.°50.262'	N59.°52.660'	-155.8377	59.877667
NK100A	W155.°43.136'	N59.°50.584'	-155.718933	59.843067
NK100A1	W155.°43.140’	N59.°50.982’	-155.608500	59.849700
NK100B	W155.°25.541'	N59.°26.073'	-155.425700	59.934550
NK100C	W155.°24.595'	N59.°55.822'	-155.409917	59.930367
NK119A	W155.°24.104'	N59.°55.088'	-155.401700	59.918130
NK119B	W155.°24.703'	N59.°55.633'	-155.411717	59.927217
SK100A	W155.°46.545'	N59.°50.010'	-155.775750	59.833500
SK100B	W155.°31.452'	N59.°47.591'	-155.524200	59.793183
SK100B1	W155.°28.434’	N59.°48.312’	-155.4739	59.8052
SK100B2	W155.°48.652'	N59.°26.329'	-155.43881	59.81086
SK100C	W155.°24.857'	N59.°48.777'	-155.414283	59.812950
SK100D	W155.°18.159'	N59.°49.084'	-155.302650	59.818067
SK100F	W155.°16.877'	N59.°50.909'	-155.281283	59.848483
SK100G	W155.°17.083'	N59.°52.457'	-155.284717	59.874283
SK119A	W155.°25.693'	N59.°49.326'	-155.428217	59.822100
SK124A	W155.°22.009'	N59.°41.523'	-155.366816	59.692200
SK131A	W155.°16.503'	N59.°52.146'	-155.275050	59.869100
SK133A	W155.°17.917'	N59.°52.369'	-155.298617	59.872817
SK134A	W155.°17.577'	N59.°52.937'	-155.292950	59.882283
SK136A	W155.°17.182'	N59.°53.222'	-155.286367	59.887033
SK136B	W155.°18.639'	N59.°53.887'	-155.310650	59.898117
UT100A	W155.°18.013'	N59.°43.241'	-155.300217	59.720683
UT100B	W155.°15.215'	N59.°47.215'	-155.253583	59.786917
UT100C	W155.°13.068’	N59.°48.240’	-155.2178	59.8040
UT100C1	W155.°9.816’	N59.°50.382’	-155.1636	59.8397
UT100C2	W155.°10.200’	N59.°52.764’	-155.1700	59.8794
UT100D	W155.°11.995'	N59.°54.481'	-155.199917	59.908017
UT100E	W155.°16.637'	N59.°55.090'	-155.277283	59.918167
UT119A	W155.°15.372'	N59.°47.461'	-155.250600	59.791020
UT119B	W155.°18.466'	N59.°47.977'	-155.307767	59.799617
UT135A	W155.°09.289'	N59.°53.042'	-155.154817	59.884033
UT138A	W155.°11.430'	N59.°54.510'	-155.190500	59.908500
UT141A	W155.°13.913'	N59.°54.295'	-155.231883	59.904917
UT146A	W155.°15.884'	N59.°54.625'	-155.264733	59.910417

a. WGS 84 (World Geodectic System 84) used

FIGURES

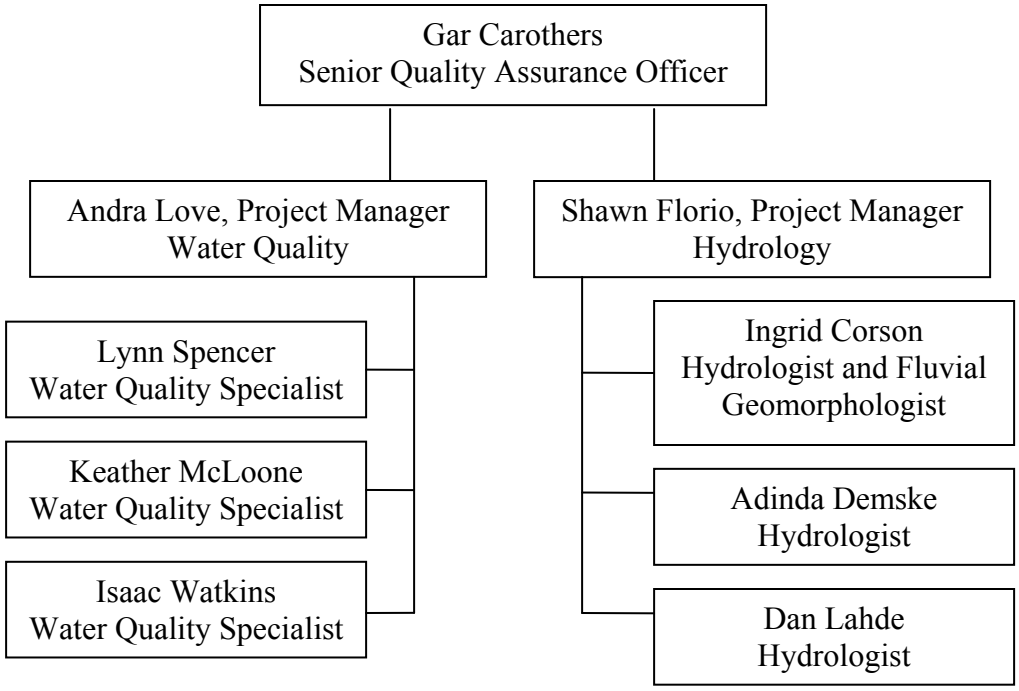


FIGURE 1. Surface Water Program Organization Chart

155°48'0"W 155°36'0"W 155°24'0"W 155°12'0"W 155°0'0"W

60°0'0"N 59°48'0"N

Black Lake
"Cone (Black) Mountain"
Groundhog Mountain
Big Wiggly Lake
mainstem Koktuli River
North Fork Koktuli
North Fork Koktuli River
NK100B
NK100C
NK119B
NK119A
UT100E
UT146A
UT100D
UT138A
SK136B
UT141A
SK136A
SK134A
KR100A
UT135A
SK100G
UT100C2
SK133A
SK131A
Frying Pan Lake
Koktuli Mountains
Koktuli River
NK100A (USGS Gage)
North Fork Koktuli River
NK100A1
SK100F
Upper Talarik
SK100A
UT100C1
South Fork Koktuli
Upper Talarik Creek
SK119A
SK124A
SK100D
South Fork Koktuli River
SK100B1
SK100B2
SK100C
UT100C
UT119B
SK100B (USGS Gage)
UT119A
UT100B (USGS Gage)
Sharp Mountain
Chiquita Lake
Kaskanak Creek
Kaskanak Creek
KC100A
UT100A
Lake #2
Lower Talarik Creek
Iliamna Lake

Pebble Project
NORTHERN DYNASTY MINES INC.

Figure 2
2007 Field Sampling Plan, Surface Water-Quality and Hydrology Stations, Mine Study Area
DRAFT

Legend
- Major Drainage Boundary
- Sub-drainage Boundary
- Continuous Discharge Station
- Instantaneous Discharge Station
- Stream
- Water Feature
- General Pit Outline
- Village Corporation Boundary



0 1.25 2.5 3.75 5 Miles
0 1.25 2.5 3.75 5 Kilometers
N
Scale 1:170,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: HDR_Fig4-2_StudyAreaDrainages.mxd	Date: Aug 01, 2007
Version: 1	Author: HDR - MC, JC

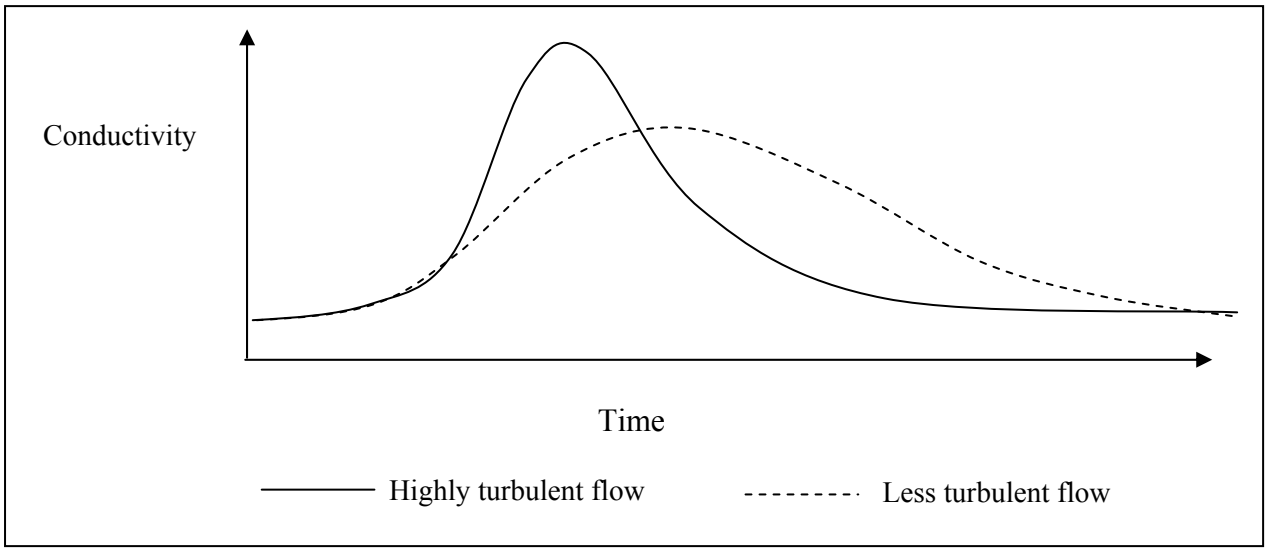


FIGURE 3. Conductivity Recorded at the Point Where Salt Slug Is Fully Mixed Across the Channel

344,679 359,919 375,159 390,399

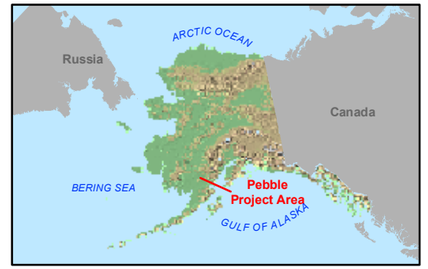
6,648,209

6,632,969

ASP 5 NAD 83

Black Lake
"Cone (Black) Mountain"
Lilly Lake
Groundhog Mountain
Big Wiggly Lake
North Fork Koktuli River
South Fork Koktuli River
Frying Pan Lake
Koktuli Mountain
Upper Talarik Creek
Sharp Mountain
Chiquita Lake
Kaskanak Creek
Lake #2

15 18 17 19 13 7 6 8 9 4 3 2 14 16 1



Pebble Project
NORTHERN DYNASTY MINES INC.

Figure 4
2007 Field Sampling Plan, Seep Sampling Stations and Inventory Locations

DRAFT

Legend

- Current Sampling Sites
- Inventory Points to Date
- 18 Numbered Existing Inventory Areas
- New Inventory Area
- Stream
- Water Feature
- Drainage Boundary
- General Pit Outline
- Village Corporation Boundary

Miles 0 1 2 3 4 5 N

Kilometers 0 1 2 3 4 5

Scale 1:155,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

HDR_2007FieldStudyPlan6.1-2.mxd	Date: August 7, 2007
Version: 3	Author: HDR/RDI-MO/DWR

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APPENDICES

APPENDIX A

SURFACE WATER QUALITY AND HYDROLOGY STUDY PROGRAM CHANGES 2004-2007

Surface Water Quality and Hydrology Program Changes, 2004 through 2007

The surface water-quality and surface hydrology programs have undergone changes since inception in 2004. These modifications have been in response to project design changes, project-specific requirements, agency suggestions, and evaluation of data from previous years. The program changes from 2004 through 2007 are summarized below.

2004 STUDY OVERVIEW

The study programs surface water quality and for surface hydrology were designed and initiated in 2004. Most of the 2004 field work (April through September) was conducted by CH2M Hill Inc. HDR Alaska, Inc., assumed responsibility for these programs in late September 2004.

Surface Water Station Selection

The selection and development of surface water stations was a coordinated process involving the engineering design team and other baseline study teams, including those looking at water chemistry, hydrology, fisheries, aquatic resources, sediment, and trace elements. Twenty-nine stream stations were selected for water quality sampling and hydrology measurements in the study area that included the possible mine, mill, and tailings facilities and the drainages associated with them. Station locations were finalized based on a May 2004 field trip by Dave Bunte (CH2M Hill), Dave Meyer (U.S. Geological Survey [USGS]), Jim Buell (Buell and Associates), and John Morsell (Northern Ecological Services). Fourteen of these stations were selected for continuous flow (CQ) monitoring. Pressure transducers and dataloggers were installed by Northern Dynasty Mines Inc. (NDM) contractors at 11 of the CQ stations in July 2004. The USGS installed its standard stream-gauging equipment at three CQ stations in August 2004.

Surface Water Quality

Water samples were collected consistently from 29 stations over seven field events from April through October. A Hydrolab Quanta multi-probe meter was used to measure in situ field parameters. Depth-integrated water samples were collected using a DH-48 sampler. Six stations (UT100A, UT100D, NK100A, NK100C, SK100A, and SK100G) were sampled for organic constituents, including pesticides, volatile compounds, and semivolatile compounds in August and October.

Surface Hydrology

Surface water discharge measurements were completed coincident with the collection of water quality samples at each of the same 29 stations throughout 2004.

Seeps

A total of 11 seeps were sampled for water quality in 2004. Two of the seeps sampled in May were found to be dry in September, and an additional two seeps were identified and sampled as replacements. Five of these seeps were located in the South Fork Koktuli drainage, five seeps were located in the Upper Talarik Creek drainage, and one was located in the North Fork Koktuli drainage.

Sediments

Sediments were collected at a total of 23 stations in June, July, and September. SK100G and UT100B were resampled in August. The samples were analyzed for total cyanide, anions, ammonia, and metals.

2005 STUDY OVERVIEW

The 2005 surface water-quality and hydrology programs incorporated changes based on findings from the 2004 study and on agency recommendations. The surface water programs included 32 stations in 2005. Three new stations were added in the South Fork Koktuli drainage. SK124A was added to provide baseline data for mine development concepts that were under consideration. SK100B1 and SK100B2 were added to fill data gaps in the characterization of the gaining reach (or "springs") where groundwater upwelling occurs.

Surface Water Quality

Several changes were made in the sampling equipment in 2005. The DH-48 depth-integrated sampler was replaced with the DH-81 sampler, based on technical advice by the USGS on the potential for metal contamination from the DH-48. The Quanta Hydrolabs were replaced with YSI 556 multi-probe meters and Hach 2100P turbidimeters to improve the reliability of the field-parameter measurements.

Surface Hydrology

The surface hydrology program in 2005 continued the data collection effort that was initiated in 2004. In addition, the 2005 studies included groundwater/surface water exchange measurements, hyporheic temperature measurements, and baseflow (low-flow) stream profiles.

Other changes to the programs in 2005 included the initiation of three new stations noted above. Two of these new stations (SK124A and SK100B1) were installed as continuous discharge stations. Only instantaneous discharge (IQ) measurements were collected at SK100B2. IQ data were collected to provide flow data for flow-integrated water-quality samples.

HDR installed thermistor strings and measured temperatures in the hyporheic zone of streams at four locations in the mine study area. This work was completed in consultation with Water Management Consultants (WMC). Mini-piezometers were installed coincident with the thermistor strings. Hyporheic flows also were measured using stream seepage meters. This program was a pilot study to test the feasibility of these technologies for a larger data-collection effort throughout the mine site study area. Two of the four thermistor and piezometer stations were destroyed during freshets within the first year. This approach to hyporheic zone measurements was abandoned in late 2005; although the two remaining

thermistor strings continue to collect data, which are periodically downloaded by HDR hydrologists during field visits. The fisheries program has assumed responsibility for collecting any further temperature data in the hyporheic gravels.

Baseflow measurements—by way of a series of low-flow streamflow profiles—were completed to assist in understanding the gaining and losing aspects of the drainages in the mine study area. These profiles consisted of 10 to 15 instantaneous discharge measurements each along the north and south forks of the Koktuli River and along Upper Talarik Creek. The measurements were collected during the low-flow period immediately prior to the spring freshet. Measurements were collected using the same field methods described in the 2007 field sampling plan for the monthly discharge measurements. This data collection effort was successful and was continued in subsequent years.

Seeps

The seep program was modified considerably in 2005. After a review of the available database of springs surveyed to date at the possible mine area, a comprehensive reconnaissance of springs was planned with input from WMC. Aerial inventories were conducted in January, March, June, and July that expanded the mapped area to include the greater project area. Nine seeps were sampled in March for water quality and discharge. Following the June and July reconnaissance efforts, 24 seeps were selected for future water quality sampling and discharge measurements. Based on Mine Development Concept 25 and discussions with WMC, only a few of the seeps sampled in 2004 by CH2M Hill and in March 2005 by HDR were sampled in July, August, and October 2005. Portable weirs (60^{o}, 90^{o}, V-notch) were developed to measure discharge in larger seeps. Direct catch into a calibrated container was used in the smaller seeps. Total and ferrous iron was not measured using Hach field test kits in 2005 because the total iron results in 2004 from analytical samples and from the Hach kits were not in agreement.

Sediments

Sediments were collected concurrently with water-quality samples at 17 stations over three sampling events conducted in June, July, and September. Seven stations were sampled in June and July (KC100A, NK100A, NK119A, SK100A, SK100B, SK100C, and SK100G). SK100F, SK119A, and UT100E were sampled in June. UT119B and UT141A were sampled in July. Six lakes in the study area (Black Lake, Big Wiggly Lake, Frying Pan Lake, Chiquita Lake, Lake No. 2, and Mud Lake) were added to the sediment sampling program. Seven seeps were sampled for sediments in July and September.

