Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2005 STUDY PLANS

CHAPTER 11. FISH & AQUATIC HABITAT

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
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
HGM	hydrogeomorphic
IEE	Initial Environmental Evaluation
IM	initial monitoring station
LCNPP	Lake Clark National Park and Preserve
LDN	Land Design North
m	meter
MCHTWG	Mulchatna Caribou Herd Technical Working Group
MDC	mine development concept
mg/L	milligrams per liter
ML/ARD	metal leaching/acid rock leaching
mm	millimeters
MRL	method reporting limit
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
PAH	polyaromatic hydrocarbon
PCBs	polychlorinated biphenyls
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
RBP	rapid bioassessment protocol
SHPO	State Historic Preservation Officer
SOP	standard operating procedure
SRB&A	Stephen R. Braund & Associates
SVOC	semi-volatile organic compound
SWE	snow/water equivalent

TIN	triangulated irregular network
TPH	total petroleum hydrocarbons
USACE	United States Army Corp of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	volatile organic compound
WMC	Water Management Consultants
WMP	water monitoring plan
WQ	water quality

11. FISH AND AQUATIC HABITAT

11.1 Fisheries Studies for the Mine Site

11.1.1 Objectives of Study

Year 2005 aquatic resources studies will build on work completed during the 2004 field season. Some ongoing programs will be continued, and new studies will be initiated where necessary. The objectives of the 2005 work are as follows:

- Complete documentation of the distribution and relative abundance of aquatic resources in the project study area.
- Provide information required for assessment of project-induced environmental changes.
- Assist in project planning to address the effects of any potential environmental changes identified.
- Acquire predevelopment baseline data for post-development studies and monitoring.

Emphasis will be on filling data gaps identified during the 2004 season and refining study programs to increase confidence in the environmental database.

11.1.2 Proposed Study Plan

11.1.2.1 Study Area

The study area at the mine consists of an area in a 10-mile radius around the ore body (Figure 11-1). Some specific study programs, as described below, will extend beyond this boundary to include the full length of the north and south forks of Koktuli River, a portion of the main stem of Koktuli River, and most or all of Upper Talarik Creek (continued access limitations to the lower reaches may preclude investigations in this area).

11.1.2.2 Major Tasks

Task 1: Ongoing Review of Existing Information

Existing information relative to mine-area aquatic habitats will continue to be gathered and reviewed. The mine-area information review will include all aspects of aquatic resources within the Upper Talarik Creek and Koktuli River drainages, including portions of drainages downstream from potential development areas so that mine-area resources can be placed in the context of overall watersheds. Information sources will include scientific literature, gray literature, resource-agency files, interviews with agency personnel, and interviews with local residents and sport-fishing guides. A bibliography of information sources will be included as part of the environmental baseline document.

Task 2: Late Winter and Spring Field Investigations—Assessment of Overwintering Habitat and Spawning Surveys for Arctic Grayling and Rainbow Trout

Overwintering Habitat Assessment. During late winter 2004, minnow traps were set in 48 selected locations for stream sampling (primarily in open water) throughout the three major drainages. The overall catch rates were low and consisted mainly of juvenile Dolly Varden and coho salmon. Winter sampling will be conducted again during the 2005 field season, with emphasis on sampling a greater variety of habitats and improving sampling efficiency using several different sampling methods. Sampling will take place in late March to early April. Overwintering study sites will be selected based on several indicators of possible wintering activity, as follows:

- Spring and seepage areas, as determined by the presence of open water or thin ice.
- Areas where juvenile salmon and Dolly Varden were especially abundant in early summer 2004.
- Known deep-pool areas that may provide winter refugia.

Sampling techniques will depend on the presence or absence of ice and on ice thickness, as well as the depth and width of the sample area. Sampling methods will include the following:

- Open-water areas will be sampled using a combination of baited minnow traps and electroshocking (Smith-Root Model LR-24 backpack shocker). In small, shallow streams with extensive open water, electroshocking will be the primary method. Beach seines may also be employed to sample pool areas, if appropriate. Minnow-trap set times will vary from a few hours to overnight, depending on the species present and habitat characteristics. Traps will be baited with preserved salmon eggs that have been disinfected with Betadine solution.
- In areas of ice cover, minnow traps will be the primary sample method. Traps will be set through holes in the ice. In most cases, traps will be set overnight.

A small, unnamed lake in the South Fork of Koktuli River drainage (Figure 11-1) will also be investigated during the winter field period. Grayling were abundant in this lake during summer 2004. The lake will be investigated further in March 2005 to determine whether it supports a resident, year-round grayling population. An underwater video camera will be used to record selected under-ice areas of the lake. Bait bottles filled with salmon eggs will be lowered through holes in the ice to help attract fish to the camera vicinity. If fish are observed, a videotape recording will be made to confirm fish presence. Minnow traps set through the ice and/or hook-and-line ice fishing may also be employed as supplemental methods.

All sampled fish will be identified as to species, measured, and returned alive to the point of capture.

Arctic Grayling Spawning Survey. Air and ground surveys conducted in spring 2004 within the headwaters of the South Fork of Koktuli River drainage (streams flowing into Frying Pan Lake) were not successful in locating arctic grayling spawning areas. However, electrofishing conducted in summer 2004 found age 0 grayling immediately below Frying Pan Lake, which suggests that grayling spawning occurred in upper portions of the South Fork of Koktuli River watershed. The 2005 spring spawning survey efforts will emphasize location of arctic grayling spawning areas and attempt to identify resident and/or migratory spawning aggregates. Discussions with the Alaska Department of Fish and Game (ADF&G) and the Alaska Department of Natural Resources (ADNR) indicate that spawning aggregates of arctic grayling could originate from areas downstream of the inner mine area or from resident populations within the proposed inner mine area.

To help determine grayling spawning periodicity before field efforts, all available temperature data collected in 2004 will be reviewed. According to available literature from the Red Dog and Fort Knox mines, active spawning by large numbers of fish occurs when water temperatures reach 4°C (McLean, 2004). Arctic grayling are known to spawn immediately after ice-out and remain near spawning sites from four to 18 days (McLean, 2004).

Radio tags will be used to locate grayling spawning areas, to gather information on migratory patterns, and to try and determine if spawning aggregates are composed of resident and/or migratory populations. Transmitters will be implanted in May and programmed to remain active until early August, at which time the tags will turn off; they will then turn back on again in mid-April 2006. Telemetry surveys will begin again in mid-April 2006; aerial surveys will be conducted using a helicopter or small fixed-wing aircraft to locate radio-tagged fish. Radio-tagged fish will be tracked to determine migratory patterns to spring spawning areas. In 2006, telemetry surveys will be conducted until the end of the tag life, which is estimated to occur in mid-August. Global positioning system (GPS) coordinates for all radio-tracked fish positions will be recorded, and movement maps will be prepared for each successfully tracked fish.

Arctic grayling will be captured using fike-net traps, electrofishing, or angling as early in the breakup period as possible. Capture locations will, of necessity, emphasize open-water areas, but may also include capture through the ice of ponds, lakes, or stream pools. Captured fish will be measured to fork length and assessed for sexual maturity. As many as 30 fish will have radio transmitters surgically implanted. An ADF&G biologist will spend two days with the radio-tag team to provide technical assistance and training during the radio tagging effort.

The radio tags used will be Lotek Model MCFT-3BM. The radio tags have a weight of seven grams in air. Using the two percent rule (Winter, 1983) this corresponds to a minimum tag weight of 350 grams (i.e., seven grams equals two percent of 350 grams) and a minimum tag length of 320 millimeters (Fish, 1998). Length-to-weight ratios will be verified in the field prior to tagging, and if necessary, minimum tag lengths will be adjusted in the field to ensure compliance with the two percent rule.

Radio tags will be programmed to be on for 14 weeks immediately after implantation, then off for 35 weeks, and back on for an additional 14-week period beginning in April 2006. This schedule will conserve tag battery life and will allow potential tracking during the spawning period in both 2005 and 2006. Tag frequencies have been coordinated with resource agencies to avoid duplication and confusion with other research efforts. A two-person survey crew will use telemetry equipment to track radio-tagged fish using a combination of helicopter and foot travel.

Telemetry surveys will be conducted in spring 2006 to locate grayling spawning areas. Once located, spawning areas will be assessed using visual observation, snorkeling, and/or electrofishing (where appropriate) to confirm grayling presence, numbers, and likelihood of spawning. Habitat features (channel type, length, width, depth, substrate, and water temperature) of probable spawning areas will be recorded. In addition, GPS locations will be recorded, and photographs will be taken. The frequency of tracking during the probable spawning period will depend on fish movements and tracking success, but will likely be two to three times per week.

Task 3: Summer Sampling Program—Delineation of Habitat Types and Fish Use

Habitat Mapping. In 2004, most stream segments within probable areas of direct effect from proposed mine facilities were investigated on foot, and stream habitats were mapped in detail. The 2004 habitat-mapping effort provided habitat descriptions for portions of Upper Talarik Creek adjacent to the mine area. A review of this information in conjunction with proposed mine development plans suggested that additional information from upstream portions of the creek would be desirable. The 2005 field efforts will focus on wadeable sections of the northern reaches of Upper Talarik Creek.

These areas will be surveyed on foot using the same stream-habitat survey methods employed in 2004, which were adapted from the *Aquatic Habitat Management Handbook* developed by the U.S. Forest Service (2001). This method establishes standard quantitative methods for aquatic ecologists conducting fish and aquatic stream-habitat surveys in coastal Alaska. Method protocols are described in detail in the above handbook with level of detail (tier level) depending on the specific need. A modified Tier II survey that includes measurement and/or description of stream length, macrohabitat distribution, macrohabitat surface area, channel type, presence of bank cover, and presence of woody debris is proposed for the mine area. Cross-sectional geometry and flow will be measured at selected locations along each stream reach. It should be noted that stream channels will also be classified to the alpha level using the Rosgen and Hilton (1996) channel-type criteria.

In addition to the above field investigation and to further help document baseline aquatic-habitat conditions, aerial habitat-mapping information collected in 2004 will be processed. The 2004 data consist of geo-referenced videography recorded from a low-flying helicopter for all major drainages in the project area. The images will be played back and processed on a computer, and a map of stream habitats will be developed from the combined photographic and video images. Ground-truthing may be required in selected areas. Stream maps based on a geographic information system (GIS) will provide a detailed representation of stream configuration along with a delineation of macrohabitat types (pools, riffles, runs).

Quantitative Sampling of Stream Fish. During the 2004 field season, quantitative fish sampling was conducted in areas where detailed habitat mapping had been completed. This effort will be continued in 2005 to include newly mapped areas as described above (upper reaches of Upper Talarik Creek) or where other data gaps from the 2004 sampling effort have been identified.

In mapped streams, abundance or density of fish will be estimated for each habitat type, following the method of Hankin and Reeves (1988). In this method, a subsample of habitat units (such as pools, riffles, and runs) is selected, and fish number and density per unit surface area are estimated within each unit. Average density for each unit type is calculated, and overall fish abundance within the waterbody is estimated by extrapolating over the full length using habitat areas established by the habitat-mapping program. In some small streams with uniform habitat distribution, it may be more appropriate to estimate fish abundance within representative reaches rather than by habitat unit.

Fish-density estimation methods in streams will depend on stream characteristics and may include electroshocker total count, electroshocker removal, snorkel counts, or minnow-trap removal. For the removal estimates, each designated sample unit will be sampled a minimum of three times, with all captured fish displaced outside the sample segment. The number of fish caught during each sample event will be graphed as a function of accumulated prior catch. A regression will be calculated for the data, and the x-intercept of the negatively sloping regression line will provide an estimate of the total number of fish in the sample unit. All fish caught during the sample efforts will be identified as to species, measured, and returned alive at or near the point of capture.

Another specific information gap identified following review of the 2004 study program concerns a segment of the South Fork of Koktuli River downstream from Frying Pan Lake (Figure 11-1). This reach was not sampled in 2004 because it went dry to the point where it contained only shallow pools of standing water. This section of stream has been known to have intermittent flow or to dry completely during years of low precipitation (Buell, 1994) and possibly in most years. This reach also dries in some and possibly most winters. However, observations in 2004 indicate that this reach does contain fish during periods in the spring when it is flowing. Therefore, it is reasonable to believe that the intermittent or drying reach of the South Fork of Koktuli River serves a fish-habitat function, although it may be seasonally influenced by reduced or no flow.

The intermittent reach of the South Fork of Koktuli River will be sampled for fish abundance and distribution once while it is flowing continuously (moderate flow conditions; no dry areas) at less than bank-full stage when the stream is wadeable, and again under reduced or intermittent flow conditions. The same methods described above (Hankin and Reeves, 1988) will be used during each of the two sampling events. It should be noted that habitat mapping was completed within the intermittent reach during 2004. A minimum of five 100-meter-long sample sites will be flagged and their locations recorded on a GPS. Fish abundance in each sample site will be estimated, and distribution during each flow condition will be documented.

Quantitative Sampling of Lake Fish. A Peterson mark-and-recapture study was conducted in Frying Pan Lake in 2004 to approximate the abundance of northern pike. The sampling results were analyzed using the Chapman estimator. During the mark period, 46 northern pike were captured, marked, and released alive. During the recapture period, a total of 61 fish were examined for marks, 10 of which (recaptures) were tagged. Northern-pike abundance was estimated to be 264 fish, with a calculated variance (Nv) of 69. This calculated abundance equates to a density of 2.0 fish per hectare. The population-abundance estimate variance is high because of the low sample size. The low sample size is likely a result of conducting the mark-recapture too late in the summer (July) and the associated higher water temperatures. Agency comments have indicated that the above estimate was adequate. An additional recapture event for northern pike in Frying Pan Lake may be conducted on an opportunistic basis.

Another area for which additional study is needed is a group of small lakes and beaver ponds southwest of Frying Pan Lake and three lakes directly north of Frying Pan Lake (Figure 11-1). These aquatic habitats may be within the area of direct disturbance for the proposed project, and additional information on fish use is desirable. Fish sampling methods will employ both gill nets and minnow traps which will be fished at a standardized level of effort for each lake. If fish are present, catch per unit effort will be calculated and a relative abundance index will be determined for each lake.

In addition to biological information, depth profiles will be determined for selected lakes, including Frying Pan Lake and some larger lakes in the South Fork of Koktuli River basin. Lakes to be selected for bathymetric study will be determined based on their value to fish and their relationship to project development. Lake bathymetry will be determined using a tag line or electronic depth finder. A minimum of two transects running in a north/south and east/west pattern will be recorded; if possible, transects will be established so that they intersect at what is believed to be the deepest part of each lake sampled.

Qualitative Sampling. During 2004, 42 locations within the project study area, but outside the probable zone of direct effect, were sampled using qualitative methods to identify general patterns of fish use and habitat value. This program will continue in 2005, emphasizing specific areas where additional information is perceived as being necessary for project planning and assessment of potential changes.

One area that will receive special emphasis is a groundwater upwelling zone in the central portion of the South Fork of Koktuli River (Figure 11-1). This area separates the intermittent-flow zone from the perpetual-flow zone downstream and may represent the upstream limit of salmon spawning in most years. Fish utilization, both spawning and rearing, will be examined in greater detail than in 2004. This stream reach will be sampled and/or observed three times during the open-water season, including during the peak of sockeye salmon spawning. Spawning locations will be noted, with special emphasis on relating spawning areas to upwelling zones.

Other sites that will receive special study in 2005 are the flow-habitat study stations described below under Task 6. Each flow-habitat study site will be sampled for fish presence and life-stage use. A reach of stream approximately 100 meters long encompassing the flow-habitat transect will be sampled for fish presence. Relative-abundance indices will be developed for major mesohabitat types (run, riffle, pool). In areas where removal sampling is not possible, snorkeling techniques will be used. Each observation will take into account the following parameters:

- Species and life stage.
- Number of fish.
- Distance from shore.
- Depth.
- Major mesohabitat type (run, riffle, or pool).
- Other observed characteristics.

The relative-abundance indices will indicate the occupied depth and distance from shore for a species/life-stage pair and can also be stratified to consider river reach. This information can be analyzed with the wetted perimeter relationships to estimate the effect that decreased or increased flow in a reach might have on fish.

Within all of the above areas, a variety of methods will be used to sample fish, depending on the nature of the habitat. Available methods will include backpack electroshocker, minnow traps, snorkeling, seines, and angling. Variable-mesh gill nets may be selectively used in ponds and lakes. All fish captured will be identified, measured, and released at the point of capture. Sample locations will be marked using GPS coordinates.

Task 4: Salmon-Spawning Surveys

Aerial helicopter surveys of the full length of Upper Talarik Creek, North Fork of Koktuli River, and South Fork Koktuli of River were conducted in 2004 for chinook, sockeye, and coho salmon. Aerial surveys for adult salmon will be continued in 2005 during the spawning season to acquire additional information about the distribution and number of spawners. Timing of surveys for the various salmon species (chinook, sockeye, and coho) will be based on experience gained in 2004. Multiple surveys for each species will be conducted to ensure observation of the spawning peak. A minimum of three surveys will be conducted for each species, although Chinook- and sockeye-spawning periods overlap and surveys for these species may be combined. Special effort will be dedicated to determining the upstream limits of spawning in stream headwaters in the project study area. Surveys in 2004 included about one mile of the main stem of Koktuli River below the confluence of the north and south forks. The 2005 survey program will include at least one survey during the peak of the chinook and sockeye salmon runs along the full length of the Koktuli River to its confluence with the Mulchatna River.

Salmon will be counted by species, and GPS waypoints will be entered at each probable spawning location. Live and dead fish will be counted separately. Digital photography may be used as an aid in counting large aggregations of sockeye salmon. Spawning distribution maps will be prepared by overlaying GPS coordinates on digitized maps of the project study area. The surveys will result in estimates of peak abundance rather than actual escapement. Various methods of estimating actual escapement from successive surveys will be investigated and used if applicable.

Task 5: Fish-tissue and Index-species Sampling

A series of water-quality and hydrology stations has been established within and adjacent to the project study area for determination of stream baseline conditions. A subset of these stations has been selected for biological sampling in addition to the water-quality studies (Figure 11-1). Biological sampling in 2004 included trace-metal analysis of fish tissues, fish-abundance index sampling, and macroinvertebrate and periphyton sampling. The macroinvertebrate and periphyton sampling is discussed in Sections 11.3 and 11.4.

Fish-tissue Sampling During the 2004 field season, fish were sampled at 16 stream stations and two lakes for tissue metals analysis. During the 2005 field season, each stream-sampling station will be sampled again for the same species and by the same methods and analyses as in 2004 (Table 11-1). In response to agency comment, two additional lakes will be sampled: one additional lake south of the South Fork of Koktuli River drainage (to be determined) and one additional lake (Black Lake) northwest of the Pebble deposit within the dominant southeasterly wind direction (Figure 11-1). This will provide a basis for detecting potential project-induced changes in these waterbodies. Black Lake is known to contain robust populations of both grayling and humpback whitefish, and may contain northern pike, a target species for trace-element sampling. Candidate lakes south of the South Fork Koktuli have not been sampled for fish presence.

Final selection of additional lakes for fish-tissue sampling will be made pending determination of the presence of target species, especially northern pike. One lake to the north and one lake to the south of the Pebble deposit will be selected if target species are present. If no northern pike are found in candidate lakes, sampling of grayling or whitefish or another species may be conducted, pending discussions with Northern Dynasty Mines Inc. (NDM) and agency representatives.

TABLE 11-1
August Fish-tissue and Index-species Monitoring at Proposed Mine Site

Stream Monitoring

- Targets juvenile salmonids
- 16 stream reaches, 200 meters each
- Habitat description of each monitoring reach
- Standardized level of effort with use of minnow traps
- 10 minnow traps per monitoring reach fished for approximately 24 hours each
- Juvenile fish-tissue analysis (whole-body samples), consisting of 10 discrete samples per site, plus 10% quality control samples.
- Analytical parameters include antimony, arsenic, cadmium, copper, lead, mercury, methyl mercury, nickel, selenium, and silver
- Water-quality measurements—pH, conductivity, alkalinity, temperature, and turbidity—at each monitoring reach

Lake Monitoring

- Targets fish present in 4 lake environments
- Juvenile trapping and angling or gill nets for adult fish
- Juvenile salmonids, northern pike, grayling, and white fish
- Analytical parameters same as for stream monitoring
- Pike analysis conducted on liver and muscle, with field dissection
- Whole-body analysis for white fish and grayling if present in adequate numbers

The number of fish-tissue samples and laboratory analytes associated with the proposed mine site are shown in Table 11-2. At most of the stream stations, fish for the tissue samples will be collected using baited minnow traps in conjunction with the fish-abundance index sampling described below. If insufficient fish are caught in minnow traps, additional fish may be collected by backpack electroshocker.

Processing of fish for tissue samples, subsequent handling, and transport to the analytical laboratory will follow procedures outlined in the quality assurance program plan (QAPP) prepared by NDM (2005). Shaw Environmental Inc. will be responsible for filling out electronic chain-of-custody forms (e-Chain) for fish-tissue samples prior to laboratory transport.

Each fish will be placed into an individual plastic bag and frozen as soon as possible. Collection personnel will use powder-free surgical gloves to handle fish samples. Large fish from lake samples will be placed in clean plastic bags and put on ice immediately after capture. Dissection of liver and muscle tissue 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 washing tools and work surfaces and for preparing quality control (QC) equipment blanks will follow the QAPP (NDM, 2005).

TABLE 11-2
Schedule for Fish-tissue Sampling at Proposed Mine Site

Location	Fish Species	No. of Primary Samples	No. of QC Samples	Total No. of Samples	Analytes
		Stream Sampling			
SK100A	Juvenile salmon	10 (whole body)	Split of Homogenate (1 fish)	11	Antimony, arsenic, cadmium, copper, lead, nickel, selenium, total mercury, methyl mercury, and silver
SK100B	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
SK119A	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
SK100C	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
SK100F	Juvenile northern pike and grayling	20 (whole body)	Same as above	22	Same as above
SK100G	Arctic grayling	10 (whole body)	Same as above	11	Same as above
KC100A	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
NK100A	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
NK100B	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
NK100C	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
NK119A	Dolly Varden	10 (whole body)	Same as above	11	Same as above
UT119A	Dolly Varden	10 (whole body)	Same as above	11	Same as above
UT100B	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
UT100C	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
UT100D	Juvenile salmon	10 (whole body)	Same as above	11	Same as above
UT100E	Dolly Varden	10 (whole body)	Same as above	11	Same as above

Location	Fish Species	No. of Primary Samples	No. of QC Samples	Total No. of Samples	Analytes
Lake Sampling					
Frying Pan Lake	Northern pike	10 fish, 20 samples (10 liver and 10 muscle)	1 fish, 2 samples (1 liver, 1 muscle) (split of homogenate)	22	Same as above
Big Wiggly Lake	Northern pike	10 fish, 20 samples (10 liver and 10 muscle)	1 fish, 2 samples (1 liver, 1 muscle) (split of homogenate)	22	Same as above
Black Lake and 1 lake to be determined	Northern pike (if present)	20 fish, 40 samples (20 liver and 20 muscle)	2 fish, 4 samples (2 liver, 2 muscle (split of homogenate)	44	Same as above
Same 2 lakes as above	Grayling (if present)	10 (whole body)	Split of homogenate (1 fish)	11	Same as above
Same 2 lakes as above	Whitefish (if present)	10 (whole body)	Split of homogenate (1 fish)	11	Same as above
Total Number of Tissue Samples				297	

QC = quality control

Fish-Abundance Index Sampling. Standardized, repeatable fish sampling was initiated in 2004 at 16 stream sample sites. Standard fish sampling targeted juvenile salmonids, if present, and consisted of sampling with the use of 1/4-inch-mesh steel minnow traps baited with salmon eggs. Ten traps were set in a variety of habitat types at each station within a stream reach of 100 to 400 meters. Trap locations were recorded on a GPS unit, marked with stakes, and delineated on sketch maps so that the same trap locations can be used from year to year. Traps were fished for about 24 hours. Captured fish were identified, counted, measured, and released. The exact same procedures will be repeated in 2005. Species to be used as index species at each site were selected in 2004 based on catchability (Table 11-3). The same species will be emphasized in 2005 and future years. Some sites will likely be incorporated in a long-term monitoring program during and following project development.

TABLE 11-3
Fish Index Species (based on 2004 data)

Site	Index Species
North Fork of Koktuli River	
NK100A	Juvenile coho and chinook salmon
NK100B	Juvenile coho and chinook salmon, Dolly Varden
NK100C	Juvenile coho salmon, Dolly Varden , and arctic grayling
NK119A	Mixed-age Dolly Varden
South Fork of Koktuli River	
SK100A	Juvenile coho and chinook salmon
SK100B	Juvenile chinook salmon and Dolly Varden
SK100C	Not sampled in 2004—dry stream
SK100F	Mixed-age arctic grayling
SK100G	Juvenile arctic grayling
SK119A	Juvenile coho salmon and Dolly Varden
Upper Talarik Creek	
UT100B	Juvenile coho salmon
UT100C	Juvenile coho salmon and rainbow trout
UT100D	Juvenile coho salmon and Dolly Varden
UT100E	Mixed-age Dolly Varden
UT119A	Mixed-age Dolly Varden
Kaskanak Creek	
KC100A	Juvenile coho salmon

All index species are juvenile salmon or sub-adult resident fish.

Task 6: Flow-Habitat Study

(to be completed at a later date)

11.2 Fisheries Studies for Access Road, Port Site, and Power-transmission Line

During 2004 field efforts, streams crossed by proposed access-road corridors were investigated to confirm fish presence or non-presence and to identify physical and biological attributes. A suite of information was entered on standard data sheets for each stream investigated. Other streams with only ephemeral flow also were noted. The 2005 field efforts will focus on aquatic habitats not investigated in 2004 and will include the following elements:

- Streams crossed by road corridors that were not investigated during 2005 because of access difficulties (fewer than five streams).
- The Kamishak Bay tributary stream (“Y Valley Creek”) located west of the port site.
- Streams located within the proposed power-transmission corridor on Iniskin Island (pending final alignment determination).

- Juvenile fish-tissue sampling for trace-metal analysis at five locations.
- Aquatic habitats and fish use at potential barge-landing areas on Lake Iliamna and at Williamsport (pending final determination of site[s]).

11.2.1 Objectives of Study

Year 2005 aquatic-resources studies will continue to investigate aquatic habitats associated with proposed road, port, and electrical-transmission corridors. As with the work at the proposed mine site, the objectives of the 2005 work are as follows:

- Complete documentation of the distribution and relative abundance of aquatic resources in the project study area.
- Provide information required for assessment of project-induced environmental changes.
- Assist in project planning to address the effects of any potential environmental changes identified.
- Acquire predevelopment baseline data for post-development studies and monitoring.

11.2.2 Proposed Study Plan

11.2.2.1 Study Areas

The study areas for the road, port, and powerline alternatives are spread over a wide geographical area (Figure 11-2). Listed below are study areas specific to each infrastructure component:

- A 3,000-foot area on either side of the centerline of the access-road corridor (established in 2004 by NDM and the Alaska Department of Transportation and Public Facilities) and the road corridor leading to the proposed docking facility (Figure 11-2).
- A 500-foot area on either side of the centerline of the electrical-transmission corridor that crosses the Iniskin Peninsula, beginning near Chinitna Bay on the north and extending to Iniskin Bay and proposed Port Site 1 in the south (Figure 11-2).
- Anadromous stream No. 248-20-10060 (also known as “Y Valley Creek”) located between Port Sites 1 and 4, extending from the mean high-tide line to a point upstream where fish use no longer occurs, a distance estimated to be about two miles (Figure 11-2).
- As many as three alternative barge-landing areas: two on Lake Iliamna and one at Williamsport (Figure 11-2). Near-shore study areas associated with the barge-landing areas will extend over a 500-foot radius into Lake Iliamna. Onshore study areas will be based on the aquatic habitats present at each proposed barge-landing site and aquatic habitat that could logically be affected by a barge-landing area.

11.2.2.2 Major Tasks

Task 1: Review Existing Information

Existing information relative to the potential study areas listed above will be reviewed. Information sources will include scientific literature, gray literature, resource-agency files, interviews with agency personnel, and information gathered during 2004 specific to the streams. An annotated bibliography will be compiled and included in the environmental baseline document. For Lake Iliamna, known sockeye salmon-spawning sites along the shoreline will be emphasized.

Task 2: Port-site Stream Investigation, and Surveys of Roads and Transmission-line Corridors

Port-site Stream Investigation. The anadromous stream located between Port Sites 1 and 4 (Stream Catalog No. 248-20-10060), also known as “Y Valley Creek,” will be divided into reaches based on gradient and distribution of habitat types. Representative study sites will be established within each separate reach. The length of each study site will be equal to at least 40 channel widths.

Each representative study site will be surveyed on foot with the use of stream habitat survey methods adapted from the *Aquatic Habitat Management Handbook* developed by the U.S. Forest Service (2001). This method establishes standard quantitative methods for aquatic ecologists conducting fish and aquatic stream-habitat surveys in coastal Alaska. Method protocols are described in detail in the above handbook with level of detail (tier level) depending on the specific need. A modified Tier II survey that includes measurement and/or description of stream length, macrohabitat distribution, macrohabitat surface area, channel type, presence of bank cover, and presence of woody debris is proposed for the study area. Cross-sectional geometry pebble counts and flow will be measured at selected locations in each study site.

Each study site will be characterized for fish-species presence and relative abundance using minnow traps and electrofishing capture. Ten minnow traps will be set in each study site and allowed to operate for approximately 24 hours, after which the traps will be pulled. Electrofishing will be conducted in areas where water depths do not allow minnow trap use. Captured fish will be identified as to species, measured to fork length, and released at the point of capture.

In addition to ground investigations, aerial spawning surveys will be conducted on Y Valley Creek to determine the presence and abundance of salmon and steelhead trout. Investigations in 2004 indicated that pink and chum salmon were present in mid-August, and there is a possibility that the stream could be used by chinook salmon earlier in the summer and by coho salmon and steelhead trout in the fall. At least three helicopter surveys will be conducted during the mid-summer period, focusing on the known runs of chum and pink salmon. Additional surveys to detect the presence of chinook salmon in early summer and coho salmon and steelhead in the fall will be conducted as needed. Adjustments to this study effort may be made pending determination of the likely level of disturbance from infrastructure development.

Road-corridor Survey. Streams associated with the proposed primary road corridor that were not surveyed during 2004 (estimated at fewer than five) will be surveyed in 2005. Methods used for corridor stream crossing investigations will be the same as those used in 2004.

A biological team will access each stream near the corridor-crossing location. Because road routes will likely not be surveyed in the field and will likely be subject to field design change, the access points will necessarily only be an approximation of crossing locations. The team will collect a standard suite of physical data and descriptive information at each stream crossing, with the effort concentrated within a stream reach extending for 40 widths within the corridor. The data will include basic water-quality information (pH, dissolved oxygen, conductivity, temperature, and turbidity), average and maximum depth, average width, water velocity, estimated flow, cover characteristics, bank characteristics, riparian vegetation, substrate composition, habitat distribution, and channel type. Photographs will accompany the physical descriptions. Fish migration barriers downstream of road crossings will be noted when observed from the air.

The study reach will be sampled for fish using a variety of methods, depending on the physical and biological characteristics of the stream. Methods will include snorkeling, backpack electroshocker, beach seine, angling, and baited minnow-type traps. Because of the need to set minnow traps over a prolonged period, the use of traps will be limited to special circumstances where repeat access is practical. The amount of effort to be expended in sampling at each stream will be determined by the team leader. The intent will be to adequately characterize potential fish use within the sample reach. Within small, wadeable streams, the entire 200-meter reach will be sampled with the electroshocker, if practicable. All fish captured will be identified as to species, measured, and released alive near the point of capture.

A field estimation of habitat value to various species and life-history stages will be determined based on fish presence and physical characteristics. The team will provide comments about special conditions, ways to address effects of changes, and other considerations. Data will be recorded on standard field data sheets. A standard data sheet is included as Appendix 11-A.

Power-transmission-corridor Survey. One proposed transmission corridor transects the Iniskin Peninsula from north to south, paralleling and running within the valleys of two anadromous fish streams. The extent of additional information required for these streams will depend on the exact route of the line and the degree of disturbance expected. A road and winter trail appear on maps of this area for much of the length of the potential alignment, suggesting that additional disturbance may be less than if the alignment were in a pristine area. Aquatic resources potentially affected by the transmission line will be initially assessed by aerial reconnaissance that will be conducted in conjunction with other study programs in the area. If the corridor is selected for future development, a detailed study plan will be developed for initiation in future years. The upstream extent of anadromous fish resources in these watersheds will be delineated using aerial surveys of spawning salmon conducted once during the peak of salmon spawning. The aerial survey will be conducted in conjunction with study efforts on Y Valley Creek as described above.

Task 3: Fish-tissue Sampling

Six fish-tissue sampling sites along the proposed access road corridor were established in 2004. Collection of data at five of these sites will continue in 2005 (Figure 11-2). Procedures for collection of water chemistry, hydrology, and stream macroinvertebrate data are described in sections of the study plan associated with each discipline. Procedures for collection of fish at the corridor study sites for tissue analysis are described below.

During 2005, five fish-tissue sample sites and species will be sampled along the proposed primary road corridor. Tissue sampling will occur once during the month of August in coordination with tissue sampling at the proposed mine site. The fish species, number of fish-tissue samples, and laboratory analytes associated with the road-corridor study sites are shown in Table 11-4.

TABLE 11-4
Schedule for Fish-tissue Sampling Along the Proposed Road Corridor

Location	Fish Species	No. of Primary Samples	No. of QC Samples	Total No. of Samples	Analytes
Ursa 100B	Dolly Varden	10 (whole body)	2	12	Antimony, arsenic, cadmium, copper, lead, nickel, selenium, silver, total mercury, and methylmercury
UT138	Juvenile salmon	10 (whole body)	2	12	Same as above
Bear Den Creek	Juvenile salmon	10 (whole body)	2	12	Same as above
Red Creek	Juvenile salmon	10 (whole body)	2	12	Same as above
Y Valley Creek	Juvenile salmon	10 (whole body)	2	12	Same as above
		Total Number of Tissue Samples		**60**	

In most cases, fish will be collected using a backpack electroshocker. Minnow traps may be used as a supplemental capture method if insufficient fish are captured with the shocker. Protocols for handling, preserving, and transporting fish samples, as well as maintaining the proper chain-of-custody, will be the same as those described for the mine-site fish-tissue sampling and will comply with the project QAPP (NDM, 2005).

Task 4: Barge-landing Areas

Barge transport of materials and equipment across Lake Iliamna between the town of Iliamna and Pile Bay Village is being considered as a means of transport during early mine development. Similarly, barges may be used to carry materials to Williamsport on Cook Inlet prior to port completion. Location and design of barge-landing sites is currently under development. Following delineation of barge-landing locations, aquatic habitats will be investigated as needed, depending on the site characteristics.

Shoreline areas associated with potential barge-landing areas and associated staging yards will be assessed to determine whether aquatic habitats will be affected. The 2005 study effort for the barge-transportation system will be limited to reconnaissance and review of existing information only, with emphasis on aerial observations conducted in conjunction with other studies. Enough information will be collected so that detailed study plans can be developed for initiation in future years if necessary. Near-shore habitats in portions of Lake Iliamna potentially affected by facility development or operation will be investigated by underwater surveys. As many as five transects will be established perpendicular to the shoreline at each of the Lake Iliamna barge-landing areas. Actual transect length will depend on water depth, water clarity, and visibility. Transect surveys are expected to be no longer then 250 feet in length. A two-person self-contained underwater breathing apparatus (SCUBA) team will document substrate type, fish presence, and active or potential spawning areas in the barge-landing areas. Transects will be surveyed in July, when sockeye salmon are abundant in Lake Iliamna.

Data on shoreline spawning areas used by sockeye salmon have been collected over a period of several years by investigators from the University of Washington, Fisheries Research Institute. These data will be reviewed, and maps will be prepared showing shoreline sockeye-spawning areas in the general vicinity of any potential barge-landing area.

Intertidal and shallow subtidal marine habitats potentially affected by a Williamsport barge site will be investigated under a separate study plan.

11.3 Macroinvertebrate and Periphyton Studies for Proposed Mine Site

11.3.1 Objectives of Study

Macroinvertebrate and periphyton populations are effective indicators of water quality, productivity, and habitat variability. The varied life histories and contaminant tolerances of indicator species can be used to integrate and track both short- and long-term environmental changes that could occur. The objective of the macroinvertebrate and periphyton study is to characterize baseline populations and to describe habitat conditions.

Preliminary results from the 2004 macroinvertebrate and periphyton study provided information used to develop the 2005 study plan. The 2005 sampling effort and subsequent data analysis will further characterize the diversity and abundance of aquatic macroinvertebrates and periphyton in the project study area with a greater degree of quantifiability and sensitivity and will help to define among-years variability in baseline conditions.

11.3.2 Proposed Study Plan

11.3.2.1 Study Area

The mine-site study area (Figure 11-1) includes the general project vicinity within a 10-mile radius around the ore body. Specific study sites, as described below, have been selected to characterize macroinvertebrate populations and periphyton densities 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 but will be located strategically so that these sites may be used in the future for comparative purposes after project development. Study sites will be located on the north and south forks of Koktuli River, on Upper Talarik Creek, and at two lake sites (Figure 11-1).

11.3.2.2 Methods

The methods used in 2004 to characterize the macroinvertebrate and periphyton populations in the proposed mine and road corridor study areas are described in the rapid bioassessment protocol (RBP) developed by the U.S. Environmental Protection Agency (EPA) and others (Plafkin et al., 1989). This methodology includes habitat evaluation as well as macroinvertebrate and periphyton (diatom) taxa identification. Specifically, the macroinvertebrate collection and processing methodology followed those outlined in the *Alaska Stream Condition Index (ASCI): A Modification of the USEPA Rapid Bioassessment Protocols* (Major and Barbour, 1997).

As a result of differing agency opinions on preferred macroinvertebrate sampling methodology, two study approaches have been adopted for 2005. The ADNR Office of Habitat Management and Permitting 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, for comparison, an additional five macroinvertebrate samples will be collected at each site, using a Surber sampler, in accordance with the ADNR methodology. The methods for collection and processing of diatom data in accordance with the RBP periphyton procedures will not be used in 2005. Instead the periphyton data collection will consist of 10 periphyton samples collected in one riffle location in accordance with the ADNR methods. Samples will be analyzed for chlorophyll-*a,b,c*, and data will be used to assess productivity at each site.

The 2005 sampling program has been streamlined to accommodate use of multiple methods that will allow enhanced quantification of characteristics of the benthic macroinvertebrate and periphyton communities. To keep the number of sample analyses manageable and incorporate the additional sampling methods, the number of sites and the frequency of sampling have been reduced from 2004. Seven sites in the proposed mine area will be sampled and have been selected for collection of 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.) Five of the sites are comprehensive biological sampling stations and will be sampled for in situ macroinvertebrates and periphyton in June 2005. The seven sites are shown in Figure 11-1 and are listed in Table 11-5.

TABLE 11-5
Macroinvertebrate and Periphyton Sampling Sites for Proposed Mine Area

<table>
<tr><th>Location</th><th>Sampling Method/Type</th><th>No. of Samples</th><th>No. of QC Samples</th><th>Total No. of Samples</th></tr>
<tr><td>Frying Pan Lake</td><td>Modified ASCI</td><td>1</td><td rowspan="7">1 for ASCI samples</td><td rowspan="7">83 Total:
82 primary samples and
1 QC ASCI sample</td></tr>
<tr><td>Big Wiggly Lake</td><td>Modified ASCI</td><td>1</td></tr>
<tr><td>SK100B</td><td>ASCI, Surber, Chlorophyll-a,b,c</td><td>16</td></tr>
<tr><td>NK100A</td><td>ASCI, Surber, Chlorophyll-a,b,c</td><td>16</td></tr>
<tr><td>NK100C</td><td>ASCI, Surber, Chlorophyll-a,b,c</td><td>16</td></tr>
<tr><td>UT100B</td><td>ASCI, Surber, Chlorophyll-a,b,c</td><td>16</td></tr>
<tr><td>UT100D</td><td>ASCI, Surber, Chlorophyll-a,b,c</td><td>16</td></tr>
</table>

In addition to reducing the number of sampling sites at the mine area, the frequency of sampling has been reduced from two events to one event per open water season. Sampling will occur in early June 2005. Preliminary data analysis from 2004 indicates that June may be the month when the greatest numbers of macroinvertebrates are present for sampling and also when the warmer season has progressed enough to permit growth of periphyton.

Drift sampling, which was employed in 2004, has been eliminated. Preliminary results indicated that except at two sites (UT100B and UT100D on Upper Talarik Creek), drift nets collected less information on the composition of the macroinvertebrate community than did substrate sampling (NDM, in press).

11.3.2.3 Major Tasks

Task 1: Background Research

A comprehensive survey of available information was conducted at the start of the project. Information sources included scientific literature, gray literature, resource-agency files, and interviews with agency personnel and local individuals. The results of the literature review were assembled in an annotated bibliography that will be updated as the project progresses.

Task 2: Macroinvertebrate Field Sampling

As noted in the introduction, macroinvertebrates will be collected using two different methodologies at each stream site—ASCI and ADNR (or Surber). In addition, a modified version of the ASCI method will be used to sample Frying Pan Lake and Big Wiggly Lake.

ASCI Rapid Bioassessment Method. ASCI samples will be collected from aquatic habitats along a 100-meter (m) stream reach at each study site. The ASCI protocols require 20 “jabs” or “kicks” with a D-frame 363-micrometer-mesh kick net. Kick nets are used by disturbing or “kicking” the substrate upstream of the net so that organisms flow into the net and are trapped. The jabs or kicks are partitioned proportionally between habitat types—cobble, sand/soft sediment, aquatic vegetation, snags, undercut bank—in the 100-meter reach. The collected insects and debris are composited into one sample. The samples will be preserved with alcohol and labeled for later sorting and identification in the laboratory. This method is intended to integrate observations across habitat types present, but is not quantitative in nature. Thus, results give ecological insights into the aquatic area under investigation, but are not well suited for quantitative, repeatable monitoring.

In addition to sampling the macroinvertebrate population, a visual aquatic and riparian habitat assessment will be completed and ambient water-quality data will be collected. Examples of field data forms are found in Major and Barbour (1997) and in Appendix 11-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 (substrate confined by fines).
- Velocity-depth combinations.
- Sediment deposition.
- Channel flow status.
- Channel alteration.
- Channel sinuosity.
- Bank stability.
- Bank vegetative protection.
- Riparian-zone vegetation width.

Each of the ten habitat parameters will be evaluated to determine relative habitat quality. Based on a variety of habitat conditions identified on the field data sheet, a score of 1 through 20 will be assigned for each parameter. Depending on the score chosen, the habitat for each parameter will fall into one of four habitat-quality categories (poor, marginal, suboptimal, or optimal). The process of categorizing the recorded scores is intended to minimize sampler bias when assigning categories to habitat parameter quality.

Field measurements of pH, dissolved oxygen, conductivity, alkalinity, and water temperature will be collected at each station. All instruments will be serviced before the field season and/or as necessary and will be calibrated before use as prescribed by the manufacturer.

Modified ASCI Rapid Bioassessment Method in Lakes. Two lakes in the mine area, Big Wiggly and Frying Pan, will be sampled using a modified ASCI approach. 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.

Surber (ADNR) Quantitative Method. Surber samplers are used to obtain semi-quantitative information for density and composition of macroinvertebrate populations on stream-bottom habitats. HDR will use a version of the Surber sampler sometimes called a “Slack sampler,” which is a custom-made Surber sampler with a metal pole attached for ease of sampling in deeper waters. 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.

The purpose of this sampling effort is to describe baseline conditions prior to project development which can be compared to post-development conditions once monitoring begins. The method to be used is the method preferred by ADNR.

Five samples will be collected with the Surber sampler from a selected riffle/cobble area at each sampling site. Only riffle/cobble habitats will be sampled. Habitat characterization completed in 2004 indicates that this habitat type is available for sampling at all previously established sampling reaches that are included in the 2005 macroinvertebrate and periphyton study. The location of the riffle/cobble area within the 100-meter stream reach for a sampling site will be documented using a 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.

Task 3: Periphyton Field Sampling

At each sampling site, ten periphyton samples will be collected from the same stream reach from which the macroinvertebrate samples are collected and from the same riffle/cobble areas from which samples are collected using 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. Sample collection follows the modified EPA rapid bioassessment protocol for chlorophyll (Barbour et al., 1999) used by the ADNR (ADF&G, 1998). 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 scrubbed 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. As much water as possible will be extracted and 1 milliliter of saturated magnesium carbonate will be added to the filter as a preservative. The dry filter will be wrapped in a large coffee filter (to absorb any additional water), labeled, placed in a Ziploc bag, and packed over silicon-gel desiccant. This process will be repeated until 10 discrete periphyton samples (one sample per cobble) have been collected from each sampling station.

At camp, filters will be frozen in a lightproof container with desiccant for shipment to the laboratory. Shaw Environmental Inc. will be responsible for filling out electronic chain-of-custody forms (e-Chain) for periphyton samples that will be sent to ADNR for analysis of chlorophyll-*a,b,*c for comparison with post-development monitoring information.

Task 4: Macroinvertebrate Sample Processing and Identification

ASCI macroinvertebrate samples collected in 2005 will be processed and identified using the same methods as in 2004. Before identification, organisms must be sorted from sample debris. Macroinvertebrates collected using ASCI protocols will be subsampled, and approximately 300 individuals will be sorted from the debris. All organisms from the Surber samples will be sorted, unless the numbers warrant subsampling. All sorted samples will be preserved in labeled vials with alcohol for later identification. HDR biologists or an approved subcontractor will identify all samples to genus or the lowest practicable taxon above genus. Identified macroinvertebrates will be preserved in alcohol in labeled vials. A reference collection will be submitted to the laboratory of the Environment and Natural Resources Institute (ENRI) for taxonomic quality control.

Examples of laboratory bench sheets can be found in Major and Barbour (1997).

Task 5: Periphyton Sample Processing

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.

Task 6: Data Analysis and Reporting

Macroinvertebrate Data Analysis. Data will be compiled into a taxa-list format and will be analyzed to develop population-density estimates and metrics suitable for use as indicators of habitat change in the project study area. Population densities for each station will be calculated based on the sampling method. A relative population density of macroinvertebrates in the entire study reach at each station can be calculated from ASCI data. A quantitative population density of the riffle/cobble substrate can be calculated from the data collected using the Surber sampler.

Following are examples of metrics that may be developed:

- *Taxa richness* is calculated as the total number of taxa, usually genera, identified in specific categories. For example, all macroinvertebrates in each subsample for each station will be identified to the lowest taxon practicable, and from this list the sums of all taxa for the following will be calculated:
  - *Ephemeroptera* (mayflies)
  - *Plecoptera* (stoneflies)
  - *Trichoptera* (caddis flies)
  - *Chironomidae* (true flies)
- *Percent EPT* is the portion of the population at each station that is made up of organisms in the families *Ephemeroptera*, *Plecoptera*, and *Trichoptera* and is calculated by dividing the total number of EPT organisms in the subsample by the total number of organisms in the subsample.
- *Percent Chironomidae*, similarly, is the portion of the population represented by that family and is calculated for each station by dividing the sum of all *Chironomidae* in the subsample by the total number of organisms in the subsample.
- *Percent dominant taxa* is the portion of the population represented by the most populous taxa and is calculated for each station by determining which taxa represents the largest number of organisms in the subsample and dividing that number by the total number of organisms in the subsample.
- A biotic index such as the Community Tolerance Index for each station may be derived by weighting the tolerance value of each family identified for the subsample. The tolerance value for families of aquatic macroinvertebrates has been established previously and appears in scientific literature (Wisseman, 1996; Hilsenhoff, 1988).
- The student’s t-test, analysis of variance (ANOVA), and simple linear regression may be used to test for trends and relationships in the data and to determine differences between the macroinvertebrate sampling methodologies for future sampling purposes.

Periphyton Data Analysis. Concentration of chlorophyll-*a,b,c* is generally 1.5 percent of dry weight of organic matter from which the biomass of periphyton in the sampled five-square-centimeter area can be calculated. The student’s t-test, ANOVA, and simple linear regression may be used to test for trends and relationships among samples sites and between years.

11.4 Macroinvertebrate and Periphyton Studies for Road/Port Sites

11.4.1 Objectives of Study

The objective of the macroinvertebrate and periphyton study is to characterize baseline populations and habitat conditions, as further described in Section 11.3.1.

11.4.2 Proposed Study Plan

11.4.2.1 Study Area

The road/port study area is limited to select locations within the proposed road corridor and near potential port-site alternatives (Figure 11-2). Study sites will be located on Upper Talarik (site UT138), Ursa, Bear Den, Red, and Y Valley creeks.

11.4.2.2 Methods

The overall 2005 sampling program has also been streamlined to accommodate use of multiple methods that will allow enhanced quantification of characteristics of the benthic macroinvertebrate and periphyton communities. Methods for conducting the road/port sampling program will be identical to those outlined for the mine-area sampling program (Section 11.3.2.2), except the modified ASCI approach used for the lake sites in the mine area will not be used in the road/port study area. Figure 11-2 and Table 11-6 provide sample-site locations and information for the road/port study.

TABLE 11-6
Macroinvertebrate and Periphyton Sampling Sites for Proposed Road/Port Areas

Location	Sampling Method/Type	No. of Samples	No. of QC Samples	Total No. of Samples
Ursa 100B	ASCI, Surber, Chlorophyll-*a,b,c*	16	1 for ASCI samples	81 Total: 80 primary samples and 1 QC ASCI 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		

Samples will be collected from five locations along the proposed road corridor and at port-site alternatives (Figure 11-2). The sites are comprehensive biological sampling stations and will be sampled for in situ macroinvertebrates and periphyton in June 2005.

11.4.2.3 Major Tasks

Task 1: Background Research

Research will continue for macroinvertebrate and periphyton information in the Upper Talarik, Ursa, Bear Den, Red, and Y Valley creeks along the proposed road corridor and at the port site. Information sources will include scientific literature, gray literature, resource-agency files, and interviews with agency personnel. The annotated bibliography will continue to be updated.

Task2: Macroinvertebrate Field Sampling

The macroinvertebrate field-sampling methods that will be used during the 2005 road/port sampling program include the ASCI rapid bioassessment method and Surber quantitative method. Protocols for these two field-sampling methods are described in Section 11.3.2.3, under Task 2.

Task 3: Periphyton Field Sampling

At each sampling site, periphyton samples will be collected from the same stream reach from which the macroinvertebrate samples are collected and from the same riffle/cobble areas from which samples are collected using the Surber sampler. The periphyton field-sampling methods used in the road/port study area will be identical to those used in the mine study area (Section 11.3.2.3, under Task 3).

Task 4: Macroinvertebrate Sample Processing and Identification

Methods for processing and identifying macroinvertebrates collected from the road/port study area will be identical to those used at the mine area (Section 11.3.2.3, under Task 4).

Task 5: Periphyton Sample Processing

Methods for processing periphyton samples collected from the road/port study area will be identical to those used at the mine area (Section 11.3.2.3, under Task 5).

Task 6: Data Analysis and Reporting

Macroinvertebrate Data Analysis. The data will be analyzed to develop a taxa list, population density, and metrics suitable for use as indicators of habitat change in the project study area, as described for macroinvertebrate data analysis in Section 11.3.2.3, under Task 6.

Periphyton Data Analysis. The data for the road/port study area may be analyzed using the same approach described for periphyton data analysis in Section 11.3.2.3, under Task 6.

11.5 Iliamna Lake Study

11.5.1 Objectives of Study

The objective of the 2005 Iliamna Lake study is to establish baseline conditions in the lake relative to water quality, sediments, zooplankton, and mussel tissues. This study will supplement the ongoing investigations of fresh-water systems in the mine and road areas by gathering information on the present conditions of the lake. The information generated in this baseline study may be used during the development of the project environmental impact statement.

11.5.2 Proposed Study Plan

11.5.2.1 Study Area

The Iliamna Lake study will focus on the northeast portion of the lake. The study area is bounded on the west at the mouth of Upper Talarik Creek and extends east to the Pile Bay port site (Figure 11-3). These boundaries were identified based on currently proposed project activities and transportation-corridor alternatives (including road and lake transportation options).

11.5.2.2 Sample-Site Selection and Timing

The study area will include five sampling sites in Iliamna Lake. These sites will be located in Pile Bay, in Pedro Bay, at the mouth of Upper Talarik Creek, at a site near the Iliamna boat dock (Northeast Bay), and at a site near Roadhouse Bay (Figure 11-3). These locations were chosen based on their proximity to the proposed mine, road alignment, barge-landing sites, or currently populated villages.

Sampling stations have been identified on Figure 11-3. The sample sites were selected to represent nearshore areas (in areas where lake depth is less than 20 meters) in an effort to characterize conditions in the mixing zone of the stream/lake interface. The sites will be close to inflowing tributaries and/or proposed project facilities so that baseline conditions in the lake can be established in areas that receive runoff from the proposed project area.

Water-quality samples, zooplankton samples, and field measurements will be collected once per month from May through October for a total of six sampling events. Sediment and mussel tissues will be collected twice during the year, in June and September.

11.5.3 Major Tasks

The 2005 Iliamna Lake-sampling program will focus on:

- Ambient water-quality conditions and water-quality samples,
- Sediment analysis,
- Zooplankton, and
- Mussel-tissue collection.

Table 11-7 shows a brief overview of the sampling program. Water samples will be collected at three depths at each site. Samples will be collected at one meter below the surface, at the midpoint of the thermocline (or at half-depth if no thermocline is present), and at one meter above the substrate. This sampling strategy should detect effects of lake stratification on the results of the analyses (if any).

Major tasks associated with the Iliamna Lake study are more thoroughly described in the following sections and are presented in the intended order of collection at each site. Examples of the field data forms are provided in Appendix 11-C.

TABLE 11-7
2005 Iliamna Lake-sampling Program

Sample Type	No. of sampling events	No. of samples collected per event	Parameters	Laboratory (primary & duplicate samples)	Laboratory (triplicate samples)
Field Parameters	6	N/A	pH, DO, ORP, turbidity, temperature, conductivity	No sample collection or laboratory analyses (field data collection only)	
Water: Surface	6	1	See Table 11-8	SGS[1]/NCA[2]	CAS
Water: Thermocline	6	1	See Table 11-8	SGS[1]/NCA[2]	CAS
Water: Substrate	6	1	See Table 11-8	SGS[1]/NCA[2]	CAS
Zooplankton	6	1	Identify to major groups such as order (when possible)	HDR	N/A
Sediment	2	1	See Table 11-9	SGS	CAS
Mussel Tissue	2	1 (composite)	See Table 11-10	CAS	NCA

1. SGS (SGS Environmental Services, Inc) will analyze primary/duplicate water samples for major ions, dissolved solids, nutrients, and trace elements.

2. NCA (North Creek Analytical, Inc) will analyze primary/duplicate water samples low levels of mercury.

CAS = Columbia Analytical Services, Inc.

DO = dissolved oxygen

N/A = not applicable

ORP = oxidation reduction potential

11.5.3.1 Task 1: Background Research

A web-based literature search was conducted to identify existing studies on Iliamna Lake. Results of the search indicated that the University of Washington operates a research station on Iliamna Lake with staff from ADF&G's Commercial Fisheries Division—Central Region. Follow-up telephone conversations were used with results of the literature search to develop the scope of work and study plan.

- John Hains and Robert Kennedy: correspondence regarding their Verkhne Viiskii Reservoir limnology study; communications assisted in choosing sample collection materials and decontamination methods (acid washing tips).
- Dr. Thomas Quinn, Professor at the University of Washington: communication regarding freshwater mussels and limnology studies in Lake Iliamna.
- Bethany Lee, Undergraduate at the University of Washington: communication regarding her research with locating and collecting fresh-water mussels in Lake Iliamna. Studies conducted under the guidance of Dr. Thomas Quinn.
- Steve Smith, University of Alaska Anchorage: communication regarding mussel studies.
- Robert J. Behdun, P.E.: communication regarding lake-sampling techniques and water-sampling equipment.

- Bob Ourso, USGS: teleconference regarding acid washing the sampling equipment between sampling events to remove trace metals and avoid cross-contamination issues.

11.5.3.2 Task 2: Surface Water-quality Samples and Laboratory Analyses

Water-quality Field Parameters

Field parameters—including temperature, dissolved oxygen, conductivity, pH, oxidation reduction potential (ORP), and turbidity—will be measured and recorded during each sampling event. Secchi-disk transparency will be recorded during each of the five sampling events.

Temperature, dissolved oxygen, pH, conductivity, and ORP will be measured using a YSI 556 multiprobe system. Upon arrival at the site, the YSI temperature probe will be used to record measurements at one-meter depth increments beginning at the surface and ending at 20 meters depth (or at the substrate). The temperature profile will be used to determine the depth of the three water-quality samples collected at each site (i.e., at one meter depth, at the midpoint of the thermocline, and at one meter above substrate). If no thermocline is found, the second sample will be collected at half the total depth at the site.

Water-quality Sample Collection

Water quality samples will be collected monthly from the five sampling stations (Figure 11-3) from May through October to establish baseline water-quality conditions for Iliamna Lake. These baseline conditions will characterize current conditions and site resources, and the data will be used for comparison to future conditions. The data will also be used to support future aquatic and fish-resources habitat assessments. Sampling sites will be accessed by boat. Exact sample locations will be marked with a handheld GPS. Site-specific information will be recorded on a field data sheet (Appendix 11-C). Information recorded will include date and time, site conditions, station identification (GPS and landmark features), sampler identification, weather observations, wind conditions, estimated wave height, sample location depths, number of samples/sample containers at the site, and presence of notable biological organisms.

Water-quality samples will be collected at three depths using an 8-L Model 1010 Niskin water sampler (grab sampling device) for a total of three samples per site. Samples will be placed in clean polypropylene bottles provided by the laboratory and which have been prepackaged with the appropriate preservatives, if necessary. The order of water-sample collection (for analysis) and the volume collected will follow procedures outlined in the QAPP (NDM, 2005) and the applicable field sampling plan (HDR, in press). All field-collection and processing equipment will be made of non-metallic material, such as Teflon or glass, to prevent sample contamination and to minimize analyte losses through adsorption.

Water samples will be analyzed for the analytical parameters listed in Table 11-8. Details regarding methods, method detection limits and quality assurance/quality control (QA/QC) protocols are presented in the QAPP (NDM, 2005). Samples will be analyzed for major ions, dissolved solids, nutrients, trace elements, and total and dissolved metals. Samples to be tested for organics (semi-volatile organic compounds [SVOCs], volatile organic compounds [VOCs], pesticides/polychlorinated biphenyls [PCBs]) will be collected during the June and September sampling events only. Sample handling and transportation to the analytical laboratories will follow procedures outlined in the QAPP and the field sampling plan (HDR, in press). Shaw Environmental, Inc. will be responsible for filling out and maintaining electronic chain-of-custody (e-Chain) and packaging samples for transport to the appropriate laboratory.

TABLE 11-8
Surface-water Analytes for Lake-sampling Program

Analytes	
Aluminum, total and dissolved	SVOCs
Antimony, total and dissolved	VOCs
Arsenic, total and dissolved	Pesticides
Barium, total and dissolved	PCBs
Beryllium, total and dissolved	pH
Bismuth	Conductivity
Boron	Alkalinity
Cadmium, total and dissolved	Acidity
Calcium, total and dissolved	Ammonia
Chromium, total and dissolved	Chloride
Cobalt, total and dissolved	Cyanide-total
Copper, total and dissolved	Cyanide-WAD
Iron, total and dissolved	Fluoride
Lead, total and dissolved	Nitrate + nitrite
Magnesium, total and dissolved	Phosphorus-total
Manganese, total and dissolved	Sulfate
Mercury, total and dissolved	Silicon
Molybdenum, total and dissolved	Total dissolved solids
Nickel, total and dissolved	Total suspended solids
Potassium, total and dissolved	Thiocyanate
Selenium, total and dissolved	
Silver, total and dissolved	
Sodium, total and dissolved	
Thallium, total and dissolved	
Tin, total and dissolved	
Vanadium, total and dissolved	
Zinc, total and dissolved	

11.5.3.3 Task 3: Zooplankton Field Collection and Laboratory Analyses

Zooplankton aid in characterizing the lake and are an indicator of the overall lake condition. Vertical sample tows will be collected from the substrate to the surface to obtain an integrated sample. Unless a prominent thermocline is found or other conditions warrant sampling at different depths, the sampling design for zooplankton will not be dependent upon stratification, but will be composited as a whole vertical-depth sample. Sampling strategies may be modified as more data are gathered. Results will be compared to gather insight about changes in the population that may occur throughout the open-water period or from site to site.

The preserved zooplankton samples will be transported with the field team to HDR's laboratory for identification and analysis. Zooplankton will be processed in accordance with the methods outlined in the *Standard Methods for Examination of Water and Wastewater*, 20th edition (APHA, 1998).

11.5.3.4 Task 4: Sediment Field Collection and Laboratory Analyses

Sediment samples will be collected at each sampling site (Figure 11-3) during the June and September sampling events and will be collected in the same vicinity as the mussel beds (described below). In the event that mussel beds are not found near the site, sediment will be collected with an Ekman grab sampler at the same location where the water-quality samples are collected. Sediment samples will be collected in clean eight-ounce glass amber jars provided by the laboratories. Sediment analysis will provide baseline characteristics of the benthic environment of Lake Iliamna.

Shaw Environmental, Inc., will be responsible for filling out and maintaining electronic chain-of-custody (e-Chain) and transporting samples to the appropriate laboratory. The primary and duplicate samples will be shipped to CAS, and triplicate samples will be shipped to NCA (Table 11-7). Samples will be filtered to isolate fine-grain sediments at the laboratory. Sample analysis will consist of the same suite of trace metals that is presented in the sediment portions of the trace metals program for 2005. Table 11-9 presents a summary of analyses for the sediment samples.

TABLE 11-9
Summary of Sediment Analyses for Lake-sampling Program

Analyte	Method
Total Metals	SW6010B/6020
Hg	SW7471 (CVAA)
Total Cyanide	E335.2
Chloride	E300.0
Fluoride	SM4500-FC
Sulfate	E300.0
Ammonia as N	E350.3
PAH	SW8270Csim

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.

SW – U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third Edition, September 1986.

PAH = polyaromatic hydrocarbon

11.5.3.5 Task 5: Mussel-tissue Field Collection and Laboratory Analyses

Mussels will be collected at the sites (Figure 11-3) during the June and September sampling events. They are being collected because they have been shown to be good bioaccumulators of aquatic contaminants such as pesticides, other organics, and metals. This is consistent with the use of marine mussels as indicators and consistent with the Mussel Watch Program endorsed by EPA and other regulatory agencies. Tissue analysis will provide additional baseline characteristics of Lake Iliamna and can serve as the basis for comparison once monitoring starts after project development. Snorkeling equipment and/or

Aqua-scope and SCUBA equipment, if necessary, will be used to locate mussel beds during the May water-quality and zooplankton sampling event. During the June sampling event, ten mussels (or enough to achieve 75 grams of wet weight) will be collected at each site (assuming mussels are present at each site). The mussels from the individual sites will be double-bagged in Ziploc bags and labeled in accordance with procedures in the QAPP (NDM, 2005). A sample split will be used for QA/QC purposes.

The mussels will be frozen and shipped on gel ice from Iliamna to the appropriate primary or QA laboratories by Shaw Environmental, Inc., who will also be responsible for filling out and maintaining electronic chain-of-custody (e-Chain). The primary and duplicate samples will be shipped to CAS, and triplicate samples will be shipped to NCA (Table 11-7). Mussel-tissue samples will be analyzed for the same suite of analytes as for the fish-tissue analyses (Table 11-10).

TABLE 11-10
Summary of Tissue Analyses for Lake-sampling Program

Analyte	Method
Total Metals	PSEP/E200.8
Pesticides	SW8081/SW8082
PCBs	SW8081/SW8082
PAH	SW8270Csim

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.

SW – U.S. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third Edition, September 1986.

11.5.3.6 Task 6: Data Analysis and Reporting

A 2005 summary progress report will be prepared in 2006 that includes data collected in the lake in 2005. An analysis and discussion of results and observed trends will be presented. These data will also be included in the 2006 environmental baseline document.

11.6 Bibliography

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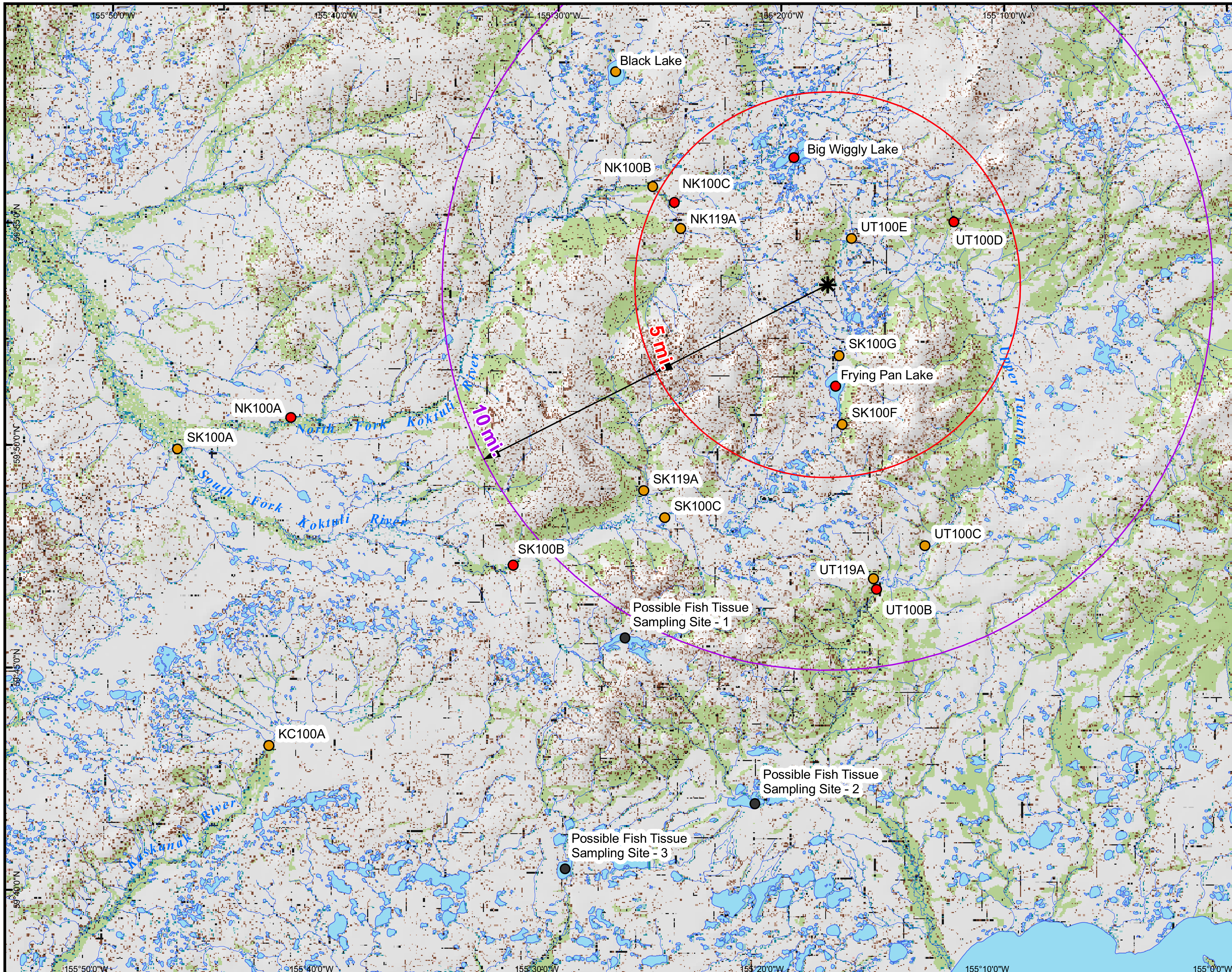
FIGURES

Northern Dynasty Mines Inc.

Pebble Project

Fish and Aquatic Habitat Study Plan
Fish Tissue, Macroinvertebrate, and
Periphyton Sampling Sites
Mine Study Area
Figure 11-1

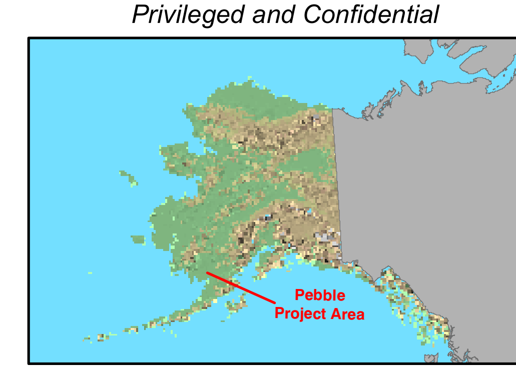


Legend

- 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

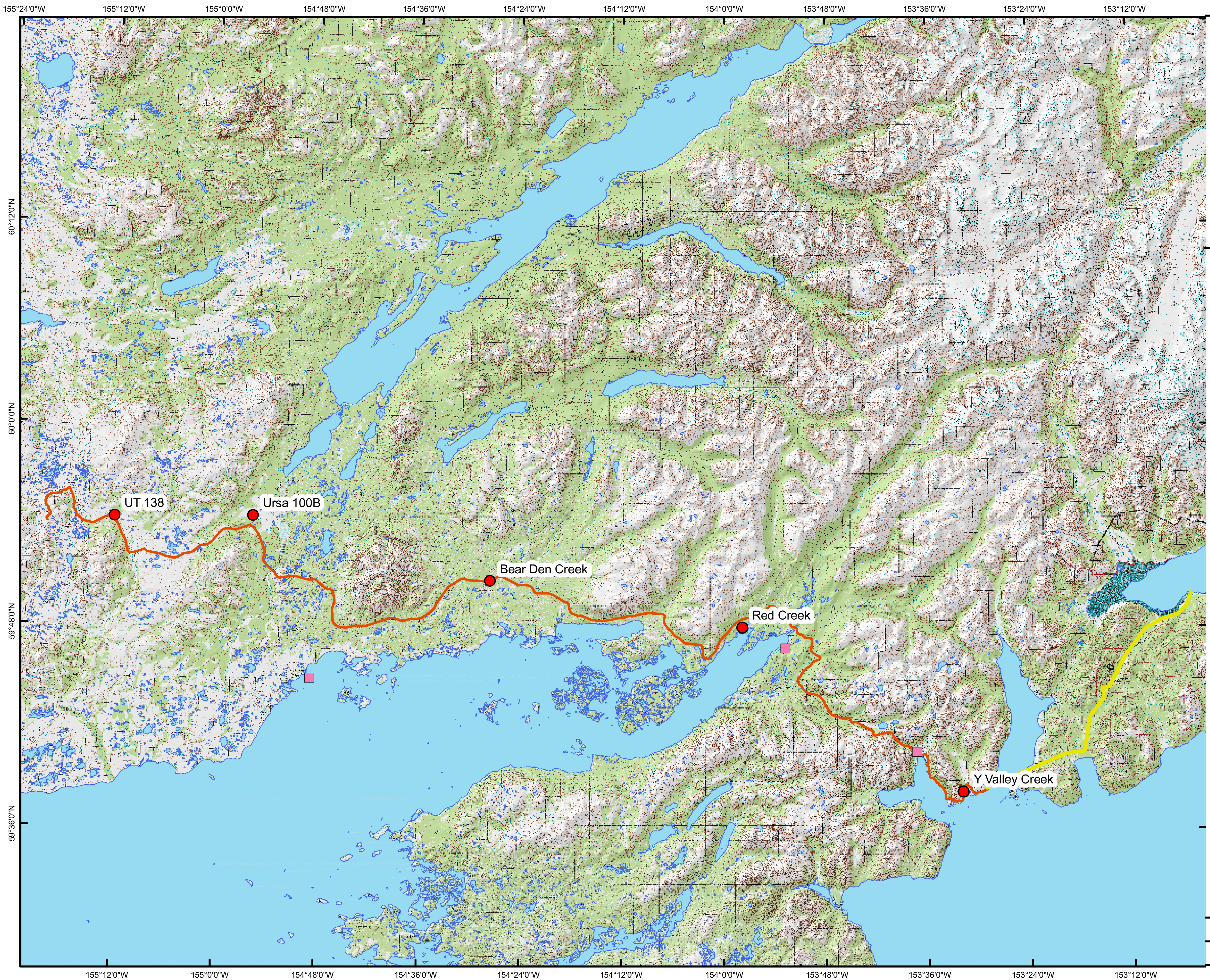
0 0.5 1 2 3 4 5 Kilometers

Scale 1:166,821

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

File: Fig 11-1 Fish_Aquatic_Habitat Study Plan	**Date: March 21, 2005**
Version: 1	**Author: HDR-JS**

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



Northern Dynasty Mines Inc.

