Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2005 STUDY PLANS

CHAPTER 5. GROUND WATER HYDROLOGY

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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
L	liter(s)
LCNPP	Lake Clark National Park and Preserve
LDN	Land Design North
m	meter(s)
MCHTWG	Mulchatna Caribou Herd Technical Working Group
MDC	mine development concept
mg	milligram(s)
ML/ARD	metal leaching/acid rock leaching
mm	millimeter(s)
MODIS	moderate resolution imaging spectroradiometer
MRL	method reporting limit
µm	micrometer(s)
NASA	National Aeronautics and Space Administration
NDM	Northern Dynasty Mines Inc.
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic & Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
ORP	oxidation reduction potential
PJD	preliminary jurisdictional determination
PSD	prevention of significant deterioration
psi	pounds per square inch
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
SHPO	State Historic Preservation Officer
SOP	standard operating procedure
SRB&A	Stephen R. Braund & Associates
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
WMC	Water Management Consultants
WMP	water monitoring plan
WQ	water quality

5. GROUNDWATER HYDROGEOLOGY

Water Management Consultants (WMC) is the prime consultant for the hydrogeology study at the proposed mine site with support provided by SLR Alaska. Bristol Environmental and Engineering Services Corporation (BEESC) will conduct the groundwater hydrogeology work for the road and port.

5.1 Mine Site

5.1.1 Objectives of Study

The objectives of the groundwater hydrology study for the mine site are as follows:

- To characterize the existing groundwater-flow regime within the project area and define how the local groundwater regime interacts with the regional groundwater system. This will necessarily include evaluation of the interaction between groundwater and surface water and the presence of cross-basin transfer of groundwater, both of which appear to be important within the study area. The study will need to include an assessment of both seasonal and long-term changes in the system.
- To identify the potential changes to the groundwater regime that may result from construction, operation, and closure of the mine. These may potentially include changes in groundwater recharge and discharge quantities, as well as spatial and temporal distributions, changes in recharge-water quality, changes to the groundwater geochemical setting, and the transport and fate of constituents that may enter the groundwater system. This aspect of the study is being conducted in cooperation with SRK International Engineering.
- To identify potential measures to mitigate conditions that could result from the interaction of the mining operations and closure with the groundwater environment and to provide an assessment of the effectiveness of mitigation.
- To define and recommend measures to reduce impacts on groundwater within and down-gradient from the project area.
- To interact with environmental and design teams to identify all potential impacts due to groundwater and propose effective mitigation methods.

Achievement of the above objectives will require comprehensive collection of data, including information on surface and subsurface geology, hydrogeologic parameters such as piezometric levels and hydraulic conductivities, locations of groundwater recharge and discharge areas, and existing groundwater quality within areas of mineralized and barren rock as well as within the alluvial aquifers.

The work will include development of conceptual and numerical models to characterize the background conditions, to provide input to the initial environmental evaluation, and to support ongoing design work, particularly the potential influence of mine operations on and proposed mitigation measures for the groundwater system. Close coordination will be required with other team members to understand the impact of groundwater changes on terrestrial and aquatic life and to evaluate the potential benefits of proposed mitigation schemes. The work program will require working closely with regulators from the Alaska Department of Natural Resources, the Alaska Department of Environmental Conservation, and the U.S. Environmental Protection Agency to meet their requirements and to gain approval of monitoring plans and programs.

5.1.2 Proposed Study Plan

5.1.2.1 Study Area/Scope

The Pebble Mine site is located in the headwater areas of Koktuli River and Upper Talarik Creek (Figure 5-1). The main stems of the creek and river flow primarily within flood plain channels eroded into widespread glacial deposits. The valley glacial infill is bounded by bedrock mantled with glacial deposits. Pre-mining groundwater levels, flow, and chemistry will be defined within major bedrock units and within the overburden. This will allow a detailed assessment of the potential impacts during mining operations and after mine closure.

The study area will encompass all local and regional groundwater which has the potential to become affected by the proposed project or which has the potential to affect the surface-water system. The specific extent of the groundwater study area will be determined based on the initial data collected and preliminary project design.

The open pit for the mine is proposed along the margins of the valley infill deposits, so that certain sectors of the pit wall may be excavated into saturated overburden. Mining is expected to require dewatering of the sands and gravels and some additional dewatering of bedrock. During dewatering, local groundwater levels will likely become depressed within the overburden. The baseline groundwater program is intended to quantify the pre-mining conditions in the vicinity of the proposed pit.

Several alternatives were considered for the location of the mill, tailings-storage facilities, and other components. Therefore, groundwater characterization was required at two tailings facilities to assist in alternatives assessment. The groundwater regime and related environmental considerations with respect to downstream water supply and aquatic (fisheries and wetlands) resources will be important factors for optimizing the location and design of the mill and related mine-rock and tailings-storage facilities. As planning proceeds, sampling sites no longer required for mine design or long-term monitoring may be dropped from the regular monitoring schedule. Other baseline data required to assess the tailings areas include geologic descriptions, piezometric levels and flow directions, and hydraulic conductivity distributions.

The underlying groundwater system will be an important consideration for the operational and post-closure water balance of the tailings area. Baseline groundwater conditions will be carefully assessed to allow evaluation of the effect of the tailings facility on the local water tables, groundwater underflow, surface water baseflow, and local and down-gradient surface and groundwater quality. Consideration will be given to size, capacity for tailings to store water, conductivity of tailings, and hydrogeologic characteristics of the foundation material.

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

5.1.2.2 Methods/Approach to the Groundwater Study

The general approach used for this second phase of the groundwater study will be as follows:

- Collation and interpretation of existing data.
- Detailed determination of additional monitoring requirements.
- Sampling of existing baseline monitoring wells.
- Installation, testing, and sampling of new baseline monitoring wells.
- Hydraulic testing of the key hydrogeologic units.
- Development of a site-wide conceptual groundwater model.
- Development of a detailed understanding of the hydrology in the area of the ore body.
- Development of a detailed understanding of the hydrology in the chosen tailings area, and use of the data to help optimize the location and design of the tailings-management program.
- Identification of the key groundwater issues which may influence the project, and development of potential mitigation options.
- Development of focused numerical models, as appropriate.
- Use of all collected data and models to help develop optimized engineering solutions for pit dewatering, the mine water balance, potential groundwater discharge, tailings management, and mine closure.
- Meetings and information access.

The next sections describe the tasks that are planned to implement this approach.

5.1.2.3 Major Activities: Task 1—Field Work

The hydrogeology field work will be conducted by SLR Alaska with oversight by WMC. WMC will provide recommendations to Northern Dynasty Mines Inc. for selection of the drilling contractor, will site the drill holes, will provide input to SLR for the field protocols, and will analyze the data. SLR will develop field protocols together with WMC, will procure the necessary equipment, and will carry out the field work. The field work related to spring surveys, stream-seepage measurements, monitoring of the hyporheic zone, and low-flow streamflow profiles will be conducted by HDR Alaska Inc. WMC has collaborated with HDR to develop the scopes of work for these tasks and will continue to be involved in their execution.

The following paragraphs outline the planned field investigations for 2005. The field program consists of multiple components: monitoring well and piezometer installation, well/piezometer development, slug testing, cross-hole aquifer testing, groundwater sampling, seep and spring sampling, stream-seepage evaluation, and piezometer installation and hydraulic testing. The following paragraphs describe each of these components in more detail.

Background Monitoring Well Installation

Based on the past field season, approximately six additional baseline monitoring wells are planned at the mine site. Similar to 2004, expected installation depths range from 30 to 200 feet. The locations of these wells were decided in consultation with Knight Piesold during March and April, 2005. The background wells will be used primarily to help characterize groundwater geochemistry down-gradient of the proposed tailings-impoundment location and the open pit so that sufficient information is available for design to proceed and to meet permitting requirements. Planned and existing drilling locations are presented in Figure 5-1.

As in 2004, an Odex drilling system is planned for the installation of these wells. This drilling technique eliminates problems associated with the addition of drilling mud and also has the advantage of using a casing for well installation, so that the screen is completed in the appropriate geologic horizon. The wells will be constructed of 2-inch-diameter PVC casing.

Each monitoring well will be developed, response tested, and completed with a dedicated submersible sampling pump. Dedicated pumps eliminate problems that can result from cross-contamination of wells and reduce problems associated with transport of equipment between sites.

In some locations, the overburden is deeper than 200 feet. At these locations, installation of monitoring wells with proper seals will likely not be possible, but collecting data on the geology will be worthwhile. An alternate drilling method will be used to penetrate all the way to bedrock and collect data on the overburden geology. Suitable drilling methods would include PQ coring or triconing with split-spoon sampling.

Piezometer Installation and Hydraulic Testing

Approximately 25 to 30 piezometers will be installed in the proposed pit and tailings areas for the purpose of hydraulic testing and for defining regional gradients. These piezometers cover both the groundwater and geotechnical programs. Most of these piezometers are expected to be dual completion, that is, with monitoring zones at two different depths. These piezometers will be constructed of 2-inch-diameter PVC casing. Slug testing in the completed piezometer will provide hydraulic conductivity data for the completion zone.

Pumping tests will be conducted in the alluvium at the proposed tailings-management sites. Each test site will include a pumping well and multiple piezometers for monitoring water levels. A total of about eight piezometers divided among four locations may be required for these pumping tests. The data from these in situ tests will help define the environmental impact from the tailings areas.

The pumping tests will typically last about 24 hours. The flow rate of the pumping well will be recorded regularly. The water levels in the pumping well and observation wells will be recorded frequently with transducers and with manual sounding tapes. Barometric pressure will be monitored during the test so that the necessary corrections can be applied to the water-level measurements. After the pump is turned off, the recovery of water levels also will be recorded.

Groundwater Sampling

The methods and protocols to be used for groundwater-quality sampling are described in Chapter 6, Water Chemistry. In addition to the water-quality sampling, water levels will be measured in monitoring wells and piezometers nine times during the year, concurrent with surface-water sampling (described in Chapter 6).

Tracer Testing

Tracer testing has been considered as a method to define groundwater flow directions, rates, and resident times under natural gradient conditions. However, tracer testing under natural gradient conditions is time consuming, can be difficult to complete, and may not provide definitive information. The isotope analysis described below is a natural tracer methodology that is more likely to provide the required information at this site. If necessary, single well dilution tests can be carried out in monitoring wells to provide discrete velocity measurements. These tests have not been included in this program.

Isotope Analysis

Natural isotopes of chlorine, sulfur, carbon, hydrogen, and oxygen can be useful for characterizing sources of recharge, geochemical processes within groundwater systems, and travel times from recharge areas to discharge areas. A comparison of water quality in recharge areas with that in discharge areas can help to distinguish where the recharge water is discharging. These data can then be used to help determine where impacts from mine elements such as the tailings impoundment will occur. Understanding the geochemical processes within the system can help to postulate natural attenuation reactions that might mitigate the effects of the mine on groundwater quality. Age-dating of the groundwater also helps to determine how long the groundwater has been resident in the groundwater system, which improves estimates of travel times from recharge areas to discharge areas. A program of isotope analysis for surface water and groundwater is planned for 2005.

Groundwater Supply Investigation

The question of groundwater supply feasibility has been raised from time to time so a groundwater supply investigation may be conducted during the 2005 field season. The requirement for and timing of such an investigation will be decided in consultation with Northern Dynasty Mines Inc.

Low-flow Streamflow Profiles

Even more important to the hydrogeology study than the continuous streamflow measurements is a series of low-flow streamflow profiles. These profiles will consist of 15 to 20 streamflow measurements along the North Fork Koktuli, South Fork Koktuli, and Upper Talarik. The measurements will be collected three times during periods of low flow prior to spring runoff in 2005. The measurements are important to the hydrogeology study because all of the streamflow will be due to groundwater discharge. As such, these streamflow profiles will be very useful for identifying areas where groundwater discharge to streams is more pronounced and therefore where groundwater impacts in streams are most likely to occur.

In conjunction with the streamflow measurements, water samples will be collected from the stream and from mini-piezometers that are driven into the hyporheic zone and groundwater zone. These water samples will be used in conjunction with other groundwater and surface-water samples to interpret groundwater recharge and discharge patterns.

Stream Seepage Investigation

Because surface water/groundwater interaction is a significant concern in this project, a survey will be conducted to determine which portions of the streams are “losing” and which are “gaining.” This survey will include installation of seepage meters and mini-piezometers. The seepage meters will measure the seepage directly and will be installed once to test the feasibility of using seepage meters in this terrain. The mini-piezometers will be used to measure vertical head differences between the stream stage and the underlying materials. The mini-piezometers will be measured each time surface-water samples are collected. As such, the stream seepage evaluation will allow interpretation of high-flow periods during spring runoff and fall storms, and low-flow periods during the summer and winter. Samples of the stream water and groundwater seepage will be collected once when the seepage-meter installation is attempted. A total of four stations to monitor stream seepage are planned.

Seep and Spring Sampling

This task will start with a review of the available database of springs surveyed to date and a comprehensive mapping of springs. The active springs were mapped in January during a field visit to sample surface water. The springs were mapped again in March, and samples were collected and flows were measured. A comprehensive mapping of springs was also completed in June. WMC will visit the springs mapped during June and will select the springs that are to be included in the ongoing monitoring program. This program will provide additional data for the baseline characterization and dewatering-system design and will consist of sampling and surveying the identified priority springs as part of the baseline study in support of environmental permitting. Flow rates will be recorded again in August and October. Samples will be collected again in October. Each visit to a spring will also include documenting field descriptions of the spring, taking several pictures, and measuring field geochemical parameters (pH, specific conductance, temperature).

5.1.2.4 Major Activities: Task 2—Input to Tasks by Others

A number of tasks being completed as part of other baseline studies will be interrelated with the hydrogeology baseline study. These tasks and their association with the hydrogeology study are discussed in the following paragraphs.

Streamflow data collection

The streamflow data are highly relevant to the hydrogeological characterization because these data contribute significantly to understanding the interaction between surface water and groundwater. Selected streamflow monitoring stations will be visited, and the data will be reviewed as they are being collected.

Meteorological data collection

WMC understands that the following meteorological data are being collected:

- Total precipitation (glycol mix with tipping bucket).

- Evaporation.
- Wind speed and direction.
- Temperature.
- Barometric pressure.

The data most relevant to the hydrogeological analysis are total precipitation and evaporation. The meteorological station will be visited, and data collection protocols will be discussed with the team member responsible for the station. The data will be reviewed as they are being collected.

Site-wide water balance

WMC understands that a site-wide water balance is being calculated by other team members. Input will be provided to the water balance, as required, so that it includes the findings from the hydrogeological characterization, including the groundwater recharge assessment. This input will include requirements for data processing, choice of catchment areas, and choice of water balance model calibration points.

Site-wide mass balance

WMC understands that a site-wide mass balance is being calculated by other team members. WMC will provide input as required to the mass balance so that it includes input from the hydrogeological characterization. This input will primarily be related to groundwater flow rates, groundwater chemistry and attenuation capacity of the aquifer solids.

Pit lake study

The understood goal of this task is to develop an integrated plan to optimize the short- and long-term chemistry of the final pit lake. This task will include examining the effect of groundwater inflows to and discharge from the pit lake on the water balance, the influence of groundwater quality on pit lake water quality, and the groundwater residence times for groundwater leaving the pit area. The pit lake study will focus on options for optimizing the lake-water chemistry and development of a management plan for potential discharge from the pit lake to the down-gradient hydrologic system. WMC will provide input on the groundwater aspects of the pit lake study.

Bench-scale attenuation testing

Bench-scale testing of aquifer materials from the mine site will be conducted. The understood goal of this task is to estimate the natural attenuation properties of aquifer materials along the groundwater flow-paths down-gradient from key facilities such as the tailings impoundment and the open pit. The two primary attenuation mechanisms are expected to be acid neutralization—which will cause metal precipitation—and adsorption on aquifer minerals such as ferric hydroxide coatings and clay minerals. A mineralogical analysis is recommended to determine the types of mineral phases precipitated as a result of acid neutralization within the aquifer and to determine if naturally occurring metal hydroxides are present in the aquifer. The results of this testing will be incorporated in the groundwater impact assessment developed for the site.

5.1.2.5 Major Activities: Task 3—Data Review and Analysis

The review and analysis of hydrogeology data include the following subtasks:

- Quality assurance/quality control for all data-collection activities.
- Review of drill-hole logs to select monitoring zones and interpret the overall geologic environment as it relates to the most important hydrogeologic issues at the site.
- Interpretation of three-dimensional groundwater-flow directions from water-level data.
- Analysis of slug tests (single well).
- Analysis of pumping tests (multiple wells).
- Interpretation of groundwater and surface-water chemistry data to help with the interpretation of groundwater/surface water interaction.

5.1.2.6 Major Activities: Task 4—Groundwater Recharge Analysis

Using the results from the surface-water field program, the groundwater field program, and the site-wide water balance, a groundwater recharge analysis will be developed to help clarify the interaction between surface water and groundwater. This important step will provide a rational connection between precipitation, surface water. and groundwater components of the hydrologic system. This analysis will include the following components:

- Precipitation.
- Runoff and streamflow.
- Evapotranspiration.
- Sublimation.
- Groundwater recharge.
- Groundwater discharge.
- Groundwater pumping from the dewatering system.
- Changes in groundwater storage.
- Mill usage.
- Losses from mill.
- Discharge to tailings impoundment.
- Tailings pore water storage.

This analysis will form the basis for the pit-dewatering design and groundwater calculations. Some iterations between the recharge analysis and groundwater model will be required to develop a consistent interpretation.

5.1.2.7 Major Activities: Task 5—Pit Dewatering and Impacts

This task will consider the following issues:

- Planned number, location, and pumping rates of alluvial and bedrock dewatering wells.
- Planned pumping rates of working-level sumps in the pit floor.
- Prediction of required bedrock and alluvial dewatering rates for the life of the project.
- Considerations of passive options to reduce the amount of alluvial groundwater to be managed during operations.
- Design of measures to allow wall-rock depressurization in any low permeability sectors of the pit slopes.
- Prediction of the pumped-water chemistry from the bedrock and alluvium during the life of the mine.
- Preparation of a plan for excess water discharge, as required, and possible use of groundwater discharge to minimize potential downstream impacts.
- Baseline groundwater characterization for any areas considered for groundwater discharge.
- Soils infiltration and leaching potential characterization for any areas considered for groundwater recharge.
- Prediction of the effect of dewatering on nearby habitats.
- Water rights support.

Work completed during this task will provide a useful tool for input to the pit lake study. WMC will work with the engineers who will design the open-pit dewatering system and will provide input to the environmental impact assessment regarding the expected response of the open-pit-operation pit dewatering. This will include consideration of the site-wide water balance and the water-quality studies. The task is expected to include development of a numerical model to allow effective consideration of the dynamic interaction of mine operations, surface water, and groundwater in the pit area. This model can also be used to address groundwater considerations for the pit lake study.

5.1.2.8 Major Activities: Task 6—Tailings Area Hydrogeology and Impacts

This task will assess the impact of the tailings area on the groundwater system and will deal with any tailings-area design elements related to hydrogeological issues. Considerations to be included in the task include:

- Leakage rates from tailings area.
- Changes in groundwater levels expected from operation and closure of the tailings facility.
- Potential down-gradient flow and chemistry changes to the surface-water and groundwater regimes.
- Seepage recovery design.

Special emphasis will be placed on evaluating changes to surface water/groundwater interaction because of the significance of this interaction on mining impacts. Evaluation of impacts on down-gradient groundwater chemistry will include an estimate of the anticipated mass-loading from the tailings impoundment to the groundwater system. Pre-mining, operational, and post-closure conditions will be simulated to allow comparison of pre-mining baseline conditions with the predicted operational and post-closure mass-loading. Mitigation measures also will probably be planned and designed using the mass-loading model.

The detailed objectives and scope of numerical modeling for the groundwater system will be progressively refined as the project evolves. In any case, a three-dimensional numerical groundwater model will be developed for assessing groundwater flow rates, flow directions, and travel times. The U.S. Geological Survey code MODFLOW will be used for assessing flow rates and the particle-tracking code MODFPATH will be used for assessing flow directions and travel times. This model will be developed in the summer of 2005 in a very simple form to help define the most important hydrogeologic issues at the site and to help guide the field program. The model will be progressively refined as field data become available and the conceptual model is developed. The model will be developed at the site scale to incorporate the controlling hydrologic boundaries, and smaller submodels may be extracted as required to examine site-specific components at a larger scale. Having a model at the site scale will facilitate impact assessments on neighboring basins. The resulting model will be suitable for the purposes of the bankable feasibility study and the environmental impact statement. Conservative parameters will be used in the model to compensate for any uncertainties in hydrologic or hydrogeologic conditions.

5.1.2.9 Major Activities: Task 7—Groundwater Supply Assessment

Although a groundwater supply is not currently part of the water-supply strategy, it has been recognized as a potential source of water. Therefore, a groundwater supply may be required for providing startup water for the mill. To accommodate this possibility, a groundwater supply assessment has been included in the scope and budget as an optional task. This assessment would evaluate whether the required water could be feasibly supplied from the groundwater system and whether the impacts on surface-water flows would be potentially detrimental. This task will include conceptual design of a well field and recommended investigation and testing required to refine and verify the concept.

5.1.3 Deliverables

5.1.3.1 2004 Progress Report

A report is being prepared that summarizes progress to date and presents an analysis of data collected to date. This report will also include a preliminary interpretation of groundwater conditions at the site, including recharge areas, discharge areas, and groundwater-flow directions.

5.1.3.2 Initial Environmental Evaluation

A report will be prepared that will outline the expected environmental impacts based on the information gathered to date.

5.1.3.3 2005 Field Report

A report will be prepared that documents the follow-up hydrogeology field work completed during 2005. The report will include field information supplied by SLR as well as analysis of field data completed by WMC.

5.2 Road/Port Site

5.2.1 Objectives of Study

The objective of the study for the road and port is to establish baseline conditions for groundwater flow and evaluate potential impacts to groundwater hydrogeology for the environmental impact statement.

5.2.2 Proposed Study Plan

It is not expected that groundwater will be affected by the development of the road. At this time, hydrogeologic work along proposed road corridor will be restricted to aerial photo interpretation and field observations made during the course of other surveys. If areas of substantial groundwater recharge are noted, and these sites have the potential to be affected by the road, further work will be carried out on an as-needed basis.

Structures to be built at the port site may also require analysis of potential groundwater impacts. The need for more detailed investigations will be evaluated once a preferred port site is selected.

FIGURE

Figure 5-1 Planned Groundwater and Geotechnical Drilling Locations