2006 STUDY OVERVIEW

The 2006 surface water-quality, surface hydrology, seep, and sediment programs for the mine study area had the same objectives, study area, and methods as the 2005 program. The program was updated based on project design changes and an evaluation of the results from 2005 studies. One station (NK119B) was dropped from the program in June. The number of sampling events was increased to include the months of November and December to further characterize winter conditions.

Surface Water Quality

Frying Pan Lake was sampled at the inlets, outlet, and the deepest part of the lake for water quality once in July. Water quality samples were collected in the six lakes that were sampled for sediments in 2005. Orthophosphate and separate analyses for nitrate and nitrite was done by the analytical laboratory for all surface water-quality samples and seep samples starting in May 2006. No samples were collected in 2006 for analysis for volatile organic compounds, semivolatile organic compounds, and pesticides.

Surface Hydrology

The surface hydrology program for 2006 included collection of baseline and baseflow (low-flow) stream discharge measurements. The objective of the data collection was to increase the period of record and the reliability of the database. Stream discharge measurements continued to be collected coincident with the surface water-quality sampling.

Similar to 2005, baseflow (low-flow) discharges were measured in late winter, immediately prior to the onset of the spring freshet. Knight Piésold Ltd. joined HDR in this field effort and assisted in the successful initiation of the use of a salt-dilution method to measure discharge. Following this field effort, the salt-dilution method has been successfully used at select stations for the stream discharge program as well.

Seeps

The 24 seeps that were sampled in 2005 were sampled during four events in 2006 (March, June, August, and October). Additional inventory was conducted during two efforts in June and October. The areas of interest were identified by WMC based on changes in project design. From these areas, 20 new seep stations were selected for ongoing sampling. These new stations were sampled once during October. Seeps were measured for total and ferrous iron using a Hach colorimeter 890 to provide an estimate of redox conditions. In June, SRK Consulting, in conjunction with HDR, conducted a ground survey of seeps in the area of the potential mine pit. Fifteen stations were selected from this survey and were sampled concurrently with the established seep program during October. These stations were not measured for total and ferrous iron using the Hach field kit.

Sediments

Sediments were collected concurrently with water quality samples at 12 stream stations in June. Additional analysis was performed for total sulfur and acid volatile sulfide (AVS-SEM) for all sediment samples in 2006. No sediments were collected from seeps.

Small Ponds Study

This program was initiated to characterize conditions of ponds in the area of potential tailings facilities. This program was designed and implemented in conjunction with the trace elements program, which collects vegetation samples in the same locations. Water-quality and sediment samples were collected in select ponds at four stations each in the South Fork Koktuli drainage, North Fork Koktuli drainage, and Upper Talarik Creek drainage.

2007 STUDY OVERVIEW

The surface water-quality, surface hydrology, seep, and sediment programs will continue in 2007 with the same objectives, study area, and methods as in previous years. Adjustments have been made to the programs to address project design changes and data gaps identified by evaluation of the study results to date. The number of stream stations in 2007 is being increased to 36. Seven new continuous flow and water-quality stations (UT135A, UT100C, UT100C1, UT100C2, NK100A1, NK100C, and NK119B) are being added in 2007, all as a result of the Pebble East discovery. Four of these stations (UT100C, UT135A, NK100C, and NK119B) were previously established instantaneous flow stations that will now measure discharge continuously during the ice-free months. The remaining three stations (UT100C1, UT100C2, and NK100A1) are new. The stream-sampling program will consist of 12 monthly sampling events for surface hydrology and water quality at all stations.

Surface Water Quality

The total number of stream-sampling stations is being increased to 36, as described above. Water-quality samples to be analyzed for gasoline-range organics, diesel-range organics, and residual-range organics will be collected once in June and once in December at UT100A, UT100D, NK100A, NK100C, SK100A, SK100G, and Big Wiggly Lake. Beginning in June, dissolved organic carbon will be added to the suite of analyses for samples collected monthly at all sites to further characterize metal speciation and bioavailability.

Black Lake, Big Wiggly, Frying Pan Lake, Chiquita Lake, Lake No. 2, and Mud Lake will again be sampled for water quality.

Surface Hydrology

The total number of stations is being increased to 36, as described above. In total, 23 CQ locations will be operating in 2007. As in past years, three of these will be managed by the USGS. The remaining 20 CQ stations will be operated by HDR.

Additional stream stations may be added in the lower reaches of the Upper Talarik Creek on lands owned by the Alaska Peninsula Corporation (APC); however, plans for these stations have not been finalized.

One baseflow event is planned for 2007. Similar to the baseflow measurements in 2005 and 2006, these measurements will be collected in late winter immediately prior to the spring freshet.

The 2007 surface hydrology program includes the collection of data on fluvial geomorphology. Data collection for fluvial geomorphology was initiated and then discontinued in 2005 under the fisheries program. The objective of this task is to support the habitat findings of the instream flow study. Where the instream flow study documents fish habitats under current conditions, the fluvial geomorphic study will characterize baseline geomorphic conditions and develop regime equations to understand the hydrologic sensitivity of the geomorphology of these streams.

To characterize baseline fluvial geomorphic conditions on the north and south forks of Koktuli River and on Upper Talarik Creek, an analysis of data collected in 2005 will be completed (Phase 1), and the results

will be discussed with NDM and the hydrology, instream flow, and fluvial geomorphology teams. The 2007 field sampling strategy (Phase 2) will be refined based on the results of this analysis and discussion. Two field sampling events in 2007 are currently proposed: one in mid-July and a second in August.

Seeps

At the request of WMC and SRK, the seeps program will expand to double both the area of inventory and the number of sampling stations. The expanded area corresponds to areas of interest in the Pebble East zone. The sampling schedule will be timed to target a winter low-flow event (March), a breakup event (May), a summer event (August), a fall storm event (September), and a late fall event (late October). In May approximately 10 new sampling stations will be selected in the Upper Talarik drainage basin (Inventory Area 19) northeast of the potential mine site for the Pebble West deposit. These stations will be added to the ongoing sampling program, increasing the total number of stations to approximately 54. Additional stations will be selected and added to the sampling program in July, expanding the program to include approximately 100 stations. Additional inventory is scheduled to be conducted in late October when the seeps are most visible. Fifteen seep stations in the mineralized area will be sampled two times: once during high flow and once during low flow. Ferrous iron sampling with the Hach test kit has been discontinued due to lack of detections.

Sediments

Stream sediments will be sampled once during June at a subset of stream water-quality stations in conjunction with the water-quality sampling event. Sediments will not be analyzed for AVS-SEM or total sulfur.

Small Ponds Study

The ponds first sampled in 2005 will again be sampled for water quality and sediment in 2007. Unlike 2006, sediments will not be analyzed for AVS-SEM or total sulfur.

APPENDIX B

STREAM WATER QUALITY AND HYDROLOGY FIELD FORM

Station ID:	**Date: / /07**	**Start Time :** **End Time:**	**GPS - Lat:**
Team:		**Site Observer/ Bear Guard:**	**Long:**
Photos:	**Camera:**	**Weather: Air: ° (C) Wind:**	**Precip:**
HYDROLOGY	**SAMPLER:** _____		
Method: (Wade) (Ice) (Boat) (Salt)		**Type of meter: (M. McBirney)**	**Meter #:**
Gage Height: Time:		IQ Measurement description and constraints:	
		Control: (Channel) (Section)	
WATER QUALITY	**SAMPLER:** _____	**WQ SAMPLE TYPE: (Grab) (Integrated Grab) (DH81)**	**Time:**

In-situ Field Parameters

Meter Make and Model: YSI 556#

Meter Make and Model: Hach Turb.#

Diss. Metals Filter Lot #: _____

Filtered by: _____

DI Water Lot Name: _____

Sample Type

Duplicate:	**Y**	**N**
Triplicate:	**Y**	**N**
MS/MSD:	**Y**	**N**
Sediment:	**Y**	**N**

Meter Readings

Altimeter:	_____	mm Hg
Temperature:	_____	°C
Specific Conductivity:	_____	mS/cm^c
Relative Conductivity:	_____	µs/cm
DO:	_____	% saturation
DO:	_____	mg/L
pH:	_____	STD units
ORP:	_____	mV
Turbidity:	_____	NTU

Additional Comments:

Hg Trip Blank: _____07TAPOWS60___ (prim) _____07CASKWS60___ (trip)

Sketch, Notes and Remarks

Site: Time IQ taken: -- SG Height: +/- Time SG:

Date: / /07 Team: SG Height: +/- Time SG:

Time Interval: 30 Seconds Other: _____ Meter #

Angle Coef. (deg)	Notes	Sec #	Distance (ft)	Depth (ft)	VELOCITY At Depth .6 (fps)	At Depth .2 (fps)	At Depth .8 (fps)
	Bank	0					
		1					
		2					
		3					
		4					
		5					
		6					
		7					
		8					
		9					
		10					
		11					
		12					
		13					
		14					
		15					
		16					
		17					
		18					
		19					
		20					
		21					
		22					
		23					
		24					
		25					
		26					
		27					
		28					
		29					
		30					
TOTAL							

APPENDIX C

SEEP WATER QUALITY AND HYDROLOGY FIELD FORM

Station ID: SP **Date:** 0 / /07 **Start Time:** **End Time:**

Team: **Site Observer/ Bear Guard:**

GPS - Lat: **Long:** **Elev:**

Weather: **º (C)** **Wind:** **Precip./ visibility:**

Sample Matrix: SEEPS **Camera #:**

HYDROLOGY - Sampler:_____

Method: (V-notch Weir) 60º_____' 90º_____' 120°_____' **(3' Flat Weir)**_____' **Estimate % Capture** _____

(Direct catch): _____Gal/Liter_____Sec, _____Gal/Liter_____Sec, _____Gal/Liter_____Sec

WATER QUALITY - Sampler:_____

In-situ Field Parameters

YSI 556 Multiprobe # _____

Hach 2100P Turbimter.# _____

Diss. Metals Filter Lot # _____

Filtered by: _____

Meter Readings

Altimeter	_____	**mmHg**
Temperature:	_____	**°C**
Spec.Conductivity:	_____	**mS/cm**
Rel. Conductivity:	_____	**µS/cm**
DO:	_____	**% saturation**
DO:	_____	mg/L
pH	_____	**STD units**
ORP:	_____	**mV**
Turbidity:		**NTU**

Ferrous Iron _____mg/L

Total Iron mg/L

Comments:

Samples Collected:

Primary	Y	N
Duplicate	Y	N
Triplicate	Y	N
MS/MSD	Y	N

Hg (Test America) Blank: ____ 07TAPOWS60___ **Hg (Columbia Analytical) Blank:**_____07CASKWS60

Site: _____ **Date: __0/____/07_____**

Sketch and Notes:



PEBBLE PROJECT
ENVIRONMENTAL BASELINE STUDIES
2008 FIELD SAMPLING PLAN

SURFACE HYDROLOGY AND WATER QUALITY
Mine Study Area

DRAFT

April 2008

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ACRONYMS AND ABBREVIATIONS

APCS	Alaska Peninsula Corporation Services
°C	degrees Celsius
CAS	Columbia Analytical Services, Inc.
COC	chain-of-custody
CQ	continuous discharge
DI	deionized
DO	dissolved oxygen
DOC	dissolved organic carbon
FSP	field sampling plan
GPS	global positioning system
HDR	HDR Alaska, Inc.
IQ	instantaneous discharge
KC	Kaskanak Creek
KR	mainstem Koktuli River
µS/cm	microSiemens per centimeter
mL	milliliter(s)
MS/MSD	matrix spike/matrix spike duplicate
NK	North Fork Koktuli River
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RRO	residual range organics
SGS	SGS Environmental Services, Inc.
Shaw	Shaw Alaska, Inc.
SK	South Fork Koktuli River
TBM	temporary benchmark
USGS	U.S. Geological Survey
UT	Upper Talarik Creek

2008 FIELD SAMPLING PLAN

SURFACE HYDROLOGY AND WATER QUALITY MINE STUDY AREA

1. Introduction

This field sampling plan (FSP) describes the protocols for the planned baseline studies of surface hydrology and water quality for streams and seeps in the mine study area during 2008 for the Pebble Project. The U.S. Environmental Protection Agency's source book for hardrock mining (EPA, 2003) provided guidance during the development of this baseline data-collection program. Changes in the study programs from 2004 through 2008 are summarized in Appendix A.

2. Project Organization and Responsibility

Figure 1 provides an organizational chart showing key staff from HDR Alaska, Inc. (HDR), and Alaska Peninsula Corporation Services (APCS) involved in the surface water studies. HDR will coordinate the field work for the surface hydrology and water quality programs in the mine study area. APCS will operate three stations on land belonging to the Alaska Peninsula Corporation in the lower section of Upper Talarik Creek and at one station on the Newhalen River. Three stations—UT100B, SK100B, and NK100A—are operated independently by the U.S. Geological Survey (USGS).

The fluvial geomorphology study, which previously had been managed under the surface water program, will be managed by Inter-Fluve, Inc., in 2008 and is not included herein. A separate field sampling plan is being developed for that program.

3. Field Activities

3.1 Stream Measurements

The stream-sampling program will consist of monthly measurements and sampling for surface hydrology and surface water quality. The program is designed to quantify the amount of flow and seasonal flow patterns and to describe and characterize the water chemistry throughout the year under a range of different hydrologic conditions at key locations. Hydrologically significant events such as winter low flow and spring breakup will be targeted.

Table 1 summarizes the sampling at each of the surface hydrology and surface water stream stations in the mine study area during the period of record, including changes for 2008. Station locations are illustrated on Figure 2. Monthly field events in 2008 will be conducted in similar fashion as those in 2005

through 2007. However, there have been changes to the number of stations that will be included in the 2008 program, as summarized below:

- In August 2007 APCS added three new continuously gaged sites in the lower reaches of Upper Talarik Creek (UT100APC3, UT100APC2, and UT100APC1). UT100APC1 is located approximately one-quarter mile downstream of, and replaces, the former UT100A. Another new station (NH100APC1) was initiated on Alaska Peninsula Corporation land on the Newhalen River. NH100APC1 is not a continuously gaged station, but instantaneous discharge is measured coincident with the collection of water-quality samples. APCS plans to operate these four stations in 2008 using the same data-collection methods described herein.
- Four continuously gaged stations (SK100A, SK100B1, SK100F, and SK100G) have been removed from the surface hydrology program in 2008 because the period-of-record is now adequate to confidently predict discharge at these four locations (if required) using the continued data collection from other nearby continuous gages. No continuous gages will be installed at these four sites in 2008. However, instantaneous measurements will be collected from three of these sites along with water-quality samples. SK100B1 will have instantaneous measurements with water-quality samples collected through the May 2008 event and then be removed.
- Seventeen stations will not be sampled for water quality after May 2008. In addition, water-quality samples are no longer collected at UT100A because APCS has replaced UT100A with UT100APC1.

These changes to the surface water program are reflected in Table 1. The resulting 2008 program includes the following:

- Monthly collection of water-quality samples and instantaneous discharge measurements at 39 stations from January through breakup (expected) in May.
- Monthly collection of water-quality samples and instantaneous discharge measurements at 22 of the same stations from June through the remainder of 2008.
- Operation of 22 continuously-gaged (discharge) stations during the ice-free months. Monthly measurements of instantaneous discharge also will be collected at these gaging stations 12 months per year for the purpose of improving the reliability of the rating curves and to estimate the winter hydrograph.

3.2 Seep Measurements

The 2008 surface water program also will include sampling of seeps for flow and water quality in March, May, July, September, and October, along with completion of the 2007 seep inventory. The locations for these activities are listed in Table 4 and illustrated in Figure 3.

4. Surface Hydrology Methods

This section covers methodology and instrumentation employed by HDR and APCS. The three USGS stations (UT100B, SK100B, and NK100A) are operated independently by the USGS; the USGS data-collection methodology is available from the USGS.

The continuous stage (CQ) dataloggers used by HDR and APCS for this project are either MiniTROLL or Level TROLL 500 units manufactured by In-Situ, Inc. Each datalogger is designed to record water depth and water temperature. A 5-pound-per-square-inch pressure transducer within the datalogger records changes in water-surface elevation and has an accuracy rating to 0.012 feet. The units are set to record water depth and temperature at 15-minute intervals.

Dataloggers will be reinstalled in April through June 2008 at each of the CQ stations operated by HDR. The schedule for these installations is dependent on individual site conditions (e.g., ice-cover and water level). The dataloggers will be housed in a polyvinyl chloride (PVC) sleeve that will be attached to an angle iron anchored in the streambed. The datalogger housing will be installed by driving an angle iron into the streambed until the angle iron is solidly anchored. Where possible, the angle iron that was installed in previous years will be used again in 2008. A prefabricated PVC housing will be connected to the angle iron at the channel bottom with steel clamps. Holes will be drilled in the PVC housing to allow unrestricted water pressure over the sensors. The datalogger will be fixed in place within the housing. An additional PVC conduit will be installed above the housing. This conduit protects the communications cable that is permanently connected to the submerged datalogger. The communications cable, which is secured to the angle iron/fence post and extends above the estimated high-water elevation, allows data to be downloaded without disturbing the datalogger.

Staff gages also are installed at each CQ station for quality assurance. During monthly field visits, manual readings of the staff gages will be compared with the stage values provided by the electronic CQ gage. If either of the gages physically moves, the movement will be detected by comparing the two gage readings in the field. If movement is indicated, the gage(s) may be resurveyed and a mathematical adjustment will be applied to the data.

A differential survey will be performed for each of the HDR-operated CQ gages and associated staff gages following installation in the spring and prior to removal in the fall. Cross-sections also are typically surveyed once per year at each CQ station. As noted above, an additional differential survey may be performed if elevation movement is observed while the CQ dataloggers are in place (i.e., during ice-free months). Multiple temporary benchmarks (TBMs) at each CQ station provide differential vertical datum checks for the gage equipment to monitor movement. CQ station elevations are assumed local datums and are not interconnected with other CQ station TBMs.

Data from the dataloggers are scheduled to be downloaded monthly from installation in the spring through October 2008.

4.1 Instantaneous Discharge Measurements

Instantaneous discharge (IQ) measurements will be collected at each sampling location during each field event, as site conditions permit. Field procedures defined by the USGS (Rantz and others, 1982) will be used to obtain the IQ measurements. Depending on stream conditions, a current meter, a tracer (salt)-dilution method, or both will be used to obtain discharge estimates. Use of a current meter is most appropriate in streams of adequate depth that have laminar flow characteristics. The salt-dilution method, which is detailed in Section 4.1.2, is an alternative method that may be applicable in turbulent or shallow flow conditions.

4.1.1 Current-meter Method

A Marsh McBirney meter is typically used for all current-meter measurements. When a current meter is used, measurements will be taken by using top-setting wading rods. If the water is too deep or swift to wade, a boat may be employed to obtain discharge measurements. A sounding weight may be used with the boat to help stabilize the current meter. Backup current meters are kept on hand for use in the event of equipment malfunctions.

Procedures for taking discharge measurements using a current meter in ice-free conditions are outlined below.

1. Visually check wading rod and current meter (Marsh McBirney) for damage. Repair damage to equipment and replace batteries as necessary.
2. Calibrate the Marsh McBirney FlowMates at the start of each field event by placing them in a 5-gallon bucket of water and letting them stand for 5 minutes. Re-zero if needed.
3. Anchor surveyor's measuring tape tautly across the stream perpendicular to the direction of stream flow and attach on either side of the stream. Calculate the width of the entire stream cross-section.
4. Determine the spacing of the vertical partial sections (referred to as "verticals"). This is typically accomplished by splitting the entire stream cross-section into approximately 25 to 35 verticals. The number of verticals will be based on an estimated distribution of the discharge across the entire cross-section. At locations with narrow stream cross-sections, a smaller number of verticals may be used. Space the verticals to meet the USGS objective that no vertical partial section should contain more than 10 percent of the total discharge. The ideal measurement is one in which no partial section contains more than 5 percent of the total discharge. Equal widths of verticals across the entire cross-section are not recommended unless the discharge is well distributed. Widths of the vertical partial sections should become less as depths and velocities become greater (USDOI, 1969). Vertical water-column readings will be taken at each vertical.
5. The person wading in the stream will call out the location of the first vertical with respect to the surveyor's tape to the person on shore who is recording data (data recorder).
6. Using the wading rod, the person wading in the stream will, if possible, measure water depth at that vertical to the nearest 0.05 foot. The wading person will call out this depth reading to the data recorder, and adjust the height of the current meter on the top-set wading rod according to the depth at that vertical. For water columns less than or equal to 2.5 feet deep, a single measurement of velocity at 60 percent of the water-column height from the stream bottom will be recorded. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water-column height.
7. Person wading in stream will stand downstream of the surveyor's tape, facing upstream and holding the wading rod vertical in the water with the current meter facing directly into the current. Person should stand to the side, rather than directly behind the meter, to avoid influencing velocity readings. Occasionally flow at a vertical may not be perpendicular to the tape due to a rock upstream or other flow restrictions. If the obstruction cannot be cleared and the flow is more than 20 degrees off perpendicular, the person in the stream should orient the meter

directly into the flow and call out the angle of flow with respect to perpendicular. A correction will be applied to the velocity measurement from the vertical when calculating the discharge.

8. Person wading in stream will observe visual output of velocity measurements at each vertical. Velocity measurements will be made for 30 seconds, and velocity will be recorded. The time interval will be noted on the data sheet. In the event of extreme weather or flow conditions, a minimum of 20 seconds may be used for velocity measurements made with a Marsh McBirney meter.
9. The person recording data will record this and other appropriate information on the field form.
10. Repeat above procedure at each vertical.

Winter conditions present additional challenges for collecting instantaneous discharge measurements. When ice is present in the channel, the following changes to the above will be adopted:

1. Assess the condition of the ice. If the ice is determined to be safe enough to work on, then proceed with site preparations. If the ice and or ice/flow conditions are unsafe, do not attempt a measurement at that location. Ice and flow conditions a short distance upstream or downstream of the station may be suitable for taking a measurement.
2. Site preparations include auguring holes and/or chopping ice across the channel perpendicular to the flow with spacing that allows for approximately 25 to 30 partial sections. In some channels it may not be possible to auger this many holes. If it is not possible to auger 25 to 30 holes due to a narrow channel, auger as many holes as feasible to achieve as many velocity measurements as practicable. Note that the closest spacing for any velocity measurement will be 0.20 feet, so it is possible to take two measurements in one hole, recording one measurement on each side of the hole. If the channel is narrow, consider using the salt-dilution method described in Section 4.1.2.
3. The effective depth is the depth of the water below the ice when there is ice/water contact. Once all holes are drilled through to water or substrate note whether or not there is contact between the flowing water and the ice cover. For each vertical where there is ice/water contact, measure the effective depth; otherwise, measure the depth of the water at verticals where there is no ice/water contact as described above for ice-free conditions. If there is contact between the water and the ice cover, an ice-cover multiplier of 0.92 will be applied to each velocity measurement to adjust the flow for the increased friction supplied by the ice cover.
4. Make velocity measurements as described above. Note that the person taking measurements may be standing on top of the ice and not in the stream.
5. In some cases flow under ice will be pressurized and will flow upwards out of an augured hole. If pressurized water is encountered, wait 15 minutes after the hole is complete and asses the situation. If the water is no longer flowing up out of the augered hole(s), proceed with site preparations and velocity measurements. If the water is still coming through the hole(s), it may be possible to create a temporary snow dam that will allow the water to pool up, creating a pressure head that will equilibrate and stop water flowing out of the hole. If the upward flow is contained, the hydrographer may continue site preparations and make velocity measurements. Measurement may not be practicable if the upward flow is not contained.

4.1.2 Salt-dilution Method

Although the current-meter method is often a preferred method of measuring instantaneous stream discharge, it can be difficult to obtain good velocity readings in small steep streams because of turbulent (non-laminar) flow. In addition, measuring very shallow flows, flows under ice cover in winter, and flows during bankfull conditions that characterize breakup may require alternative methods, such as tracer dilution, to improve IQ estimates. The salt-dilution method will be used at stations where hydrologists determine, based on field conditions, that the method will likely provide a more reliable discharge measurement.

Tracer dilution is a standard USGS method used to measure stream discharge (Rantz and others, 1982). The salt-dilution method uses common table salt (NaCl) as a tracer to measure discharge without the use of a current meter. Salt is preferred as a tracer over other known tracers because it is nontoxic to aquatic organisms at the concentrations and exposure times associated with the measurements. Salt is also inexpensive, easily obtained, and convenient to work with. Measurements will be made with a conductivity meter read by a datalogger (adding salt changes the conductivity of water).

The slug injection method of salt dilution involves injection of a known mass (or "slug") of salt and is further described by Hudson and Fraser (2005). This method will be used for stream discharge measurements in the mine study area. As described below, a known amount of salt will be introduced at one point in the stream, and as it passes a point downstream where it is expected to have completely mixed in the flow, the conductivity at that point will be measured. Stream flow is calculated from the area under the resulting conductivity curve.

1. Determine mixing length required.

   This method requires that the salt be fully mixed with the stream water so the salt concentration is uniform across the channel at the conductivity measurement point. Salt is added as a slug and is conveyed downstream by the stream flow. At the same time, it disperses longitudinally, vertically, and horizontally in the channel.

   In highly turbulent mountain streams, full mixing occurs in stream lengths equivalent to approximately 10 to 20 channel widths. For stream sections that are relatively low gradient, mixing lengths may be significantly longer than 20 channel widths. The actual mixing length may be determined for each station by deploying multiple conductivity probes at different downstream distances as described in Hudson and Fraser (2005), deploying more than one probe at each cross-section, or a combination of these approaches. It is recommended that the mixing length be verified at least once at each of the gaging stations.

2. Determine mass of salt for injection.

   The accuracy of the method is partly a function of the accuracy of the conductivity probe and the level to which conductivity is increased above the background conductivity. Background conductivity varies depending on geologic and catchment conditions and the proportion of groundwater to surface water runoff (Moore, 2004); therefore, background conductivity may vary between stations and between flows at the same station. For purposes of discharge estimation, conductivity should be increased as much as 500 percent in conditions of low background conductivity, but approximately 50 percent is suitable for high background conditions. For

background conductivities between 50 and 100 microSiemens per centimeter (µS/cm; typical of the mine study area), Moore (2004) suggests that the maximum observed conductivity should be 100 to 200 percent greater than background conductivity.

The mass of salt required to achieve the necessary increase in conductivity depends on the discharge and mixing conditions. In highly turbulent streams, mixing occurs rapidly and the salt wave does not disperse significantly longitudinally (downstream) by the time the salt is fully mixed laterally across the channel. Consequently, conductivity is high and the salt wave passes quickly. In less turbulent conditions, a greater quantity of salt is required for an equivalent peak conductivity recording and the salt wave takes longer to pass because the salt plume disperses longitudinally more than in highly turbulent conditions. Figure 4 illustrates the contrast between conductivity in high turbulence and in lower turbulence.

The quantity of salt required for effective measurement at each station depends on channel mixing length and the background conductivity. Moore (2004) presents a range of salt quantities used by various authors. Based on this information, approximately 2 kilograms (kg) for each 1 cubic meter per second (35.3 cubic feet per second) of estimated flow will be used as a reasonable starting point. The hydrographer will visually estimate the stream discharge on site to determine the amount of salt tracer to inject for measurement. The final mass may be adjusted as needed to achieve an appropriate increase in conductivity at the measurement point.

3. Inject known mass of salt.

   The slug-injection salt-dilution method uses a mass balance approach to calculate discharge. Therefore, the mass of salt added must be known accurately (±1 percent is recommended). The salt may be weighed on site with an electronic scale; however, use of preweighed bags (0.25 kg or greater) is recommended.

   The mass of salt may be injected as dry salt or may be dissolved in a bucket of stream water before it is injected. Pre-dissolution does not alter the method as long as the salt mass is known and the salt is completely dissolved before injection. When practical, pre-dissolution is recommended to assist in rapid dispersal of the tracer. Dry injection may be used; however, the primary disadvantage of dry injection is that dry salt may not mix as rapidly when added to the stream.

4. Place conductivity probes in the channel and start logging.

   Unitdata Starlog conductivity probes and dataloggers (or equivalent) will be used to measure and record stream conductivity. The conductivity probes will be placed downstream of the injection point at an appropriate distance as determined by the hydrologist. Background stream conductivity and temperature will be measured and recorded before injection of the salt tracer. Stream conductivity will be recorded every five seconds throughout the entire discharge-measurement event.

4.2 Baseflow Measurements

The objective of baseflow measurements is to characterize surface water stream flows generated by groundwater expressions in the stream channel. Baseflow conditions typically occur during low-flow conditions. These data will provide information about gaining and losing aspects of the study area drainages, which will be used in the development of hydrogeologic models.

To measure baseflow conditions, a series of stream low-flow profiles will be completed in late March or early April 2008. No data collection is planned for summer 2008, because past efforts to collect baseflow data during the summer have been unsuccessful. The low-flow profiles will involve measuring instantaneous discharge at multiple stations each in the north and south forks of the Koktuli River and in Upper Talarik Creek. Specific measurement locations will be determined from data collected in previous years from existing baseflow stations and based on current site conditions. Discharge measurements will be collected with the same methods described above for the monthly instantaneous discharge measurements. Water-quality field parameters (specific conductance, relative conductance, temperature, pH, dissolved oxygen, and oxidation-reduction potential) also will be measured at each station using a YSI 556 multi-probe meter (Section 6.1.4).

4.3 Seep Flow Measurements

Instantaneous flow measurements are planned to be collected at each seep sampling site (Table 4; Figure 3) five times per year to capture winter baseflow (March), spring breakup (May), summer low flow (July), a fall storm event (September), and late fall (late October).

On the initial visit to a sampling station, a GPS (global positioning system) point will be recorded, a fiberglass stake will be placed, and the station will be developed, beginning with selecting a location that will capture the maximum percentage of the seep flow while maintaining repeatability and consistency of the flow measurement. Often several smaller flows are channelized to a location with suitable characteristics for capturing the flow. Any channeling of flows is to be documented with sketches and photographs. The sampling station itself will be smoothed and reshaped to accept the portable weir or to create a free over-fall for direct catch (see below). Large rocks and other obstructions are to be removed. On return visits, collection ditches will be maintained for repeatability of the flow measurement. During spring events, snowdrifts can occasionally necessitate sampling at locations that are near, but not exactly the same as, the original location.

Due to the variability in the size of seeps, two methods and/or apparatus are to be used to measure discharge:

- **Direct Catch**: This method is to be used for seeps with small flows and as a supplementary method on mid-sized seeps to calibrate the weir flow data. This method will be limited to locations where the flow path is steep enough to allow the container to be positioned under an over-fall and to flows that can be captured in a 5-gallon bucket in two to three seconds. A V-notch weir or a small rubber skirt is to be used to create a free over-fall. Direct flow is to be captured over a timed period into a calibrated container. The quantity and the time interval are to be recorded a minimum of three times and then averaged. This method is quick and repeatable and is the preferred method where applicable.
- **Portable Weirs**: Portable weirs are to be used at locations where direct catch is not feasible. Four portable weirs are to be used on this project: 60º, 90º, and 120º V-notch weirs, and a 3-foot rectangular weir. The size of the weir will depend on the amount of seep flow. All of the weirs are fitted with a rubber skirt that conforms to the bottom of the flow channel. Sediments, mud, moss, and/or rocks are to be used to seal the skirt along its upstream edge, and static water pressure will hold the weir and skirt in place. The seal is to be fitted to the ground surface, and the size of the quiescent pool behind the weir will be adjusted until the best approximation of ideal

weir conditions is achieved. The weir is to be leveled laterally, and the level of the detention pool will be allowed to stabilize. The height of the water head above the crest of the weir will then be recorded. All weirs are labeled on the upstream side with water head scales for rapid, accurate readings. The percentage of the total flow being captured will be estimated and recorded. Conditions that affect this percentage are the shape and slope of the channel, the coarseness and gradation of the substrate, and the availability of sealing materials (mud, moss, sand, etc.). Once a station has been established, the percentage of capture should remain approximately equal for successive sampling events.

The flow measurement methods outlined above are intended to give relative and repeatable flow values in order to compare flows at different times of the year and in different weather, groundwater, and precipitation regimes.

5. Seep Inventory Methods

The seep inventory program is intended to document the locations and relative sizes of seeps in the mine study area. A seep is defined by HDR for the purposes of this task as follows:

- To be recorded and mapped, a seep must exhibit a distinct groundwater point source and a distinct flow path extending downslope approximately 30 feet or until it enters a larger drainage feature.
- Large diffuse seep areas that coalesce into a distinct flow path with dry ground up-gradient also are recorded.

Features that are ***not*** mapped include the following:

- Small features that appear to be directly reabsorbed downslope.
- Small drainages with accumulating surface runoff.
- Meltwater features that coalesced below snow fields.
- Marshy areas and ponds with no distinct flow path below the feature.

The seep inventories are to be conducted using aerial surveys with helicopter support. Field personnel will fly over all inventory areas in a helicopter (typically an R-44 for optimal visibility) at altitudes ranging from 50 to 150 feet above ground level. Initially, inventory areas are to be canvassed at higher altitude and speed to reconnoiter the seeps. A more detailed inventory will then be flown at a lower altitude. Inventory altitude will vary depending on the terrain and vegetation. In open areas with less topographic detail and/or fewer seeps, inventories are to be conducted at a higher altitude to allow for wider visibility and faster inventory. In areas with thick brush, more complex topography, or more seeps, inventories are to be conducted at lower altitudes.

The helicopter pilot will help to ensure complete coverage of the target areas. A navigator, sitting in the copilot seat, will have primary responsibility for identifying seeps, determining relative size, logging GPS waypoints and waypoint numbers, relaying size and waypoint numbers to the recorder/photographer, keeping track of area coverage, and directing the pilot. A recorder/photographer in the rear seat will maintain the field logbooks; will record waypoints, seep size, and photo numbers; and will take photos.

Areas are to be flown in a manner intended to achieve 100 percent coverage. The track-log feature on the GPS unit is to be used to ensure that all areas were canvassed completely. A goal of the inventory is to obtain an accurate location with the GPS waypoint feature so seeps can be found again easily. Because of the variables of altitude, viewing angle, GPS location update rates, helicopter speed, maneuverability in high winds, and pilot and observer limitations, each seep point is expected to have an estimated accuracy of +/-100 feet.

Depending on the terrain and the general layout of the seep areas, each pass will be flown across the slope contours (especially when the seeps are found to be located in bands of similar altitudes) or upslope in individual drainages when seeps are scattered randomly in smaller drainage basins. In high-wind situations, the helicopter will make a slow inventory pass upwind over the area and return downwind to start a new pass.

6. Surface and Seeps Water-quality Sampling Methods

HDR's surface water-quality program includes collection of water samples from streams and seeps in the mine study area.

6.1 Sampling for Surface Water Quality in Streams and Seeps

Stream water sampling will occur monthly at 39 stations (Table 1 and Figure 2) on the North Fork Koktuli River (NK), South Fork Koktuli River (SK), mainstem of the Koktuli River (KR), Upper Talarik Creek (UT), Kaskanak Creek (KC), and New Halen River (NH) in January through May 2008. Beginning in June 2008, stream water sampling will occur monthly at 22 stations (Table 1). Water-quality samples will be analyzed for all parameters listed for surface and seep water in Table 1-5 of the 2008 quality assurance project plan (QAPP; PLP, In press).