Pebble Project

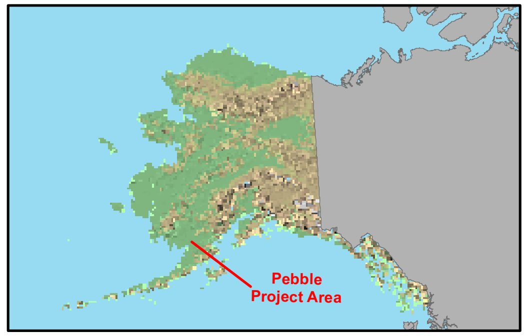
Fish and Aquatic Habitat Study Plan
Fish Tissue, Macroinvertebrate, and
Perip hyton Sampling Sites - Road, Port,
and Transmistudysion Line Study Area
Figure 11-2

Legend

- 2005 Sampling Sites (Fish & Macro)
- Barge Landing Areas
- Road Corridor
- Transmission Line

Sites from HDR, file date 01/25/2005

Privileged and Confidential



0 0.5 1 2 3 4 Miles

0 1.25 2.5 5 7.5 10 Kilometers

N

Scale 1:424,706

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

File: Fig11-2 Fish_Aquatic_StudyPlan	**Date: March 17, 2005**
Version: 1	**Author: HDR-DS**

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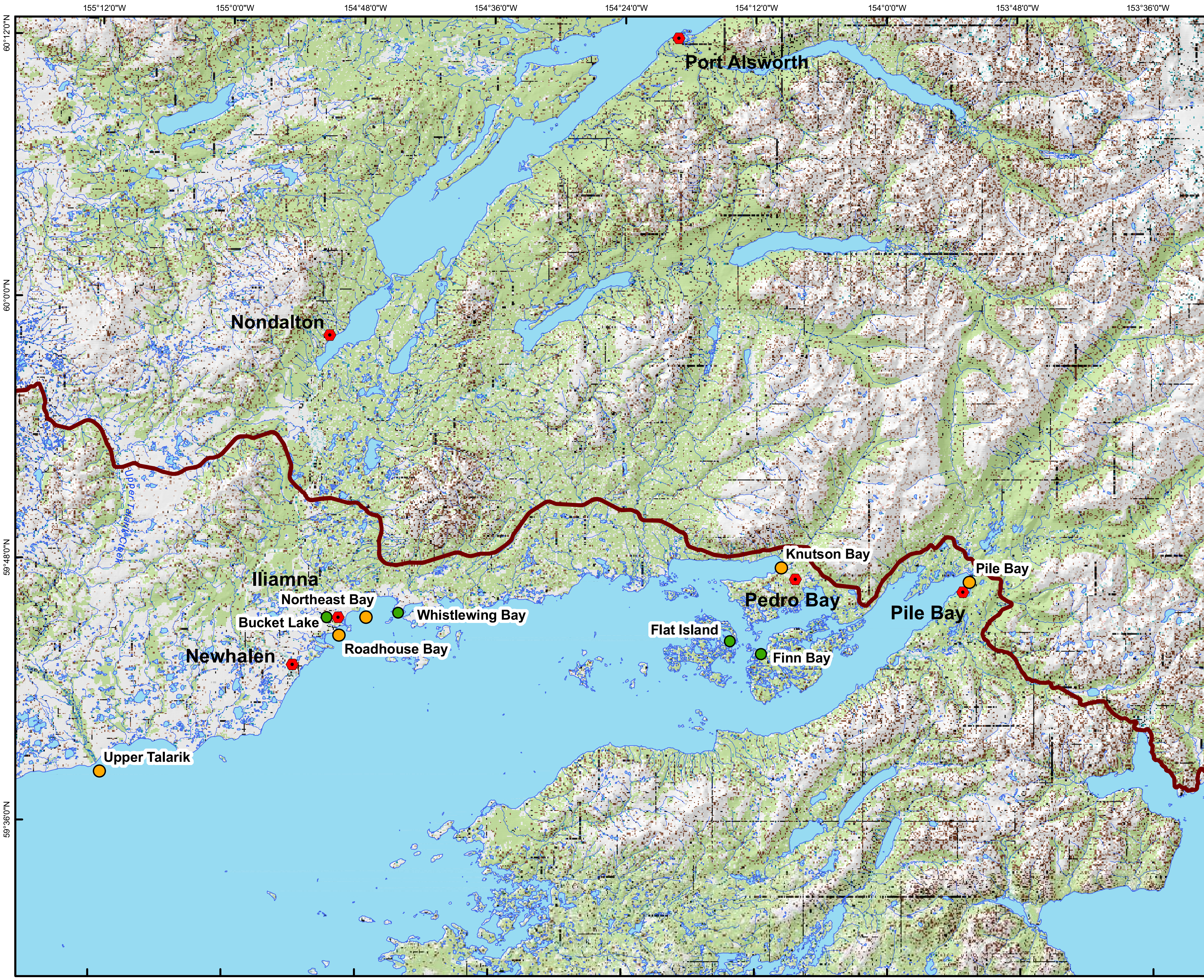


Northern Dynasty Mines Inc.

Pebble Project

Iliamna Lake Study Plan

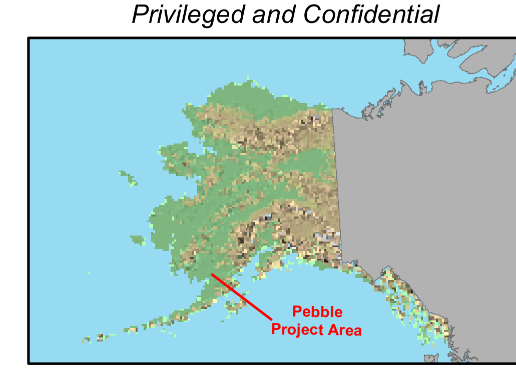
Figure 11-3

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: Fig1iliamnastdypln.mxd	Date: March 3, 2005
Version: 1	Author: HDR-DS

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APPENDIX 11-A
Corridor Stream-crossing Data Sheet

Stream Survey Form

Observers____
Date____
Stream Name____
Time____
Stream Location____
Photo Numbers____
Latitude____
GPS Waypoint____
Longitude____
Water Temperature____

Stream Characteristics

Width: 1)__________ 2)__________ 3) __________

Average: _______________

Velocity:

Depth (ft)	Velocity (fps)

Discharge: Width ________x Avg Depth ________x Avg Velocity(ft/sec) ________=

Discharge _________(cu ft/sec)

Gradient %: 1)__________ 2)__________ 3) __________

Channel:

___ Deeply Incised

___ Moderately Incised

___ Alternating Riffles & Pools

___ Braided

___ Other

Rosgen Channel Type Classification:

Aa+ B C D DA E F G

Habitat Distribution (# & %):

Pools:	Backwater________	Scour________	Slough________
Fastwater:	Glide________	Riffle_________	Cascade________

Comments:

Habitat Characteristics

Bank Cover:

Feet of Undercut Bank: ____

Overhanging Vegetation:

____ Not Present ____ Present less than 10% ____ Present more than 10%

Instream Cover:

Woody Debris:

____ Not Present ____ Present less than 10% ____ Present more than 10%

No. of LWD Clusters:

LWD 5-9 pieces ______ LWD with > 10 pieces______

Beaver Dam _________

Substrate Cover (%):

Bedrock _______ Boulders (>12”) _______ Cobbles (>3-12”) _______

Gravel _______ Sand _______ Silt _______ Organics _______

Fish Habitat:

Spawning: ____ High ____ Moderate ____ Low

Rearing: ____ High ____ Moderate ____ Low

Wintering: ____ High ____ Moderate ____ Low

Bank Characteristics (Looking Downstream)

Incision Depth				Composition				Bank Stability			
Left		Right		Left		Right		Left		Right	
<1ft		<1ft		Bedrock		Bedrock		Low		Low	
1-3 ft		1-3 ft		Boulder		Boulder		Moderate		Moderate	
3-6 ft		3-6 ft		Gravel and Cobble		Gravel and Cobble		High		High	
>6 ft		>6 ft		Sand		Sand					
				Silt		Silt					
				Vegetative Mat/Peat		Vegetative Mat/Peat					

Comments:

Fish Presence:

Name	NP	1-5 fish	> 5 fish	Lengths
Arctic Grayling				
Dolly Varden				
Rainbow Trout				
Pink salmon				
Chum salmon				
Chinook salmon				
Coho salmon				
N. Pike				
Sockeye salmon				
Humpback Whitefish				
Least Cisco				
Blackfish				
Longnose Sucker				
Burbot				
3-spine Stickleback				
9-spine Stickleback				
Slimy Sculpin				
Other				

General Comments:

Adult Migration Blockage Measurements

Location (Lat / Lon)	Barrier Type	Permanent or Ephemeral	Max. Fall Height	Max. Pool Depth (Falls Only)	Gradient %	Resting Pool (Y/N)	Distance

APPENDIX 11-B
Macroinvertebrate and Periphyton
Field Data Forms

Macroinvertebrate/Periphyton/Water Quality
Field Data Collection Form

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

Site Name:</td><td>Date:

Time:</td><td colspan="2">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>Type: Water

Periphyton

Duplicate</td><td colspan="2">Macro – ASCI

Macro – Surber

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

APPENDIX 11-C
Field Data Forms for
Iliamna Lake Study

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

GPS: N_______________________________ **Start time:**_______________ **Weather:** Air Temp:~_______ ^{o}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:

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:_________°C	pH:___________units Temp:_________°C	pH:___________units Temp:_________°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 thiocyanate, 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: