INDIAN AND NORTHERN AFFAIRS CANADA
WASTE MANAGEMENT PROGRAM

SÄ DENA HES MINE

ENVIRONMENTAL BASELINE
AND
GEOTECHNICAL EVALUATION REPORT

DRAFT

Prepared by:

geo-engineering (M.S.T.) LTD.

April 2000

DRAFT COPY

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AND
GEOTECHNICAL EVALUATION REPORT

Prepared for:
INDIAN AND NORTHERN AFFAIRS CANADA
WASTE MANAGEMENT PROGRAM
Whitehorse, Yukon

Prepared by:
GEO-ENGINEERING (M.S.T.) LTD.
Calgary, Alberta

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1.0 INTRODUCTION

The Waste Management Department of Indian and Northern Affairs Canada commissioned Geo-Engineering (M.S.T.) LTD. (Geo-Engineering) to compile an environmental baseline and to evaluate geotechnical, hydrological and hydrogeological conditions of the Sä Dena Hes mine. The authorization to proceed with the first phase of the study was received on January 10, 2000. The scope of this work was outlined in Geo-Engineering's proposal dated October 29, 1999 and is summarized below:

- collection and review of available information, including, but not limited to: aerial photographs, site maps, records, existing permits, water licences, operating permits, inspection reports, non-compliance reports, listings, etc., pertaining to site, users and occupants;
- collection of information on the operational history of the site, including, but not limited to: process changes, waste management changes, spills, leaks, operational upsets, regulatory actions, complaints, etc;
- establish current land tenure, status, disposition, etc.;
- identification of existing structures and equipment to determine their structural integrity, mobility and ability to meet design criteria upon closure of the site;
- collection of information about abandoned site, including, but not limited to:
    - whether the sites have been abandoned in accordance with an approved abandonment plan,
    - if the sites meet the standards of all relevant legislation;
- collection of information relating to the abandonment plans for all other sites including, but not limited to:
    - whether the sites have approved or conceptual abandonment plans and the requirement to submit an abandonment plan for review and approval, and
    - review and description of existing and intended land uses of the site and surrounding areas,
    - review of existing financial security arrangements.

On that bases, the following mine site aspects are to be addressed:

- topography, including physical hazards,
- surface water and drainage,

- ground water,
- fill materials and debris,
- surface disturbances,
- type and condition of vegetation,
- storage tanks (underground and above ground),
- chemical storage areas,
- hazardous or potentially hazardous materials,
- wells, water reservoirs,
- utilities,
- buildings,
- landfills, disposal areas,
- dams and tailings ponds,
- pits, adits,
- ore loading facilities, stockpile areas,
- wastewater treatment and disposal areas,
- explosives manufacturing and storage,
- roads,
- traditional uses (including historical, archaeological, etc.),
- soils,
- climatological data.

Preparation of this report represents the final phase of this study stage. The report is issued as a preliminary document and a ground truthing reconnaissance and additional site investigations are supposed to be undertaken prior to issuing the final report.

2.0 BACKGROUND AND HISTORY

2.1 MINE LOCATION

The Sä Dena Hes property is located in the southeastern segment of the Yukon, approximately 70 kilometres by road from the Town of Watson Lake. The mine site is reached via the Robert Campbell Highway, north of Watson Lake. At approximately km 47 of the Robert Campbell Highway, a 25 km access road branches from the highway and extends to the property (Figure 1-1).

Most of the mineral occurrences are situated above the tree line on hills ranging in elevation from 1,200 to 1,500 m above sea level (a.s.l.). The plant site and the camp are located on a bench approximately at elevation 1,030 m a.s.l. The tailings pond and water supply reservoir straddle the headwaters of the Tom and False Canyon Creeks, their valley bottoms being at about elevation 960 m a.s.l. (Photo 1).

Photo 1: General view of the tailings pond (left), reclaim pond (right) and the mill from the Jewel Box underground mine waste dump.

The Sä Dena Hes mine comprises the Jewelbox and Burnick underground mines, two undeveloped mineralized zones – Gribbler Ridge and Attila, and a number of other exploration targets within the claims group.

2.2 MINE HISTORY

The Sä Dena Hes property was initially known as Mt. Hundere. Lead and zinc deposits were discovered in 1962 by prospectors work for the Francis River Syndicate, and for the next few years geochemical and geophysical surveys, as well as some exploration drilling, were conducted. Between 1979 and 1982, Cima Resources Ltd. and Canadian Natural Resources Ltd. carried out diamond drill programs totaling almost 3,000 metres in 72 holes, and outlined an estimated 250,000 tonnes of zinc and lead mineralization.

In 1984, Canamax purchased the property and began systematic geological and geochemical prospecting, including airborne geophysical surveys, with follow-up ground geophysics. By the end of 1988, Canamax had completed 23,333 metres of drilling in 193 holes and estimated a zinc-lead-silver mineral inventory of over 5 million tones in a number of zones.

Mineralization has been delineated by drilling in three separate areas: Jewelbox Hill, Gribbler Ridge and North Hill. Additional areas, namely Porcupine Hill, have been defined by surface mapping, geochemical and geophysical surveys, and bulldozer trenching. Frame Mining Corporation and Hillsborough Resources Limited of Toronto jointly purchased the property from Canamax resources in 1989 and transferred their interest to Curragh Resources Inc.

In 1989, the Mt. Hundere Joint Venture (Curragh resources Ltd. – 80%, and Hillsborough Resources Ltd. – 20%) completed 29,000 metres of diamond drilling in 150 holes in the Jewelbox Hill and North Hill areas. This program resulted in an assessment of proven plus probable mineable reserves of 3.9 million tones at 11.5% Zn, 3.8% Pb, and 53 grams/tonne Ag.

In 1990, Kilborn Ltd. prepared a development plan, the project secured financing from the Bank of Nova Scotia, and the property was put into production in August 1991. The first shipment of zinc and lead concentrate to the port of Skagway occurred in September 1991.

Mine production rates and mill processing exceeded design capacity of 1,500 tonnes per day during the production period. The maximum mill throughput was over 1,800 tonnes per day. During the 16 months of production, some 700,000 tonnes of ore were mined and processed. Approximately 120,000 tonnes of zinc concentrates were produced with a grade of 59% Zn and 54,000 tonnes of lead concentrates at a grade of 77% Pb. The mine was shut down in December 1992, apparently due to declining metal prices.

Curragh Resources sought and received Court protection under the *Corporations and Creditors Arrangement Act* in 1993. On September 20, 1993, Coopers & Lybrand Ltd. was appointed by the court as Receiver and Manager of the Sä Dena Hes property. In March 1994, Cominco Ltd. purchased the property through the Receiver according to a Court Order. The property has been kept on care and maintenance except for a brief period in the winter of 1998 when Cominco began preparations for reopening. A downturn in metal prices forced a re-evaluation and subsequent suspension of work.

The remaining proven and probable reserves are estimated at 1,300,000 tonnes at 10.5% Zn, 2.3% Pb and 4.3 grams/tonne Ag. The mine life is projected to be 3.8 years. While the mill is capable of higher throughput rates, production is severely limited by mining and hauling constraints. At this time, the other potential ore zones, such as Gribbler and Attila, are considered exploration targets at best and it is not believed that they would produce any significant additional tonnage.

The site is under the care of a full-time, on-site, caretaker. The caretaker provides security for the site, conducts daily checks of the mill and the general area, daily checks of the Tailings Management Facility, as well as conducting monthly and quarterly environmental sampling.

2.3 EXISTING LICENCES

Cominco currently holds two Water Licences: Type A – QZ97-025, formerly IN90-002 for quartz mining, which expires on September 15, 2000, and Type B – MS97-901 for miscellaneous works along the main property access road. The company is required to comply with the terms and conditions of both these licences and of the *Yukon Waters Act*. Compliance with licence terms and conditions is monitored by DIAND Water Resources Division.

A Production Lisence would have to be secured prior to re-opening the mine pursuant to Section 139 of the Yukon Quartz Mining Act. Similarly, a slate of other licences and/or permits (such as, for example, transportation of heavy equipment, solid waste disposal, etc.) would have to be renewed for the mine operation re-start.

3.0 SITE CHARACTERIZATION

3.1 PHYSIOGRAPHY AND SURFACE GEOLOGY

Sä Dena Hes mine is located in a mountainous area in the Hyland Plateau physiographic unit. To the west, the Hyland Plateau is bordered by the Liard Plain which contains the Liard and Frances Rivers.

Surface drainage flows both north and south from the Sä Hena Hes mine area. A number of valley streams, of which Tom Creek is the largest, drain southward to the Frances River. North of Mt. Hundere ridge, most creeks flow northward to join False Canyon Creek which eventually flows to the Frances River, northwest of the mine area.

The mine area features broad valleys and rounded ridge crests. Relief is 450 to 600 m within the study area; Mt. Hundere is the highest point at 1,576 m. Late Wisconsin ice covered all of the area during the glacial period. It likely flowed southward to join the southeasterly flowing piedmont glacier in the Liard plain. As deglaciation commenced and the ice sheet retreated and downwasted, glaciers remained in the valleys while ridge crests and upper slopes were ice-free. Till deposits in the valley bottoms and on lower slopes are the result of direct glacial deposition. Tills with a silty sandy matrix reflect the regional glaciation; in the upper valleys a coarser, looser till may be found which reflects deposition from ablating valley glaciers.

Large volumes of meltwater emanated from the retreating ice. Loose, surficial deposits were eroded from slopes, transported by meltwater streams and deposited as glaciofluvial terraces, outwash plains and ice-contact kames and eskers. These granular sediments infilled much of the valley lowlands. In places they are associated with silt deposits laid down in glacial lakes formed by temporary ponding of meltwater.

In post-glacial time, deposition and erosion continued. Colluvial deposits are gravity-transported materials common to sloping ground. Angular bedrock fragments with interstitial sand and silt are ubiquitous on ridge crests and upper and mid-slope positions. Fluvial sediments and organic materials accumulated on floodplains, fans and adjacent valley lowlands. Fluvial erosion, lateral and vertical cutting through existing surface materials, is an on-going, but generally imperceptible, process; it is usually most dynamic in steeper-gradient channels and where unstable bank materials exist. Landslides and snow avalanches occur locally on steeper sloping terrain. The periglacial process (driven by the freeze-thaw cycle) is evident on alpine and subalpine slopes.

The mill site and associated mine infrastructure is not in the path of significant landslides or avalanches. Localized slides exist along the access road route.

3.2 BEDROCK GEOLOGY AND MINERALIZATION

The original claim area, as shown in Figure 3-1, covers most of a 9 km by 7 km block of Lower Cambrian meta-sedimentary rocks that has been up-faulted into sedimentary rock of Silurian to Triassic age.

The predominant rock type on the property is a variably calcareous and non-calcareous grey to black phyllite. Limestone, which hosts the mineralization, occurs in units up to 100 metres thick but makes up less than 5% of the exposed strata through the uplift but is a larger proportion of the rocks near the ore deposits. Narrow, steeply dipping dikes of intermediate to felsic composition, are relatively widespread but form a minor part of the rock package.

Over much of the mine area, bedding dip is usually fairly consistent and gentle (mostly less than 25°), there are certain exceptions and a number of unexplained localized complexities. Dips of 45° or more occur locally on Jewelbox Hill, and predominate in the Upper Burnick and Attila Zones.

The sulphide mineralization is fairly similar throughout the Mt. Hundere property, although mineral proportions vary from place to place. It consists of medium to coarse-grained sphalerite and galena more or less evenly distributed in skarn layers. There is very little iron sulphide present. Variable but minor amounts of quartz and calcite commonly occur as blebs. Silver values are associated with the galena and no separate silver-bearing materials have been identified. The ratio of Ag to Pb is variable. At Jewelbox Hill, an average Pb grade of 9% corresponds to 66 g/t Ag, but in the Burnick Zones 0.4% Pb is associated with 40 g/t Ag.

Parts of some of the mineralized zones show varying degrees of oxidation. At an early stage, smithsonite develops from sphalerite, and iron and manganese oxides from the skarn silicates. In extreme case, the sphalerite and calc-silicates are completely converted to smithsonite and iron oxides, and the galena to cerussite. Although most of the oxidized mineralization appears to occur *in-situ*, there are a few cases where downward migration has apparently occurred, resulting in smithsonite healed cracks in unaltered limestone in the footwall of oxidized skarn mineralization.

3.3 CLIMATE

The Sä Dena Hes mine is located in the rain shadow of the Coast, St. Elias and Cassiar mountains. Continental climate, similar to that of the central and eastern Yukon, exists at the mine site. Early onset of the winter season, relatively cold winter and short summer with moderate temperatures are typical climatic features. The data presented below are excerpted from the recent Access/SRK study.

Since long-term climatological records are not available at the Sä Dena Hes minesite, the climate of the mine site was evaluated from the data of regional climate stations. The records of nine stations operated by the Atmospheric Environment Service (AES) were used to evaluate the mine site climate. In addition, six snow survey records collected by the Department of Indian Affairs and Northern Development (DIAND) were employed in estimating snowpack levels. The locations of the regional stations, except for the single evaporation station which is located several hundred kilometers from the mine site, are shown on Figure 3-2.

Elevation is believed to control the distribution of precipitation in the region. Figure 3-3, a plot of mean annual precipitation (MAP) values versus elevation as derived from the data of regional AES stations illustrates well this control. A best-fit linear regression of these data showed that the average precipitation gradient in the region is about 48 mm per 100 m of ascent. Using Watson Lake Airport as a base (elevation 689 m and MAP 490 mm) and applying the observed regional precipitation gradient, the tailings impoundment (elevation 1,090 m) was estimated to experience a MAP of about 690 mm. Because of local variations in topography which affect precipitation, the Access/SRK study suggests that the actual mean precipitation at the tailings impoundment may differ by as much as 100 mm from the value calculated.

The estimated average monthly snowfall and rainfall for the tailings impoundment are shown in Table 1, together with other estimated climatic parameters for this area. The mean annual precipitation can be expected to comprise about 300 mm rainfall and 390 mm snowfall as water equivalent. Precipitation occurs through the year with the driest month typically being April, and the wettest being October.

Table 1.- Estimated Mean Monthly Climatic Parameters for Tailings Impoundment Site

Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Rainfall (mm)	2.4	0.4	0.8	2.2	24.9	45.2	60.6	59.4	64.2	36.3	3.6	1.3	301
Snowfall (cm)	60	59	46	23	9	2	0	0	7	47	60	76	389
Total Precipitation (mm)	62	60	47	25	34	47	61	60	71	83	64	78	690
Daily Max. Temp. (°C)	-20.2	-12.3	-5.3	1.3	8.1	14.2	17.1	14.5	8.4	-0.4	-13.1	-18.0	-0.5
Daily Min. Temp. (°C)	-31.3	-28.2	-22.6	-13.2	-3.2	1.7	5.3	3.7	-2.3	-10.1	-24.4	-27.9	-12.7
Daily Mean Temp (°C)	-25.7	-20.3	-14.0	06.0	2.5	7.9	11.2	9.1	3.0	-5.3	-18.7	-22.9	-6.6
Evaporation (mm)	0	0	0	0	53	105	130	99	43	0	0	0	430

Table 2 shows the estimated extreme precipitation values fro the tailings pond area:

Table 2.- Estimated Precipation Extremes

Return Period	Total Precipation (mm)
100 Year High	920
20 year High	850
Mean Actual	690
100-Year Low	540
20-Year Low	470

Temperature estimates, presented in the Access/SRK 1999 report, are based on data compiles at the Watson Lake, Cassiar and Good Hope Lake AES Stations. The mean annual temperature at the mine site is predicted to be –6.6°C, which compares to a value of –3.1°C at the Watson Lake Airport.

A rough indication of the temperature extremes at the mine site can be made by referencing the long-term (52-year) and reliable climatological record at the Watson Lake Airport. The extreme minimum temperature experienced at this station was -50°C; the extreme maximum temperature was 34°C.

3.4 SURFACE WATER HYDROLOGY

3.4.1 Drainage Basins

Sä Dena Hes mine is located within the drainage basin of False Canyon Creek, a left bank tributary of Frances River. False Canyon Creek has a total catchment area of 492 km^2 and discharges some 55 km above the Frances River and Liard River confluence. The access road is located within the drainage basin of Tom Creek, a left bank tributary of Liard River. Figure 3-4 shows the location of the proposed project in relation to the major rivers and lakes of the region.

The open pits, underground workings and waste rock dumps associated with the Jewelbox ore zones are located at the divide between two False Canyon Creek tributary catchment basins. All drainage from the Jewelbox development was directed to Camp Creek (unofficial name), a steep-gradient tributary of False Canyon Creek that drains the eastern flank of Mt. Hundere. The mill site is also located in the catchment of Camp Creek. The Burnick development is entirely confined to the headwaters of another False Canyon Creek tributary. The tailings impoundment is located in a saddle that lies between the two above-mentioned False Canyon Creek tributaries.

3.4.2 Data Base

No long-term records of streamflow were available for the mine site drainages at the time of the mine design. The mine site hydrology was characterized using the data of regional streamflow gauging stations operated by both the Water Survey of Canada (WSC) and the Department of Indian Affairs and Northern Development (DIAND). A total of eight WSC and seven DIAND stations were used to identify generalizations about the variation of streamflow across the region.

Ten monitoring stations were established in 1989 on the streams in the general vicinity of the mine. Figure 3-5 shows the locations of the eight stations installed in the False Canyon Creek basin (designed F1 through to F8) and the two stations constructed in the Tom Creek basin (T1 and T2). Each monitoring station was equipped with both a staff and crest gauge.

Recent data on surface water hydrology are available in the Draft Detailed Decommissioning and Reclamation Plan, prepared by Access Mining Consultants and SRK Consulting in September 1999. Their assessment is based on site-specific data (i.e., collected in the mine area) and on regional data. The review concluded that site-specific data on their own were inadequate to fully characterize the hydrology of the minesite streams. This is because of the relatively short record of spot flow measurements which do not cover the winter period. Therefore, the data collected by the WSC and DIAND were used to characterize the minesite hydrology using a technique known as Regional Analysis. Essentially, this involved deriving empirical relationships between the measured streamflow. These empirical relationships then formed the basis for estimating flows that ungauged locations on the minesite streams. The sub-sections below describe the steps undertaken to apply the regional analyses to the minesite streams.

3.4.3 Average Flow Estimates

It is known that elevation generally accounts for a large proportion of the variation in mean annual precipitation within a mountainous region. Similarly, mean annual runoff (MAR) would also be a function of elevation. Figure 3-6 (compiled by SRK) shows how this observation was exploited to estimate the average flows the minesite streams. The vertical axis of this figure displays values of MAR expressed as equivalent depths of water. The horizontal axis shows values of median elevation, which is the variable adopted to quantify the elevation characteristics of the regional and minesite catchments.

Median elevation and MAR values, plotted on Figure 3-6, were used to develop a relationship to evaluate the conditions at the minesite. Two steps were undertaken to develop the relationship. Firstly, a linear regression was fitted to all data points. This defined a straight line with a slope of 0.60 mm per m. Secondly, the intercept of this straight line was adjusted to force the line through the data point for Tom Creek. This adjustment was based on the premise that, of all the WSC catchments, the one for Tom Creek is probably the most representative of the conditions within the False Canyon Creek catchment. These two catchments share a significant portion of their respective drainage divides and also possess similar elevational characteristics.

Expressed as an equation, the adopted relationship between mean annual runoff (MAR in mm) and catchment median elevation (E in m) is:

$$MAR = 0.60E - 397$$

3.4.4 Flood Estimates

Since site-specific flow data are unsuitable for determination of design floods, empirical procedures were used by SRK to calculate maximum annual flood (MAF) and the 200-year and 1000-year event. The latter event is specified as the design flood for the tailings storage facility. Most of the Yukon's annual floods are caused by snowmelt, as evidenced by the high frequency of annual flood peaks occurring in the months of May and June. However, some of the extreme floods on small catchments are generated by intense rainstorms. In recognition of the importance of this second mechanism, the Rational Method was adopted by SRK to assess the design floods for the minesite streams.

The Rational Method entails applying the following formula:

$$Q = CIA/3.6$$

Where: Q is the peak instantaneous discharge of the flood (m^3/s);
C is a runoff coefficient (dimensionless);
I is the average rainfall intensity which causes the flood (mm/h);
and,
A is the catchment area (km^2).

The runoff coefficient specifies the proportion of the rainfall that quickly runs off the catchment to form the flood hydrograph. The remainder of the rainfall is retained on the catchment for subsequent evaporation or slow release to the catchment's streams. A low runoff coefficient for frequent floods and a high coefficient for rare events were chosen for this analysis. Values of 0.3, 0.9, and 0.95 were adopted to represent the "wetness" of the study catchments during, respectively, the mean annual flood, the 200-year flood, and the 1000-year flood.

A regional analysis of streamflow gauging stations, located in the vicinity of the mine, was used to estimate the same flood events. A total of 25 regional gauging stations was used for this purpose. For each station, the average of its annual series of flood peaks was calculated to provide an estimate of the mean annual flood. The annual series was then fitted to a theoretical frequency distribution (Generalized Extreme Value) to provide an estimate of the flood events.

These flood estimates were transposed to the mine site by correlating the catchment areas and the relationships between unit discharge and the catchment area for the mean annual, the 200-year and the 1000-year flood were examined. The data exhibited the expected inverse trend between unit flood discharge and catchment area (i.e., the unit flood discharge increases as catchment area decreases). The flood estimates applicable for the tailings storage facility are summarized in Table 3.

For the 200-year and 1000-year floods, the objective was to provide conservative estimates so that any structure designed to either of these standards would, in effect, possess an inherent factor of safety. This objective was met by selecting the higher of the two estimates provided by the Rational Method and the Regional Analysis.

TABLE 3.- Estimated Peak Instantaneous Flood Discharges for Tailings Impoundment Spillway

Location	Flood-Prediction Method			Adopted Flood Estimate (m^3/s)
	Rational Method (m^3/s)	Regional Analysis, Best-fit Curve (m^3/s)	Regional Analysis, Envelope Curve (m^3/s)	
Mean Annual Flood	0.7	0.4	1.0	0.4
200-Year Return Period Flood	4.5	1.0	3.9	4.5
1000-Year Return Period Flood	5.6	1.1	5.6	5.6

Note: Tailings Impoundment Catchment Area is 1.33 km^2.

3.5 GROUNDWATER

Groundwater conditions are quite variable within the mine area and its immediate vicinity. Jewelbox and North Hills, as well as the high ground on the east side of the tailings pond area, represent recharge areas for the local flow system. The most important boundary is the upper one, effectively the ground surface through which all significant recharge occurs. Because of generally shallow overburden cover and relatively competent bedrock, the infiltration capacity is low. Bedrock structure and the rugged topography likely contribute to the existence of a relatively localized flow system above the elevation of valley flows. Such flows were encountered in Jewelbox and Burnick underground mines.

A continuous shallow groundwater system exists in the valley bottoms of Tom and False Canyon Creeks and their tributaries. Recharge to these aquifers is both from local precipitation and by lateral inflow from adjoining hillsides. As a result, the valley floor represents a discharge area relative to the hilly terrain.

3.6 SEISMICITY

A seismic hazard assessment has been carried out for the site by the Pacific Geoscience Centre at SRK's request. The details are included in Appendix A of Volume V of the Water Licence Application. The assessment provides the peak horizontal ground acceleration as a function of probability of exceedance. With respect to the remoteness of the project site and the low risk in terms of loss of life, it was chosen to consider a 1 in 475-year seismic event. This event has a 10% chance of exceedance in 50 years.

The peak horizontal acceleration in bedrock resulting from the 1 in 475-year seismic event is 0.055 g. Qualitatively, this is equivalent to Zone 1 by National Building Code standards and represents a low seismic risk. Since the tailings are expected to be stored in the tailings facility in perpetuity one may argue that an inadequate seismic event was used for the design.

3.7 SOILS AND VEGETATION

3.7.1 Soils

Organics overlying morainal or fluvial material occur in wetlands such as in the Tera and False Canyon Creek areas. Upper alpine zones with little or no soil cover, are exposed on the hills above the treeline while colluvium-covered slopes occur below them.

A layer of silty loam or gravelly sandy loam supports white spruce and mixed deciduous forests. These moderately well drained soils are slightly acidic to neutral (pH 6.1 to 7.3) with low to moderate organic matter and with a low level of available nutrients. Wetlands supporting black spruce vegetation have soils of mesic, fibric peat or silty loam. These poorly drained soils are slightly to strongly acidic, have high organic matter and have very little nutrients available. Alpine and sub-alpine vegetation is found on moderately well drained silty loam or loamy sand. These soils are slightly acid to neutral with low organic matter and with a low level of available nutrients.

3.7.2 Vegetation

The Sä Dena Hes mine site is located in the Liard Basin Ecoregion (ESWG, 1995). The site includes boreal forest, sub-alpine and alpine vegetation zones with treeline at an approximate elevation of 1400 m a.s.l. A terrain mapping program consisting of aerial photographic interpretation augmented with field reconnaissance was completed for the IEE. The results were presented in the IEE, Volume IV, Section 2.1.2 (SRK, 1990). A more current vegetation inspection was conducted in July 1999 by SRK and its results are summarized in the 1999 SRK/Access preliminary reclamation study. The following vegetative description of the site is an excerpt from this report.

Climax vegetation in the boreal forest zone is either white spruce (*Picea glauca*), black spruce (*Picea mariana*), subalpine fir (*Abies lasiocarpa*) or a combination of these species. Black spruce and alpine fir are the most common boreal vegetation communities in the area. Black spruce forest is prevalent on poorly drained bogs and fens such as those in the tailings impoundment area. Open stands of black and white spruce are found on upland slopes. The area around the mill and camp upwards to the treeline is primarily subalpine fir.

Paper birch (*Betula papyrifera*) occurs on moist sites throughout the area. Trembling aspen (*Populus tremuloides*) is found on well-drained south-facing slopes, and balsam poplar (*Populus balsamifera*) colonizes alluvial gravel bars and other moderately well-drained disturbed sites. Lodgepole pine (*Pinus contorta*) forms pure even-age stands in some upland areas on the mine site, presumably following fire. Larch (*Larix laricina*) is found in lowland bogs along the main access road.

Willow (*Salix spp.*), alder (*Alnus crispa*), rose (*Rosa acicularis*) and Labrador tea (*Ledum groenlandicum*) are the common understorey shrubs. Mountain ash (*Sorbus scopulina*) is found in the tailings impoundment area. Ground cover is dominated primarily by kinnikinnick (*Arctostaphylos uva-ursi*), bearberry (*Arctostaphylos rubra*), crowberry (*Empetrum nigrum*).... End of line was missing from your sheet.

3.8 WILDLIFE

The mine area encompasses several mature mountains with a predominance of boreal forest and limited alpine and sub-alpine terrain. This habitat is capable of supporting various ungulates, large carnivores, other fur-bearers and many bird species.

Wildlife habitat within the Sä Dena Hes Mine project area was studied in 1989. This investigation involved a review of published and unpublished reports on wildlife in the Southeast Yukon, wildlife surveys and trapline catch information, interviews with personnel knowledgeable about the area, and field reconnaissance. The results are contained in Section 2.4 within the "Mt. Hundere Development Initial Environmental evaluation, Supporting Document IV, Biophysical Evaluation" (SRK, 1990).

3.9 FISHERIES

Fisheries monitoring programs have been conducted concurrently with the biological monitoring program, as stipulated in the water use licence, every two years since 1992. Baseline fisheries investigations of drainages within the Sä Dena Hes study area were completed by Environmental Sciences Ltd. (ESL) on the False Canyon Creek drainage in June and September of 1989 as a component of the Initial Environmental Evaluation for the Mt. Hundere Development. ESL also conducted fish surveys on the Tom Creek drainage as well as on a tributary to Francis River, where grayling and slimy sculpin were captured. A summary of the results from this investigation are provided in Chapter 2.5 of the report entitled *"Mt. Hundere Development Initial Environmental Evaluation, Volume IV Biophysical Evaluation of Project Site"*, (SRK, 1990).

Pre- and post-development fish sampling indicate that fish production capabilities in the upper False Canyon Creek drainage are relatively low. The most productive area within the system appears to be the lower reaches of False Canyon Creek near the confluence with the Frances River.

Six species of fish were found within the False Canyon Creek drainage: slimy sculpin (*Cottus cognatus*), Arctic grayling (*Thymalius arcticus*), round whitefish (*Prosopium cylindraceum*), burbot (*Lota lota*), northern pike (*Esox lucius*), and char species (*Salvelinus sp.*). Slimy sculpin were the most abundant species captured, representing 75% of the total catch, followed by Arctic grayling at 20%. There was reported no significant change in the occurrences or fish types since the start of the mining operation.

Two baseline benthic invertebrate investigations were conducted within the Sa Den Hes study area prior to mine development. In September 1989, ESL collected baseline benthic invertebrates from 23 sites. Samples from only three of these sites were identified and analyzed, and the remaining 20 were archived. A discussion of this study was provided in the report entitled *"Mt. Hundere Development Initial Environmental Evaluation"*, Volume IV Biophysical Evaluation of Project Site, (SRK, 1990). In July 1990, Environmental Protection Services (EP) of Whitehorse, Yukon, conducted baseline biological monitoring at ten sites, four of which lie within the False Canyon Creek drainage. Details of this study are reported in the "*Mount Hundere Baseline Study, June 1988 and June 1990.* Data Report No. 94-02. Environmental Protection Branch. 1994.

Baseline stream sediment samples were collected by Environmental Protection Services (EP) in 1988 and 1990 (EPS, 1994). Stream sediment samples have been collected concurrently during the biological monitoring program as described in the water licence, every two years since 1992. In 1998, assessments were also conducted on North Creek upstream and downstream of the North Creek dike. These data indicate that effects on sediment metals concentrations due to mine operations were apparent at ten kilometres downstream, but were undetectable beyond that.

3.10 TRADITIONAL LAND USE

Land use in the area surrounding the Sä Dena Hes Mine property was addressed in the IEE for the project (SRK, 1990). The IEE should be referred to for a detailed discussion of the results of those investigations. Table 4 provides a summary of current and historical projects/activities within this area.

There have been a variety of activities in the area, most of which have taken place around the Robert Campbell Highway. Yukon Territorial Government and Federal Government departments have also historically conducted various works along the highway, such as right of clearing and maintenance. There are a few privately held lots along the highway and various First Nation site-specific and land claims within the general vicinity of the property area. In addition to the mineral claims held by the Sä Dena Hes Operating Corporation, there are a number of mineral claims held within the area by various parties. Various trapping concessions are held in the project area and actively trapped. Current trapping and hunting are the primary activities in the project area. Much of the hunting is conducted from the roadways. Various trapping concessions are held in the project area and actively trapped. Currently trapping and hunting are the primary activities in the project area. Much of the hunting is conducted from the roadways. Various trapping concessions that are held in the project area are summarized in Table 4.

An evaluation in 1990 of current use of the Mount Hundere area by First Nation residents of the Watson Lake area found that primary use of the area was for hunting, fishing, and trapping. No spiritual or special places were identified. The study hypothesized that the impact of the project would not necessarily come from the mine itself, but rather the increased pressure of hunting from both natives and non-natives along the access road.

TABLE 4.- List Of Previous And Current Activities In The Mine Area

Activity Type	Permit Licence Holder	Comments
MAP SHEET 105A/6		
MINERAL TENURE		
MC Lots, 1-21	Glimmer Resources	Mineral claims designated GMS (expire 01/08/11
MC Lots, 1-21	Minofocus International Inc.	Mineral claims designated BOMB (expire 99/10/10)
MC Lots 1-32	Pacific Bay Minerals	Mineral claims designated CAM (expire 02/02/26
MC Lots 13-1583 (various)	Cominco	Mineral claims designated HOLMES (expire 01/12/15)
MC Lots 1-144	McCrory Holdings Ltd.	Mineral claims designated EAGLE (expire 05/08/24)
WATER USE		
LAND USE/MINERAL LAND USE		
YA3W436 (expired 96/04/30)	Kaska Forest Resources	Activities related to forestry THA Liard Block
YA5Q025 (closed 97/09/13)	YTG-CTS	Blanket maintenance km 10-50.5 Robert Campbell Highway
YA6S187	YTG-CTS – Transportation and Engineering	Geotechnical investigations at various locations between km 55-232 Robert Campbell Highway
YA6E255 (closed 98/04/21)	YTG-CTS	Right of way clearing km 55-232 Robert Campbell Highway
YA6S260 (expired 99/01/31)	YTG-CTS – Transportation and Engineering	Geotechnical investigations at various locations between km 34-222 Robert Campbell Highway
YA7N301 (closed 98/04/30)	Geological Survey of Canada – Dr. Isa Asudeh	Seismic geological investigations
YA7X296 (closed)	Ivan Johnson	Establish a portable sawmill on the site within a timber operating unit, in the vicinity of km 43 Robert Campbell Highway
OTHER		
S-67, S-68, S-168, S-265, S-79	Liard First Nation	Site-specific lands
Various trapping Concessions continued from other maps sheets (see below)		

Activity Type	Permit Licence Holder	Comments
MAP SHEET 105 A-10		
MINERAL TENURE		
MC Lots 42-46	Sä Dena Hes Operating Corp.	Mineral claims designated JEWEL (expire 99/08/24)
MC Lots 120-308	Sä Dena Hes Operating Corp.	Mineral claims designated HUN (expire 09/03/01)
MC Lots 329-422	Sä Dena Hes Operating Corp.	Mineral claims designated HUN (expire 02/09/06)
MC Lots 1-8	Sä Dena Hes Operating Corp.	Mineral claims designated HAWK (expire 03/08/24)
MC Lots 1-78	Sä Dena Hes Operating Corp.	Mineral claims designated CIMA (expire 09/03/01)
MC Lots 1-12, 40, 41	Sä Dena Hes Operating Corp.	Mineral claims designated MICA (expire 09/03/01)
MC Lots 1-22	Sä Dena Hes Operating Corp.	Mineral claims designated THUNDER (expire 03/08/24)
MC Lots 1-10, 19, 20	Alex Black	Mineral claims designated ECHO (expire 99/10/05)
WATER USE		
IN90-002	Mount Hundere Joint Venture	Original water licence for project was to expire 00/09/15. Licence was amended QZ97-025 by new owner Sä Dena Hes Operating Corp.
QZ97-025	Sä Dena Hes Operating Corp.	
QZ97-091 (expires 04/12/31)	Sä Dena Hes Operating Corp.	Type B water licence to construct a runoff catchment berm, at km 15.5 of main mine access road.
OTHER		
S-219	Liard First Nation	Site-specific land
R-15	Liard First Nation	Settlement land
Registered Trapping Concession #356	Jim Stewart/Andy Szabo	Trapping Concession
MAP SHEET 105 A/07		
MINERAL TENURE		
MC Lots 1-144 (various active)	Sä Dena Hes Operating Corp.	Mineral claims designated GMN (expire (05/10/26)
LAND USE/MINERAL LAND USE		
Tom Creek Lookout Site	DIAND – Fire Management	Lookout tower and cabin designated YFS 001
OTHER		
R-15	Liard First Nation	Settlement Lands
Registered Trapping Concession #358	Leo Stewart	Trapping Concession
Registered Trapping Concession #359	Alice Broadhagen	Trapping Concession

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For a more comprehensive description the reader is referred to the afore-mentioned IEE Volume III, Appendix C (SRK, 1990).

4.0 MINE WORKINGS

This section discusses the mine workings, their characteristics and physical stability. Surface facilities, such as buildings and other mine infrastructure are considered under a separate heading. Figure 4-1 shows the current mine infrastructure and water monitoring stations.

4.1 JEWELBOX ORE BODY

The Jewelbox ore body is located on the hill of the same name, west of the mill. Curragh started development of this ore body in 1990 and produced ore using several different underground mining methods. These methods included room and pillar, mechanized cut and fill, and longhole stopping. At the end of the mine operation Curragh reportedly high-graded this resource, rendering the recovery of the remaining reserves expensive.

The surface features of Jewelbox include the 1408 Portal, the 1250 Portal, two ventilation raises, a small open pit and the associated waste rock dumps. The main safety issue is access to mine workings.

In 1999, the water level in the workings was at the 1,344 m elevation and slowly increasing. Prior to the dewatering of the workings by Cominco in December 1998, the water level had been recorded at the 1,350 m elevation after the mine had been closed for approximately four years. It is not known what would be the stabilized water level or if it could reach the portal elevation of 1,408 m.

The 1250 Portal is located on the north side of Jewelbox Hill, in the Camp Creek catchment. Original mine plans considered underground mine development from this portal, but subsequent exploration did not confirm expected ore reserves. As a result, there is no significant tunnel at this portal.

The mine workings at Jewelbox are ventilated by two ventilation raises that extend up from the underground workings to 'daylight' on the hillside above the 1408 Portal. One of the ventilation raises is located near the summit of Jewelbox Hill, while the other is located immediately up slope behind the shop building at 1408 Portal.

The Jewelbox pit is located above the Main Zone pit (Figure 4-1). The pit bottom is at elevation of 1,400 m and its rise at 1,430 m. Surface runoff forms a pond in the bottom of the pit which fluctuates seasonally. Pit walls continue to degrade and experience periodic rock falls, causing a safety concern.

The waste dumps associated with the mining of Jewelbox and Main Zone represent one of the major terrain disturbances at the Sä Dena Hes minesite. Waste rock from the Jewelbox underground was placed immediately below the 1408 Portal and covers and area of 2.6 hectares. In the upper section of this dump (1.3 ha), the material was placed in two to three lifts with berms. The material was end-dumped on relatively steep slopes at the angle of repose (1.3:1) causing localized sloughing. However, it is not believed that this instability represents a significant hazard.

Waste rock from the Jewelbox Pit was dumped on a ridge immediately east of the pit. The dump was built in two phases with the ultimate crest at elevation 1,442 m and covers and area of about 1.9 hectares. The side slopes of the dump range from 1.3:1 (H:V) to 2:1 (H:V).

Waste rock was also deposited on relatively steep ground immediately below the upper Jewelbox pit dump. The face of this dump is about 1.3:1 (H:V) and the crest has been over-steepened. The dump covers an area of about 0.4 hectares.

Waste rock from the Jewelbox Pit can also be found above and below the access road to the Main Zone Pit. This material was end-dumped on relatively steep ground with the dump faces at slopes of 1.3:1 and covers an area of about 0.9 ha. Rocks from localized rock falls are deposited downslope from the toe of this dump.

4.2 MAIN ZONE ORE BODY

The Main Zone is located in the head area of the Camp Creek catchment and north of the Jewelbox Zone. The Main Zone workings consist of a pit, an adit and waste dumps. There are no significant underground workings associated with this ore zone. Access into the adit and raveling of open pit walls represent the main safety concerns.

The adit, sized 4.5 m by 4.5 m in section, is located at an elevation of 1,380 m. No underground development was undertaken from this adit. A low volume seepage discharges from the adit into the Main Zone pit.

The Main Zone pit is the lower of the two open pits on the south flank of the Camp Creek headwater area. The pit is a sidehill excavation with the pit floor at elevation 1,370 m, rising to an elevation of about 1,400 m with relatively steep slopes. Degradation of pit walls causes periodic rockfalls, constituting a safety hazard. Low concentrations of iron sulphides, in association with abundant carbonates, are not expected to trigger acid generation. As noted above, the drainage from the 1380 Portal flows into this pit but infiltrates into the pit floor and through the waste dump is discharged into Camp Creek.

Waste rock from the Main Zone pit was end-dumped on the hillside below the pit floor, into the headwaters of Camp Creek. The slope of the dump is about 1.3:1 and covers an area of about 0.3 ha. The waste rock is composed primarily of limestone with some ore-type skarn material. Some of the skarn had decomposed resulting in the release of coarse sphalerite and galena-rich sand. Water was seen flowing inside the dump, presumably originating from the Main Zone pit or the Jewelbox pit.

Phyllite waste rock was also end-dumped on the hillside above Camp Creek and adjacent to the 1250 Portal. This dump is relatively small (less than 0.2 ha) with a slope of about 1.3:1. This dump reportedly contains no mineralized material.

4.3 BURNICK ORE BODY

The Burnick ore body is located on the North Hill, approximately 4 km north from the mill. There are three portals and a waste dump associated with this mine. Very little development has been done to date; however, future mining is planned, including possibly an open pit.

At the 1,200 m level of the Burnick mine, there are two portals separated only by a several metre-wide rock wall. The north portal is the main access to the Burnick ore body, while the south portal provides propane heating for the ventilation air. Mine water drains from the ventilation portal at a rate of approximately 15 l/min during winter and about two or three times bigger during the warm season. In 1998, Cominco built a temporary shotcreted dam inside the ventilation portal to control sediment in the discharge.

The third portal is at elevation 1,300 m and accessible by an old exploration road. This portal is currently sealed to limit movement of air through the workings. There is no mine water drainage from the portal.

The waste rock from the Burnick Zone workings is located in a sidehill dump immediately below the 1,200 m portal and covers an area of about 1.4 ha. The dump crest is about 100 m long and the dump height is about 50 m. The northeast portion of the dump is unstable. The slide headscarp traverses the existing shop building floor. This slide appears to be deep-seated and its movement continues.

A small settlement basin (a dugout) is located downslope from the rock waste dump. No significant flow into this pit was observed during the previous summer inspections.

4.4 TAILINGS STORAGE

As previously stated, the tailings pond straddles the headwaters of two local catchment areas. This is a significant advantage since no stream diversion was required for the pond itself. On the other hand, this topography necessitated construction of two cross-valley dams, referred to as the North Dam and South Dam, between which the tailings are stored. In order to allow deposition of tailings only within the northern segment of the pond, a coffer dam was constructed (by end-dumping of till material) approximately midway between the north and south dams. However, towards the end of 1992, tailings were pumped into the southern portion of the pond as well. South of the tailings impoundment is the reclaim dam which detains supernatant water decanted from the tailings pond.

The original design of the south dam, at the Sä Dena Hes tailings impoundment, called for the construction of a starter dam to elevation 1,098 m and a crest width of 10 m. However, in order to defer construction costs, the mine decided to construct the starter dam in two stages. The first stage of the starter dam, which was completed in July 1991, was built to elevation 1,096 m with a crest width of 7 m. The south dam was extended in 1992, supposedly by two metres, to the originally proposed design elevation (1,098 m) of the starter dam. However, due to the inclement weather in the fall, the construction was discontinued and the upstream side of the crest was left at elevation 1,996 m while the downstream segment of the crest was built-up to elevation 1,997 m (Photo 2). Heavy seepage and some soft spots were observed (since 1991) along the toe of the south dam, triggering concern about the dam stability. This condition was considered to be potentially hazardous. A stability analysis, undertaken by Geo-Engineering, indicated the Factor of Safety against sliding to be in the order of 1.3. To mitigate this condition, Cominco contracted SRK to provide design and inspection services for the construction of the toe buttress, which started in September 1997. However, due to freezing

Photo 2: View of the South Dam and deposited tailings.

Photo 3: Windblown tailing at the north dam.

temperatures and heavy snowfall, work on the buttress was terminated on October 2, 1997. The project was restarted on July 15, 1998 and the buttress was completed on July 21, 1998.

The soils at the tailings impoundment and reclaim pond comprise up to about 1 m of organic soil underlain by mixtures of gravel, sand and silt of varying gradation which are, in turn, underlain by shale or phyllitic bedrock. In general, the soils thicken towards the bottom and south end of the valley. For example, the till is only a few metres deep at the north dam; about 5 to 12 m deep at the south dam and in excess of 19 m deep at the reclaim dam. The pre-construction groundwater table was encountered at or just below the ground surface in the valley bottom and at variable depths along the sides of the valley. Some sand and gravel layers were found to be of high permeability and, as a result, the anticipated (design) seepage losses were exceeded.

The current configuration of the starter dam includes an upstream slope of 2:1 (H:V) and a downstream slope of 2.5:1, as shown on Figure 4-3. A sand and gravel drain covered by geotextile filter fabric was constructed at the base of the south dam. It starts at about the dam centerline and extends the downstream toe of the original starter dam. The original design also called for the downstream half of the dam to be constructed of sandy till. As construction progressed, it became apparent that there would be a shortage of sandy till and the design was modified. The modification consisted of replacing the sandy till with silty till and placing a 6 m thick zone of sand and gravel along the downstream face as erosion protection. At the crest, silty till was placed to a depth of at least one metre across the entire width in order to maintain a minimum horizontal width of 4.5 m of silty till on the upstream face.

As noted above, a 12 m wide and 100 m long toe buttress was constructed across the deepest portion of the valley at the toe of the south dam. The buttress consists of a shot rock foundation layer, capped by an 0.3 m thick bedding layer of sand and gravel, and covered by a layer of geotextile filter fabric. A drainage blanket of screened sand and gravel was then placed to a minimum depth of 1 m extending out a distance of about 11 m from the original dam toe. The original 1990 drainage blanket was exposed to provide reasonable continuity with the new blanket. A second layer of geotextile was then placed over the drainage blanket prior to placing the final top zone of the buttress. The top zone or cap consists of pit run sand and gravel.

The north dam was designed with a centre low permeability core with silty till shells but without a drainage layer and a toe berm (Figure 4-3).

An emergency spillway, consisting of two 900 mm diameter corrugated steel pies (CSP), was constructed at the west abutment of the south dam. No spillway exists on the north dam.

Instrumentation in the dam consists of piezometer nests and settlement gauges. Four of the piezometer nests are located along the top of the south dam and one set is located at its downstream toe.

The stability of the proposed extension of the south dam crest to elevation 1,098 m was assessed by SRK in 1992 using the computer program CLARA, Version 2.31. The stability was analyzed along the maximum dam section at Station 0+460 for both static and seismic (dynamic) loading conditions. The dynamic loading conditions were approximated by the pseudo-static method, with a maximum horizontal acceleration of 0.069 g, which has a probability of exceedence in 50 years of 10 percent. The dam material, as well as the foundation soil, were assumed to have an internal friction of 35 degrees and zero cohesion.

The phreatic surfaces were based on the June 1991 piezometer readings. The piezometers indicated that, at the bedrock/till contact, there is a zone of high pore pressure which has been modeled in foundation soil "A". The dam materials were assumed to be to the water table in the embankment. Piezometer readings from the zone of high pore pressure at the reclaim dam indicate that the rise in pore pressure at the downstream toe is approximately half the rise in the pond elevation; this condition was assumed to apply at the south dam. Assuming a 2 m freeboard, the maximum pond elevation for the south dam, with its crest at elevation 1,098 m, will be about 3 m higher than in 1991.

The results of the analyses show the most critical shallow, intermediate and deep failure surfaces. All analyses were run with circular failure surfaces using Bishop's Simplified Solution. The factors of safety (FS) obtained are as shown on Table 5:

Table 5.- Computed Factor of Safety

Failure of Surface	Static	Pseudo-Static
Shallow	1.6	1.3
Intermediate	1.7	1.3
Deep	1.7	1.4

Both dams were inspected regularly by DIAND's Water Resources personnel and by the undersigned. The most recent inspection was undertaken in September 1999 and observations made are summarized below.

Very few changes have occurred at the north dam since its construction. Dry tailings in the pond are at the crest of the dam (elevation 1,098 m) at the west abutment and about 1 m below the crest at the east side. Airborne tailings are deposited on the crest and downslope side of this dam. No cracks or deformations were observed.

Seepage is discharged at and slightly above the toe of the north dam. It appears that the volume of seepage from both abutments is of the same magnitude since 1991. Seepage from the east abutment continues to be lighter than from the centre and west side. Iron precipitates exist locally. It was estimated that the total flow is in excess of 2 l/s (25 igpm). The flow from a pipe installed downstream from the dam was reportedly 0.7 l/s (SRK, October 20, 1993). Minor sand boils occur at the toe of the dam in the valley bottom and on the west abutment. However, there is no evidence of material transport. Moderate softening of the toe of the dam embankment has been noticed at some of the seepage zones.

South dam shows signs of deformations along the upstream dam face. An almost continuous crack was observed on the dam crest, paralleling the face, in 1999 There were four minor and shallow slumps on the upstream dam face which were upgraded prior to the 1999 site visit. Erosion rills are relatively deep on the downstream side of the dam. Water (seepage) was heard to run through the toe berm. It was estimated, prior to the construction of the toe berm, that seepage at the low point of the dam could be in the order of 60 l/min. Heavy seepage was observed discharging from the east abutment.

An interceptor ditch is located above the tailings pond on the east side of the catchment. This ditch is supposed to direct runoff away from the pond both to the north and the south. However, no flow was observed by the writer. Drainage ditches associated with the access roads on the west side of the tailings pond direct runoff away from the facility on the west side.

4.5 RECLAIM POND

A reclaim dam was built to retain supernant water decanted from the tailings pond for reuse in the mill. The dam is about 18 m high at the maximum section with both slopes at 2.5(H):1(V). The mine plan involved recycling of the reclaimed water to the mill with a controlled discharge into Camp Creek from April to October each year. During operations and when the pond water level became too high, water was decanted from the tailings pond to the reclaim through a concrete decant tower (located adjacent to the upstream crest of the South Dam, as shown in Figure 4-3) and an 0.5 m diameter corrugated steel pipe ("SCP") into the reclaim pond. Water was discharged from the reclaim pond to Camp Creek during the licenced allowable discharge period, April through to October. The reclaim pipeline (about 300 mm dia.) is located along the west side of the access road to the mill as shown on Figure 3-6. A short section of the pipe near the reclaim pumphouse is buried.

Foundation conditions at the reclaim pond were found to be complex, requiring modifications of the original design. On the east side of the valley, the bedrock (phyllite) was found 1 to 2 m below ground surface, while on the west valley slope it was encountered at depths of up to 20 m. The overburden materials are stratified and comprise two layers of sand and gravel interspersed with a till layer, capped at the ground surface with another till layer. Significant pore pressures were encountered in granular materials.

The reclaim dam (Figure 4-4) was designed as a zoned structure with a low permeability upstream section, key trench and inverted gravel filter at the downstream toe. The filter was covered, in 1992, with a toe support berm, comprised of blast rock 0.5 to 2.0 m in diameter. In addition, an about 50 m long and up to 1.3 m thick till blanket was placed into the original creek channel.

The buttress constructed in 1992 did not reach to the east abutment which became unstable, chiefly because of heavy seepage (estimated at 120 l/min). Cominco eventually extended the rock buttress to shore the unstable area.

No significant deformation or fissures were noticed on this dam during past inspections.

Camp Creek, in the area of the reclaim pond, was diverted by a cut-and-fill canal located on the west side of the pond. The diversion is about 0.5 km long and the creek flows through the reclaim pond overflow spillway and a rock-lined chute into its original channel. Minor sloughing occurs periodically at several locations of the channel. Attempts to control erosion, using corrugated steel segments, were not very successful.

The spillway is a rock-lined channel with two steel corrugated culverts (below the access road to the pumphouse and the dam) and an exit chute. The spillway was designed for a 1 in 200 year flood event.

There are two sections along the south side of the exit chute (Photo 4) where the rip-rap erosion protection is too low and does not provide sufficient freeboard for the design flow. One is at the beginning of the cute and the second one about 50 m above the bottom. The stilling basin at the chute is also poorly rip-rapped (Photo 5).

Erosion has occurred at both the outlets and inlets to the spillway CMP's. The erosion at the inlet end is caused by runoff from above the road that flows through the tailings pipeline CMP conduit.

Because of high pore pressures in the reclaim dam foundation, the designer (SRK) recommended that the water level in the pond should be maintained at or lower than elevation 1,079.5 m to ensure embankment stability. Monitoring of the seepage at the toe should be continued on Piezometers RDW-2A, 2B, 2C, 3A, 3B, GW1A and 1B.

4.6 MINE INFRASTRUCTURE

The main components of the mine infrastructure are the ore concentrator (the "mill"), associated warehouses, storages, service buildings and the camp. Table 6 lists the various infrastructure components and their dimensions or other characteristics.

Figure 4-5 depicts the general arrangement of the central office, accommodation and mill site buildings and services. Other infrastructure and facilities associated with outlying mine components, such as the Jewelbox mine shop and office are also listed in Table 6. A brief description of the main infrastructure components is presented in the following paragraphs.

Photo 4 : General view of the reconstructed spillway chute at the Reclaim Pond dam.

Photo 5 : Detail view of the chute.

Table 6.- Infrastructure Description

Component	**Description** *(Note, all concrete slabs 0.20 m thick)*
CONCENTRATOR BUILDINGS	
Concentrator Complex	Area of 1761 m^2, 352 m^3 concrete slab
Crusher House	8 m x 12 m metal building 91 m^3 concrete slab
MCC	6 m x 11 m metal building, 14 m^3 concrete slab
MCC	6 x 13 m, 16 m^3 concrete slab
Reagent Bins	2 m x 5 m, 2 m^3 concrete slab
Coarse Ore Bin	9 m x 8 m, 14 m^3 concrete slab
POWER HOUSE	13 m x 27 m metal building, 77 m^3 concrete slab
SERVICE GARAGE	13 m x 15 m, metal clad building, 41 m^3 concrete slab
ACCOMMODATION BUILDINGS	
Bunk Trailer (10)	7 m x 33 m metal trailers (removable)
Bunk Trailer (10)	8 m x 64 m metal trailers (removable)
Bunk Trailer (10)	8 m x 50 m metal trailers (removable)
Kitchen Trailers (4)	19 m x 39 m metal trailers (removable)
Office Trailers Complex	22 m x 23 m, 98 m^3 concrete slab
MISCELLANEOUS BUILDINGS/STRUCTURES	
Ambulance Garage	13 m x 10 m metal building
Water Distribution and Pump House	Area = 182 m^2, metal clad building
Warehouse	8 m x 14 m metal trailer (removable)
Security and First Aid Building	8 x 14 m metal trailer (removable)
Cold Storage Warehouse	10 m x 16 m metal building
1480 Portal Shop	20 m x 10 m metal clad building, earth floor, concrete footings
1480 Portal Office	4 m x 10 m ATCO trailer
1480 Portal Fuel Tanks	2 tanks, 2,000 l in bermed enclosure
Burnick 1200 Portal Shop	40 x 20 m metal clad building, earth floor, concrete footing
Burnick 1200 Portal Fuel Tank	
Miscellaneous Core Racks, Gribbler Ridge	Wooden structures
Water Storage	17 m x 3 m, storage tank
Radiator Banks	5 x m 8 m, 8 m^3 concrete slab
Storage Slab	6 m x 47 m, 57 m^3 concrete slab
Warehouse and Dry Lab	Area of 760 m2, 152 m^3 concrete slab
Ball Storage	3 m x 5 m, 3 m^3 concrete slab
Diesel – 5,000 l; Gasoline – 2,000 l	Area of 729 m2, 56 m^3 concrete slab
Decant Tower	50 m^3 reinforced concrete structure
NORTH CREEK DYKE	
1480 Portal Electrical Transformer	Power poles, chain link fence
Water Intake Pumphouse/Stop	2 m x 3 m wooden sheds (x3); 1.2 m^3 concrete slab

The ore concentrator (the "mill") is comprised of the mill building itself, the crusher house, conveyors, and truck load-out facility. All buildings are made from steel and constructed on concrete slab flooring. A list of equipment currently located in the mill is found in Table 7.

The mill building houses the ball and sag mills, as well as other processing equipment.

The power house contains three diesel generators which supply power for the entire mining operation. The power is distributed via approximately 6 km of three-phase, overhead power lines. There is also approximately 600 metres of 60 mm diameter "TEC" cable leading from Jewelbox 1440 portal to the Main Zone pit.

The water supply system consists of a series of three electrical 100 hp water pumps housed in 2.5 m x 2 m wooden shacks. These pumphouses are located in the lower North Creek drainage. There is approximately 2 km of water line (300 mm dia.). The disturbed area around the pumphouses at False Creek Canyon was previously reclaimed.

The North Creek dyke is located about 1 km north of the existing tailings impoundment. The dyke was not designed and was constructed in the summer of 1991 by Golden Hill Ventures (GHV). The dyke was constructed to provide a reservoir from which water was pumped to the northern end of the tailings impoundment in preparation for the start-up of the mill.

The dyke has a maximum height above original ground of about 5 m, it is about 50 m long and the crest is 7 to 10 m wide. The dyke slopes are 2.5:1 to 3:1. Fill used to construct the dyke is a silty sandy till and it is estimated that about 200 m^3 of this material was placed without significant compaction. This caused settlement and localized shallow sloughing. The dyke was graded several times and recently (1999) appeared to be stable.

A 600 mm diameter pipe at the base of the dyke allows flow in the North creek to pass through the dyke. Three other culverts, varying in size from 600 to 1000 mm in diameter, provide capacity to pass the 200-year event. A plan of the dyke, showing the current location of the culverts and layout of the dyke, is shown on Figure 4-6.

The service garage is located north of the mill and office complex. A 13 m x 15 m metal clad building is founded on a concrete slab.

Table 7.- Mill Equipment List

Equipment	Manufacturer	Quantity	Size	Remarks
Grizzly		1	760 mm x 760 mm	
Rock Breaker	Teledyne	1	30 kW	Hydraulic
Reciprocating Feeder	Universal Engineering	1	1525 mm x 4267 mm	
Jaw Crusher	Allis Chalmers	1	1220 mm x 1067 mm	Used
Ore Conveyor	Trans-Continental	1	900 mm	500 t/p
Belt Magnet	J.F. Comer	1	3 H.P.	
Reclaim Conveyor	Trans-Continental	1	900 mm	250 t/h
Reclaim Vibrating Feeder	AISCO	1	1067 mm x 2240 mm 5 H.P.	
Ore Bin	GEM Steel	1	200 t	
SAG Vibrating Feeder	AISCO	1	1067 mm x 2240 mm 5 H.P.	
SAG Feed Conveyor	Trans-Continental	1	900 mm	100 t/h
SAG Mill	MPSI	1	5500 mm dia. X 2134 mm, 970 H.P. Var.Sp.	
Liner Handler	McLellan Industries	1		
SAG Discharge Pumps	G.I.W.	2	150 mm x 100 mm 60 H.P.	
Vibrating Screens	Simplicity	1	1525 mm W x 3600 mm L., 10 Mesh, 25 H.P.	
Ball Mill	Allis Chalmers	1	3050 mm dia. x 3680 mm, 900 H.P.	Used
B.M. Discharge Pumps	I.T.T.	2	250 mm x 200 mm 60 H.P.	
B.M. Cyclones	Technequip/Krebs	2	D20B	
Lead Unit Flotation Cells	Outokumpu	4	5.1 m^3, 25 H.P./Cell	
Lead Unit Cell Blower	Roots	1	297 m^3/hr., 24.8 kPa	
Flotation Cells, Lead Rgh and zinc Rgh	Denver	2 sets, 15/set	5.7 m^3, 25 H.P./Cell	Used
Lead and Zinc CLNR Flotation Cells	Denver	2 sets, 14/set	1.4 m^3, 7.5 H.P./Cell	
Lead Regrind Mill	Taylor	1	1830 mm x 2140 mm 150 H.P.	
Lead Regrind Mill	Taylor	1	1830 mm x 2140 mm 150 H.P.	
Lead Rgr Cyclones	Techniquip/Krebs	3	D6B	

Equipment	Manufacturer	Quantity	Size	Remarks
High Rate Thickener	Outokumpu/ Supaflo	2	4600 mm dia.	
Lamella Clarifier	Lamella	2	570 mm x 55°	
Slurry Storage	GEM Steel	3	5500 mm dia. x 14000 mm	
Pressure Filters	Filtra Systems	2	Lead - 28 m^2, Zinc - 32 m^2	
Concentrate Bin	GEM Steel	2	3500 mm dia. x 9000 mm	
Minifab Flocculant Mixer	Allied Colloids	1	1 m3	Flocculant Mixing
Lime Grinding Mill	SALA	1	900 mm dia. x 1525 10 H.P.	
Fresh Water Tank	GEM Steel	1	200,000 USG	
Flotation Air Blower	Spencer	1	21240 lm^3/hr, 14.5 kPa	Used
Air Compressor	Ingersol Rand	2	2500 m^3/hr, 750 kPa, 350 H.P.	
Air Dryer	Xebic	1	170 lm^3/hr., 758 kPag	
Pressure Filter Air Receiver Tank	Ingersol Rand	1	1830 mm dia. x 4000 mm	
Courrier 30 OSA	Outokumpu	1	10 streams, Lead Zinc, Iron, % Solids	
DCS	Fisher Controls	1		
PLC	Allen Bradley	1		
Truck Scale	Canadian Weigh Scale	1	100 t	Computerized loading system
Diesel Generator	Midwest	2	2 MW	
Diesel Generator	Midwest	2	1 MW	

Note: Unless otherwise stated, dimensions are in millimeters.

Approximately 30 sleeping/wash ATCO trailers and 6 kitchen/recreation ATCO trailers provided the campsite accommodation. The wooden skirting was provided around the trailers for thermal protection and as a cover for piping and cable connections.

The office complex consists of six ATCO trailer units set up on wood block footings and joined under a common roof. The trailers around their perimeter are skirted.

