



NORTHERN DYNASTY MINES INC.

**DRAFT ENVIRONMENTAL BASELINE STUDIES
PROPOSED 2007 STUDY PLANS**

**CHAPTER 4.
SURFACE WATER HYDROLOGY**

DRAFT

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ACRONYMS AND ABBREVIATIONS

ABR	Alaska Biological Research, Inc.
APC	Alaska Peninsula Corporation
CQ	continuous discharge
DEM	digital elevation model
HDR	HDR Alaska, Inc.
IQ	instantaneous discharge
KC	Kaskanak Creek
KR	Koktuli River Main Stem
NK	North Fork Koktuli River
pzf	point of zero flow
SK	South Fork Koktuli River
SWE	snow/water equivalent
TBM	temporary benchmark
USGS	U.S. Geological Survey
UT	Upper Talarik Creek

4. SURFACE WATER HYDROLOGY

The surface hydrology program includes surface water hydrology, fluvial geomorphology, and snow-course surveys. HDR Alaska, Inc. (HDR), will lead the surface hydrology and fluvial geomorphology work for the mine study area. ABR, Inc. (ABR), will lead the snow-course surveys.

In addition to the studies noted above, the Alaska Peninsula Corporation (APC), together with Northern Dynasty Mines Inc., has begun planning for surface hydrology baseline studies to be conducted hydraulically down-gradient of the current mine study area. The intent of the APC studies is to provide an additional study of baseline hydrologic conditions in the lower reaches of Upper Talarik Creek. Study methods are intended to be comparable to those described herein.

4.1 Surface Hydrology Program—Mine Study Area

4.1.1 Objectives of Study

Objectives of the baseline surface hydrology program include the following:

- Documentation of baseline hydrologic conditions.
- Collection of data for input into engineering design.
- Support of the permitting process.
- Collection of baseline data in support of other disciplines (e.g., hydrogeology, fish and aquatic resources, wetlands habitat).

The hydrology and fluvial geomorphology programs provide information on physical flow and channels for surface water systems within the study area. Data from these studies become important components for other project disciplines. For example, hydrologic data are necessary inputs for engineering calculations such as the site water balance. The surface hydrology program also interfaces with ongoing groundwater studies (Chapter 5) to provide a comprehensive characterization of baseline hydrologic conditions at the mine study area. Surface-hydrology discharge data are used by the surface water-quality program (Section 6.1) to model water-quality conditions in the surface water systems. The fluvial geomorphology study will characterize baseline conditions relative to stream-channel form, maintenance, and stability. The fish study team will use these data to characterize streambed substrate (i.e., sediment) and habitat.

4.1.2 Study Area

The mine study area for the surface hydrology program encompasses approximately 360 square miles and is shown in Figure 4.1-1 relative to the surrounding regional watersheds. The mine study area includes the currently known ore body and the surrounding area where the mine, mill, and tailings disposal facilities may be located. It also includes the north and south forks of the Koktuli River, Upper Talarik Creek, Kaskanak Creek, and tributaries of these waterbodies (Figure 4.1-2).

Surface water from the Kaktuli River drains to Bristol Bay via the Mulchatna and Nushagak Rivers. Waters from Upper Talarik Creek drain to Iliamna Lake before reaching Bristol Bay through the Kvichak River. The headwaters of Kaskanak Creek empty directly into the Kvichak River. Lower Talarik Creek is not hydrologically connected to Upper Talarik Creek, but is a separate drainage that is not included in the study area, although it is shown in Figure 4.1-2 for reference.

4.1.3 Proposed Study Plan

A summary of tasks for the surface hydrology study for 2004 through 2007 is provided in Table 4.1-1.

4.1.3.1 Surface Hydrology Data Collection

Consistent with previous years, the 2007 hydrologic data-collection program will consist of a combination of instantaneously measured and continuously gaged stations. The instantaneous discharge (IQ) stations provide discharge measurements for flow-integrated water quality samples. Water quality samples are collected at these locations at the same time that IQ measurements are made. Continuous discharge (CQ) stations continually measure and record stream stage (which is later converted to discharge) during the ice-free months. Hydrographs for the study area are developed from the CQ data.

The number of hydrology stations in 2007 is being increased to 36 from 32. Figure 4.1-2 shows the locations of the 2007 hydrology stations. Due to the Pebble East discovery, seven new CQ stations are being added to the surface hydrology program in 2007. Three of the new gages (NK100B, NK119B, and UT135A) will be installed at locations that were previously measured for instantaneous discharge only. Four of the new gaging stations (NK100A1, UT100C, UT100C1, and UT100C2) are at locations where IQ measurements either have not been collected or have been collected only intermittently since 2004. The intermittent IQ measurements at these stations were collected either as part of an initial data-collection effort in 2004 (e.g., April and May 2004 at UT100C) or during late-winter baseflow measurements in 2005 and 2006 (e.g., March and April 2007 at UT100C). Table 4.1-2 provides a summary of data collection at each station by year, as well as the rationale for selection of each station. In total, 23 CQ locations will be operating in 2007. Three of these will continue to be managed by the U.S. Geological Survey (USGS) and 20 by HDR.

Table 4.1-2 provides the 2007 data-collection schedule for each station. In 2007, the frequency of field measurements has been increased to once per month throughout the year. This change provides additional measurements during the winter months compared to previous years.

4.1.3.2 Baseflow (Low Flow) Data Collection

As in previous years, baseflow will be measured in 2007 during low-flow conditions in late winter, as near to the onset of the spring freshet as practical. Experience from field efforts in 2005 and 2006 indicate that the time period from late March to early April provides high-quality baseflow data. As shown on Figure 4.1-3, instantaneous discharge measurements are planned for 33 locations throughout the north and south forks of the Kaktuli River and in Upper Talarik Creek. Many of these locations are consistent with established IQ and CQ monitoring stations, but some locations are specifically for low-flow measurements. The resulting data are useful in understanding gain and loss for each drainage and the cross-drainage transfer of water. The data may also be used by fish biologists to identify upwelling areas in streams that may coincide with spawning habitat.

4.1.3.3 Fluvial Geomorphology Study

Fluvial geomorphology studies will be conducted in 2007 in the study area to characterize baseline conditions related to stream-channel form, maintenance, and stability. The fluvial geomorphic study may also be considered a companion study to and support for the habitat findings of the ongoing instream flow study. Where the instream flow study documents fish habitats under current conditions, the fluvial geomorphic study is intended to characterize baseline geomorphic conditions and to develop regime equations to characterize the sensitivity of the geomorphology to changes in stream hydrology. HDR will manage this work, which will be subcontracted to Inter-Fluve, Inc. (Inter-Fluve).

The instream flow study evaluates existing habitat conditions at measured cross-sections and predicts how changes in stage (discharge) affect the hydraulics within the static boundaries of the measured cross-sections. Understanding the degree to which a change in the hydrologic regime would affect channel shape adds a powerful predictive tool to the instream flow study. The fluvial geomorphic study will provide empirical data to support the instream flow study.

The initial task of the fluvial geomorphology study is to understand existing conditions and how the system's dependent variables change with a change in discharge. Alluvial stream channels such as North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek adjust their width, depth, and slope to accommodate the streamflow and sediment load; if either the streamflow or sediment load changes, channels respond by modifying their shape and/or slope to move the water and sediment they convey (Leopold and Wolman, 1957). For this study, hydrologic discharge and sediment are independent variables, and channel width, depth, and slope are dependent variables.

In 2005, Inter-Fluve collected fluvial geomorphic data from 17 stream locations in the study area. However, these data have not yet been evaluated; therefore, the 2005 data set will be analyzed prior to data collection in 2007 to better plan the specifics (e.g., numbers and locations of collection sites) of the 2007 field effort. Specific analyses to be included in the 2005 data evaluation include the following:

- Longitudinal reach and valley slope.
- Existing channel patterns.
- Hydraulic and incipient motion.
- Empirical relationships.

Data collection in 2007 is expected to be conducted between July and September. Data will be collected at stations that best represent geomorphic channel conditions throughout the watershed and between major tributaries. Channel characteristics to be noted and documented during site visits include vegetation patterns, bank stability, and observed use of fish habitat. Field work will consist of revisiting 2005 study sites, as needed, as well as data collection at new sites. As noted above, the numbers and locations of new sites will be determined following the evaluation of the existing 2005 data set.

4.1.4 Methods/Approach

Field sampling for surface hydrology and fluvial geomorphology will be performed according to standard methods. An overview of these methods is provided below. The detailed methodology for surface

hydrology is provided as part of the *Draft Environmental Baseline Studies; 2007 Field Sampling Plans; Surface Water Quality, Hydrology, and Sediment* (NDM, In press).

4.1.4.1 Surface Hydrology Data Collection

Equipment and Installation for Continuous Discharge Data

Twenty-three CQ stations (Figure 4.1-2) will be operated in the study area as part of the data-collection program in 2007. Three of these stations will be operated by USGS personnel; HDR will operate the other 20. Each of these stations measures and records stage every 15 minutes during ice-free months. Consistent with hydrographic data collected previously on this project, no continuous stage measurements are collected during winter months. Continuous discharge records for Alaskan streams are not typically obtainable because stage/discharge relationships are not applicable under ice-affected conditions (Nolan and Jacobson, 2000). Instead, winter discharge hydrographs will be estimated using instantaneous discharge measurements in conjunction with meteorological data, winter flow values published by the USGS for Station SK100B, and a general understanding of hydrograph recession patterns during winter low-flow conditions.

The USGS CQ stations are operated independently by that agency. A discussion of their study methods is therefore not provided here. The discussion below pertains to HDR-operated CQ stations.

Each of the HDR-operated CQ gages consists of an integrated electronic datalogger, vented pressure transducer, and temperature sensor manufactured by In-Situ, Inc. A 5-pounds-per-square-inch pressure transducer within the gage will record changes in water surface elevation every 15 minutes with an accuracy rating of 0.012 foot. Surface water temperature also will be recorded at the same frequency. Each datalogger is calibrated annually by the manufacturer.

Prior to field installation, stilling-wells for the CQ gages are typically prefabricated by drilling holes into polyvinyl chloride (PVC) housing. Each gage is seated onto a bolt near the bottom of a stilling-well. Closed-cell-foam pipe insulation serves to tightly secure the tubular gage within the stilling-well. Photo 4.1-1 shows a completed stilling-well setup. CQ gages are set in the stream by securing them to a steel angle iron that has been solidly anchored in the streambed. Protective conduit is installed above the stilling-well to shield the communications cable and vent tubing. Photo 4.1-2 shows a typical CQ gage stream installation.

Staff gages (Photo 4.1-2) also are installed at each CQ station as a quality-assurance measure. During monthly field visits, manual readings of the staff gages will be recorded and compared with the electronic stage values provided by the electronic CQ gage. If either of the gages physically moves, the movement will be detected by comparing the two gage readings in the field. If movement is indicated, the gage(s) may be reset with a differential (elevation) survey and a mathematical adjustment will be applied to the data.

Differential surveys will be performed for each of the HDR-operated CQ gages and associated staff gages following installation in the spring and prior to removal in the fall. As noted above, an additional differential survey may also be performed if elevation movement is observed while the CQ monitors are in place (i.e., during ice-free months). Multiple temporary benchmarks (TBMs) at each CQ station provide differential vertical-datum checks for the gage equipment at each station to monitor movement.

Therefore, CQ-station elevations are assumed local datums and are not interconnected with TBMs at other CQ stations.

Management of Continuous Stage/Discharge Data

Raw data will be downloaded from the dataloggers during monthly trips to each CQ station. The values reported from each datalogger include date, time, elapsed time (seconds), water temperature, and stage for the periods between field visits to the station.

The date, time, and channel pressure for each period-of-record will be copied into a single file for data analysis and adjustment. A minor amount of electronic drift (or shift) is typical of time-series data for pressure transducers. The magnitude of drift—typically less than 0.1 foot—is calculated by comparing the electronic value for the transducer elevation with the values calculated during the differential elevation survey(s). The total amount of the drift is divided by the time elapsed (in days), and an estimated shift in the datalogger for each day may be established. This daily shift will be added to each of the stage-data readings and recorded as a shifted-stage value.

A rating curve represents the relation between stage and discharge at a particular location in a stream. A “defining relation” for a curve is typically derived by mathematically fitting a curve to a set of measured concurrent stage and instantaneous discharge values. Stage/discharge relationships developed for the Pebble Project follow standard methods outlined by Maidment (1993). For example, in a long straight channel where channel friction control dominates, a rating curve has the following form:

$$Q = C(h + a)^n \quad (1)$$

where Q = discharge,

C and n = constants

h = stage

a = stage at which discharge is zero

Values of n for different cross-section shapes are as follows:

Rectangular: $n = 1.67$ (assuming width > 20 times depth)

Parabolic $n = 2.17$ (assuming width > 20 times depth)

Triangular $n = 2.67$

Because natural channels are often approximately parabolic in cross-section, a value of about 2 for the exponent n is appropriate where there is channel friction control. Where there is a series of natural controls for different ranges of stage, different values of C , a , and n may apply for each range of stage.

Instantaneous Discharge Measurements

Instantaneous discharge measurements will be collected monthly at each of the 36 stations listed in Table 4.1-2. A detailed schedule of discharge measurements is provided therein. The instantaneous discharges collected monthly at the 23 CQ stations are combined with stage data (collected via the installed gaging

equipment) to develop the stage/discharge relationships described above. Instantaneous discharge data collected at the remaining 13 stations—identified as IQ stations—are provided to the water quality program for flow-integrated water quality analyses. No continuous discharge measurements are collected at the IQ stations.

Instantaneous measurements will be collected based on the procedures defined by the USGS (Rantz et al., 1982) and the field sampling plan (NDM, In press). Price AA-, Pygmy, and Marsh McBirney-type current meters may be used, depending on stream depths and velocities. All current-meter measurements are taken with top-setting wading rods. Although less frequently employed, a salt-dilution slug-injection method will also be used at locations that are not amenable to the current-meter method.

Starting in 2007, winter measurements will be collected monthly during ice-covered months, typically January through April and November and December. This work will include instantaneous discharge measurements through the ice or in open channels. As much as is practical, HDR will attempt to collect these data from all 36 of the locations listed in Table 4.1-2. However, the exact number and locations of the winter measurements will be determined in the field according to safety considerations and the effects of icing on channel control. Winter discharge measurements will follow the USGS procedures described in *Stream Discharge Measurements Under Ice Cover* (Nolan and Jacobson, 2000).

4.1.4.2 Baseflow Data Collection

Instantaneous discharge measurements will be collected once during late winter (low-flow conditions). No continuous discharge measurements are being collected for this effort. Discharge measurements of baseflow will be collected using the same methods employed for the instantaneous discharge measurements described above.

The preferred conditions preceding baseflow measurements include cold temperatures consistently below freezing to avoid surface runoff from snowmelt entering the stream. In order to avoid changing conditions, the IQ measurements will be collected from all stations in each drainage within as short a period as possible—typically one day per drainage. Thus, complete data collection from the three drainages (Figure 4.1-3) is expected to require three to five days, depending on weather.

4.1.4.3 Fluvial Geomorphology

The 2007 data collection for the fluvial geomorphology study will use standard methods that are described in applicable literature (e.g., Kondolf and Piegay, 2003; Rosgen, 1996; Sanders, 1998; Wolman, 1954). Specific data-collection efforts expected in 2007 include cross-sectional and longitudinal surveys; Wolman pebble counts; and upstream, downstream, and cross-sectional photos. Additional methods such as bulk bed-load sampling may be employed, depending on the outcome of the 2005 data evaluation. Site documentation will include noting channel characteristics (such as bankfull indicators) and site observations (such as vegetation patterns, bank stability, and habitat use).

Site selection and survey

As mentioned above, the number of sites and their locations will be determined after an evaluation of the 2005 data. Sites will be selected that best represent channel geometry and hydraulic conditions and that include geomorphic indicators that identify the channel-forming flow for that reach of river. At each site,

three to four representative cross-sections and a longitudinal profile will be surveyed and tied to a relative site-elevation datum.

Wolman pebble count

The Wolman pebble count is a sampling of a predetermined number of grains (commonly 100) from the streambed in a random manner in order to characterize the bed grain-size at a given site. At least one Wolman pebble count will be made at each site.

4.2 Snow Surveys and Snow-distribution Mapping

4.2.1 Study Area

The study areas for the snow surveys are depicted on Figure 4.2-1.

4.2.2 Proposed Study Plan

Spring snow surveys will be continued in 2007 to complement concurrent surface hydrology studies by characterizing the distribution, snow/water equivalent (SWE), and ablation rates of late-season (pre-breakup) snow across the landscape in the vicinity of the mine. The 2007 plan for the snow surveys includes the following five components, one of which has been added in 2007, as noted below:

- Snow-distribution survey in the mine study area.
- Snow-distribution survey in the extended mine study area (new in 2007).
- Ablation surveys in late April and May.
- Snow-distribution modeling, including predictive modeling.
- Ablation modeling.

Table 4.2-1 is a summary of tasks for the snow surveys in 2004 through 2007, and Table 4.2-2 provides an overview of sampling at each sampling location throughout the course of the study.

4.2.3 Methods/Approach

At all snow sampling plots, snow depth and density are measured using standardized snow survey methods and equipment. Snow/water equivalent will be calculated from three measures of snow depth and snow density. Percent snow cover will be visually estimated at each measurement site. At selected plots, supplemental rapid measurements of snow depth (not density) will be obtained to better quantify the variation in snow accumulation. Survey-grade GPS (global positioning system) measurements of snowpack elevations also will be acquired during field surveys to characterize the volumes and distribution of snow accumulation zones and to provide precise locations of each sample to support statistical analysis of variability in snow distribution.

4.2.3.1 Snow-distribution Survey—Mine Study Area

Snow surveys have been performed in the mine study area (Figure 4.2-1) since 2004. All the snow sampling plots surveyed in the mine study area in 2006 will be revisited in early April 2007. In addition, several transects will be added to cover under-sampled sub-basins (these added transects are not yet laid out and so are not depicted on the figure). In total, snow depths and density will be measured along 15 to 18 slope/aspect transects and two permanent snow courses. Sampling along the slope/aspect transects will extend from ridge tops to valley bottoms with snow depths and densities measured at 100-foot elevation intervals.

4.2.3.2 Snow-distribution Survey—Extended Mine Study Area

Field snow-distribution surveys will be expanded to cover the extended mine study area (Figure 4.2-1), with sampling conducted in late March to early April 2007. This will ensure that basin-wide water-volume estimates and snow-distribution modeling will be driven by field data for the full spatial extent of the watersheds. The extended mine study area will be sampled using a regular grid with a density of approximately one sample plot per 3 square miles, for a total of about 90 plots. In addition, Landsat satellite imagery will be reviewed to identify drift areas that remain snow-covered in late April after thinner snow cover has melted. When drift areas occur close to a grid plot (within 200 meters), an additional plot will be sampled over the drift.

4.2.3.3 Ablation Surveys

Snow ablation rates will be measured during late-spring field surveys. Snow-course stations will be surveyed biweekly (three field visits) beginning at the end of April to provide repeated measures of snow during breakup. Digital photography acquired from helicopters during ablation surveys will provide quantitative estimates of snow-covered areas.

4.2.3.4 Snow-distribution and Ablation Modeling

The approach to mapping spring snow distribution combines terrain modeling with detailed field surveys of spring snow depths and densities. The terrain model is derived from a detailed digital elevation model (DEM) of the mine area. The terrain model layers currently consist of four fixed grids (elevation, slope, aspect, and equivalent latitude) and two sets of direction-dependent grids (shelter and drift). ABR expects to incorporate a layer for vegetation canopy structure when it becomes available as a product of the wetlands and habitat mapping.

Since wind redistribution plays a dominant role in late-season snow distribution, identifying wind-shelter and drift-formation areas is important to accurately model spring snow distribution (Winstral and Marks, 2002). Two DEM-derived parameters were calculated specifically to address wind redistribution:

- Shelter (S_x) is a continuous parameter that characterizes the exposure of a grid cell to winds from a particular direction.
- Drift (D) is a binary parameter that identifies cells prone to large drift formation using a two-part test: first, an upwind source of snow must exist; second, there must be a flow separation caused by a steep downwind terrain drop-off.

Sx and D grids were calculated for the dominant directions of winds capable of transporting snow.

Statistical modeling of snow distribution will continue. The modeling is used for the following purposes:

- Predict snow distribution under various development scenarios.
- Improve snow-distribution models from the initial three years (2004 through 2006) of baseline data collection.
- Allow snow-distribution models to be confidently extrapolated to the extended mine study area.

The modeling work will consider ordinary least squares, regression tree, and kriging approaches to snow-distribution modeling.

The ablation model will be extended to incorporate local meteorological data (in addition to field sample data, the snow-distribution map, and satellite-derived snow-covered area) and will be calibrated to hydrograph data. Ablation-rate maps and ablation curves for monitored basins will be produced.

4.2.3.5 Long-term Monitoring

Since snow accumulation has high inter-annual variability, spring field surveys will be continued. In 2004, two snow courses (high and low altitude) were established and were used both as locations within the local (mine site) distribution survey network and as repeated-measurement sites to compare with measurements from existing National Resource Conservation Service (NRCS) snow survey sites in the Bristol Bay water resource area. At this time, there is no suitable record of long-term snowfall data (such as NRCS snow courses and SNOWTEL sites) applicable to the vicinity of the mine. The existing sites are too distant to be used as proxy data for determining the maximum probable spring snow amounts. Additional years of monitoring in the vicinity of the mine will improve confidence in the relative snow-distribution map and allow for a more accurate prediction of maximum potential spring snow loads.

4.3 Surface Hydrology—Transportation Corridor

No data collection for the surface hydrology study is planned for 2007 in the transportation corridor.

4.4 References

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TABLES

TABLE 4.1-1
Pebble Project Environmental Studies
Studies Summary for Surface Water Hydrology, 2004-2007
Consultant: HDR Alaska

Discipline	2004 Study Tasks	2005 Study Tasks	2006 Study Tasks	2007 Study Tasks
Surface Water Hydrology	Mine Studies Area			
	Surface Hydrology Data Collection (7 Events)	Surface Hydrology Data Collection (8 Events)	Surface Hydrology Data Collection 10 Events)	Surface Hydrology Data Collection (12 Events)
		Baseflow Measurements (1 Event)	Baseflow Measurements (1 Event)	Baseflow Measurements (1 Event)
		Upper Hyporheic Temperature Monitoring		Fluvial Geomorphology (2 Events)
		Flow Exchange Measurements During Low Flow		
		Aerial Survey of Hydrography for Potential Temporary Road Corridor		

**Table 4.1-2
Pebble Project
Period-of-Record Index
Surface Water Hydrology, Mine Study Area**

Sample Location	Year ¹	Period-of-Record By Discipline																								Station Rationale
		Hydrology ²												Water Quality												
		Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	
KC100A	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q		Evaluate potential interbasin transfer of water from South Fork of Koktuli River
	2005	I			I	C	C	C	C	C	C	C		Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	C	C	C	C	C	C	C	I		Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
KR100A	2004					I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q		Integrates north and south forks of Koktuli River; Lowest watershed site
	2005				I			I	I	I	I					Q		Q	Q	Q	Q	Q	Q	Q		
	2006				I			I			I		I			Q		Q	Q			Q		Q		
	2007	I	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
NK100A (USGS)	2004							I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		Lower mainstem North Fork Koktuli near South Fork Koktuli confluence
	2005	I			I	C	C	C	C	C	C	C		Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006				I	C	C	C	C	C	C	C			Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
NK100A1	2004																									Intermediate point on mainstem downstream of potential mine development concept (MDC) tailings facility
	2005																									
	2006																									
	2007			I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
NK100B	2004									I	I	I						Q	Q			Q	Q	Q		Downstream of potential MDC tailings option; Integrates NK100C and NK100A.
	2005	I			I	I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
NK100C	2004				I	I	I	C	C	C	C							Q	Q	Q	Q	Q	Q	Q	Q	North Fork Koktuli "basin" integrator for headwaters
	2005	I			I	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
NK119A	2004				I	I	I	C	C	C	C							Q	Q	Q	Q	Q	Q	Q	Q	Downstream of potential MDC tailings site
	2005	I			I	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006	I	I	I	I	C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
NK119B	2004				I	I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q	Q	Drains "back side" of ore body
	2005	I			I	I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I																					
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100A	2004				I	I	I	C	C	C	C							Q	Q	Q	Q	Q	Q	Q	Q	Lower mainstem South Fork Koktuli near confluence with North Fork Koktuli
	2005	I			I	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100B (USGS)	2004				I	I	I	C	C	C	C							Q	Q	Q	Q	Q	Q	Q	Q	Mainstem downstream of potential MDC options; located downstream of gaining reach.
	2005	I			I	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100B1	2004																									Mainstem downstream of potential MDC options; located within gaining reach.
	2005										I	I	C	C									Q	Q		
	2006	C	C	C	C	C	C	C	C	C	C	C	C	I	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100B2	2004																									Mainstem downstream of potential MDC options; located near beginning of gaining reach.
	2005					I	I	I	I	I	I							Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100C	2004							I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q	Q	Mainstem downstream of potential MDC options; located near downstream end of losing reach; upstream of flow gain; Cominco CQ Station 16
	2005	I			I	C	C	C	C	C	C			Q				Q	Q	Q	Q	Q	Q	Q		
	2006			I	I	I	I	C	C	C	C		I					Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	I	I	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100D	2004							I	I	I	I							Q	Q	Q	Q	Q	Q	Q	Q	Mainstem within losing reach; Cominco Station 5
	2005	I			I	I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006			I	I			I	I	I	I		I					Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100F	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q	Q	Mainstem downstream of Frying Pan Lake (possible losing reach); same reach as Cominco CQ Station 17
	2005	I			I	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
SK100G	2004				I	I	I	I	C	C	C							Q	Q	Q	Q	Q	Q	Q	Q	Upper-most main stem station; integrates mine/mill; located upstream of Frying Pan Lake; same reach as Cominco Stations 6 and 14
	2005	I			I	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q	Q		
	2006	I	I	I		C	C	C	C	C	C			Q	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	

Sample Location	Year ¹	Period-of-Record By Discipline																								Station Rationale
		Hydrology ²												Water Quality												
		Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	
SK119A	2004				I	I	I	I	C	C	C								Q	Q	Q	Q	Q	Q	Tributary downstream of MDC Options A and J; flow to aquifer recharge-discharge area; Cominco Stations 18 and 20	
	2005	I	I	I	C	C	C	C	C	C	C	C							Q	Q	Q	Q	Q	Q		
	2006		I	I		C	C	C	C	C	C	C	I						Q	Q	Q	Q	Q	Q		
	2007	I	I	I	C	C	C	C	C	C	C	C	I	I					Q	Q	Q	Q	Q	Q		
SK124A	2004																							Tributary with potential to contain MDC facilities; important data for understanding gaining reach downstream on mainstem.		
	2005	I	I	I		C	C	C	C	C	C								Q	Q	Q	Q	Q			
	2006	I	I	I			C	C	C	C	C	C	I						Q	Q	Q	Q	Q			
	2007	I	I	I	I	C	C	C	C	C	C	C	I	I					Q	Q	Q	Q	Q		Q	
SK131A	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	Drains Kottuli Mountain; Control stream for water quality.		
	2005	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006		I	I			I	I	I	I	I	I	I						Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I	I					Q	Q	Q	Q	Q		Q	
SK133A	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	South of ore body; control stream for water quality.		
	2005				I	I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006		I	I			I	I	I	I	I	I	I						Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I	I					Q	Q	Q	Q	Q		Q	
SK134A	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	South of ore body; control stream for water quality.		
	2005	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006	I	I	I			I	I	I	I	I	I	I						Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I	I					Q	Q	Q	Q	Q		Q	
SK136A	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	Drains ore body		
	2005	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006	I	I	I			I	I	I	I	I	I	I						Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I	I					Q	Q	Q	Q	Q		Q	
SK136B	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	Drains ore body		
	2005	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006	I	I	I			I	I	I	I	I	I	I						Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I	I					Q	Q	Q	Q	Q		Q	
UT100A	2004				I	I	I	I	I	I									Q	Q		Q	Q	Downstream of mineralized zone; integrates all of Upper Talarik Creek.		
	2005	I	I	I		I	I					I							Q	Q	Q	Q	Q			
	2006		I	I			I	I	I	I	I								Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I	I					Q	Q	Q	Q	Q		Q	
UT100B (USGS)	2004				I	I	I	C	C	C									Q	Q	Q	Q	Q	Lower reach of Upper Talarik Creek; downstream of tributary UT1.190; downstream of mineralized zone.		
	2005	I	I	I	C	C	C	C	C	C	C								Q	Q	Q	Q	Q			
	2006		I	I	C	C	C	C	C	C	C	C	I						Q	Q	Q	Q	Q			
	2007	I	I	I	C	C	C	C	C	C	C	C	I	I					Q	Q	Q	Q	Q		Q	
UT100C	2004				I	I													Q	Q		Q		Intermediate point downstream of Pebble East on mainstem		
	2005				I																					
	2006				I																					
	2007		I	I	C	C	C	C	C	C	C	C	I	I					Q	Q	Q	Q	Q		Q	
UT100C1	2004																							Intermediate point downstream of Pebble East on mainstem		
	2005																									
	2006				I																					
	2007		I	I	C	C	C	C	C	C	C	C	I	I					Q	Q	Q	Q	Q		Q	
UT100C2	2004																							Downstream of Pebble East on mainstem; provides data to understand flow balance with Northeast Tributary (UT1.135)		
	2005																									
	2006				I																					
	2007		I	I	C	C	C	C	C	C	C	C	I	I					Q	Q	Q	Q	Q		Q	
UT100D	2004				I	I	I	I	C	C	C								Q	Q	Q	Q	Q	Integrates all Upper Talarik Creek from mine, mill, embankment facilities; Cominco CQ Station 13		
	2005	I	I	I	C	C	C	C	C	C	C								Q	Q	Q	Q	Q			
	2006		I	I	C	C	C	C	C	C	C	I							Q	Q	Q	Q	Q			
	2007	I	I	I	C	C	C	C	C	C	C	I	I						Q	Q	Q	Q	Q		Q	
UT100E	2004				I	I	I	I	C	C	C								Q	Q	Q	Q	Q	Upper reach of Upper Talarik; downstream of potential flow gain from NF Kottuli; upstream of drainage from ore body; control for MDC options ; same reach as Cominco Station 8		
	2005	I	I	I	C	C	C	C	C	C	C								Q	Q	Q	Q	Q			
	2006	I	I	I	C	C	C	C	C	C	C	I							Q	Q	Q	Q	Q			
	2007	I	I	I	C	C	C	C	C	C	C	I	I						Q	Q	Q	Q	Q		Q	
UT119A	2004				I	I	I	I	C	C	C								Q	Q	Q	Q	Q	Integrates mine/mill groundwater impacts on Upper Talarik Creek from reduced flow from South Fork Kottuli for potential MDC options; water-quality and biological sampling.		
	2005	I	I	I	C	C	C	C	C	C	C								Q	Q	Q	Q	Q			
	2006	I	I	I	C	C	C	C	C	C	C	I							Q	Q	Q	Q	Q			
	2007	I	I	I	C	C	C	C	C	C	C	I	I						Q	Q	Q	Q	Q		Q	
UT119B	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	Lower reach of Upper Talarik Creek; downstream of mineralized zone		
	2005	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2007	I	I	I	I		I	I	I	I	I	I	I						Q	Q	Q	Q	Q		Q	
UT135A	2004				I	I	I	I	I	I	I								Q	Q	Q	Q	Q	Major Upper Talarik Creek tributary near confluence with main stem of Upper Talarik; winter flow contribution; Cominco CQ Station 19		
	2005	I	I	I		I	I	I	I	I	I								Q	Q	Q	Q	Q			
	2006		I	I			I	I	I	I	I	I							Q	Q	Q	Q	Q			
	2007	I	I	I	I	C	C	C	C	C	C	I	I						Q	Q	Q	Q	Q		Q	

Sample Location	Year ¹	Period-of-Record By Discipline																								Station Rationale													
		Hydrology ²												Water Quality																									
		Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N		D												
UT138A	2004				I	I	I	I	I	I	I	I													Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q			Drains "Pig Mountain"
	2005	I	I	I	I	I	I	I	I	I	I	I													Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q			
	2006	I	I	I	I	I	I	I	I	I	I	I	I												Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		
	2007	I	I	I	I	I	I	I	I	I	I	I	I	I											Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
UT141A	2004				I	I	I	I	I	I	I	I																Q	Q	Q	Q	Q	Q	Q	Q	Q			Low point for potential new drainage north of potential MDC options.
	2005				I	I	I	I	I	I	I	I															Q	Q	Q	Q	Q	Q	Q	Q	Q	Q			
	2006				I	I	I	I	I	I	I	I	I														Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		
	2007				I	I	I	I	I	I	I	I	I	I											Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
UT146A	2004				I	I	I	I	I	I	I	I																Q	Q	Q	Q	Q	Q	Q	Q	Q			Drains ore body; headwaters in mineralized zone
	2005				I	I	I	I	I	I	I	I													Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q			
	2006				I	I	I	I	I	I	I	I	I												Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		
	2007				I	I	I	I	I	I	I	I	I	I											Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
Black Lake	2004																																						
	2005																																						
	2006																																						
	2007																																						
Big Wiggly	2004																																						
	2005																																						
	2006																																						
	2007																																						
Frying Pan Lake	2004																																						
	2005																																						
	2006																																						
	2007																																						
Chiquita Lake	2004																																						
	2005																																						
	2006																																						
	2007																																						
Lake No. 2	2004																																						
	2005																																						
	2006																																						
	2007																																						
Mud Lake (Near Lily Lake)	2004																																						
	2005																																						
	2006																																						
	2007																																						
Ponds	2004																																						
	2005																																						
	2006																																						
	2007																																						
Seeps	2004																											X					X						
	2005																									X				X	X		X						
	2006																									X			X	X		X	X						
	2007																									X	X		X	X	X		X	X					

KEY:

- C Continuous stage/discharge hydrometric data collected in streams (gaged stations with dataloggers).
- D Macroinvertebrate sites sampled with drift nets AND ASCI methods; periphyton collected with RBP, and diatoms were assessed.
- F Sediment samples collected. Seep sediment samples show number of seeps sampled through 2007. Sediment symbol not shown on associated map.
- I Instantaneous stream discharge measurements taken each month coincident with water quality sampling (ungaged stations without dataloggers).
- M Macroinvertebrate samples from lakes collected with a modified ASCI approach and dredge. Periphyton collected with RBP, and diatoms were assessed
- P Plankton tows.
- Q Surface water quality samples collected for field and laboratory analyses.
- S Macroinvertebrate sites sampled with Surber Sampler AND ASCI methods; periphyton collected with ADNR methods, and chlorophyll a was assessed.
- T Fish tissue samples from adult northern pike consisted of discrete muscle and liver samples. Arctic grayling and whitefish are sampled for muscle tissue
- W Before 2007, fish tissue samples consisted of discrete whole-body juvenile fish. In 2007, adult grayling and whitefish (muscle tissues) will be sampled. If species is not present in adequate numbers, an alternative location will be selected.
- X Seep flow measurements and water quality samples collected.

NOTES:

- 1 Work for 2007 is shown as planned, but has not yet been completed.
- 2 At stations where continuous hydrometric data are collected, continuous hydrographs will be estimated throughout winter months using standard hydrometric Stream gages are reinstalled each spring as early as breakup conditions allow.
- 3 One stream sample site (to be determined in the field) in each of the three major drainages will be sampled for arctic grayling and whitefish; the sample matrix will be muscle tissue (filet). In lakes, grayling, whitefish and northern pike will be collected; muscle tissue samples will be collected from all three species, as well as liver (archive) samples from northern pike.

TABLE 4.2-1
Pebble Project Environmental Studies
Study Summary for Snow Surveys, 2004-2007
Consultant: ABR, Inc.

Discipline	2004 Data Collected or Tasks	2005 Data Collected or Tasks	2006 Data Collected or Tasks	2007 Tasks to be Completed
Snow Surveys	Mine Studies Area*			
	Information Gathering / Literature Search	Information Gathering / Literature Search & Review	Information Gathering / Literature Search & Review	Information Gathering / Literature Search & Review
	Scope, Schedule, Field Sampling Plan	Scope, Schedule, Field Sampling Plan	Scope, Schedule, Field Sampling Plan	Scope, Schedule, Field Sampling Plan
	2004 Study Plan	2005 Study Plan	2006 Study Plan Summary	2007 Study Plan
	Snow Distribution Surveys (April)	Snow Distribution Surveys (April)	Snow Distribution Surveys (April)	Snow Distribution Surveys (April)
	Snow Ablation Surveys (May)	Snow Ablation Surveys (May)	Snow Ablation Surveys (May)	Snow Ablation Surveys (April and May)
	Data Entry and Analysis	Data Entry and Analysis	Data Entry and Analysis	Data Entry and Analysis
	Communication and Data Management	Communication and Data Management	Communication and Data Management	Communication and Data Management
	Coordination with NDM, Agency Meetings	Coordination with NDM, Agency Meetings, and Monthly Reporting	Coordination with NDM, Agency Meetings, and Monthly Reporting	Coordination with NDM, Agency Meetings, and Monthly Reporting
		2004 Progress Report	Preliminary Environmental Baseline Document	Environmental Baseline Document

* In 2007, the study area was extended to include the full extent of the north and south Fork Kuktuli and Upper Talarik basins.

TABLE 4.2-2
Pebble Project
Period-of-Record Index, Snow-course Surveys
Consultant: ABR

Transect	Stations	Year	Distribution	Ablation
1	13	2004	x	x
		2005	x	x
		2006	x	x
		2007	x	x
2	10	2004	x	x
		2005	x	x
		2006	x	x
		2007	x	x
3	5	2004	x	
		2005		
		2006		
		2007		
4	7	2004	x	
		2005		
		2006		
		2007	x	
5	7	2004	x	
		2005		
		2006	x	
		2007	x	
6	9	2004	x	
		2005	x	
		2006	x	
		2007	x	
8	8	2004	x	
		2005	x	
		2006	x	
		2007	x	x
9	7	2004	x	
		2005		
		2006		
		2007	x	
10	5	2004	x	
		2005		
		2006		
		2007		
11	7	2004	x	
		2005	x	
		2006	x	
		2007		
12	8	2004	x	
		2005	x	
		2006	x	
		2007	x	
13	6	2004	x	
		2005		
		2006		
		2007	x	
14	9	2004	x	
		2005	x	
		2006	x	
		2007	x	x

Transect	Stations	Year	Distribution	Ablation
20	10	2004		
		2005	x	
		2006	x	
		2007	x	
21	8	2004		
		2005	x	
		2006	x	
		2007	x	x
22	8	2004		
		2005	x	
		2006	x	
		2007	x	
23	8	2004		
		2005	x	
		2006	x	
		2007	x	
24	7	2004		
		2005	x	
		2006	x	
		2007	x	
25	9	2004		
		2005	x	
		2006	x	
		2007	x	
26	7	2004		
		2005	x	
		2006	x	
		2007	x	x
27	7	2004		
		2005	x	x
		2006	x	x
		2007		
30	10	2004		
		2005		
		2006		
		2007	x	x
34	13	2004		
		2005		
		2006		
		2007	x	x
38	11	2004		
		2005		
		2006		
		2007	x	x
Extensive Grid Plots	21	2004		
		2005		
		2006		
		2007	x	x
Met Station 1	1	2004	x	
		2005	x	
		2006		
		2007	x	
Met Station 2/4	1	2004	x	
		2005	x	
		2006		
		2007	x	
Met Station 3	1	2004		
		2005		
		2006		
		2007	x	

FIGURES

Figure 4.1-1
2007 Study Plan
Surface Water Hydrology
Regional Drainages

DRAFT

Legend

-  General Pit Outline
-  Village
-  Mine Study Area
-  River
-  Waterbody
-  Nushagak Drainage
-  Kvichak Drainage



0 10 20 30 40 Miles

0 10 20 30 40 Kilometers

Scale 1:1,300,000

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



File: fig4-1_Regional_Drainages

Date: Aug 01, 2007

Version: 1

Author: HDR- LS, JC, MC

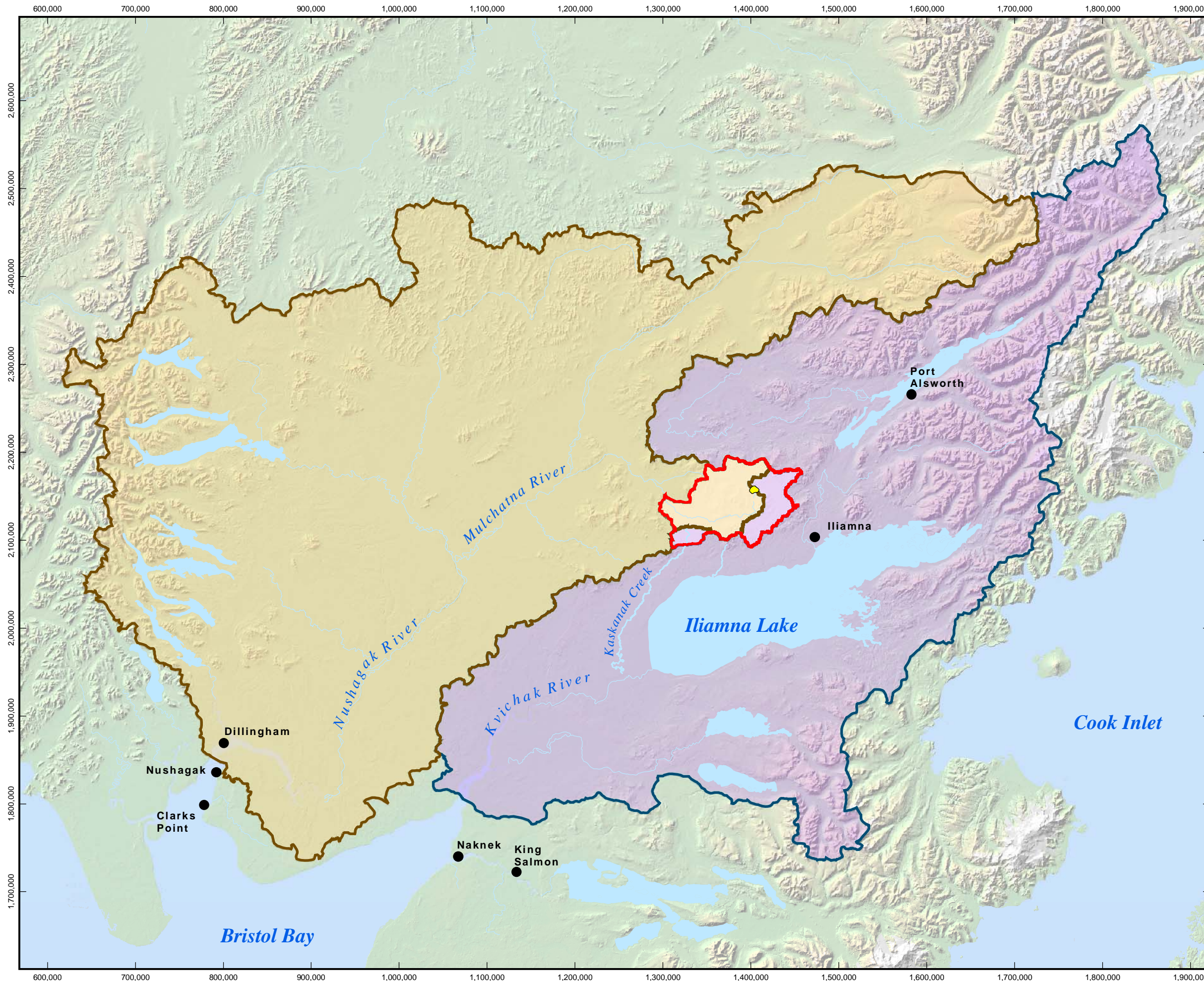








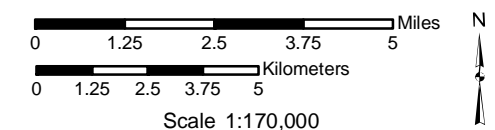
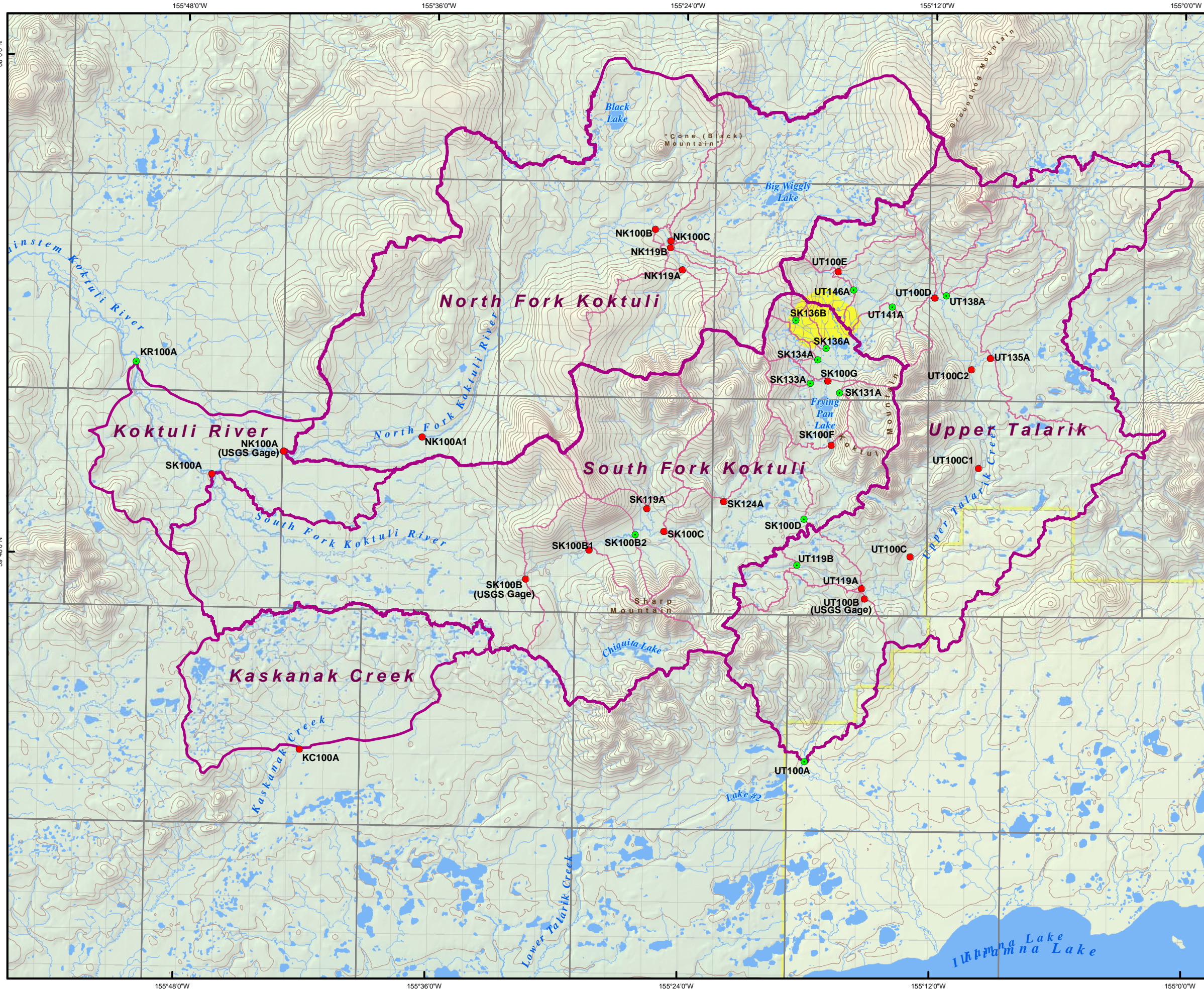


Figure 4.1-2
 2007 Study Plan
 Surface Water Hydrology
 Mine Study Area Drainages and
 Hydrologic Stations

DRAFT

Legend

-  Major Drainage Boundary
-  Sub-drainage Boundary
- Baseline Hydrologic Stations
 -  Continuous
 -  Instantaneous
-  Stream
-  Water Feature
-  General Pit Outline
-  Village Corporation Boundary









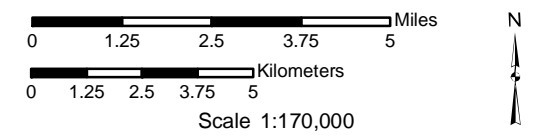
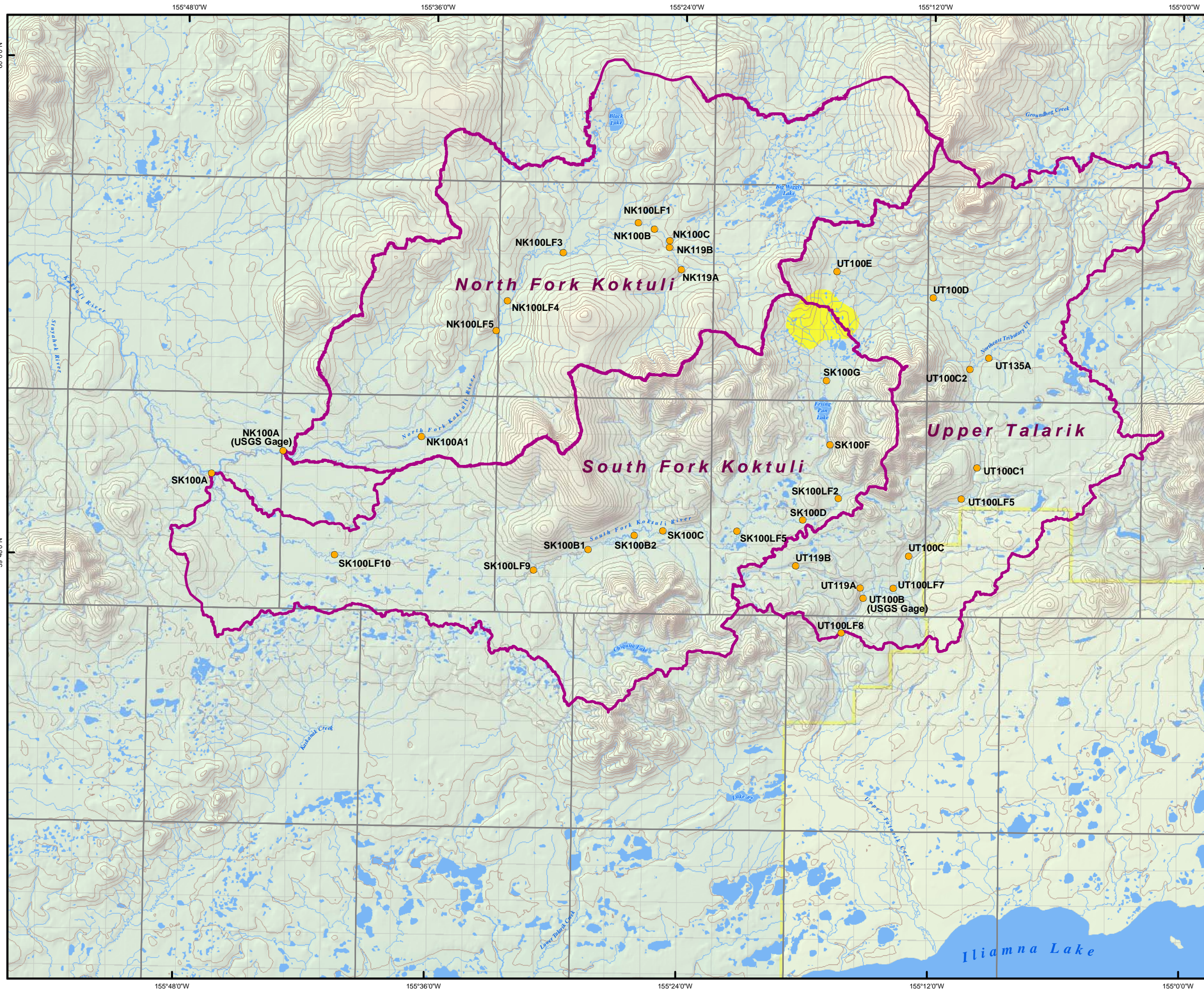
Scale 1:170,000
 Alaska State Plane Zone 5 (units feet)
 1983 North American Datum

Figure 4.1-3
 2007 Study Plan
 Surface Water Hydrology
 Baseflow Stations, Mine Study Area

DRAFT

Legend

-  Baseflow Station
-  Drainage Boundary
-  Stream
-  Water Feature
-  General Pit Outline
-  Village Corporation Boundary



Scale 1:170,000
 Alaska State Plane Zone 5 (units feet)
 1983 North American Datum

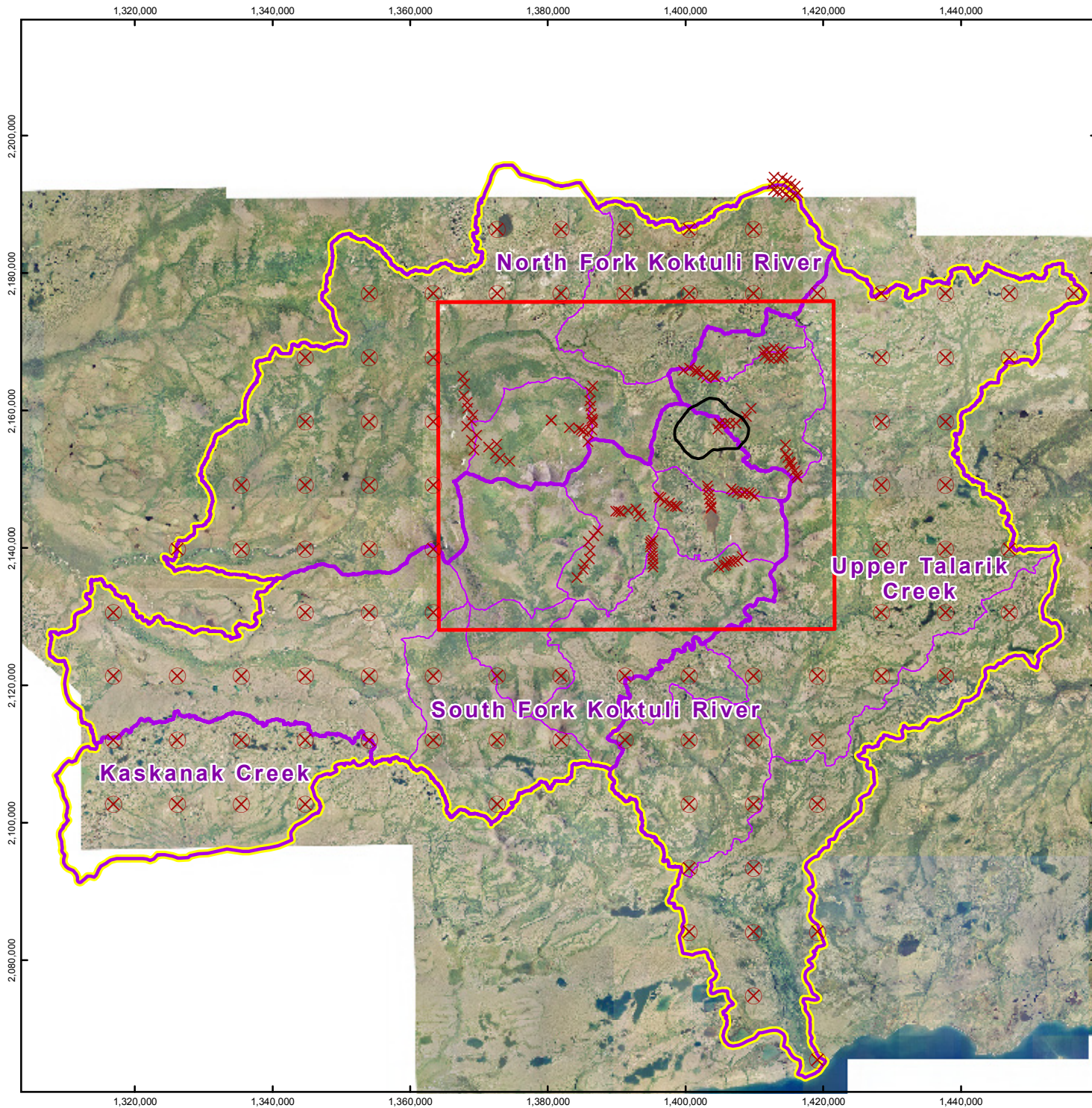
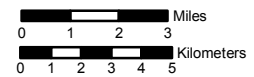


Figure 4.2-1. Snow Survey Study Areas and Field Sampling, 2007

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- × Transect / Snow Course Plots
- ⊗ Preliminary Extensive Grid Plots
- ▭ Mine Study Area
- ⬭ Extended Study Area
- ⬭ Major Basins
- ⬭ Monitored Sub-basins
- ⬭ General Pit Outline



Scale 1:250,000

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

PHOTOGRAPHS



PHOTO 4.1-1: Close-up of datalogger/transducer fixed in stilling-well



PHOTO 4.1-2: Typical continuous gage and staff gage (installed)