Water-quality sampling at seeps will occur five times per year to capture winter baseflow (March), spring breakup (May), summer low flow (July), a fall storm event (September), and late fall (late October). Water-quality samples will be collected coincidentally with instantaneous flow measurements at each seep (Section 4.3; Table 4; Figure 3).

6.1.1 Depth-integrated Stream Sampling

Analytical samples will be collected in accordance with the USGS's protocol for equal discharge increment sampling (Shelton, 1994) and will incorporate depth-integrated techniques. Depth-integrated sampling will be conducted using a DH-81 sampler where adequate depths permit its use. Sampling in shallow streams and winter sampling may be accomplished with grab or integrated grab samples as described in Section 6.1.2.

The areas along a cross-section where depth-integrated samples will be collected are determined by dividing the stream width into segments based on visually estimated percent discharge. Individual depth-integrated samples from a cross-section will be composited in a 5-gallon plastic bucket. By compositing the samples before filling the sample bottles, a complete cross-sectional and depth-integrated sample will be collected. An exception to this protocol will be samples for analysis of low-level mercury, dissolved organic carbon (DOC), and turbidity, which will be collected using grab-sampling techniques (Section

6.1.2) before collection of the depth-integrated samples. Methods for depth-integrated sampling are described below:

1. Label sample bottles with the project name, date, time, preservative (if added), sample identification code (Section 6.3.1), analysis, sampler's initials, and "HDR Alaska."
2. Remove the trip blank from the cooler for a minimum of 5 minutes during sampling activities. Do not open the zipper-seal bags in which the blank is enclosed and ensure that the blank gets returned to cooler before leaving site.
3. Visually check the DH-81 sampler for damage.
4. Decontaminate all parts of the water-sampling equipment, including nozzle, body, and gasket of DH-81 and 5-gallon plastic compositing bucket, as described in Section 6.4.
5. Locate sampling stations by dividing the stream cross-section into segments with visually estimated equal discharge. A minimum of four segments should be sampled at each cross-section. If more sample volume is required to fill all sample bottles, more sample material will be collected with the DH-81 by dividing the stream width into more segments of equal discharge.
6. At a selected stream segment, lower the DH-81 sampler into the stream all the way to the streambed at a steady rate making sure the sampler handle is vertical. The collection bottle should be just less than half-full upon encountering the streambed. Raise the sampler at a rate similar to the descent rate. The collection bottle should not be completely full upon removal from the stream. Pour contents of collection bottle into the clean 5-gallon bucket.
7. Repeat Step 6 in all segments along the cross-section until the appropriate amount of water has been collected.
8. Put on nitrile gloves, and collect analytical samples from the composite sample in the 5-gallon bucket by pouring directly from the bucket into the sample bottles (requires two people). The water in the bucket should be kept well mixed between pours by swishing the bucket to prevent settling of minerals. With the exception of organics samples, sample containers should not be allowed to overflow because of the risk of losing preservatives in the overflow.
9. Fill out appropriate field forms (Appendix B) documenting sampling location, time, and other pertinent information before leaving the sampling station.

6.1.2 Grab Sampling

Grab sampling always will be used for the collecting samples for analysis for low-level mercury, DOC and turbidity. At each stream sampling site, the mercury sample will be collected first, followed by the DOC sample, and then the turbidity sample, and then, when possible, all other samples will be collected using the DH-81 and a 5-gallon bucket. All samples will be collected by grab sampling in cases where use of the DH-81 sampler is not possible because of low flow or when conditions are below freezing and there is risk of the sample freezing in the bucket (e.g., winter sampling). Sampling at seep sites will always be grab sampling with samples for mercury analysis collected first, followed by turbidity samples, and then all other samples.

Procedures for collecting grab samples are outlined below:

1. Label sample bottles with the project name, date, time, preservative (if added), sample identification code (Section 6.3.1), analysis, sampler's initials, and "HDR Alaska."
2. Remove the trip blank from the cooler for a minimum of 5 minutes during sampling activities. Do not open the zipper-seal bags in which the blank is enclosed and ensure that the blank gets returned to cooler before leaving site.
3. Locate a sampling station at a point in the stream or seep where water is deep enough to avoid introducing substrate sediments into the sample. In the event that the water at the site is not deep enough, do not collect a sample.
4. Put on nitrile gloves.
5. Samples for low-level mercury analysis must be filled first, direct from the stream or seep, and not taken out of the double zipper-seal bagging. Submerge the capped bottle so that the mouth of the bottle is about 2 to 3 inches below the surface of the water. Uncap the bottle while it is below the water surface, and fill it slowly. To prevent loss of preservative, do not overfill the bottle. Cap the sample bottle, and empty excess water from the zipper-seal bags. Seal both zipper-seal bags.
6. DOC sampling is conducted second; DOC sample bottles should be completely submerged in the water and capped while under water to remove all empty headspace from the bottle.
7. The turbidity sample is collected third and should be collected directly from the stream or seep using the VOA vile included in the sampling kit.
8. For all other samples, submerge an unpreserved sample bottle so the mouth of the container is about 2 to 3 inches below the surface of the water, whenever possible. Pour the sample from the collection bottle into other sample bottles until all bottles are full. Do not overfill bottles that contain preservative.
9. Fill out appropriate field forms (Appendices B and C) documenting sampling location, time, and other pertinent information before leaving the sampling station.

6.1.3 Under-ice Sampling

During winter months, the water-quality stations are frequently frozen over. Sampling protocols have been designed to accommodate these conditions. Because laboratory-provided sample bottles and a sampling pole are the only equipment used, no decontamination is necessary. The procedures for sampling under ice cover are as follows.

1. Drill a hole at least 15 feet upstream from the instantaneous flow cross-section to prevent contamination from the auger.
2. Surge the hole vigorously using a plunger pole, and allow water to flush for 10 to 15 minutes.
3. Label sample bottles with the project name, date, time, preservative (if added), sample identification code (Section 6.3.1), analysis, sampler's initials, and "HDR Alaska."
4. Affix an unpreserved sample bottle to the sampling pole.

5. Insert the sample bottle into the auger hole below the level of the ice, taking care to capture as little ice as possible.
6. Fill the sample bottle for low-level mercury analysis first, the bottle for DOC analysis second (stream sites only), and then fill the remaining sample bottles.

6.1.4 Measurement of Field Parameters

A YSI 556 multi-probe meter will be used at each site to measure the following field parameters: specific conductance, relative conductance, temperature, pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP). A Hach 2100P meter will be used at the field laboratory to measure turbidity. Section 6.5 outlines the calibration and maintenance procedures for these two meters. The procedures for using these instruments are described below.

Calibration and confidence solutions will accompany the meter to the field each day in case a suspicious reading warrants either a calibration check or recalibration.

6.1.4.1 YSI 556 Multi-probe Meter

1. Turn the YSI 556 on.
2. Place the probe in the stream or seep, upstream of the sampling area, and allow it to equilibrate. Once the temperature reading has stabilized, read the other parameters within five minutes.

6.1.4.2 Hach 2100P Meter

1. Turn on the instrument, and place it on a flat, sturdy surface.
2. Clean the sample cell using a KimWipe and several rinses with deionized (DI) water. Be careful to handle the cell by the top to avoid smudging or scratching the glass. Do not use paper towels on cells.
3. Invert the sample-collection vial once and fill the cell with sample water. Apply a thin film of silicone oil to the outside of the cell. Wipe with a clean, lint-free cloth to create an even film on the surface of the cell. Avoid excess oil.
4. Place the sample cell in the instrument compartment making sure that the orientation mark on the cell aligns with the raised mark on the meter. This alignment should be duplicated for all water readings taken with sample cell. Close the lid.
5. Press **Read**. The final measurement will display after approximately 13 seconds. If the reading is very unstable, press **Signal Average** to average 10 measurements. This action takes approximately 20 seconds.
6. Record the meter reading on the turbidity log sheet and on the field form (Appendices B and C).

6.1.5 Sample Filtration

All dissolved metals samples and DOC samples will be filtered within 12 hours of the time they are collected. Samples will be filtered at the base camp after each field day. Two people are required to filter samples. Sample filtration procedures are outlined below:

1. Put on clean nitrile gloves.
2. Prepare enough filtration sets for the samples collected during the day. Use specially-designated, clean titanium scissors to cut tubing to desired length. Attach a filter to the tubing, and place the filtration set in clean zipper-seal bag.
3. Set up bottles for dissolved metals filtration. Pair each unpreserved dissolved metals sample-collection bottle with an empty 500 milliliter bottle preserved with HNO_3 and mark the lids of both bottles with the same number. This prevents confusion during transfer of bottle labels in Step 4.
4. Transfer all bottle labels from the dissolved metals collection bottles (unpreserved) onto the filtered-sample bottles (preserved with HNO_3), and tape them on.
5. On the field forms, record the lot number of filters to be used for dissolved metals samples.
6. Both sample handlers will put on clean nitrile gloves; one person will be "clean hands" and the other will be "dirty hands."
7. *Dirty hands:* open one pair of bottles and place them inside the plastic filter hood without touching the inside of the lids or the water.
8. *Dirty hands:* open the zipper-seal bag without touching enclosed filters or tubing. *Clean hands:* remove one filter and tubing set (filter train). Be sure that the ends of the tubing are not touched and that the ends of the tubing do not rest on an unclean surface.
9. *Clean hands:* run the silicone tubing through the hole in the hood. *Dirty hands*: arrange the tubing into the peristaltic pump. *Clean hands:* place the filter over the preserved sample bottle and the other end of the tubing in the filled sample-collection bottle without touching the bottles.
10. *Dirty Hands:* turn on the peristaltic pump. *Clean hands:* monitor the transfer of water from the non-preserved to preserved (HNO_3) sample bottle taking care not to touch the outsides of the bottles.
11. *Dirty hands:* cap and remove the filled preserved sample bottle, then remove and dispose of the empty collection bottle. Put the dissolved metals filtered-sample bottles with other bottles from the same station to be packaged for shipping.
12. Repeat Steps 6 through 11 until all samples for dissolved metals analyses are filtered.
13. Once all dissolved metals samples are filtered, arrange pairs of a filled DOC collection bottle (unpreserved 250-milliliter amber glass jar) and an empty filtered-sample bottle (250-milliliter amber glass jar preserved with HCl for samples going to SGS Environmental Services, Inc. [SGS]; H_2SO_4-preserved plastic bottle for samples going to Columbia Analytical Services, Inc. [CAS]) and number the lids; use the same number on both lids in a pair to prevent confusion during transfer of bottle labels.
14. Transfer bottle labels from the DOC sample-collection bottles onto the filtered-sample bottles, and tape them on.
15. *Dirty Hands*: uncap and place a 1-liter bottle of DOC DI water and a wastewater container under the hood. *Clean Hands*: place one filter train (tubing end) into the DI bottle, and filter the entire liter into the waste container. Next, filter approximately 50 to 100 milliliters of sample from a filled sample-collection bottle to the waste container. Remove tubing end of filter train from the

collection bottle and keep pump running until no more water comes out. *Dirty Hands*: Turn off peristaltic pump. Remove waste container, and replace it with preserved filtered-sample bottle; remove bottle lid. *Clean Hands*: position filter as necessary, and filter remaining sample into the preserved DOC filtered-sample bottle.

16. *Dirty hands:* cap and remove the filtered-sample bottle, then remove and dispose of empty collection bottle. C*lean hands*: remove the tubing and discard the filter train.
17. Put the DOC filtered-sample bottles with other bottles from the same station to be packaged for shipping.
18. Repeat Steps 13 through 17 until all the samples for DOC analysis have been filtered.
19. Record filter lot number for the filters used with DOC samples on field form.

6.2 Field Quality Control Samples

6.2.1 Deionized Water Blanks

For each sampling event, two DI water blanks will be collected. The first will be taken from the plastic jug of water provided by the primary laboratory conducting the analyses and used for equipment decontamination in the field. A sample of this DI water will be collected in an empty bottle preserved for total metals analysis, the bottle will be labeled (Section 6.3.1), and the sample will be submitted to the primary laboratory along with the other samples. The name assigned to the DI water jug in use for the event will be recorded on all field forms.

A second DI water blank will be collected from a glass container of DI water used for decontamination of the filter train when processing DOC samples (Section 6.1.5). This sample will be collected in an empty glass jar preserved (HCl) for DOC analysis, the jar will be labeled (Section 6.3.1), and the sample will be submitted to the primary laboratory along with the other samples.

6.2.2 Equipment Blanks

Equipment blanks will be collected and submitted for analysis as described below. The equipment blanks are prepared at the field lab and are designated according to the protocols described in Section 6.3.1. The types of blanks that are collected for each sampling event are as follows:

- 401 blanks are analyzed for total metals and are samples of equipment rinse water collected after decontamination of sample-collection equipment (the DH-81 water sampler and bucket).
- 402 blanks are analyzed for dissolved metals and are samples of DI water that is run through the filter and tubing train used in the dissolved metals filtering process.
- 403 blanks are analyzed for dissolved metals and are samples of equipment rinse water collected after decontamination of sample-collection equipment and then filtered according to the dissolved metals filtering protocol.
- 404 blanks are analyzed for DOC and are samples of DI water that is run through the filter and tubing train used in the DOC filtering process.

In summer, stream sampling involves sample-collection equipment (5-gallon bucket and DH-81), as well as filtering equipment for samples for dissolved metals or DOC analysis, so all four types of equipment blanks are required. During winter stream sampling, no sampling equipment other than the sample bottles comes in contact with the sample water; therefore, no collection-equipment rinse blanks (401 or 403 blanks) will be collected.

Equipment blanks for sample-collection equipment are collected at a 5 percent frequency and are prepared as follows:

1. Decontaminate the DH-81 and 5-gallon bucket as described in Section 6.4.
2. Pour DI water into the DH-81 sample bottle and dispense through the nozzle into the 5-gallon bucket.
3. Label a total metals bottle and an unpreserved dissolved metals bottle with "equipment blank," the project name, date, time, preservative (if any), sample identification code, analysis, sampler's initials, and "HDR Alaska."
4. Pour the water from the 5-gallon bucket into the sample bottles.
5. Filter the 403 blank according to the dissolved metals filtering procedure (Section 6.1.5).

Filter-equipment blanks for dissolved metals analysis (402) are collected at a rate of one per lot of filters and are prepared as follows:

1. Label an unpreserved and an preserved dissolved metals bottle with "equipment blank," the project name, date, time, preservative (if any), sample identification code, analysis, sampler's initials, and "HDR Alaska."
2. Fill the unpreserved dissolved metals bottle directly from the appropriate DI water container provided by the laboratory.
3. Filter this DI water in the unpreserved dissolved metals bottle into the associated preserved dissolved metals bottle according to the dissolved metals filtering procedure (Section 6.1.5).

Filter-equipment blanks for DOC analysis (404) are collected at a rate of one per lot of filters and are prepared as follows:

1. Label an unpreserved and an preserved DOC bottle with "equipment blank," the project name, preservative (for the latter), collection date and time, sample identification code, analysis, sampler's initials, and "HDR Alaska."
2. Fill the unpreserved DOC bottle directly from the appropriate DI water container provided by the laboratory.
3. Rinse the filter with 1 liter of the same DI water (stored in a glass bottle provided by the lab).
4. Filter the DI water in the unpreserved DOC bottle into the associated preserved DOC bottle according to the DOC filtering procedure (Section 6.1.5).

6.2.3 Trip Blanks

Trip blanks will be provided by the laboratories and will be analyzed for low-level mercury. For both the streams and seeps sampling, trip blanks for primary and duplicate samples will be provided by SGS, and the trip blanks for triplicate samples will be provided by CAS. Each field team will take a primary/duplicate trip blank in the field with them every day. The trip blank will accompany the mercury bottles and samples throughout the day. If it is expected that samples will be sent to base camp mid-day, a separate small cooler should be used to carry only low-level mercury bottles/samples and the trip blank. Mercury samples should remain in field with sampling personnel and return at end of day so that **all** mercury samples for that day remain with trip blank at **all** times. Each triplicate bottle set is equipped with its own triplicate trip blank, which accompanies the bottles/triplicate samples throughout the day and is transferred to Shaw at the end of the day. The trip blank identification numbers will be recorded on the field form.

6.2.4 Field Duplicates

Field duplicates are quality control (QC) samples and will be collected at a frequency of 10 percent of all samples collected during the year for all parameters. They are collected in the same way as primary samples and will be analyzed by the primary laboratories.

6.2.5 Field Triplicates

Field triplicates are quality assurance (QA) samples and will be collected at a frequency of 10 percent of all samples collected during the year for all parameters. They are collected in the same way as primary samples and will be analyzed by the QA laboratory.

6.2.6 Matrix Spikes and Matrix Spike Duplicates

Matrix spike and matrix spike duplicate (MS/MSD) samples are QC samples and will be collected at a frequency of 5 percent during each sampling event for analysis by the primary laboratory. Matrix spikes are not required for QA samples.

6.3 Sample Handling

Table 2 lists the sample container types and volumes typically used for surface water samples, as well as any preservation required.

In the field during warm weather, samples will be stored in coolers with frozen gel-ice at a temperature of approximately 4°C (±2°C). During May through October for the streams water-quality program, and for all sampling events in the seeps program, an HDR "sample handler" will be included as part of the field team. This person will stay at the field lab in support of the sampling teams, and will provide the following services:

- Be on hand to receive sample coolers as they are sent in from the field. When full sample coolers are sent to base camp before the end of the day, the sampling team will radio base camp and request that an HDR or Shaw staff member is on hand to receive coolers directly from the pilot.

- Organize and prepare sample bottles for sampling the following day, and complete a QC check on bottle labels.
- Complete sample filtering for dissolved metals and DOC samples received during the day. Prepare materials for filtering to be conducted when sampling teams arrive with the rest of the day's samples.
- Complete turbidity testing for received samples and create a daily turbidity log.
- Create daily transfer logs and ensure that all protocols are followed for sample transfer to Shaw personnel.

No HDR sample handler will be necessary during winter sampling events or for sampling days that include only surface water hydrology sampling. During winter sampling, field teams will retain custody of the samples until after they have completed the filtration process, at which point they will be transferred to Shaw personnel for shipping.

6.3.1 Sample Labeling

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 any), sample identification code, analysis, and sampler's initials. Sampling locations will be recorded on the sample bottles, on field forms, and in the logbooks. Samples will be identified with a sample identification code, as in the example below:

0507SK100AWS001

Where:

0507 signifies the month and year (MMYY).

SK100A is the location identification.

WS is the matrix code for surface water.

001 is a sequential sample number.

Sequential sample numbers are coded as follows:

001 through 199 are codes for a primary field sample.

201 is the code for a field duplicate.

301 is the code for a field triplicate.

401 signifies an equipment rinse blank for total metals analysis (sample-collection equipment only).

402 signifies an equipment rinse blank for dissolved metals analysis (filter equipment only).

403 signifies an equipment rinse blank for dissolved metals analysis (sample-collection and filter equipment).

404 signifies an equipment rinse blank for dissolved organic carbon analysis (filter only).

501 is the code for a field DI water blank for total metals analysis.

502 is the code for a field DI water blank for total organic carbon (TOC) analysis.

600 series numbers (601, 602, etc.) are codes for a field trip blank.

Sample identification codes for trip blanks use laboratory codes instead of location codes. The only trip blanks included in this field sampling plan are those for low-level mercury analysis. The codes for the laboratories performing that analysis are as follows:

CASK— Columbia Analytical Services, Inc.

SGSA—SGS Environmental Services, Inc.

6.3.2 Sample Custody

When sample coolers are sent to HDR or Shaw personnel at base camp, appropriate sample custody procedures—such as dates and times being entered and signed by both the person in possession of the samples and the receiver of the samples—will be followed using a sample transfer log. HDR personnel will enter samples in the Shaw transfer log by the end of each day.

Chain-of-custody (COC) will be maintained following the procedures outlined in the 2008 QAPP (PLP, In press). COC forms will accompany each cooler shipped from Iliamna to analytical laboratories. Electronic COC forms will be generated by Shaw personnel at base camp. After the COC form is completed, the form will be inserted in a zipper-seal bag which will be sealed and taped to the inside of the cooler lid.

Sample coolers for shipment to the laboratories will be packed by Shaw personnel. If no Shaw personnel are available, coolers will be packed by HDR personnel according to the following procedure:

1. Line cooler with cardboard or bubble wrap and then with a large trash bag.
2. Pack individual sample sets together in large zipper-seal bags.
3. Place zipper-seal bags into the trash bag-lined cooler, insert temperature blank, then close the bag tightly and place frozen gel-ice outside trash bag.
4. Insert bubble wrap to fill remaining space in the cooler to secure the sample sets.
5. Tape COC form to inside of cooler lid.
6. Close cooler and secure the lid with strapping tape by wrapping tape around the entire cooler and back onto itself. Press tape to secure it to cooler, especially on the bottom to prevent tape from ripping when coolers slide across a surface.
7. Attach two signed, dated, and timed custody seals onto cooler lid, one on the front and one on the back opposite corner, and tape over with clear tape.
8. Attach shipping label that includes the COC identification to the top of cooler, and tape over completely with clear tape.

Sample coolers will be shipped from Iliamna to Anchorage on Iliamna Air Taxi. Below is the procedure, typically performed by Shaw, for shipping laboratory samples from Iliamna to Anchorage:

1. Place the following shipping information on the coolers:

   Shaw Environmental, Inc.
   Anchorage, Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   COOLER Identification Number:

2. Place "Keep Chilled" labels on the coolers.

3. Deliver the samples to Iliamna Air Taxi (or other airport-to-airport service) and complete the airbill information for shipment. Write the following information on the airbill:

   Shaw Environmental, Inc.
   Anchorage, Alaska
   NOTIFY ON ARRIVAL: Shaw Environmental 243-6300
   "KEEP COOL"

4. Complete a cooler tracking log for shipping from Iliamna to Anchorage, and convey the information to Shaw personnel in Anchorage as soon as possible.

In Anchorage, Shaw personnel will receive the coolers and arrange delivery to the appropriate analytical laboratories. Coolers designated to go to SGS Environmental Services, Inc., will be hand-delivered, and coolers designated to go to other laboratories will be shipped by Alaska Airlines Gold Streak (or other equivalent airport-to-airport service).

Laboratory Contacts: The addresses and other contact information for the respective laboratories are provided below.

SGS Environmental Services, Inc.
200 W Potter Dr
Anchorage, AK 99518-1605
Phone (907) 562-2343 Fax (907) 561-5301
Project Chemist: Karen Waak
karen.waak@sgs.com

Columbia Analytical Services, Inc.
1317 S. 13th Ave.
Kelso, WA 98626-284
Phone: (360) 577-7222 Fax: (360) 636-1068
Project Chemist: Lynda Huckestein
LHuckestein@caslab.com
Direct phone: (360) 501-3358

6.4 Sampling Equipment Decontamination

Sampling equipment that will be decontaminated before sample collection is the DH-81 collection bottle, cap, and nozzle and the 5-gallon bucket used for compositing samples. Methods for decontaminating sampling equipment are outlined below.

1. Spray all parts of the equipment with a premixed Alconox and DI water solution. Use a brush to spread the solution and scrub the equipment. If there is obvious sediment or biological material on the equipment, use the brush to remove the material.

2. Rinse the equipment three times using DI water, and ensure that all traces of the Alconox solution and other materials are removed.
3. Rinse the equipment three times in ambient stream water downstream of the sampling location before collecting a sample.

During near-freezing conditions, Alconox should be removed from the decontamination process due to the difficulty in rinsing the cleaning agent off the equipment. During winter sampling events, water samples will be collected by taking grab samples with an unpreserved sample bottle and filling the remaining bottles so that decontamination is not necessary.

6.5 Maintenance and Calibration of Field Meters

A YSI 556 field meter will be used to measure the following parameters: specific conductance, relative conductance, temperature, pH, dissolved oxygen, and oxidation-reduction potential. A Hach 2100P will be used to measure turbidity. The procedure for collecting field measurements is outlined in Section 6.1.4. Maintenance, decontamination, and calibration of the meters are described below.

6.5.1 Equipment Maintenance

Maintenance for the field meters will be performed in Anchorage (typically by TTT Environmental) before travel to the field. Maintenance for the Hach 2100P includes cleaning, battery replacement, and lamp replacement. Maintenance for the YSI 556 includes cleaning of sensors and replacement of the DO membrane. Complete descriptions of these procedures can be found in the instrument manuals, which will be kept with the instruments at all times. If the maintenance and troubleshooting procedures in the instrument manuals are insufficient, the instruments will be sent to their respective manufacturers for repair.

6.5.2 Equipment Calibration

6.5.2.1 YSI 556 Meter

In the field, the instruments will be checked daily using confidence solution and will be calibrated as needed. All results from the calibrations and daily calibration checks will be logged in a calibration log that will accompany each meter.

Electrolyte solution must be added to the membrane cap before initial use. Install the membrane cap as follows:

1. Unscrew and remove probe sensor guard.
2. Discard old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare electrolyte solution.
5. Fill membrane cap half full with electrolyte solution.

6. Reattach membrane cap onto sensor, moderately tightly. A small amount of solution should overflow.
7. DO NOT touch the membrane surface.
8. Screw probe sensor guard on moderately tightly.

All of the sensors, except the one for temperature, require calibration if air-pressure changes occur. Calibration tips are as follows:

- Ensure that all sensors are completely immersed in calibration solutions.
- The top vent hole of the conductivity sensor must also be immersed during some of the calibrations.
- Loosen the transport/calibration cup during DO calibration to allow pressure equilibration.
- For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the probe module. It may be desirable to save the old calibration standards for this purpose.
- Rinse the probe module between calibration solutions with ambient-temperature water.
- Use paper towels or clean cotton cloths to dry the probe between rinses. Making sure the probe is dry reduces carry-over contamination of calibration solutions and increases the accuracy of the calibration.
- Install port plugs in all the ports where the sensors are not installed. It is extremely important to keep these electrical connectors dry.

The YSI 556 meters will be calibrated for four parameters: DO, pH, specific conductance, and ORP. Calibration procedures are provided below.

- Before calibrating the instruments, clean the sensors with an Alconox solution and rinse several times with DI water.
- Shake off excess water before immersing the probe in the calibration cup with solution. Make sure that the sensors are covered when running the calibration. Used calibration solution can be used to rinse the sensors before calibration to provide an extra level of accuracy.

The steps for entering the calibration mode are as follows:

1. Press the **On/Off** key to display the Run screen.
2. Press **Escape** to display the main menu.
3. Use the arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.

Conductivity Calibration

1. On the Calibration screen, select Conductivity and press **Enter**.

2. Select Specific Conductance and press **Enter**. (Calibrating for specific conductance will also calibrate for conductivity and salinity.)
3. Place 55 milliliters (mL) of the conductivity solution in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the conductivity cell. Make sure that the conductivity sensor is completely immersed past the vent hole.
5. Tighten the calibration cup onto the probe module.
6. Allow at least 1 minute for the temperature to stabilize. Note the temperature of the calibration solution for the pH and ORP calibrations.
7. When the specific conductivity reading is stable for 30 seconds, press **Enter**.
8. Enter the calibration value as reported on the used calibration-solution bottle. (The value for specific conductivity is always in microSiemens per centimeter at 25°C.) Press **Enter** again to accept the calibration.
9. Record the final specific conductivity reading. Press **Escape** to return to the calibrate screen.
10. Rinse the sensors and calibration cup, and save the solution for a pre-rinse prior to the next calibration.

Dissolved Oxygen Calibration

Before calibrating for DO, place the probe in water which is at a temperature similar to field temperatures (it may be necessary to add ice to the water, especially in winter).

1. On the Calibration screen, select Dissolved Oxygen and press **Enter**.
2. Select DO% and press **Enter**. (Calibrating for DO% will also calibrate DO in milligrams per liter).
3. Place 1/8 inch of water into the calibration cup, and place the probe module into the cup, making sure that the DO and temperature sensors are NOT immersed in the water.
4. Secure the cup to the module by only one or two threads to ensure that the DO sensor is vented to the atmosphere.
5. Use the keypad to accept the internal barometric pressure reading.
6. Allow 10 minutes for the air in the calibration cup to become saturated with water and for the temperature to equilibrate. When the DO% reading shows no significant change for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
7. Press **Escape** to return to the Calibration menu.

pH Calibration

1. On the Calibration screen, select pH and press **Enter**.
2. Select 3 point and press **Enter**. A 3-point calibration is used to calibrate for surface water measurements that are both basic and acidic.

3. Place 30 mL of the first pH buffer in the clean, dry calibration cup, and immerse the sensors in the solution.
4. Rotate or move the probe module up and down to remove any bubbles from the pH sensor. Make sure that the sensor is completely immersed.
5. Tighten the calibration cup onto the probe module.
6. Enter the value of the pH buffer at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.
7. Press enter and allow at least 1 minute for the temperature to stabilize.
8. When the pH reading is stable for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
9. Press **Enter** to return to the specified pH calibration screen.
10. Rinse the probe module, calibration cup, and sensors in DI water and dry.
11. Repeat steps 3 through10 for the second and third buffer solutions.
12. Press **Escape** to return to the Calibration screen.
13. Rinse the sensors and calibration cup, and save the solution for a pre-rinse before the next calibration.

Oxidation-reduction Potential Calibration

1. On the Calibration screen, select ORP and press **Enter**.
2. Place 30 mL of the ORP solution in the clean, dry calibration cup, and immerse the sensors in the solution.
3. Rotate or move the probe module up and down to remove any bubbles from the ORP sensor. Make sure that the sensor is completely immersed.
4. Tighten the calibration cup onto the probe module.
5. Enter the value of the ORP solution at the current temperature. The temperature of the stored calibration solutions should have been recorded during the conductivity calibration.
6. Press **Enter** and allow at least 1 minute for the temperature to stabilize.
7. When the ORP reading is stable for 30 seconds, press **Enter**. Press **Enter** again to accept the calibration.
8. Press **Escape** to return to the Calibration screen.
9. Rinse the sensors and calibration cup, and save the solution for a pre-rinse before the next calibration.

Return to Factory Settings

1. Press the **On/Off** key to display the Run screen.
2. Press the **Escape** key to display the Main Menu.

3. Use arrow keys to highlight the Calibration selection.
4. Press **Enter**. The Calibration screen is displayed.
5. Use the arrow keys to highlight the Conductivity selection. Note: The conductivity sensor is being used as an example; however, this process will work for any sensor.
6. Press **Enter**.
7. Use the arrow keys to highlight the Specific Conductance selection.
8. Press **Enter**.
9. Press and hold down the **Enter** key and press the **Escape** key.
10. Use the arrow keys to highlight the YES selection. This returns a sensor to the factory settings.
11. Press **Enter**.
12. Press **Escape**.

6.5.2.2 Hach 2100P Turbidimeter

Routine calibration checks will be performed on the 2100P Turbidimeter by using Gelex secondary turbidity standards. The Gelex standards must have values assigned to them by TTT Environmental (TTT) immediately after calibration has been performed with formazin. These standards will be used as a calibration check before every field day. If the readings are outside 5 percent accuracy, the instrument will be recalibrated using StablCal stabilized formazin standards before being used for recorded measurements. A recalibration will be performed at a minimum of once every three months by TTT. Methods for checking the calibration are outlined below.

Calibration

1. If the StablCal standards have been sitting for longer than one month, shake them to break the condensed suspension into its original particle size. If the standards are used weekly, start at Step 2, below. Standards of less than 0.1 nephelometric turbidity units (NTU) should not be shaken.
   a. Shake the standard vigorously for 2 to 3 minutes to resuspend any particles.
   b. Allow the standard to stand undisturbed for 5 minutes.
2. Gently invert the bottle 5 to 7 times.
3. Prepare the standard vial.
   a. Clean the cell with a KimWipe (outside) and a DI water rinse. Do not using paper towels on cell.
   b. Allow the cell to air dry. Handle the cell by the top to avoid scratching or contaminating the glass surface.
   c. Apply a small bead of silicone oil to the surface of the cell, and rub with a lint-free cloth. The cloth will absorb oil, and after a few applications, it will be sufficient to rub the cloth over the cell. Avoid using too much oil; the cell should appear dry with little or no visible oil.
4. Turn on the instrument by pressing **I/O**.

5. Press **CAL**. The CAL and SO icons will display, indicating that it is calibrating the first standard at 0 NTU.
6. Rinse the sample cell one time with the standard and discard the rinse.
7. Fill the cell with the first standard. Cap the cell and let it stand for 1 minute.
8. Insert the cell in the compartment by aligning the orientation mark on the cell with the mark on the front of the compartment.
9. Close the lid.
10. Press the → arrow key to get a numerical display.
11. Press **Read**. The instrument will count from 60 to 0 and then switch to the next standard.
12. Repeat Steps 6 through 11 for the three remaining standards.
13. When the last standard is done, the display will increment back to S0. Press **CAL** to accept the calibration, and the instrument will return to measurement mode.
14. If E1, E2, or CAL? is flashing after the CAL button is pressed, check the standards and repeat the calibration. Refer to the instrument manual for troubleshooting guidelines.

Checking Calibration

1. Check the instrument calibration using the Gelex standards.
2. If the readings are not within 5 percent of the previously established values, recalibrate using the StablCal stabilized formazin standard.

6.6 Sample Laboratory Analysis

The 2008 QAPP (PLP, In press) lists the laboratory analyses that will be performed for the 2008 program for water quality. Primary and duplicate (QC) samples of stream and seep water will be analyzed by SGS Environmental Services, Inc., in Anchorage, Alaska. Triplicate (QA) samples of stream and seep water will be analyzed by Columbia Analytical Services, Inc., in Kelso, Washington.

7. Record Keeping

All records will be made in waterproof ink or pencil. Corrections will be made by drawing a single line through the corrected entry. Corrections will be initialed and dated. All corrected entries will remain legible.

7.1 Field Logbooks

Field logbooks will be used to record any deviations from the sampling methods, as well as any additional notes that are not recorded on the field forms. Calibration logbooks will be maintained for each field-parameter meter. The data in the calibration logbooks will include the name of the person doing the calibration, date and time, calibration solution and expiration date, and the pre-calibration and post-calibration readings, along with the “true” value (listed on the calibration solution bottle) for comparison.

7.2 Field Forms

Field forms (Appendices B and C) will be used to record all field data including the location of the sampling station (Tables 3 and 4 and Figures 2 and 3), recorded measurements, and details of primary, QC, and QA samples collected at the station. Improvements to field forms may be made throughout the year, as needed.

8. Field Performance and System Audits

Shaw will conduct periodic audits of the stream and seep sampling programs to ensure that the programs are adhering to protocols outlined in this field sampling plan. Shaw personnel will accompany each field team to the field to audit compliance with the protocols for both hydrology and water-quality sampling. Sample handling and equipment calibration and maintenance procedures also will be reviewed at field camp. The audit results will be provided by Shaw personnel to HDR field personnel and will be reviewed to ensure that field sampling protocols are being followed or are modified appropriately when necessary to meet the data-quality objectives.

9. References

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TABLES

TABLE 1.
Surface Hydrology and Water Quality Period-of-Record Index
Mine Study Area

Sample Location	Year[1]	Period-of-Record By Discipline																																		Comment
		Surface Hydrology[2]												Surface Water Quality												Sediment										
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
KC100A (HDR)	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q								F	F		F				
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F						Water-quality measurements discontinued after May 2008
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q												
	2007		I	I	I	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													Continuous gage maintained through 2008
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			
KR100A (HDR)	2004				I		I	I	I	I	I						Q	Q	Q	Q	Q	Q									F		F				
	2005			I			I	I	I	I	I					Q			Q	Q	Q	Q	Q															
	2006			I			I	I			I		I			Q			Q	Q			Q		Q													No change in status.
	2007		I	I	I	I	I	I	I	I	I	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NH100APC1 (APCS)	2004																																				
	2005																																				
	2006																																				APCS initiated site in August 2007. Program managed by APCS.
	2007								I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NK100A (USGS)	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q								F	F		F				
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F						No sediment sampling in 2008.
	2006			I	C	C	C	C	C	C	C				Q	Q		Q	Q	Q	Q	Q	Q		Q						F							
	2007				C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q							F						USGS maintains continuous gage.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NK100A1 (HDR)	2004																																				
	2005																																				
	2006																																				No change in status.
	2007		I	I	I	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NK100B (HDR)	2004								I	I	I										Q	Q	Q								F							
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q								F	F		F				No sediment sampling in 2008.
	2006		I	I	I	I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F						
	2007		I	I		C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q							F						
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NK100C (HDR)	2004					I		I	C	C	C							Q	Q	Q	Q	Q	Q								F	F		F				
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F		F				
	2006		I	I	I	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F						No sediment sampling in 2008.
	2007		I	I		C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q							F						
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NK119A (HDR)	2004						I	I	C	C	C								Q	Q	Q	Q	Q								F	F		F				
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F						No sediment sampling in 2008.
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q												
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q							F						Continuous gage maintained through 2008.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
NK119B (HDR)	2004					I	I	I	I	I	I							Q	Q	Q	Q	Q	Q														
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q															Water quality measurements discontinued after May 2008.
	2006		I	I																																
	2007		I	I	I	I	C	C	C	C	C	I	I				Q	Q	Q			Q	Q	Q	Q													Continuous gage maintained through 2008.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			

Sample Location	Year[1]	Period-of-Record By Discipline																																		Comment
		Surface Hydrology[2]												Surface Water Quality												Sediment										
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
SK100A (HDR)	2004				I		I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F							Continuous gage discontinued in 2008. IQ discharge measurements only. No sediment sampling in 2008. Water quality maintained through 2008.
	2005	I		I	C	C	C	C	C	C	I			Q		Q		Q	Q	Q	Q	Q	Q	Q							F	F						
	2006		I	I	I	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F							
	2007	I	I	I	C	C	C	C	C	C	C		I	Q	Q	Q	Q	Q	Q	Q		Q	Q	Q	Q						F							
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
SK100B (USGS)	2004						I	I	C	C	C							Q	Q	Q	Q	Q	Q								F	F		F				No sediment sampling in 2008. USGS maintains continuous gage.
	2005			I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F						
	2006		I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F							
	2007	I	I		C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q						F							
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
SK100B1 (HDR)	2004																																				No water quality or hydrology after May 2008. No continuous gage installed in 2008.
	2005									I	I	C	C									Q	Q														
	2006	C	C	C	C	C	C	C	C	C	C	C	I		Q	Q		Q	Q	Q	Q	Q	Q		Q													
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
SK100B2 (HDR)	2004																																				No change in status.
	2005					I	I	I	I	I	I							Q	Q	Q	Q	Q	Q														
	2006		I	I		I	I	I	I	I	I		I		Q			Q	Q	Q	Q	Q	Q		Q													
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q			Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
SK100C (HDR)	2004						I	I	C	C	C							Q	Q	Q			Q								F	F		F				Water quality measurements discontinued after May 2008. No sediment sampling in 2008. Continuous gage maintained through 2008.
	2005	I		I		C	C	C	C	C	C			Q				Q	Q	Q		Q	Q								F	F						
	2006			I	I	I	C	C	C	C	C		I					Q	Q	Q	Q	Q	Q		Q						F							
	2007		I	I	I	C	C	C	C	C	C	I	I					Q	Q	Q		Q	Q	Q	Q						F							
	2008	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			
SK100D (HDR)	2004						I	I	I	I	I						Q	Q	Q	Q	Q	Q											F				No water quality or hydrology after May 2008. No continuous gage installed in 2008.
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q														
	2006		I	I	I		I	I	I	I	I		I						Q	Q	Q	Q	Q		Q													
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
SK100F (HDR)	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q								F	F		F				Continuous gage discontinued in 2008. IQ discharge measurements only. No sediment sampling in 2008. Water quality maintained through 2008.
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F							
	2006	I	I	I	I	C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q													
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q						F							
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
SK100G (HDR)	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F	F	F	F				Continuous gage discontinued in 2008. IQ discharge measurements only. No sediment sampling in 2008. Water quality maintained through 2008.
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F						
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q													
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	Q						F							
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
SK119A (HDR)	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F	F		F				Water quality measurements discontinued after May 2008. Continuous gage maintained through 2008.
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F							
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q		Q		Q						F							
	2007		I		I	C	C	C	C	C	C	I	I	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			
SK124A (HDR)	2004																																				Water quality measurements discontinued after May 2008. Continuous gage maintained through 2008.
	2005	I		I		I	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q														
	2006	I	I	I			C	C	C	C	C		I	Q	Q	Q			Q	Q	Q		Q		Q													
	2007	I	I	I		C	C	C	C	C	C	I	I	Q				Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			

Sample Location	Year[1]	Period-of-Record By Discipline																																		Comment
		Surface Hydrology[2]												Surface Water Quality												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
SK131A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q									F		F				
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q	Q														No water quality or hydrology after May 2008.
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q												
	2007	I	I	I		I	I	I	I	I	I	I	I	Q	Q			Q	Q	Q	Q	Q	Q	Q	Q													No continuous gage installed in 2008.
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
SK133A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q														
	2005			I		I	I	I	I	I	I							Q	Q	Q	Q	Q	Q														No water quality or hydrology after May 2008.
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q												
	2007		I	I	I	I	I	I	I	I	I	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													No continuous gage installed in 2008.
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
SK134A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q														
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q														
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q													No change in status.
	2007		I	I	I	I	I	I	I	I	I	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
SK136A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q														
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q														No water quality or hydrology after May 2008.
	2006	I	I	I		I	I	I	I	I	I			Q	Q	Q		Q	Q	Q	Q	Q	Q		Q												
	2007		I	I	I	I	I	I	I	I	I	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													No continuous gage installed in 2008.
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
SK136B (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q														
	2005	I				I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q														No water quality or hydrology after May 2008.
	2006		I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q												
	2007		I	I	I	I	I	I	I	I	I	I	I		Q			Q	Q	Q	Q	Q	Q	Q	Q													No continuous gage installed in 2008.
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
UT100A (HDR)	2004					I			I	I	I						Q	Q			Q	Q	Q											F				
	2005	I		I		I	I	I			I			Q		Q		Q	Q	Q			Q															Station physically moved to UT100APC1 in August 2007.
	2006			I			I	I		I						Q			Q	Q	Q	Q	Q		Q												
	2007			I		I	I	I							Q	Q	Q	Q	Q	Q																		No HDR program in 2008. UT100APC1 under APCS control.
	2008																																				
UT100APC1 (APC)	2004																																				
	2005																																				
	2006																																				APCS initiated site in August 2007. Program managed by APCS.
	2007								I	I	I	I	I								Q	Q	Q	Q	Q												
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q												
UT100APC2 (APCS)	2004																																				
	2005																																				
	2006																																				APCS initiated site in August 2007. Program managed by APCS.
	2007								I	I	I	I	I								Q	Q	Q	Q	Q												
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q												
UT100APC3 (APCS)	2004																																				
	2005																																				
	2006																																				APCS initiated site in August 2007. Program managed by APCS.
	2007								I	I	I	I	I								Q	Q	Q	Q	Q												
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q												
UT100B (USGS)	2004					I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F	F	F	F				
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F		F				No sediment sampling in 2008.
	2006		I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q							F						USGS maintains continuous gage.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													

Sample Location	Year[1]	Period-of-Record By Discipline																																		Comment
		Surface Hydrology[2]												Surface Water Quality												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
UT100C (HDR)	2004				I	I											Q	Q													F							
	2005			I																																	
	2006				I																																No change in status.
	2007		I	I	I	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q											
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q												
UT100C1 (HDR)	2004																																				
	2005																																				Water quality measurements discontinued after May 2008.
	2006				I																																
	2007		I	I	I	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q											Continuous gage maintained through 2008.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			
UT100C2 (HDR)	2004																																				
	2005																																				Water quality measurements discontinued after May 2008.
	2006				I																																
	2007		I			C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q											Continuous gage maintained through 2008.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			
UT100D (HDR)	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F	F		F				
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F	F		F				
	2006		I	I	I	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F							No sediment sampling in 2008.
	2007	I	I		I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q						F							
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
UT100E (HDR)	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F	F		F				
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F							No sediment sampling in 2008.
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q						F							
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q						F							Continuous gage maintained through 2008.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
UT119A (HDR)	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q								F	F		F				
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q								F							No sediment sampling in 2008.
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q						F							
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q						F							Continuous gage maintained through 2008.
	2008	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
UT119B (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q															
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q									F						
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q						F							No water quality or hydrology after May 2008.
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
UT135A (HDR)	2004					I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q															
	2005	I		I		I	I	I	I	I				Q		Q		Q	Q	Q	Q	Q	Q															Water quality measurements discontinued after May 2008.
	2006		I			I	I	I	I	I			I		Q	Q		Q	Q	Q	Q	Q	Q		Q													
	2007		I		I	C	C	C	C	C	C	I	I		Q			Q	Q	Q	Q	Q	Q	Q	Q													Continuous gage maintained through 2008.
	2008	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q																			
UT138A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q									F		F				
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q															
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q													No water quality or hydrology after May 2008.
	2007	I	I		I	I	I	I	I	I	I	I	I	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			
UT141A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q									F		F				
	2005			I		I	I	I	I	I	I					Q		Q	Q	Q	Q	Q	Q									F						No water quality or hydrology after May 2008.
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q						F						
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q							F						No sediment sampling in 2008.
	2008	I	I	I	I	I								Q	Q	Q	Q	Q																			

Sample Location	Year[1]	Period-of-Record By Discipline																																	Comment
		Surface Hydrology[2]												Surface Water Quality												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
UT146A (HDR)	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q									F		F				
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q															
	2006		I			I	I	I	I	I	I		I		Q			Q	Q	Q	Q	Q	Q		Q													No change in status.
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	Q													
	2008	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q													

KEY:

	Shaded cells indicate a change for 2008. Details are provided in the comments column.
C	Continuous stage/discharge hydrometric data collected in streams (gaged stations with dataloggers).
F	Sediment samples collected. Seep sediment samples show number of seeps sampled through 2007. Sediment symbol not shown on associated map.
I	Instantaneous stream discharge measurements taken each month coincident with water-quality sampling (ungaged stations without dataloggers).
Q	Surface water-quality samples collected for field and laboratory analyses.

NOTES:

1 Work for 2008 is shown as planned, but has not yet been completed.

2 At stations where continuous hydrometric data are collected, continuous hydrographs will be estimated throughout winter months using standard hydrometric methods. Stream gages are reinstalled each spring as early as breakup conditions allow.

TABLE 2
Water Sample Container Types, Sample Volumes, and Preservation Requirements

Bottle Type (SGS) Summer Streams	Bottle Type (SGS) Winter Streams	Bottle Type (SGS) Seeps	Bottle Type (CAS - QC)	Analysis	Preservative
(1) 500 mL HDPE	(1) 250 mL HDPE	(1) 250 mL HDPE	(1) 1 L HDPE	Total metals	HNO_3
(1) 500 mL HDPE	(1) 250 mL HDPE	(1) 250 mL HDPE	(1) 1 L HDPE	Dissolved metals	HNO_3
(1) extra unpreserved for dissolved metals collection	(1) extra unpreserved for dissolved metals collection	(1) extra unpreserved container for dissolved metals collection	(1) extra unpreserved container for dissolved metals collection		
(1) 250 mL HDPE	(1) 120 mL HDPE	(1) 500 mL HDPE	(1) 1 L HDPE	Cyanide total	NaOH
				Cyanide (weak acid dissociable)	NaOH
				Cyanide, available (low level confirmation)	NaOH
(1) 500 mL HDPE	(1) 120 mL HDPE	(1) 250 mL HDPE	(1) 1 L HDPE	Ammonia as N	H_2SO_4
				Phosphorus total	H_2SO_4
				Nitrate-nitrite total	H_2SO_4
(2) 1 L HDPE	(1) 500 mL HDPE (TSS)	(2) 500 mL HDPE (TDS, TSS, acidity)	(1) 1 L HDPE	TDS	None
				TSS	None
(2) 1 L extra volumes needed for MS/MSD	(2) 500 mL HDPE (TDS, acidity, alkalinity, specific conductivity, pH, anions)	(1) 500 mL HDPE (alk., cond., pH)		Alkalinity	None
				Acidity	None
				Specific conductance	None
				pH	None
(1) 120 mL HDPE	No separate bottle needed	No separate bottle needed	No separate bottle needed	Chloride	None
(1) 120 mL HDPE extra volume for MS/MSD				Fluoride	None
				Sulfate	None
(1) 250 mL HDPE	No separate bottle needed – analyzed from sample set 1	(1) 125 mL HDPE	No separate bottle needed – analyzed from sample set 1	Thiocyanate	HNO_3

Bottle Type (SGS) Summer Streams	Bottle Type (SGS) Winter Streams	Bottle Type (SGS) Seeps	Bottle Type (CAS - QC)	Analysis	Preservative
(1) 500 mL PTFE	(1) 500 mL PTFE	(1) 500 mL	(1) 500 mL fluoropoly no extra volume for MS/MSD	Low-level mercury	HCl
(1) 250 mL amber glass jar (1) 250 mL amber glass jar, unpreserved for field collection	(1) 60 mL amber glass jar (1) 60 mL amber glass jar, unpreserved for field collection	n/a	(1) 250 mL plastic bottle (1) 250 mL plastic bottle unpreserved for field collection	Dissolved organic carbon	HCl (SGS) H_2SO_4 (CAS)
(1) 250 mL amber glass jar (1) 250 mL amber glass jar, unpreserved for field collection	(1) 60 mL amber glass jar (1) 60 mL amber glass jar, unpreserved for field collection			Total organic carbon	HCl

Notes:

°C = degrees Celsius

CAS = Columbia Analytical Services, Inc.

HCl = hydrochloric acid

HDPE = high-density polyethylene

HNO_3 = nitric acid

H_2SO_4 = sulfuric acid

MS/MSD = matrix spike/matrix spike duplicate

mL = milliliter

L = liter

NA = not applicable

NaOH = sodium hydroxide

PTFE = polytetrafluoroethylene (fluoropoly)

SGS = SGS Environmental Services, Inc.

TDS = total dissolved solids

TSS = total suspended solids

*Collection bottle sizes decrease in winter due to limitations in available flow at most sites. The winter bottle types reflect minimum required quantities as defined by the primary laboratory (SGS).

TABLE 3
Surface Hydrology and Water-quality Stream Station Locations, 2008

Station Identification	Degrees, Decimal Minutes[a]		Decimal Degrees[a]	
	Longitude	Latitude	Longitude	Latitude
KC100A	W155.°42.129'	N59.°43.402'	-155.702150	59.723367
KR100A	W155.°50.262'	N59.°52.660'	-155.8377	59.877667
NH100APC1	W154.°58.637’	N59.°45.515'	-154.977277	59.75858
NK100A	W155.°43.136'	N59.°50.584'	-155.718933	59.843067
NK100A1	W155.°43.140’	N59.°50.982’	-155.608500	59.849700
NK100B	W155.°25.541'	N59.°26.073'	-155.425700	59.934550
NK100C	W155.°24.595'	N59.°55.822'	-155.409917	59.930367
NK119A	W155.°24.104'	N59.°55.088'	-155.401700	59.918130
NK119B	W155.°24.703'	N59.°55.633'	-155.411717	59.927217
SK100A	W155.°46.545'	N59.°50.010'	-155.775750	59.833500
SK100B	W155.°31.452'	N59.°47.591'	-155.524200	59.793183
SK100B1	W155.°28.434’	N59.°48.312’	-155.4739	59.8052
SK100B2	W155.°48.652'	N59.°26.329'	-155.43881	59.81086
SK100C	W155.°24.857'	N59.°48.777'	-155.414283	59.812950
SK100D	W155.°18.159'	N59.°49.084'	-155.302650	59.818067
SK100F	W155.°16.877'	N59.°50.909'	-155.281283	59.848483
SK100G	W155.°17.083'	N59.°52.457'	-155.284717	59.874283
SK119A	W155.°25.693'	N59.°49.326'	-155.428217	59.822100
SK124A	W155.°22.009'	N59.°41.523'	-155.366816	59.692200
SK131A	W155.°16.503'	N59.°52.146'	-155.275050	59.869100
SK133A	W155.°17.917'	N59.°52.369'	-155.298617	59.872817
SK134A	W155.°17.577'	N59.°52.937'	-155.292950	59.882283
SK136A	W155.°17.182'	N59.°53.222'	-155.286367	59.887033
SK136B	W155.°18.639'	N59.°53.887'	-155.310650	59.898117
UT100APC1	W155.°18.197'	N59.°43.037'	-155.303288	59.717282
UT100APC2	W155.°14.846'	N59.°42.112'	-155.247433	59.701873
UT100APC3	W155.°12.633'	N59.°39.388'	-155.210549	59.656469
UT100B	W155.°15.215'	N59.°47.215'	-155.253583	59.786917
UT100C	W155.°13.068’	N59.°48.240’	-155.2178	59.8040
UT100C1	W155.°9.816’	N59.°50.382’	-155.1636	59.8397
UT100C2	W155.°10.200’	N59.°52.764’	-155.1700	59.8794
UT100D	W155.°11.995'	N59.°54.481'	-155.199917	59.908017
UT100E	W155.°16.637'	N59.°55.090'	-155.277283	59.918167
UT119A	W155.°15.372'	N59.°47.461'	-155.250600	59.791020
UT119B	W155.°18.466'	N59.°47.977'	-155.307767	59.799617
UT135A	W155.°09.289'	N59.°53.042'	-155.154817	59.884033
UT138A	W155.°11.430'	N59.°54.510'	-155.190500	59.908500
UT141A	W155.°13.913'	N59.°54.295'	-155.231883	59.904917
UT146A	W155.°15.884'	N59.°54.625'	-155.264733	59.910417

a. WGS 84 (World Geodetic System 84) datum

TABLE 4
Seep Sampling Locations, 2008

Station Identification	Degrees, Decimal Minutes[a]		Decimal Degrees[a]	
	Longitude	Latitude	Longitude	Latitude
SP26	W155° 17.529'	N59° 54.2508'	-155.292	59.90418
SP31	W155° 26.5228'	N59° 53.0008'	-155.442	59.88335
SP40	W155° 16.6197'	N59° 55.2684'	-155.277	59.92114
SP41	W155° 16.9297'	N59° 53.5233'	-155.282	59.89205
SP44	W155° 21.1387'	N59° 53.4171'	-155.352	59.89029
SP53	W155° 22.5593'	N59° 54.9264'	-155.376	59.91544
SP57	W155° 29.5217'	N59° 55.6183'	-155.492	59.92697
SP62	W155° 17.0687'	N59° 54.3362'	-155.284	59.9056
SP66	W155° 13.782'	N59° 55.6105'	-155.230	59.92684
SP73	W155° 12.445'	N59° 53.48'	-155.207	59.89133
SP75	W155° 8.4444'	N59° 52.4584'	-155.141	59.87431
SP78	W155° 9.2934'	N59° 50.092'	-155.155	59.83487
SP84	W155° 13.156'	N59° 47.5752'	-155.219	59.79292
SP86	W155° 22.5613'	N59° 49.4049'	-155.376	59.82341
SP93	W155° 23.0402'	N59° 52.3459'	-155.384	59.87243
SP96	W155° 24.6429'	N59° 50.8957'	-155.411	59.84826
SP99	W155° 32.79'	N59° 53.2326'	-155.547	59.88721
SP100	W155° 35.0841'	N59° 50.9355'	-155.585	59.84892
SP101	W155° 31.9213'	N59° 49.3227'	-155.532	59.82204
SP104	W155° 28.6257'	N59° 50.6598'	-155.477	59.84433
SP108	W155° 14.943'	N59° 53.7526'	-155.249	59.89588
SP109	W155° 11.3857'	N59° 49.1344'	-155.190	59.81891
SP112	W155° 24.7728'	N59° 47.035'	-155.413	59.78392
SP113	W155° 23.788'	N59° 54.384'	-155.396	59.9064
SP116	W155° 17.4354'	N59° 55.1282'	-155.291	59.9188
SP0105	W155° 14.4362'	N59° 52.6104'	-155.241	59.87684
SP0205	W155° 12.7845'	N59° 52.2361'	-155.213	59.8706
SP1805	W155° 17.3783'	N59° 47.7797'	-155.290	59.79633

a. WGS 84 (World Geodetic System 84) datum

FIGURES

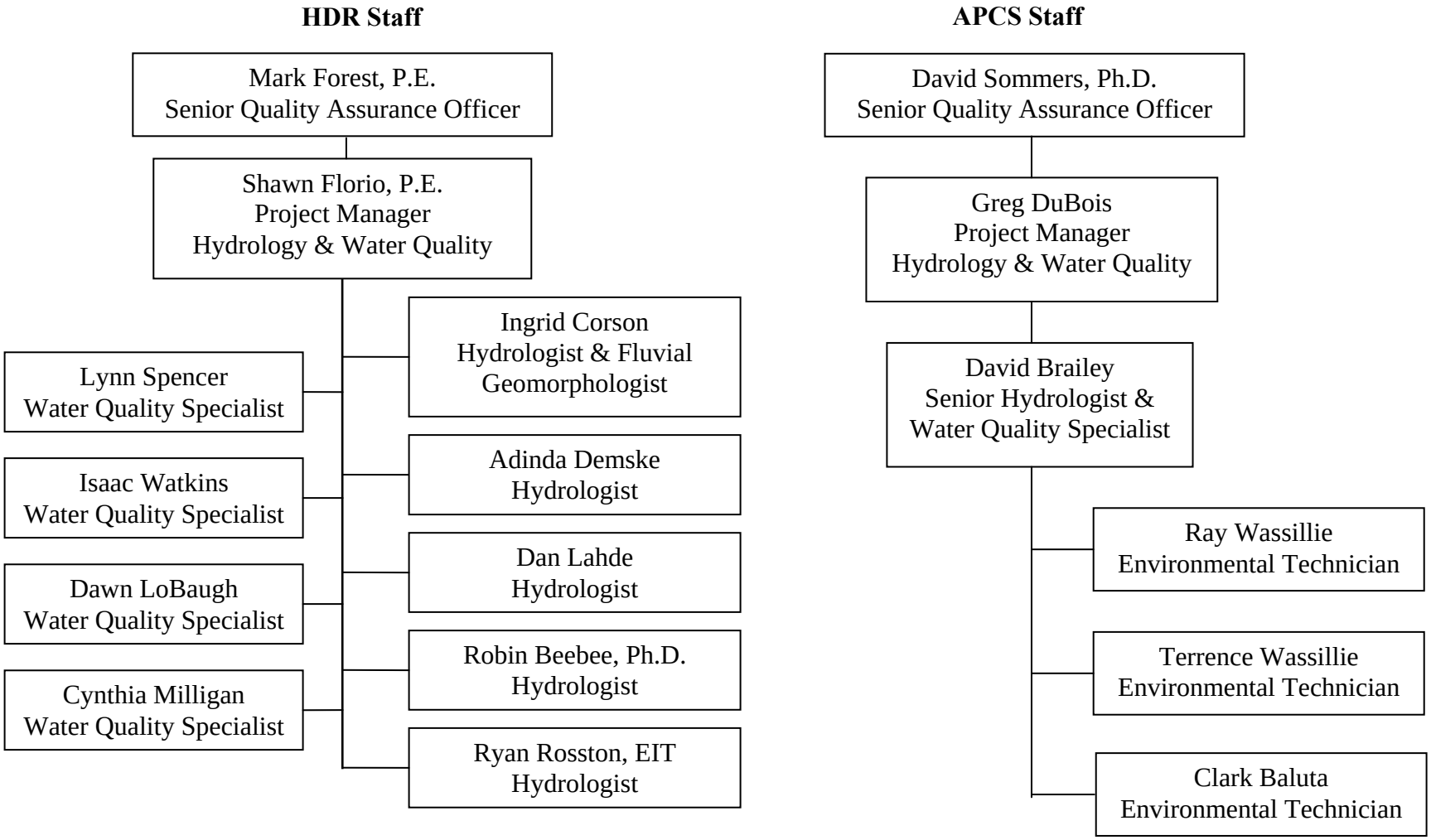


FIGURE 1. Surface Water Program Organization Chart, Key Personnel

1,300,000 1,350,000 1,400,000 1,450,000

2,200,000 2,150,000 2,100,000

Cone (Black) Mountain
Groundhog Mountain
Groundhog Creek
Black Lake
Big Wiggly Lake
North Fork Kokhuli River
Kokhuli River
Stuyahok River
North Fork Tributary C.U.
Frying Pan Lake
Mountain
Upper Talarik Creek
Sharp Mountain
Chiguniu Lake
First Creek
Iliamna Lake

NK100B
NK100C
NK119B
NK119A
UT100E
UT146A
SK136B
UT100D
UT138A
UT141A
SK136A
SK134A
UT135A
SK100G
SK133A
SK131A
UT100C2
KR100A
NK100A
NK100A1
SK100A
SK100F
UT100C1
SK124A
SK119A
SK100D
SK100B1
SK100B2
SK100C
UT119B
UT100C
SK100B
UT119A
UT100B
NH100APC1
KC100A
UT100APC1
UT100APC2
UT100APC3

Figure 2
2008 Field Sampling Plan
Surface Hydrology and Water Quality Sampling Stations

DRAFT

Legend

- HDR Drainage Boundary
- APCS Drainage Boundary

Sampling Stations

- Continuous
- Instantaneous
- APCS Sampling Station

- Stream
- Waterbody
- General Deposit Location
- Village Corporation Boundary (Private Land)



0 1.25 2.5 3.75 5 Miles

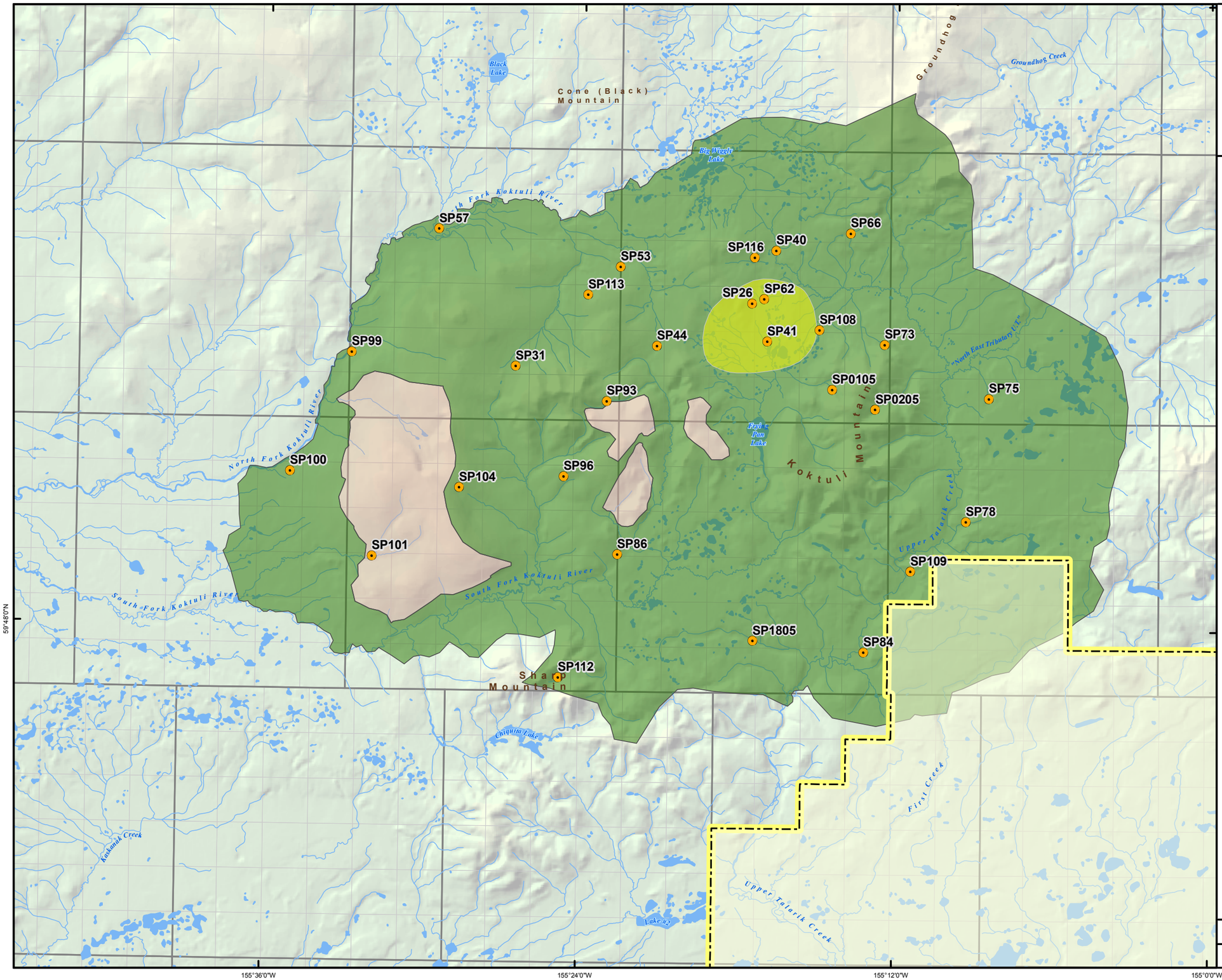
0 1.25 2.5 3.75 5 Kilometers

Scale 1:170,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: HDR_WQ_2008FSP_V01	Date: April 23, 2008
Version: 1	Author: HDR - MC

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THE pebble PARTNERSHIP

Figure 3

2008 Field Sampling Plan
Seep Sample Sites
and
2008 Inventory Areas

DRAFT

Legend

- Seep Sample Site
- 2008 Inventory Area
- Previous Inventory Area
- Stream
- Waterbody
- General Deposit Location
- Village Corporation Boundary (Private Land)



Miles
0 1.25 2.5 3.75 5
Kilometers
0 1.25 2.5 3.75 5

N

Scale 1:135,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: HDR_Seep_2008FSP_V01.mxd	Date: April 23, 2008
Version: 1	Author: HDR - MC

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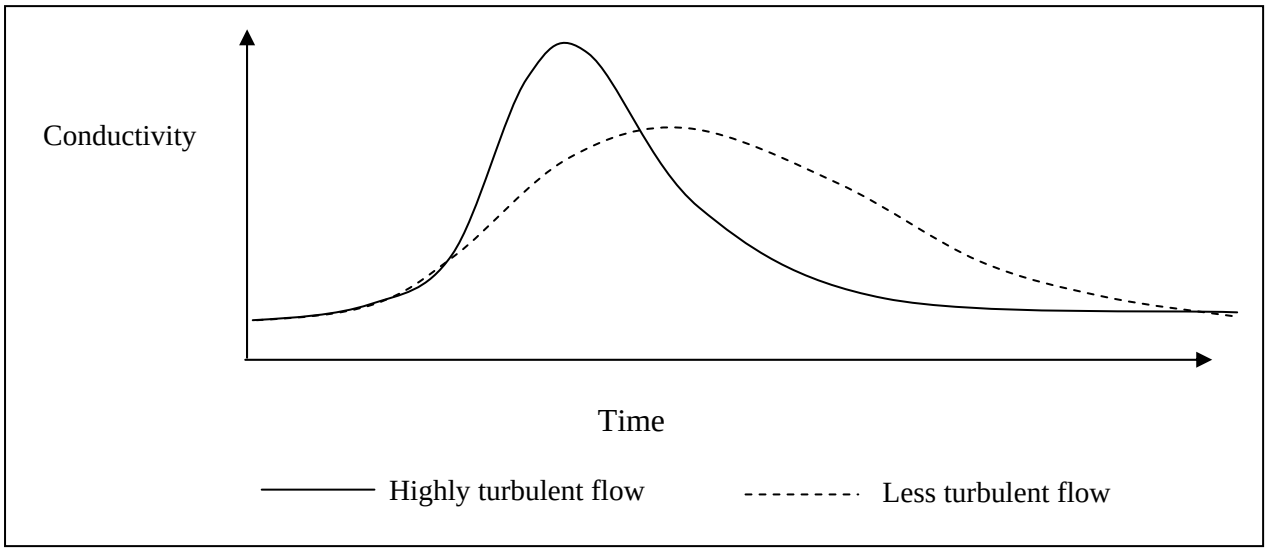


FIGURE 4. Salt Dilution Measurements, Conductivity as a Function of Turbulent Flow

APPENDICES

APPENDIX A

SURFACE WATER QUALITY AND HYDROLOGY STUDY PROGRAM CHANGES 2004 through 2008

Surface Water Quality and Hydrology Program Changes, 2004 through 2008

The surface water-quality and surface hydrology programs have undergone changes since inception in 2004. These modifications have been in response to project design changes, project-specific requirements, agency suggestions, and evaluation of data from previous years. The program changes from 2004 through 2008 are summarized below.

2004 STUDY OVERVIEW

The study programs surface water quality and for surface hydrology were designed and initiated in 2004. Most of the 2004 field work (April through September) was conducted by CH2M Hill Inc. HDR Alaska, Inc., assumed responsibility for these programs in late September 2004.

Surface Water Station Selection

The selection and development of surface water stations was a coordinated process involving the engineering design team and other baseline study teams, including those looking at water chemistry, hydrology, fisheries, aquatic resources, sediment, and trace elements. Twenty-nine stream stations were selected for water-quality sampling and hydrology measurements in the study area that included the possible mine, mill, and tailings facilities and the drainages associated with them. Station locations were finalized based on a May 2004 field trip by Dave Bunte (CH2M Hill), Dave Meyer (U.S. Geological Survey [USGS]), Jim Buell (Buell and Associates), and John Morsell (Northern Ecological Services). Fourteen of these stations were selected for continuous flow (CQ) measurements. Pressure transducers and dataloggers were installed by Northern Dynasty Mines Inc. (NDM) contractors at 11 of the CQ stations in July 2004. The USGS installed its standard stream-gauging equipment at three CQ stations in August 2004.

Surface Water Quality

Water samples were collected consistently from 29 stations over seven field events from April through October. A Hydrolab Quanta multi-probe meter was used to measure in situ field parameters. Depth-integrated water samples were collected using a DH-48 sampler. Six stations (UT100A, UT100D, NK100A, NK100C, SK100A, and SK100G) were sampled for organic constituents, including pesticides, volatile compounds, and semivolatile compounds in August and October.

Surface Hydrology

Surface water discharge measurements were completed coincident with the collection of water-quality samples at each of the same 29 stations throughout 2004.