At the Jewelbox Portal, there is a 13 m x 40 m metal shop building with earthen floor and concrete footings. Adjacent to the shop are fuel tanks with lined fuel berms, diesel generators and a mine office trailer.

At the Burnick 1200 Portal, there is a 13 m x 40 m metal shop with an earthen floor and concrete footings. The building is practically empty and a diesel generator which used to be in a separate shed on the north side of the building, was removed. Adjacent to the portal area is a large propane tank located in a lined berm.

A system of service and haul roads exists on the mine site. They were, generally, constructed using the cut-and-fill method and unless the drainage is maintained, they will degrade with time and cause siltation problems.

The main access road, constructed in 1990, was also chiefly developed using the cut-and-fill method. The width of the road is 8 m and the drainage courses were traversed using culverts and fill embankments. Regular maintenance of drainage works is required.

5.0 WATER QUALITY

Water quality monitoring at the minesite began in 1991, as set out in Schedule 'A' and Part 'C' and Part 'D' of Water Use Licence IN90-002 and it continues under the 1998 amendment to that licence, now Water Licence QZ97-025. At present, the licensed temporary cessation monitoring program is followed. The mine operates with water quality permit limits for wastewater as stated in the YTWB licence (effluent quality standards). These permit limits are consistent with the Metal Mine Liquid Effluents Regulations issued under the Fisheries Act. Detailed discussions of the pre-mine (baseline) site water chemistry are available in the IEE (Steffen, Robertson and Kirsten, 1990). The annual reports submitted by Curragh Inc., 1991-1993 and Cominco Ltd., 1994-1998, contain a complete record of all the water quality sample results from each monitoring station during the operational and temporary closure periods. Complete water quality data for the monitoring program are also presented in Appendix C of the initial draft report on the Decommissioning and Reclamation Plan prepared by Access and SRK in 1999. Water Quality Monitoring Data will also be available in electronic form.

Prior to 1991, baseline water quality sampling sites were established in the Tom Creek Drainage. The current water quality monitoring program is conducted within the immediate mine site area extending north of the main channel of False Canyon Creek to within 13 km of its confluence with the Frances River. The water quality monitoring program has stations located at strategic locations around the mine site to monitor effluent releases and within the False Canyon Creek catchment to track downstream receiving water quality. Figure 5-1 and Figure 4-1 show the current monitoring stations.

5.1 PRE-MININ WATER QUALITY

During the period from July to August 1989, SRK conducted three surveys to determine the baseline water quality of directly effected project watersheds, specifically in Tom creek and False Canyon Creek. SRK added these sites to complement existing sites established by Curragh Resources (CRI), and Environment Canada (EPS) in conjunction with DIAND Water Resources.

A summary of baseline water quality is provided in Table 8, which also lists Water Use Licence water quality discharge limits for wastewater (effluent quality standards) and CCME Canadian Water Guidelines (CCME, 1993).

Table 8.- Pre-Mining Background for Selected Water Quality Parameters

Catchment	Monitoring Station	Total Suspended Solids (mg/L)	Dissolved Sulphate (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)
False Canyon Creek	MH-7	82.5	4.5	<0.001	0.018
	MH-11	301.7	7	<0.001	<0.005
	MH-12	337	3.9	<0.001	<0.005
	MH-14	325	8.4	<0.001	<0.005
	MH-16	337	6.8	<0.001	<0.005
CCME Guideline		*Increase of 10% above background*	*80*	*0.007*	*0.003*

Note: Current stations correspond to IEE monitoring stations in the following manner MH-7 = E2, MH-11 = F8, MH-12 = F6, MH-14 = F7, MH-16 = F3.

Key water quality parameters of interest at the site included lead, zinc, cadmium, and total suspended solids. These parameters were selected from a review of the historic water quality database and from geochemical and metallurgical investigations conducted prior to mine development. Sulphate, a conservative element and one indicative of the extent of geochemical oxidation and metal leaching, was also evaluated.

5.2 PRESENT WATER QUALITY

The primary effluent releases to the receiving waters occur from the tailings dam as seepage discharges monitored at MH-2 and MH-7. Concentrations of lead and zinc are generally within permit limits, as set out in the Water Use Licence (QZ97-025). However, occasional increases in lead and zinc concentrations were observed during the operating period.

Dissolved sulphate concentrations are generally declining over time at those stations near the mine site itself, indicating that no significant oxidation and leaching of sulphides is occurring. The beginning of production in 1991 showed a rapid increase in sulphate concentrations at tailings dam seepages. These high levels began to decrease upon suspension of mining in 1992, with the exception of Station MH-2.

The results for sulphate and zinc at MH-2 show an increasing trend, but within permit limits; however, the water chemistry downstream of MH-2 (MH-12) shows no significant sulphate concentrations above baseline. Similarly, high concentrations of sulphate at MH-7, which peaked at 350 mg/l, are decreasing with time and diluted slightly once in receiving waters at MH-11 and decrease significantly (to near baseline) upon reaching Station MH-13.

Waste permit limits for the project are periodically exceeded at the portal discharges, and the corresponding parameters at monitoring stations further downstream consistently show levels less than CCME criteria.

Project activities and effluent discharges from the site primarily affect the False Canyon Creek drainage. Monitoring stations in this catchment are on various tributaries of the False Canyon Creek (Tributaries D and E), and the main stem of False Canon itself. From upstream to downstream, the stations on the main stem of False Canyon Creek are numbered MH-11, MH-13, MH-14, MH-16, and MH-19. Monitoring stations on Tributary E include MH-23 and MH-12, with MH-15 located on Tributary D.

Water quality monitoring summaries for selected key parameters and monitoring sites within the False Canyon Creek drainage are presented in Appendix C of the draft report on the Decommissioning and Reclamation Plans (SRK/Access, 1999) Figure 3-20 and 3-21 track water quality trends in False Canyon creek starting at the headwater stations (MH-11 and MH-12), and moving downstream to the lower station on False Canyon Creek (MH-16) for zinc and cadmium, respectively.

Water quality monitoring from the beginning of production has shown no significant effect to downstream water chemistry in the False Canyon Creek drainage area. Seasonal variations in suspended sediment loading and some metal concentrations (lead and zinc) has occurred, with individual sampling dates showing some exceedance of CCME Guidelines for Freshwater Aquatic Life.

Total Suspended Soils concentrations are reasonably consistent over the monitoring period. There are a few examples of sampling occasions where the concentrations were elevated, particularly at Station MH-11. These exceedances occurred mainly during the operational period and were related to spill events.

6.0 CLOSURE

The future of the Sä Dena Hes mine is uncertain. The mine could be reopened or abandoned at the present stage of development. It is understood that the draft report on Decommissioning and Reclamation Plan (developed by Access/SRK in 1999) considers both alternatives.

The long-term physical stability of the tailings embankments and the chemical stability of the tailings themselves are the key issues. The physical stability, in turn, depends on seepage conditions in the dams, design flood and seismic events. The chemical stability concern is, at the present time, related primarily to the zinc loading.

As discussed in the report, erosion and siltation control is required at various portions of the mine infrastructure, including the main mine road. Again, the degree of degradation of these structures would depend on the maintenance and timing of the mine closure.

The closure cost estimate for the Sä Dena Hes mine, as prepared by Mr. R. Rodger, was $3,434,000.00 (R. Rodger, October 1997).

The financial security called for in Water Licence QZ97-025 is set out in Part B – Security, as follows:

> *"14. The Licensee shall provide security in the total amount of four million and fifteen thousand dollars ($4,015,000).*
>
> *15. The schedule for payment of security shall be as follows:*
>
> *(a) $3,725,000 within thirty (30 days of the effective date of this licence,*
>
> *(b) $290,000 within one year of the commencement of commercial production.*
>
> *16. For clarity, if there is no commencement of commercial production under this licence, then the total amount of security shall be $3,725,000."*

Cominco reviewed the basis for the security called for as set out above. Detailed cost estimates were prepared for each mine component based on whether or not the mine reopened. Closure costs for the present mine site are estimated at $4,561,755.00. With eventual mine reopening, closure costs are estimated at $6,092,296.00, in both cases exceeding the 1997 estimates.

Respectfully submitted,

GEO-ENGINEERING M.S.T. LTD.

M. Stepanek, M.Sc., P.Eng.
Principal Consultant

MS/hh
G1776R01

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Mt. Hundere Development, Initial Environmental Evaluation of the Mt. Hundere Development on the Watson Lake Area & Yukon (in drawer B210-B240 Vancouver) 6 Volumes	SRK	1990
Mt. Hundere Joint Venture IN90-002, Volume I – Report, Volume II – Appendices and Interventions	SRK	July 1990
Mt. Hundere Joint Venture IN90-002 – Geotechnical Investigations and Final Design for Mill and Tailing Disposal Facilities	SRK	December 1990
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Sä Dena Hes Mine IN90-002 – South Dam Extension Design Report SRK Project 101204	SRK	November 25, 1992
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Report/Title/Topic	Author	Date
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1997 Annual Inspection Tailings Management Facility, Sä Dena Hes, Yukon Territory	SRJ	October 15, 1997

Report/Title/Topic	Author	Date
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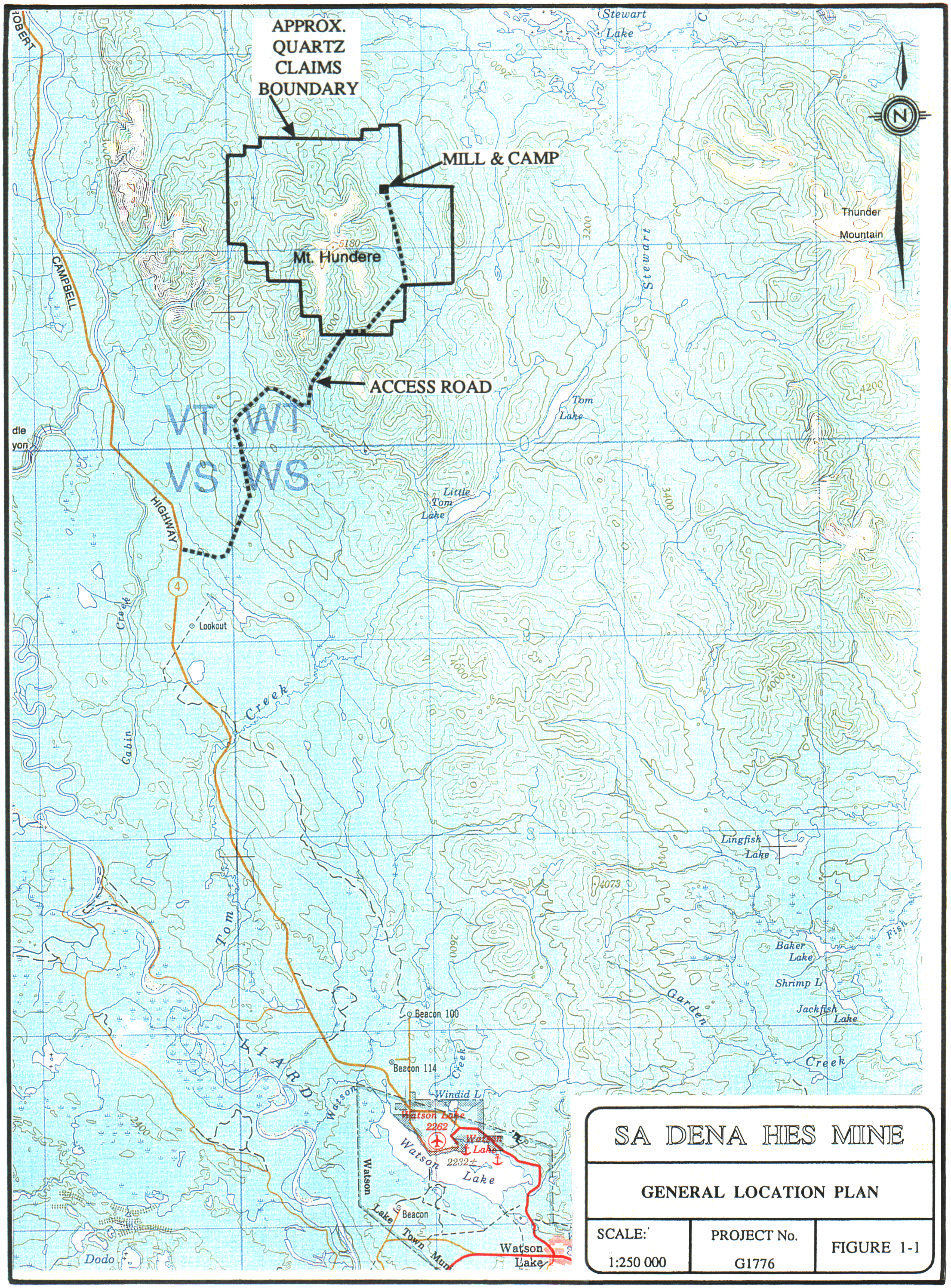
1998 Annual Report	Cominco	February 1999
Draft Detailed Decommissioning & Reclamation Plan	Access/SRK	1999

APPENDIX A

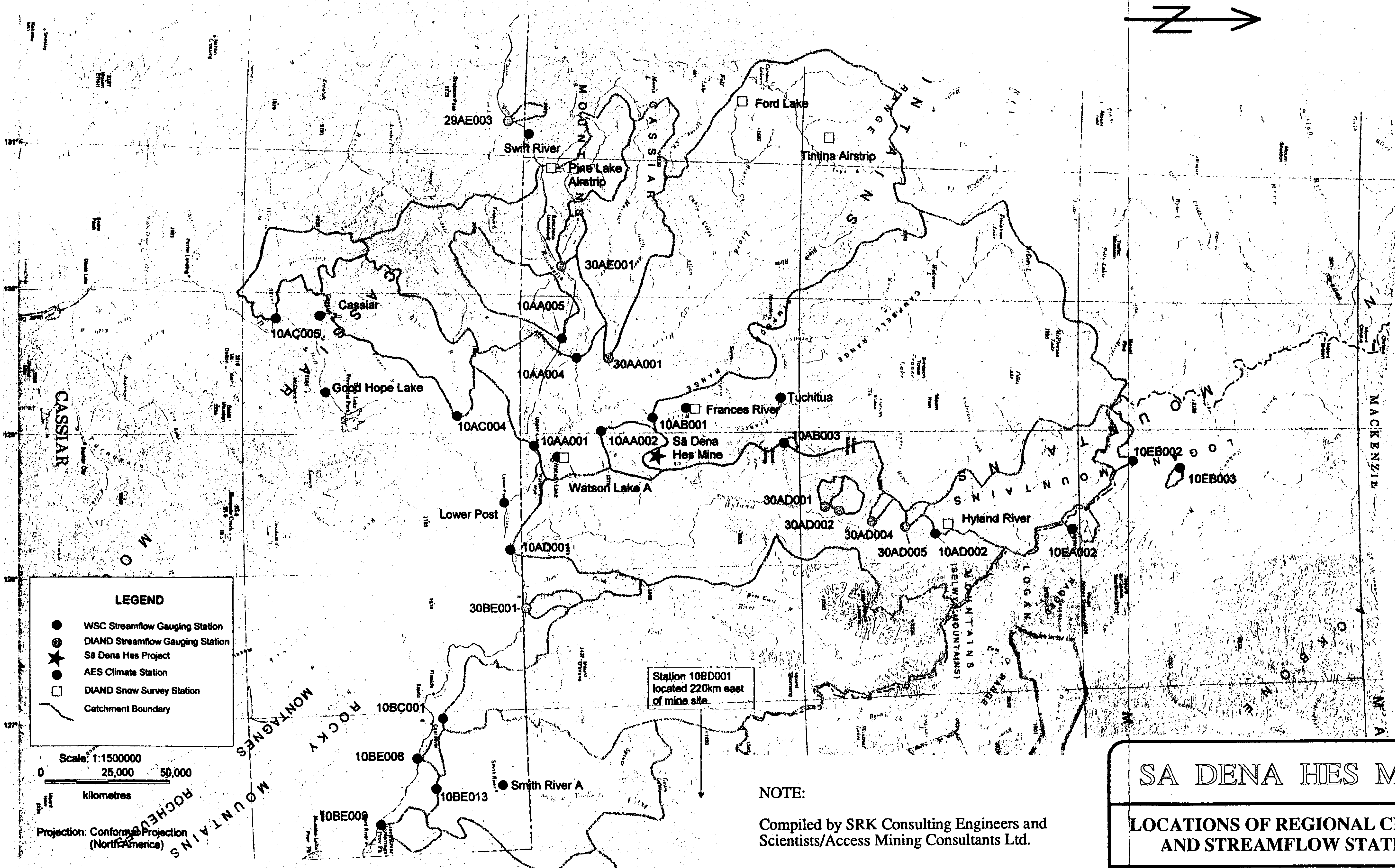
FIGURES



SA DENA HES MINE

GENERAL LOCATION PLAN

SCALE: 1:250 000	PROJECT No. G1776	FIGURE 1-1



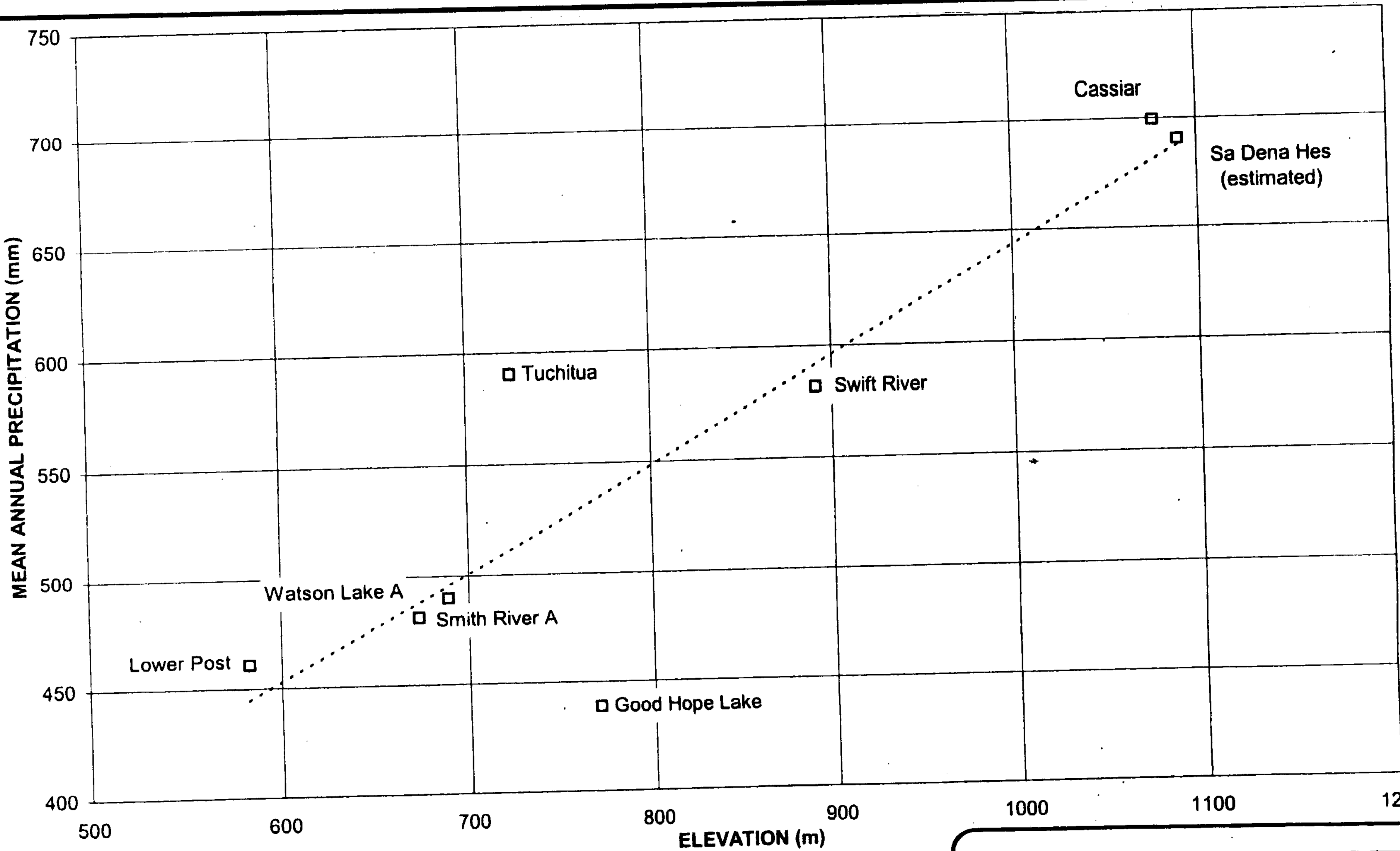
NOTE:

Compiled by SRK Consulting Engineers and Scientists/Access Mining Consultants Ltd.

SA DENA HES MINE

LOCATIONS OF REGIONAL CLIMATE AND STREAMFLOW STATIONS

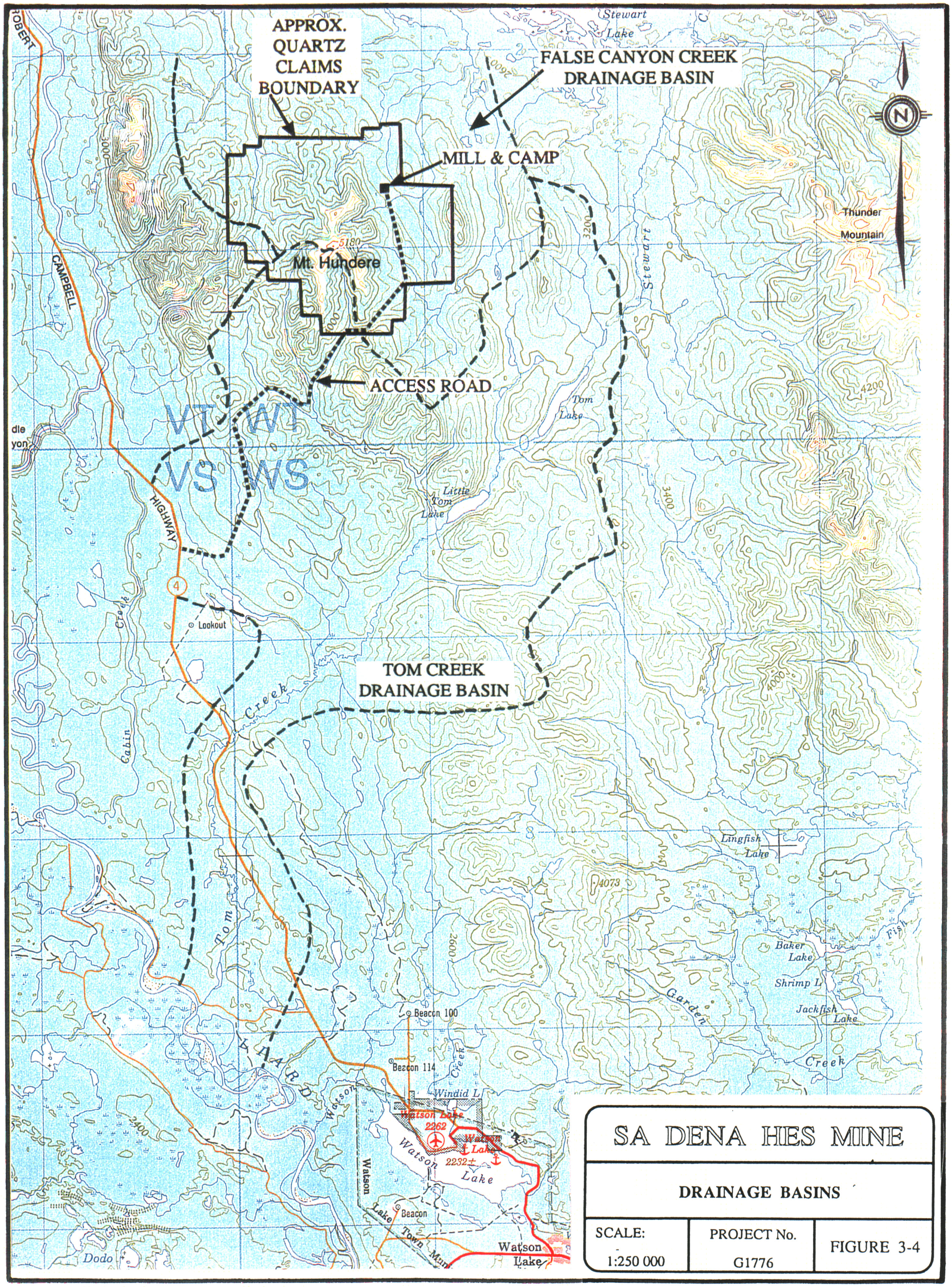
SCALE:	PROJECT No.	FIGURE 3-2
As Shown	G1776	



NOTE:

Compiled by SRK Consulting Engineers and Scientists/Access Mining Consultants Ltd.

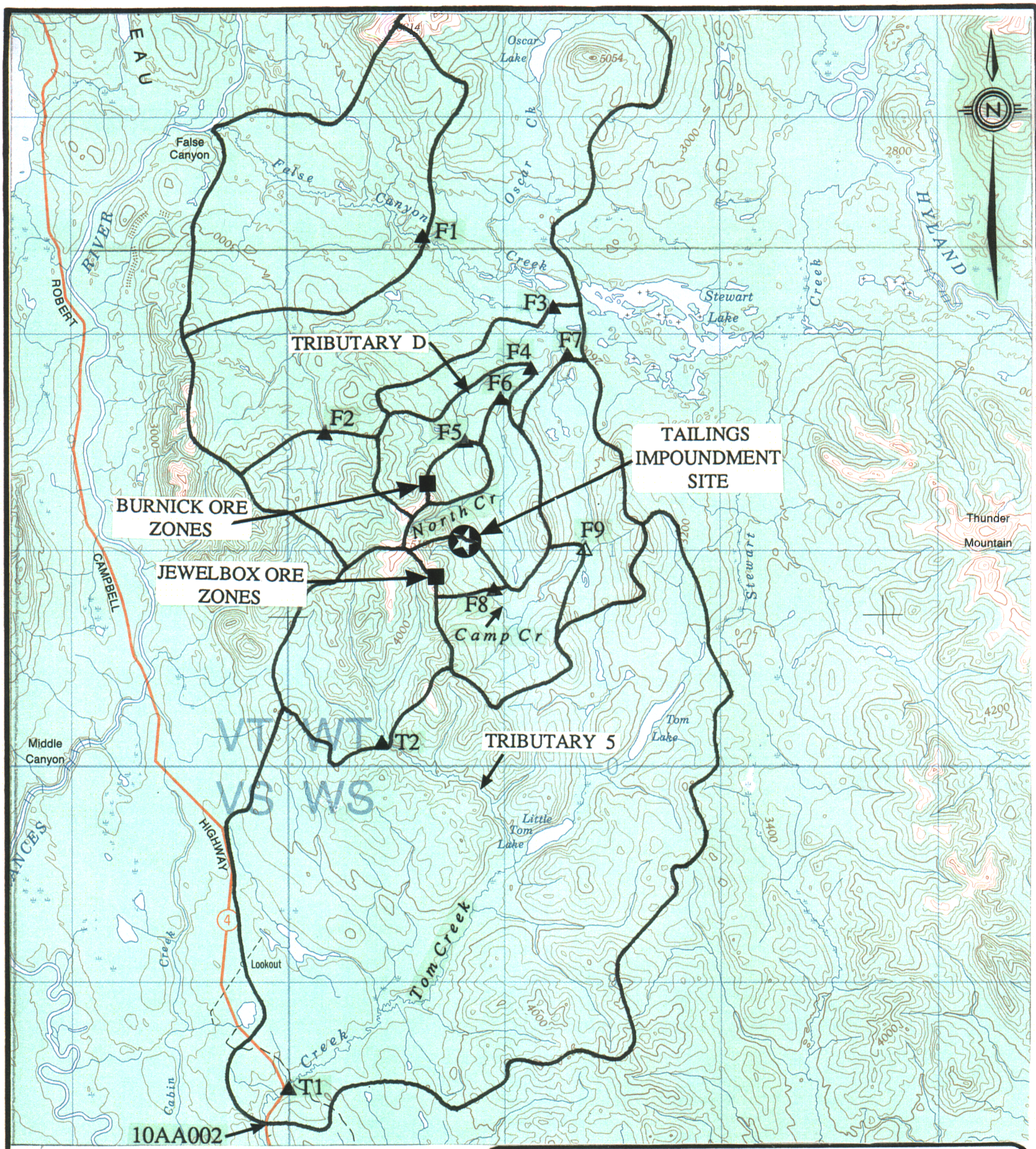
SA DENA HES MINE		
ANNUAL PRECIPITATION AND ELEVATION RELATIONSHIP		
SCALE: As Shown	PROJECT No. G1776	FIGURE 3-3



SA DENA HES MINE

DRAINAGE BASINS

SCALE: 1:250 000	PROJECT No. G1776	FIGURE 3-4



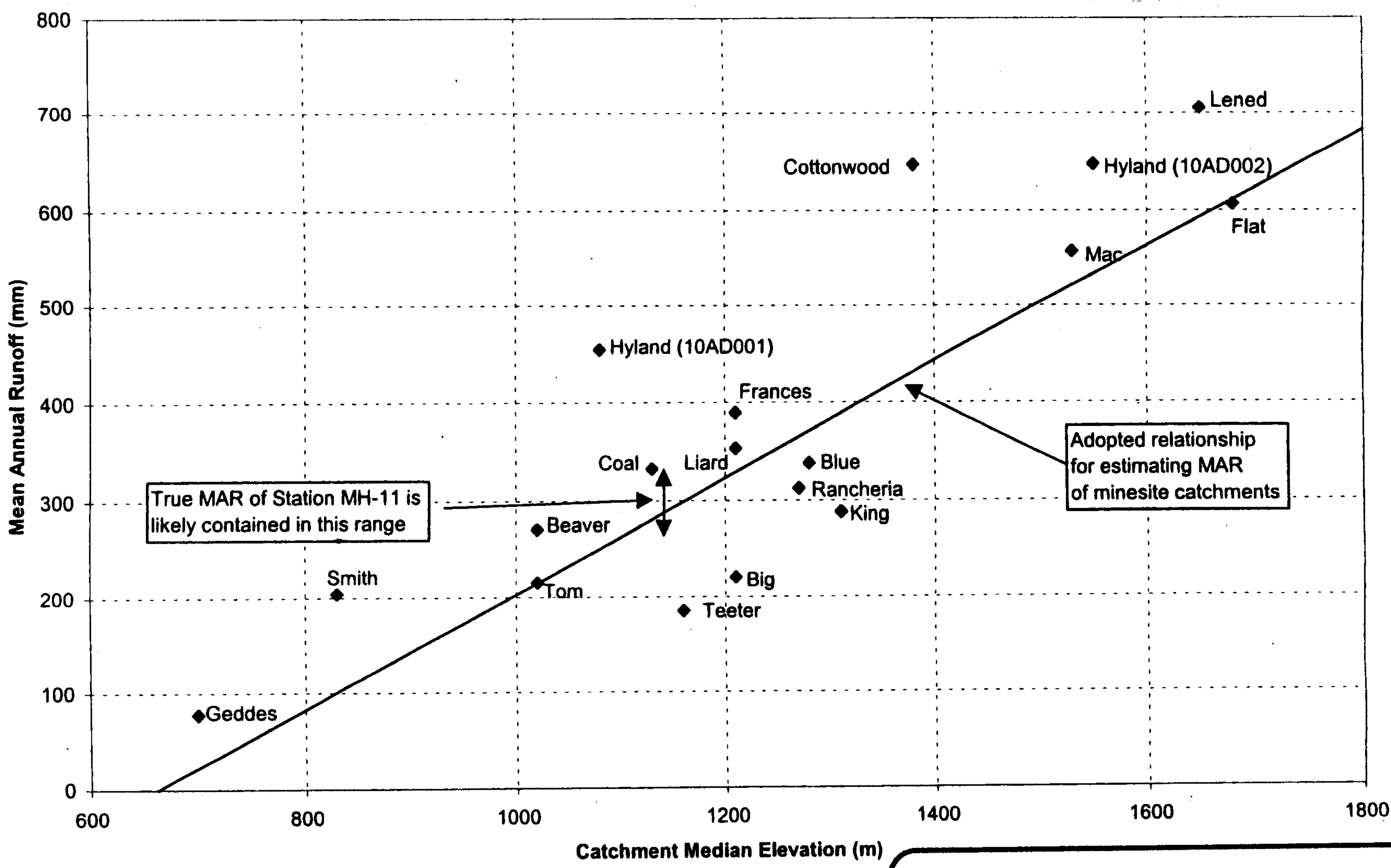
KEY

~	CATCHMENT BOUNDARY
▲F1	MINE SITE STREAMFLOW MONITORING STATION
△F9	PROPOSED STREAMFLOW MONITORING STATION
10AA002	WSC STREAMFLOW MONITORING STATION

SA DENA HES MINE

WATER MONITORING STATIONS AND DRAINAGE BASINS

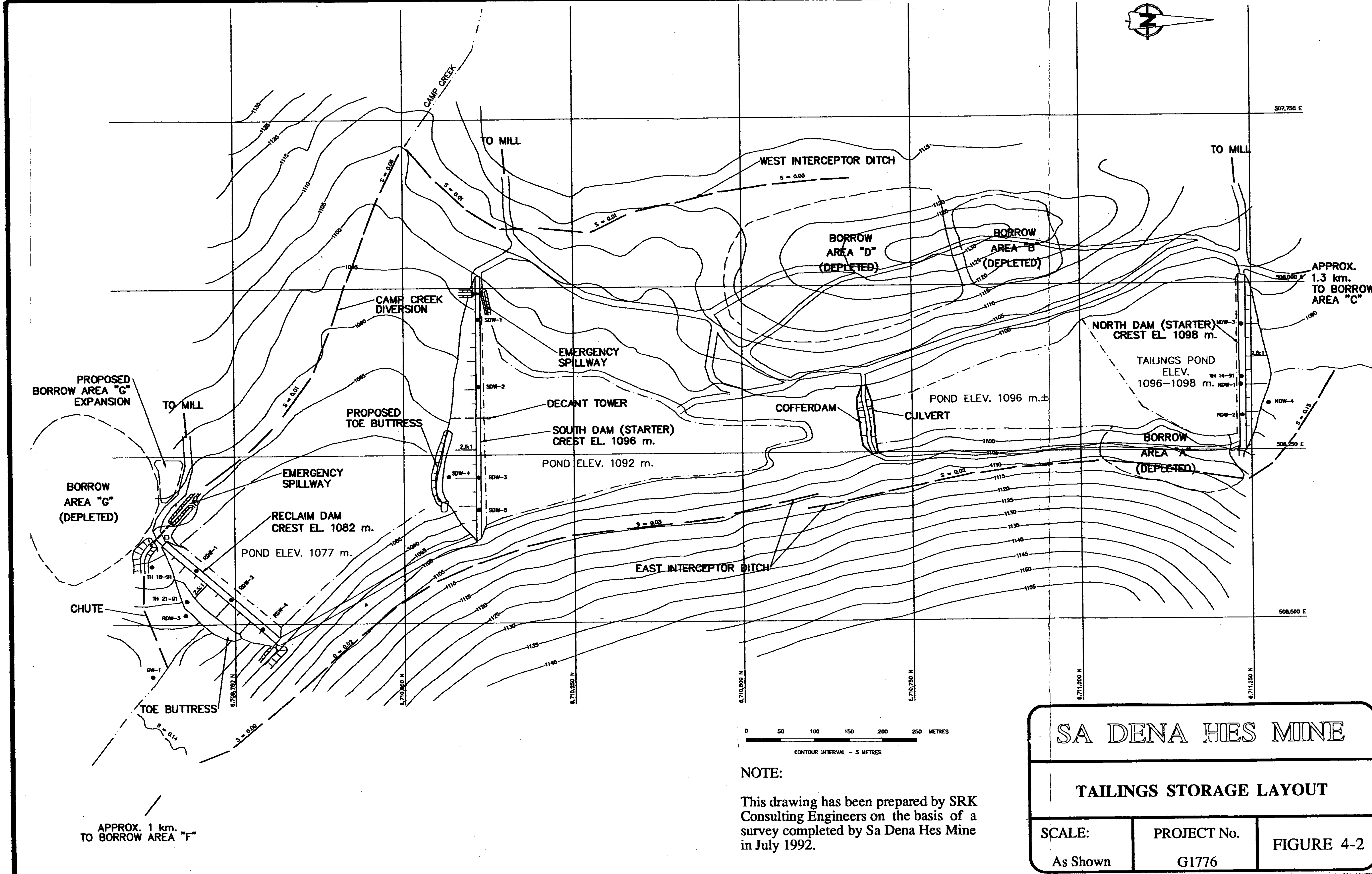
SCALE:	PROJECT No.	FIGURE 3-5
1:250 000	G1776	



NOTE:

Compiled by SRK Consulting Engineers and Scientists and Access Mining Consultants Ltd. dated August 1999.

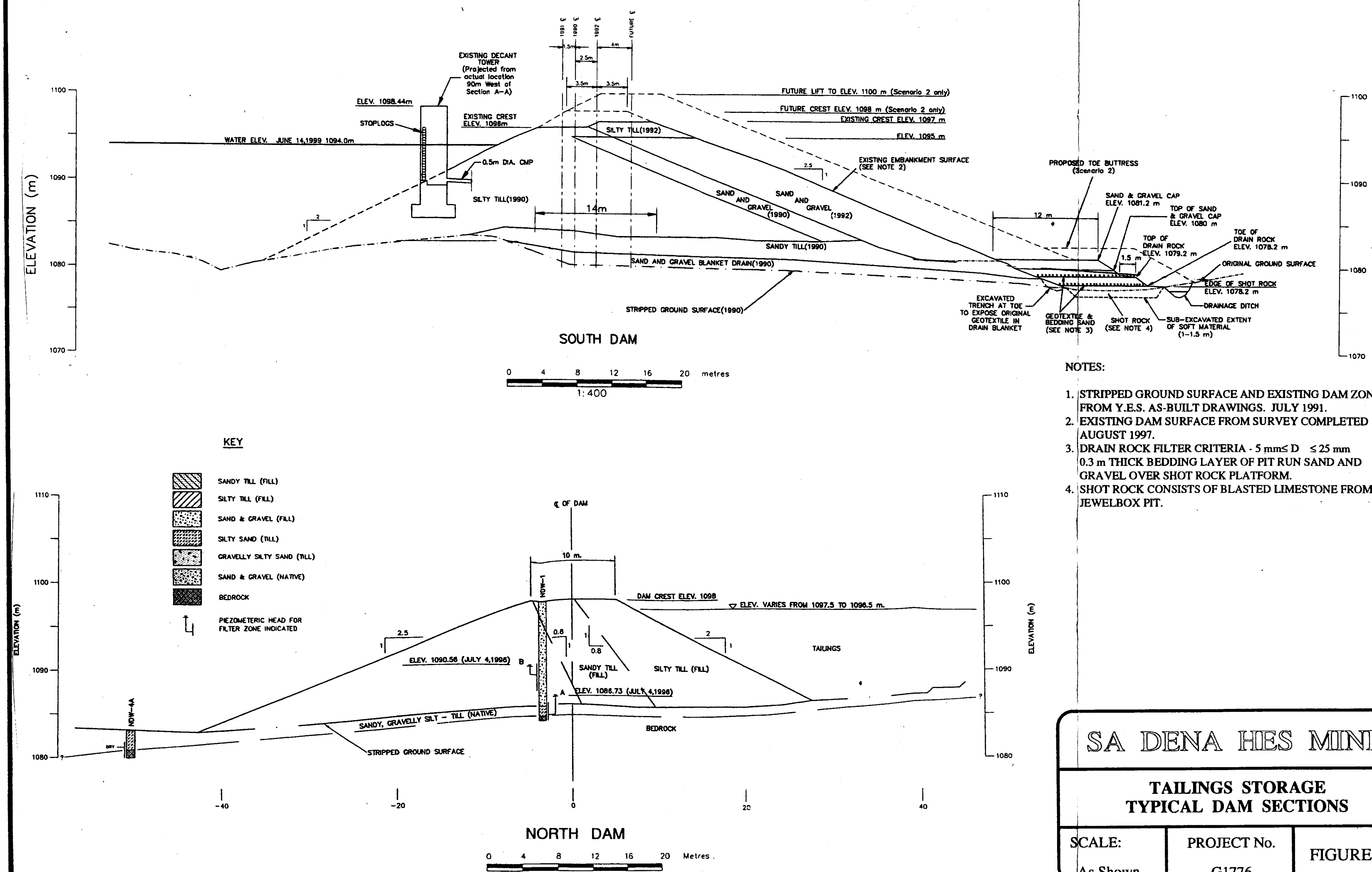
SA DENA HES MINE		
REGIONAL RELATIONSHIP BETWEEN MEAN ANNUAL RUNOFF AND CATCHMENT MEDIAN ELEVATION		
SCALE: As Shown	PROJECT No. G1776	FIGURE 3-6



NOTE:

This drawing has been prepared by SRK Consulting Engineers on the basis of a survey completed by Sa Dena Hes Mine in July 1992.

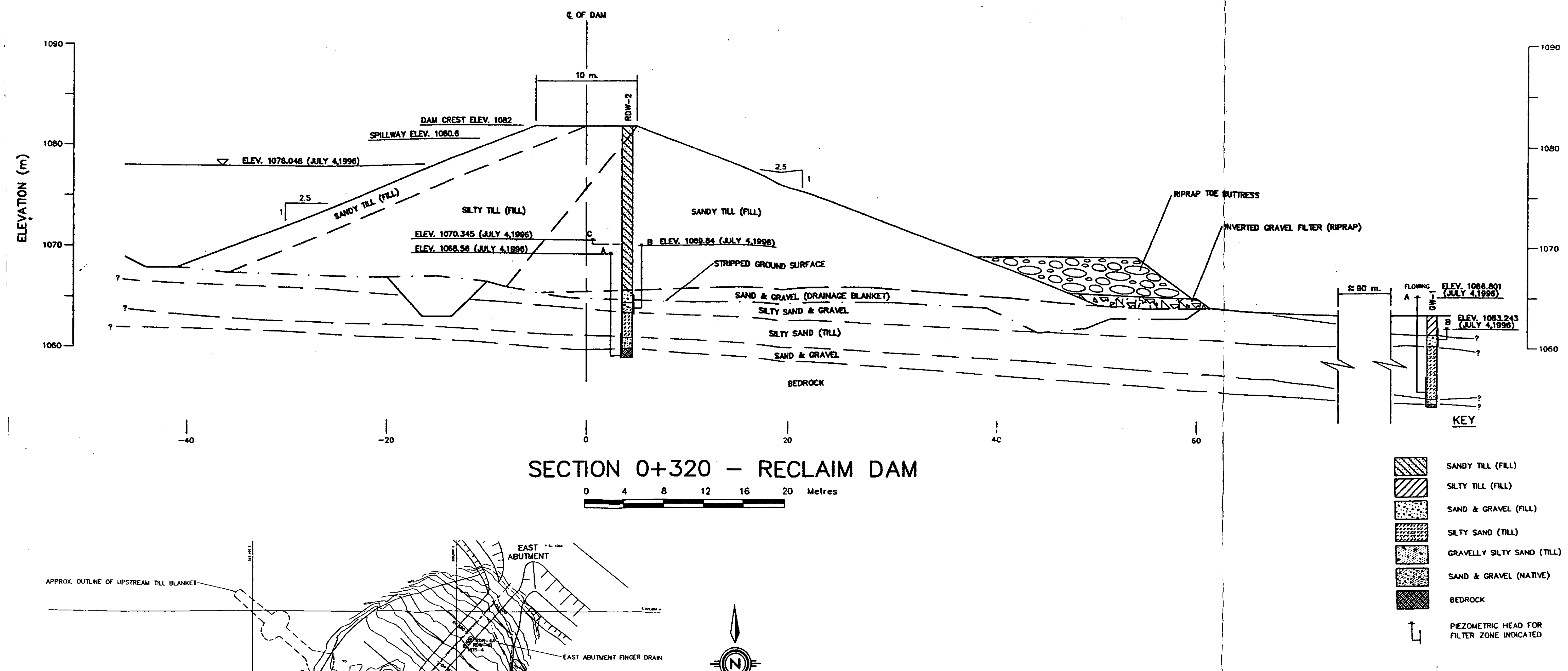
SA DENA HES MINE		
TAILINGS STORAGE LAYOUT		
SCALE: As Shown	PROJECT No. G1776	FIGURE 4-2

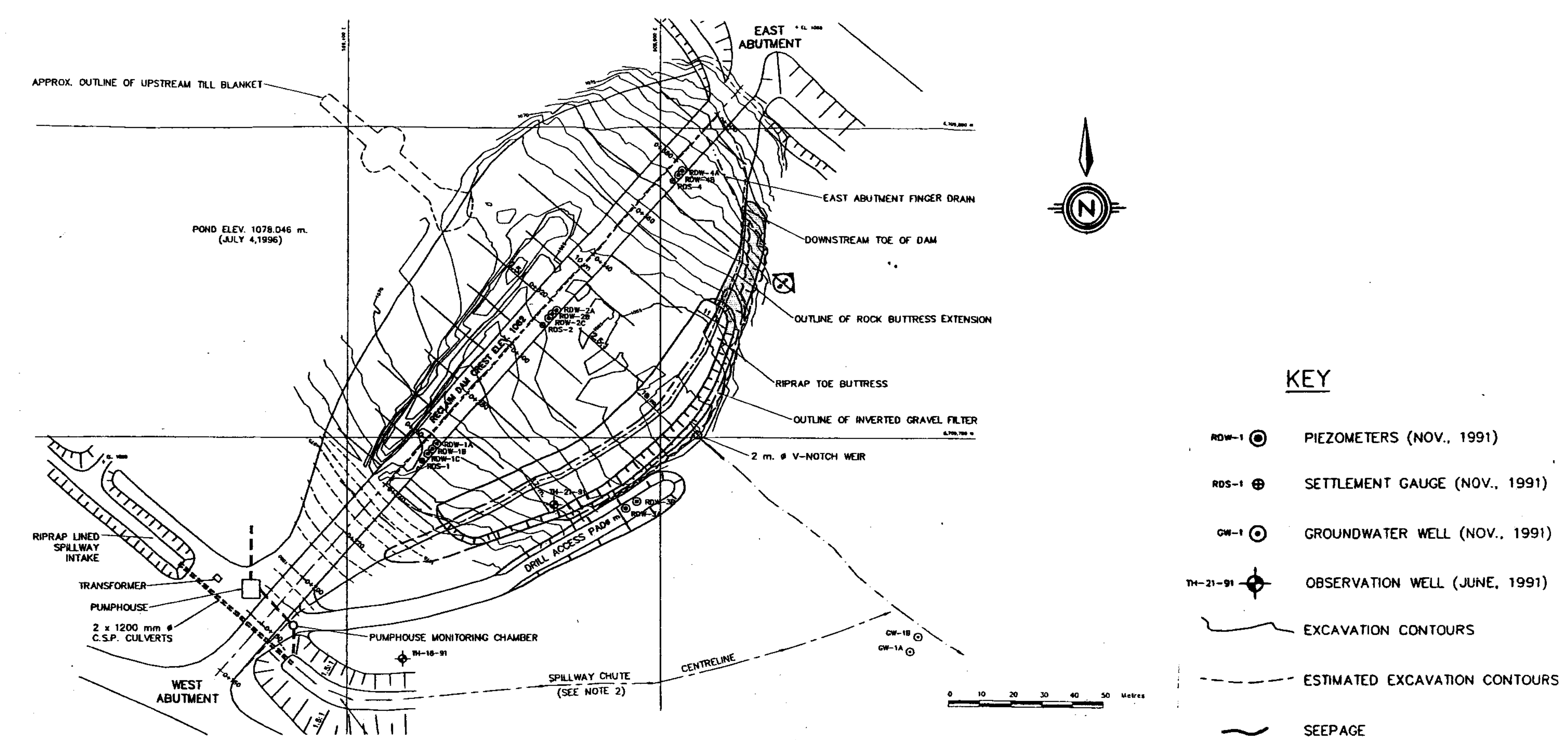


NOTES:

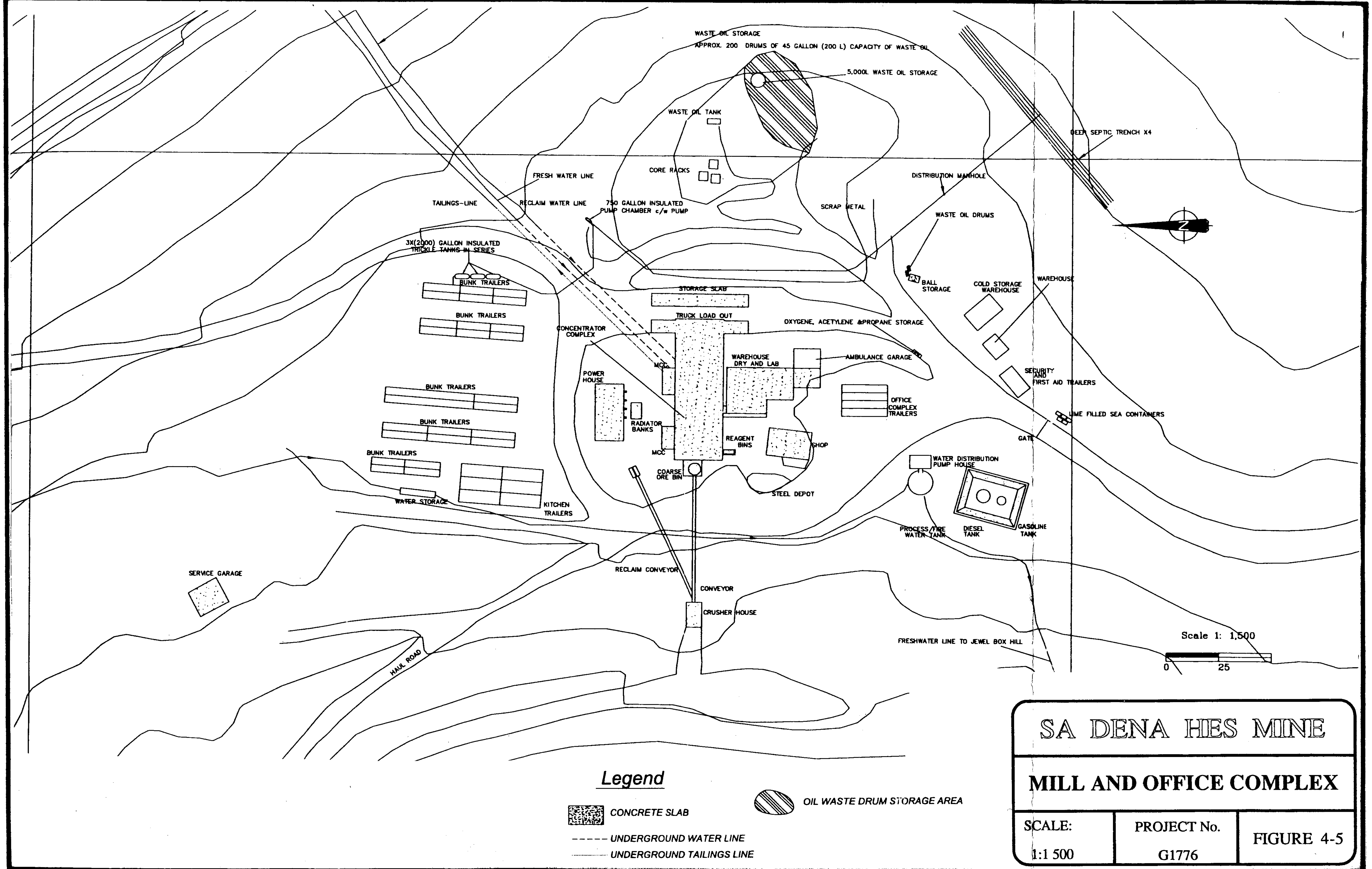
1. STRIPPED GROUND SURFACE AND EXISTING DAM ZONES FROM Y.E.S. AS-BUILT DRAWINGS. JULY 1991.
2. EXISTING DAM SURFACE FROM SURVEY COMPLETED AUGUST 1997.
3. DRAIN ROCK FILTER CRITERIA - 5 mm≤ D ≤25 mm 0.3 m THICK BEDDING LAYER OF PIT RUN SAND AND GRAVEL OVER SHOT ROCK PLATFORM.
4. SHOT ROCK CONSISTS OF BLASTED LIMESTONE FROM JEWELBOX PIT.

SA DENA HES MINE		
TAILINGS STORAGE TYPICAL DAM SECTIONS		
SCALE: As Shown	PROJECT No. G1776	FIGURE 4-3

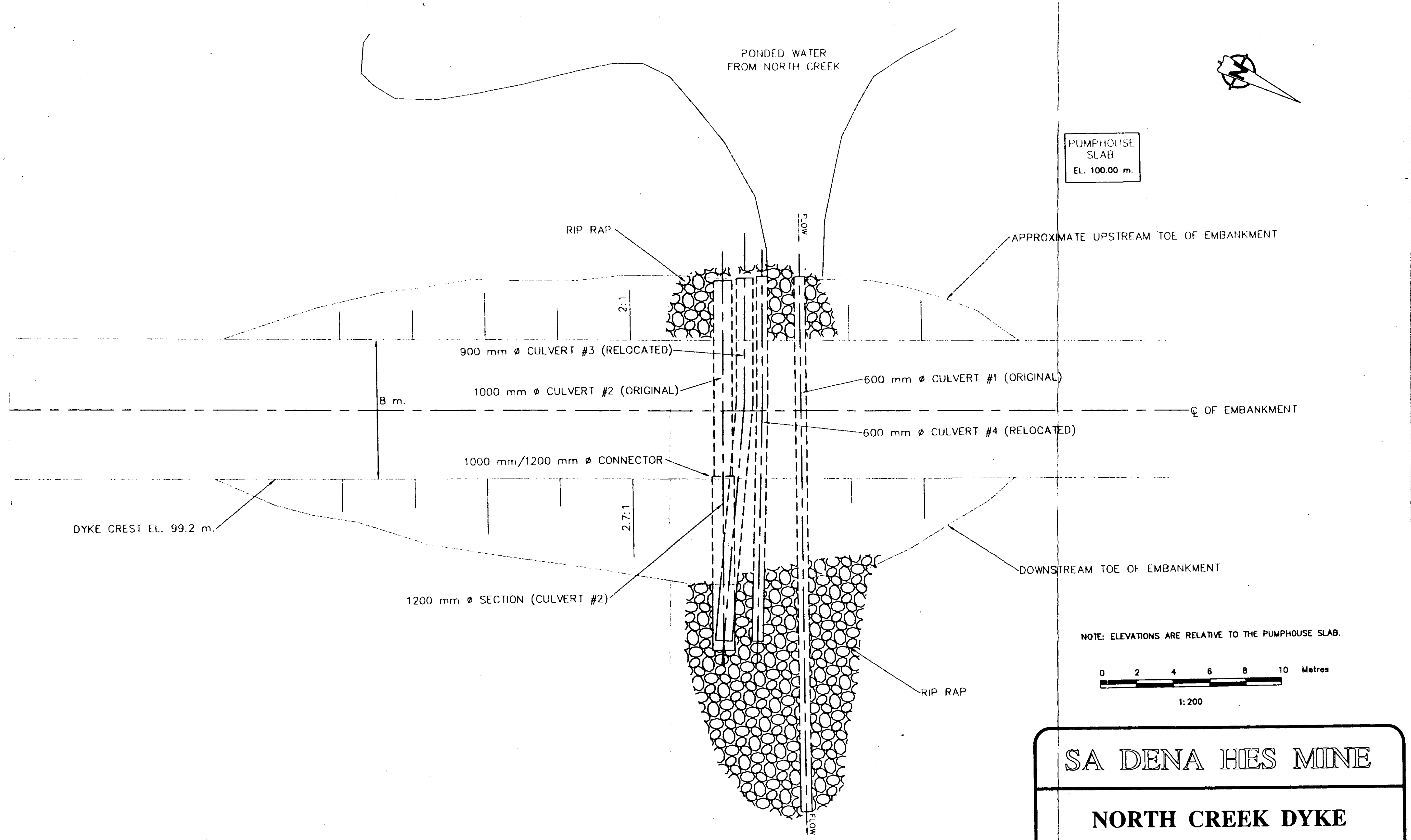




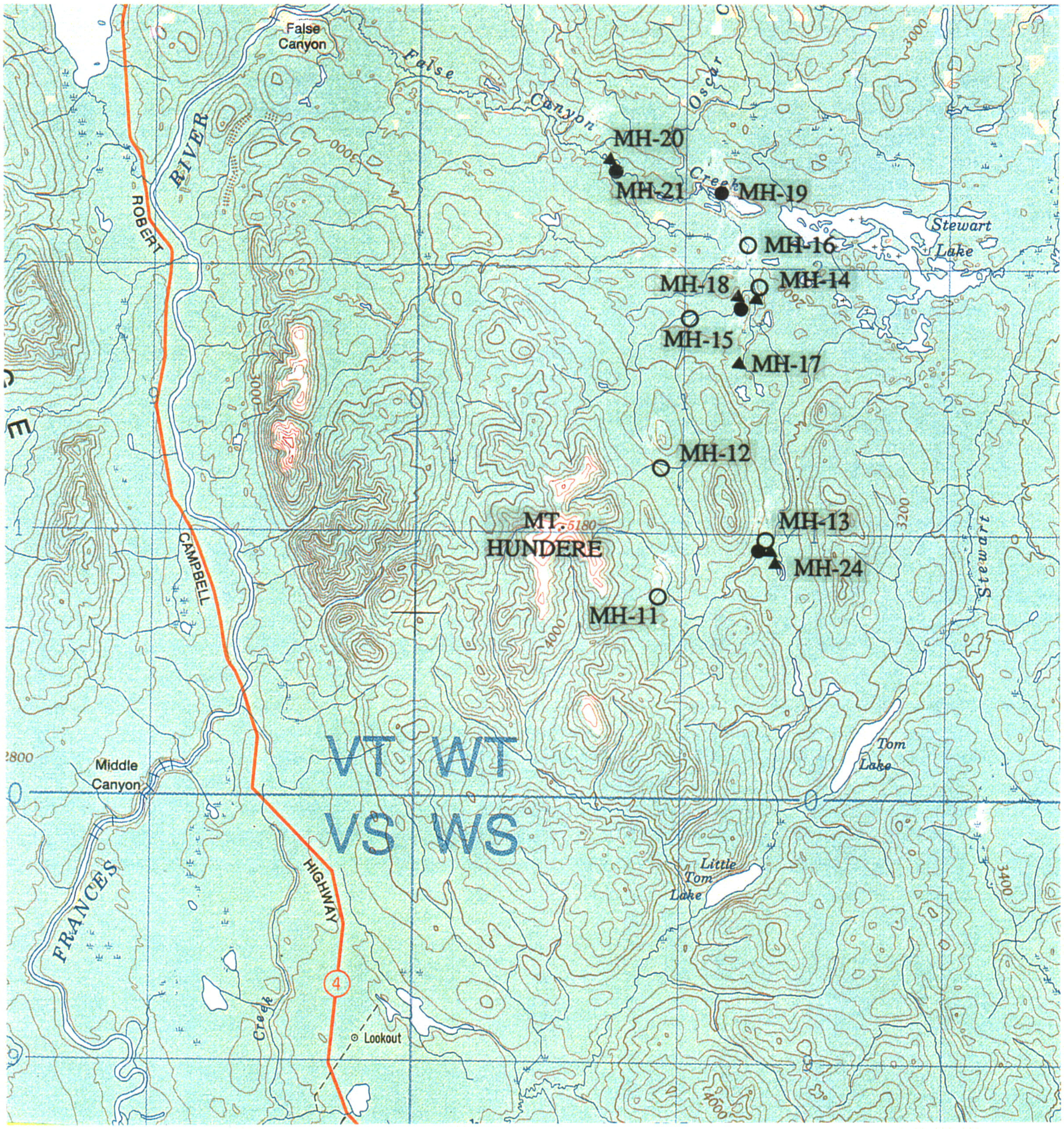
SA DENA HES MINE		
RECLAIM POND DAM LAYOUT AND SECTION		
SCALE: As Shown	PROJECT No. G1776	FIGURE 4-4



SA DENA HES MINE		
MILL AND OFFICE COMPLEX		
SCALE: 1:1 500	PROJECT No. G1776	FIGURE 4-5



SA DENA HES MINE		
NORTH CREEK DYKE		
SCALE: 1:200	PROJECT No. G1776	FIGURE 4-6



LEGEND

- ○ Water Monitoring Station
- ▲ Fish Monitoring Station
- ● Benthick Monitoring Station

SA DENA HES MINE		
WATER QUALITY MONITORING STATION		
SCALE: 1:250 000	PROJECT No. G1776	FIGURE 5-1