Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2005 STUDY PLANS

CHAPTER 7. NATURALLY OCCURRING CONSTITUENTS IN SURFACE SOIL, SEDIMENT, VEGETATION AND FISH

NOVEMBER 2005

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ACRONYMS

AASHTO	American Association of State and Highway Transportation Officials
ABA	acid-base accounting
ACHP	Advisory Council on Historic Preservation
ACL	alternative cleanup level
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
agl	above ground level
AHRS	Alaska Heritage Resource Survey
AKNHP	Alaska Natural Heritage Program
ANOVA	analysis of variance
APE	area of potential effect
AS	alpine rock and dwarf scrub habitat
ASCI	Alaska Stream Condition Index
ASTM	American Society for Testing and Materials
BEESC	Bristol Environmental & Engineering Services Corporation
BMR	baseline monitoring report
°C	degrees Celsius
CAD	computer-aided drafting
CC	comprehensive stations with continuous-stage monitoring
CIR	color infrared
CQ	continuous discharge
CWOC	comprehensive stations without continuous-stage monitoring
DECD	Alaska Department of Economic and Community Development
DEM	digital elevation model
DNR	Alaska Department of Natural Resources
DO	dissolved oxygen
DOT&PF	Alaska Department of Transportation & Public Facilities
DQOs	data quality objectives
EBD	environmental baseline document
EC	environmental consequences
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration

FHWA	Federal Highway Administration
FSP	field sampling plan
GIS	geographic information system
GPS	global positioning system
HDR	HDR Alaska, Inc.
HGM	hydrogeomorphic
IEE	Initial Environmental Evaluation
IM	initial monitoring station
L	liter(s)
LCNPP	Lake Clark National Park and Preserve
LDN	Land Design North
LM	lowland wet graminoid, moss meadow habitat
LS	lowland low and tall alder/willow scrub habitat
m	meter(s)
MCHTWG	Mulchatna Caribou Herd Technical Working Group
MDC	mine development concept
mg	milligram(s)
ML/ARD	metal leaching/acid rock leaching
mm	millimeter(s)
MODIS	moderate resolution imaging spectroradiometer
MRL	method reporting limit
µm	micrometer(s)
NASA	National Aeronautics and Space Administration
NDM	Northern Dynasty Mines Inc.
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic & Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
ORP	oxidation reduction potential
PJD	preliminary jurisdictional determination
PSD	prevention of significant deterioration
psi	pounds per square inch
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control

RS	riverine willow scrub habitat
SHPO	State Historic Preservation Officer
SLR	SLR Alaska
SOP	standard operating procedure
SRB&A	Stephen R. Braund & Associates
SS	subalpine dwarf, low, and tall scrub habitat
SWE	snow/water equivalent
TIN	triangulated irregular network
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UF	upland dwarf scrub, lichen flats habitat
US	upland dwarf, low, and tall scrub habitat
USACE	United States Army Corp of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMC	Water Management Consultants
WMP	water monitoring plan
WQ	water quality

7. NATURALLY OCCURRING CONSTITUENTS IN SOIL, SEDIMENT, VEGETATION, AND FISH

SLR Alaska (SLR) will lead the naturally occurring constituents study for the mine site, supported by HDR Alaska Inc. (HDR), and Bristol Environmental and Engineering Services Corporation (BEESC) will complete the naturally occurring constituents study for the road and port. SLR will provide oversight for the program to maintain consistency between the mine site and road/port sections.

7.1 Mine Site

The 2005 study plan for the mine site will provide data for the baseline characterization of naturally occurring constituents in soil, sediment, vegetation, and fish. Naturally occurring constituents include trace elements, anions, and petroleum hydrocarbons. Field work for the mine site will occur in the middle and late summer of 2005.

7.1.1 Objectives of Study

This study will continue with field procedures established in the 2004 study of naturally occurring constituents in soil, sediment, vegetation, and fish and will update those procedures as appropriate based on knowledge gained during previous sampling events. The objective of the study is to provide defensible documentation and characterization of the natural levels of trace elements, anions, and petroleum-range hydrocarbons (from organic decomposition) existing in environmental media prior to mining operations. Specific media studied by SLR at the mine site will include surface and subsurface soils, and terrestrial and aquatic vegetation. HDR will study sediments in streams, lakes, and seeps in the mine area. HDR also will collect fish-tissue samples from lakes and streams in the mine area. These baselines 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.

7.1.2 Proposed Study Plan

7.1.2.1 Study Area/Scope

Based on the Bureau of Land Management cadastral survey system of range/township/section, the proposed mine, mill, and storage facilities are encompassed by an area 16 survey sections long by 10 sections wide comprising a total area of 160 square miles. The study area for naturally occurring constituents for the mine site is shown on Figure 7-1. The study program for fish tissue extends beyond this area to include the full length of the North and South Forks of the Koktuli River and all of Upper Talarik Creek. The study area for fish is described in greater detail in Chapter 11, Fish and Aquatic Resources.

The 2005 study will accomplish the following scope of work:

- Adequately characterize naturally occurring constituents (e.g., trace elements) in:
  - Surface soil;
  - Terrestrial vegetation that is used as forage by wildlife or food or medicine by humans;
  - Aquatic vegetation, which is consumed by moose, associated with lakes and ponds in the mine-site area;
  - Sediment found in tundra lakes, ponds, streams, and seeps; and
  - Fish tissues.
- Document statistical variance of the natural trace-element concentrations in each of the above media.
- Collect sufficient data to support long-term site-monitoring objectives.

A subset of soil samples will also be collected from depth (1.5 feet below ground surface) for similar analyses. Also, a subset of surface-soil samples will be additionally analyzed for total organic carbon (TOC, also referred to as fraction organic carbon or FOC) and total petroleum hydrocarbons (TPH) as diesel range organics (DRO) and residual range organics (RRO). This biogenic "fingerprinting" will provide information for calculating more realistic alternative cleanup levels (ACLs) that can be applied as part of petroleum-spill cleanup plans.

7.1.2.2 Methods and Approach

Mine operations will include open-pit mining and construction of earthen impoundment dams and tailing ponds, gravel roads, and pads. These are features that will cut across landforms common to the study area. These specific landforms have characteristic types of surface soils, sediment, and vegetation common to the site and the region. Overlain on this are different habitat types, which also cut across landforms.

A valid sampling strategy must include a sufficient distribution of data points (sample locations) to create a statistically representative and technically valid data set. Therefore, a systematic random sampling program was developed and employed to establish sampling locations that ensure a more accurate representation of study area conditions.

This systematic random sampling program is based on the Bureau of Land Management's cadastral survey system of township/range/section. This allows for sampling locations to be re-established in the field via global positioning system (GPS). Sample locations for soil, terrestrial and aquatic vegetation, stream and lake sediment, and fish tissue all will be recorded using GPS. A grid using the existing cadastral survey sections as grid cells was laid out over the study site resulting in 160 grid cells. Starting in the southwest corner, each section/cell was assigned a temporary sequential number, and a random number generator was used to select 50 cells. Each selected cell was then inspected to identify landform types. Landforms and their 2004 estimated physiographic distribution and correlative sample types by media are presented in Table 7-1. Table 7-1 also shows the number of samples targeted for collection in 2004, as well as the actual number of samples that were collected in 2004.

TABLE 7-1
2004 Numbers[1] of Surface-soil, Vegetation, and Sediment Samples by Type and Landform

Sample Types	Ground Moraines	Outwash Plains	Talus Slopes	Stream Channel & Flood Plains	Tundra Lakes & Ponds	Total
			Estimated Physiographic Distribution			
	37%	16%	24%	17%	6%	100%
			Number of Surface-Soil Samples			
Organic-rich silts (OL)	10 (15)	5 (7)	6 (4)	0 (4)	0 (0)	21 (30)
Fine sands with silts and clay (ML and CL)	10 (15)	5 (8)	6 (0)	0 (0)	0 (0)	21 (23)
Poorly graded gravel with sands and silts (GP and GM)	10 (12)	5 (9)	6 (5)	0 (3)	0 (0)	21 (29)
Glacial till (GM and GC)	10 (2)	5 (0)	6 (0)	0 (0)	0 (0)	21 (2)
			Number of Vegetation Samples			
High brush shrubs including species such as willow, American green elder, and blueberry	10 (10)	5 (6)	6 (1)	0 (1)	0 (0)	21 (18)
High brush sedges and, grasses such as blue joint	10 (15)	5 (10)	6 (2)	0 (3)	0 (0)	21 (30)
Alpine tundra shrubs, such as dwarf arctic birch, crowberry	10 (1)	5 (2)	6 (0)	0 (1)	0 (0)	21 (4)
Alpine sedges	10 (6)	5 (4)	6 (1)	0 (1)	0 (0)	21 (12)
			Number of Sediments Samples			
Stream[2]	0 (0)	0 (0)	0 (0)	57 (39)	0 (0)	57 (39)
Lake and Pond	0 (0)	0 (0)	0 (0)	0 (0)	21 (21)	21 (21)
					Total	246 (208)

1. Numbers in parentheses represent number of samples actually collected in 2004.
2. Stream-sediment sampling locations and frequency are based on surface water-quality sampling (Chapter 6) and will occur at 16 surface-water stations three times during 2005.

Sampling of Soil and Vegetation

To adequately characterize soil and vegetation, a sufficient number of samples from each media must be collected to be statistically valid. The sampling strategy for 2005 is designed to collect sufficient samples to be statistically meaningful and to enable differences between baseline conditions and future conditions to be identified.

In 2004, the types and relative abundance of the different habitats was unknown, so sample sites were located based on landform (e.g., geology, amount of vegetative coverage). As can be seen from Table 7-1, insufficient numbers of samples were collected in some cases, both on the basis of landform and

representativeness across sample types. Several locations had insufficient plants for collection or had only one or two species in sufficient abundance. For example, only 13 samples were collected from talus slopes instead of the 48 planned for this terrain type. Therefore, a different approach will be used in 2005 to ensure the best representative coverage of various plant species of interest.

For 2005, the number of samples will be based more on habitat type than on landform. ABR, Inc., has compiled habitat information, and a total of seven broad habitat types have been identified. The seven terrestrial habitat types identified at the mine site by ABR are listed below, along with the number of plant sampling locations from 2004 in parentheses:

- Alpine rock and dwarf scrub (AS; 0)
- Lowland low and tall alder/willow scrub (LS; 0)
- Lowland wet graminoid, moss meadow (LM; 0)
- Riverine willow scrub (RS; 1)
- Subalpine dwarf, low, and tall scrub (SS; 8)
- Upland dwarf scrub, lichen flats (UF; 5)
- Upland dwarf, low, and tall scrub (US; 4).

Based on research and reconnaissance done during the 2004 sampling season, the areal extent of the seven habitat types will be considered in light of the landforms recognized in 2004, and the identification of grids used as specific sampling locations will be modified appropriately. In 2004, a total of 18 plant sampling locations were distributed across four of these habitat types, and no samples were collected in three habitat types. One to seven species of plants were sampled at a given location in 2004. These habitats have been overlain on the project map to compile estimates of their relative distribution and the total number of soil and plant samples collected in 2004 from each habitat.

The numbers of soil and vegetation samples are presented by habitat type in Table 7-2. Locations of the soil and vegetation sampling sites are shown on Figure 7-2. The values in parentheses in the table represent the targeted number of samples for each sampling event in 2005. SLR expects that approximately the same number of total soil samples will be collected as in 2004, but at least some of the sample locations will differ. Where possible, the vegetative sampling locations used in 2004 will also be sampled in 2005 to provide an indication of annual variability in trace-element concentrations in vegetation. For some habitats (e.g., UF), fewer plant samples will be collected than in 2004. For habitats where additional sample locations are needed (e.g., AS), grid locations will be randomly selected until an appropriate number containing the target habitat types are identified. Soil will also be collected from the locations where plants will be sampled. For habitats where fewer soil samples are planned for collection in 2005 (e.g., SS), locations where no plants will be sampled will be preferentially removed from the sampling program using a randomized approach. It is expected that a single grid section will be identified for soil and plant sampling in each of the LS and RS habitat types, and two grid sections will be identified for sampling in each of the AS and LM habitats.

TABLE 7-2
2004 and Proposed 2005 Numbers[1] of Samples for Soil and Vegetation by Habitat Type

Habitat/Medium	SS	UF	US	AS	LM	RS	LS	Total
Estimated Physiographic Distribution								
(qualitative estimate)	35%	25%	25%	5%	5%	4%	1%	100%
Number of Soil Samples								
Surface-soil Samples	35 (28)	11 (20)	29 (20)	1 (4)	2 (4)	2 (3)	0 (1)	80 (80)
Subsurface-soil Samples	2 (2)	1 (2)	5 (2)	0 (0)	0 (1)	1 (1)	0 (0)	9 (8)
							Total Soil	89 (88)
Number of Vegetation Samples[2]								
Non-woody Vegetation	26 (26)	25 (19)	17 (19)	0 (4)	0 (4)	6 (3)	0 (1)	74 (78)
Fruits and Berries[3]	4 (6)	4 (5)	3 (5)	0 (1)	0 (1)	1 (1)	0 (1)	12 (20)
							Total Plant	86 (98)

1. Values in parentheses are number of samples targeted for collection during each event in 2005.
2. Each species collected from a given location is counted as a separate sample (excluding duplicates).
3. August sampling event only.

Sampling for soil and vegetation will occur in two events in 2005: one in mid-July and one in late August. Early browse is not typically available at the mine site until mid-summer. Samples will be collected from the same sampling locations in both July and August to enable evaluation of seasonal variation of trace-element concentrations. Wherever possible, soil and vegetation samples will be co-located.

The purpose of two separate vegetation sampling events is to address the different browse available at different times during the summer months, as well as the different types of receptors that may ingest plant material. In July at the mine site, willow shrubs begin to flower, and these flowers and new growth provide a food source for caribou. Although it is likely that caribou will move during the season and possibly frequent different areas from year to year, data indicate that, if they appear at the mine site at all, they are most likely to be abundant in early July. Therefore, July is the most appropriate time to collect such samples. Also, small mammals will eat primarily new vegetative growth, and these animals provide part of the food base for wolves and brown bears. Therefore, collection and analysis of this forage material will provide an indication of the baseline levels of trace elements in the diet of ecological receptors within the area of the mine site.

By late August, fruits have developed on plants, and these berries serve as a food source both for brown bears and for subsistence use by humans. Therefore, it is important to collect samples at this time, since elemental uptake into berries differs from that for new growth. As a result, the dietary concentrations of trace elements in edible plant parts is likely different between the two time periods. Samples collected during the latter event can also be used to evaluate annual variability of trace elements, since vegetation samples were collected in late August and early September of 2004.

Portions of some plants are used for medicinal purposes by humans (e.g., fireweed leaves can be boiled and used for asthma and coughs, while crowberries are used as a remedy for stomach ache or diarrhea).

Therefore, similar to 2004, these plants have been included as target species for collection in both sampling events in 2005.

Before soil and vegetation sampling begins, general sample locations—both identified in 2004 that will be resampled in 2005 or newly selected locations from the random grid system—will be translated into longitude/latitude coordinates and transferred to a navigational global positioning system (GPS) on-board the helicopter being used during the study. This GPS data will be recorded in a format compatible with the existing geographical information system. The field team will use the helicopter to locate each section, where up to three sample locations will be staked and marked. For locations sampled in 2004, the same coordinates will be marked and sampled in 2005 to allow direct comparison of annual variability.

Collection of Soil Samples. Surface-soil samples will be collected to a depth of 0.5 feet using hand tools such as stainless steel, aluminum, or disposable polyethylene shovels or trowels. Disposable polyethylene equipment will be preferentially used to reduce the potential for cross-contamination between samples. 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 and other large particles from the soil samples during collection.

Consistent with the approach used in 2004, at about 10 percent of the surface-soil locations, samples will be collected from the deeper 0.5- to 1.5-foot interval. The number of deeper samples to be collected within a given habitat will be based on the areal extent of each habitat type, as shown in Table 7-2. Subsurface-soil samples will be collected using methods consistent with the approach used in 2004 and following requirements set forth in the project QAPP (NDM, 2005).

Collection of Terrestrial Vegetation Samples. Sampling for vegetation will occur in two events in July and late August 2005, concurrent with soil sampling. At the mine site, plant uptake of trace elements is the mechanism of most interest to the characterization program for trace elements in vegetation. Non-woody material will be collected from the plants to ensure 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). Vegetation samples will always be collected from the same locations as soil samples.

Each sample will be a composite from at least three plants within a taxonomic group (genus or species) previously identified at the mine site in the 2004 surveys. The particular species sampled will be based on overall dominance; bio-uptake potential; and use as wildlife forage or subsistence or medicinal use. Where possible, the same species collected in 2004 will also be collected in 2005 to enable an evaluation of annual elemental variability within a species. In 2004, the following six major taxa were sampled: forbs, grasses/sedges, lichens, mosses, shrubs, and trees. Few trees were present at the mine site. Primary species sampled in 2004 included fireweed (representing forbs), various species of sedges, caribou moss (representing lichens), green terrestrial moss (representing mosses), and bog blueberry (representing shrubs). Willows would be sampled where possible as representative of tree species.

Aquatic Vegetation. Aquatic vegetation associated with lakes and ponds in the mine site area will also be sampled in 2005. Aquatic vegetation is used for dietary consumption by moose and human subsistence use. This represents a new sampling medium for 2005. Aquatic vegetation sampling is planned for late August or early September 2005, concurrently with collection of soil and terrestrial vegetation and as close as possible to HDR's late-season sediment and surface-water sampling to maximize the value of the

resulting data. Aquatic vegetation will be collected at the same waterbodies as the sediment and surface-water sampling whenever practical.

Collection 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 (e.g., *Calthra palustra*); therefore, roots and tubers of aquatic plants will be collected where feasible. Vegetative portions above the water line will also be collected, but will be kept separate from roots and tubers. Different tools than those used for terrestrial plant collection may be necessary to clip and collect aquatic vegetation, depending on its location (e.g., edge of lake versus deeper areas) and type of plant (e.g., grasses would need to be clipped at the sediment surface, while flowering plants can be clipped above the water surface, if sufficient mass is available).

Sampling of Stream, Lake, and Seep Sediments

Sediment from seeps, lakes/ponds, and rivers/streams will be sampled by HDR. The sampling strategy for sediments will follow a slightly different format given that the matrix is closely related to water quality.

Stream and Seep Sediments. The frequency of stream-sediment sampling is different than lake/pond sediment sampling due to the dynamic changes expected from variation in stream flow. Stream-sediment sampling will be carried out in close coordination with work related to surface-water hydrology and surface-water quality (Chapters 4 and 6, respectively). Stream-sediment sampling will occur three times in 2005 to encompass the greatest variation in hydrologic conditions (e.g., flows vary due to breakup and storm events). The 2005 sampling events for stream sediments will occur in June, July, and September to represent spring breakup, summer, and autumn flows. Stream-sediment samples will be collected at the same times and locations as surface-water-quality samples (Chapter 6). The 16 specific stream-sediment sampling locations sampled in 2004, which are also planned for sampling in 2005, are identified in Table 7-3. The locations of the surface-water monitoring stations that will also be used for stream-sediment sampling are presented in Chapter 4, Figures 4-3 through 4-6.

TABLE 7-3
Stream-sediment Sampling Locations

Stream	Identification Number for Monitoring Sites
South Fork Koktuli River	SK100A, SK100B, SK100C, SK100F, SK100G, SK119A
North Fork Koktuli River	NK100A ,NK100B, NK100C, NK119A
Kaskanak Creek	KC100A
Upper Talarik Creek	UT100B, UT100C, UT100D, UT100E, UT119A

Sediment sampling sites are co-located with fish, macroinvertebrate, and water-quality sampling sites.

Stream-sediment samples will be composited from three locations across the channel at each sample site (as was done in 2004). For two of the streams, discrete samples also will be collected from each of the sample locations used for compositing. The discrete samples will be analyzed in parallel with the composites to evaluate cross-channel variations in metals concentrations in sediment. If significant or consistent variation in these discrete samples is indicated, the sampling protocol will be reevaluated. The focus of the stream-sediment sampling is those sediments that are exposed to the water column and are

expected to be moved on an annual basis, as well as sediments that are not available for resuspension and represent long-term stable sediments. Sampling locations at the two streams where discrete samples will be collected will focus on these different types of sediments.

Sediment samples also will be collected from up to 10 seep locations in July and October. Sediment samples will be collected at a subset of the seeps where water-quality samples are collected (Chapter 6).

Lake Sediments. Sediment will be collected from a total of six lakes in July. Samples will be collected from the following lakes:

- Frying Pan Lake and Big Wiggly Lake.
- Two new lake sites, one south of the mine site area and one (Black Lake) to the north, co-located with proposed fish-tissue monitoring sites. Final locations are to be determined as described in Chapter 11, Fish and Aquatic Resources.
- Two lake sites considered prime moose pond habitat and co-located with aquatic vegetation sampling sites. Final locations are to be determined.

Lake and tundra pond sediment samples will be collected from a boat. Since wind-induced sediment re-suspension and focusing is common in exposed lakes and ponds, and has been observed in the area, samples will be collected on the leeward side of shallow ponds or the deepest area of deeper ponds (greater than 4 to 15 feet, depending on fetch). Samples will be collected from the top 0.5 feet of sediment by using Lexan tubes, Ponar dredge, or Eckman dredge (depending on field conditions). The tundra pond and lake-sediment sampling will be coordinated with the aquatic-resources biological program.

Sampling for tundra lake/pond sediments will occur concurrent with sampling for the road and port areas if possible.

Fish-tissue Sampling

A series of water-quality and hydrology monitoring stations have been established within and adjacent to the mine area for determination of baseline conditions and subsequent long-term monitoring. A subset of these stations was selected for biological monitoring in addition to the water studies. Biological monitoring in 2004 included trace element analysis of fish tissues. Fish-tissue samples will be collected from 16 streams and four lakes in the mine area. Details of the fish-tissue sampling program are discussed in Chapter 11, Fish and Aquatic Resources.

Sample Handling and Chemical Analysis

Sampling-handling procedures—including packing, chain-of-custody, and shipping—will follow the guidelines provided in the FSPs for naturally occurring constituents (SLR, in press), sediment (HDR, in press[b]), and fish and aquatic resources (HDR, in press[a]), as well as those in the 2005 QAPP (NDM, 2005).

All surface-soil samples will be submitted for analysis of trace elements, anions, ammonia, and total cyanide as outlined in the FSP (SLR, in press) and the QAPP. At about 5 percent of the soil sampling locations, surface soil will be additionally analyzed for TOC and TPH (Method AK102/103). This

biogenic "fingerprinting" will provide information for use in calculating more realistic alternative cleanup levels (18 AAC 75.341) that can be applied during cleanup in the event of petroleum spills caused by mining operations. Appropriate quality assurance/quality control (QA/QC) samples will be collected and analyzed.

All terrestrial vegetation samples will be submitted for analysis of trace elements, ammonia, and total cyanide as outlined in the FSP (SLR, in press) and the QAPP. Appropriate field QA/QC samples will be collected and analyzed.

All aquatic vegetation samples will be submitted for analysis of trace elements, ammonia, and total cyanide as outlined in the FSP (SLR, in press) and the QAPP. Appropriate field QA/QC samples will be collected and analyzed.

All sediment samples will be submitted for analysis of trace elements, anions, ammonia, and total cyanide as outlined in the surface-water/sediment FSP (HDR, in press[b]) the QAPP. The laboratory will sieve the sediment samples and conduct analysis on the fraction less than 2 millimeters.

Fish tissues will be analyzed for a subset of trace elements, as outlined in the QAPP. Based on a comparison of total mercury and methyl-mercury in fish muscle and liver tissues collected in 2004, approximately 90 percent of the mercury in both types of fish tissue is in the form of methyl-mercury. Therefore, in 2005 mercury analyses will be limited to total mercury in muscle tissue. Appropriate field QA/QC samples will be collected and analyzed.

Analytical methods are discussed in the applicable FSPs and in the QAPP.

7.1.2.3 Major Activities

Major activities in 2005 are described below:

- To ensure clear direction for field sampling and adequate QA, FSPs will be prepared to be followed in the field by SLR, BEESC, and HDR personnel at the mine-site and the road/port study areas to ensure consistency across the sampling program.
- A data review will be conducted to research, compile, document, and review existing data including past soil and vegetation studies, aerial photography, topographic maps, and other documents to determine target sample areas. Conditions at these locations will be visually verified in the field prior to establishing the sample points.
- Samples for each media will be collected from the mine site as described above.
- Field and laboratory data will be analyzed and the results reported.

7.1.3 Deliverables

SLR senior risk assessor, Dr. Mark Stelljes, will evaluate the 2004 project data and the 2005 study plans to provide project-level advice, and will work with NDM throughout 2005 to provide advice and consultation regarding the baseline environmental studies in general and naturally occurring constituents in particular.

The following project deliverables will be prepared during the trace elements studies to be conducted for the mine site in 2005:

- 2004 Field Season Progress Report.
- Information to be Included in the Initial Environmental Evaluation.

7.2 Road/Port Site

7.2.1 Objectives of Study

The objective of the 2005 study for the road/port is to establish the baseline concentrations of naturally occurring constituents in fish and in stream and lake sediments within the road corridor and at the proposed port facility. Area fish and sediment types and chemical characteristics established in the baseline studies will be used primarily to evaluate the potential ecological effects of fugitive dust from the road and other media-based impacts at the port facility, once they are constructed and in use. Trace elements are often detected at higher concentrations in sediments than in the overlying surface water and often relate much closer to fish-tissue data than water-quality results.

7.2.2 Proposed Study Plan

7.2.2.1 Study Area/Scope

The study area will include the preferred road corridor, as identified by the Alaska Department of Transportation and Public Facilities, between the mine site and Cook Inlet and will also include the area surrounding the proposed port site as shown in Figure 7-3. The “road corridor” is defined to be a one-mile-wide band centered along the defined alignment.

Sampling for 2005 is intended to continue to characterize trace element concentrations in fish and sediments along the road corridor and at the port site to establish current baseline conditions for the environmental impact statement and for evaluation of potential future ecological concerns associated with road-dust migration. Plants and soil will not be sampled in 2005 since data from 2004 provide an indication of baseline conditions for these media. Additionally, until the final alignment of the road and final location of the port are identified, additional soil and plant sampling along the proposed corridor is not appropriate. However, sediment and fish-tissue sampling will be conducted in 2005 because the final road alignment must cross these streams.

7.2.2.2 Methods/Approach

Sampling activities in 2005 are intended to characterize the entire length of the road corridor and to be representative of the sediments and fish present along the route and at the port site. In 2004, soil and vegetation samples were collected at regular intervals along the road corridor; one sample for every 4 miles. Sediment samples were collected from 15 streams at the same locations as surface water-quality samples and in five selected tundra ponds.

Activities planned for the road corridor for 2005 include collection of sediments from streams and tundra ponds and fish-tissue sampling. All activities will be coordinated with SLR to ensure consistency between methods used in the road corridor and those used at the mine site. Sampling procedures will be followed to ensure continuity with sampling efforts completed in 2004 so that data for both seasons will be comparable.

Sediment Samples

Stream sediments will be collected from eight streams (Figure 7-3) where water-quality sampling will be conducted. These locations will represent a subset of those sampled in 2004. As was done in 2004, stream-sediment samples will be composited from three locations across the channel at each sample site. For one stream, discrete samples also will be collected from each of the sample locations used for compositing. The discrete samples will be analyzed in parallel with the composite to evaluate cross-channel variations in sediment metals concentrations. Based on these analyses, the sampling protocol may be reevaluated, as discussed in Section 7.1.2.2 for the mine area.

The five tundra ponds sampled in 2004 will be revisited and sampled in 2005 to provide baseline characteristics of sediments (Figure 7-3). A predominant wind direction and resulting sediment deposition was observed at the tundra ponds sampled along the road. Samples will be collected from the leeward side of the pond in the upper 5 inches of sediment. Sediment samples will be collected following the same procedures as used for sediment sampling in the mine area.

Stream and pond sediments will be collected in conjunction with the May, July, and September water-quality sampling events. Sediment samples will be analyzed for inorganic compounds and trace elements as shown in Table 7-4. Analytical methods are described in the surface water/sediment FSP for the road/port (BEESC, in press) and in the QAPP (NDM, 2005)

TABLE 7-4
Road/Port Stream and Pond Sediments Sample Analysis

Analyte
Total Hg
Total Metals
Total Cyanide
Chloride
Fluoride
Sulfate
Ammonia as N

Fish-tissue Sampling

HDR will collect fish-tissue samples from five streams along the road corridor. Fish-tissue sampling will occur once during the month of August in coordination with tissue sampling at the mine site. Details of the sampling methods and analyses are described in Chapter 11, Fish and Aquatic Resources.

7.2.2.3 Major Activities

Major activities planned for 2005 are as follows:

- Data Review—research, compile, document, and review existing data including past soil and vegetation studies, aerial photography, topographic maps, and other documents to determine target sample areas. Conditions at these locations will be visually verified in the field prior to establishing sample points.
- Collect samples for each media from the road corridor and port facility as described above.
- Analyze field and laboratory data.
- Report results.

7.2.3 Deliverables

The following deliverables are planned for 2005:

- 2004 Field Season Progress Report.
- Initial Environmental Evaluation.

7.3 References

Bristol Environmental and Engineering Services Corporation (BEESC). In press. Surface-water and Sediment Studies, Road/Port, 2005 Field Sampling Plan. Prepared for Northern Dynasty Mines Inc.

HDR Alaska, Inc. (HDR). In press(a). Fish and Aquatic Resources, 2005 Field Sampling Plan. Prepared for Northern Dynasty Mines Inc.

———. In press(b). Surface-water Quality, Hydrology, and Sediment—Mine Area; 2005 Field Sampling Plan. Prepared for Northern Dynasty Mines Inc.

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

SLR Alaska (SLR). In press. Environmental Baseline Studies for Naturally Occurring Constituents, 2005 Field Sampling Plan. Prepared for Northern Dynasty Mines Inc.

FIGURES

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

59°48'0"N

Groundhog Mountain

Groundhog Mtn

Groundhog Creek

Sharp Mtn

Petrof Falls

Pete Andrews

Upper

R. 35 W.

R. 34 W.

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

Pebble Project

NORTHERN DYNASTY MINES INC.

Pebble Project
2005 Study Plan

Naturally Occurring Constituents in Surface Soil, Sediment, Vegetation and Fish
Figure 7- 1.

Legend

- Mine Area Study Boundary
- Mineral Deposit

Privileged and Confidential

Miles
0 1 2 3 4

Kilometers
0 1 2 3 4 5 6

Scale 1:155,000

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

File: RDI_11X17Sections_topo_bndV3.mxd	Date: August 25, 2005
Version: 3	Author: RDI

1,400,000

2,150,000

236221
236272 236273
236271
235282
235271
235281 236281
236352 236353
236351
235361
335051
336012 336013
336011
335021
336042
336043
336041
335031 335032
335092 335093
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335162 335163
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335191 335192
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336211 336212
335201
335231 335232
335283 335284
336281 336282
336261
335301
335302
335261
336341 336342
336361 336362
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435061 435062
435161 435162
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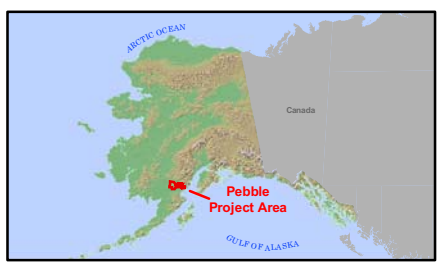
536051

Privileged and Confidential



N

Miles
0 0.8 1.6 2.4 3.2

Kilometers
0 0.9 1.8 2.7 3.6

Scale 1:85,000

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

Legend

Sample location type

- Soil
- Aquatic Vegetation
- Soil and Terrestrial Vegetation

Pebble Project
NORTHERN DYNASTY MINES INC.

Pebble Project
2005 Study Plan
Natural Occuring Constituents
Sampling Locations for Soil and
Vegetation, Mine Area
Figure 7-2

File: RDI_SLR_trace7_2_11x17P_v2.mxd	Date: Sept. 13, 2005
Version: 2	Author: RDI

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.

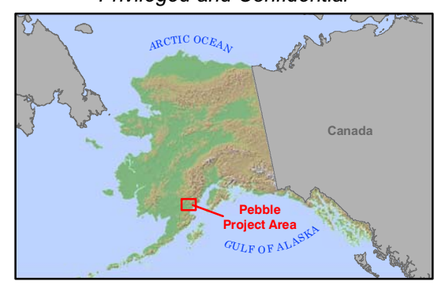
Pebble Project

Trace Element Sampling
Figure 7-3

Legend

- Towns
- 2005 Surface Water Quality and Sediment Sampling Locations
- Tundra Ponds
- Port Site 1
- Preferred DOT&PF Road Corridor
- 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_20050804.mxd	Date: August 4, 2005
Version: 1	Author: BEESC-ME