Seeps

Eleven seeps were sampled for water quality in 2004. Two of the seeps sampled in May were found to be dry in September, and an additional two seeps were identified and sampled as replacements. Five of these seeps were located in the South Fork Koktuli drainage, five seeps were located in the Upper Talarik Creek drainage, and one was located in the North Fork Koktuli drainage.

Sediments

Sediments were collected at 23 stations in June, July, and September. SK100G and UT100B were resampled in August. The samples were analyzed for total cyanide, anions, ammonia, and metals.

2005 STUDY OVERVIEW

The 2005 surface water-quality and hydrology programs incorporated changes based on findings from the 2004 study and on agency recommendations. The surface water programs included 32 stations in 2005. Three new stations were added in the South Fork Koktuli drainage. SK124A was added to provide baseline data for mine development concepts that were under consideration. SK100B1 and SK100B2 were added to fill data gaps in the characterization of the gaining reach (or "springs") where groundwater upwelling occurs.

Surface Water Quality

Several changes were made in the sampling equipment in 2005. The DH-48 depth-integrated sampler was replaced with the DH-81 sampler, based on technical advice by the USGS on the potential for metal contamination from the DH-48. The Quanta Hydrolabs were replaced with YSI 556 multi-probe meters and Hach 2100P turbidimeters to improve the reliability of the field-parameter measurements.

Surface Hydrology

The surface hydrology program in 2005 continued the data collection effort that was initiated in 2004. In addition, the 2005 studies included groundwater/surface water exchange measurements, hyporheic temperature measurements, and baseflow (low-flow) stream profiles.

Other changes to the programs in 2005 included the initiation of three new stations noted above. Two of these new stations (SK124A and SK100B1) were installed as continuous discharge stations. Only instantaneous discharge (IQ) measurements were collected at SK100B2. IQ data were collected to provide flow data for flow-integrated water-quality samples.

HDR installed thermistor strings and measured temperatures in the hyporheic zone of streams at four locations in the mine study area. This work was completed in consultation with Water Management Consultants (WMC). Mini-piezometers were installed coincident with the thermistor strings. Hyporheic flows also were measured using stream seepage meters. This program was a pilot study to test the feasibility of these technologies for a larger data-collection effort throughout the mine site study area. Two of the four thermistor and piezometer stations were destroyed during freshets within the first year. This approach to hyporheic zone measurements was abandoned in late 2005; although the two remaining

thermistor strings continue to collect data, which are periodically downloaded by HDR hydrologists during field visits. The fisheries program has assumed responsibility for collecting any further temperature data in the hyporheic gravels.

Baseflow measurements—by way of a series of low-flow streamflow profiles—were completed to assist in understanding the gaining and losing aspects of the drainages in the mine study area. These profiles consisted of 10 to 15 instantaneous discharge measurements each along the north and south forks of the Koktuli River and along Upper Talarik Creek. The measurements were collected during the low-flow period immediately prior to the spring freshet. Measurements were collected using the same field methods described in the 2007 field sampling plan for the monthly discharge measurements. This data collection effort was successful and was continued in subsequent years.

Seeps

After a review of the available database of springs surveyed to date at the possible mine area, a comprehensive reconnaissance of springs was planned with input from WMC. Aerial inventories were conducted in January, March, June, and July that expanded the mapped area to include the greater project area. Nine seeps were sampled in March for water quality and discharge. Following the June and July reconnaissance efforts, 24 seeps were selected for future water-quality sampling and discharge measurements. Based on Mine Development Concept 25 and discussions with WMC, only a few of the seeps sampled in 2004 by CH2M Hill and in March 2005 by HDR were sampled in July, August, and October 2005. Portable weirs (60^{o}, 90^{o}, V-notch) were developed to measure discharge in larger seeps. Direct catch into a calibrated container was used in the smaller seeps. Total and ferrous iron was not measured using Hach field test kits in 2005 because the total iron results in 2004 from analytical samples and from the Hach kits were not in agreement.

Sediments

Sediments were collected concurrently with water-quality samples at 17 stations over three sampling events conducted in June, July, and September. Seven stations were sampled in June and July (KC100A, NK100A, NK119A, SK100A, SK100B, SK100C, and SK100G). SK100F, SK119A, and UT100E were sampled in June. UT119B and UT141A were sampled in July. Six lakes in the study area (Black Lake, Big Wiggly Lake, Frying Pan Lake, Chiquita Lake, Lake No. 2, and Mud Lake) were added to the sediment sampling program. Seven seeps were sampled for sediments in July and September.

2006 STUDY OVERVIEW

The 2006 surface water-quality, surface hydrology, seep, and sediment programs for the mine study area had the same objectives, study area, and methods as the 2005 program. The program was updated based on project design changes and an evaluation of the results from 2005 studies. One station (NK119B) was dropped from the program in June. The number of sampling events was increased to include the months of November and December to further characterize winter conditions.

Surface Water Quality

Frying Pan Lake was sampled at the inlets, outlet, and the deepest part of the lake for water quality once in July. Water-quality samples were collected in the six lakes that were sampled for sediments in 2005. Orthophosphate and separate analyses for nitrate and nitrite was done by the analytical laboratory for all surface water-quality samples and seep samples starting in May 2006. No samples were collected in 2006 for analysis for volatile organic compounds, semivolatile organic compounds, and pesticides.

Surface Hydrology

The surface hydrology program for 2006 included collection of baseline and baseflow (low-flow) stream discharge measurements. The objective of the data collection was to increase the period of record and the reliability of the database. Stream discharge measurements continued to be collected coincident with the surface water-quality sampling.

Similar to 2005, baseflow (low-flow) discharges were measured in late winter, immediately prior to the onset of the spring freshet. Knight Piésold Ltd. joined HDR in this field effort and assisted in the successful initiation of the use of a salt-dilution method to measure discharge. Following this field effort, the salt-dilution method has been successfully used at select stations for the stream discharge program as well.

Seeps

The 24 seeps that were sampled in 2005 were sampled during four events in 2006 (March, June, August, and October). Additional inventory was conducted during two efforts in June and October. The areas of interest were identified by WMC based on changes in project design. From these areas, 20 new seep stations were selected for ongoing sampling. These new stations were sampled once during October. Seeps were measured for total and ferrous iron using a Hach colorimeter 890 to provide an estimate of redox conditions. In June, SRK Consulting, in conjunction with HDR, conducted a ground survey of seeps in the area of the potential mine pit. Fifteen stations were selected from this survey and were sampled concurrently with the established seep program during October. These stations were not measured for total and ferrous iron using the Hach field kit.

Sediments

Sediments were collected concurrently with water-quality samples at 12 stream stations in June. Additional analysis was performed for total sulfur and acid volatile sulfide (AVS-SEM) for all sediment samples in 2006. No sediments were collected from seeps.

Small Ponds Study

This program was initiated to characterize conditions of ponds in the area of potential tailings facilities. This program was designed and implemented in conjunction with the trace elements program, which collects vegetation samples in the same locations. Water-quality and sediment samples were collected in select ponds at four stations each in the South Fork Koktuli drainage, North Fork Koktuli drainage, and Upper Talarik Creek drainage.

2007 STUDY OVERVIEW

The surface water-quality, surface hydrology, seep, and sediment programs continued in 2007 with the same objectives, study area, and methods as in previous years. Adjustments were made to the programs to address project design changes and data gaps identified by evaluation of the study results to date. The number of stream stations in 2007 was increased to 39. Three new sites were added in the lower sections of Upper Talarik Creek (UT100APC1, UT100APC2, and UT100APC3) and are being operated by APCS. APCS also added one site (NH100APC1) on Alaska Peninsula Corporation land on the Newhalen River. Seven new HDR-operated continuous flow and water-quality stations (UT135A, UT100C, UT100C1, UT100C2, NK100A1, NK100C, and NK119B) were added in 2007, all as a result of the Pebble East discovery. Four of these stations (UT100C, UT135A, NK100C, and NK119B) were previously established instantaneous flow stations where discharge began to be measured continuously in 2007 during the ice-free months. UT100C1, UT100C2, and NK100A1 were new stations. The stream-sampling program consisted of 12 monthly sampling events for surface hydrology and water quality at all stations.

Surface Water Quality

The total number of stream-sampling stations was increased to 39 as described above. Water-quality samples to be analyzed for gasoline-range organics, diesel-range organics, and residual-range organics were collected once in June at UT100A, UT100D, NK100A, NK100C, SK100A, SK100G, and Big Wiggly Lake. Beginning in June, dissolved organic carbon (DOC) was added to the suite of analyses for samples collected monthly at all sites to further characterize metal speciation and bioavailability.

Black Lake, Big Wiggly Lake, Frying Pan Lake, Chiquita Lake, Lake No. 2, and Mud Lake were sampled for water quality.

Surface Hydrology

The total number of surface hydrology stations was increased to 39 in 2007. Twenty-three CQ locations were in operation by the end of 2007; three of these were managed by the USGS, 17 CQ stations were operated by HDR, and three CQ stations were operated by APCS. The remaining 16 hydrology stations did not include continuous discharge gages; instantaneous discharge measurements were taken monthly at these stations for the purpose of providing flow values coincident with water-quality samples.

One baseflow-measurement event occurred in 2007. Similar to the baseflow measurements in 2005 and 2006, these measurements were collected in late winter immediately prior to the spring freshet.

The 2007 surface hydrology program included the collection of data on fluvial geomorphology. Data collection for fluvial geomorphology was initiated and then discontinued in 2005 under the fisheries program. The objective of this task was to provide fluvial geomorphology data to support the instream flow study. Where the instream flow study documents fish habitats under current conditions, the fluvial geomorphic study characterized baseline geomorphic conditions and developed regime equations to understand the hydrologic sensitivity of the geomorphology of these streams.

To characterize fluvial geomorphic conditions on the north and south forks of Koktuli River and on Upper Talarik Creek, an analysis of data collected in 2005 was completed (Phase 1), and the results were

discussed with NDM and the hydrology, instream flow, and fluvial geomorphology teams. The 2007 field sampling strategy (Phase 2) was refined based on the results of this analysis and discussion.

Seeps

The seeps program was expanded to double both the area of inventory and the number of sampling stations. The expanded area corresponds to areas of interest in the Pebble East zone. Sampling occurred at established sites five times in 2007: March, May, July, September, and October/November. By the end of the 2007 sampling season, 100 seep sampling sites had been established. Inventories occurred in the deposit area, including portions of the Upper Talarik drainage basin. Fifteen seep stations in the mineralized area were sampled two times as part of a request from the geochemistry team on the project: once during high flow and once during low flow. Ferrous iron sampling with the Hach test kit was discontinued because of lack of detections.

Sediments

Stream sediments were sampled once during June at a subset of stream water-quality stations in conjunction with the water-quality sampling event. Sediments were not analyzed for AVS-SEM or total sulfur.

Small Ponds Study

The twelve ponds first sampled in 2006 were again sampled for water quality and sediments in 2007. Unlike 2006, sediments were not analyzed for AVS-SEM or total sulfur.

2008 STUDY OVERVIEW

The surface water-quality, surface hydrology, and seep programs will continue in 2008 with the same objectives, study area, and methods as in previous years. Adjustments have been made to the programs to address project design changes and data gaps identified by evaluation of the study results to date.

Surface Water Quality

Water-quality samples will be collected monthly from January through May at 39 stations. The number of stations to be sampled from June through December has been reduced to 22. Table 1 of the 2008 field sampling plan provides a sampling schedule for each stream station.

Water-quality samples will be analyzed for inorganics, including metals, and organics, including dissolved organic carbon (DOC), which is now a regular part of the suite of analyses for samples collected monthly at all sites to further characterize metal speciation and bioavailability.

Surface Hydrology

Instantaneous discharge measurements will continue to be collected at 39 stations through May 2008. Beginning in June 2008, discharge measurements will be collected at 30 stations: 22 continuously gaged locations and eight additional stations where instantaneous discharge measurements will be collected

coincident with water-quality samples. As in past years, three CQ stations will be managed by the USGS. Three CQ stations will be operated by APCS. The remaining 16 CQ stations will be operated by HDR. Table 1 of the 2008 field sampling plan details this schedule.

Four continuously gaged stations (SK100A, SK100B1, SK100F, and SK100G) have been removed from the surface hydrology program in 2008 because the period-of-record is now adequate to confidently predict discharge at the four terminated locations (if required) based on the continued data collection at other nearby continuous gages. No continuous gages will be installed at these four sites in 2008.

One baseflow-measurement event is planned for 2008. Similar to the baseflow measurements in 2005, 2006, and 2007, these measurements will be collected in late winter immediately prior to the spring freshet.

The 2008 fluvial geomorphology study will be managed and executed by Inter-Fluve, Inc. and is not included herein. HDR's Ingrid Corson will remain active in the fluvial geomorphology program in order to maintain continuity with the surface hydrology program.

Seeps

There is no new inventory work scheduled for 2008; however, HDR will complete inventories in June 2008 for two areas that were not completed in 2007 due to inclement weather. The number of seep sampling stations will be reduced to 28 in 2008. The sampling schedule will be timed to target a winter low-flow event (March), a breakup event (May), a summer event (August), a fall storm event (September), and a late fall event (late October).

Sediments

Stream and seep sediments will not be sampled in 2008.

Small Ponds Study

The small pond study will not continue in 2008.

APPENDIX B

STREAM WATER QUALITY AND HYDROLOGY FIELD FORMS

Station ID:	**Date:** / /08	**Start Time :** **End Time:**	**GPS - Lat:**
Team:		**Site Observer/ Bear Guard:**	**Long:**
Photos:	**Camera:**	**Weather: Air:** º (C) **Wind:**	**Precip:**
HYDROLOGY	**SAMPLER:** _____	**Type of flow: Laminar Turbulent Other:**_____	
Method: (Wade) (Ice)	IQ Measurement description and constraints:		
(Boat) (Salt)	Control: (Channel) (Section)		
WATER QUALITY	**SAMPLER:** _____	**WQ SAMPLE TYPE: (Grab) (Integrated Grab) (DH81)**	**Time:**

In-situ Field Parameters

Meter Make and Model: YSI 556#

Meter Make and Model: Hach Turb.#

Diss. Metals Filter Lot #: _____

DOC Filter Lot #: _____

Filtered by: _____

DI Water Lot Name: _____

Sample Type

Duplicate:	**Y**	**N**
Triplicate:	**Y**	**N**
MS/MSD:	**Y**	**N**
Sediment:	**Y**	**N**

Meter Readings

Altimeter:	_____	mm Hg
Temperature:	_____	℃
Specific Conductivity:	_____	mS/cm^c
Relative Conductivity:	_____	µs/cm
DO:	_____	% saturation
DO:	_____	mg/L
pH:	_____	STD units
ORP:	_____	mV
Turbidity:	_____	NTU

Additional Comments:

Hg Trip Blank: _____08SGSAWS60___ (prim) _____08CASKWS60___ (trip)

Sketch, Notes and Remarks

Hydrology level 1 review	Name:	Date:
WQ level 1 review	Name:	Date:

Site: **Time IQ taken:** **--** **SG Height:** **+/-** **Time SG:**

Date: **/ /08** **Team:** **SG Height:** **+/-** **Time SG:**

Time Interval: 30 Seconds **Other: _____** **Meter type: (M. McBirney)** **Meter #**

Angle Coef. (deg)	Notes	Sec #	Distance (ft)	Depth (ft)	VELOCITY At Depth .6 (fps)	At Depth .2 (fps)	At Depth .8 (fps)
	Bank	0					
		1					
		2					
		3					
		4					
		5					
		6					
		7					
		8					
		9					
		10					
		11					
		12					
		13					
		14					
		15					
		16					
		17					
		18					
		19					
		20					
		21					
		22					
		23					
		24					
		25					
		26					
		27					
		28					
		29					
		30					
TOTAL							

APPENDIX C

SEEP WATER QUALITY AND HYDROLOGY FIELD FORMS

2008 IQ/ WQ Measurements
Pebble Project - SEEPS

Station ID: SP / SRK **Date:** / /08 **Start Time:** **End Time:**

Team: (B. Spencer) (L. Spencer) **Site Observer/ Bear Guard:**

GPS - Lat: **Long:** **Elev:**

Weather: º (C) **Wind:** **Precip./ visibility:**

Sample Matrix: SEEPS **Camera #:**

HYDROLOGY - Sampler: (LS) (BS) _____

Method: (V-notch Weir) 60º_____' 90º_____' 120°_____' **(3' Flat Weir)**_____' **Mini-weir** _____ **Est% Capture** _____

(Direct catch): _____Qt/Gal/Liter_____Sec, _____Qt/Gal/Liter_____Sec, _____Qt/Gal/Liter_____Sec

WATER QUALITY - Sampler: (LS) (BS) _____ Time:_____

In-situ Field Parameters

YSI 556 Multiprobe # _____

Hach 2100P Turbimter.# _____

Diss. Metals Filter Lot # _____

Filtered by: _____

DI Water ID: _____

Meter Readings

Altimeter	_____	mmHg
Temperature:	_____	℃
Spec.Conductivity:	_____	mS/cm^{c}
Rel. Conductivity:	_____	µS/cm
DO:	_____	% saturation
DO:	_____	mg/L
pH	_____	STD units
ORP:	_____	mV
Turbidity:		NTU

Comments:

Samples Collected:		
Duplicate:	Y	N
Triplicate:	Y	N
MS/MSD:	Y	N

Hg (Test America) Blank: 08TAPOWS6____ **Hg (Columbia Analytical) Blank:** 08CASKWS60____.__

Hydrology level 1 review	Name:	Date:
WQ level 1 review	Name:	Date:

Sketch, Notes and Remarks - See reverse side

Site:_____ **Date: _____ / ____ /08**

Sketch and Notes: