Deloitte & Touche

Preliminary Seepage Collection Options
Faro & Grum Waste Rock Dumps

2004/05 Task 14d

Prepared for

Deloitte and Touche Inc.

On behalf of

Faro Mine Closure Planning Office

Prepared by

SRK Consulting
Engineers and Scientists

In Association with
Robertson GeoConsultants Inc.

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1 Introduction

A recent review of available groundwater quality data at the Faro Mine site by Robertson GeoConsultants Inc. (RGC) indicated elevated levels of acid rock drainage (ARD) related contaminants in groundwater at various locations around the Faro and Grum mine sites. As part of the on-going closure planning for the site, SRK was retained by Deloitte Touche to carry out additional field investigations to better characterize local groundwater conditions and to assess options to intercept any ARD impacted seepage for collection and treatment. This report presents the results of the 2004 groundwater investigation and seepage collection assessment for three previously defined areas of waste rock dump seepage: (i) the Emergency Tailings Area (old Faro Creek valley), (ii) North Fork Rose Creek below the rock drain and (iii) the Grum Creek areas, which were identified during the initial review and planning stage as the areas with highest priority for seepage interception (Figure 1). Lower priority areas were not completed as part of this program.

This report has been prepared as part of the ongoing technical evaluation for the closure planning of the Faro Mine. Aspects of this report may have been superceded by subsequent technical studies.

2 Background

A series of memoranda were produced in the summer of 2004 providing initial review and comments on groundwater quality downstream of the Faro, Grum and Vangorda waste rock dumps (WRDs). The full text for this memo, ***Initial Review of Groundwater Quality downstream of Faro, Grum and Vangorda WRDs, Yukon Territory, July 14, 2004***, is provided in Appendix A. Available groundwater quality data was reviewed for each of the identified reaches and priorities assigned based on the observed historic time trends and current concentrations of acid rock drainage (ARD) related contaminants, specifically, zinc and sulphate, as well as parameters such as pH and alkalinity. The following is a summary of the findings of this review (see Appendix A for more detail).

2.1 Faro Waste Rock Dumps

Seven reaches were identified as being possibly influenced by seepage from the Faro WRDs. A summary of findings is included for each reach. The general locations of each reach are shown on Figure 1.

A.1 Northeast Dumps draining towards North Fork Rose Creek (NFRC)

Groundwater in this reach has circum-neutral pH and significant alkalinity (200-400 mg/L). Sulphate concentrations in shallow groundwater in this reach have gradually increased from ~300-500 mg/L (1996) to 1,200-1,700 mg/L (2003). However, zinc concentrations have remained relatively low over the last 8 years (<0.5 mg/L).

While WRD seepage is present at low concentrations, this area was identified as a low priority for seepage interception at this time.

A.2 Zone 2 Pit draining towards NFRC

Groundwater is slightly to moderately acidic (pH 4.5-6.5) with low to moderate alkalinity (10-100 mg/L). This area has been affected by at least one historic "spill" from the Zone 2 pit. Concentrations in each of the available monitoring wells (BH-1-4) vary suggesting heterogeneous subsurface conditions and/or variable contaminant sources. Groundwater in all three wells is relatively dilute (SO4 ~100-200 mg/L), but shows significant residual zinc concentrations (1-3 mg/L in BH-1, -3 and -4; increasing in BH-2 to ~10-20 mg/L currently). Further study of surface water quality from the NFRC, hydrogeologic conditions and source of contaminants were recommended but were judged to be a low priority considering overall recent improvements in water quality.

A.3 Intermediate Dump draining towards NFRC (above rock drain)

Data from a single available monitoring well in this reach (P96-6) indicates that groundwater is well buffered (pH 6-7) with significant alkalinity (200-300 mg/L). No significant increase in sulphate and zinc suggests any significant influence of WRD seepage to date. Hence, seepage interception in this reach was considered to be a low priority at this time.

A.4 Intermediate Dump draining towards NFRC (below rock drain)

Water quality in the five available monitoring wells of the "S-cluster" indicates significant increase in zinc and sulphate over time. As an example, data from monitoring well S1A (in weathered bedrock) shows increases in sulphate from 140 mg/L in 1989 to 4,400 mg/L in late 2003 and increases in zinc from <0.1 mg/L as recently as 1998 to ~80 mg/L in September 2003. At the time of the water quality review trends in these monitoring wells did not yet show levelling off of contaminant concentrations. It was postulated that seepage from the Intermediate Dump may be moving towards the NFRC along an old drainage channel identified on pre-mining topographic maps. Further review of hydrogeologic conditions and surface water quality along the NFRC were recommended. This reach was considered to be a potential target area for seepage interception.

A.5 Main Dump East draining towards Rose Creek Valley

Groundwater quality in this reach has been monitored in a single monitoring well located along the southern toe of the Main Dump (P96-7), which is screened in the overburden and fractured bedrock. Groundwater has pH ranging from 6.5-7.5 and moderate alkalinity (150-250 mg/L). Sulphate has shown a gradual increase over the 8-year period of monitoring, from ~400 mg/L to ~2,000 mg/L. However, zinc concentrations have remained very low (<0.1 mg/L). This area was considered a lower priority for seepage interception relative to neighbouring reaches, specifically reaches A.4 and A.6.

A.6 Main Dump West and Northwest Dumps draining into Faro Creek Valley

Reach A.6 was subdivided into three subsections:

A.6.1 Surface Seepage in Faro Creek Channel (X23)

Water quality has been monitored regularly since 1986 at a perennial stream which "daylights" just below the Main Dump, near sampling station X23. Sulphate concentrations have increased from ~1,500 mg/L to >4,000 mg/L with spikes to >6,000 mg/L in 2000 and 2001. Zinc, as well as manganese, show similar trends to sulphate with 5-8 fold and 3-5 fold increases, respectively. From the perspective of load reduction, interception and treatment of surface seepage at this location was considered a high priority.

A.6.2 Subsurface Seepage in Faro Creek Channel (Emergency Tailings Area – ETA)

Two monitoring wells were installed close to X23 in 1996 (P96-8A and 8B), completed in overburden and fractured bedrock. Sulphate and zinc concentrations show similar trends to surface water quality at X23. Sulphate has increased from ~2,000 mg/L in 1996 to ~4,000 mg/L in 2003. Zinc has increased from ~2 mg/L to >100 mg/L in the same 8-year time span. Alkalinity ranges from 150-350 mg/L and pH ranges from 6-7, suggesting possible buffering within the WRD itself. Further characterization studies to quantify subsurface seepage from the WRD, as well as detailed flow measurements along the creek downstream from X23 were recommended as a high priority to aid in determining the incremental benefit of seepage collection to downstream environments.

A.6.3 Potential Seepage from Faro Pit

Potential seepage from the Faro Pit along the old Faro Creek channel was also identified as an area for further investigation. While seepage from Faro Pit into the old Faro creek channel is not considered a current issue due to the lower elevation of the water level in the pit relative to the topographic low on the pit wall along the creek channel, increased load to the creek channel could become an issue if the pit water level is allowed to rise. Further studies of subsurface conditions and installation of a monitoring well were suggested, but were considered a low priority relative to areas where seepage has been observed or is anticipated.

A.7 Northwest Dumps draining towards Guardhouse Creek

No monitoring wells were available in this area, but data from a test pit program suggested no significant impact of WRD seepage. This area was considered a low priority for seepage interception at this time.

2.2 Grum and Vangorda Waste Rock Dumps

Five reaches were reviewed for potential ARD seepage from the Grum and Vangorda WRDs. A summary of findings is included for each reach. Reach locations are shown on figure 1.

B.1 Grum Dump draining southeast

Water quality data was reviewed from monitoring wells located in a tributary of Grum Creek below the central portion of the Grum Dump. Seepage from the Grum Dump is interpreted to have had a smaller impact on local groundwater than seepage from the (older) Faro waste rock dumps. Sulphate concentrations in the shallow monitoring well have increased only in the last four years, from ~50 mg/L in 1996 to ~1250 mg/L in 2003. Zinc concentrations remain low in the shallow groundwater at ~0.01 mg/L. The deeper, confined aquifer showed consistently low sulphate concentrations for the period of record (~150 mg/L until 2001). The deep monitoring well (P96-9B) was subsequently damaged and can no longer be monitored. Shallow groundwater along the southeast slopes of the Grum Dump was interpreted to represent seepage from Grum Dump with limited dilution from recharge and/or local groundwater. Shallow seepage collection in this area could become a future issue (protection of Vangorda Creek) and was given a moderate priority relative to the Faro sites. While no indication of breakthrough of seepage to the deeper, confined aquifer has been observed, this was considered an important monitoring point below the Grum Dump and replacement of P96-9B was recommended as a relatively low priority.

B.2 Grum Dump draining southwest

No groundwater monitoring wells are available in this area, but based on results from a recent seep survey (SRK, 2003), sulphate and zinc levels are observed to be low (SO4 <500 mg/L; Zn <0.03 mg/L). Groundwater quality to the southwest of Grum Dump was not expected to show significant impact of WRD and seepage interception in this reach was given a low priority.

B.3 Potential Seepage from Grum Pit

Review of available pit and seepage water level elevations suggested a possible presence of pit induced seepage but water quality data from the pit and seeps ruled out the pit water as a source of seepage. A desktop review of available material was suggested, with additional fieldwork based on results, if necessary.

B.4 Vangorda Dump draining towards Dixon Creek

Water quality data from the two available monitoring wells, V34 and V35, show contrasting conditions. V34 is interpreted to be representative of background conditions with pH of 7.5-8.0, high alkalinity (~400 mg/L) and low metals (Zn ~0.01 mg/L). V35 shows limited influence of WRD seepage. Sulphate has increased over time, with peak concentrations of 750-1,000 mg/L, but zinc remains low (0.01-0.1 mg/L). Seepage collection in this area was given a low priority.

B.5 Vangorda Dump draining towards Vangorda Creek

Data from six monitoring wells were reviewed for this reach. All wells with the exception of one show levels representative of background conditions. One well, V36 provide early indications of the potential presence of WRD seepage. In general, however, groundwater in this reach was interpreted to show very little impact of WRD seepage and seepage interception in this area was considered to be a low priority.

2.3 Summary of Recommendations

Based on the results of this groundwater quality review, a preliminary priority listing of recommended hydrogeological field studies was developed, including test pitting, seismic surveying, drilling, well installation, and hydraulic testing (Table 1 in Appendix A). The three reaches given a high priority ranking for the 2004 field investigation included (i) the Emergency Tailings Area (old Faro Creek valley), (ii) North Fork Rose Creek below the rock drain and (iii) the Grum Creek areas, which were identified during the initial review and planning stage as the areas with highest priority for seepage interception (Figure 1).

The recommendations of the initial data review (Table 1 in Appendix A) provided a framework for developing the 2004 field program.

3 Project Objectives

A hydrogeological investigation program was subsequently developed and outlined in a memo dating August 13, 2004: ***Task 14d – Complete Seepage Investigations for Faro and Grum Waste Rock Dumps***. The full text of this memo is included as Appendix B. The final program, as implemented, involved a field component, data analysis and preliminary assessment of seepage collection options.

The field program included drilling, well installation, hydraulic testing, test pitting and geophysical surveying based on the priority listing developed as part of the initial review of groundwater quality. Specific drilling objectives were outlined in the Task 14d memo, which also assigned a priority ranking. Table 1 lists drilling targets in order of priority and sequence.

Table 1: **Proposed Drilling Targets with Location and Priority***

Task 14d Well ID	Location	Area	Priority
#2A	At toe of Haul Road in old drainage channel NW of S-cluster	Faro	High
#2B		Faro	
#3A	In ETA immediately north of mine access	Faro	High
#3B		Faro	
#4	~10 m distance from #3A & B	Faro	High
#6A	Near Grum Creek along access road below Grum Dump	Grum	High
#6B		Grum	
#7A	Between two shallow drainages west of P96-9 along access road below Grum Dump	Grum	High
#7B		Grum	
#5A	In old Faro Creek channel along access road to Faro Pit	Faro	Moderate
#5B		Faro	
#1	Below Zone 2 pit near NFRC	Faro	Low
#96-9B replacement	Below Grum Dump	Grum	Low

* As described in Section 2 of this report.

The scope of work for this project also included reduction of all field data, including development of drillhole and test pit logs and analysis of hydraulic testing data.

For each area, preliminary seepage collection options were identified. In areas where multiple options were identified, a qualitative comparison of these options was carried out and a preliminary preferred option was selected. Preliminary costing is only provided for the preferred option of seepage interception in a given reach.

4 Field Program Methodology and Results

4.1 Drilling and Well Completion

4.1.1 Methodology

Drilling was conducted with a track-mounted Prospector drilling rig owned and operated by Midnight Sun Drilling of Whitehorse, Yukon. Drillholes were six-inch (152 mm) reverse-circulation with an ODEX casing advance. Drill chips were funnelled at the surface through a cyclone and logged for rock or sediment type as well as the presence or absence of water. Six-inch steel casing was advanced during drilling.

Drillholes were continuously logged using standard geologic descriptors and ASTM grain sizes. Samples were taken regularly. Drill logs can be found in Appendix C.

Upon reaching final depth, the drilling shoe was removed and 2” (51 mm) schedule 40 PVC casing installed inside the six-inch steel casing. The drive shoe was cut off using a pneumatic casing cutter and the six-inch casing pulled using attachments on the drill head as sand, grout or backfill (bentonite, cuttings or both) were emplaced around the monitoring well components. Depths of materials around the PVC monitoring well components were measured relative to ground surface continuously during installation to ensure proper depths of sand backfill and plugs.

Bentonite/cement grout, mixed as thick as the mud pump would push (approximately ½ bag grout to 5 US gallons of water), was used to seal the well annulus above sand-filled monitoring intervals. Grout was mixed at surface and pumped down a 1” (26 mm) PVC tremmie pipe to the bottom of the hole using a pneumatic mud pump.

In the case of the pumping well, a stainless steel screen was installed within the steel casing using the same methodology as above. A stainless steel continuous slot screen was attached to the PVC casing with an adaptor, and PVC was run to surface.

Monitoring wells were developed using a Waterra pump. Water was developed until field conductivity and pH readings stabilised, and at least three well volumes had been removed.

The pumping well was developed for approximately eight hours using a 1-meter jet tool. The jet tool is a fitting attached to the end of the drill string that has ports along its side to direct high pressure air or water through the screen slots. The jet tool was either set at a fixed depth for a period of time or moved up and down. Surface fittings at the top of the pumping well were meant to direct all flow out through the cyclone, but improper fittings allowed significant leakage to occur. Surging was completed periodically by shutting off the air and allowing water to flow back into the well. This water was blown out for a period of time and the process repeated. In instances when it was necessary to add water to increase jet pressure, record was kept of how much water was added and balanced by blowing with air only. Field conductivity readings were taken during this development, but were not considered characteristic. Final field readings were taken after completion of a 12-hour pumping test.

4.1.2 Results

Table 2 summarises details on drillhole locations and completions. Drillhole locations at the Faro and Grum sites are shown on Figures 2 and 3, respectively. More detail on the subsurface conditions encountered at each site is provided in the drill logs shown in Appendix C.

SRK04-1 was added at the beginning of the field program. SRK04-1 was completed along a preliminary alignment for a potential seepage ditch or pipeline from the NFRC area to the mine access road. This drillhole was added to assess the extent of shallow WRD seepage towards the west of the S cluster. In addition it was a potential control point for a planned ground penetrating radar (GPR) survey line along the proposed alignment. Upon reaching a depth of 25.9 m (85 ft) without reaching bedrock, the hole was terminated. No significant groundwater flow (ARD impacted or otherwise) was encountered at this location and therefore no piezometers were completed in this hole.

Table 2: Summary of 2004 Drilling and Monitoring Well Installation

SRK Drillhole ID	Easting	Northing	Total Depth (m)	Table 1 Monitor Well ID	Completed Monitoring Well ID	Stick-up Elevation (m.a.s.l.)	Screen Interval (m.b.g.s.)
SRK04-1	583,977	6,912,760	25.9	None			
SRK04-2	584,363	6,912,889	19.8	Modified #2A	SRK04-2A	1097.59	16.5 – 19.5
				Modified #2B	SRK04-2B	1097.74	7.8 – 12.7
SRK04-3	582,977	6,913,824	13.4	#3A	SRK04-3A	1104.55	10.4 – 11.9
				#3B	SRK04-3B	1104.63	5.5 – 7.0
SRK04-4	582,977	6,913,837	11.9	#4	SRK04-04 (Pumping Well)	1104.80	7.6 – 11.6
SRK04-5	592,871	6,903,205	24.1	#6A	SRK04-5A	0.7874[1]	22.2 – 23.7
				#6B	SRK04-5B	0.8128[1]	13.1 – 14.6

Note [1] Surveyed elevation of stick-ups not available at the time of preparation of this report – stick-up from ground surface presented

SRK04-2 was re-located from its planned position upon arrival at site due to the proximity of the originally planned location to the locations of the “S-cluster” wells (which had been plotted incorrectly on older site maps). At the new location (Figure 2) bedrock was not encountered to a depth of approximately 20 m (65 feet) and the hole was terminated (Appendix C). Additional drilling was considered unnecessary because the drilled depth was significantly greater than expected, was below the elevation of the NFRC, and no significant groundwater flow (ARD impacted or otherwise) was encountered.

During development of SRK04-2A/B, the PVC monitoring wells were found to be damaged. It is likely that damage occurred during completion of these monitoring wells. Sand was encountered in the shallow piezometer at a depth of 7.8m and grout was encountered in the deep piezometer. Furthermore, the deep piezometer was found to be blocked at a depth of 12.2 m, 7.6 m above the bottom of the borehole. This monitoring location should be fully de-commissioned.

SRK04-3 and SRK04-4 were drilled in the coarse alluvial sediments of the old Faro Creek valley and completed following the initial design specifications (Appendix C).

SRK04-5 encountered flowing artesian conditions at a depth of 12.5 m. The deep monitoring well was completed in weathered bedrock and the shallow piezometer was completed immediately below the inferred aquitard (Appendix C). Both monitoring wells were still flowing on September 12, approximately 3 days after well completion. Static water levels for either monitoring well could not be identified but are greater than 2.7 m above ground surface. A 4.6 meter grout plug was installed above the screened section in the shallow monitoring well, as well as bentonite mixed with cuttings and straight bentonite chips. Upon final completion of these monitoring wells, annular flow was observed, the flow rates of which were difficult to determine due to the flowing monitoring wells, but were estimated at less than 1 L/s. Rehabilitation work was immediately undertaken by excavating around the monitoring wells to a depth of approximately 2 m with a backhoe and the equivalent of 170 litres of bentonite pellets emplaced in the well annulus. At this time it is uncertain whether annular flow continues. The monitoring wells were left unplugged due to the potential for freeze-related damage.

4.2 Test Pitting

Seven test pits were completed in the NFRC area, between the toe of the WRD and the S-cluster wells. Test pits were dug with a Hundai Robe-290LC excavator owned by Tim Moon Excavating. The maximum depth of reach for the machine was 7.29 m. Geology was logged from within the test pit until a depth of 1.5 m, at which point visual description of the test pit lithology was completed from the rim in combination with assessment of material brought up within the excavator bucket. Samples were bagged and tagged regularly or at significant changes in geology. Test pit locations are included on Figure 2. Test pit logs are included in Appendix C.

4.3 Hydraulic Testing

4.3.1 Methodology

Hydraulic testing included slug testing of selected monitoring wells and a single 12-hour pumping test. Slug tests involve "instantaneously" introducing a volume (the slug) into a monitoring well and recording the recovery of water level to static. Initial introduction of the slug causes water levels to rapidly rise and the recovery to static is termed a falling head test. After full recovery, the slug is quickly pulled from the monitoring well causing water level to rapidly drop. Water level rise to static is recorded. Hydraulic conductivity can be determined from the change in drawdown.

Slug tests were conducted using 26 mm (1-inch) solid, sealed PVC slugs in either 1.5 or 2.5 meter lengths. Static water levels were measured before insertion of slugs. Digital pressure transducers (Leveloggers) were installed to depths below the maximum depth of the slug and programmed to record at 0.5 second intervals for the period of the tests. At the end of tests, all data was downloaded to a field PC for later analysis.

The single 12-hour pumping test conducted on SRK04-4 was run between 17:00 on September 9 and 5:26 on September 10. The pumping test was run using a submersible pump rated to 50 USGPM (0.19 m^3/min). Difficulties with the available magnetic flow meter required flow rates to be measured using a five US gallon bucket (18.9L). Flow rates were measured at the end of the pump outlet hose regularly over the course of the entire test. Water was discharged into a culvert below the main mine access road, approximately 30.5 m from the pumping location. Water in the culvert discharged into a pipeline before being released into Faro Canyon about 45 m downstream of the pumping well location.

Regular flow measurements were also taken at the groundwater seep below the main access road (station X7) to determine if pumping resulted in a decrease of the seepage rate. Measurements were made at the same location over the course of the pumping test. The earthen banks of the creek were worked to reroute water to a single measurement station. While it was recognized at the time of the test that there was no single location where all seepage could be measured, the majority of the water was captured at the selected location.

Water levels were recorded using either a Levelogger or manually with a water level tape. Water levels were recorded in the pumping well and observation wells during pumping and in the pumping well during recovery. Table 3 summarizes the flow measurements and water level recording locations associated with the pumping test.

Table 3: Summary of pumping test flow measurements and water level recording locations

Pump Flow Measurements			
Start of Test	1.7 L/s	End of Test	1.8 L/s
Average = 1.8 L/s			
GW Seepage Measurements			
Start of Test	2.8 L/s	End of Test	2.8 L/s
Average = 2.8 L/s			
Water Level Measurements During Test			
SRK04-4 (pumping well)			
SRK04-3A			
SRK04-3B			
Water Level Recovery After Test			
SRK04-4			

Pumping rate and seepage rate data are included in Appendix D.

Data from both the pumping test and slug tests was interpreted and analysed using Waterloo Hydrogeologic's Aquifer Test Pro software. Output sheets for each test are also included in Appendix D.

4.3.2 Results

Results of all hydraulic testing are summarised in Table 4.

Table 4: Hydraulic test data

Slug Tests FH=Falling Head Test RH=Rising Head Test				
Drillhole	**Area**	**Test Type**	**K (m/s)**	**Average**
S2B	"S-cluster" NFRC	FH	$4.55x10^{-7}$	$6.1x10^{-7}$ m/s
		RH	$8.21x10^{-7}$	
S3	"S-cluster" NFRC	FH	$4.81x10^{-6}$	$4.5x10^{-6}$ m/s
		RH	$4.25x10^{-6}$	
P96-7	Above NFRC	FH	$1.20x10^{-5}$	$6.4x10^{-6}$ m/s
		RH	$6.37x10^{-6}$	
P96-8A	Near X23	FH	$2.00x10^{-4}$	$1.9x10^{-4}$ m/s
		RH	$1.90x10^{-4}$	
P96-8B	Near X23	FH	$5.10x10^{-4}$	$5.1x10^{-4}$ m/s
		RH	$6.40x10^{-4}$	
SRK04-3A	ETA	FH	$2.91x10^{-5}$	$2.6x10^{-5}$ m/s
		RH	$2.38x10^{-5}$	
BGC04-01	Top of ramp to Faro Pit	FH	$6.64x10^{-6}$	$4.8x10^{-6}$ m/s
		RH	$3.40x10^{-6}$	
Pumping Test T=Transmissivity K= Hydraulic Conductivity				
Data Recorded At:	**Type**	**T (m^2/s)**	**K (m/s)**	**Judgement**
SRK04-4	Neuman Analysis on pumping well	$1.49x10^{-2}$	$3.1x10^{-3}$	$5.1x10^{-4}$ m/s
SRK04-4	Theis on pumping well	$6.99x10^{-2}$	$1.5x10^{-2}$	
SRK04-3A	Theis on observation well	$2.96x10^{-3}$	$4.8x10^{-4}$	
SRK04-3B	Cooper-Jacob on observation well	$8.88x10^{-4}$	$1.4x10^{-4}$	
SRK04-4	Theis Recovery on pumping well	$5.1x10^{-4}$	$5.1x10^{-4}$	

Pumping test data analyses indicated that observation well response was characteristic of different aquifer types. Both confined and unconfined analytical methods were used to provide reasonable fit to the data obtained. Based on the variance, it was decided that recovery data should be given the greatest weight in terms of aquifer hydraulic parameter as it has the least uncertainty with regards to aquifer type (the "Judgement" result), while other data provide insight into the possible aquifer type and mechanisms that could affect pumping in this area.

Slug testing at the NFRC was completed in S2B and S3. The slug encountered blockages in all of the other "S-cluster" piezometers, interpreted to be due to a constriction occurring at the addition of higher PVC stickups.

Slug test data (shown in Appendix D2) shows significant noise, which acts to complicate interpretations. The noise is related to data logger accuracy (2cm) and the relative rapidity of slug recovery. At later times, as water levels became close to static, logger readings fluctuate. This data was given less weight than at earlier times.

Grain size analysis was completed on 10 test pit sediment samples to estimate hydraulic conductivity using the Hazen method. Samples were collected from discrete horizons and represent materials along the entire test pit transect. While the objective of test pitting was not necessarily the collection of hydraulic data as much as stratigraphic information, the use of samples for hydraulic analyses was considered, as an after thought, to be a useful benefit.

Grain size analyses of samples from test pits indicated significant percentages of silt to clay (up to ~40%). Samples were sieved and weighed down to a #200 (0.075mm) sieve size, the ASTM cut-off between fine sand and silt. Table 5 lists weight percent of each sample that passed the #200 sieve.

Table 5: Summary of Percent Silt/Clay

Sample ID	% Passing #200 Sieve (0.075mm)
SRK04-TP1 (4.0m)	39.6
SRK04-TP1 (5.0m)	22.8
SRK04-TP1 (7.0m)	32.7
SRK04-TP2 (2.0m)	18.1
SRK04-TP2 (3.0m)	35.1
SRK04-TP2 (4.4m)	30.6
SRK04-TP3 (1.5m)	36.7
SRK04-TP3 (6.0m)	28.0
SRK04-TP7 (7.0m)	35.4

The Hazen method is meant for sandy samples and uses the d_{10} value (10% finer than) as the effective grain size for calculating hydraulic conductivity ($K = C (d_{10})^2$ where C is a sediment type constant). Since each of these samples has more than 10% passing the finest sieve used in the analysis, the d_{10} value is not known. Using the #200 mesh size as the effective grain size and a range of reasonable values for C, the Hazen method predicts hydraulic conductivity ranging from **2.3×10^{-7} to 3.4×10^{-7} m/s**. While the Hazen method is not the most appropriate method to determine conductivity values in this type of material, it is reasonable that these values be considered maximum values of K for the test pit samples. These samples (and limited slug testing at the S cluster of wells) indicate that the area is dominated by low conductivity materials, though alluvium was identified in certain instances. Grain size analyses sheets are provided in Appendix E.

4.4 Water Quality

Water sampling was conducted by Gartner Lee Limited in early October, 2004 from new monitoring wells in addition to standard monitoring points. Table 6 lists characteristic water quality results from these monitoring wells. The full water quality results can be found in Appendix F.

Table 6: Water Quality Results

ID	Date	Field pH	Lab pH	Field Conductivity (µS/cm)	Lab Conductivity (µS/cm)	SO4 (mg/L)	Zn (mg/L)	Fe (mg/L)
NFRC AREA								
SRK04-1-(open hole)	9/13/2004	6.85	7.81	1,050	926	97.4	0.0192	0.167
S1-A	9/23/2004	6.22	7.48	1,325	5,330	4,540	92.7	<0.030
S1-B	9/23/2004	6.4	7.86	666	1400	760	0.109	0.033
S2A	9/23/2004	6.07	7.34	1,345	5,500	4,610	124	1.72
S2B	9/23/2004	6.43	7.18	1,134	3,270	2,370	29.6	97.2
S3	9/23/2004	5.97	7.31	1,390	5,360	4,560	86.7	2.06
SRK04-TP2	9/13/2004	6.54	7.23	>2,000	5,300	4,160	62.0	0.187
P96-7	9/29/2004	7.76	n/a	2,825	No Lab Results			
ETA AREA								
SRK04-3A	9/25/2004	n/a	5.64	n/a	6,600	6,480	376	1,080
SRK04-3B	9/24/2004	n/a	3.84	n/a	14,900	18,000	870	6,600
SRK04-4	9/25/2004	n/a	5.11	n/a	8,910	9,840	478	2,990
P96-8A	9/24/2004	6.12	7.09	1,038	6,010	5,120	447	<0.090
P96-8B	9/24/2004	6.28	7.05	1,670	6,320	5,560	263	1.95
GRUM AREA								
SRK04-5A	9/25/2004	n/a	8.34	n/a	459	108	0.0081	0.272
SRK04-5B	9/25/2004	n/a	8.31	n/a	450	100	0.0154	0.316
P96-9	9/24/2004	6.77	7.83	1,135	2,760	1,500	0.0176	<0.030

4.5 Geophysical Surveys

Both seismic and ground penetrating radar (GPR) surveys were conducted as part of the investigation. Surveys focused on two areas: North Fork Rose Creek and the Emergency Tailings Area. The purpose of both surveys was the delineation of depth to bedrock.

All geophysical surveys were conducted by Aurora Geosciences of Whitehorse, Yukon. Surveying of geophysical lines was completed by Yukon Engineering Services prior to arrival of the geophysical crew. Line cutting, where necessary, was completed by an Aurora line cutting crew.

At the time of writing this report, only preliminary data was available from Aurora. Preliminary results are discussed here and in Engineering Design (Section 5). Preliminary data, interpretation methods and survey specifications are included in Appendix G.

Three 115 meter seismic refraction lines were completed in the NFRC area and a single 200 meter GPR survey was completed across the bottom of the ETA, close to the main access road. Seismic refraction was used at the NFRC as opposed to GPR due to the depth of penetration limitations of GPR relative to the expected depths to bedrock.

Preliminary results of the seismic refraction survey completed in the NFRC area indicate depths to bedrock ranging from approximately 15 m to over 30 m. This correlates fairly well with bedrock depths of approximately 11.5 m measured at the location of the two deep S-cluster monitoring wells, and suggests that depth to bedrock generally increases from the S-cluster towards the toe of the WRDs.

The preliminary data also indicates that there is no clearly defined bedrock low that could be interpreted as a paleochannel, but there is a general increase in bedrock elevation from east to west. The generally lower bedrock elevation at the eastern end of the survey suggests that groundwater flux could be higher in this area.

A 220-meter long GPR survey was conducted across the ETA, passing through the newly installed wells. Figure 4 shows the location of the GPR line and preliminary results. While still preliminary, a strong reflector is visible that closely matches the depth to bedrock in each of the two drillholes. Close to the southern end of the survey (distance 0), the reflector is not visible. Close to the northern end (distance 200), the reflector ramps upwards, suggesting the presence of the old Faro Creek valley wall. Bedrock depth appears to be greatest in the vicinity of the 2004 drillholes, where it is approximately 12 m below ground surface.

4.6 Hydrogeological Setting of the North Fork Rose Creek

4.6.1 Hydrostratigraphy and Permeability

Drillhole and test pit logs for the NFRC area indicate that much of the area is underlain by till. Drillhole logs for the "S-cluster" monitoring wells indicate till to depths of 7.5 m overlying weathered bedrock. Test pits SRK04TP-1, -2, and -3, located closer to the toe of the WRD, did not intersect bedrock at depths of 7 m. All test pits indicate till at depth with possible interbedded glaciofluvial sands and gravels. Alluvium was identified in test pits 2 and 3 to depths of 2 m, probably associated with the creek that existed in this area prior to construction of the WRD. Test pits 4, 5 and 6 encountered alluvium over permafrost, which was found at depths of 0.5 to 1.5 m below ground surface. Test pit 7 encountered till to 7 m depth. SRK04-2 intersected till with minor alluvial interbeds to depths of 16 m, overlying 3.6 m of alluvium. Bedrock was not intersected at a depth of 19.8 m.

Water levels were recorded in each of the "S-cluster" monitoring wells and approximately in test pits. Three temporary river stage gauges were installed by surveyors of Yukon Engineering Services and water elevations recorded. Figure 5 shows interpreted equipotentials for the NFRC area.

Comparison of monitoring well water levels and river stage elevations suggests a complex interaction between the river and groundwater system. Comparison of water levels between shallow and deep piezometers at S1 (A deep [12.2m] and B shallow [4.5m]) and S2 (A shallow [6.7m] and B deep [12.2m])) do not indicate consistent vertical gradients. The nested piezometers at S2 (further from the creek) suggest a small upward gradient whereas the nested piezometers at S1 (closer to the creek) suggest a small downward gradient.

The water level at S3 is higher than the other S-well water level elevations, and suggests a gradient towards the creek. S3 was drilled using an auger and was terminated at a depth of only 5.5 m upon intersecting a probable boulder. The relationship between the water levels at S1 and S2 with S3 is unclear at this time. The presence of localized perched water tables in this area cannot be ruled out and may explain the significantly higher water elevation at the shallow monitoring well S3.

The difference between water levels at the monitoring wells and river stations is low enough to suggest that groundwater flow could change direction, particularly in times of high recharge, such as spring freshet.

Slug testing indicates hydraulic conductivities in this area range between approximately $4.5x10^{-6}$ m/s and $6.1x10^{-7}$ m/s. Estimates derived from the Hazen method on test pit samples suggest upper limits to hydraulic conductivity of approximately $2\text{-}3x10^{-7}$ m/s.

Hydraulic conductivity values obtained during this study are based on small scale tests and the observed data are consistent with field observations suggesting that this area is dominated by relatively fine-grained till material as opposed to more permeable alluvial material encountered in the old Faro Creek channel (see below). The observed range of K values (~ 1 order of magnitude) is typical for this type of material and suggest the potential for preferential subsurface flow in higher permeable channels.

4.6.2 Water Quality

Figure 6 shows selected water quality readings for monitoring wells and field conductivity readings for surface waters. These preliminary water quality results suggest that WRD seepage is relatively constrained to the area occupied by the creek that existed before construction of the WRD. Conductivity values decrease significantly to the west of the “S-cluster” and are also low in the NFRC itself. Water quality at SRK04-1 indicates that seepage has not reached that far from the WRD, which is consistent with previous water quality results from P96-7, which also suggested that WRD seepage has not impacted local groundwater in this area to the same extent as near the S cluster of wells (section 2).

At this time, the maximum extent of seepage to the east of the “S-cluster” is not very well constrained.

4.6.3 Anticipated Flow Rates

Conservative subsurface flow rates were calculated based on available hydraulic conductivity data and interpreted average gradients. Maximum and minimum gradients of 0.05 and 0.02 were determined from water levels measured in the S-cluster wells and test pits. The cross-sectional area used for these Darcy calculations assumes a width of 200 m, equivalent to a distance extending past test pits 5 and 3, and an average saturated thickness of 10 m, which corresponds with those at the "S-cluster" and anticipated greater thicknesses upslope. These thicknesses do not take into account preliminary data from the geophysical survey, which suggests greater depths to bedrock. Gradients were calculated from "S-cluster" monitoring well data and it is reasonable to use saturated thicknesses from these drillholes as well. Table 7 summarises flow rates in cubic meters per day for available conductivity values.

Table 7: Anticipated Flow Rates at the NFRC

Gradient	Area (m^2)	K(m/s)	Flow Rate (m^3/d)
0.02	2,000	$4.5x10^{-6}$	15.6
0.02	2,000	$6.11x10^{-7}$	2.1
0.05	2,000	$4.5x10^{-6}$	38.9
0.05	2,000	$6.11x10^{-7}$	5.3

These Darcy calculations suggest that the average groundwater flow in this reach may vary from about 2 to 40 m^3/day (0.02-0.46L/s). In other words, the estimated flow rates along this reach are believed to be relatively low (compared to at the old Faro Creek channel), primarily as a result of the relatively low hydraulic conductivity of the local material.

4.7 Hydrogeological Setting of the Emergency Tailings Area

4.7.1 Hydrostratigraphy and Permeability

Drilling in the ETA indicate tailings to approximately 6.5 m overlying relatively coarse grained sand and gravel, which continues to weathered bedrock. Alluvium thicknesses range from 4.5 to 5 m thickness. Weathered bedrock is not as highly developed in this area, likely due to the presence of the former Faro Creek channel.

Drill logs for P96-8, which is located approximately 400 m upgradient, close to the toe of the Faro WRD and creek monitoring station X23 (Figure 7) indicate bedrock at approximately 8 m depth, also overlain by coarse alluvial deposits (sand and gravel).

Water levels in the newly installed wells (SRK04-4, SRK04-3A and 3B) indicate that groundwater flow moves from the area of P96-8 towards the newly installed wells close to the main access road. At this time, it is uncertain how much subsurface flow emanates from the small valley below the mill. Surface water is only periodically seen here, often at times when the feed line running from the Faro Pit treatment plant is in operation.

Groundwater emerges from the ETA along a clearly visible seepage face below the main access road, on the opposite side from the newly installed monitoring wells. Recent measurements of flow at X23 and the culvert passing under the access road suggest that groundwater upwells into the creek along an unknown reach below X23. Flow measurements taken by Laberge Environmental on October 20, 2004 (representing baseflow conditions) at X23 and the road culvert were 1.4 L/s and

4.1 L/s, respectively. In other words, there is a substantial increase in surface flow along the ETA area. Upwelling is not considered likely closer to the access road, as groundwater levels in the new monitoring wells and pumping well were approximately 6.5 meters below ground surface. This suggests groundwater passing underneath the X23 location may discharge into the creek not far downgradient of X23 itself. Figure 7 shows water levels with interpreted equipotential lines for this region.

Hydraulic conductivity was determined through a 12-hour pumping test on SRK04-4 and slug tests in SRK04-3A, as well as P96-8A and B. These data, which are included in Table 4, indicate conductivity values on the order of $5x10^{-4}$ m/s. Slug test results at SRK04-3A indicate conductivity values lower than those from the pumping test, at $2.63x10^{-5}$ m/s. These differences may indicate heterogeneity, but the value from the pumping test is representative of a larger area than the slug test and likely provides a better estimate.

4.7.2 Water Quality

Preliminary water quality results from monitoring wells and field conductivity readings from surface waters indicate seepage from the WRD as well as local effects due to the ETA tailings. Figure 8 shows selected groundwater quality for local groundwater observed in the monitoring wells in the ETA area (sampled on September 24/25, 2004). Also shown are results of a water quality survey carried out along the Faro Creek channel a few weeks later (on October 19 2004) by Laberge Environmental. During this survey, seepage flows were sampled along the ETA area (at X23 and at the culvert) and further downstream in the Faro Creek Canyon (including groundwater flow discharging at the seepage face, X7).

Both surface water (at X23) and groundwater (at P96-8) observed upstream of the ETA shows very similar water quality with highly elevated SO4 and Zn suggesting that both surface and subsurface flow at X23 are comprised primarily of the same source, i.e. seepage from the Faro WRDs. Note that the surface samples (including X23) were analysed for **total** metals which may explain the higher Fe (total) concentrations at X23 compared to Fe (diss.) in the near-by groundwater.

The presence of the tailings deposited in the ETA area is seen to have a strong influence on groundwater quality further downstream. While groundwater in the deeper alluvial sediments (at SRK04-3A) shows a very similar water quality to that observed further upstream, the shallow groundwater (at SRK04-03B) clearly shows higher concentrations of all contaminants of concern, including SO4, Zn and Fe. The very high iron concentrations suggest that seepage from the old tailings in the ETA area is the most likely source for this additional loading. Note that the pumping well SRK04-4 shows an intermediate water quality, which is consistent with its well completion (screened across the entire alluvial sediments). The water quality of seepage intercepted at this location via pumping can be expected to be similar to the composition observed at SRK04-4. Iron concentrations in this pumping well remain fairly elevated suggesting that problems with well fouling (iron precipitation) may be an issue (unless the tailings are removed).

The seepage flow emerging on the downstream side of the access road (at X7) is more consistent with the groundwater quality observed in the deeper monitoring well (SRK04-3A) than in the shallow groundwater well (SRK04-3B), suggesting that deeper groundwater flow represents a proportionally greater load than the shallow groundwater flow.

The tailings deposited in the ETA area also appear to increase the load in surface seepage flowing across the ETA area. For example, field EC readings increase from 6,470uS/cm at X23 to 7,310uS/cm at the culvert, despite a threefold increase in surface flow. It is unclear at this time whether this substantial increase in load occurs as a result of contact with the tailings along the flow path (in the stream channel) or whether (perched) tailings pore water actually discharges into the stream channel.

The sulphate and zinc concentrations observed in surface seepage in the Faro Creek Canyon (below the confluence of surface seepage from the culvert and groundwater discharging along the seepage face) are remarkably similar to those observed upstream of the ETA area (at P96-8) and in groundwater moving in the deeper alluvial sediments downstream of the ETA area (SRK04-3A). Note, however, that the total flow of this combined seepage (estimated to be ~10.2 L/s using tracer dilution test) is significantly higher than the two clearly identified upstream sources (3.5 L/s from X7 and 4.1 L/s from the culvert). Assuming the seepage estimates are reliable, then an additional groundwater discharge of about 2.5 L/s, with a similar composition to the deep groundwater observed in SRK04-3A, is occurring in the lower portion of the Faro Creek Canyon.

Note that the combined seepage in the Faro Creek Canyon (consisting of contributions from surface flow and groundwater flow discharging to surface) represent a significant contaminant load to the downstream environment. For example, assuming a flow rate of 10 L/s, the combined seepage down Faro Creek Canyon represents an annual sulphate load of about 1731 t/year and an annual zinc load of ~100 t/year. Monitoring of this seepage further downstream suggests that most of this seepage is currently lost due to leakage into the tailings and/or underlying groundwater system of the Rose Creek aquifer (RGC, in progress). These calculations illustrate that interception of the seepage along the old Faro Creek valley would result in a significantly reduction of contaminant loading to the downstream environment.

4.7.3 Anticipated Flow Rates

Flow rates in the ETA are more constrained than those at the NFRC area. While only preliminary, geophysical data in this area (shown in figure 4) provides a general cross-sectional area for the flow system. An approximate value of 600 m^2 is used for total cross-sectional area. Using a gradient of 0.02, derived from water levels at the available monitoring wells, and an average hydraulic conductivity value of $5x10^{-4}$ m/s, a flow rate of 520 m^3/day (6.0 L/s) is calculated.

During the pumping test groundwater seepage from below the access road was estimated at approximately 3 L/s. Follow-up flow measurements carried out at this location by Laberge Environmental on October 20, 2004 indicated a flow of 3.5 L/s. In other words, the data suggest that only about 50% of all groundwater emerges in the seepage area below the access road. When combined with surface flow measurements taken at the culvert of 4.1 L/s, it is estimated that approximately 10.1 L/s of combined flow move down the Faro Canyon area. This estimate is in very good agreement of total (combined) seepage flows of 10.2 L/s measured near the mouth of Faro Canyon in October 2004 by salt dilution (Ken Nordin, pers. Comm.).

4.8 Hydrogeologic Setting of the Grum Creek Area

4.8.1 Hydrostratigraphy and Permeability

The drilling of SRK04-5 identified alluvium to 4.6 m, overlain by approximately 3.6 m of sandy clay. Below the clay, approximately 13 m of sand and gravel with clayey zones was intersected and is interpreted as till. Weathered bedrock was encountered below the till for 3 m. The hole was terminated at a final depth of 24 m in weathered bedrock.

Flowing artesian conditions were encountered at depths greater than 12.5 m, which coincides with previous results from P96-9B, which is located approximately 100 m away from SRK04-5. Water pressures in the confined aquifer are equivalent to water levels greater than 2.7 m above ground surface. A confined aquifer is interpreted to be present at depths below approximately 12 m, overlain by an unconfined aquifer. Flow in both should be from the higher elevation dump areas towards Vangorda Creek. At this time lateral extents, recharge or discharge zones for the confined aquifer are unknown.

Slug testing could not be completed in the SRK04-5 monitoring wells due to flowing conditions.

4.8.2 Water Quality

Preliminary results from SRK04-5A and 5B suggest that groundwater in the deeper, confined, system is not impacted by WRD seepage from the Grum Dump at this time (Table 6). The water quality observed in these deeper, confined layers is consistent with water quality observed previously in the deeper piezometer at P96-9B which is now inaccessible (see Appendix A). It can therefore be concluded that deeper groundwater flowing in confined (typically artesian) aquifers beneath the Grum Dump is not significantly impacted by WRD seepage at this time (and may not be for a very long time).

Groundwater quality monitoring at P96-9A (in a near-by drainage channel) suggests that shallow groundwater flowing in an unconfined layer of alluvial sand and gravels is impacted by WRD seepage from Grum Dump (Table 6 and Appendix A). Despite the proximity to the Grum Creek channel, an unconfined layer with significant flow of shallow groundwater was not encountered during drilling at SRK04. At this point, it is unclear whether the lack of shallow groundwater is characteristic of this area or not. Additional drilling in this reach may be required to better evaluate the spatial extent of WRD seepage and its impact on the shallow groundwater system.

4.8.3 Anticipated Flow Rates

In our opinion, there is insufficient hydrogological information (hydraulic conductivity estimates, gradients, cross-sectional area) available at this time in order to provide reliable estimates of flow rates in the reach downstream of the Grum WRD. Additional hydrogeological field work (including additional drilling and hydraulic testing) would be required to allow such estimates of flow rates to be made.

5 Discussion of Preliminary Options

5.1 North Fork Rose Creek Collection System

5.1.1 Overview

A review of the historic monitoring data (RGC, 2004) had indicated that seepage from the Intermediate Dump may have impacted shallow groundwater (in overburden soils and weathered bedrock) along the north side of the North Fork of Rose Creek below the rock drain (see Appendix A). While the results of the 2004 field investigation have confirmed this initial conclusion they also demonstrate that the area affected by WRD seepage (in terms of elevated SO4 and zinc) may be much smaller than originally anticipated. Field reconnaissance as well as additional drilling and test pitting suggest that the impacted area is likely limited to a relatively small reach (no more than 200-300m) defined by the mouth of a historic drainage channel (now overdumped by waste rock) which acts as a conduit for waste rock dump seepage towards the Rose Creek valley. Maps of pre-mining topography show that this local drainage channel extends up to the base of the sulphide cell buried in the Intermediate Dump and it is hypothesized that drainage from the sulphide cell is the primary source of the highly elevated SO4 and zinc seen in shallow groundwater at the mouth of this drainage channel (i.e. in the "S" cluster of wells).

The results of the 2004 field investigation further suggest that the local overburden soils are primarily comprised of till-like sediments with significant fines content. As a result, the local flow rates are relatively low (compared to, for example the Faro Creek channel) and the contaminant loading to the downstream environment is therefore limited. Nevertheless, the concentrations of the constituents of concern (in particular zinc but also manganese and iron) are relatively high and the proximity to the North Fork of Rose Creek warrants further assessment of seepage interception. In the following, we discuss different options on how to intercept this seepage and present a preliminary conceptual design for the preferred option.

It should be stressed that the hydrogeological information available at this time is insufficient to allow a detailed design of a seepage interception system (e.g. extraction rates, number and spacing of wells etc.). Additional site characterization will likely be required in order to finalize any design of a seepage interception system in this area. It should also be noted that there is still significant uncertainty about the impact of this seepage on the downstream aquatic environment, in particular the North Fork of Rose Creek. A detailed assessment of the interaction of the shallow groundwater and the NRFC and the impact of this seepage on surface water quality were beyond the scope of this study. However, such a study is likely needed to determine whether seepage interception in this reach is indeed required to protect the aquatic environment.

5.1.2 Discussion of Options

The water quality monitoring in this area indicates that both shallow (and potentially perched) groundwater in the overburden soils as well as deeper groundwater (in deeper till and weathered bedrock) is similarly impacted and may require interception. For the purpose of this discussion it is therefore assumed that all groundwater flowing above and within weathered bedrock will have to be intercepted.

The general depth to bedrock in this area (>10m) and the local constraints of space and topography generally preclude the use of a seepage collection ditch to intercept all of the impacted groundwater. Conversely, the local subsurface conditions (till-like material with significant local heterogeneity) are not well-suited for an active interception system using a “traditional” fence of wells for several reasons. First, this fine-grained material will likely require a very tight spacing of interceptor wells (in the order of 5-10m) owing to its relatively low hydraulic conductivity. Second, the combination of low K material and limited available drawdown (<5m) will result in frequent cycling of individual pumps and potential “fouling” of the well screens requiring high maintenance of the pumping system. Finally, the presence of local heterogeneity may result in some by-pass of groundwater, in particular of shallow groundwater in perched layers, which may already be present and/or could develop in response to pumping.

Based on these considerations, at this time our preferred option for seepage collection along this reach would be to engineer a high permeability zone in which a series of pumping wells are installed (see Figure 9). This high K zone would be constructed by excavating a trench to the maximum depth feasible (likely 6-7m) and backfilling it with coarse fill (clean sand and gravel). The pumping wells would be drilled and completed after construction of the backfilled trench and screened partially in the backfill and partially in the underlying till and weathered bedrock. The purpose of this high K zone is threefold. First, the zone facilitates interception of any shallow seepage (including contaminated surface runoff currently observed throughout the area). Second, the presence of a high K zone reduces the number of pumping wells required to maintain adequate drawdown along the line of interception. Thirdly, this set-up would significantly improve pumping operations (and therefore maintenance) because of a reduction in pump cycling and fluctuations in the local water table.

Figure 10 shows the preliminary alignment of the proposed seepage interception system (SIS) including preliminary locations of pumping wells. The alignment of the SIS will have to be finalized once the full extent of the area impacted by WRD seepage has been determined. The exact number, locations, and screen interval of the pumping wells will also have to be finalized once additional field investigations (including hydraulic testing) have been completed.

It is envisioned that the SIS would be operated using automatic pump switches, which maintain a small but significant drawdown (say at least 0.3m) below the creek elevation at all times. An excessive drawdown (say >1m) should be avoided as it would induce seepage from the North Fork Rose Creek towards the SIS. Monitoring wells would be installed to monitor the performance of the SIS and demonstrate “compliance”. A concern during operation of the SIS would be the potential for iron oxidation when groundwater enters the well casing and comes in contact with air. This could result in clogging of the well screen and/or pump reducing the efficiency of the pumping system ("well fouling"). In order to minimize such well fouling, the pumping system should therefore be designed and operated in such a way that the screen of a given pumping well remains saturated at all times.

A preliminary estimated capital cost based on three pumping wells and a ditch system of the required length is estimated at approximately $712,000. The number of pumping wells and ditch length is only representative at this time. Until further assessment of the area is complete, a final cost estimate cannot be completed. This does not include the cost of setting up power to the site. A breakdown of this cost estimate is included in Appendix H.

Annual operating costs are estimated at approximately $27,000 including power and routine maintenance, assuming no significant work on the pumping system is required. Re-furbishing of wells due to fouling (iron, calcium encrustation, etc.) will be necessary on the scale of 10-15 years, though determination of exact frequency will not be possible until real conditions have been observed. This will require mobilisation of a drill to site and approximately 1.5 days per well. Based on three pumping wells at today's rates, refurbishing costs would be approximately $27,000 including drill, mob/demob and crew. If pump replacement were required, available site equipment could be used for pump removal (*e.g.,* HIAB) with pump replacement costs of approximately $30,000 for three wells.

5.2 Emergency Tailings Area Collection System

5.2.1 Overview

A review of the historic monitoring data indicated that WRD seepage is day-lighting at the toe of the Main Dump and has impacted shallow groundwater flow moving in the permeable alluvial soils of the historic Faro Creek channel, referred to here as the ETA (see Appendix A). Additional field investigations carried out in 2004 have provided a better understanding of groundwater flow in the ETA. Drilling and geophysical surveys in the lower part of the ETA have confirmed the presence of highly permeable alluvial sediments (sand and gravel) in the old Faro Creek channel. The results of hydraulic testing suggest that approximately 6 L/s of highly impacted groundwater is flowing in these alluvial soils. Flow measurements suggest that approximately half of this groundwater flow emerges in a discrete seepage face immediately downstream of the mine access road. Most of the remaining groundwater flow appears to discharge to surface along the lower reach of the Faro Creek Canyon.

Detailed flow measurements of surface seepage further upstream also suggest that the upper reach of the Faro Creek channel (between the toe of the WRD dump and just upstream of the ETA) represents a groundwater discharge zone where WRD seepage is discharging to surface.

Detailed groundwater quality monitoring carried out in this area as part of this study (including sampling of recently completed monitoring wells, seeps and surface seepage in the ETA area) has confirmed that groundwater in this reach is highly contaminated. Furthermore, it has shown that concentrations of contaminants of concern (SO_4, Zn, Fe, and others) are significantly higher at the downstream side of the ETA (at the mine access road) compared to at the upstream end (at X23). The two likely sources for this increase in contaminant loading in groundwater are (i) the tailings deposited in the ETA and (ii) seepage from the mill area (including associated ore stock piles and waste rock dumps).

The results of the 2004 field investigation demonstrate that all seepage from the ETA area (surface and groundwater) is highly contaminated. In our opinion, this seepage should be collected and treated regardless of the final closure option for the Rose Creek tailings facility. Flow measurements carried out as part of the Rose Creek tailings study (RGC, in progress) indicate that as much as 90% of the combined seepage from the ETA is lost due to leakage into the tailings and/or natural ground before it reaches the Intermediate Pond (RGC, in progress). The results of the 2004 field investigation provide a solid framework for evaluating alternative options for seepage interception in the ETA area. In the following we discuss different options on how to intercept this seepage and present a preliminary conceptual design for the preferred option. For the purpose of this discussion we have assumed that the tailings in the ETA will be removed prior to installation of a SIS.

5.2.2 Discussion of Options

Pump testing has confirmed the feasibility of intercepting the contaminated groundwater in the ETA area by means of a "traditional" fence of interceptor wells. Similarly, the interception of surface seepage is relatively straight forward as the surface seepage is running year-round and flow rates are comparatively steady due to flow attenuation in the WRDs, which represent the majority of the upstream catchment area. Hence, the primary points of discussion in terms of options selection include the location of the SIS and the merits of intercepting the seepage as surface flow versus intercepting (at least part of) the seepage as groundwater.

Three options were identified for the Emergency Tailings Area. Table 8 presents advantages and disadvantages for each option with capital costs assuming a treatment plant is located at the Intermediate Dam.

Option 1 – Surface seepage collected in shallow ditches at toe of WRD (X23), collected in a sump and piped to the treatment plant; groundwater is collected at pumping wells located downgradient of X23 and the mill area valley, and connected to the pipeline from the X23 sump (Figure 11).

Option 2 – Surface seepage is collected in sump located where the surface water crosses under the main access road through a culvert; groundwater is collected at a line of pumping wells (~3) located immediately upstream of the mine access road (Figure 12).

Option 3 – Surface seepage collected in sump at mouth of Faro Canyon; residual groundwater is intercepted by pumping wells at the mouth of Faro Canyon (Figure 13).

Estimated costs for each of the three options were based on available surface and subsurface water flow estimates. Surface water collection systems are based upon gravity drained sumps, linked to common main lines with the pumping well outlet lines. All pipes are HDPE, insulated and buried to three meters, the estimated freeze penetration depth. Pipeline size was determined based on a conservative estimate of baseflow rates. Pipeline costs assume that water is directed to a treatment plant located close to the Intermediate Dam.

Sumps were sized to baseflow rates and designed for minimal storage. At this time, sump designs are only preliminary and costs are based on installation of one HDPE manhole each. Estimates of flood discharge rates and volumes for catchments beneath the WRDs are not well understood. Sump dimensions at this time are considered conservative for flow rates that have been observed at monitoring stations such as X23, but may need to be scaled up if and when further understanding of seepage from the WRDs becomes available and the risk of spillover from higher flow rates can be assessed.

Pumping well systems for options 1 and 3 are conservatively estimated, based on available data from the results of testing close to the main access road.

Preliminary estimated capital costs associated with each option are included in Appendix H. Note that the cost of providing a power connection to the selected pumping site(s) has not been included in this capital cost. Operating costs for each collection system are estimated in Table 9, with pumping costs based on pipeline options discussed in section 5.2.4.

Table 8: ETA Option Comparison

	Description	Advantages	Disadvantages	Capital Cost	Annual Operating Cost
Option 1	Surface seepage collected in shallow ditch at toe of WRD (X23); groundwater collected at pumping wells below X23 and mill	- Single location - Highest water temp. (low risk of freezing) - Least susceptible to flooding - No recharge of WRD seepage to subsurface - Potential reclamation of E.T.A.	- Miss runoff from Mill area - Incomplete understanding of subsurface at both pumping well areas - Sensitivity of pumping system to narrow flow area increases potential maintenance issues (iron-precipitation)	**$856,000**	**$23,000**
Option 2	Surface seepage collected in sump near access road culvert; groundwater collected at fence of wells (~3) upstream of access road	- Capture of all subsurface flow - Good understanding of subsurface conditions - Good access - Best subsurface system for year-round collection - Surface system OK in winter - If installed before tailings removal, will help with de-watering of tailings - Potential reclamation of E.T.A.	- Multiple system access required - Additional maintenance of pumping system - Surface flow from X23 continues to culvert leading to iron-precipitation in channel	**$842,000**	**$29,000**
Option 3	Surface seepage collected in shallow ditch at mouth of Faro Canyon; residual groundwater collected in 1-2 wells at mouth of Faro Canyon.	- Single access and power supply - Majority of flow captured as surface flow - Good access	- Freezing has greater negative effect - Large catchment area - Larger potential for bypass or washout during high precipitation events - Increase in total volume to treatment plant - Large impacted area remains upstream; Fe-precipitation continues in Faro Canyon	**$735,000**	**$23,000**

Table 9: Estimated Operating Costs

	Pipeline Option		
Design Option	5a	5b	5c
1	$33,000	$21,000	$23,000
2	$39,000	$28,000	$29,000
3	$33,000	$21,000	$23,000

Operating costs assume power at $0.13 per kWhr, and sumps require 0.33 days to clean using a suction pump truck or other available equipment. Routine inspections are assumed to require one day for all options.

5.2.3 Preliminary Preferred Collection Option

At this time, Option 2 is the preferred collection option. An evaluation of advantages and disadvantages (Table 8) indicates that option 2 has the greatest number of favourable attributes.

An initial assessment of options that took the presence of tailings into account indicated:

- A high probability of contamination bypassing the collection system
- A high probability of increased loading to the treatment plant due to infiltration or flow through the tailings
- A very low probability of reclamation of the ETA

If tailings are retained in the ETA, each of the options presented would require modifications. In the event that tailings do remain in the ETA, option 2 still provides the best means of collecting seepage before reaching downstream environments.

In the event that tailings are removed, option 2 collects seepage closest to the source with the greatest chance of capturing residual contamination (from the ETA area), which is likely to exist for many years. Option 1 does not collect any residual contamination, and option 3 allows residual contamination to continue flowing through Faro Creek Canyon, possibly leading to further discoloration due to iron oxidation and seepage into the subsurface, which is not as well understood as in the ETA.

Option 2 could provide a strategic advantage to ETA tailings removal. Water level measurements recorded during the 2004 field program indicate that in the area of the new drillholes, the lower sections of the tailings are saturated. It is probable that this occurs upgradient towards X23 as well. Excavation to alluvium in the area of the proposed fence, emplacement of a clean fill bench and installation of the pumping wells upon this bench prior to tailings removal, could both allow dewatering of much of the tailings pore water, as well as capturing infiltration if a hydraulic monitoring method were used (*i.e.*, high pressure water guns). Figure 14 is a schematic design drawing based on data from the new drillholes illustrating this option.

A preliminary pumping well configuration for option 2 must take into account the probable presence of hydraulic boundaries as well as the implications of limited available drawdown. Pumping rates must be configured to capture all subsurface flow while protecting the wells themselves. High Fe concentrations in ETA water (refer to table 6) indicate that if screens are exposed to oxygen during pumping, fouling will likely occur, decreasing screen lifetime and efficiency. As shown on Figure 14, total available drawdown to the top of the screened interval is approximately three meters. Fe concentrations in the groundwater suggest that if the water level drops below the screened area, encrustation problems would likely decrease screen effectiveness, thereby increasing long-term maintenance and the need for possible replacement (“well-fouling”).

Selection of proper pumping rates will take into account the geometry of the flow system, as boundary effects caused by valley walls will increase total drawdown. Boundary effects will likely be present for pumping systems in all of the collection system options (but least pronounced for option 2).

Based on the preliminary geophysical survey data for the ETA, three pumping wells should provide the necessary capture zone to collect all subsurface flow in the ETA. Each of the pumps would be rated based on overlapping cones of depression taking into account the available data on the location of valley walls. The pumping system shown in Figure 14 would likely be comprised of a central pump with a higher rating than the two peripheral pumps. Designs would be based on available drawdown to the top of the screened interval with a margin of safety to keep the screens submerged. As a backup, each pump would be equipped with automatic controls linked to pressure transducers that would shut down the pump if too much drawdown occurred.

The cost estimate for option 2 includes the possibility of different pump ratings based on the results of a simple numerical model that accounts for valley geometry based on the preliminary geophysical survey. All pumping system costs include automatic controls.

5.2.4 Pipeline Options

The total length of pipeline required connecting collection systems at NFRC and the ETA will be dependent on final location of the treatment plant. Until this location is chosen, final alignments for collection pipelines cannot be completed. Three options are available based on possible treatment plant locations:

1. Pump all water to Faro Pit
2. Gravity drain/pump to treatment plant near base of Faro Creek Canyon
3. Gravity drain/pump to treatment plant near Intermediate Dam

Costs for each of these alternatives are included in the cost breakdowns included in Appendix H. Costs included in Table 10 assume the treatment plant is located near the Intermediate Dam (pipeline Option 3).

In the case of tailings removal from the ETA, final topography will influence the ultimate alignment of any pipeline. For the purpose of this cost assessment, pipelines are assumed to follow the shortest path down grade from collection system to possible treatment plant location.

For freeze protection, pipelines are assumed to be insulated and installed to a minimum 3 m burial depth. An alternative option for freeze protection is the installation of a heat trace system within pipelines.

Table 10 and 11 show estimated relative capital and operating cost for burial versus heat tracing for 1,000 m of pipeline.

Table 10: Estimated Capital Costs for 1000 m Pipeline

Option	Materials	Excavation	Capital Cost
Heat Trace with HDPE insulated pipe	$125,000	0	$125,000
3 m excavation with HDPE insulated pipe and manholes every 500m	$112,000	$54,000	$166,000

Table 11: Estimated Annual Operating and Total Costs for 1000 m Pipeline

Option	Maintenance	Power Requirements/yr[1]	Sum Capital and Operating Costs
Heat Trace with HDPE insulated pipe	$2,000 (clear manholes and inspect electrics?)	$9,400	$134,000
3 m excavation with HDPE insulated pipe and manholes	$1000 (clear manholes)	$0	$166,000

[1]The power requirements are based on current rates of $ 0.13 per KWhour and operating requirements of 6 months per year @ 5 W/ft (16.5 W/m) for the heat trace.

Use of a heat trace system allows pipelines to be laid along the ground surface and makes no assumption about pipeline support structures. A significant benefit of heat trace is that the pipelines are easily accessed for repairs or service. In addition, pipeline removal, if ever required in the future, is relatively inexpensive to undertake.

The total length of pipeline required to connect collection systems at NFRC and the ETA will be dependent on final location of the treatment plant. Until this location is chosen, final alignments for collection pipelines cannot be completed. In the case of tailings removal from the ETA, final topography will control the ultimate alignment of any pipeline. For the purpose of this cost assessment, pipelines are assumed to follow the shortest path down grade from collection system to possible treatment plant location.

5.3 Grum Creek

5.3.1 Seepage Collection Options

At this time, seepage collection options presented in the SRK report ***Design Options for Seepage Collection, Grum Waste Rock Dump, June 2004*** are considered appropriate.

Three collection options were presented in the Grum Dump design option report. The following is a summary for each option with associated cost estimates.

1. Sediment and Seepage Control Ditches

   This option proposes a sedimentation basin for collection of clean water and removal of suspended load before release to a tributary, and till-lined open channels to capture and convey seepage and shallow subsurface waters that require water treatment. Capital cost was estimated at about $418,000. Operational costs would be minimal, involving inspection of ditches and sumps, as well as occasional removal of sludges.

2. Sediment Control Ditch, Seepage Collection Sumps and Pipes

   Option 2 describes the use of seepage-specific HDPE sumps connected via pipelines to a central pond holding area, from where contaminated water would be directed to a treatment plant. Capital cost was estimated at approximately $559,000. Operational costs would include maintenance of the sumps and holding pond. Additional maintenance costs would arise if pumping stations were required along the pipeline.

3. Groundwater Collection Wells

   The use of groundwater collection wells was presented as an option, but no system proposed due to unavailability of groundwater data. No cost estimates were provided for this option.

At this time, available water quality data for the deeper, confined, aquifer system suggests that, in the local area of the newly installed monitoring wells, WRD seepage impacts are not present. From a planning perspective, if groundwater collection was required from the deeper aquifer, interception wells would be the only option due to the depth of the aquifer. Methodology for collection of shallow groundwater will depend on the thickness and depth of the shallow aquifer.

6 Conclusions and Recommendations

6.1 North Fork Rose Creek below Rock Drain

A combined pumping well and seepage ditch collection system (in the form of an engineered high permeability zone which allows surface seepage as well as groundwater to be pumped efficiently) is considered to be the only feasible option at this time. The capital cost of such a system is estimated to be in the order of $712,000. However, there are significant uncertainties associated with this cost estimate due to limited knowledge on the extent of contamination and subsurface conditions. As part of detailed engineering, a drilling program focusing on likely peripheral contaminated areas is recommended. It is recommended that up to 6 drillholes be completed to bedrock using split spoon or other method capable of collecting depth-specific sediment samples. Monitoring wells should be installed in every other hole.

In addition, additional hydraulic testing should be carried out to better constrain the likely groundwater flow rates to be intercepted. For this purpose, air lift testing should be carried out at different depths in all open drill holes and slug testing should be carried out in all completed monitoring wells.

Finally, at least two permanent staff gauges should be installed along the creek in the area of the S-cluster to provide a better record of relative water levels between the creek and monitoring wells. The relative elevations of the creek level and the local groundwater table should be monitored for at least one year to evaluate the potential for groundwater discharge into the creek and vice versa.

6.2 Emergency Tailings Area

Option 2, which consists of a groundwater collection system at the main access road, is the preliminary recommended collection option at this time. The capital cost associated with option 2 is estimated to be about $850,000. Uncertainty in the final design of option 2 components is related to understanding of probable flood specifications for the combined X7 and X23 catchments, as well as the presence of geologic heterogeneity and/or multiple aquifer types. The X23 gauging location should be rehabilitated and maintained to allow for routine monitoring, the data from which could be compared with other monitoring networks and flood hydrographs to provide a practical flood hydrograph for design purposes. Modifications to preliminary sump volumes could be made, if necessary, and final designs or plans prepared once a decision on removal of tailings is received.

A brief desktop modeling study should be completed, based on the available simple model, to develop a pumping configuration for the ETA valley geometry, once the geophysical survey data has been fully interpreted.

6.3 Grum Creek

WRD seepage into groundwater in the Grum Creek area is still not well understood. Deeper aquifers do not appear to be affected by seepage as of yet, but numerous surface seeps with poor water quality have been identified in the area and may locally impact shallow groundwater flow

A shallow monitoring well (<10 m) is recommended along Grum Creek, in the vicinity of SRK04-5, to complement the deeper monitoring wells. Further drilling in this area, such as proposed drillhole #7A and #7B and replacement of P-96b, should be completed in cooperation with other programs, such as the AMP, to increase utility and minimise cost.

6.4 Additional Areas

Lower priority seepage areas identified in the July, 2004 memorandum (Appendix A) but not included in this program should be re-evaluated in terms of cost and assessed in the near future. If areas such as the North Fork Rose Creek require seepage interception then these seepage collection systems, particularly pipelines, should be designed to work in concert with other nearby systems to reduce overall costs.

This report, **"Preliminary Seepage Collection Options: Faro & Grum Waste Rock Dumps – 2004/05 Task 14d"**, has been prepared by SRK Consulting (Canada) Inc.

Prepared by

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Hydrogeologist

Dr. Christoph Wels, Ph.D., M.Sc.
Principal & Senior Hydrogeologist

Reviewed by

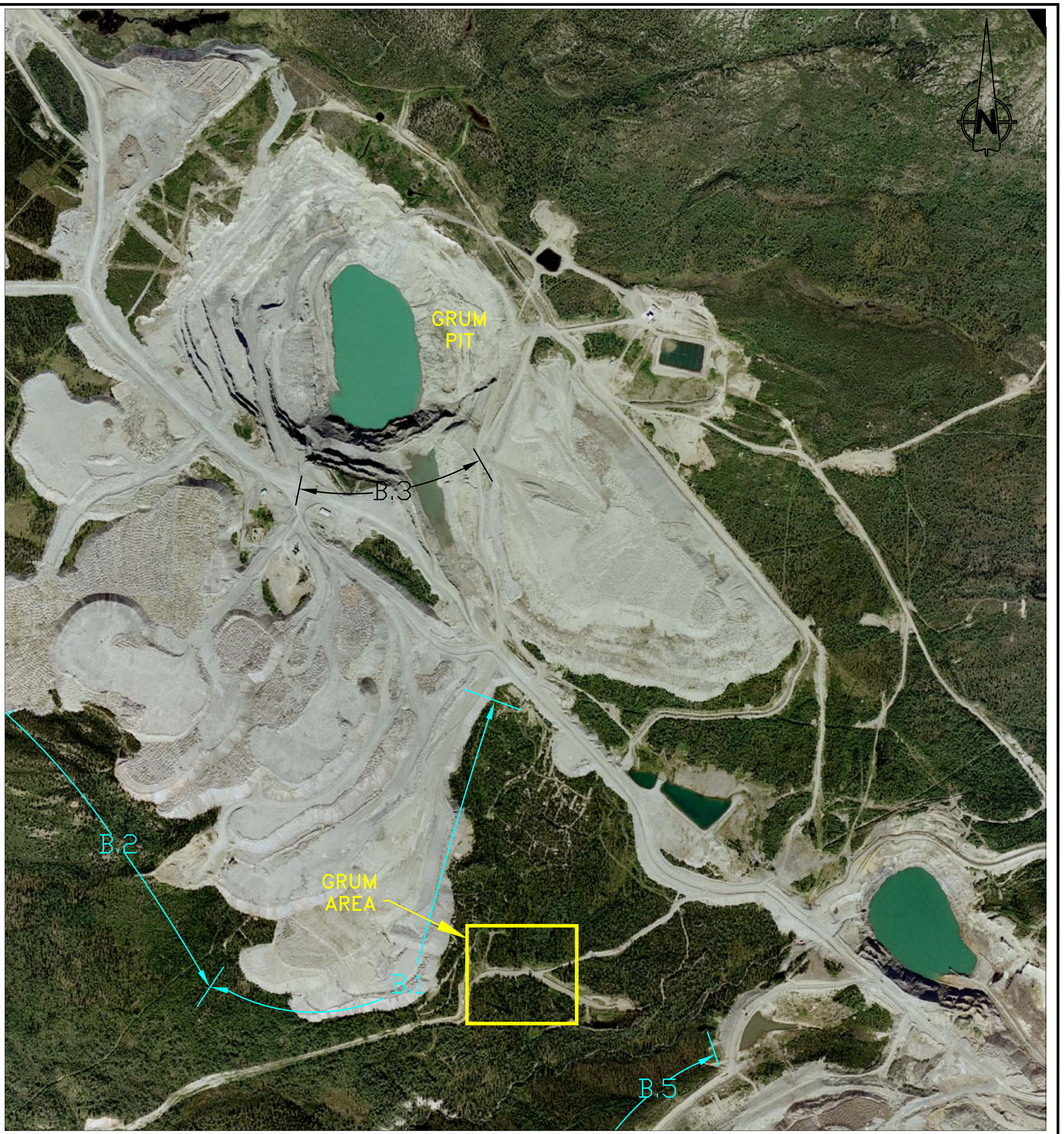
Cam Scott, P.Eng.
Principal

Figures

FARO PIT AREAS

0 200 400 600 800 Metres
1:15,000

Notes: Map derived from 1:50,000 scale
NTS Mapsheet 105 K/3 and 105 K/6
North American Datum 1927
Transverse Mercator Projection



GRUM PIT AREA

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1:15,000

REACH B.4 (VANGORDA DUMP DRAINING TOWARDS DIXON CREEK) NOT SHOWN ON MAP

A.4 — REACH IDENTIFIED IN RGC, 2004 MEMO (APPENDIX A)

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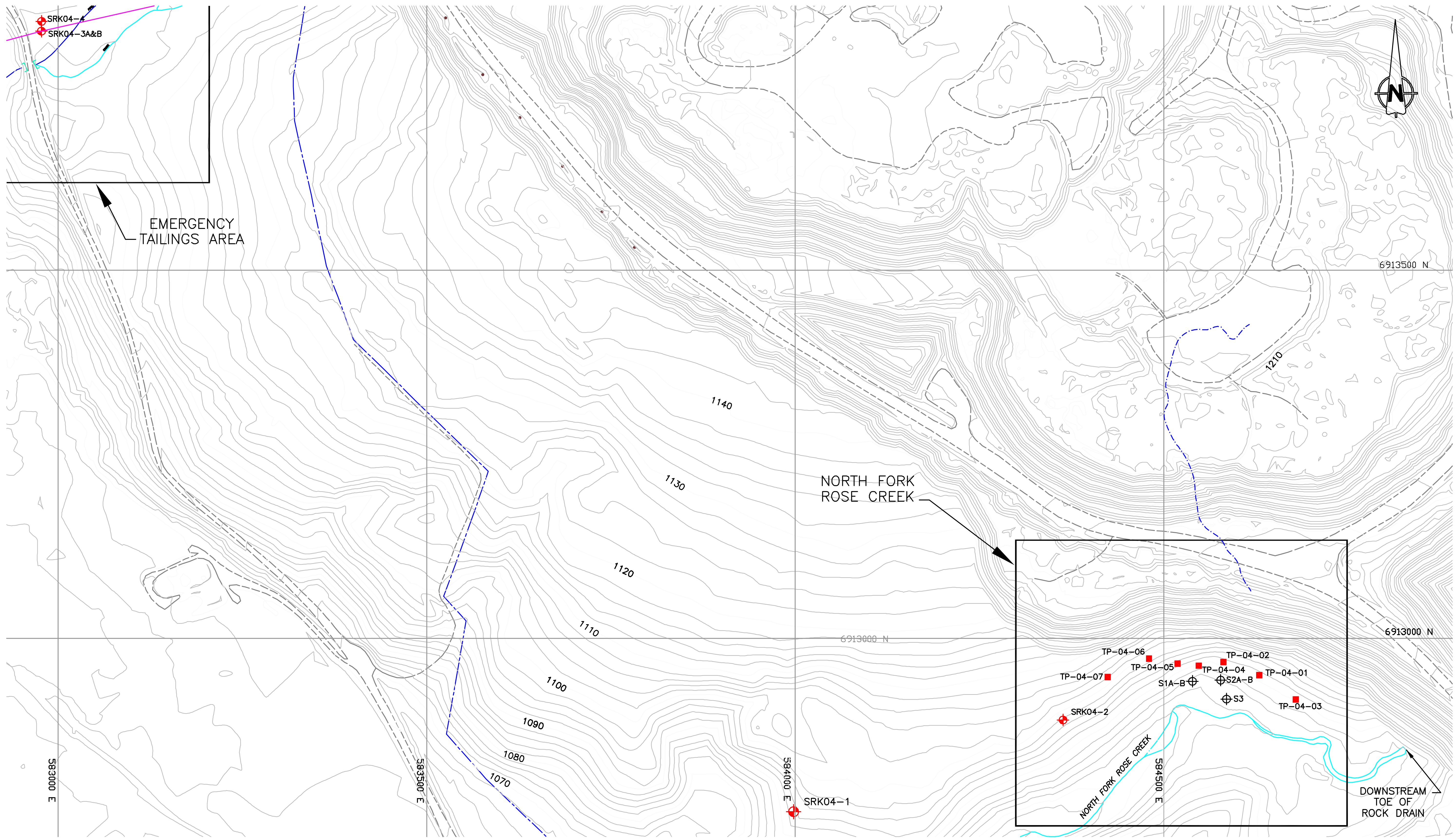
FARO MINE SITE	
2004 FIELD WORK AREAS	

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		1

File Ref: 2003 SITE PLAN-photo.dwg



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SRK CONSULTING

Faro Mine, Yukon

Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

LEGEND

- 2004 DRILLHOLE LOCATION
- "S" CLUSTER MONITORING WELLS
- 2004 TEST PIT LOCATION

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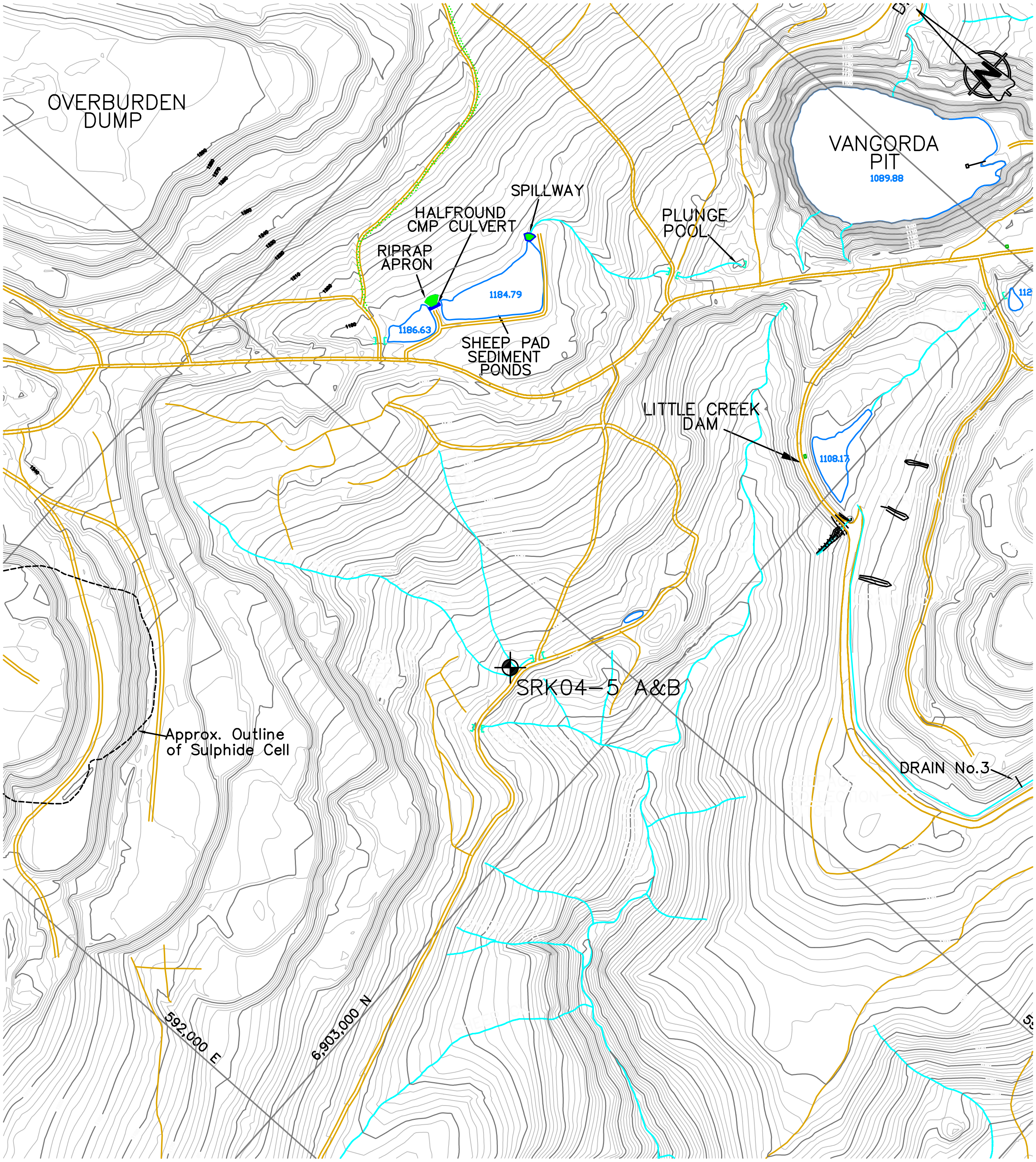
FARO MINE SITE

2004 DRILLHOLE LOCATIONS

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		2

File Ref: Sample_plan-NAD27.dwg



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LEGEND

2004 DRILLHOLE LOCATION

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Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

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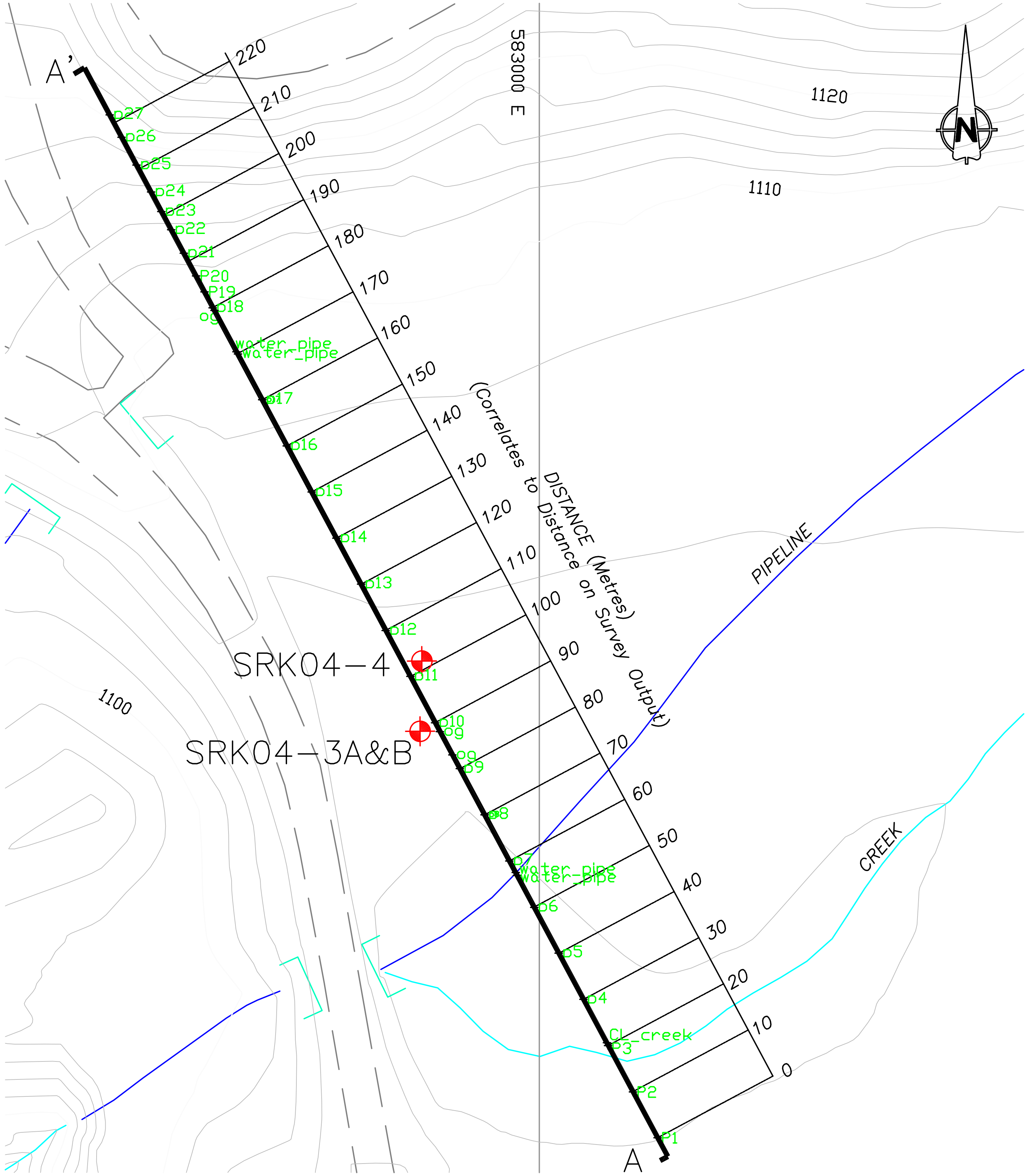
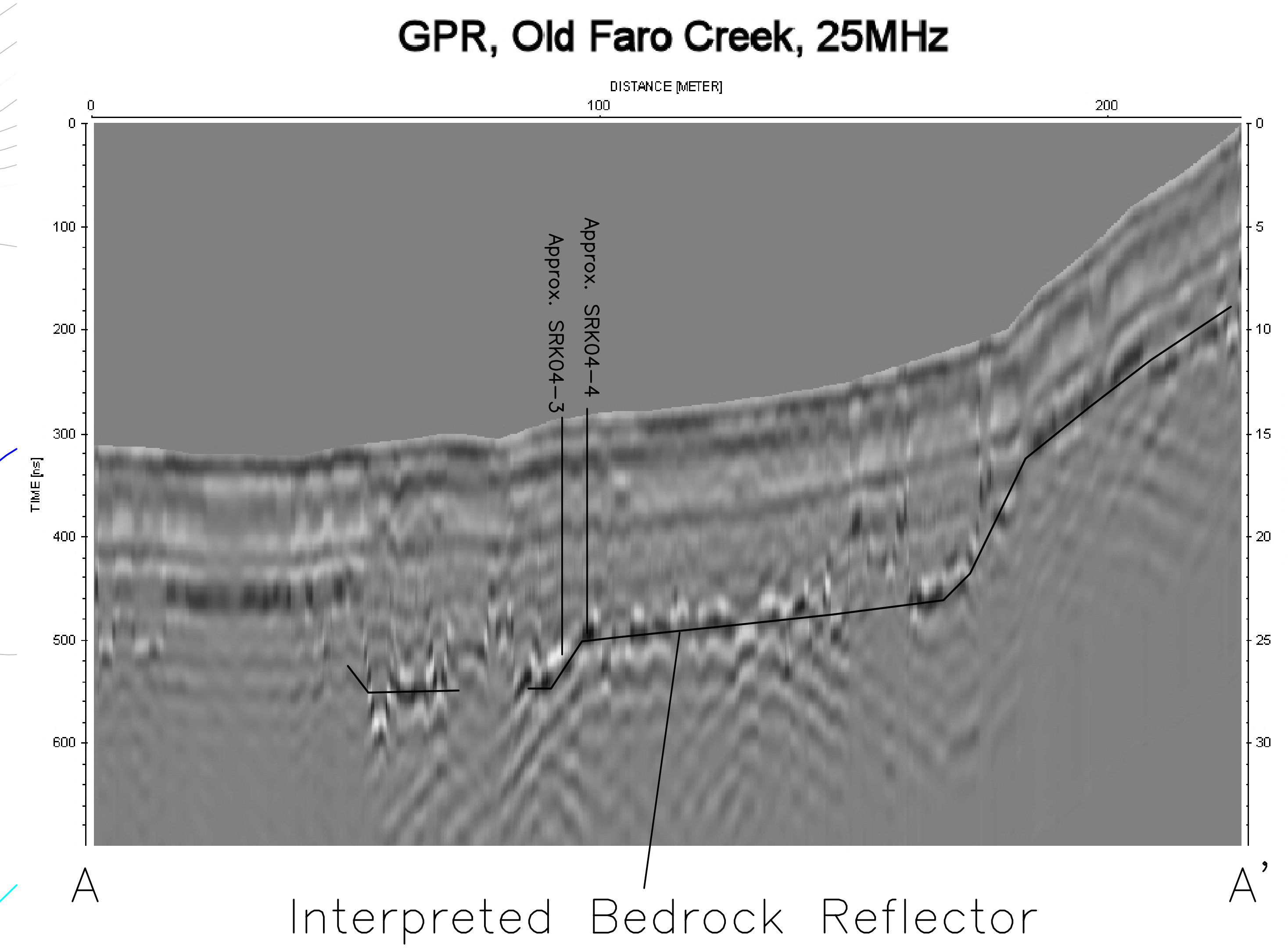
GRUM SEEPAGE COLLECTION

2004 MONITORING WELL LOCATION PLAN

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.056	Nov.2004		3

Dwg Ref: *.dwg





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SRK CONSULTING
Faro Mine, Yukon

Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
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LEGEND

+P1 2004 SURVEY POINTS
2004 BOREHOLE LOCATION

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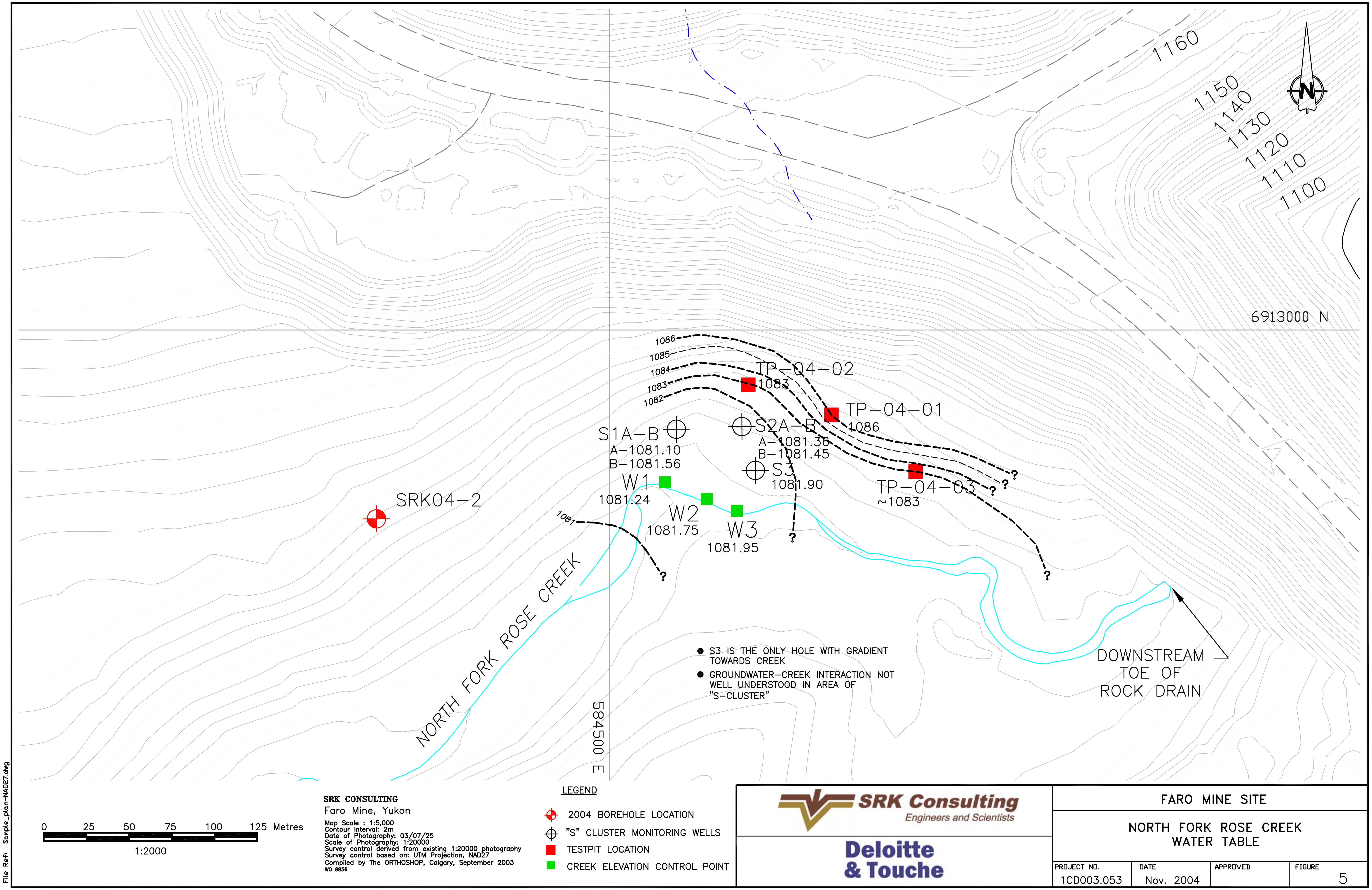
FARO MINE SITE

PRELIMINARY GEOPHYSICAL RESULTS AT ETA

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		4

File Ref: Sample_plan-NAD27.dwg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1140
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1110
1100
N
6913000 N
584500 E
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1084
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1082
1081
TP-04-02
1083
TP-04-01
1086
TP-04-03
~1083
S1A-B
A-1081.10
B-1081.56
S2A-B
A-1081.36
B-1081.45
S3
1081.90
W1
1081.24
W2
1081.75
W3
1081.95
SRK04-2
NORTH FORK ROSE CREEK
DOWNSTREAM TOE OF ROCK DRAIN
S3 IS THE ONLY HOLE WITH GRADIENT TOWARDS CREEK
GROUNDWATER-CREEK INTERACTION NOT WELL UNDERSTOOD IN AREA OF "S-CLUSTER"
0 25 50 75 100 125 Metres
1:2000
SRK CONSULTING
Faro Mine, Yukon
Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856
LEGEND
2004 BOREHOLE LOCATION
"S" CLUSTER MONITORING WELLS
TESTPIT LOCATION
CREEK ELEVATION CONTROL POINT
SRK Consulting
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FARO MINE SITE
NORTH FORK ROSE CREEK WATER TABLE
PROJECT NO. 1CD003.053
DATE Nov. 2004
APPROVED
FIGURE 5
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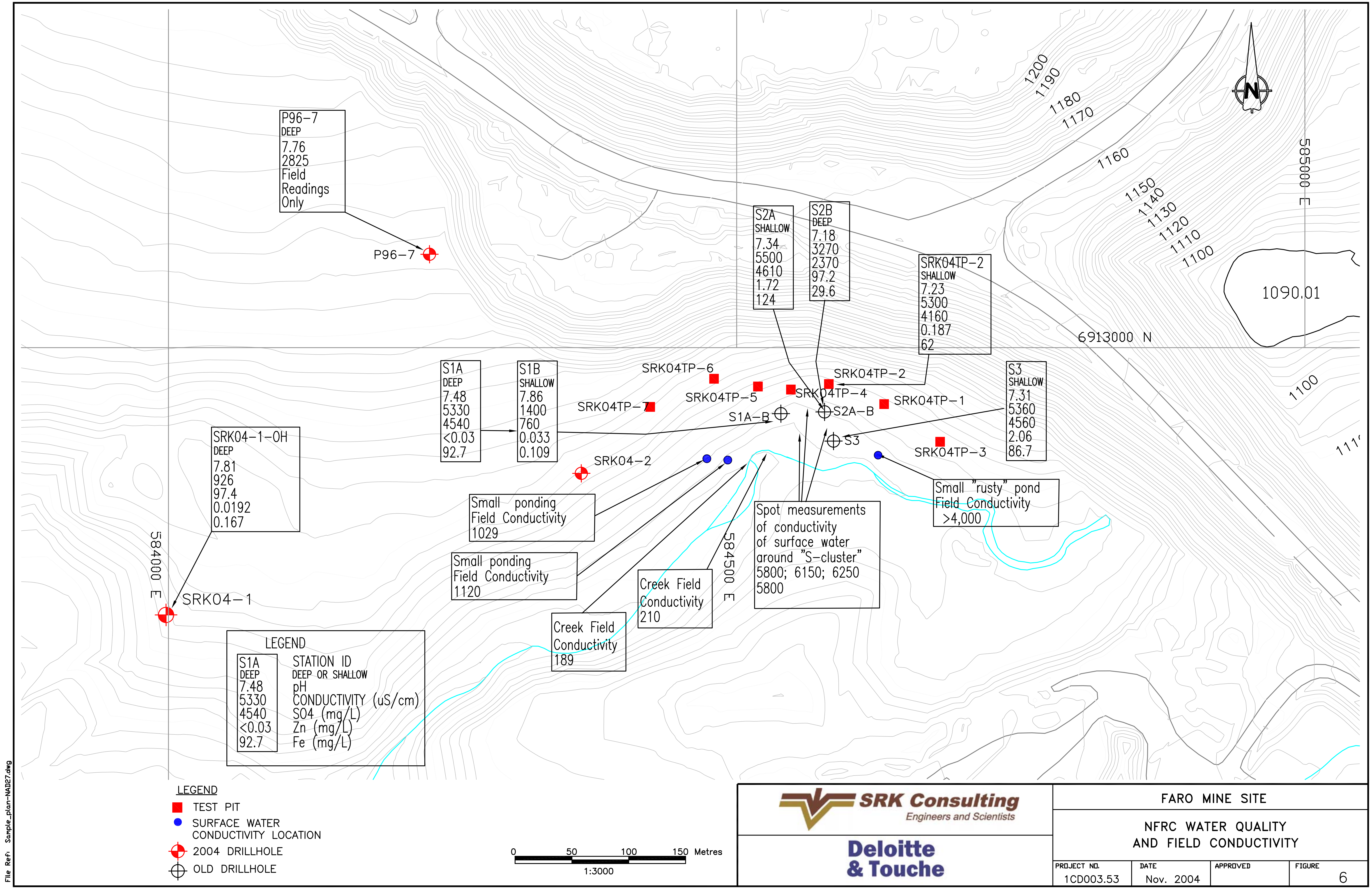
P96–7
DEEP
7.76
2825
Field
Readings
Only
P96–7
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1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
585000 E
1090.01
6913000 N
S2A
SHALLOW
7.34
5500
4610
1.72
124
S2B
DEEP
7.18
3270
2370
97.2
29.6
SRK04TP–2
SHALLOW
7.23
5300
4160
0.187
62
S1A
DEEP
7.48
5330
4540
<0.03
92.7
S1B
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7.86
1400
760
0.033
0.109
SRK04TP–6
SRK04TP–5
SRK04TP–7
SRK04TP–4
SRK04TP–2
SRK04TP–1
SRK04TP–3
S1A–B
S2A–B
S3
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SHALLOW
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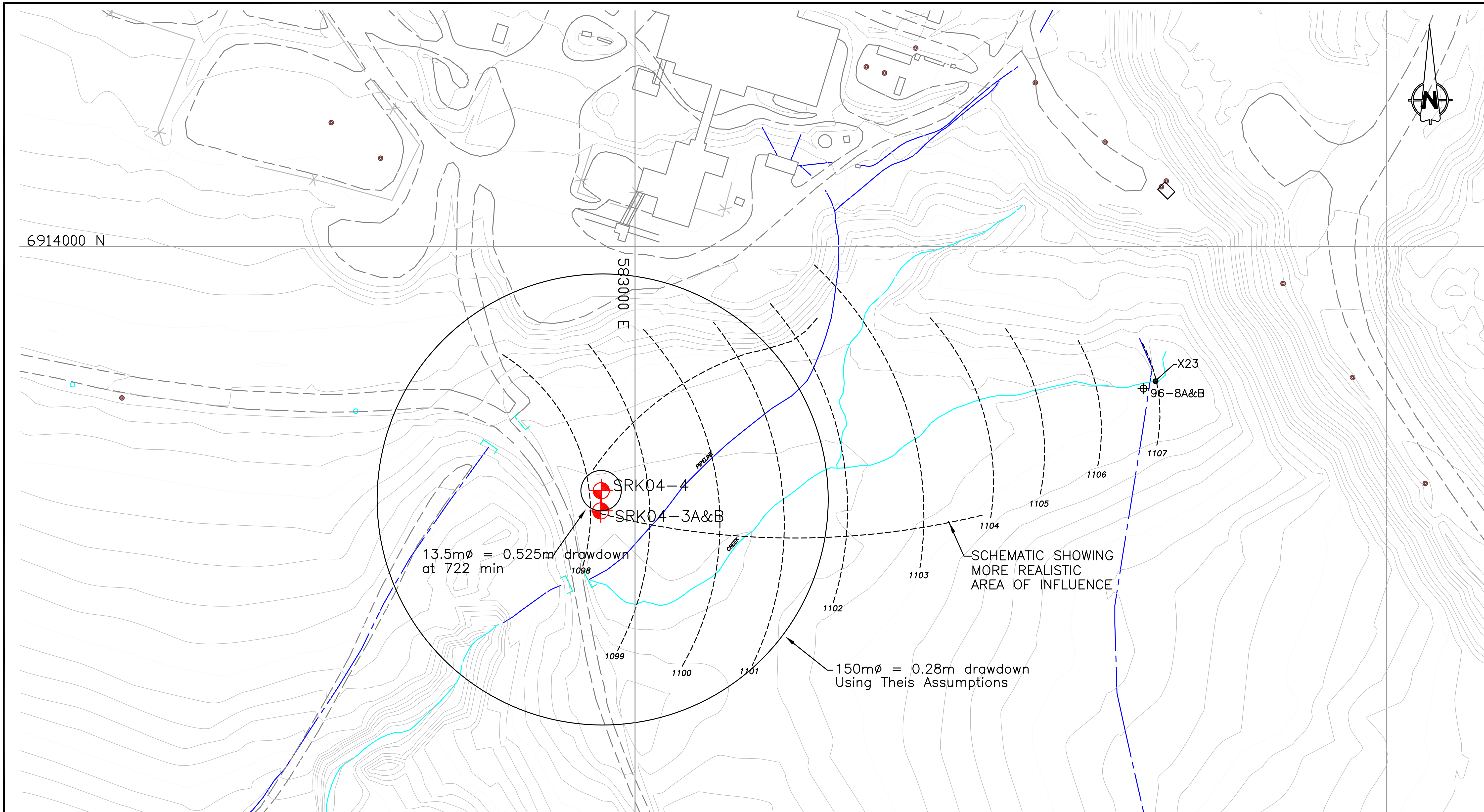
4560
2.06
86.7
1100
SRK04–1–OH
DEEP
7.81
926
97.4
0.0192
0.167
SRK04–2
Small ponding
Field Conductivity
1029
Small ponding
Field Conductivity
1120
Creek Field
Conductivity
210
Creek Field
Conductivity
189
Spot measurements
of conductivity
of surface water
around "S–cluster"
5800; 6150; 6250
5800
Small "rusty" pond
Field Conductivity
>4,000
584000 E
584500 E
SRK04–1
LEGEND
S1A
DEEP
7.48
5330
4540
<0.03
92.7
STATION ID
DEEP OR SHALLOW
pH
CONDUCTIVITY (uS/cm)
SO4 (mg/L)
Zn (mg/L)
Fe (mg/L)
LEGEND
TEST PIT
SURFACE WATER CONDUCTIVITY LOCATION
2004 DRILLHOLE
OLD DRILLHOLE
0 50 100 150 Metres
1:3000
SRK Consulting
Engineers and Scientists
Deloitte & Touche
FARO MINE SITE
NFRC WATER QUALITY AND FIELD CONDUCTIVITY
PROJECT NO.
1CD003.53
DATE
Nov. 2004
APPROVED
FIGURE
6
File Ref: Sample_plan-NAD27.dwg



WELL ID	STICK UP ELEVATION	WATER LEVEL ELEVATION
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SRK04–3A	1104.55	1098.45
SRK04–3B	1104.63	1098.37
96–8A	1109.78	1106.88
96–8B	1109.70	1106.90

0 25 50 75 100 125 Metres

1:2000

SRK CONSULTING
Faro Mine, Yukon
Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

LEGEND

- 2004 BOREHOLE LOCATION
- "S" CLUSTER MONITORING WELLS
- TESTPIT LOCATION
- CREEK ELEVATION CONTROL POINT

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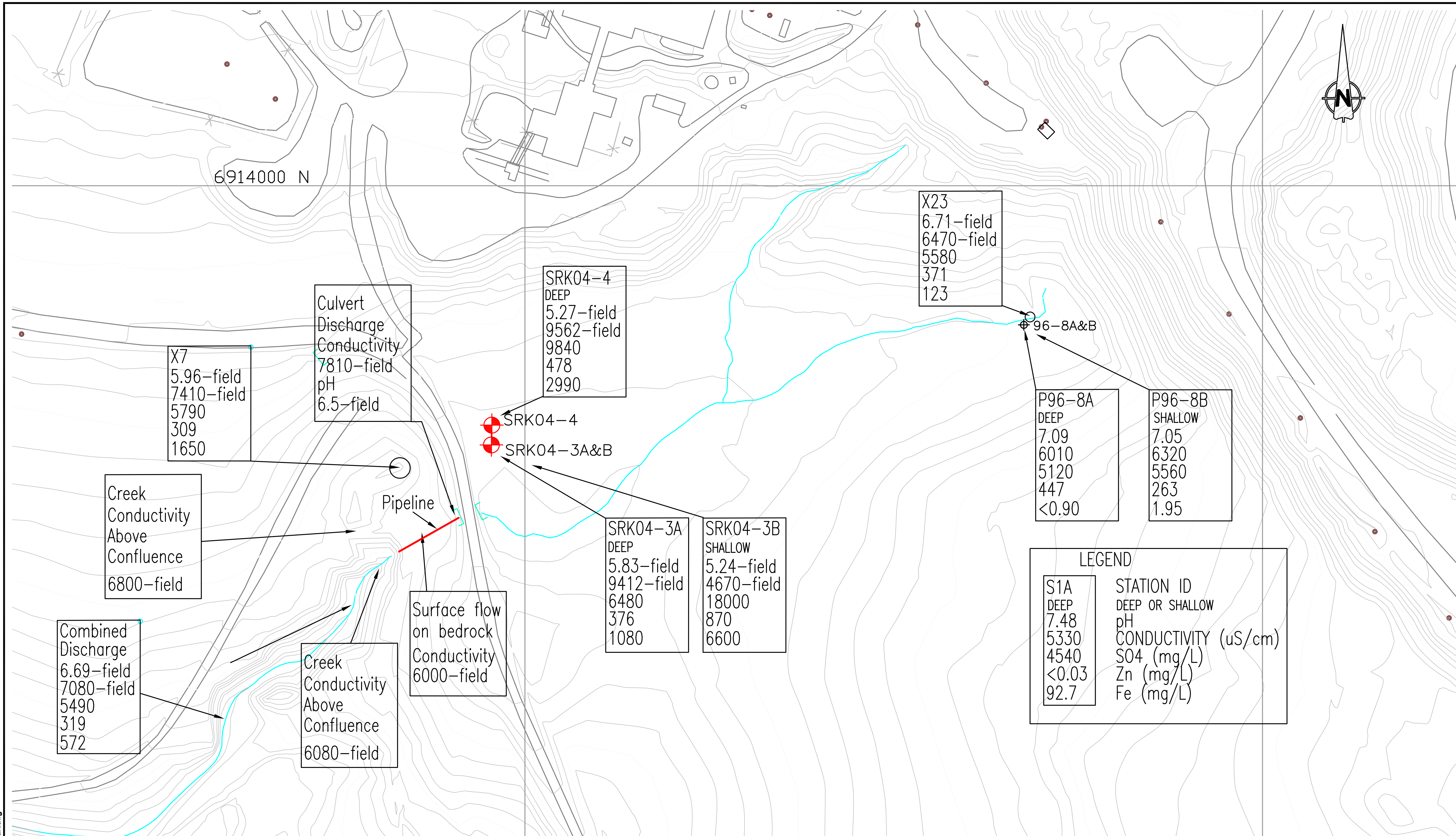
FARO MINE SITE

HYDROGEOLOGIC SETTING AT ETA

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		7

File Ref: Sample_plan-NAD27.dwg



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Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

50 0 100 200 300 feet

25 0 50 100 150 Metres

File Ref: dnwater-quality-plan.dwg

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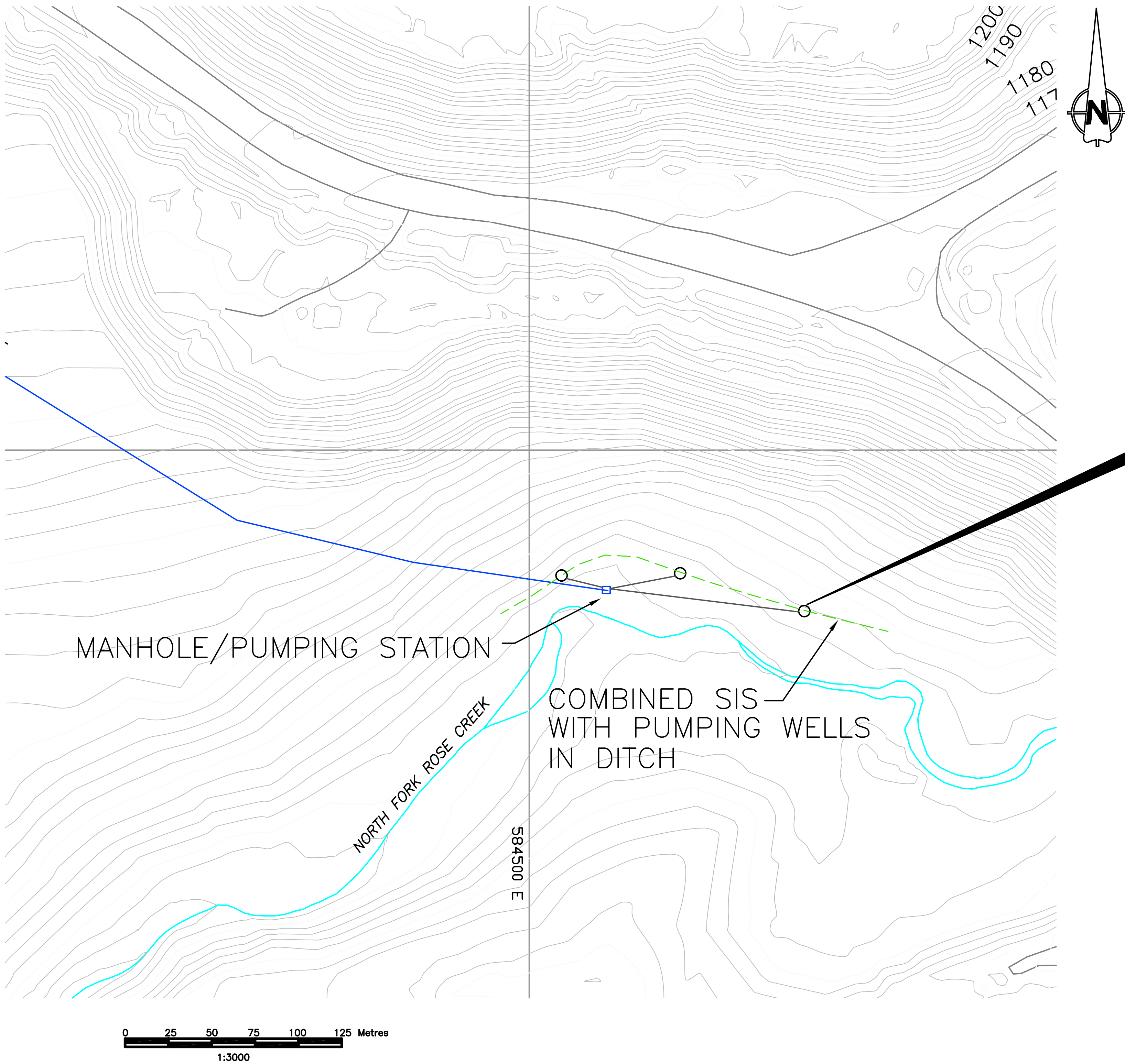
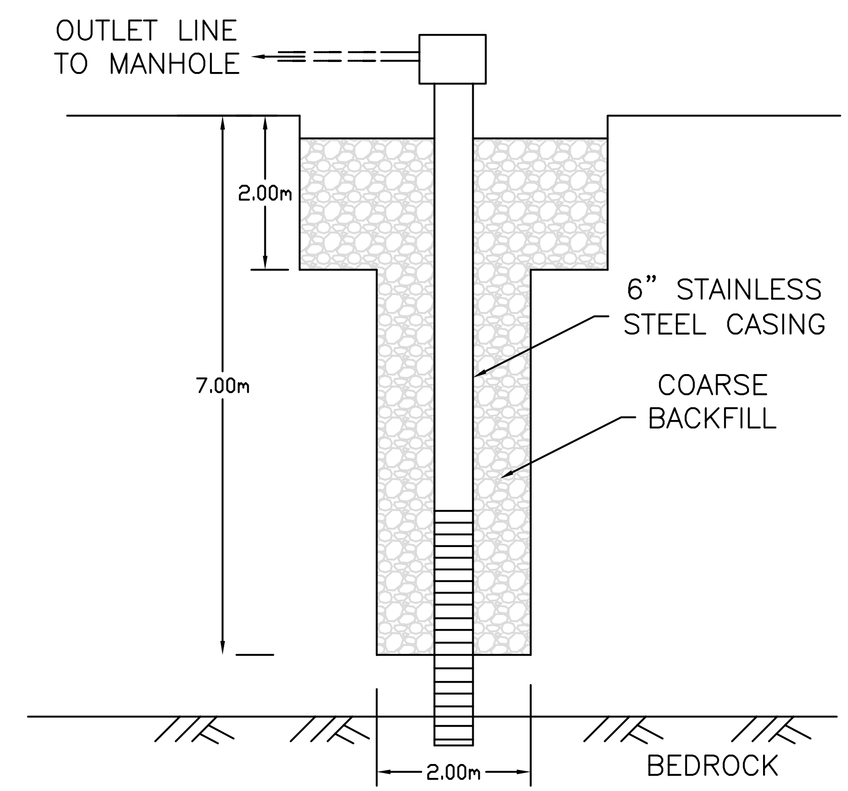
FARO MINE SITE

ETA WATER QUALITY AND FIELD CONDUCTIVITY

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.53	NOV. 2004		8





SCHEMATIC OF SEEPAGE COLLECTION SYSTEM
N.T.S.

SRK CONSULTING
Faro Mine, Yukon
Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
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Survey control based on: UTM Projection, NAD27
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WO 8856

File Ref: Sample_plan-NAD27.dwg

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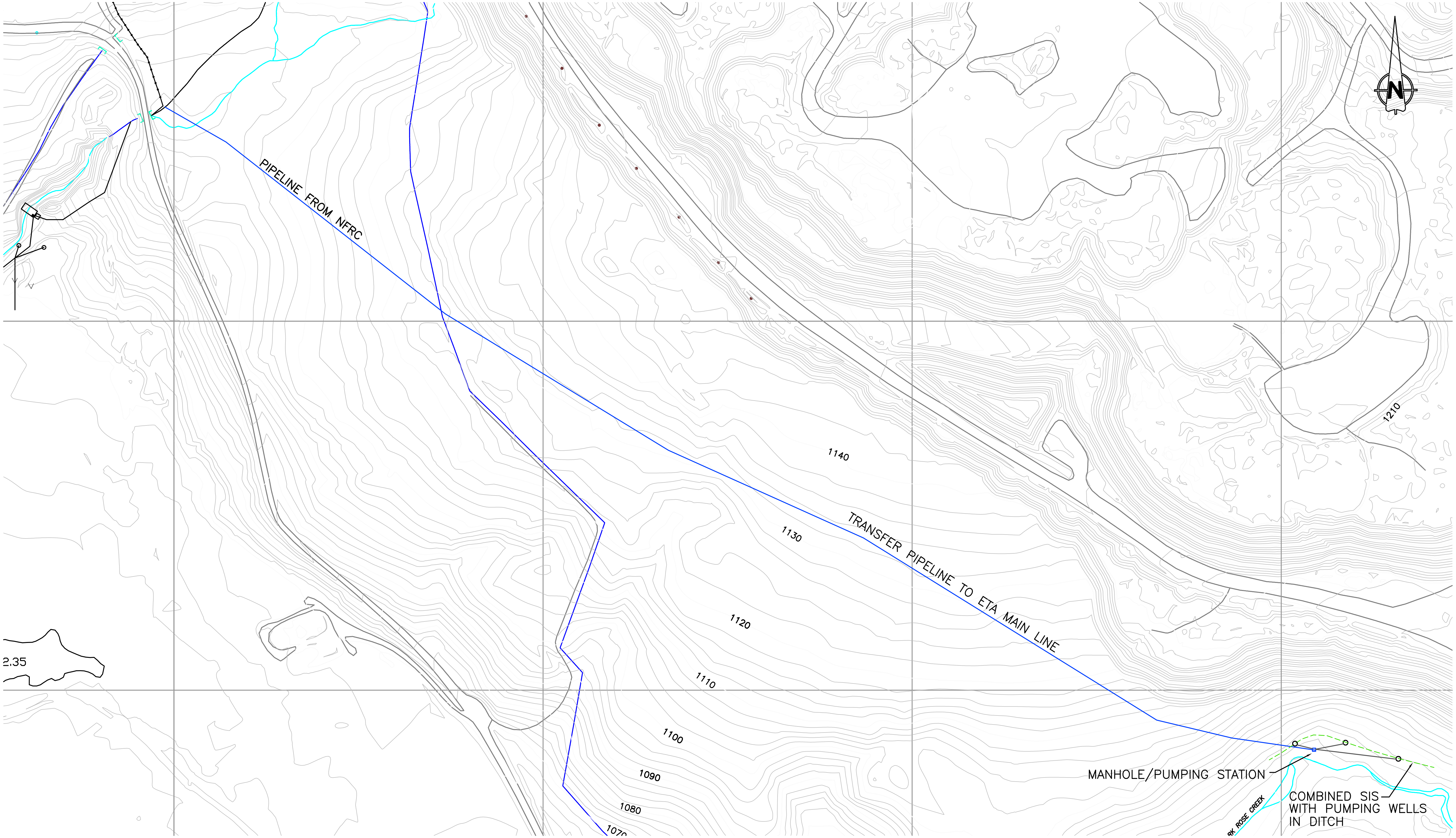
FARO MINE SITE

DETAIL OF NFRC OPTION

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		9



SRK CONSULTING
Faro Mine, Yukon

Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

0 50 100 150 200 250 Metres
1:5000

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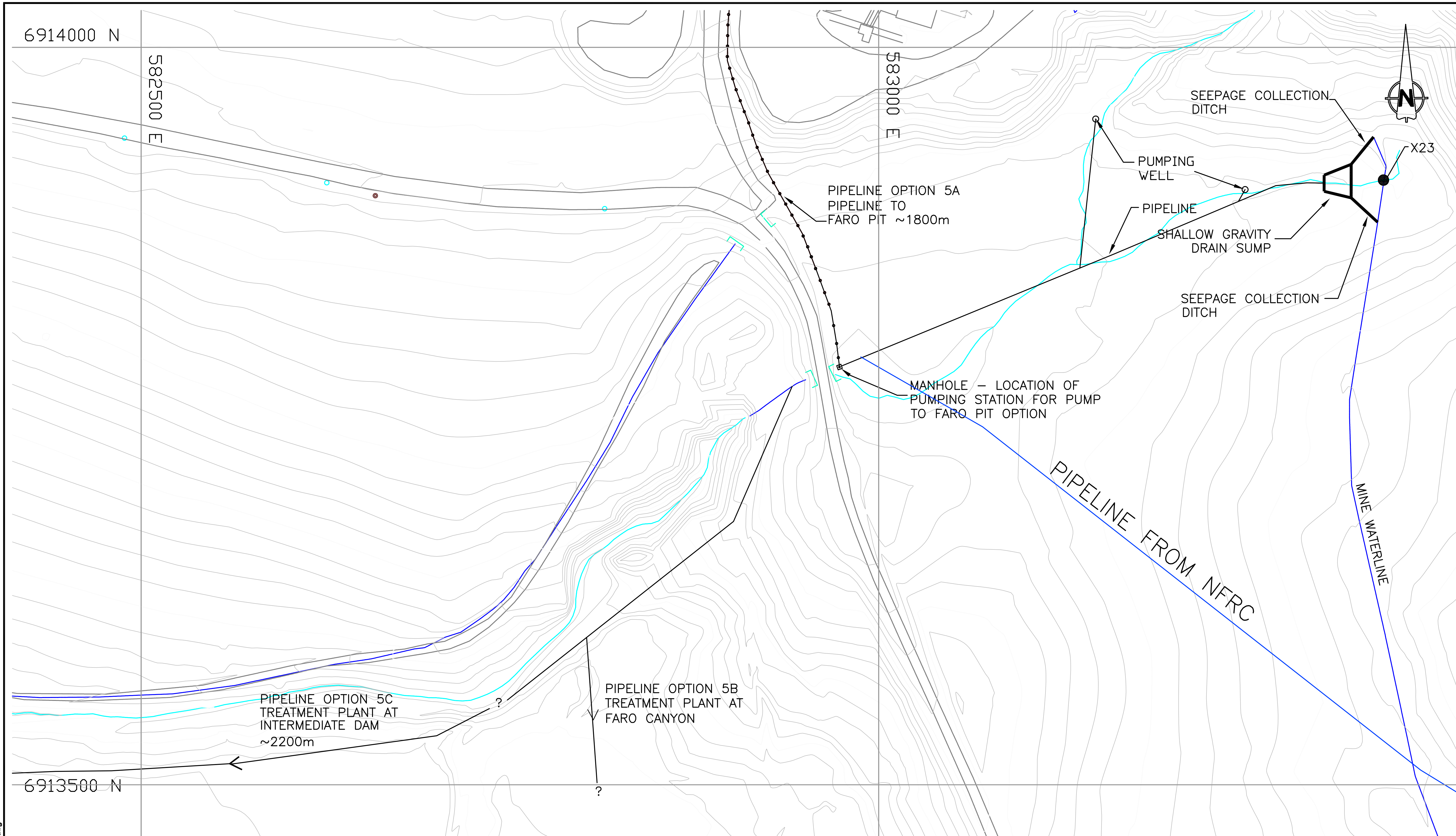
FARO MINE SITE

NFRC OPTION SCHEMATIC

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		10

File Ref: Sample_plan-NAD27.dwg



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Map Scale : 1:2500
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

0 25 50 75 100 125 Metres
1:2500

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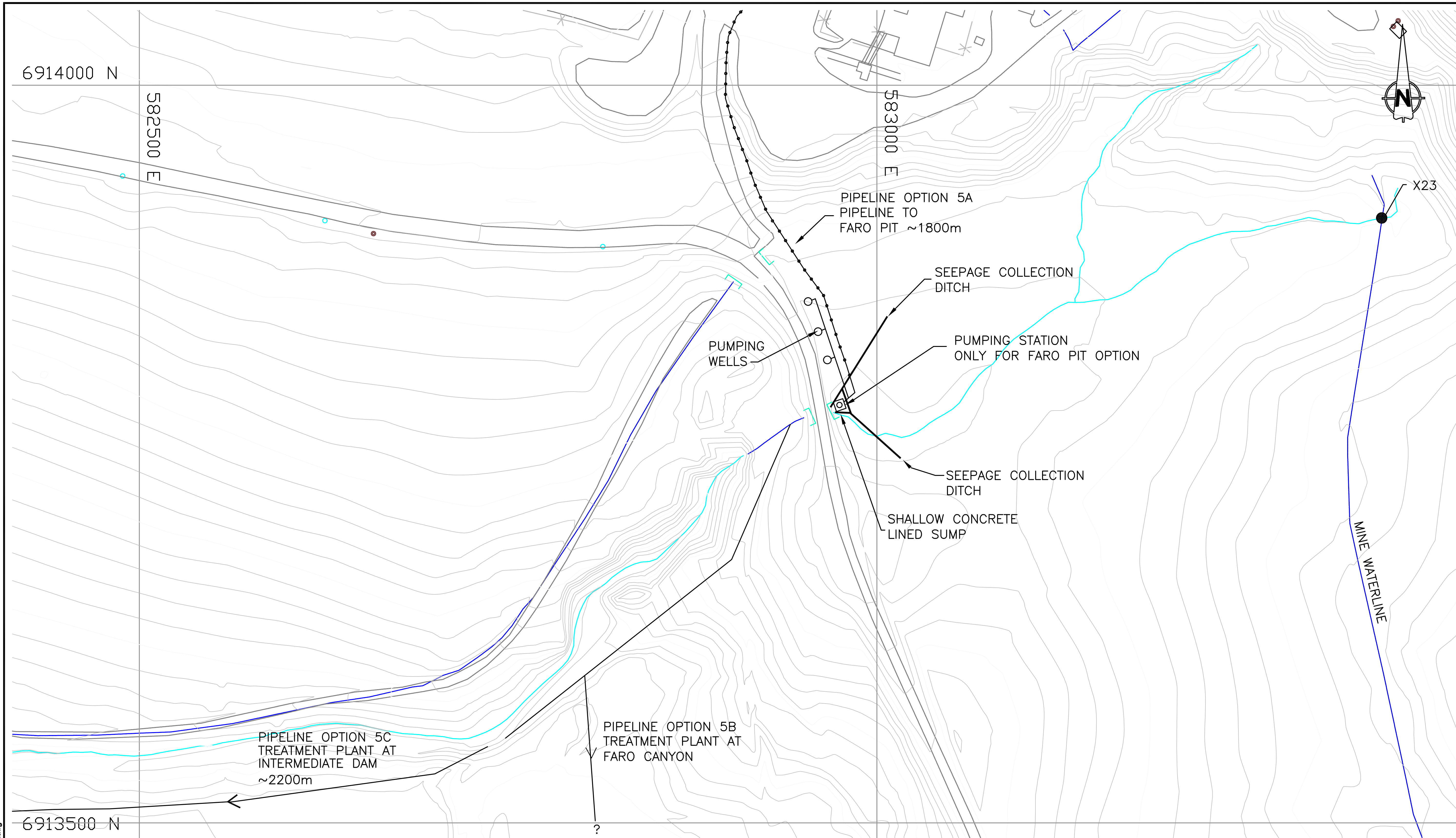
FARO MINE SITE			
ETA SEEP OPTION 1			
PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		11



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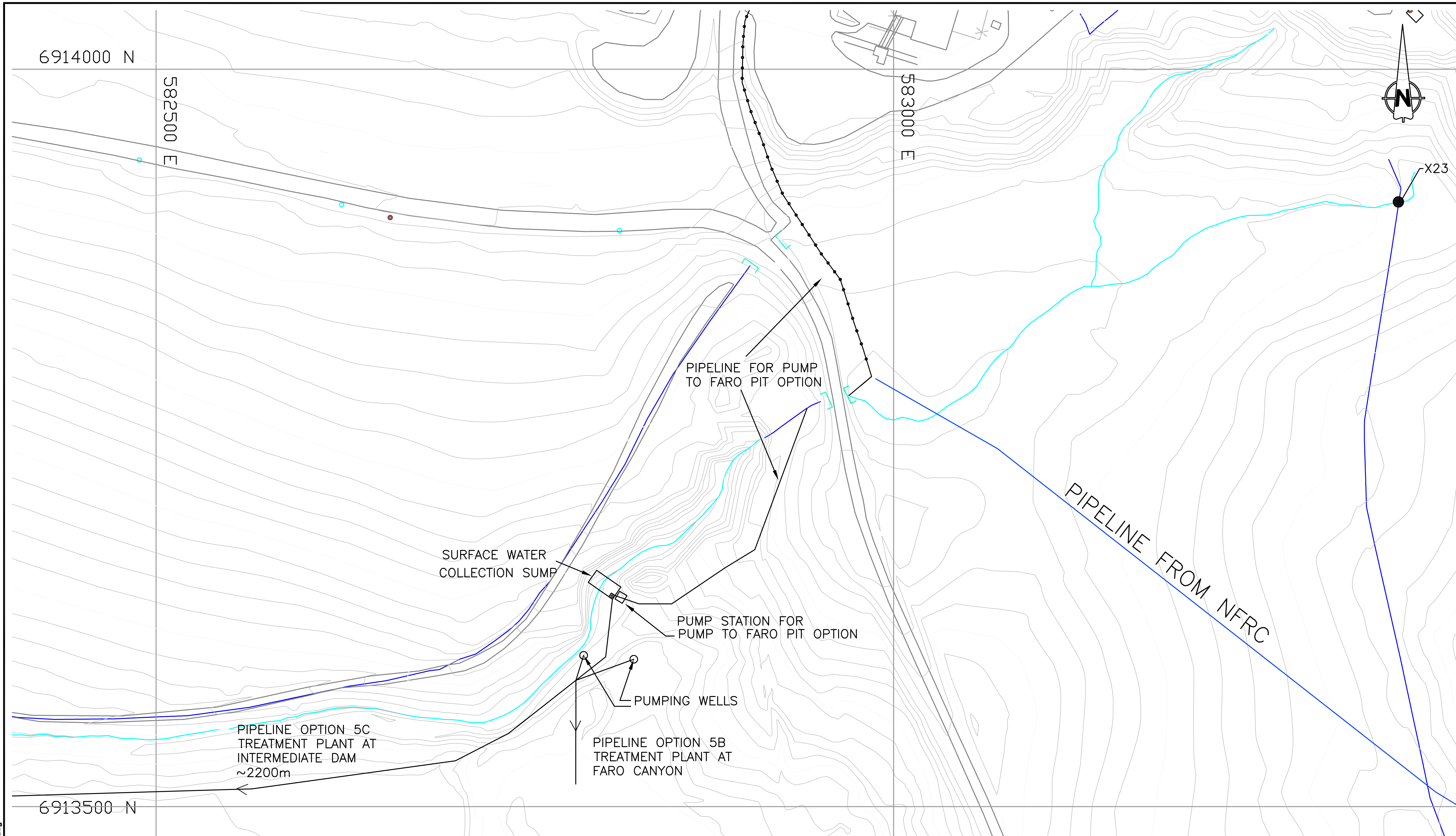
Faro Mine, Yukon

Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

SRK Consulting
Engineers and Scientists

Deloitte & Touche

FARO MINE SITE			
ETA SEEP OPTION 2			
PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		12



File Ref: Sample_plan-NAD27.dwg

SRK CONSULTING
Faro Mine, Yukon

Map Scale : 1:5,000
Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

0 25 50 75 100 125 Metres
1:2500

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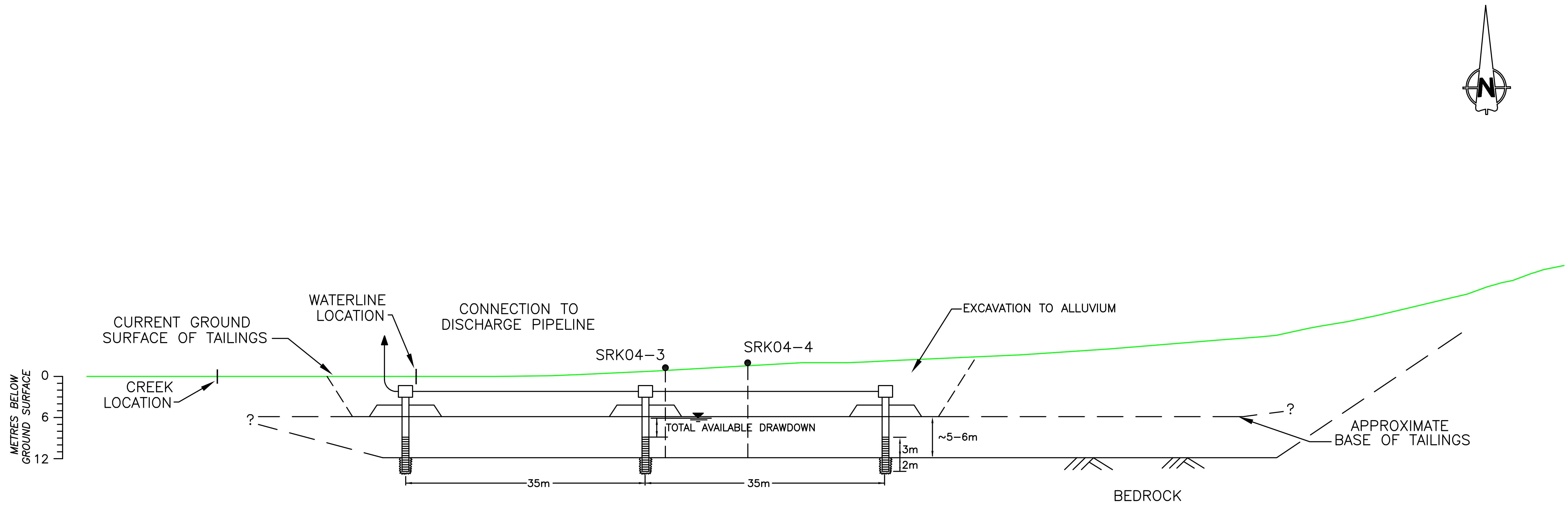
FARO MINE SITE

ETA SEEP OPTION 3

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Nov. 2004		13



SCHEMATIC: LOOKING SOUTHWEST OF PROPOSED PUMPING SYSTEM AT ETA

LEGEND

WATER LEVEL AT SRK04-4

0 5 10 15 20 25 Metres
1:600

File Ref: 2003 faro site plan-geo.dwg

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FARO MINE SITE			
SCHEMATIC PUMPING CONFIGURATION AT EMERGENCY TAILINGS AREA			
PROJECT NO. 1CD003.053	DATE Nov. 2004	APPROVED	FIGURE 14

Appendix A

Memo: *Initial Review of Groundwater Quality Downstream of Faro, Grum and Vangorda WRDs, Yukon Territory, July 14, 2004*

Robertson GeoConsultants Inc.

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Memorandum

DATE: July 14, 2004

TO: Daryl Hockley, SRK

CC: Cam Scott, SRK
Valerie Chort, Deloitte Touche

FROM: Christoph Wels, Robertson GeoConsultants Inc.

RE: Initial Review of Groundwater Quality downstream of Faro, Grum and Vangorda WRDs, Yukon Territory

Daryl:

As requested, this memo summarizes the results of my initial (brief) review of the groundwater monitoring data for the Faro, Grum and Vangorda mine sites near the town of Faro, in the Yukon Territory. The groundwater data reviewed cover the observation period from 1996 to early 2004. The primary objective of this review was to assess the requirements for collection of waste rock dump (WRD) seepage at Faro, Grum and/or Vangorda. Preliminary recommendations are also provided for additional fieldwork, which would assist in the evaluation of alternative options for seepage collection at these sites. It should be emphasized that a review of the effects of groundwater seepage on surface water quality was beyond the scope of this review. A review and assessment of potential impacts of groundwater seepage on surface water quality would complement this initial review of seepage water quality presented here.

For the purpose of this review, time trends of sulphate and zinc in shallow groundwater downstream of the WRDs were plotted and evaluated. Sulphate is an early indicator of WRD seepage whereas zinc is a metal of concern at Faro/Grum/Vangorda because it occurs in elevated concentrations in WRD seepage and is mobile under the neutral ("buffered") pH conditions typically encountered at the site.

A. Faro Waste Rock Dumps

Groundwater quality is monitored in several monitoring wells located near the toe of the Faro Dumps. Figures 1 to 5 show observed time trends of groundwater quality (sulphate and zinc) in monitoring wells located downgradient of the Faro WRDs. The monthly precipitation (at Faro Airport) and static water levels (expressed as depth to water below top of casing) are shown for comparison. In the following we briefly review the recent monitoring data for the various reaches potentially influenced by seepage from the Faro waste rock dumps.

A.1 Northeast Dumps draining towards North Fork Rose Creek

Monitoring wells in this reach include BH12A/B, BH13A/B and BH14A/B. Two of these wells (BH12A and BH13B) are now frozen and no longer sampled. Groundwater in this area is encountered at shallow depth (2-4m bgs) in shallow overburden and weathered bedrock.

Groundwater in this reach has circum-neutral pH and significant alkalinity (200-400 mg/L). A review of the recent water quality time trends suggests a gradual increase in sulphate concentrations from ~300-500 mg/L (in 1996) to 1200-1700 mg/L (in 2003) in monitoring wells located in this area (Figure 1). The very gradual increase in sulphate concentrations suggests significant dispersion along the flow path. A slow release of sulphate from the NE dumps (compared to other WRD at Faro) may also contribute to the slow increase in sulphate concentrations in the groundwater.

Zinc concentrations are still relatively low (<0.5 mg/L) in all wells in this area suggesting limited release of this metal and/or natural attenuation along the flow path.

While clearly influenced by WRD seepage, seepage interception in this reach may represent a lower priority, considering the (still) relatively low concentrations of dissolved metals and significant distance from the NFRC.

A.2 Zone 2 Pit draining towards North Fork Rose Creek

Monitoring wells in this reach include BH1, 2 and 4. Several other monitoring wells installed in 1994 in this area (BH5, 6, 7 and 8) are no longer monitored. The groundwater table in this area of the mine is only 1-2 meters below ground surface near the North Fork

Rose Creek (at BH1 and 4) but resides at increasingly greater depths towards the Zone 2 Pit (e.g. 4-5m at BH 2 and ~18m at BH8).

The groundwater in this area is slightly to moderately acidic (pH 4.5-6.5) with low to moderate alkalinity (10-100 mg/L). In the past, this area had been significantly affected by at least one historic "spill" from the Zone 2 Pit with highly elevated concentrations of SO4 (up to 9,000 mg/L) and Zinc (~100 mg/L) observed in BH-4 (Figure 2). However, groundwater in this well (and others) has markedly improved over the last 13 years. For example, SO4 and zinc concentrations in BH-4 have declined to ~100 mg/L SO4 and ~3.5 mg/L Zn over the last few years (Figure 2). Groundwater quality in BH1 and BH2 did not show the same historic impact and has remained relatively constant over time. At present groundwater in all three wells is relatively dilute (SO4 ~100-200 mg/L) suggesting no significant on-going seepage from the Zone 2 pit.

However, the residual zinc concentrations in groundwater in this area are still significant (1-3 mg/L at BH1, 3 and 4) and appear to be increasing at BH2 (currently ~10-20 mg/L). Considering the proximity of this shallow groundwater to the NFRC, there is a (small) potential for zinc loading to the NFRC. A more detailed review of the surface water quality data from the NFRC (at stations R8, R9 and R10) would be required to evaluate the potential impact of this source on the NFRC.

The historic variations in groundwater quality (which are still evident today) suggest heterogeneous subsurface conditions and/or variable contaminant sources. The fact that zinc concentrations remain elevated despite the very low sulphate concentrations (relative to Zone 2 pit water and WRD seepage) suggest that there is an in-situ source of zinc in this area. Two potential in-situ sources for zinc leaching may include (i) sediments scoured from a Gossan zone in the early days of mining when the Faro Creek diversion was routed downhill in this area, and (ii) sediments deposited in the "flood plain" during any historic spill(s) from the Zone 2 Pit. The general lack of vegetation in this area supports the hypothesis of sediment deposition in this area. Finally, attenuation of zinc within the local sediments (introduced by any historic "spill(s)") could also explain the very gradual decline in zinc concentrations in local groundwater in this reach.

In my opinion, the local hydrogeological conditions and the source of contamination (e.g. seepage from WRDs and/or Zone 2 pit, leaching or oxidation of in-situ material, desorption of historic zinc, etc.) would have to be studied in more detail in order to evaluate the requirements (and feasibility) of seepage interception along this reach.

Considering the recent improvements in ground water quality, further studies and seepage interception in this area are judged to be of lower priority.

A.3 Intermediate Dump draining towards NFRC (above rock drain)

Only one monitoring well (P96-6) is available along the eastern toe of the Intermediate Dump (draining towards the NFRC). At this location, the overburden soils are relatively thick (>18m) and consist of sandy and silty till with occasional gravel layers. The groundwater encountered at P96-6 (at 18m) is confined in a permeable gravel layer with a piezometric head of 12-13m bgs.

The groundwater in this area is well-buffered with circum-neutral pH (6.0-7.0) and significant alkalinity (200-300 mg/L). Monitoring at this well since 1996 does not show any significant increase in sulphate and/or zinc (Figure 2) suggesting no significant influence of WRD seepage (to date) on the local groundwater quality.

Based on the existing information, this area does not warrant any seepage interception at this time.

A.4 Intermediate Dump draining towards NFRC (below rock drain)

Monitoring wells in this reach include S1A/B, S2A/B and S3, which have been monitored since 1989. In this area, the profile consists of 6-7m of till overlying weathered bedrock (phyllite). The groundwater table in this area of the mine is about 3-4m bgs.

A review of the water quality time trends show a significant increase of sulphate and zinc over time, indicative of a "breakthrough" of neutralized WRD seepage (Figure 3). For example, sulphate in monitoring well S1A (in weathered bedrock) has increased from 140 mg/L in 1989 to 4,400 mg/L in late 2003. Similarly, zinc concentrations have increased from <0.1 mg/L (as recently as 1998) to ~80 mg/L in the most recent survey data available (September 2003). Other metals showing significant increases over the last 5 years include manganese (up to 43 mg/L) and Nickel (1.0 mg/L) (not shown here).

While the alkalinity in this reach has decreased from ~400 mg/L to ~200 mg/L over the last 15 years, the pH of the seepage impacted groundwater has not declined significantly and remains only slightly acidic (6.0-7.0). It is unclear whether these pH conditions reflect neutralization of ARD within the WRD itself or along the flow path.

All five wells in this reach showed similar overall trends, although the timing and magnitude of “breakthrough” of sulphate and zinc varied (Figure 3). Lithology does not appear to be primary factor in controlling the breakthrough of sulphate and zinc. For example, monitoring well S3 (screened in shallow colluvium) showed very similar time trends to those observed in S1A (screened in weathered bedrock). At S2, the breakthrough of sulphate is delayed in both the shallow well (S2A screened in colluvium) and the deeper S2B (screened in weathered bedrock), yet zinc concentrations at S2A are very similar to those observed at S1A and S3. Clearly, there are factors other than lithology influencing solute transport in this area.

A comparison of the breakthrough curves for sulphate and zinc provides insight into the degree of natural attenuation in the local aquifer material. For example, the “mean” breakthrough for sulphate at S1A (screened in weathered bedrock) occurred around 1999 whereas the “mean” breakthrough of zinc occurred about five years later (in 2003). From these observations an approximate “field retardation factor” can be estimated by dividing the mean arrival time (T_{50}) of the reactive solute (zinc) by the mean arrival time of conservative solute (sulphate). Assuming the release of both solutes started in 1990 (end of dumping of Intermediate Dump) we get R= 13yrs/9yrs= ~1.4 for transport in weathered bedrock.

It should be noted that the observed breakthrough curves are not “ideal” which limits the use of a standard retardation approach (which assumes linear soprtion/desoprtion). For example, the breakthrough curve of zinc is much steeper than that of sulphate. In theory, the opposite would be expected with more dispersion (“spreading” around the mean) for the reactive solute than the conservative solute. Consideration should be given to studying the breakthrough curves of sulphate and zinc observed in this reach (and elsewhere at Faro, see below) in more detail to evaluate the attenuation of zinc in the local soils and weathered bedrock. Such an analysis would provide a useful comparison to other attenuation studies currently planned and/or oingoing on the site.

Note that the recent water quality time trends do not yet show a leveling off of the contaminant concentrations. It is therefore possible that the water quality in this reach may further deteriorate over time. In my opinion, the highly elevated concentrations of sulphate, zinc and other metals and proximity to NFRC may require seepage interception in this reach of the Faro mine site. Additional field reconnaissance and hydraulic testing should be carried out in this reach to evaluate the requirements and feasibility of seepage interception. In addition, a detailed assessment of the surface water quality along this reach of NFRC (including a review of historic time trends at X2 and a detailed sampling during baseflow along the reach) should be carried out to evaluate the current impact (if any) of this groundwater seepage on the NFRC.

A review of the pre-mining topography (Figure 4-10 in RGC Report 033001/3) suggests that seepage from the Intermediate Dump (and its "sulphide cell") may also be moving towards Rose Creek along an old drainage channel located further northwest of the "S" well cluster. Again, additional field reconnaissance and potentially additional drilling may be required to evaluate the presence of contaminated seepage in this historic drainage channel.

A.5 Main Dump East draining towards Rose Creek valley

Only one monitoring well (P96-7) is available along the southern toe of the Main Dump (east of the Faro Creek channel). This well is located in a topographic low and was screened across the overburden and in fractured bedrock interface. In this area, the overburden is about 8.0m deep. The groundwater level in P96-7 shows significant seasonal variations, ranging from ~2m bgs to >9m bgs (Figure 3).

Groundwater in this area has a circum-neutral pH (6.5 – 7.5) and moderate alkalinity (150-250 mg/L). Sulphate concentrations in this well showed a gradual increase over the 8 years of monitoring (from ~400 mg/L to ~2,000 mg/L), indicating some influence of WRD seepage from the Main Dump (Figure 3). However, zinc concentrations remained very low (<0.1 mg/L) suggesting limited release and/or natural attenuation of this metal along the flow path.

While clearly influenced by WRD seepage, seepage interception in this reach may represent a lower priority, considering the low concentrations of dissolved metals relative to the neighboring reaches (near "S" cluster and along Faro Creek channel).

A.6 Main Dump West and Northwest Dumps draining into Faro Creek valley

A.6.1 Surface Seepage in Faro Creek Channel (X23)

The main discharge point for seepage from the Main Dump (and Northwest Dumps) is the lower Faro Creek valley. There is sufficient accumulation of dump seepage in this valley to maintain a small, perennial stream, which "daylights" just below the Main Dump near sampling station X23. The water quality of this surface seepage at X23 has been monitored regularly since 1986.

Figure 4 shows the time trends of sulphate, total zinc and total manganese observed in surface seepage at X23 for the entire observation period (1986 – 2004). The monthly precipitation is shown for comparison. Note that sulphate is shown on a linear scale (right axis) while the metals are shown on a log scale (left axis). The monitoring data show a significant increase in contaminant load at X23 over the 18 years of record. Sulphate concentrations increased from ~1,500 mg/L to >4,000 mg/L, with significant spikes (>6,000 mg/L) in recent years (2000 and 2001). The concentrations of manganese and in particular zinc mimic the general trends observed for sulphate, showing a 3-5 fold increase in Mn and a 5-8 fold increase in Zn over the 18 years of record (Figure 4).

The total metal concentrations in WRD seepage at X23 show an even more pronounced increase in 2000 and 2001 than observed for sulphate with peak concentrations reaching ~1,000 mg/L total zinc and ~100 mg/L total manganese (Figure 4). A detailed assessment of these seasonal trends was beyond the scope of this initial review. However, these significant "spikes" in contaminant concentrations could be a result of the "flushing" of stored oxidation products from the WRDs, which are accumulating during "dry" years (e.g. 1998 and 1999) and are then released during subsequent wet years (e.g. 2000).

It should be pointed out that the pH of seepage collected at X23 has remained circum-neutral throughout the 18 years of observation. As a result, concentrations of other metals of concern, which are immobile under neutral pH conditions (e.g. Cu) have remained very low despite the large increase in Mn and Zn. The fact that this "toe seepage" has remained circum-neutral indicates that there is significant buffering capacity within the system. Considering the limited (if any) contact of this seepage with the subsurface soils, it appears likely that the waste rock itself is effectively buffering any ARD produced within the WRDs.

At present, the WRD seepage at X23 is allowed to discharge into the Intermediate Impoundment, and ultimately into the Polishing Pond, where it is treated with lime. However, it is unclear how much of this seepage (and contaminant load) re-infiltrates into the tailings and ultimately enters the groundwater system in the Rose Creek Valley. While detailed loading calculations have not been carried out, reported flow measurements at X23 (ranging from ~2 L/s during baseflow to >15 L/s during snowmelt runoff) suggest that seepage at X23 may represent a significant contaminant load. Hence, from a point-of-view of load reduction, interception and treatment of WRD seepage at X23 may therefore represent a high priority at Faro. In addition, seepage collection at this location should be relatively straightforward thus providing a favorable load reduction relative to the cost of collection. However, the cost of seepage interception would have to be weighted against the "incremental" benefit to the downgradient environment considering the presence of other significant contaminant sources further downstream (e.g. Rose Creek Tailings Facility).

A.6.2 Subsurface seepage in Faro Creek channel

Seepage from the Main Dump (and Northwestern Dumps) also moves within the permeable alluvial sediments of the Faro Creek channel towards the Rose Creek Valley. Two nested piezometers (P96-8A/B) were installed in 1996 in vicinity of X23 to monitor the groundwater quality in this area (RGC, 1996). At this location the alluvial sediments are 8m thick and consist of very permeable sands and gravels overlying phyllite bedrock. The groundwater table in this area is fairly shallow (~1.5-3m bgs) and shows some seasonal fluctuations in response to variations in precipitation (Figure 5).

Figure 5 shows the time trends of groundwater quality observed at P96-8A/B. The surface water quality observed in the Faro Creek channel (X23) is shown for comparison. Both sulphate and zinc show a significant increase over time, similar to the trends observed in the "S series" well cluster downgradient of the Intermediate Dump (Figure 3). Sulphate concentrations increased from ~2,000 mg/L in 1996 to around 4,000 mg/L, whereas zinc increased from ~2 mg/L to >100 mg/L over this 8 year span (Figure 5). The water quality time trends in both wells are remarkably similar to the trends observed in WRD seepage at X23 (except perhaps for peak concentrations observed in surface seepage following storm events) suggesting that all groundwater in this area essentially represents WRD seepage.

As observed elsewhere at the Faro mine site, groundwater in this area still has significant alkalinity 150-350 mg/L and maintains near-neutral pHs (6.0-7.0) suggesting "internal" buffering within the WRD and/or buffering along the flow path (within the alluvial sediments).

Groundwater flowing within the alluvial sediments of the old Faro Creek channel (and potentially in the underlying weathered/fractured bedrock) clearly represents a significant source of sulphate and zinc loading to the downstream environment. However, much, if not most of this subsurface seepage is believed to discharge back to surface further downgradient in the old Faro Creek channel ("water fall"). If this assumption is correct, then most of this seepage also flows into the Intermediate Impoundment and is collected and treated in the Polishing Pond. Nevertheless, there is some potential for re-infiltration of this contaminated water into the tailings and ultimately into the underlying groundwater system in the Rose Creek Valley. Hence consideration should be given to collecting this contaminated seepage either as subsurface flow near X23 and/or as surface flow (combined with surface seepage from X23) before it enters the Intermediate Impoundment. As mentioned earlier, the cost of seepage interception would have to be weighted against the "incremental" benefit to the downgradient environment considering the presence of other large contaminant sources further downstream (e.g. Rose Creek Tailings Facility).

In my opinion, consideration should be given to carrying out additional characterization studies to quantify the seepage rates in this area and to evaluate the feasibility and requirements of seepage interception. These additional studies may include: (i) seismic profiling of the Faro Creek Channel near X23, (ii) hydraulic testing in this area (slug testing and potentially pump testing), and (iii) drilling into bedrock to determine the presence (quantity and quality) of groundwater below the alluvial sediments. Prior to starting any field investigation, detailed flow measurements should be carried out along the Faro Creek channel (between X23 and discharge into the Intermediate Impoundment) to quantify the amount of subsurface seepage discharging back to surface along this reach.

A.6.3 Potential Seepage from Faro Pit

The potential for seepage from the Faro Pit towards the old Faro Creek channel (at X23 and P96-8A/B) was also evaluated as part of this review. The Faro Pit received tailings until the end of mining operations in 1996 and has since been allowed to further reflood to a water level of 1140-1145 m amsl. Given this significant rise in water level there is a possibility that water from the open pit could flow towards X23 either in (potentially fractured) bedrock and/or unconsolidated material (alluvial sediments and/or mine waste)

However, our data review suggests that seepage of the Faro Pit towards the Faro Creek channel is unlikely to be a significant factor for two reasons. First, the water level in the Faro Pit has been maintained at least 15m below the topographic low in the bedrock surface (3,800 ft amsl or 1158.2 m amsl) along the Faro Creek channel reported in SRK (1991) and cited in BGC (2003). In other words, seepage from the Faro Pit towards X23 would be limited to flow in deeper bedrock (primarily along potential fractures). This scenario is unlikely to result in a significant increase in seepage flows (and/or increase in contaminant concentrations) at X23.

Second, concentrations of sulphate, Zn and other metals are significantly lower in the Faro Pit (~500 mg/L SO4 and 10-20 mg/L zinc) than in WRD seepage at X23. Based on this observation, one might expect, that significant seepage from the Faro Pit would result in a decrease of contaminant concentrations (dilution) at X23 rather than the observed recent increase in contaminants of concern (Figure 5).

In summary, it appears unlikely that seepage from the Faro Pit contributes significantly to the seepage and contaminant load observed at the toe of the Main Dump in the old Faro Creek channel. However, seepage from the Faro Pit along the Faro Creek channel towards X23 could potentially become an issue if the pit water level was allowed to rise. In my opinion, consideration should therefore be given to carrying out additional studies to evaluate the potential for seepage from the Faro Pit. These studies may include (i) drilling and hydraulic testing in the Faro Creek channel (south of the Faro Pit) to define the subsurface conditions (depth to bedrock, permeability of alluvial sediments and underlying fractured bedrock), (ii) installation of monitoring wells in this area to monitor groundwater levels and groundwater quality, and (iii) seismic surveys across the Faro Creek channel (between Faro Pit and X23) to better define the bedrock topography.

A.7 Northwest Dumps draining towards Guardhouse Creek

No monitoring wells are available in the Guardhouse Creek sub-watershed downgradient of the Northwest Dumps. The only information on subsurface conditions and seepage water quality was obtained in a test pit program carried out in 1992 (SRK, 1992). Water quality analyses on seepage samples collected in shallow test pits during this study suggested no significant impact of WRD seepage.

Based on the (limited) information available, it appears that this area of the Faro mine site receives very little seepage from the WRDs and does not contribute significant contaminant loads to Guardhouse Creek and/or Rose Creek valley. In my opinion, seepage interception in this area represents a low priority.

B. Grum and Vangorda Waste Rock Dumps

Groundwater quality is monitored in several monitoring wells located near the toe of the Grum and Vangorda waste rock dumps. Figures 6 and 7 show observed time trends of groundwater quality (sulphate and zinc) in monitoring wells located downgradient of the Grum and Vangorda WRDs, respectively. The monthly precipitation (at Faro Airport) and static water levels (expressed as depth to water) are shown for comparison. In the following we briefly review the recent monitoring data for the various reaches downgradient of the Grum and Vangorda WRDs.

B.1 Grum Dump draining southeast

A set of two nested piezometers (P96-9A/B) were installed in 1996 in a tributary to Grum Creek, which drains the central portion of the Grum Dump, to monitor the groundwater quality in this area (RGC, 1996). At this location the overburden soils were relatively thick with phyllite bedrock encountered at a depth of ~18m.

The shallow piezometer (P96-9A) was screened in alluvial sands and gravels and the deeper piezometer (P96-9B) was screened in sands and gravels confined by low permeability till. The water level in the upper (unconfined) aquifer is about 5m bgs and appears to be hydraulically connected to the creek. The lower (confined) aquifer is artesian.

A review of the time trends in P96-9A/B indicates that seepage from the Grum dump has had a much smaller impact (thus far) on local groundwater than observed at Faro. For example, sulphate concentrations in the shallow groundwater have only started to increase over the last four years, from ~50 mg/L in 1996 to ~1250 mg/L in 2003 (Figure 6). Zinc concentrations in the shallow groundwater are still very low (~0.01 mg/L). The deeper, confined aquifer has maintained low sulphate concentrations (~150 mg/L) at least until 2001 the last date of monitoring (It is my understanding that this well has been damaged and is no longer monitored).

A recent water quality survey of seeps on Grum dump (SRK, 2003) indicated average sulphate and zinc concentrations in the southeastern part of Grum Dump of ~1100 mg/L SO4 and 3.0 mg/L Zn. The observed sulphate concentrations in seeps from Grum Dump (along the toe) are very similar to those observed in the shallow groundwater, suggesting that shallow groundwater is comprised primarily of WRD seepage with little dilution from precipitation and/or regional groundwater. The lower zinc concentrations observed in shallow groundwater suggest that zinc is attenuated in the overburden soils along the flow path.

The seep survey also indicated that seepage from the southeastern part of Grum Dump has significant higher alkalinity (~500 mg/L) than the natural groundwater. As a result shallow groundwater has also shown an increase in alkalinity from ~50-150 mg/L in 1996/97 to ~450 mg/L in 2003.

While the lack of any increase in sulphate and alkalinity in the deeper aquifer clearly indicates no significant influence of WRD seepage to date, an eventual “breakthrough” of WRD seepage in this aquifer cannot be ruled out. We therefore recommend that monitoring at P96-9B be reinitiated (this may require rehabilitation and/or redrilling of this monitoring well.

Based on the above discussion we tentatively conclude that shallow groundwater along the southeast slopes below Grum Dump represents primarily seepage from Grum Dump with limited dilution from recharge and/or regional groundwater. Hence the future groundwater quality in this area will depend to a large extent on the evolution of ARD within the Grum Dump (and the Sulphide Cell in particular). In my opinion, seepage interception in this reach of Grum Dump may not be a high priority today but may be required in the future to protect Vangorda Creek.

It should be noted that the number of monitoring wells are very limited in this area. Additional hydrogeological characterization work (drilling, well installation and hydraulic testing) would be required to evaluate the feasibility and requirements of seepage interception in this reach.

B.2 Grum Dump draining southwest

No monitoring wells were available to evaluate the groundwater quality to the southwest of the Grum Dump. According to a recent seep survey (SRK, 2003), most seeps in this area have low sulphate (<500 mg/L) and very low zinc concentrations (<0.03 mg/L), representative of drainage from the calcareous phyllites and till dumped in the northwest draining portion of the Grum Dump.

Based on this (very limited) information, groundwater quality to the southwest of Grum Dump can be expected to show very little, if any, influence of WRD seepage. This area likely represents a low priority for seepage interception.

B.3 Potential Seepage from Grum Pit

The Grum pit was excavated into the historic channel of Grum Creek, which is believed to contain permeable alluvial sediments and could potentially provide a path of preferred seepage from a partially reflooded Grum Pit. A detailed review of the seepage potential was beyond the scope of this initial review. However, we noted that the current Grum pit water level (~1185.4m amsl) was similar to the approximate elevation (~1184m amsl) of seep sampling location SRK-GD-01, i.e. where seepage in Grum Greek first emerges. In other words, the pit water level is sufficiently high to potentially induce seepage from Grum Pit towards Grum Creek. No detailed pit water level records were available to evaluate the historic (and most recent) time trends of filling of Grum Pit.

Water quality monitoring in the Grum Pit show a gradual increase in sulphate and zinc over time (not shown). However, sulphate concentrations are still significantly lower (currently ~500 mg/L) than those observed at the most upgradient seep in Grum Creek (1200-1320 mg/L SO4 at seep SRK-GD-01) indicating that Grum pit water could not be the source of this seepage. Nevertheless, this does not rule out the potential for future seepage towards Grum Creek, in particular if the pit water level is allowed to rise over time. Whether such seepage would result in significant contaminant loading to Grum Creek would depend on the future pit water quality and the degree of natural attenuation along the flow path.

In my opinion, the potential for seepage from Grum Pit should be evaluated further in a desktop study, which should include a review of all existing information on the depth and nature of the overburden material in vicinity of the historic Grum Creek channel (drill logs, bedrock mapping, pit wall mapping) and review of the water balance for the Grum Pit. Additional fieldwork (drilling, seismic survey etc) may only be required if this review indicates that there is potential for significant seepage from Grum Pit towards Grum Creek.

B.3 Vangorda Dump draining towards Dixon Creek

Monitoring wells in this reach include V34 (GW94-01) and V35 (GW94-02), which have been monitored since 1994. Overburden soils to the south of Vangorda Dump consist of highly compacted, silty glacial till of relatively low permeability. The thickness of the overburden ranges from ~12m at V34 to >18m at V35. Groundwater levels in this area lie about 5-9 m bgs (Figure 7).

The water quality in V34 is believed to be typical of background groundwater in the calcareous till of the area, with slightly alkaline pH (7.5-8.0), high alkalinity (~400 mg/L), low sulphate (~40 mg/L) and very low metals including zinc (~0.01 mg/L). There has been no change in water quality over the last 10 years of monitoring except for a single "spike" in sulphate concentrations in October 2000 (Figure 7). (This outlier appears to be the result of a sampling and/or analytical error). Based on this data it appears that V34 does not receive significant seepage from the Vangorda WRD, potentially due to preferred groundwater flow in a more westerly direction towards Vangorda Creek.

In contrast, groundwater quality in V35 shows some (very limited) influence of WRD seepage, as evidenced by the gradual increase in sulphate over the last 10 years of monitoring, with peak concentrations in the range of 750-1,000 mg/L (Figure 7). As might be expected at this early stage of contaminant breakthrough, Zn concentrations are still very low (0.01-0.1 mg/L) in V35. Note, that the observed concentrations of sulphate and zinc are still much lower than in WRD seepage observed at the toe of Vangorda Dump, with SO4 as high as 20,000-30,000 mg/L and zinc concentrations in the range of ~25-7,000 mg/L (SRK, 2003). Clearly, any seepage from the WRD is currently significantly diluted and/or attenuated in the local groundwater system.

In my opinion, seepage interception along the southeast side of Vangorda Dump is not a high priority at this stage. The primary reason for the limited influence of WRD seepage on groundwater quality to date is likely the relatively low permeability of the till underlying the Vangorda WRD which limits seepage into the groundwater system.

However, it should be recognized that ARD evolution in the Vangorda Dump is well advanced (with acidic conditions in parts of the dump and very high sulphate and zinc concentrations). Hence, any seepage from the Vangorda Dump would have a very high potential of impacting the local groundwater in the long-term. It may therefore be prudent to carry out additional studies in this area at some point in the future to get a better understanding of the local hydrogeology and groundwater flow paths.

B.4 Vangorda Dump draining towards Vangorda Creek

Monitoring wells in this reach include V36 (GW94-03), V37 (GW94-04), V38 (GW94-05), P01-01, P01-02A/B and P01-03. V36 to V38 have been monitored since 1994. The "P2001" series of wells were only completed in 2001. The overburden in this area also consists primarily of highly compacted, silty glacial till of relatively low permeability. However, the thickness of the overburden thickens considerably towards Vangorda Creek (e.g. >35m at V38). (Note: the drill logs of the "P2001" series of wells were not available for this review). The groundwater levels in this area vary from ~4m bgs at P01-02A/B (likely confined) to >30m bgs at P01-03.

The groundwater quality in most of the wells in this reach is representative of, or at least close to background, with slightly alkaline pH (7.5-8.0), high alkalinity (~400 mg/L), low sulphate (~50-150 mg/L) and very low metals including zinc (<0.01 mg/L). Only monitoring well V36 (GW01-03) appears to show early signs of WRD seepage with a gradual increase in sulphate over the last 5 years (Figure 7). Again, there has been no increase in zinc thus far which is consistent with observations elsewhere at Grum and Vangorda.

In general, the local groundwater in this reach shows very little impact from WRD seepage, which might be expected considering the nature of the overburden (tight silty till), the depth to groundwater and the potential presence of permafrost. Hence, seepage interception along this side of Vangorda Dump is, in my opinion, a low priority at this stage. However, as mentioned previously, it may be prudent to study the local groundwater conditions in vicinity of the Vangorda Dump in more detail to evaluate the potential for future impacts on the local groundwater system.

An assessment of seepage from the partially flooded Vangorda Pit was beyond the scope of this review. However, it is my understanding that the water level in the Vangorda Pit is kept below the contact between the till and the bedrock suggesting that seepage in the more permeable alluvial sediments in the historic Vangorda Creek channel cannot occur.

C. Preliminary Recommendations for 2004-2005 Field Work

It is my understanding that provisions have been made for additional field investigations (to be carried out in 2004-2005), which may be required to develop seepage collection systems at the toe of Faro and Grum waste rock dumps. The five principal field activities that may be carried out to determine the requirements and feasibility of seepage collection in various reaches of the Faro and Vangorda Plateau mine sites include:

- Test pitting;
- Seismic Profiling;
- Drilling and Well Installation; and
- Hydraulic Testing

Some of this fieldwork has already been carried out in various parts of the site and/or is not required in certain parts of these sites (where the effect of WRD seepage on groundwater quality is still limited to date). In the following, I briefly summarize the objectives of these activities and provide recommendations as to where specifically these field activities might be required. It is acknowledged that budgetary, logistical and/or time constraints may prevent the implementation of all recommendations provided herein. Therefore, the various recommendations have been assigned a priority index ranging from "high", over "medium" to "low". This prioritization is primarily based on my assessment of the magnitude and timing of contaminant migration and its potential impact on nearby surface water. The cost of collection and treatment in a given area was not used as a criterion.

Table 1 summarizes the recommendations and my weighting with respect to their priority. This table should assist the project team in selecting the most appropriate set of field activities to be carried out in 2004. It should be emphasized that the recommendations listed in Table 1 only address seepage issues downgradient of the WRDs. Groundwater contamination issues at other parts of the Anvil Range Mining Complex (e.g. Rose Creek Tailings Facility) are not addressed in this memorandum.

C.1 Test Pitting

Test pitting can be used to characterize the shallow overburden (maximum 3-4m depth) and determine the depth to bedrock (where overburden is very shallow). In my opinion, test pitting is only of limited value because groundwater in many parts of the site resides at depths greater than 3-4m bgs and/or groundwater flow may occur primarily in the weathered bedrock. Test pitting may be useful, however, as a first screening tool to site locations for future drilling and/or seismic profiling (see below).

Table 1. Priority listing of recommended hydrogeological field studies.

Project Area	Test Pitting	Seismic Survey	Drilling & Well Installation	Hydraulic Testing
Faro				
Northeast Dumps towards NFRC	N/R	N/R	N/R	N/R
Zone 2 Pit towards NFRC	L	N/R	L	L
Intermediate Dump towards NFRC	N/R	N/R	N/R	N/R
Intermediate Dump towards Rose Crk	L	H	M	H
Main Dump East towards Rose Crk Valley	L	N/R	N/R	N/R
Main Dump West & NW Dumps towards old Faro Creek channel	N/R	H	H	H
Old Faro Creek Channel (near pit)	N/R	M	M	M
NW Dumps towards Guardhouse Crk	L	N/R	N/R	N/R
Grum				
Grum Dump towards southeast	L	M	M	M
Grum Dump towards southwest	N/R	N/R	N/R	N/R
Grum Creek drainage channel (near pit)	N/R	L	L	L
Vangorda				
Vangorda Dump towards Dixon Crk	N/R	N/R	N/R	N/R
Vangorda Dump towards Vangorda Crk	N/R	N/R	N/R	N/R
Vangorda Creek channel (near pit)	N/R	N/R	L	N/R

Legend:

H	High Priority
M	Medium Priority
L	Low Priority
N/R	not required at this stage

In my opinion, consideration should be given to use test pitting in the following areas:

- In the "floodplain" below Zone 2 pit (Faro) to obtain samples of in-situ material (for geochemical testing);
- South of the Intermediate Dump to guide in the siting of a seismic profile line and drilling locations;
- South of the Main Dump (East) to better characterize subsurface conditions and shallow groundwater quality;
- Downgradient of the Northwest Dumps (in the Guardhouse Creek area) to better characterize subsurface conditions and shallow groundwater quality; and
- Southeast of the Grum Dump to determine the extent of valley fill and to assist in the siting of a seismic profile line and drilling locations.

In general, test pitting is considered a lower priority compared to other required field activities (see Table 1 for ranking of priority).

C2. Seismic Surveys

Seismic surveys provide information about the groundwater table and the depth to bedrock along a survey line. This method is considered relatively cost-effective and provides valuable information for estimating seepage flows and siting drilling locations (e.g. in the center of a valley).

Consideration should be given to carrying out seismic surveys along the following profiles:

- Along the southern toe of the Intermediate Dump (near the “S” cluster of wells);
- Across the old Faro Creek channel (near X23);
- Across the old Faro Creek channel (near Faro Pit);
- Along the southeastern slope below Grum Dump (including Grum Creek valley)
- Across the old Grum Creek valley (near Grum Pit);

The priority for each of the recommended profiles is summarized in Table 1. The exact transect lines for these seismic surveys would have to be confirmed during a field reconnaissance.

C.3 Drilling & Well Installation

Drilling provides an opportunity to evaluate the subsurface conditions in overburden and underlying bedrock. The borehole can be used for hydraulic testing (in particular in bedrock) and for the installation of monitoring wells and/or pumping wells.

The following scope of drilling and well installation is recommended for the 2004/2005 field investigation:

- 1 borehole in the “floodplain” below Zone 2 pit (Faro); this borehole should be completed as a pumping well (4” screened in alluvial sediments) to allow pump testing of this area;
- 1 borehole to the NW of the “S” well cluster (near the southern toe of the Intermediate Dump); this borehole should be completed with 2 nested piezometers (2” each) screened in overburden and weathered bedrock, respectively;

- 2 boreholes in the old Faro Creek channel (near X23); 1 borehole should be completed as a monitoring well (2" screened in weathered bedrock) and the other as a pumping well (4" screened in alluvial sediments);
- 1 borehole in the old Faro Creek channel (near Faro Pit); this borehole should be advanced at least 20m into "tight" bedrock to assess fracturing and to allow packer testing; the borehole should be completed with 2 nested piezometers (2" each) screened in alluvial sediments and weathered (or fractured) bedrock, respectively;
- 2 boreholes downgradient (southeast) of Grum Dump, one adjacent to Grum Creek and a second borehole to the west of P96-09; each borehole should be completed with 2 nested piezometers (2" each) screened in overburden and weathered bedrock, respectively;
- 1 borehole in the old Grum Creek channel (between Grum Pit and seep site "SRK-GD-01"); this borehole should be advanced at least 20m into "tight" bedrock to assess fracturing and to allow packer testing; the borehole should be completed with 2 nested piezometers (2" each) screened in alluvial sediments and weathered (or fractured) bedrock, respectively;

Table 1 shows my assessment of the priority of drilling/well installation for the different sites. In my opinion, the high priority sites are required and the medium priority sites should also be drilled as part of the 2004/2005 field investigations, if the budget allows. The low priority sites are optional and could be drilled at a later stage if there are budgetary or logistical constraints.

Drilling should be carried out using an air rotary/hammer rig with ODEX type casing advance (6"- 8" OD) or a SONIC drill rig with 6" casing advance. Depending on access conditions, a track-mounted rig may be required for some sites. All boreholes should be drilled with air as a drilling fluid to detect water-bearing units.

Water level and water quality monitoring in the proposed nested piezometers would provide insight into the impact of WRD seepage (and/or pit seepage) in those areas of interest. In addition, all proposed wells should be used for hydraulic testing, i.e. to perform pump tests and/or slug tests (see below).

C.4 Hydraulic Testing

Hydraulic testing provides insight into the hydraulic properties of the aquifer units and therefore allows an assessment of seepage rates required for assessing the requirements and feasibility of seepage interception.

Consideration should be given to carrying out the following hydraulic tests:

- a constant discharge pump test in the "floodplain" below Zone 2 pit (Faro) using the proposed pumping well (or any other suitable 4" well); such a pump test would provide information about the hydraulic conductivity of the local sediments, the degree of heterogeneity within these sediments, and the interaction of the shallow groundwater with NFRC;
- slug tests in all existing and proposed piezometers of the "S" well cluster (near the southern toe of the Intermediate Dump);
- a constant discharge pump test in the old Faro Creek channel (near X23) using the proposed pumping well; such a pump test would provide information about the hydraulic conductivity of the local sediments and test the feasibility of an active interception system in this area; in addition, slug tests should be carried out in all existing and proposed piezometers in this area;
- packer testing in the proposed borehole to be drilled into bedrock near the Faro Pit; in addition, slug tests should be carried out in the two proposed piezometers in the same borehole;
- slug tests in the proposed piezometers downgradient (southeast) of Grum Dump;
- packer testing in the proposed borehole to be drilled into bedrock near the Grum Pit; in addition, slug tests should be carried out in the two proposed piezometers in the same borehole.

The pumping rate and duration of the CD pump tests will have to be determined based on a review of the available hydraulic data and will have to take into account the requirements for collection and/or disposal of pumped groundwater. It is imperative that both **drawdown and recovery data** be collected in the pumping well and the near-by monitoring wells as part of the pump test. An automated data acquisition system (using pressure transducers) should be used, where possible, for collection of water levels during drawdown and recovery. Manual water levels should also be taken as a back-up.

Slug tests should include falling head and rising head tests on all tested piezometers. The use of a downhole datalogger (e.g. Solinst Levelogger or equivalent) is highly recommended for more permeable aquifer units.

Table 1 shows my assessment of the priority of hydraulic testing for the different sites. In my opinion, the high priority sites are required and the medium priority sites should also be tested if budget and time allows.

D. Closing Comments

It should be emphasized that this review focused primarily on groundwater quality and did not include a detailed review of all previous hydrogeological studies and borehole logs. As such the author had to rely on his knowledge of local site conditions acquired during preparation of the ICAP in 1995-1996. A more detailed review of all previous hydrogeological studies (in particular borehole logs and hydraulic testing data) and a site reconnaissance should be carried out in order to assess the requirements and feasibility of seepage interception at Faro and Grum/Vangorda.

Furthermore, a review of the effects of groundwater seepage on surface water quality was beyond the scope of this review. A review of recent trends in surface water quality (in particular along the North Fork of Rose Creek) would complement this initial review of seepage water quality presented here.

In my view, the need for seepage interception at Faro, Grum and Vangorda should consider the likely contaminant load associated with seepage in a given reach and its potential impact on the receiving surface water. The results of the proposed 2004 field investigation would provide a sound basis for carrying out such an analysis.

Please contact the undersigned if you have any questions regarding this memo.

ROBERTSON GEOCONSULTANTS INC.

Christoph Wels, Ph.D.
Senior Hydrogeologist

Att. 7 figures in separate pdf file

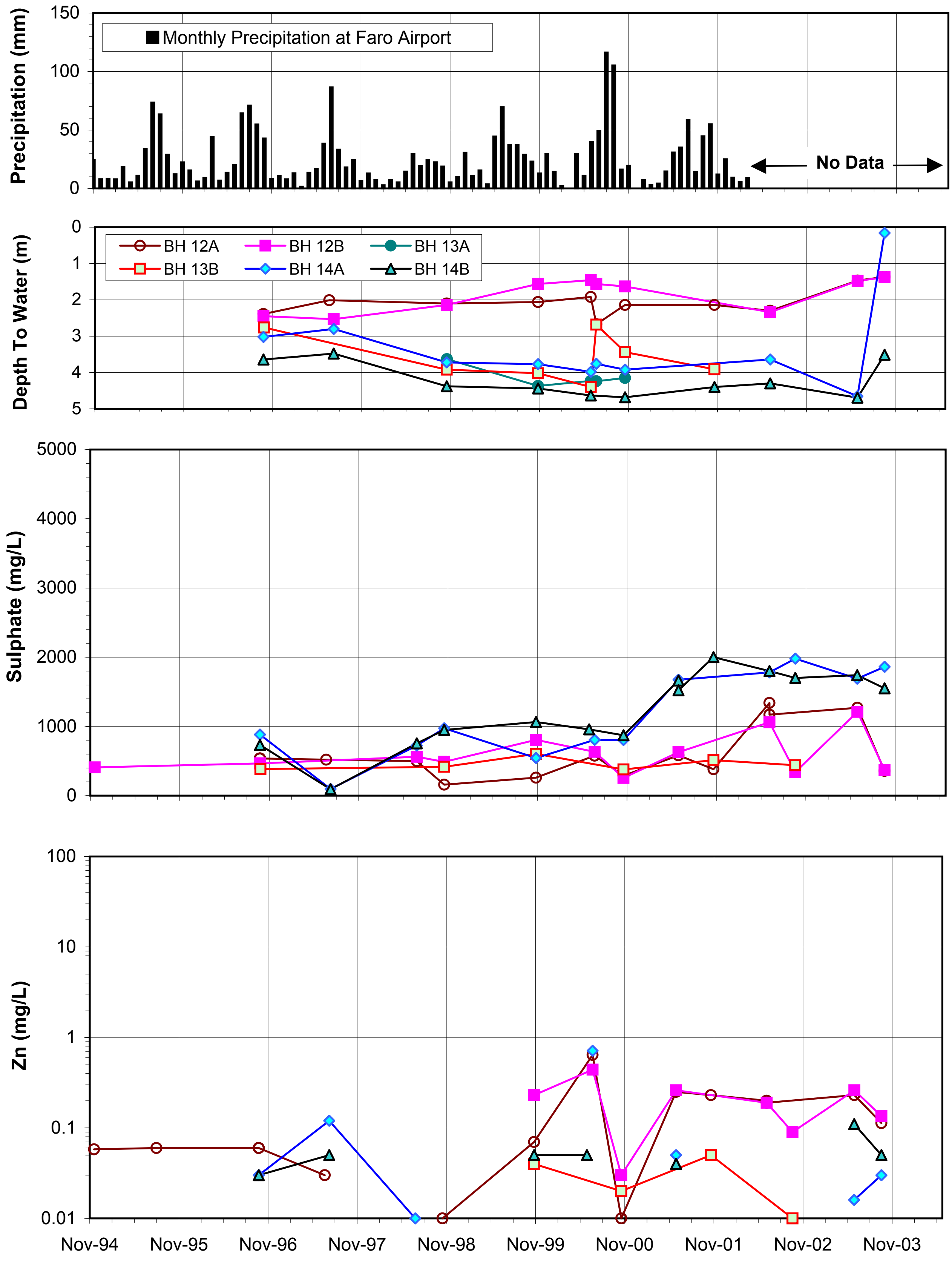

Figure 1. Groundwater quality downgradient of Northeast Dumps (towards NFRC).

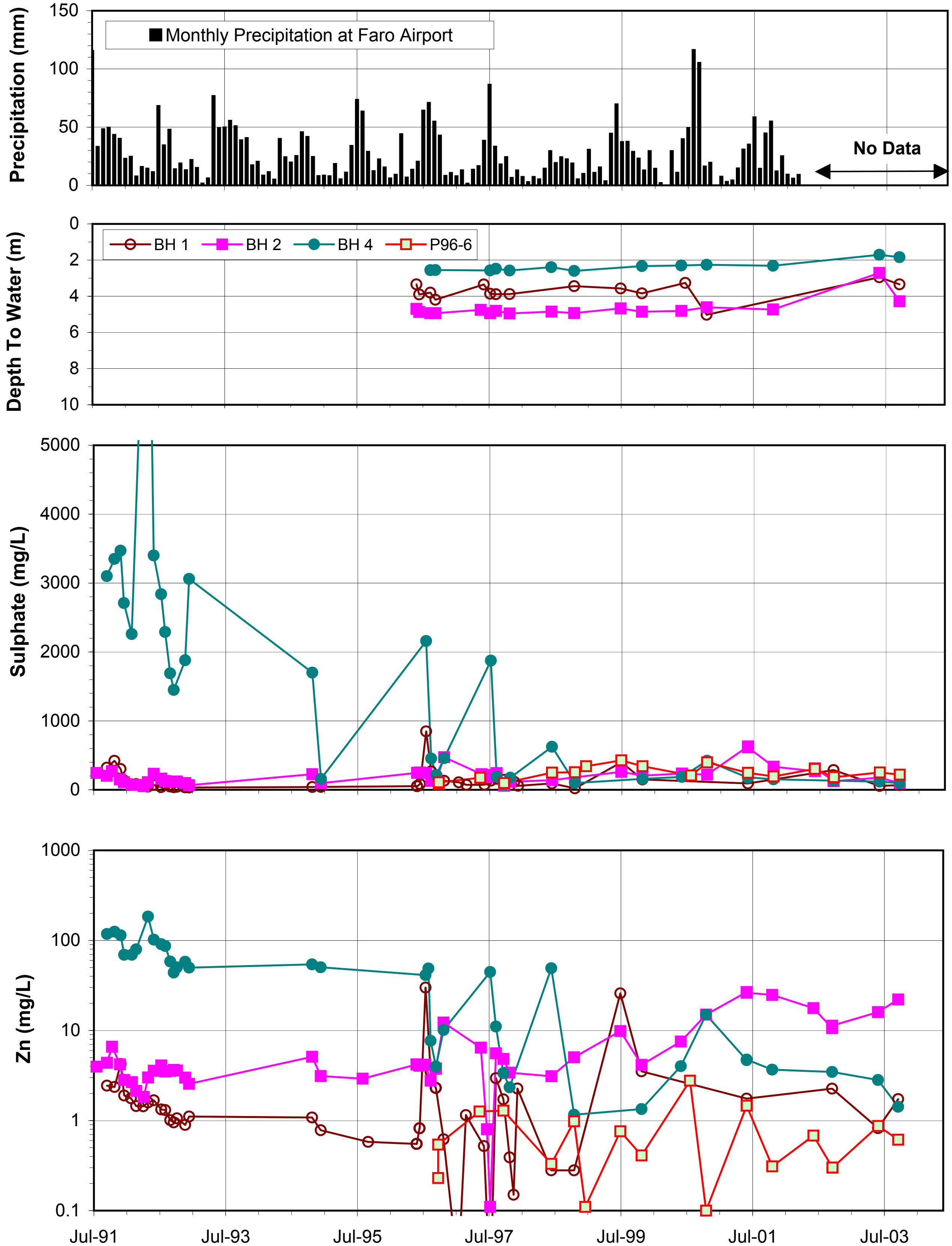

Figure 2. Groundwater quality downgradient of Zone 2 Pit and Intermediate Dumps (towards NFRC above rock drain).

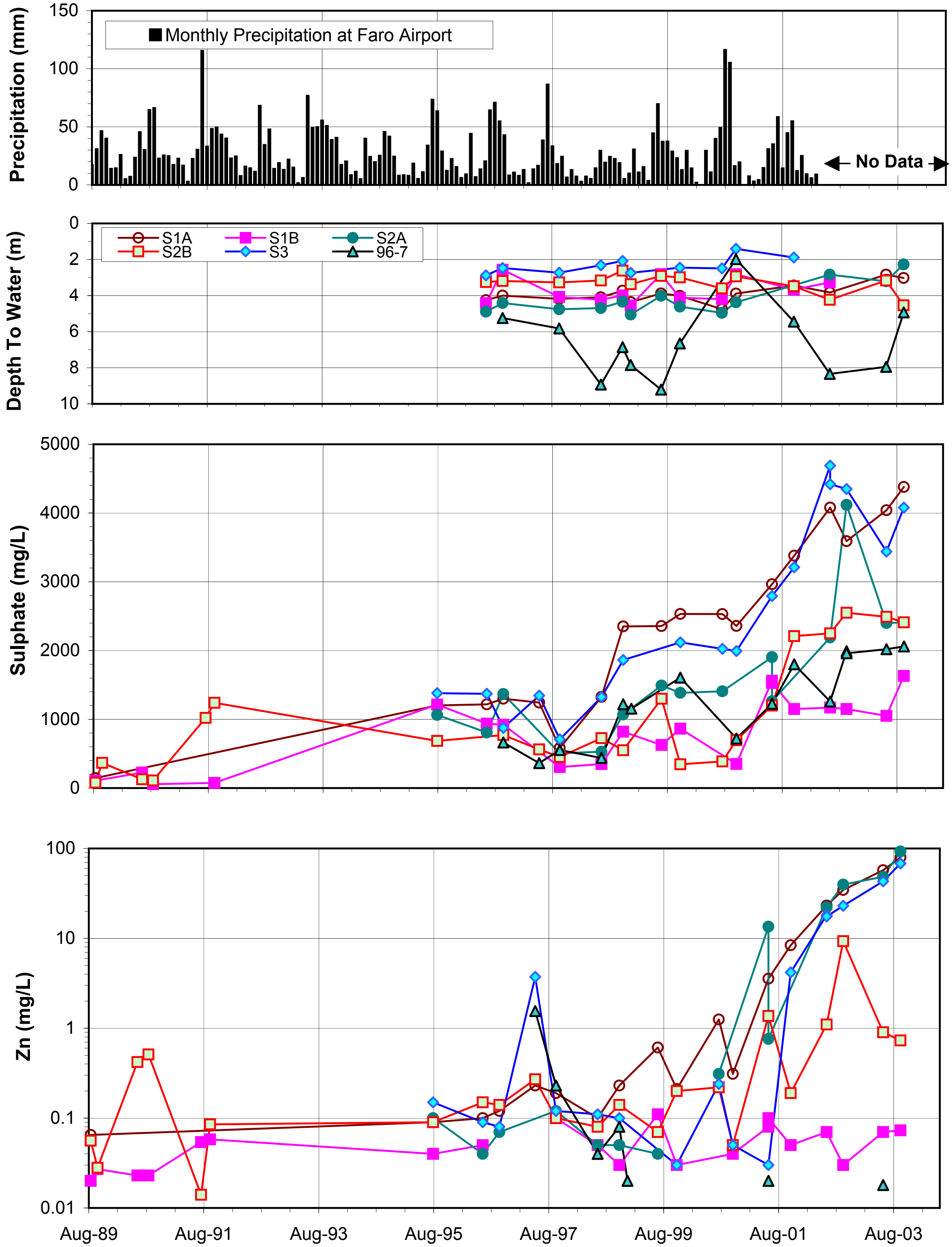

Figure 3. Groundwater quality downgradient of Intermediate Dump (towards NFRC below rock drain).

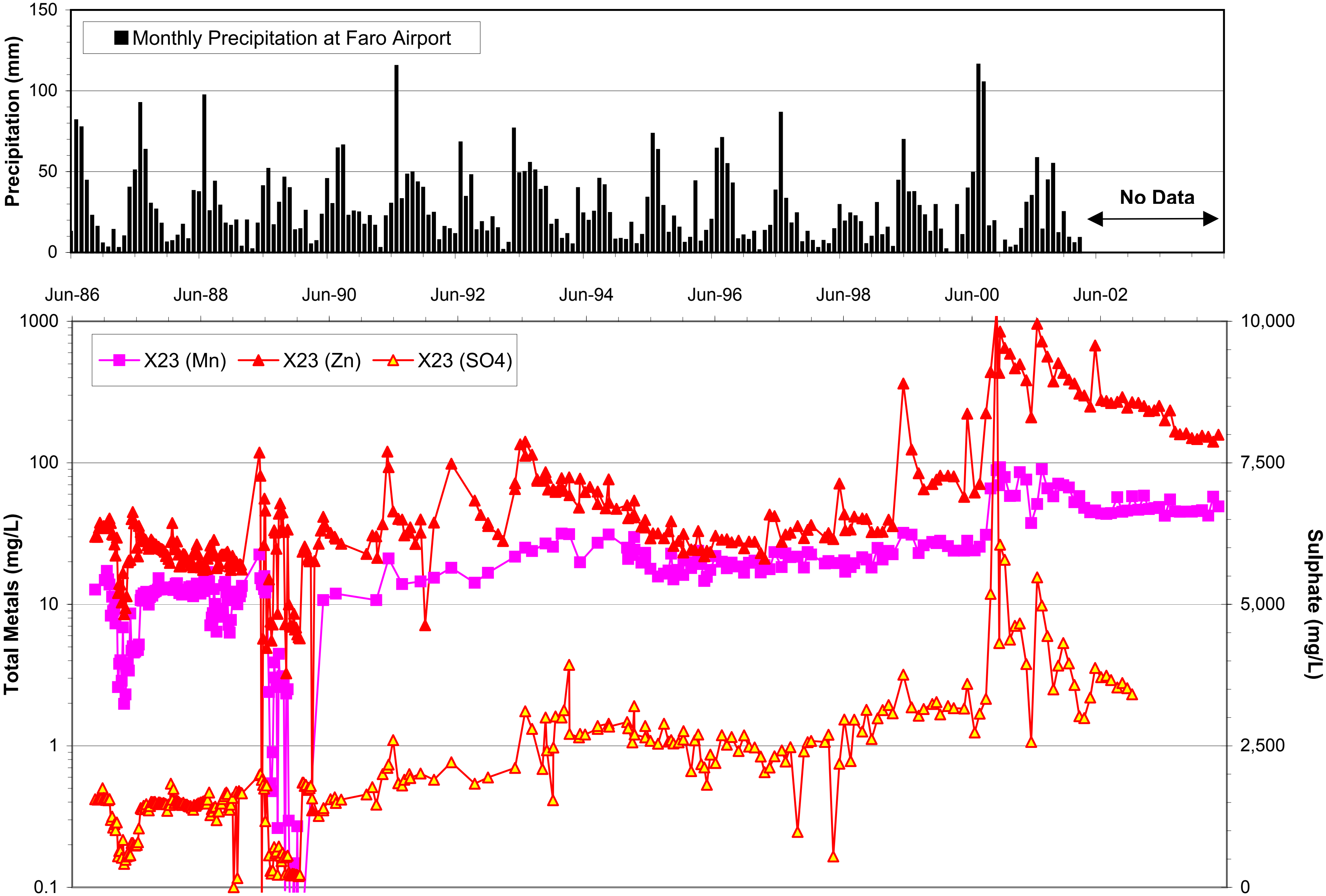

Figure 4. Time trends of sulphate, total zinc and total manganese in toe seepage at X23 (1986-2004).

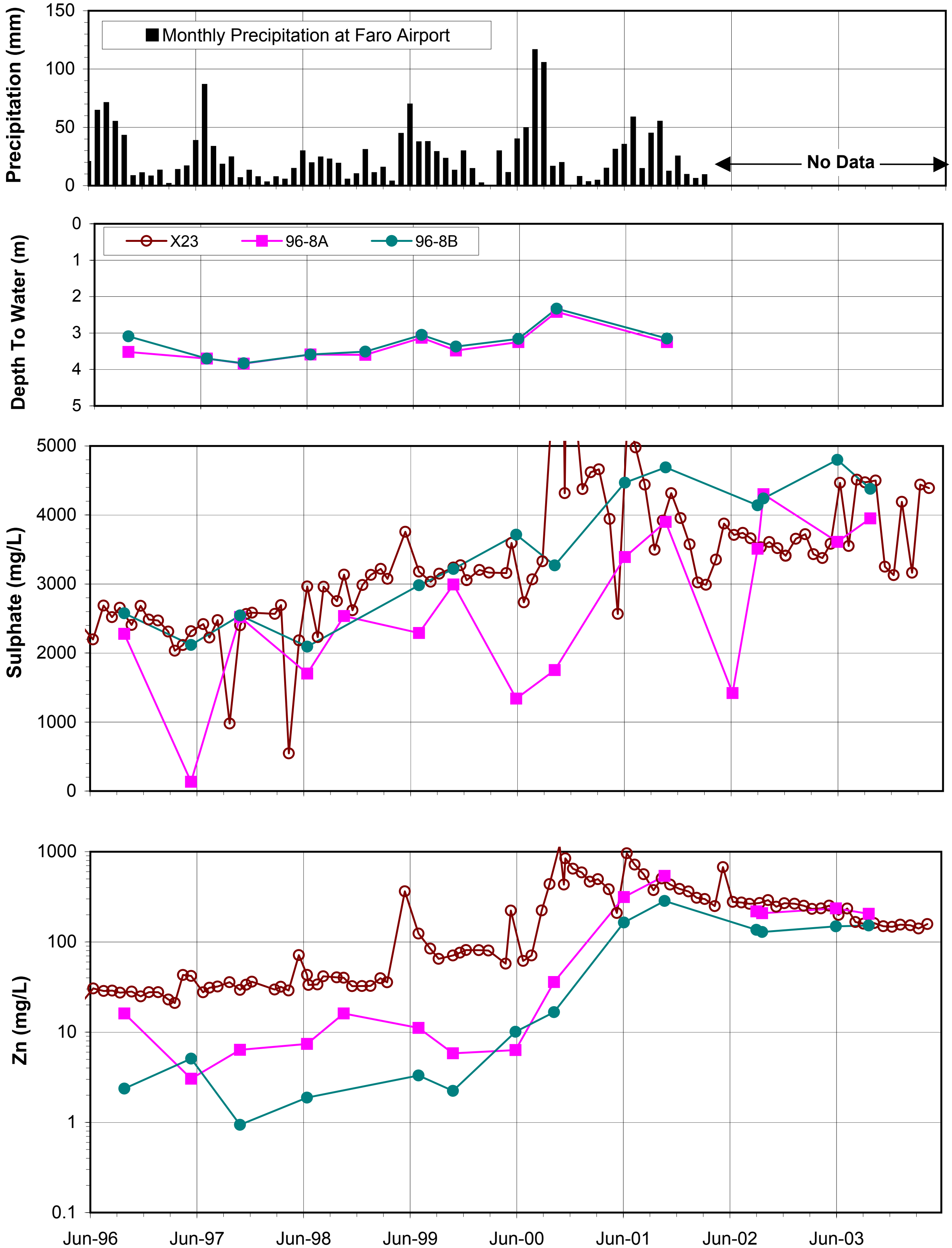

Figure 5. Water quality in surface seepage (X23) and subsurface seepage (P96-8A/B) downgradient of Main Dump (in old Faro Creek channel).

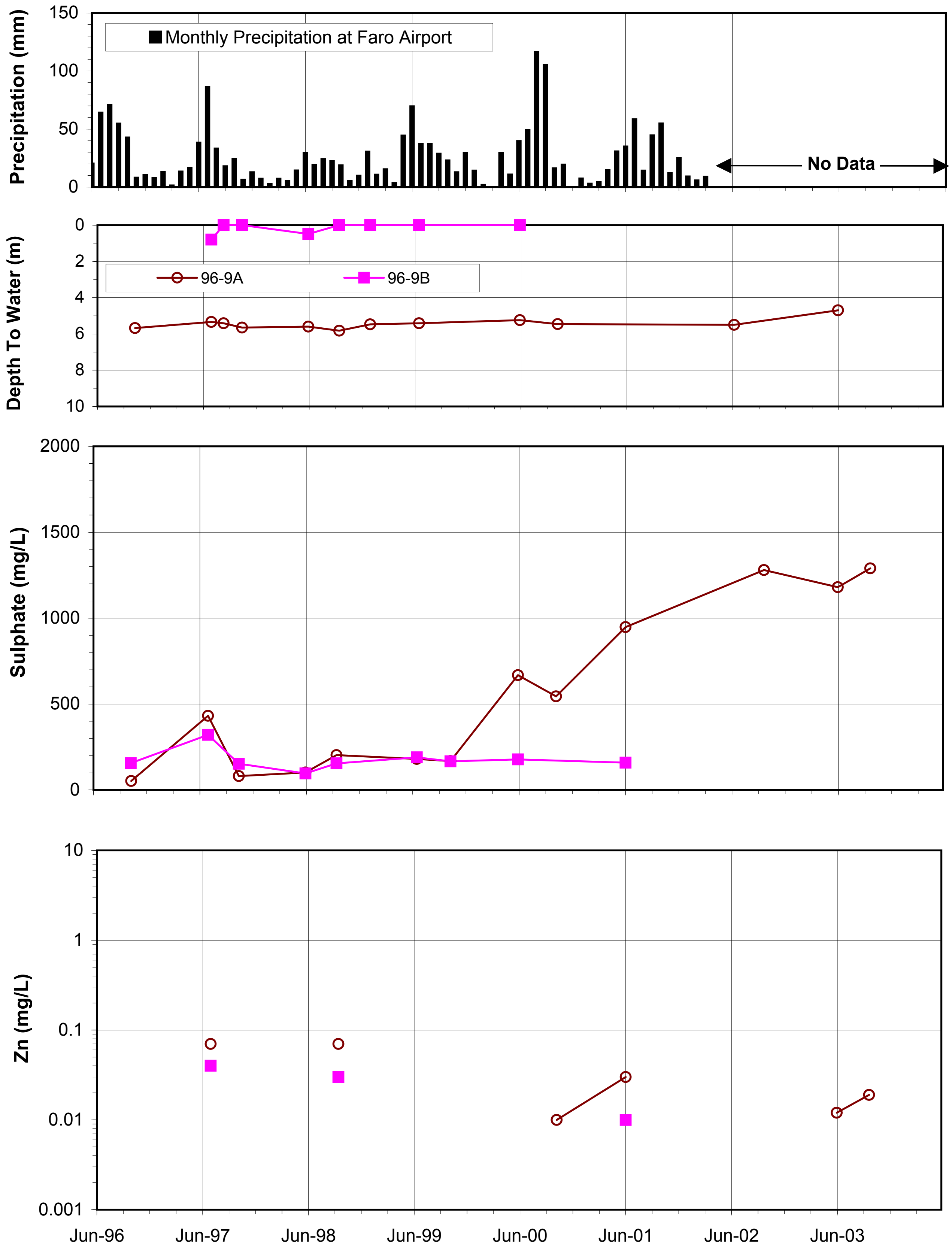

Figure 6. Groundwater quality downgradient of Grum Dump .

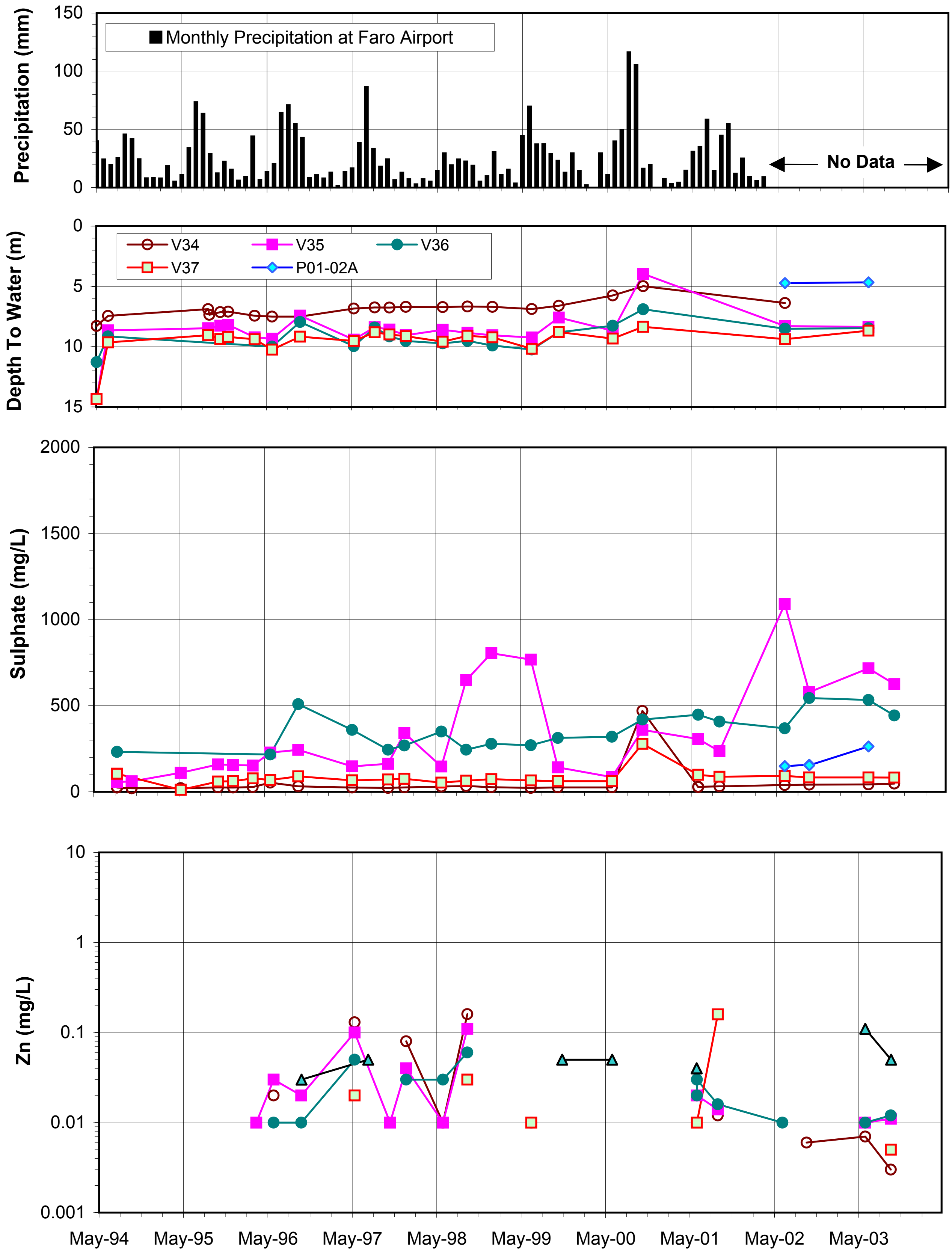

Figure 7. Groundwater quality downgradient of Vangorda Dump.

Appendix B

Memo: ***Task 14d – Complete Seepage Investigations for Faro and Grum Waste Rock Dumps***

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MEMORANDUM

DATE: August 13, 2004

TO: Valerie Chort

FROM: Michael Royle / Cam Scott / Christoph Wels (RGC)

RE: Task 14b - Complete Seepage Investigations for Faro and Grum Waste Rock Dumps

INTRODUCTION

One of the issues associated with the ongoing development of the closure plan for the Anvil Range Mining Complex is the collection of seepage from the waste rock dumps. The current D&T scope description for this task is as follows:

14. Develop Faro / Grum / Vangorda Decommissioning Methods

d) Complete Seepage Investigations and Designs

In 2003-2004, a study entitled Assess Grum Seepage Requirements was completed. In 2004-2005 field investigations required to develop seepage collection systems at the toe of Faro and Grum waste rock dumps will be completed. The recommendations developed in the study mentioned herein as well as previous studies of groundwater below the Faro and Grum dumps will be reviewed and integrated into this study. Preliminary engineering designs and cost estimates will be prepared.

The 2003-2004 study evaluated alternative options for collecting seepage below the Grum waste rock dump and provided preliminary engineering designs and costing for these alternative options. The proposed study (Task 14) builds on this earlier study in two ways. First, this study will include a more detailed assessment of collection of deeper seepage (“groundwater”) not evaluated in detail in the 2003-3004 study. Second, the assessment of seepage collection (shallow and deep) will be extended to also include the Faro waste rock dumps. The results of the 2003/2004 study (development of conceptual options and preliminary designs for shallow seepage collection at Grum) will be integrated into this proposed study.

This memorandum describes the proposed work scope and costs associated with the field investigation and subsequent office studies required to complete the preliminary designs and cost estimates for the seepage collection systems at the Faro and Grum waste rock dumps.

SCOPE OF WORK

The proposed scope of work has been divided into the following four tasks:

Task 1: Data Review and Development of Field Program
Task 2: Field Investigation
Task 3: Data Compilation and Analysis
Task 4: Engineering Design and Reporting

These are described in more detail below.

Task 1: Data Review and Development of Field Program

In order to meet the deadlines for the completion of Task 14b, this task (Task 1) was performed in advance of this proposal. The initial data review focussed on time trends of recent water quality monitoring data collected in monitoring wells and seeps located downgradient of the Faro, Grum and Vangorda waste rock dumps. The results of this review are summarized in a memorandum entitled "Initial review of groundwater quality downstream of Faro, Grum, and Vangorda WRDs, Yukon Territory" dated July 14, 2004 (attachment 1).

Based on this review, recommendations were given for additional field work to be carried out during the 2004 field season (see Table 1 for a summary). Potential field investigations evaluated for the various sites included (i) test pitting, (ii) seismic work, (iii) drilling & well installation and (iv) hydraulic testing. At the time, it was acknowledged that budgetary, logistical and/or time constraints may prevent the implementation of all recommendations provided herein. Therefore, the various recommendations were assigned a priority index ranging from "high", over "medium" to "low". This prioritization was primarily based on an assessment of the magnitude and timing of contaminant migration and its potential impact on nearby surface water. The cost of collection and treatment in a given area was not used as a criterion.

As pointed out in the memorandum it was unlikely that the available budget for Task 14 (~$200 k) would be adequate to cover all proposed field work and that the priority ranking may have to be used to finalize the scope of the field work according to the available budget. Preliminary costing of the various field work components indicated that the available budget would allow for the execution of all "high priority" and most "medium priority" activities. The finalized scope of work for the 2004 field investigation is summarized in the following section (Task 2).

Table 1. Priority listing of recommended hydrogeological field studies.

Project Area	Test Pitting	Seismic Survey	Drilling & Well Installation	Hydraulic Testing
Faro				
Northeast Dumps towards NFRC	N/R	N/R	N/R	N/R
Zone 2 Pit towards NFRC	L	N/R	L	L
Intermediate Dump towards NFRC	N/R	N/R	N/R	N/R
Intermediate Dump towards Rose Crk	L	H	M	H
Main Dump East towards Rose Crk Valley	L	N/R	N/R	N/R
Main Dump West & NW Dumps towards old Faro Creek channel	N/R	H	H	H
Old Faro Creek Channel (near pit)	N/R	M	M	M
NW Dumps towards Guardhouse Crk	L	N/R	N/R	N/R
Grum				
Grum Dump towards southeast	L	M	M	M
Grum Dump towards southwest	N/R	N/R	N/R	N/R
Grum Creek drainage channel (near pit)	N/R	L	L	L
Vangorda				
Vangorda Dump towards Dixon Crk	N/R	N/R	N/R	N/R
Vangorda Dump towards Vangorda Crk	N/R	N/R	N/R	N/R
Vangorda Creek channel (near pit)	N/R	N/R	L	N/R

Legend:

H	High Priority
M	Medium Priority
L	Low Priority
N/R	not required at this stage

Task 2: Field Investigation

For preparation of the detailed scope of work for Task 14 (this memo), a preliminary scope for drilling/well installation was prepared and costs estimated. This preliminary scope of the drilling program is summarized in a memorandum entitled "Proposed Scope of Drilling Program for Faro & Grum WRDs, Yukon Territory" dated July 21, 2004 (attachment 2). Table 2 summarizes the proposed scope of the drilling and well installation program and Figures 1 and 2 show the proposed locations. The proposed scope includes:

- five drill holes to be completed with two nested 2" piezometers each (or 10 drill holes with single 2" monitoring well installations),
- one drill hole to be completed as a single 2" monitoring well (replacement of P96-9B);
- two drill holes to be completed as 4" pumping wells (4" diameter).

As outlined in the July 14 memorandum, additional monitoring wells at Faro focus on areas where significant deterioration of groundwater quality has been recently observed (downstream of Intermediate Dump and along Faro Creek channel) and where seepage interception is likely a priority. The monitoring wells proposed for Grum follow the general recommendations provided in the 2003/2004 SRK study.

Table 2. Proposed scope of drilling program, 2004 field investigation.

Well ID	Location	Target Depth[1] (m bgs)	Target Lithology	Well Completion
Faro Site				
#1	below Zone 2 pit near NFRC	7	alluvial sediments	4" pumping well
#2A	at toe of Haul Road in old	9	colluvium	2" monitoring well
#2B	drainage channel NW of "S wells"	12	fractured bedrock	2" monitoring well
#3A	in Faro Creek channel	10	alluvial sediments	2" monitoring well
#3B	immediately north of mine access	14	fractured bedrock	2" monitoring well
#4	~ 10m distance from #3A&B	10	alluvial sediments	4" pumping well
#5A	in old Faro Creek channel along	25 (?)	alluvial sediments	2" monitoring well
#5B	access ramp to Faro Pit	30 (?)	fractured bedrock	2" monitoring well
Grum Site				
#6A	near Grum Creek along access	15 (?)	colluvium/till	2" monitoring well
#6B	road below Grum Dump	20 (?)	fractured bedrock	2" monitoring well
#7A	between two shallow drainage	5	colluvium/till	2" monitoring well
#7B	channels east of P96-9 along access road below Grum Dump	10	fractured bedrock	2" monitoring well
#96-9B (replacement)		18	fractured bedrock	2" monitoring well

Notes:
[1] final depth to be determined during drilling

The ODEX drill that would be used to for this program is owned and operated by Midnight Sun of Whitehorse and has already been mobilized to site for other drilling programs. For costing purposes we have therefore assumed that the mobilization cost is covered by other projects.

The cost of drilling for this originally proposed program was estimated to be approximately $100,000 for drilling/supplies (quote from Midnight Sun Drilling) plus ~20,000 in professional fees (without contingencies). Based on our experience, the costs of the drilling program may be higher than expected and a contingency would be required to cover unexpected delays or problems. Unfortunately, a contingency would not be covered by the funds allocated to this project without compromising data analysis and engineering design. We, therefore, propose to drill the high priority wells (#2A/B, 3A/B, 4, 6A/B, 7A/B) first and complete the lower priority wells (1, 5A/B and 96-9B replacement) only if the allocated budget for this subtask (~$120,000 for drilling & hydraulic testing) allows.

Additional field investigations proposed for this task (and included in the cost estimate) include:

- Test pitting in the reach downgradient of the Intermediate Dam (near the S cluster of wells) (10 test pits);
- Slug tests in all new monitoring wells and selected existing monitoring wells (15 slug tests in total);
- Ground penetrating radar along 2 transects (downgradient of Intermediate Dump and along Faro Creek channel between Death Valley and X 23);

The primary purpose of the geophysics is to determine the depth to bedrock along a given survey line (usually coincident with the proposed alignment of a seepage interception system). The geophysical surveys will be subcontracted to Aurora GeoSciences (Whitehorse, YT). Based on discussions with Mike Powers, from Aurora, a ground-penetrating radar survey is more cost effective than seismic surveys (initially proposed, see table 1) for the relatively shallow depth to bedrock encountered at Faro. According to Mr. Powers, this method was applied successfully in the late 1980s to determine the depth to bedrock downgradient of the Grum Dump.

It is assumed that the new monitoring wells will be included in the routine monitoring program (carried out by others) with initial sampling in September 2004. Therefore, sampling and analysis of groundwater quality from the new monitoring wells is **not** included in this project (and budget). Sampling of the new monitoring wells should be carried out no later than September 2004 to allow for adequate time to the development of results that can be used in this study.

Revisions to these subtasks may be required depending on progress during the field investigation. As outlined above, the field investigation will commence with the high priority activities (see Table 1). Medium priority activities will only be completed up to the allocated budget to provide sufficient funds for completion of the analysis and engineering designs (Tasks 3 and 4, below).

Task 3: Data Compilation and Analysis

This task will consist of the compilation and analysis of the hydrogeological data from the field investigation. Subtasks will include the following:

- Summary description of field methods;
- Documentation of well completion data;
- Preparation of borehole and test pit logs;

- Interpretation of slug and pump tests;

The results of these subtasks will be included in the final report (see Task 4).

Task 4: Engineering Design and Reporting

In this task, the analytical results will be used to develop the preliminary design and estimated costs for a seepage collection system at the Faro and Grum waste rock dumps.

First, all new and existing groundwater quality and hydraulic testing data will be reviewed to determine which reaches downgradient of the Faro and Grum dumps may potentially require seepage collection systems. For each of the major reaches, the merits of the various alternative collection options, originally described in the 2003/2004 study will be evaluated. These options include:

- Sediment control ditches;
- Seepage collection ditches;
- Localized (deeper) sumps; and
- Interceptor wells.

For each region, recommendations for seepage interception will be provided.

Based on the initial data review, the chemical evolution of ARD and contaminant migration is much more advanced at Faro than at Grum, in particular downgradient of the Intermediate Dump (near S cluster of wells) and downgradient of the Main Rock Dump (in the old Faro Creek channel). For the purposes of costing, we have assumed that preliminary engineering designs will be developed and associated costs will only be estimated for those two areas. In all other areas at Faro, the seepage collection design will be of a conceptual nature with rough costing only.

At Grum, preliminary engineering designs and associated costs have already been developed as part of the 2003/2004 SRK study. While this level of design and costing is considered adequate for the Grum area (where seepage interception may not be required for many more years) these earlier designs only consider collection of very shallow seepage. In this study, we will also evaluate the feasibility and requirements of collection of deep seepage ("groundwater") below Grum Dump.

The findings, along with drawings, will be summarized in a brief design report. The draft report will be circulated to D&T and key regulatory stakeholders for review/comment. Comments will be considered in the finalization of the report.

ESTIMATED COSTS

The estimated costs to complete the scope of work described in this memorandum are provided in Table 1, attached. The final costs are estimated to be approximately $200,000 (pre-GST).

The Task 2 component of the costs, which represents the largest part of the costs, is based on the following assumptions:

- Drill contractor costs as based on quotation SRKFARO4J dated August 7, 2004;
- Fuel to be supplied by site
- Estimated 20 days of drilling and testing;
- Two days travel for SRK field staff;
- Monitoring wells installed as double nested piezometers with fully grouted seals;
- Pumping and monitoring wells will be developed following installation;
- Transducer/dataloggers will be used for measuring changes in water levels during pumping tests;
- Pumping tests will be scheduled for an estimated 12 hours maximum of pumping and 12 hours of recovery monitoring; and
- No groundwater samples will be collected as part of this work.

The cost of drill rig mobilization is not included in this budget. It is further assumed that an excavator is provided by the site for test pitting and other preparation work (clearing of access and drill pads).

Please note the cost of the field program is based on the assumed drill hole depths listed in Table 2, and that normal drilling production rates apply. Extra time spent due to requirements for deeper drilling and/or delays in drilling will impact the schedule and may lead to curtailment of some of the drilling program. Significant modifications to the drilling program will be discussed with D&T and the regulatory stakeholders before they are implemented.

SCHEDULE

As noted, Task 1 is already completed. The field investigation (Task 2), exclusive of some final planning requirements that must be done in advance of the field work, will commence in late August. The actual timing will depend on the urgency and progress of other drilling programs that the ODEX drill is tasked to perform. Task 3 will commence following the field investigation. A draft report will be completed by November 30, 2004, provided that the initial groundwater quality results for all new monitoring wells are provided by others no later than mid-October.

Table 1: Estimated Costs

TASK	Rate ($/hr)	Senior Reviewer Wels $135	Project Manager Scott $165	Principal Geochemist Hockley $190	Senior Geochemist Sexsmith $125	Project Sc./Eng. Mackie $80	Project Sc./Eng. Findlater $85	Senior Project Sci. Royle $120	Support Staff (wordproccessing, etc.) $55	Drafting $75	TASK COST (FEES)	Travel	Food	Vehicle Rental	Drill Contrctor	Drill Contractor Equipment Costs	Geophysics	Field Equipment (Rental)	3% for telephone calls	Faxes, copying, etc.	TOTAL DISBURSEMENTS	TASK TOTAL (FEES AND DISB)
		FEES										DISBURSEMENTS										
1	Review	83.5	8.0				20.5				$14,335								$430		$430	**$14,765**
2	Planning	16.0	3.0			20.0		16.0			$6,175								$190		$190	**$6,365**
	Drill/Test	8.0	2.0			264.0		8.0			$23,490	$1,200	$400	$1,320	$91,301	$420	$7,000	$1,400	$700		$103,741	**$127,231**
3	Data Analysis	16.0				60.0	40.0	24.0	16.0	16.0	$15,320								$460	$200	$660	**$15,980**
4	Reporting	80.0	16.0	8.0		80.0	24.0	40.0	24.0	48.0	$33,120								$990	$1,500	$2,490	**$35,610**
	hrs.	203.5	29.0	8.0	0.0	424.0	84.5	88.0	40.0	64.0												
	Cost	$27,473	$4,785	$1,520	$0	$33,920	$7,183	$10,560	$2,200	$4,800		$1,200	$400	$1,320	$91,301	$420	$7,000	$1,400		$1,700		
											$92,440									**Subtotal:**	**$107,511**	
																					TOTAL:	**$199,951**

Appendix C
Drill logs and Test Pit Logs

SRK Consulting Engineers and Scientists

BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION:
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-25 **TO** 2004-08-26
DIP: 90.00 **AZIMUTH:**
COORDINATES: N E **DATUM:**

BOREHOLE: SRK04-01
PAGE: 1 **OF** 3
DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:
No completion. Water level at 14.55m b.g.s. on Sept. 13th, 2004

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH Rinse pH
- Cond Rinse conductivity
- ABA Acid Base Accounting
- Metals Metal ICP
- LE Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
			0.00 / 0.00	Till. Grey fine-medium sand with silt, clay and coarse to fine sub-rounded gravel.							
			-1.22 / 1.22	Till. Brown, dry and odourless. Fine to coarse sand and silt with fine sub-angular gravel							

Depth scale: ft 5, 10, 15, 20, 25, 30; m 1, 2, 3, 4, 5, 6, 7, 8, 9

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BOREHOLE LOG

SRK Consulting — Engineers and Scientists

PROJECT: Faro Mine Seepage Investigation	**BOREHOLE:** SRK04-01
LOCATION:	**PAGE:** 2 **OF** 3
FILE No: FARO (1CD003.053)	**DRILL TYPE:** Odex 6"
BORING DATE: 2004-08-25 **TO** 2004-08-26	**DRILL:** Air Rotary
DIP: 90.00 **AZIMUTH:**	**CASING:** 6"
COORDINATES: N E **DATUM:**	

GENERAL COMMENTS:
No completion. Water level at 14.55m b.g.s. on Sept. 13th, 2004

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH — Rinse pH
- LE — Extraction
- Cond — Rinse conductivity
- ABA — Acid Base Accounting
- Metals — Metal ICP

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION (STRATIGRAPHY)	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L (20 40 60 80)
35	11		-10.67 / 10.67	Glaciofluvial. Brown, dry, earthy. clay and silt with fine to coarse sand and minor fine sub-rounded gravel. Alternating gravel rich and clay rich interbeds.							
	12		-11.58 / 11.58	Glaciofluvial. Brown, dry, earthy, fine to coarse sand with sub-rounded to well-rounded gravel.							
40, 45, 50	13, 14, 15, 16		-12.19 / 12.19	Till. Grey, dry, earthy, clay and silt with fine to coarse sand and fine sub-angular to sub-rounded gravel.							
55	17		-16.76 / 16.76	Medium to coarse sand and fine gravel, damp.							
60, 65	18, 19		-17.07 / 17.07	Till. Grey silt and fine to coarse sand with clay and minor sub-angular fine gravel.							

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION:
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-25 **TO** 2004-08-26
DIP: 90.00 **AZIMUTH:**
COORDINATES: N E **DATUM:**

BOREHOLE: SRK04-01

DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:
No completion. Water level at 14.55m b.g.s. on Sept. 13th, 2004

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH Rinse pH
- Cond Rinse conductivity
- ABA Acid Base Accounting
- Metals Metal ICP
- LE Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
	21										
70	22										
75	23										
	24										
80	25										
85	26		-25.91 / 25.91	END OF BOREHOLE							
	27										
90	28										
95	29										

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-27 **TO** 2004-08-30
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913067.00 N 584254.00 E **DATUM:**

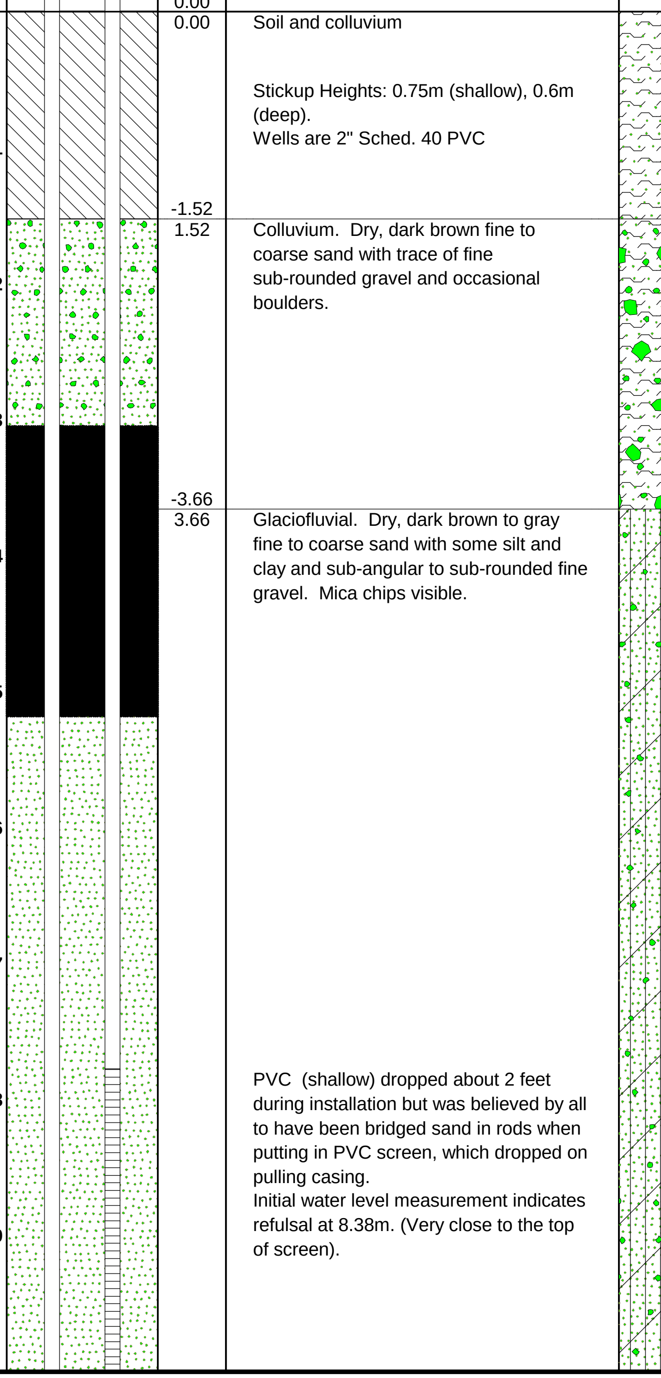
BOREHOLE: SRK04-02
PAGE: 1 **OF** 3
DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:
Drillhole located 4m prep. to road at approx. bearing of 105 deg. Hole is about 120m from NFRC parallel to access road along powerlines. No water measured in short piezo., but sand on bottom of w.l. tape suggests will still act as piezo.

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH Rinse pH
- Cond Rinse conductivity
- ABA Acid Base Accounting
- Metals Metal ICP
- LE Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) WP W W L 20 40 60 80
			0.00 / 0.00	Soil and colluvium Stickup Heights: 0.75m (shallow), 0.6m (deep). Wells are 2" Sched. 40 PVC							
5	1		-1.52 / 1.52	Colluvium. Dry, dark brown fine to coarse sand with trace of fine sub-rounded gravel and occasional boulders.							
10	2, 3		-3.66 / 3.66	Glaciofluvial. Dry, dark brown to gray fine to coarse sand with some silt and clay and sub-angular to sub-rounded fine gravel. Mica chips visible. PVC (shallow) dropped about 2 feet during installation but was believed by all to have been bridged sand in rods when putting in PVC screen, which dropped on pulling casing. Initial water level measurement indicates refulsal at 8.38m. (Very close to the top of screen).							
15, 20, 25, 30	4, 5, 6, 7, 8, 9										



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BOREHOLE LOG

SRK Consulting — Engineers and Scientists

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-27 **TO** 2004-08-30
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913067.00 N 584254.00 E **DATUM:**

BOREHOLE: SRK04-02
PAGE: 2 **OF** 3
DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:
Drillhole located 4m prep. to road at approx. bearing of 105 deg. Hole is about 120m from NFRC parallel to access road along powerlines. No water measured in short piezo., but sand on bottom of w.l. tape suggests will still act as piezo.

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH — Rinse pH
- Cond — Rinse conductivity
- ABA — Acid Base Accounting
- Metals — Metal ICP
- LE — Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
35	11			0.010 Slot 2" PVC screen							
			-11.28 / 11.28	Alluvium. Dry light tan-light brown, fine to coarse sand with fine sub-angular to rounded gravel. Coarse interbed.							
40	12		-12.19 / 12.19	Glaciofluvial (Same as 3.65m to 11.28m).							
45	13, 14										
50	15, 16										
55			-16.15 / 16.15	Alluvium. Damp, brown, fine to coarse sand and sub-rounded to sub-angular fine gravel.							
60	17, 18, 19			0.020 Slot 2" PVC screen							
65			-19.81 / 19.81	END OF BOREHOLE							

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-27 **TO** 2004-08-30
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913067.00 N 584254.00 E **DATUM:**

BOREHOLE: SRK04-02

DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:
Drillhole located 4m prep. to road at approx. bearing of 105 deg. Hole is about 120m from NFRC parallel to access road along powerlines. No water measured in short piezo., but sand on bottom of w.l. tape suggests will still act as piezo.

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH Rinse pH
- Cond Rinse conductivity
- ABA Acid Base Accounting
- Metals Metal ICP
- LE Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY: ELEVATION - m / DEPTH - m	STRATIGRAPHY: DESCRIPTION	STRATIGRAPHY: SYMBOL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY %	SAMPLES: N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
	21										
70											
	22										
75	23										
	24										
80											
	25										
85	26										
	27										
90											
	28										
95	29										

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-30 **TO** 2004-09-01
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913824.47 N 582977.28 E **DATUM:**

BOREHOLE: SRK04-03
PAGE: 1 **OF** 2
DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

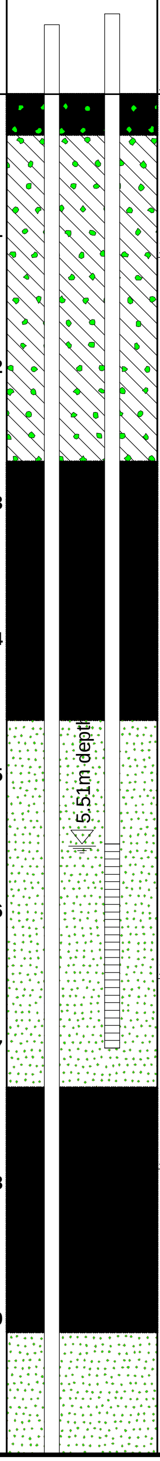
GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND

- ▨ Bentonite
- 🟩 Cuttings
- ■ Grout
- ░ Sand

LABORATORY AND IN SITU TESTS

pH	Rinse pH
Cond	Rinse conductivity
ABA	Acid Base Accounting
Metals	Metal ICP
LE	Extraction



DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
		1104.04 / 0.00	Sand and gravel fill. Stickup Heights: 0.59m (shallow), 0.51m (deep).						
	1	1102.84 / 1.20	Tailings Wells are 2" Sched. 40 PVC 0.020 Slot 2" PVC screen						
5	2								
10	3								
	4								
15	5								
20	6	1097.54 / 6.50	Alluvium with tailings						
	7								
25	8	1096.14 / 7.90	Sand and gravel alluvium						
30	9								

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-30 **TO** 2004-09-01
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913824.47 N 582977.28 E **DATUM:**

BOREHOLE: SRK04-03

DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS

pH	Rinse pH	LE	Extraction
Cond	Rinse conductivity		
ABA	Acid Base Accounting		
Metals	Metal ICP		

ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%)
1093.34 / 10.70	Weathered bedrock, sand and gravel. Actual start of weathered zone ambiguous. 2" Sched. 40 PVC screen							
1092.14 / 11.90	Bedrock							
1090.64 / 13.40	END OF BOREHOLE							

Depth scale: DEPTH - ft 35–65; DEPTH - m 11–19. Water content scale: W_P, W, W_L: 20, 40, 60, 80.

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-09-01 **TO** 2004-09-03
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913837.52 N 582977.50 E **DATUM:**

BOREHOLE: SRK04-04
PAGE: 1 **OF** 2
DRILL TYPE: ODEX 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS

pH	Rinse pH
Cond	Rinse conductivity
ABA	Acid Base Accounting
Metals	Metal ICP
LE	Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
			1104.29 / 0.00	Fill Well Stickup Height: 0.51m							
	1		1103.38 / 0.91	Tailings							
5	2										
10	3										
15	4										
	5			Half bag of sand added to top of natural fill							
20	6	6.80m depth on	1098.19 / 6.10	Alluvium with Tailings							
			1097.89 / 6.40	Alluvium							
	7			Sand in well is natural sandpack.							
25				0.13m Steel to PVC casing adaptor							
	8										
30	9			3.96m of Stainless Steel Screen; 2x20 slot at bottom, 1x10 slot at top Natural Sandpack							

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-09-01 **TO** 2004-09-03
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913837.52 N 582977.50 E **DATUM:**

BOREHOLE: SRK04-04

DRILL TYPE: ODEX 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH Rinse pH
- Cond Rinse conductivity
- ABA Acid Base Accounting
- Metals Metal ICP
- LE Extraction

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY: ELEVATION - m / DEPTH - m	STRATIGRAPHY: DESCRIPTION	STRATIGRAPHY: SYMBOL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY %	SAMPLES: N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80
35	11	Sand			Sand						
		Cuttings	1092.69 / 11.60	Possible thin weathered bedrock	Grout						
			1092.59 / 11.70	Bedrock	Grout						
	12		1092.39 / 11.90	END OF BOREHOLE							
40	13										
45	14										
	15										
50	16										
55	17										
	18										
60	19										
65											

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BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION:
FILE No: FARO (1CD003.053)
BORING DATE: 2004-09-06 **TO** 2004-09-09
DIP: 90.00 **AZIMUTH:**
COORDINATES: N E **DATUM:**

BOREHOLE: SRK04-05
PAGE: 1 **OF** 3
DRILL TYPE: ODEX 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH Rinse pH
- Cond Rinse conductivity
- ABA Acid Base Accounting
- Metals Metal ICP
- LE Extraction

ELEVATION - m / DEPTH - m	STRATIGRAPHY DESCRIPTION
0.00 / 0.00	Organics, Alluvium Stickup Heights: 0.81m (shallow), 0.78m (deep).
-1.22 / 1.22	Fine to coarse sand with sub-angular to sub-rounded gravel plus TRC silt or clay. Wells are 2" Sched. 40 PVC
-4.57 / 4.57	Clay with fine to coarse sand and minor gravel.
-8.23 / 8.23	Fine to coarse sand with fine to coarse gravel.

Column headings: DEPTH - ft; DEPTH - m; WELL DETAILS & WATER LEVEL - m; STRATIGRAPHY (ELEVATION - m / DEPTH - m, DESCRIPTION, SYMBOL); SAMPLES (TYPE AND NUMBER, CONDITION, RECOVERY %, N or RQD); LABORATORY and IN SITU TESTS; WATER CONTENT and LIMITS (%) (W_P, W, W_L; 20 40 60 80)

Depth scale: 5, 10, 15, 20, 25, 30 ft; 1–9 m

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BOREHOLE LOG

SRK Consulting — Engineers and Scientists

PROJECT: Faro Mine Seepage Investigation		**BOREHOLE:** SRK04-05	
LOCATION:		**PAGE:** 2	**OF** 3
FILE No: FARO (1CD003.053)		**DRILL TYPE:** ODEX 6"	
BORING DATE: 2004-09-06	**TO** 2004-09-09	**DRILL:** Air Rotary	
DIP: 90.00	**AZIMUTH:**	**CASING:** 6"	
COORDINATES: N	E	**DATUM:**	

GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS
- pH — Rinse pH
- Cond — Rinse conductivity
- ABA — Acid Base Accounting
- Metals — Metal ICP
- LE — Extraction

ELEVATION - m / DEPTH - m	DESCRIPTION
-12.80 / 12.80	Fine to coarse gravel with fine to coarse sand and silt.
-13.41 / 13.41	Fine sand with minor medium to coarse sand, TRC gravel and silt. 0.010 Slot 2" PVC screen
-16.46 / 16.46	Same as above but increasing coarse sand.
-17.07 / 17.07	Clay with some medium to coarse sand.
-17.68 / 17.68	Fine to coarse sand with fine to coarse angular-sub-rounded gravel. Increasing phyllite downwards.

Column headings: DEPTH - ft; DEPTH - m; WELL DETAILS & WATER LEVEL - m; STRATIGRAPHY (ELEVATION - m / DEPTH - m, DESCRIPTION, SYMBOL); SAMPLES (TYPE AND NUMBER, CONDITION, RECOVERY %, N or RQD); LABORATORY and IN SITU TESTS; WATER CONTENT and LIMITS (%) (W P, W, W L; 20 40 60 80)

Depth scale (ft): 35, 40, 45, 50, 55, 60, 65
Depth scale (m): 11, 12, 13, 14, 15, 16, 17, 18, 19

\\sfile\GE_Projects\geotec.log\templates\loglog_SRK_pm_bh.sty PLOTTED: 2004-11-08 17:04hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Faro Mine Seepage Investigation
LOCATION:
FILE No: FARO (1CD003.053)
BORING DATE: 2004-09-06 **TO** 2004-09-09
DIP: 90.00 **AZIMUTH:**
COORDINATES: N E **DATUM:**

BOREHOLE: SRK04-05
PAGE: 3 **OF** 3
DRILL TYPE: ODEX 6"
DRILL: Air Rotary
CASING: 6"

GENERAL COMMENTS:

WELL PLUG MATERIAL LEGEND
- Bentonite
- Cuttings
- Grout
- Sand

LABORATORY AND IN SITU TESTS

pH	Rinse pH	LE	Extraction
Cond	Rinse conductivity		
ABA	Acid Base Accounting		
Metals	Metal ICP		

ELEVATION - m / DEPTH - m	DESCRIPTION
-20.73 / 20.73	Same as above but with more fresh phyllite.
-21.34 / 21.34	Weathered bedrock
	0.020 Slot 2" PVC screen
-24.08 / 24.08	END OF BOREHOLE

Column headings: DEPTH - ft; DEPTH - m; WELL DETAILS & WATER LEVEL - m; STRATIGRAPHY (ELEVATION - m / DEPTH - m, DESCRIPTION, SYMBOL); SAMPLES (TYPE AND NUMBER, CONDITION, RECOVERY %, N or RQD); LABORATORY and IN SITU TESTS; WATER CONTENT and LIMITS (%) (W_P W W_L; 20 40 60 80)

DEPTH - ft: 70, 75, 80, 85, 90, 95
DEPTH - m: 21, 22, 23, 24, 25, 26, 27, 28, 29

\\sfile\GE_Projects\geotec.log\templates\loglog_SRK_pm_bh.sty PLOTTED: 2004-11-08 17:04hrs

Test Pit Logs

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-1

All depths in meters

0-0.25	Muskeg/soil cover
0.25 – 3.4	Brown, slightly damp, fine to coarse sand and rounded to sub-angular heterogeneous gravel w/ cobbles and minor silt – occasional boulder TILL Water seeping in at ~3.4 meters
3.4 – 7.0	Brown, saturated medium to coarse sand w/ fine to coarse gravel and occasional cobbles and boulders TILL

Samples: SRK04TP1-3m; SRK04TP1-4m; SRK04TP1-5m; SRK04TP1-7m

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-2

All depths in meters

0-0.5	Muskeg/organic cover with interbedded fine sand
0.5 – 2.0	Fine to coarse sand w/ gravel and cobbles; becoming coarser with depth ALLUVIUM?
2.0 – 3.0	Fine to coarse sand and fine to coarse gravel; alluvial interbeds visible – grain size varies vertically with peat layers ALLUVIUM
3.0 – 4.4	Fine to coarse sand and increasing percentage of fine to coarse gravel. Increasing boulders TILL
4.4 – 4.7	Peat
4.7 – 7.5	Sand and gravel; water encountered at approximately 5.8 meters TILL

Samples: SRK04TP2-2m; SRK04TP2-3m

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-3

All depths in meters

0 - 2.2	Clayey to silty fine sand w/ fine rounded gravel and interbeds of peat and Sand and gravel with boulders = ALLUVIUM
2.2 – 7.0	Fine to coarse sand w/ sub-angular to sub-rounded fine to coarse gravel, cobbles and occasional boulder. Zones of silty to clayey material. TILL Water seeping in at 6 meters.

Samples: SRK04TP3-1.5m; SRK04TP3-4m; SRK04TP3-6m;

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-4

All depths in meters

0 – 0.8	Fine to coarse sand and fine to coarse gravel with interbedded peat. ALLUVIUM
0.8 – 1.5	Frozen alluvium same as above
	Permafrost at 0.8 meters.

Samples: NONE

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-5

All depths in meters

0 – 0.3	Muskeg
0.3 – 0.5	Silt and sand with organics
	Permafrost at 0.5 meters.

Samples: NONE

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-6

All depths in meters

0 – 0.3	Muskeg
0.3 – 1.9	Brown, damp fine to coarse sand w/ fine to coarse gravel – bedding visible ALLUVIUM
	Permafrost at 1.9 meters. Water seeping in along permafrost contact.

Samples: NONE

Faro Mine Seepage Assessment
SRK Consulting, Inc.

Test Pit Log
Location: North Fork Rose Creek

Number: SRK04TP-7

All depths in meters

0 – 0.5	Muskeg
0.5 – 7.0	Damp, brown to gray silty fine sand w/ some medium to coarse sand and angular to sub-rounded fine to coarse gravel and occasional cobble. TILL
	NO WATER

Samples: SRK04TP7-3m; SRK04TP7-7m

Appendix D1
Pumping Test Discharge and Seepage Rates

PUMPING RATE DATA

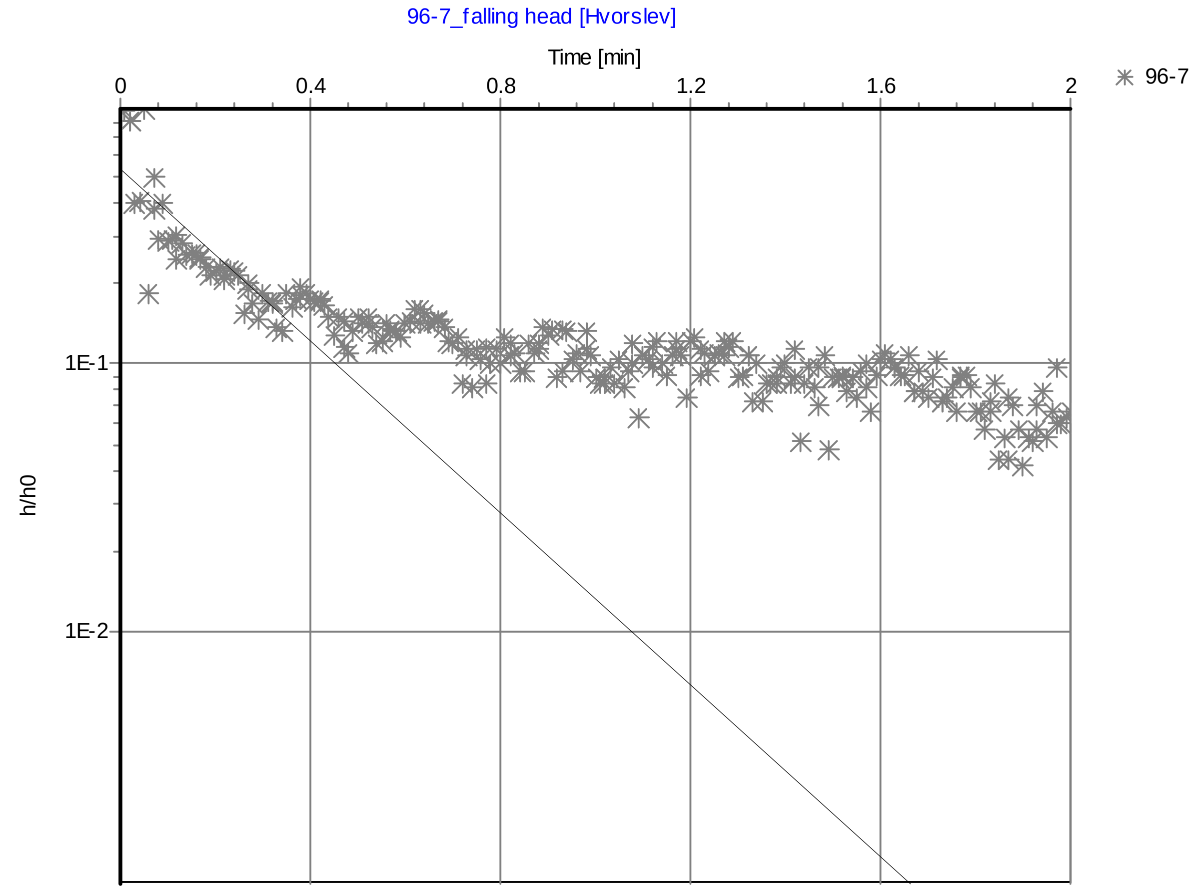
	Fill time = time to fill 5 Usgal bucket		5 gal =	18.93 l
			1 gal =	3.785 l
Test Time (min)	Fill Time (s)	Usgal/min	l/min	l/s
3.75	10	30.0	113.55	1.89
5	12	25.0	94.63	1.58
16	11	27.3	103.23	1.72
17	11	27.3	103.23	1.72
32	11	27.3	103.23	1.72
41	11	27.3	103.23	1.72
62	10	30.0	113.55	1.89
64	11	27.3	103.23	1.72
90	11	27.3	103.23	1.72
133	10	30.0	113.55	1.89
134	11	27.3	103.23	1.72
183	10	30.0	113.55	1.89
184	11	27.3	103.23	1.72
222	10	30.0	113.55	1.89
224	10.5	28.6	108.14	1.80
280	10	30.0	113.55	1.89
281	10.5	28.6	108.14	1.80
331	11	27.3	103.23	1.72
416	10.5	28.6	108.14	1.80
417	10.5	28.6	108.14	1.80
486	11	27.3	103.23	1.72
487	11	27.3	103.23	1.72
560	10.5	28.6	108.14	1.80
638	10.5	28.6	108.14	1.80
	AVERAGE	28.2	**106.7**	1.78

Seepage Face flow estimates during 12-hour pumping test

Time into test (min)	Run 1	Run 2	Bucket Size (L)		Flow Rate (L/s)		Run Average (L/s)
10	8		18.9		2.3625		2.4
11	7		18.9		2.7		2.7
36	7	7	18.9	18.9	2.7	2.7	2.7
83	5	5	14.1	14.1	2.82	2.82	2.82
136	5	5	14.1	14.1	2.82	2.82	2.82
188	5	5	14.1	14.1	2.82	2.82	2.82
226	5	5	14.1	14.1	2.82	2.82	2.82
286	5	5	14.1	14.1	2.82	2.82	2.82
335	5	5	14.1	14.1	2.82	2.82	2.82
420	5	5	14.1	14.1	2.82	2.82	2.82
490	5	5	14.1	14.1	2.82	2.82	2.82
365	5	5	14.1	14.1	2.82	2.82	2.82
645	5	5	14.1	14.1	2.82	2.82	2.82
				average	2.77	2.81	

Appendix D2
Hydraulic Test Analysis Sheets

SRK Consulting — Engineers and Scientists	**Slug Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Slug Test: **96-7_falling head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 1.08E+0 [m/d]

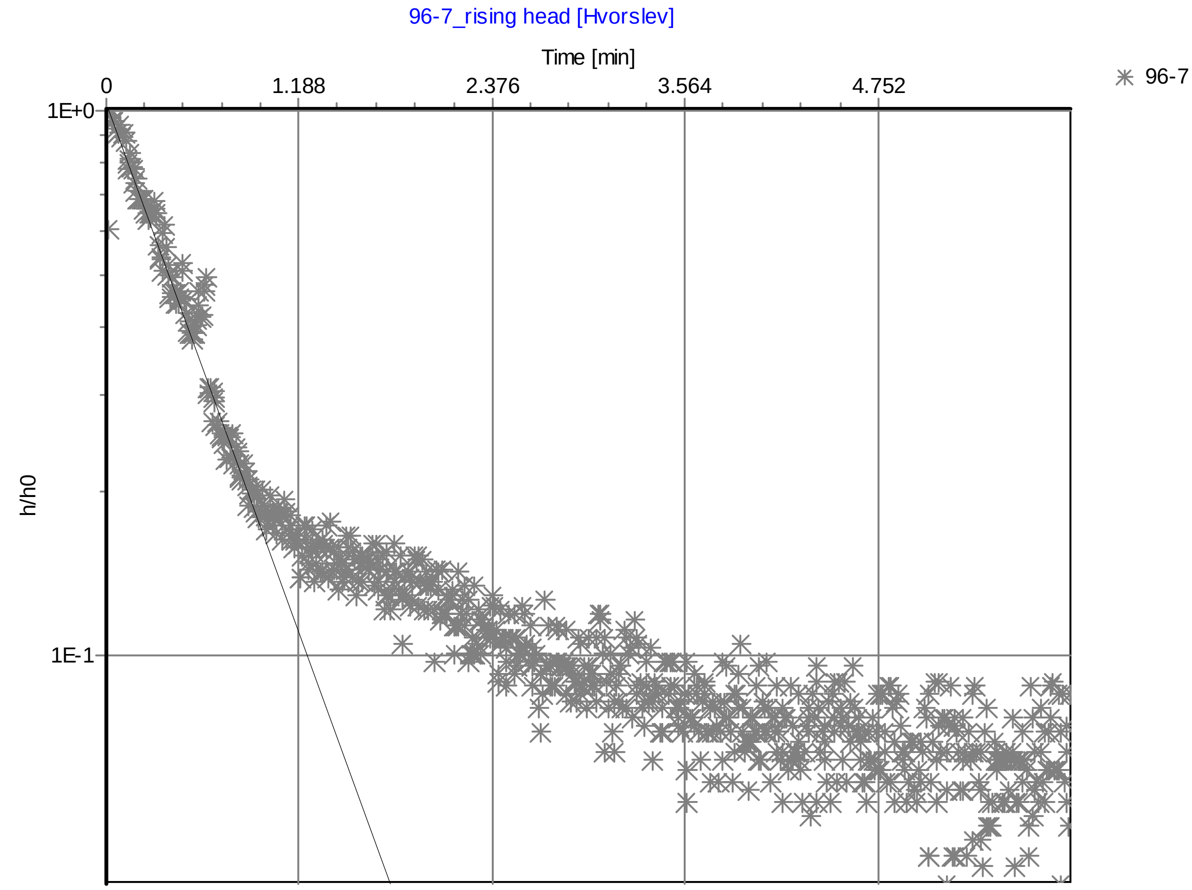
Test parameters:				
	Test Well:	96-7	Aquifer Thickness:	3.2 [m]
	Casing radius:	0.025 [m]		
	Screen length:	7 [m]		
	Boring radius:	0.076 [m]		

Comments: early time = 1.08 m/d
= 1.2e-5 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

SRK Consulting — Engineers and Scientists	**Slug Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Slug Test: **96-7_rising head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 5.51E-1 [m/d]

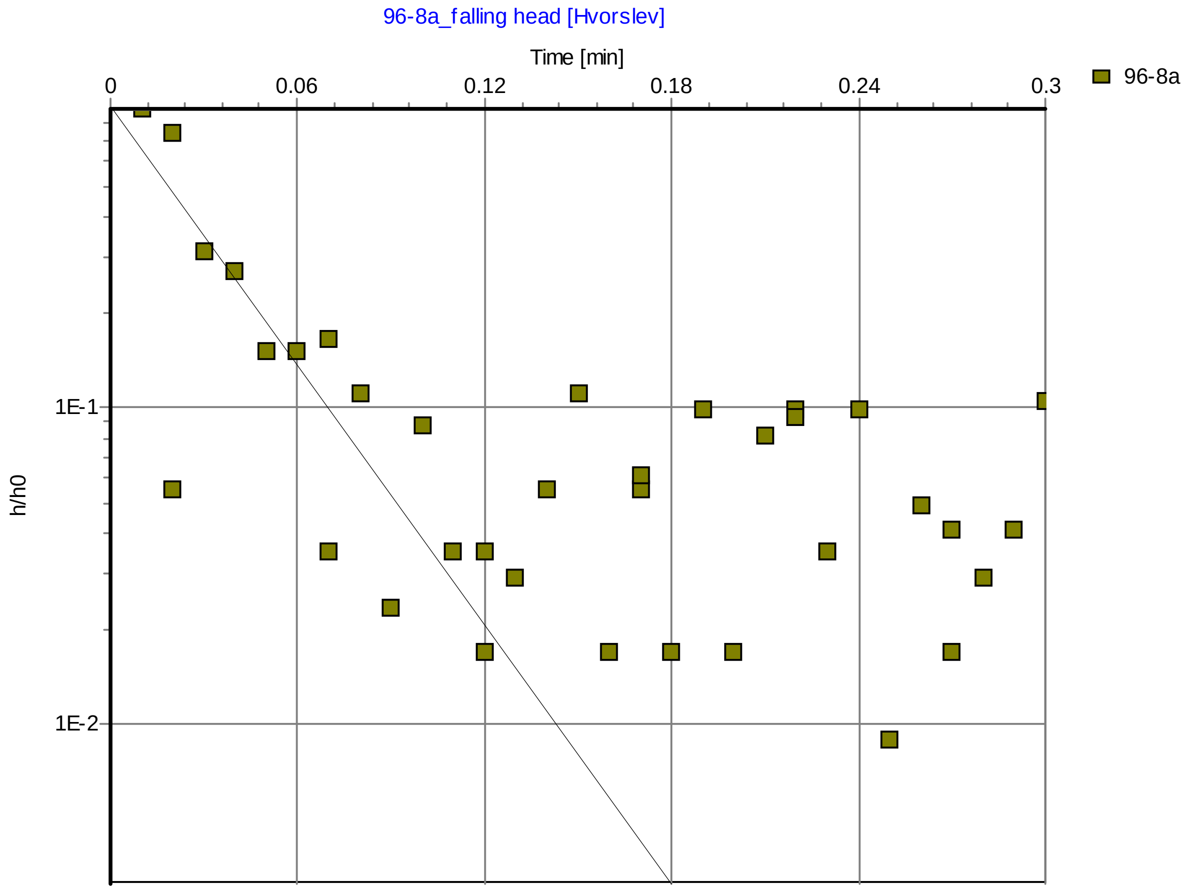
Test parameters:			
Test Well:	96-7	Aquifer Thickness:	3.2 [m]
Casing radius:	0.025 [m]		
Screen length:	7 [m]		
Boring radius:	0.076 [m]		

Comments: early time (good match) = 5.51e-1 m/d
= 6.37e-6 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

SRK Consulting — Engineers and Scientists	**Slug Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Slug Test: **96-8a_falling head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 1.75E+1 [m/d]

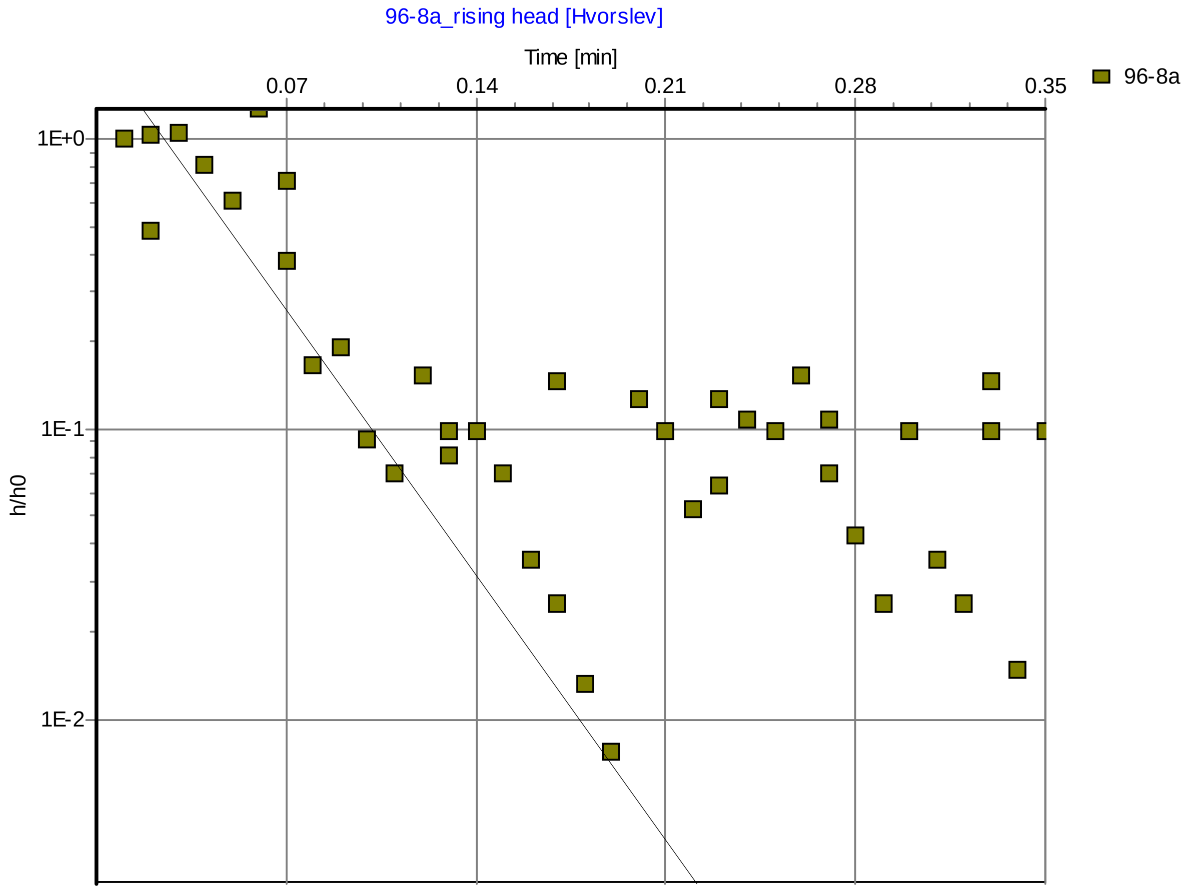
Test parameters:			
Test Well:	96-8a	Aquifer Thickness:	1.37 [m]
Casing radius:	0.025 [m]		
Screen length:	3 [m]		
Boring radius:	0.076 [m]		

Comments: poor data - only very early time can be used
1.75e+1 m/d - high K
= 2e-4 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

SRK Consulting Engineers and Scientists	**Slug Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Slug Test: **96-8a_rising head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 1.67E+1 [m/d]

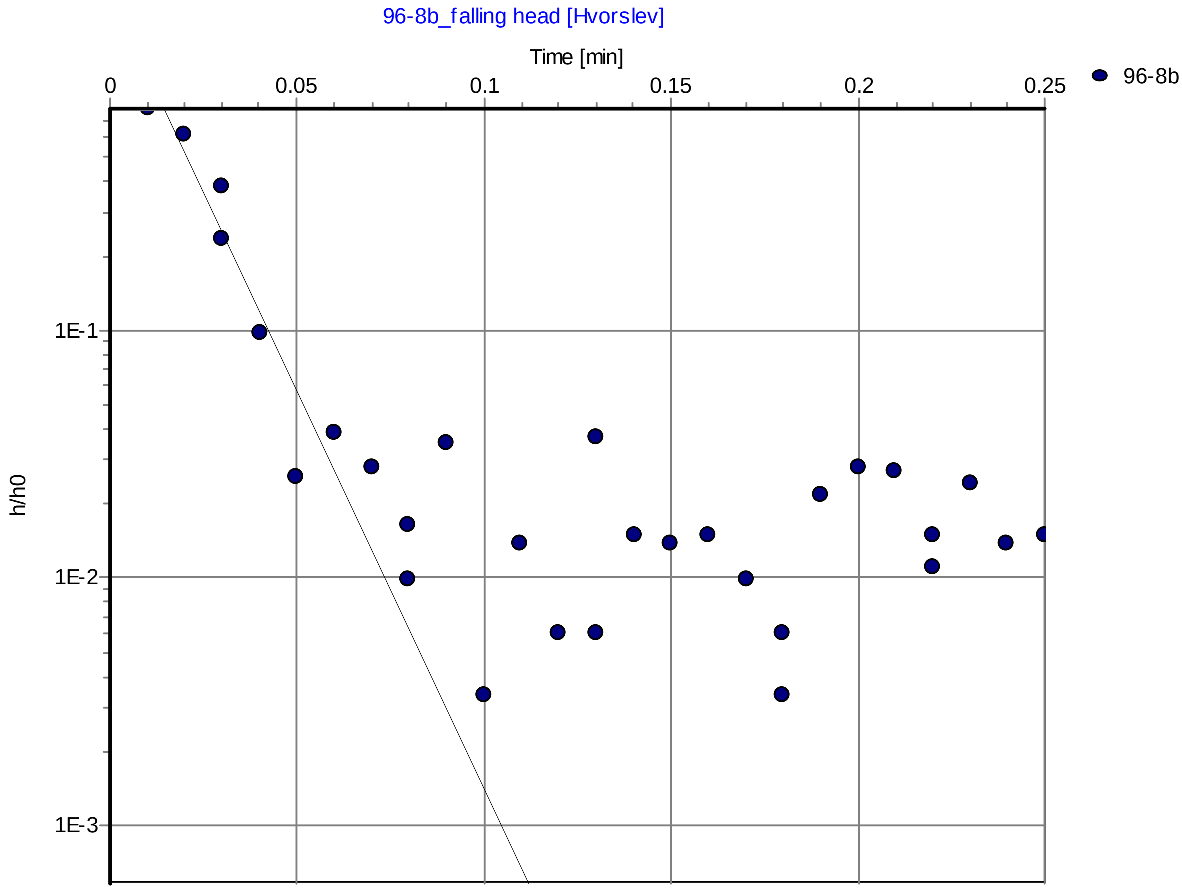
Test parameters:				
	Test Well:	96-8a	Aquifer Thickness:	1.37 [m]
	Casing radius:	0.025 [m]		
	Screen length:	3 [m]		
	Boring radius:	0.076 [m]		

Comments: only early time data can be used - relatively high K
= 1.67e+1 m/d
= 1.9e-4 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

SRK Consulting — Engineers and Scientists	**Slug Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Slug Test: **96-8b_falling head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 4.43E+1 [m/d]

Test parameters:				
	Test Well:	96-8b	Aquifer Thickness:	5.47 [m]
	Casing radius:	0.025 [m]		
	Screen length:	2.7 [m]		
	Boring radius:	0.076 [m]		

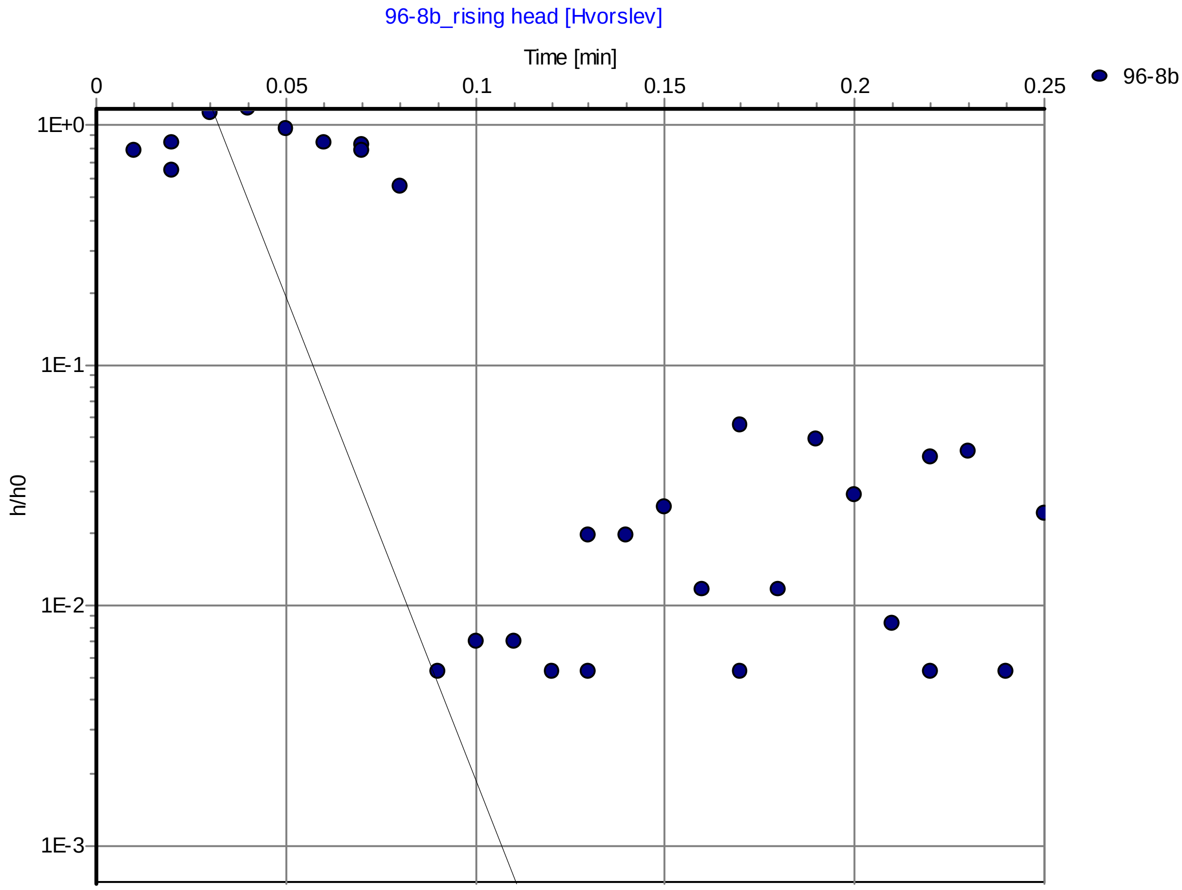
Comments: only very early data can be used - rel. high K
= 4.43e+1 m/d
= 5.1e-4 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

Slug Test Analysis Report	
Project:	Faro_2004
Number:	
Client:	

SRK Consulting
Engineers and Scientists



Slug Test: **96-8b_rising head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 5.56E+1 [m/d]

Test parameters:				
Test Well:	96-8b		Aquifer Thickness:	5.47 [m]
Casing radius:	0.025 [m]			
Screen length:	2.7 [m]			
Boring radius:	0.076 [m]			

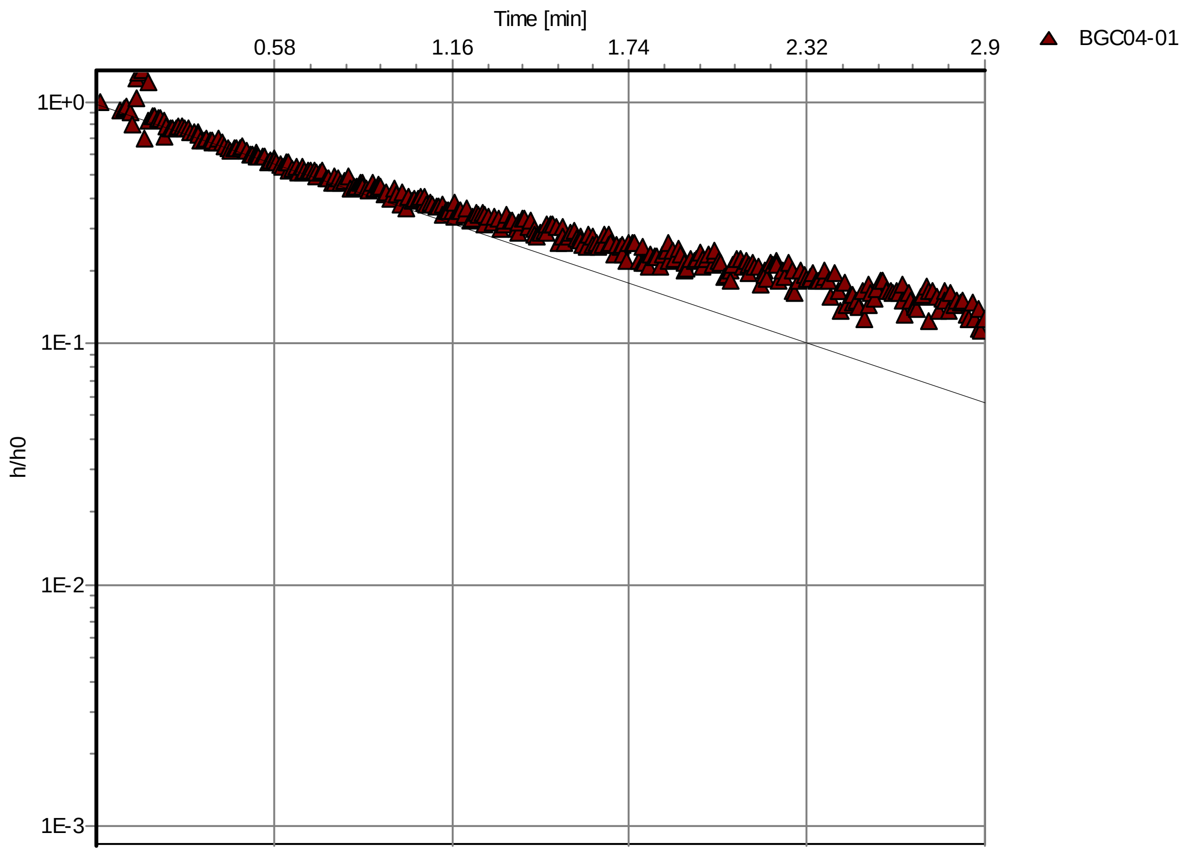
Comments:
very poor data set - values not reliable
5.56e+1 m/d
= 6.4e-4 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

SRK Consulting Engineers and Scientists	Slug Test Analysis Report
	Project: Faro_2004
	Number:
	Client:

BGC04-01_falling head [Hvorslev]



Slug Test: **BGC04-01_falling head**

Analysis Method: **Hvorslev**

Analysis Results:			Conductivity:	6.64E-6 [m/s]

Test parameters:	Test Well:	BGC04-01	Aquifer Thickness:	8.84 [m]
	Casing radius:	0.025 [m]		
	Screen length:	2.8 [m]		
	Boring radius:	0.076 [m]		

Comments: Early match K=6.64e-6 m/s
=5.7e-1 m/d

Evaluated by: dmackie

Evaluation Date: 10/18/2004

Slug Test Analysis Report	
Project:	Faro_2004
Number:	
Client:	

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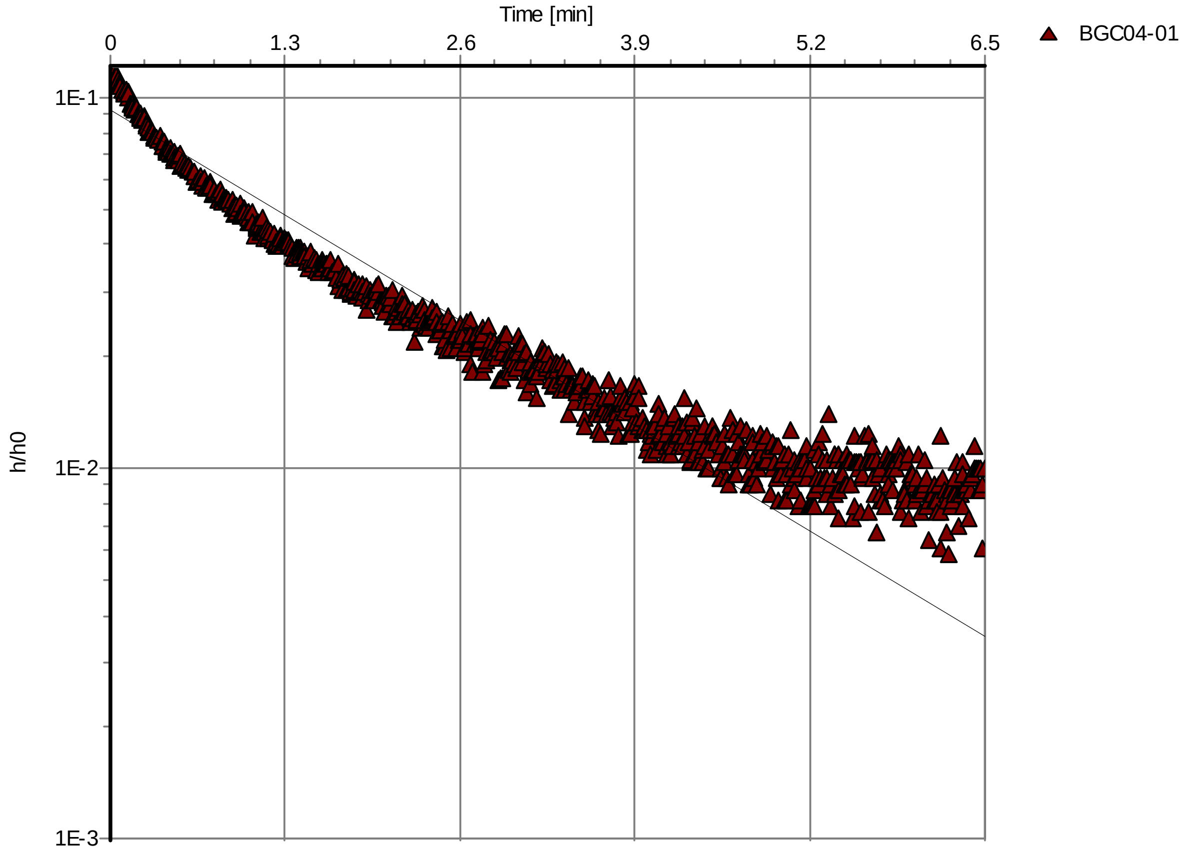
BGC04-01_rising head [Hvorslev]



Slug Test: **BGC04-01_rising head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 3.40E-6 [m/s]

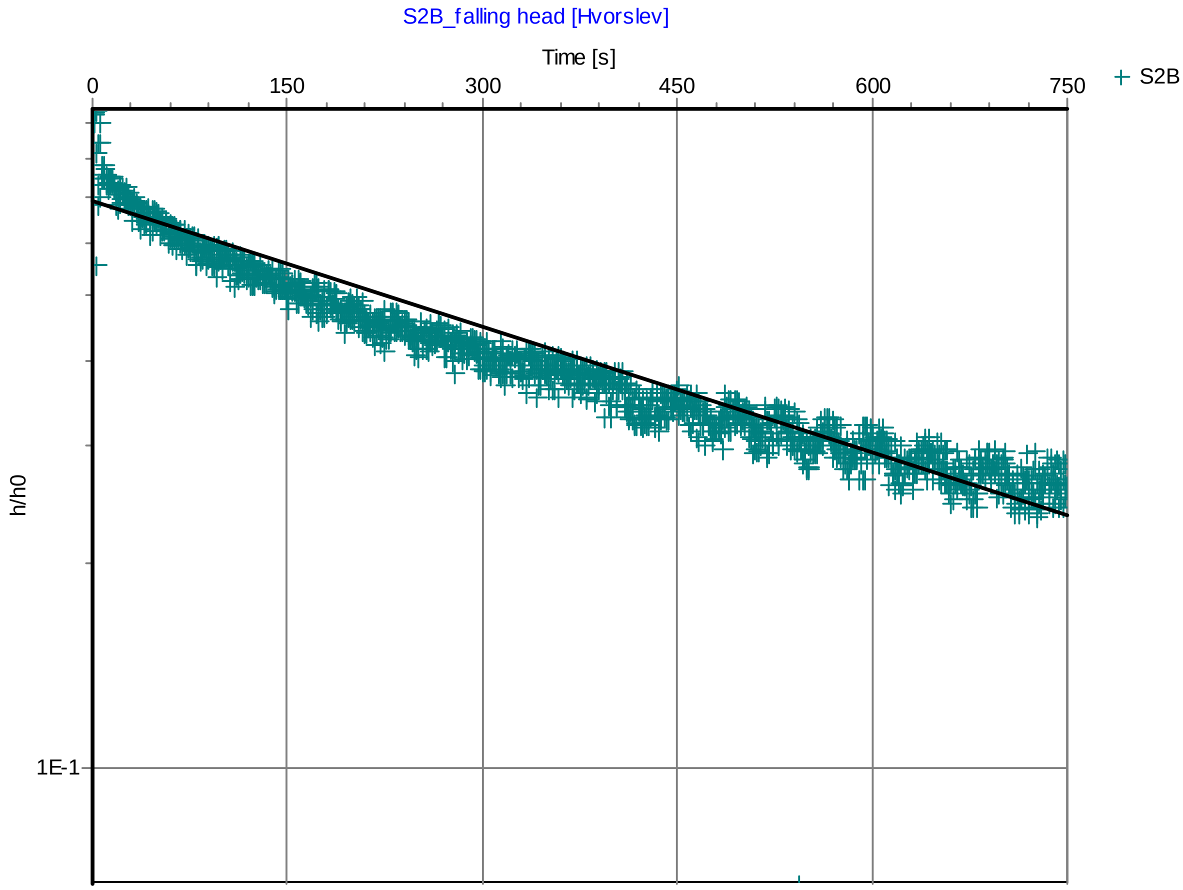
Test parameters:				
Test Well:	BGC04-01	Aquifer Thickness:	8.84 [m]
Casing radius:	0.025 [m]		
Screen length:	2.8 [m]		
Boring radius:	0.076 [m]		

Comments: early data = 3.4e-6 m/s

Evaluated by: dmackie

Evaluation Date: 10/18/2004

SRK Consulting Engineers and Scientists	**Slug Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Slug Test: **S2B_falling head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 4.55E-7 [m/s]

Test parameters:				
	Test Well:	S2B	Aquifer Thickness:	8.96 [m]
	Casing radius:	0.025 [m]		
	Screen length:	3.9 [m]		
	Boring radius:	0.076 [m]		

Comments: 3.12e-2 m/d - OK fit - data is oscillatory

Evaluated by: dmackie

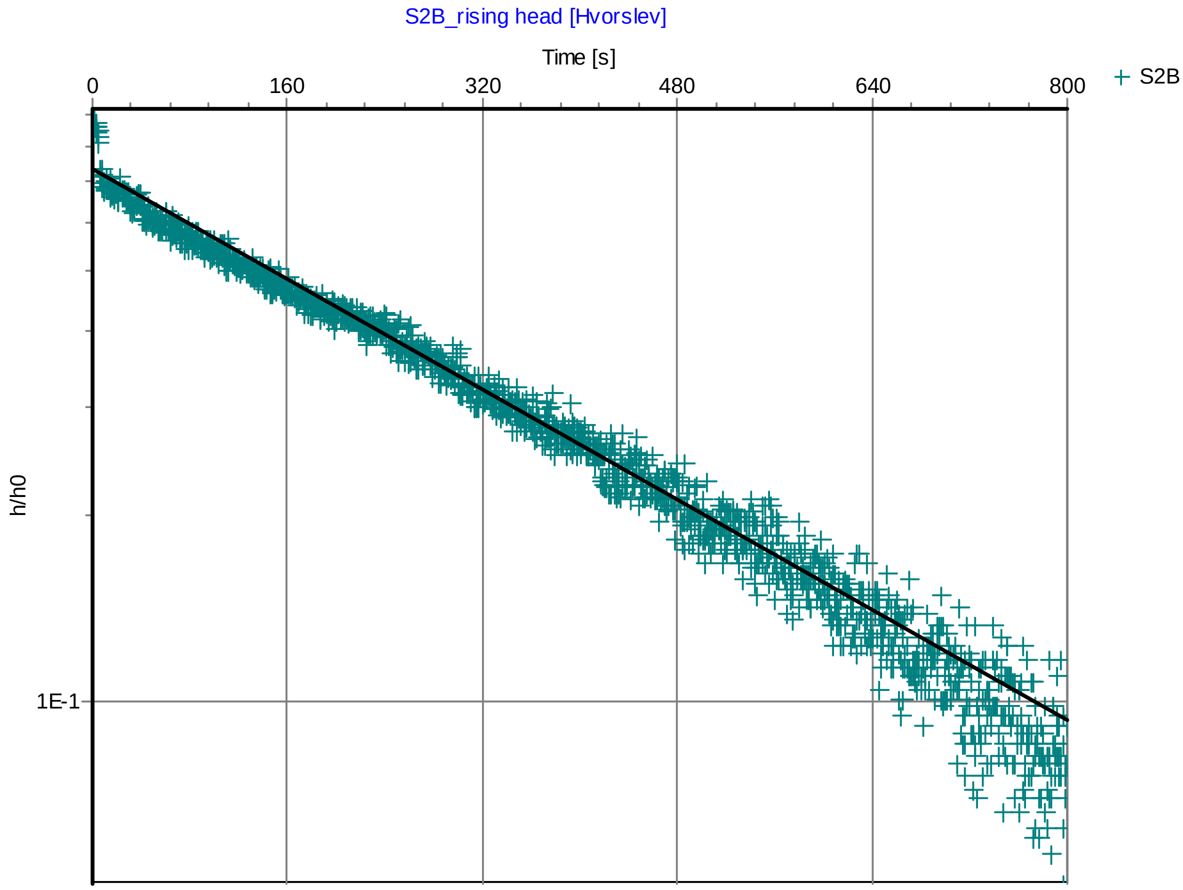
Evaluation Date: 10/7/2004

Slug Test Analysis Report

Project: Faro_2004

Number:

Client:



Slug Test: **S2B_rising head**

Analysis Method: **Hvorslev**

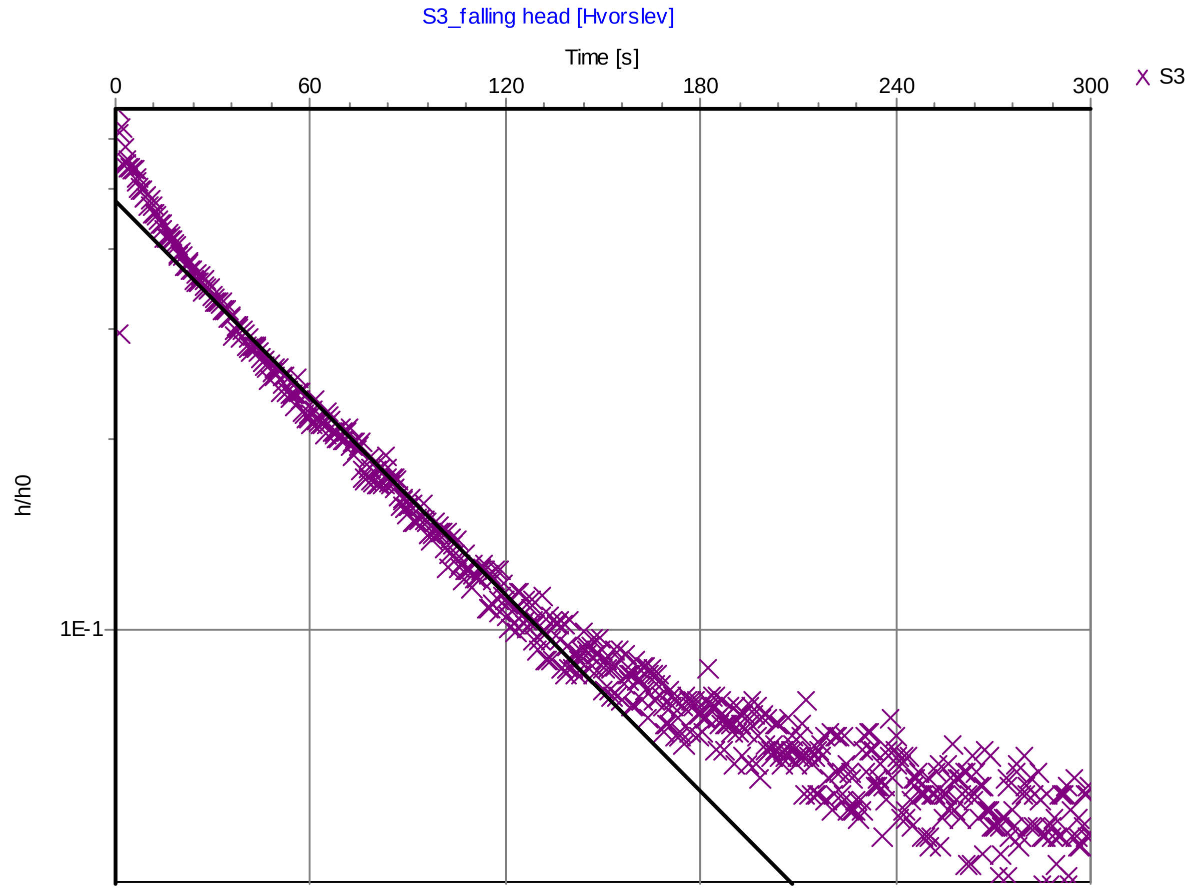
Analysis Results:		Conductivity:	8.21E-7 [m/s]
Test parameters:	Test Well: S2B	Aquifer Thickness:	8.96 [m]
	Casing radius: 0.025 [m]		
	Screen length: 3.9 [m]		
	Boring radius: 0.076 [m]		

Comments: 7.09e-2 m/d - OK fit - relatively straight data compared to S3

Evaluated by: dmackie

Evaluation Date: 10/7/2004

Slug Test Analysis Report
Project: Faro_2004
Number:
Client:



Slug Test: **S3_falling head**

Analysis Method: **Hvorslev**

Analysis Results:		Conductivity:	4.25E-6 [m/s]

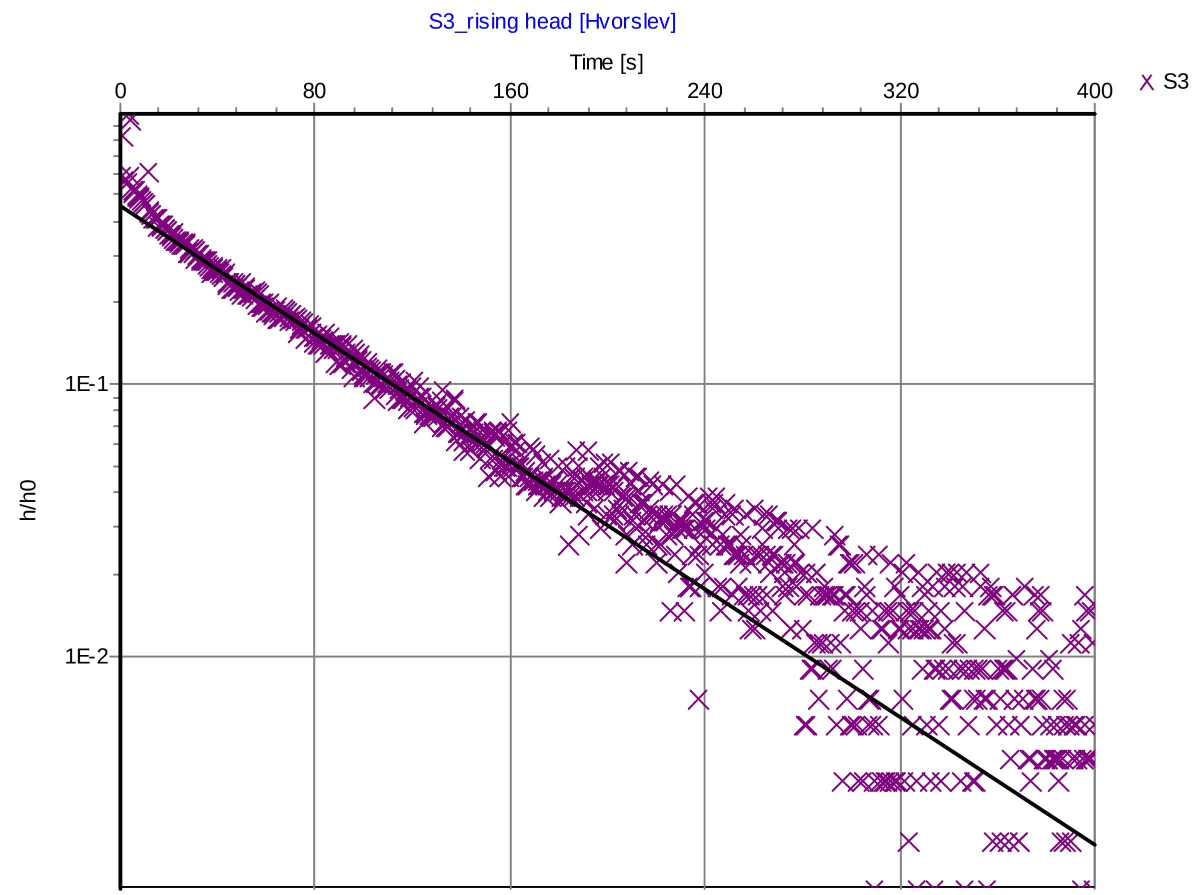
Test parameters:	Test Well:	S3	Aquifer Thickness:	4.765 [m]
	Casing radius:	0.025 [m]		
	Screen length:	3.34 [m]		
	Boring radius:	0.076 [m]		

Comments: 3.67e-1 m/d early - OK fit

Evaluated by: dmackie

Evaluation Date: 10/7/2004

Slug Test Analysis Report	
Project:	Faro_2004
Number:	
Client:	



Slug Test: **S3_rising head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 4.81E-6 [m/s]

Test parameters:			
Test Well:	S3	Aquifer Thickness:	4.765 [m]
Casing radius:	0.025 [m]		
Screen length:	3.34 [m]		
Boring radius:	0.076 [m]		

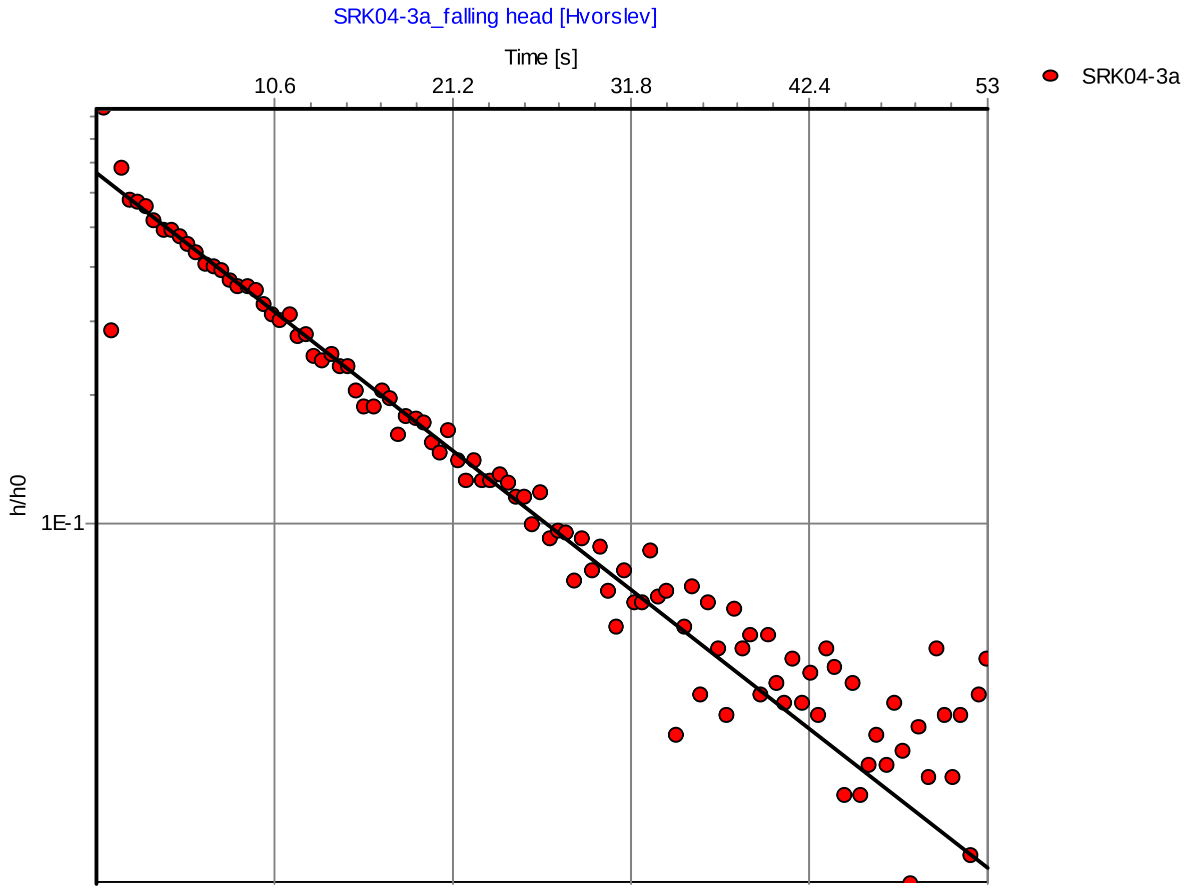
Comments: 4.16e-1 m/d early time - OK fit

Evaluated by: dmackie

Evaluation Date: 10/7/2004

Slug Test Analysis Report

Project:	Faro_2004
Number:	
Client:	



Slug Test: **SRK04-3a_falling head**

Analysis Method: **Hvorslev**

Analysis Results:

Conductivity: 2.91E-5 [m/s]

Test parameters:

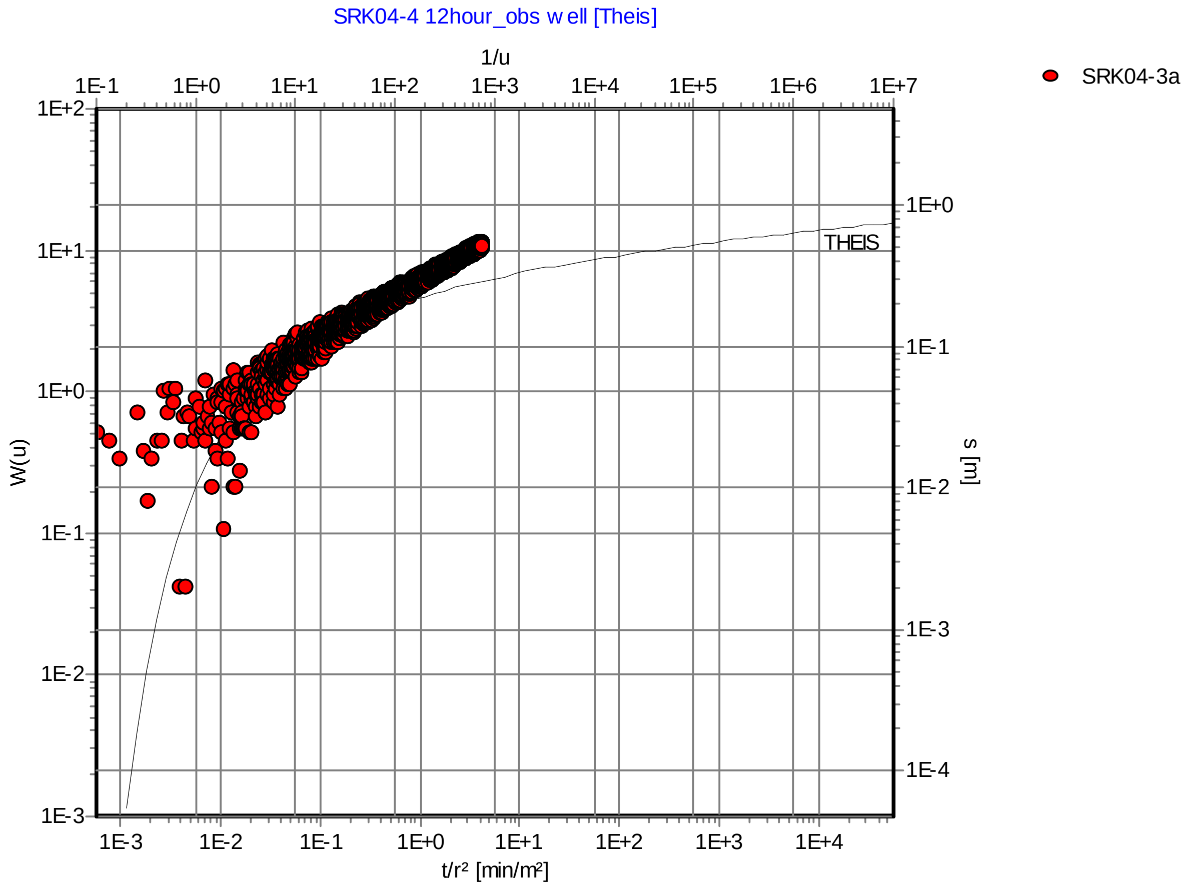
Test Well:	SRK04-3a	Aquifer Thickness:	6.13 [m]
Casing radius:	0.025 [m]		
Screen length:	2.75 [m]		
Boring radius:	0.076 [m]		

Comments: 2.51e+0 m/d for early time

Evaluated by: dmackie

Evaluation Date: 10/7/2004

SRK Consulting Engineers and Scientists	**Pumping Test Analysis Report**
	Project: Faro_2004
	Number:
	Client:



Pumping Test: **SRK04-4 12hour_obs well_3a**

Analysis Method: **Theis**

Analysis Results:	Transmissivity:	2.96E-3 [m²/s]	Conductivity:	4.77E-4 [m/s]
	Storativity:	3.99E-3		

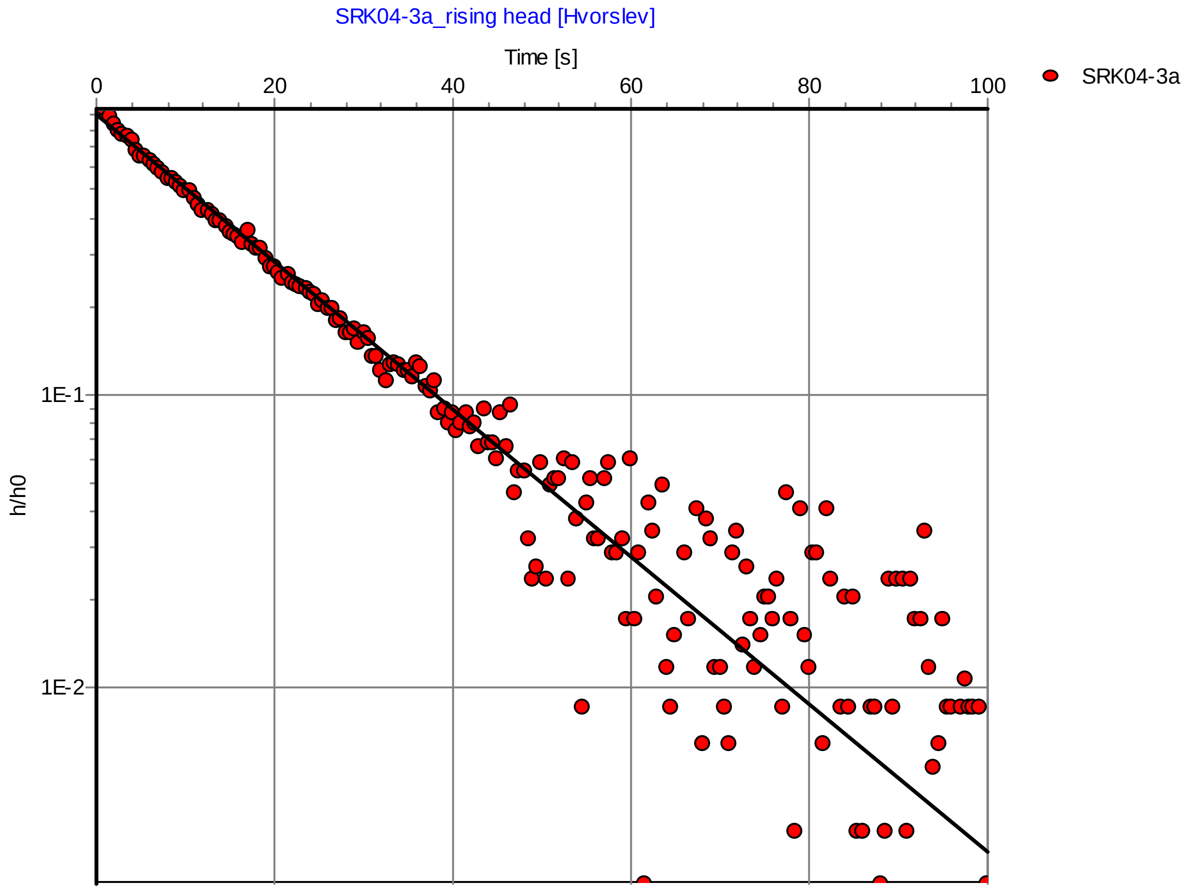
Test parameters:	Pumping Well:	SRK04-4	Aquifer Thickness:	6.202 [m]
	Casing radius:	0.051 [m]	Confined Aquifer	
	Screen length:	6.42 [m]		
	Boring radius:	0.051 [m]		
	Discharge Rate:	28.2 [U.S. gal/min]		

Comments: Poor data match - data is not acting as true Theis should

Evaluated by: dmackie

Evaluation Date: 10/12/2004

SRK Consulting Engineers and Scientists	**Slug Test Analysis Report** Project: Faro_2004 Number: Client:



Slug Test: **SRK04-3a_rising head**

Analysis Method: **Hvorslev**

Analysis Results: Conductivity: 2.38E-5 [m/s]

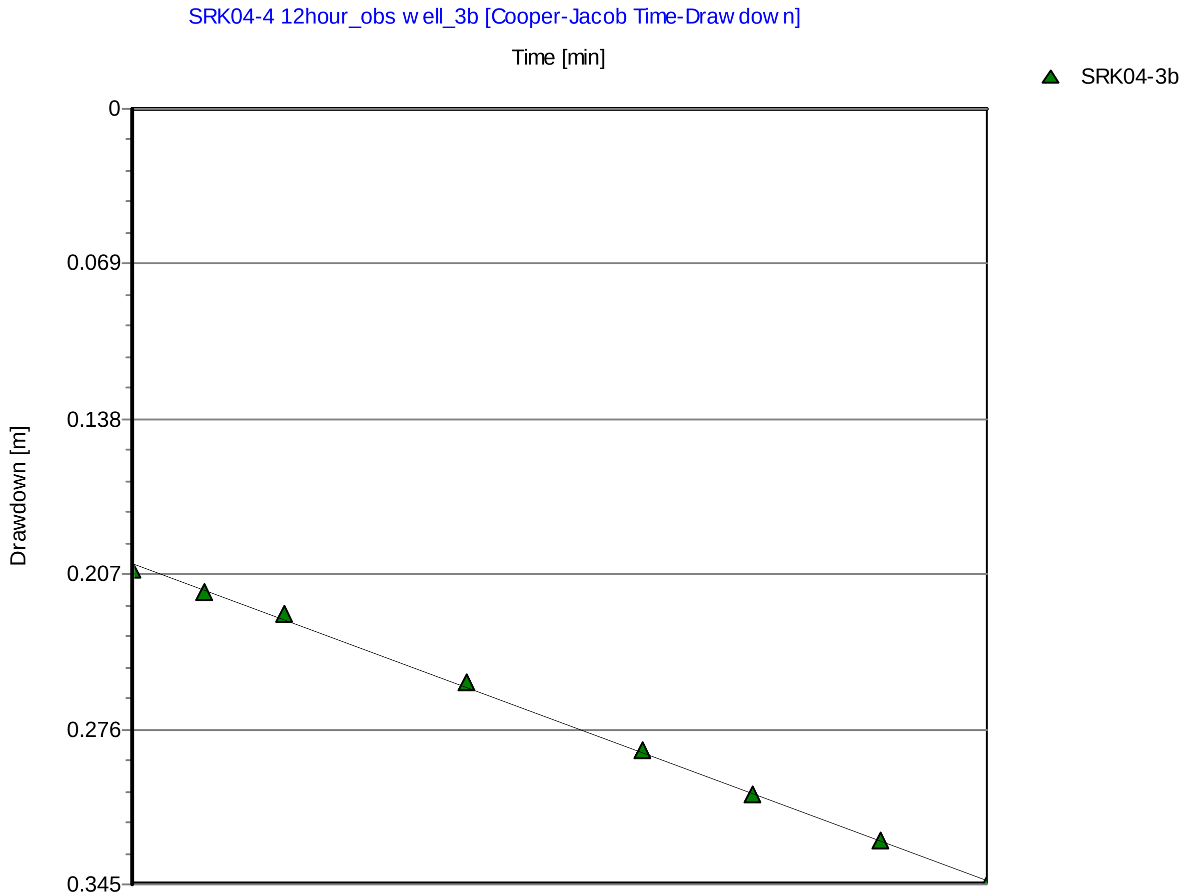
Test parameters:				
	Test Well:	SRK04-3a	Aquifer Thickness:	6.13 [m]
	Casing radius:	0.025 [m]		
	Screen length:	2.75 [m]		
	Boring radius:	0.076 [m]		

Comments: 2.05e+0 m/d early time

Evaluated by: dmackie

Evaluation Date: 10/7/2004

SRK Consulting Engineers and Scientists	**Pumping Test Analysis Report** Project: Faro_2004 Number: Client:



Pumping Test: **SRK04-4 12hour_obs well_3b**

Analysis Method: **Cooper-Jacob Time-Drawdown**

Analysis Results:	Transmissivity:	8.88E-4 [m²/s]	Conductivity:	1.43E-4 [m/s]
	Storativity:	5.84E-2		

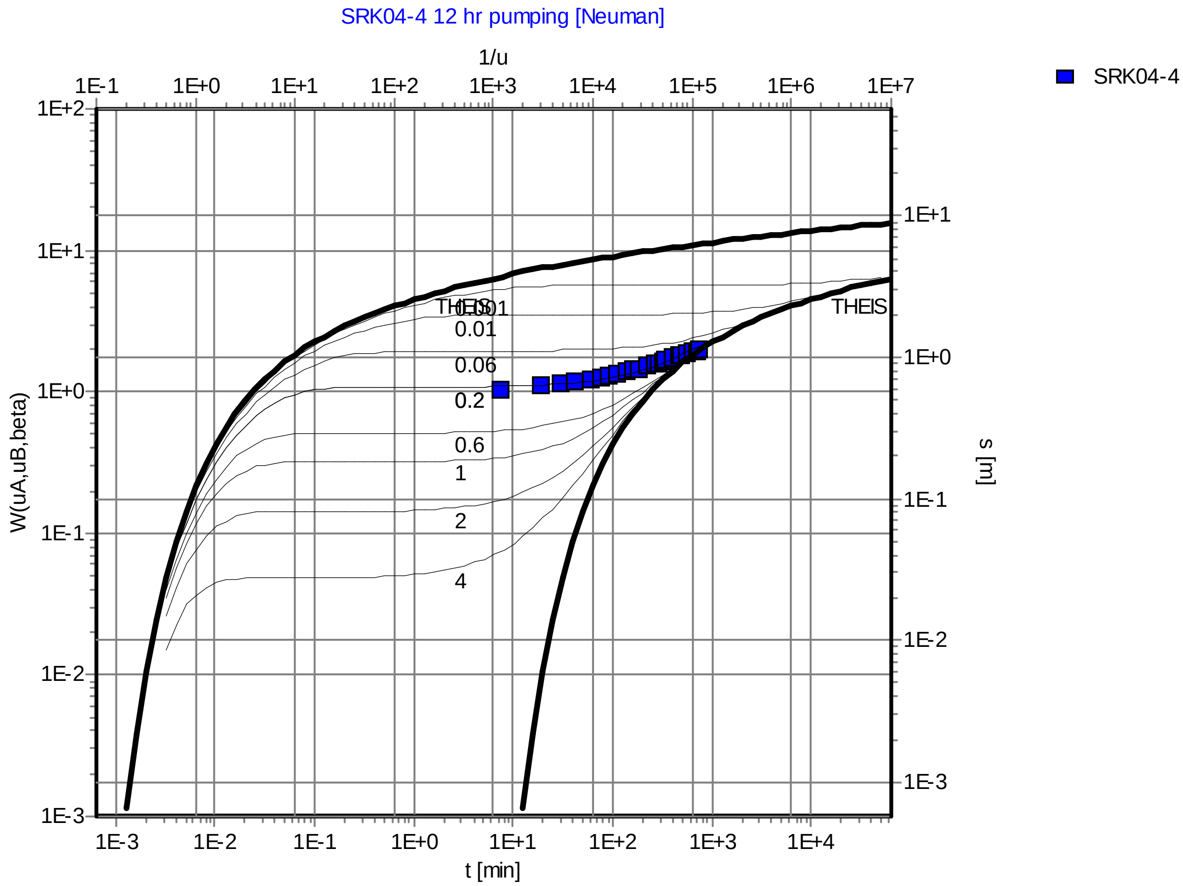
Test parameters:	Pumping Well:	SRK04-4	Aquifer Thickness:	6.202 [m]
	Casing radius:	0.051 [m]	Confined Aquifer	
	Screen length:	6.42 [m]		
	Boring radius:	0.051 [m]		
	Discharge Rate:	28.2 [U.S. gal/min]		

Comments:

Evaluated by:

Evaluation Date: 10/21/2004

Pumping Test Analysis Report	
Project:	Faro_2004
Number:	
Client:	



Pumping Test: **SRK04-4 12 hr pumping**

Analysis Method: **Neuman**

Analysis Results:	Transmissivity:	1.49E-2 [m²/s]	Conductivity:	3.10E-3 [m/s]

Test parameters:	Pumping Well:	SRK04-4	Aquifer Thickness:	4.8 [m]
	Casing radius:	0.051 [m]	Beta:	0.2
	Screen length:	6.42 [m]		
	Boring radius:	0.051 [m]		
	Discharge Rate:	106.7 [l/s]		
	LOG(Sy/S):	4		

Comments:

Evaluated by:

Evaluation Date: 10/19/2004

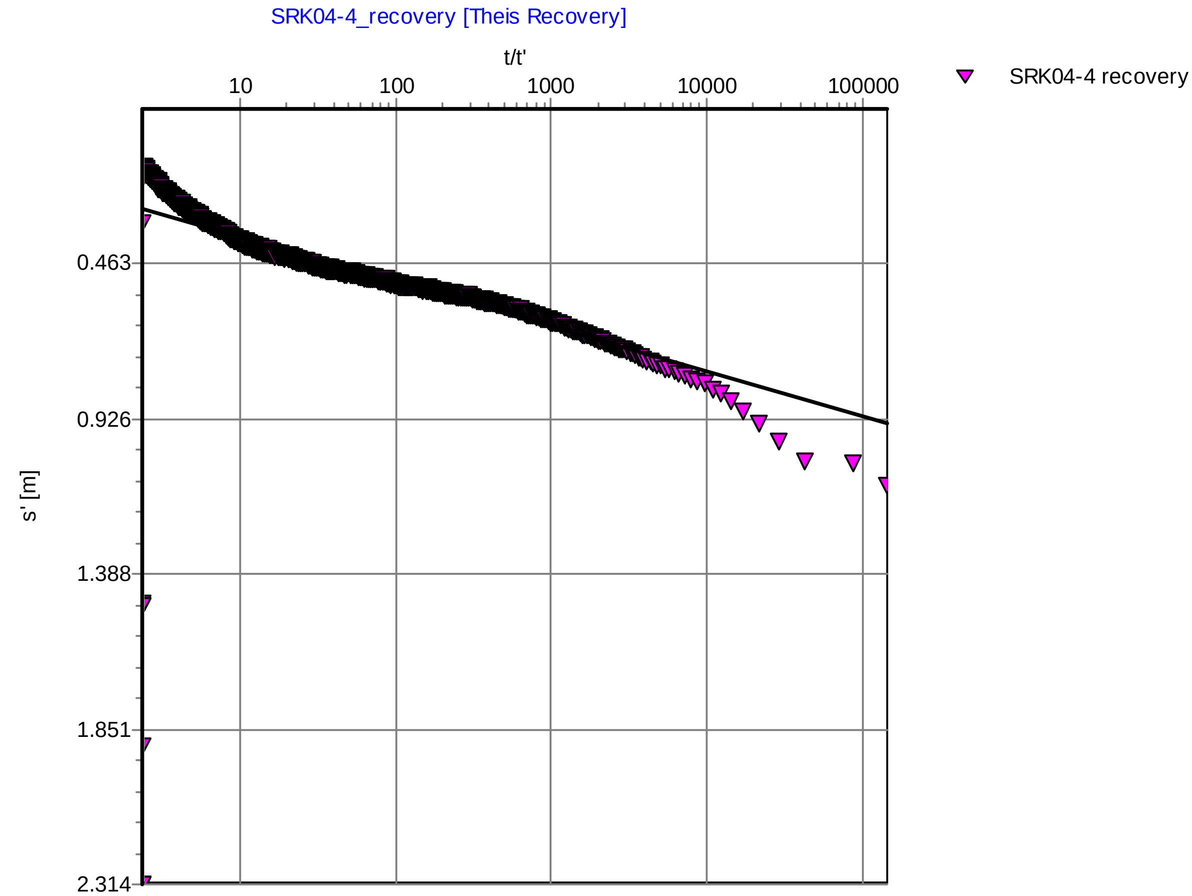
SRK Consulting
Engineers and Scientists

Pumping Test Analysis Report

Project: Faro_2004

Number:

Client:



Pumping Test:	**SRK04-4_recovery**
Analysis Method:	**Theis Recovery**

Analysis Results:	Transmissivity:	2.43E-3 [m²/s]	Conductivity:	5.07E-4 [m/s]
Test parameters:	Pumping Well:	SRK04-4 recovery	Aquifer Thickness:	4.8 [m]
	Casing radius:	0.051 [m]	Confined Aquifer	
	Screen length:	6.42 [m]		
	Boring radius:	0.051 [m]		
	Discharge Rate:	28.2 [U.S. gal/min]		
	Pumping Time	722 [min]		

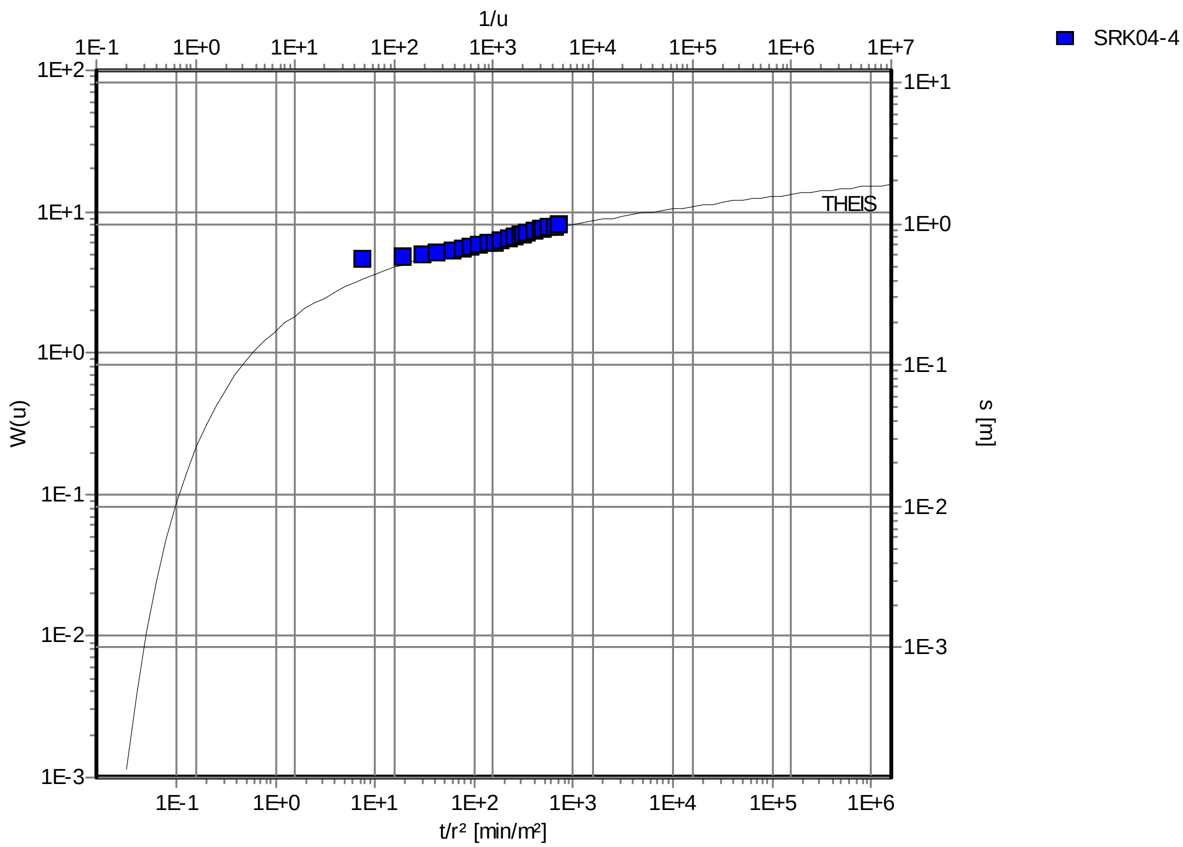
Comments: T = 2.1e+2 m2/d for match including all data except ends

Evaluated by: dmackie

Evaluation Date: 10/8/2004

Pumping Test Analysis Report
Project: Faro_2004
Number:
Client:

SRK04-4 12 hr pumping [Theis]



Pumping Test: **SRK04-4 12 hr pumping**

Analysis Method: **Theis**

Analysis Results:	Transmissivity:	6.99E-2 [m²/s]	Conductivity:	1.46E-2 [m/s]

Test parameters:	Pumping Well:	SRK04-4	Aquifer Thickness:	4.8 [m]
	Casing radius:	0.051 [m]	Unconfined Aquifer	
	Screen length:	6.42 [m]		
	Boring radius:	0.051 [m]		
	Discharge Rate:	106.7 [l/s]		

Comments:

Evaluated by:

Evaluation Date: 10/19/2004

Appendix E
Test Pit Grain Size Analyses

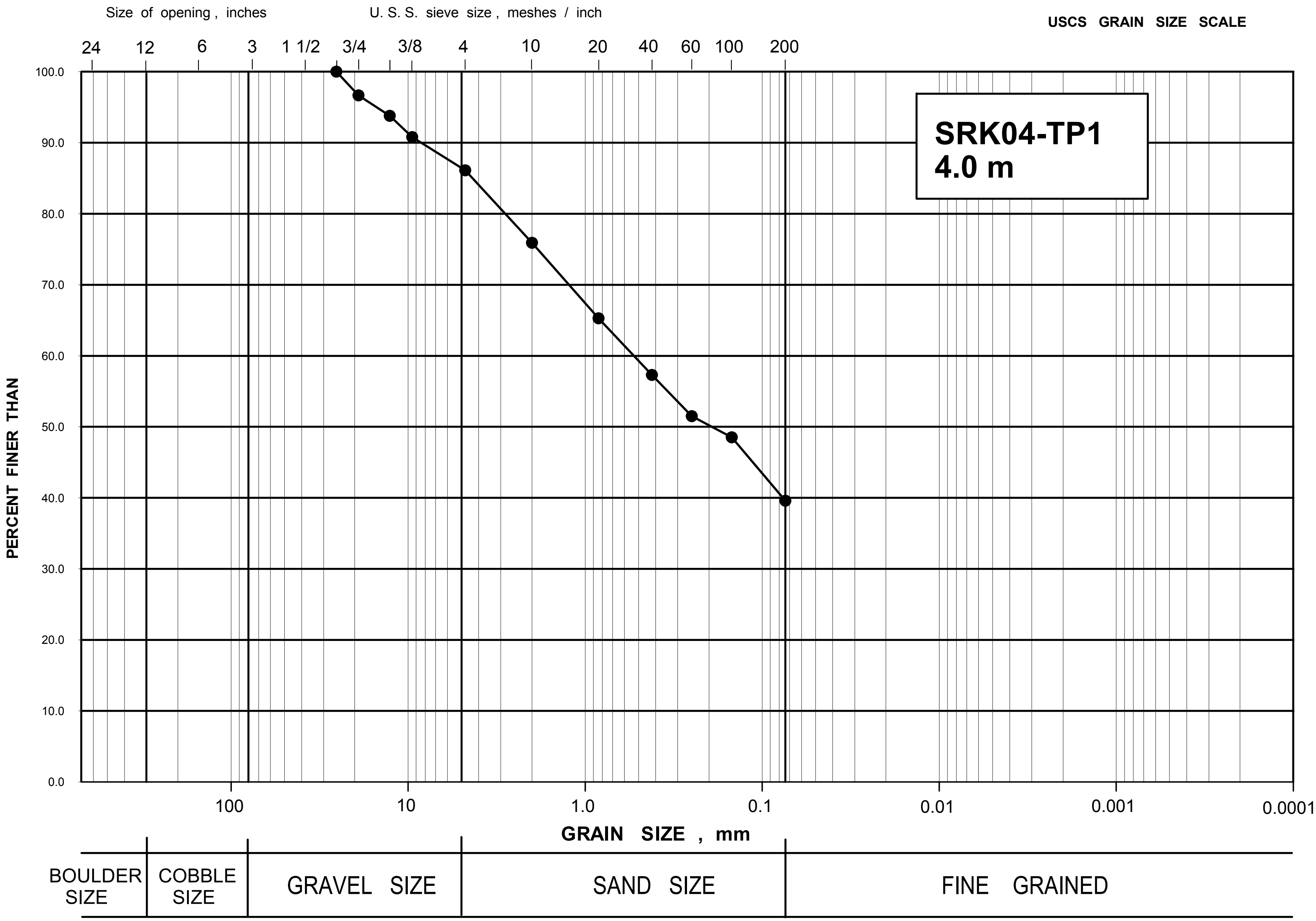
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP1
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	4.0m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	115.7
Total weight	432.0	Wash Sieve (Y/N)	Y	Weight after wash	63.3
Total Wt -#4	372.0	Total Wt of -#4 sieved	115.7	Pan Weight	0.8

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	14.4	3.3			3.3	19.1	96.7
1/2"	12.4	2.9			2.9	12.7	93.8
3/8"	13.0	3.0			3.0	9.50	90.8
#4	20.2	4.7			4.7	4.76	86.1
#10			13.7	11.8	10.2	2.00	75.9
#20			14.3	12.4	10.6	0.84	65.3
#40			10.7	9.2	8.0	0.42	57.3
#60			7.8	6.7	5.8	0.25	51.5
#100			4.0	3.5	3.0	0.149	48.5
#200			12.0	10.4	8.9	0.074	39.6
-200			53.2	46.0	39.6		

REMARKS :



Project No. 04-1416-040
Drawn TM
Reviewed LL
Date 10/27/04

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure

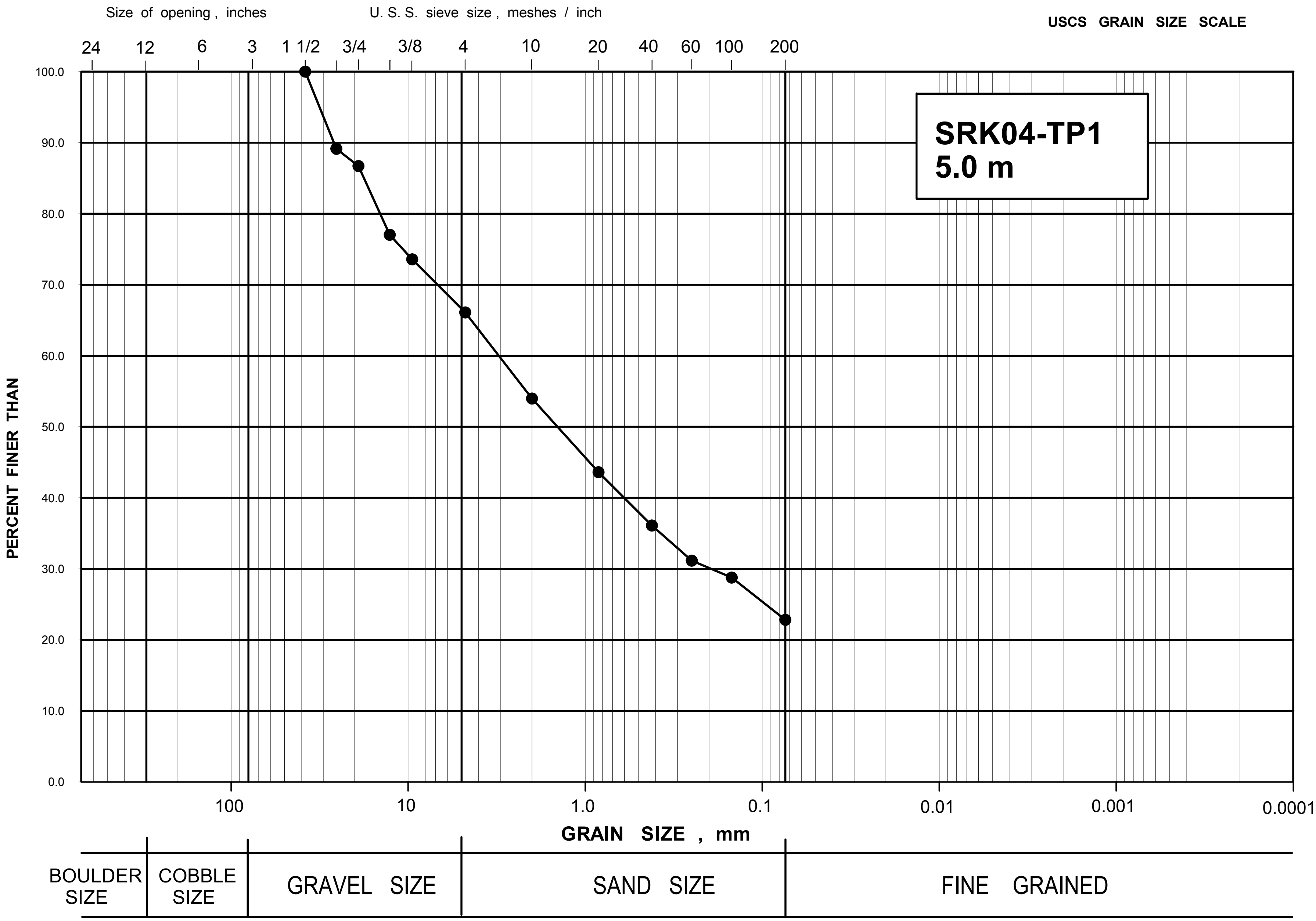
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP1
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	5.0m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	97.6
Total weight	433.9	Wash Sieve (Y/N)	Y	Weight after wash	64.2
Total Wt -#4	286.8	Total Wt of -#4 sieved	97.6	Pan Weight	0.3

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	47.1	10.9			10.9	25.4	89.1
3/4"	10.6	2.4			2.4	19.1	86.7
1/2"	41.9	9.7			9.7	12.7	77.0
3/8"	15.0	3.5			3.5	9.50	73.6
#4	32.5	7.5			7.5	4.76	66.1
#10			17.9	18.3	12.1	2.00	54.0
#20			15.3	15.7	10.4	0.84	43.6
#40			11.1	11.4	7.5	0.42	36.1
#60			7.3	7.5	4.9	0.25	31.2
#100			3.5	3.6	2.4	0.149	28.8
#200			8.8	9.0	6.0	0.074	22.8
-200			33.7	34.5	22.8		

REMARKS :



Project No. 04-1416-040 Drawn TM Reviewed LL Date 10/27/04	Golder Associates	**GRAIN SIZE DISTRIBUTION**	Figure

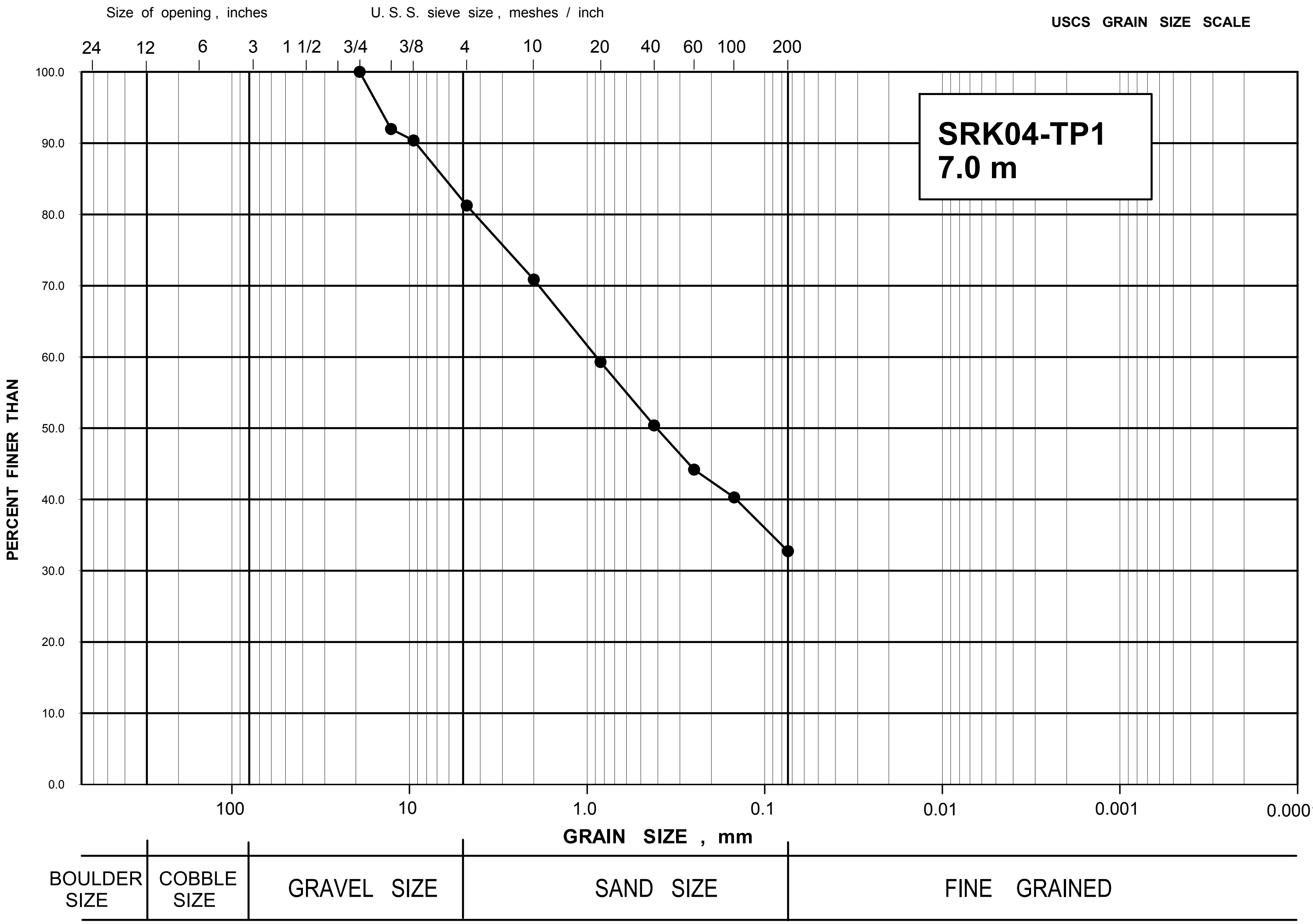
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP1
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	7.0m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	82.9
Total weight	242.2	Wash Sieve (Y/N)	Y	Weight after wash	50.2
Total Wt -#4	196.8	Total Wt of -#4 sieved	82.9	Pan Weight	0.7

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	19.4	8.0			8.0	12.7	92.0
3/8"	3.9	1.6			1.6	9.50	90.4
#4	22.1	9.1			9.1	4.76	81.3
#10			10.6	12.8	10.4	2.00	70.9
#20			11.8	14.2	11.6	0.84	59.3
#40			9.1	11.0	8.9	0.42	50.4
#60			6.3	7.6	6.2	0.25	44.2
#100			4.0	4.8	3.9	0.149	40.3
#200			7.7	9.3	7.5	0.074	32.7
-200			33.4	40.3	32.7		

REMARKS :



Project No. 04-1416-040
Drawn TM
Reviewed LL
Date 10/27/04

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure

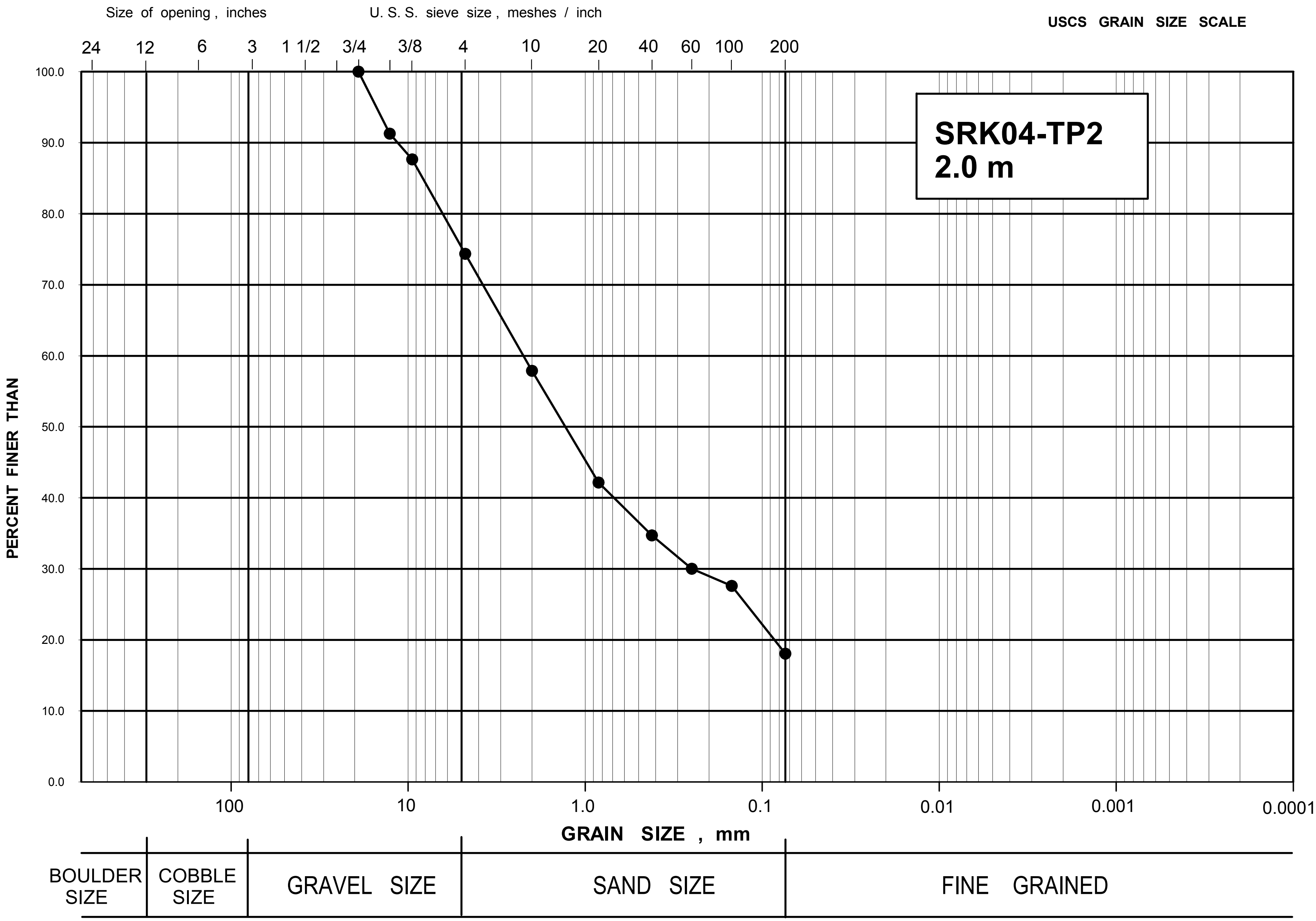
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP2
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	2.0m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	88.9
Total weight	232.5	Wash Sieve (Y/N)	Y	Weight after wash	68.7
Total Wt -#4	172.9	Total Wt of -#4 sieved	88.9	Pan Weight	1.4

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	20.3	8.7			8.7	12.7	91.3
3/8"	8.4	3.6			3.6	9.50	87.7
#4	30.9	13.3			13.3	4.76	74.4
#10			19.7	22.2	16.5	2.00	57.9
#20			18.8	21.1	15.7	0.84	42.2
#40			8.9	10.0	7.4	0.42	34.7
#60			5.6	6.3	4.7	0.25	30.0
#100			2.9	3.3	2.4	0.149	27.6
#200			11.4	12.8	9.5	0.074	18.1
-200			21.6	24.3	18.1		

REMARKS :



Project No. 04-1416-040
Drawn TM
Reviewed LL
Date 10/27/04

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure

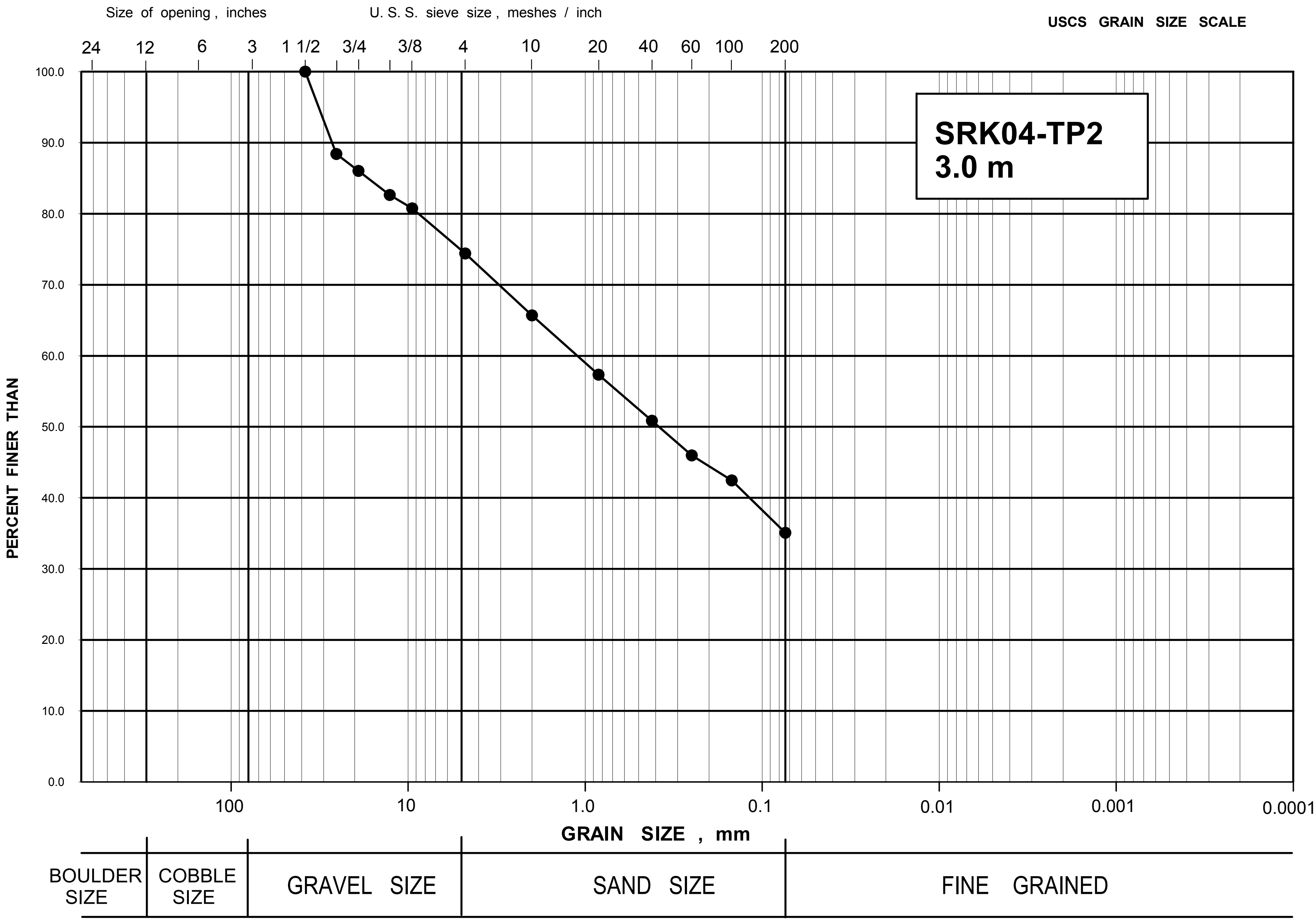
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP2
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	3.0m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	149.5
Total weight	833.9	Wash Sieve (Y/N)	Y	Weight after wash	80.6
Total Wt -#4	620.4	Total Wt of -#4 sieved	149.5	Pan Weight	1.6

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	96.6	11.6			11.6	25.4	88.4
3/4"	19.9	2.4			2.4	19.1	86.0
1/2"	28.3	3.4			3.4	12.7	82.6
3/8"	15.8	1.9			1.9	9.50	80.7
#4	52.9	6.3			6.3	4.76	74.4
#10			17.5	11.7	8.7	2.00	65.7
#20			16.8	11.2	8.4	0.84	57.3
#40			13.0	8.7	6.5	0.42	50.9
#60			9.8	6.6	4.9	0.25	46.0
#100			7.1	4.7	3.5	0.149	42.4
#200			14.8	9.9	7.4	0.074	35.1
-200			70.5	47.2	35.1		

REMARKS :



Project No. 04-1416-040
Drawn TM
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GRAIN SIZE DISTRIBUTION

Figure

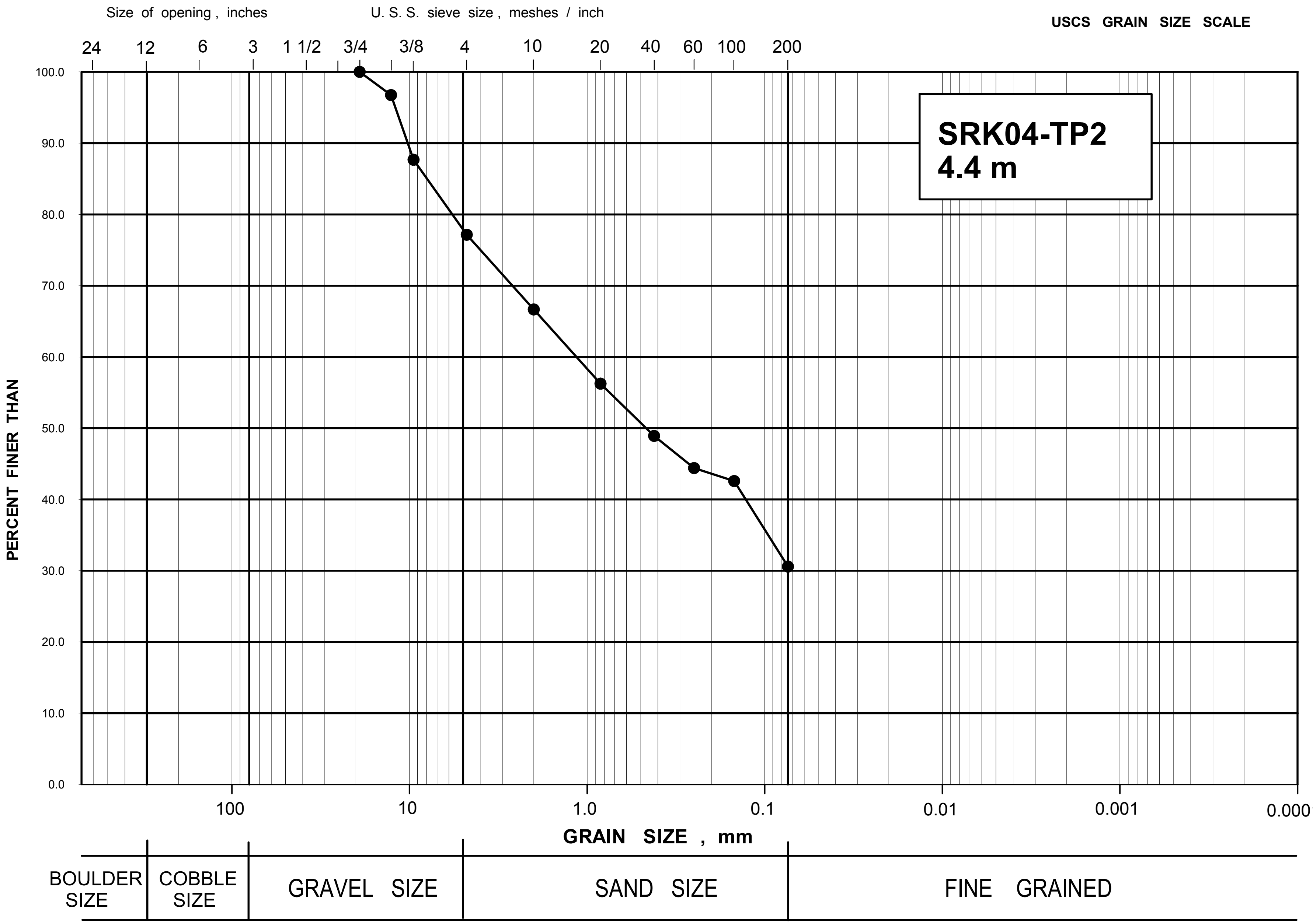
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP2
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	4.4m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	N	Weight before wash	92.6
Total weight	120.0	Wash Sieve (Y/N)	Y	Weight after wash	57.9
Total Wt -#4	92.6	Total Wt of -#4 sieved	92.6	Pan Weight	2.0

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	3.9	3.3			3.3	12.7	96.8
3/8"	10.9	9.1			9.1	9.50	87.7
#4	12.6	10.5			10.5	4.76	77.2
#10			12.6	10.5	10.5	2.00	66.7
#20			12.5	10.4	10.4	0.84	56.3
#40			8.8	7.3	7.3	0.42	48.9
#60			5.4	4.5	4.5	0.25	44.4
#100			2.2	1.8	1.8	0.149	42.6
#200			14.4	12.0	12.0	0.074	30.6
-200			36.7	30.6	30.6		

REMARKS :



Project No. 04-1416-040
Drawn TM
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Date 10/27/04

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GRAIN SIZE DISTRIBUTION

Figure

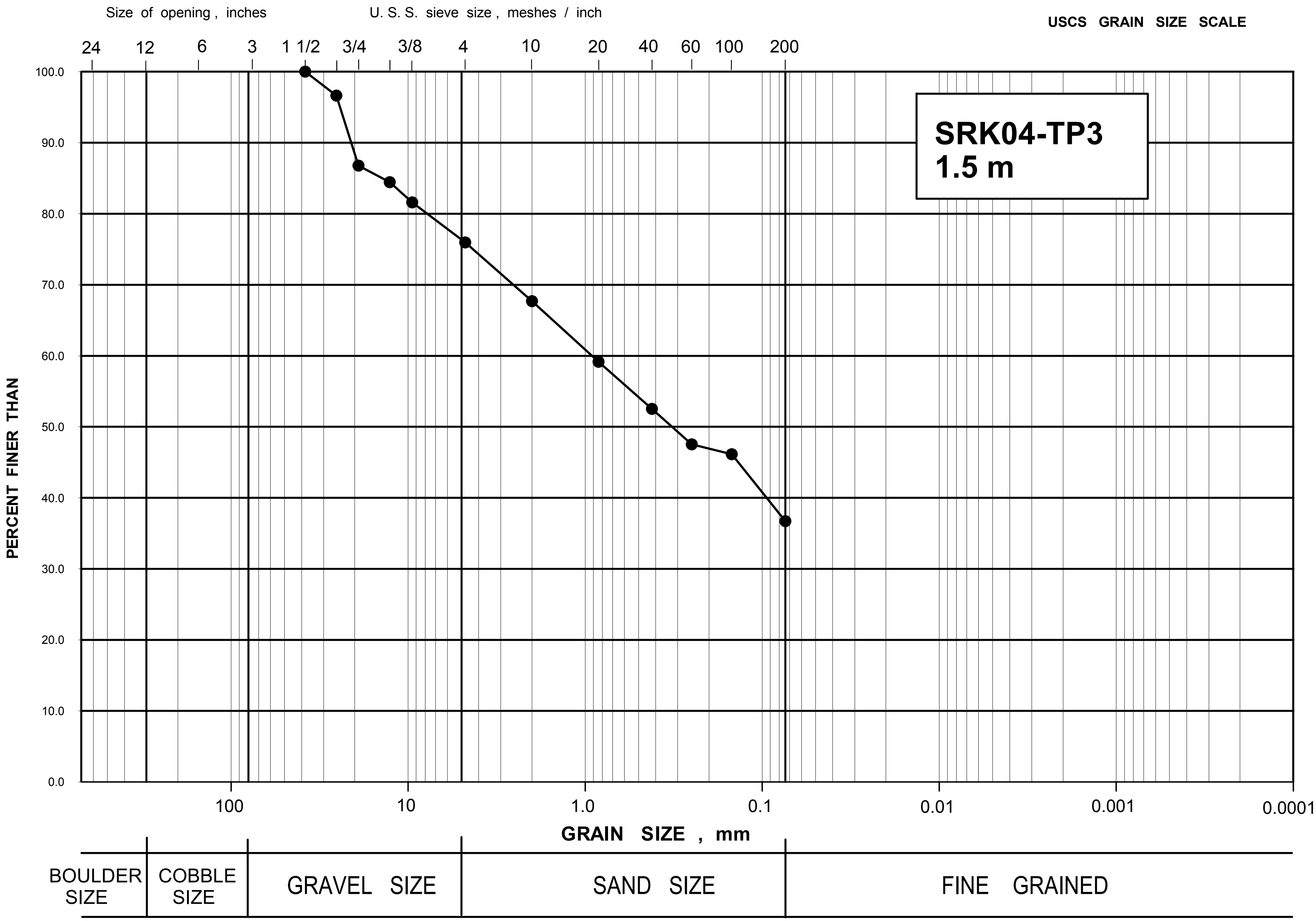
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP3
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	1.5m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	165.3
Total weight	658.4	Wash Sieve (Y/N)	Y	Weight after wash	86.8
Total Wt -#4	500.2	Total Wt of -#4 sieved	165.3	Pan Weight	1.4

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	22.2	3.4			3.4	25.4	96.6
3/4"	64.8	9.8			9.8	19.1	86.8
1/2"	15.4	2.3			2.3	12.7	84.4
3/8"	18.7	2.8			2.8	9.50	81.6
#4	37.1	5.6			5.6	4.76	76.0
#10			18.0	10.9	8.3	2.00	67.7
#20			18.6	11.3	8.5	0.84	59.2
#40			14.4	8.7	6.6	0.42	52.5
#60			10.9	6.6	5.0	0.25	47.5
#100			3.0	1.8	1.4	0.149	46.1
#200			20.5	12.4	9.4	0.074	36.7
-200			79.9	48.3	36.7		

REMARKS :



Project No. 04-1416-040 Drawn TM Reviewed LL Date 10/27/04	Golder Associates	**GRAIN SIZE DISTRIBUTION**	**Figure**

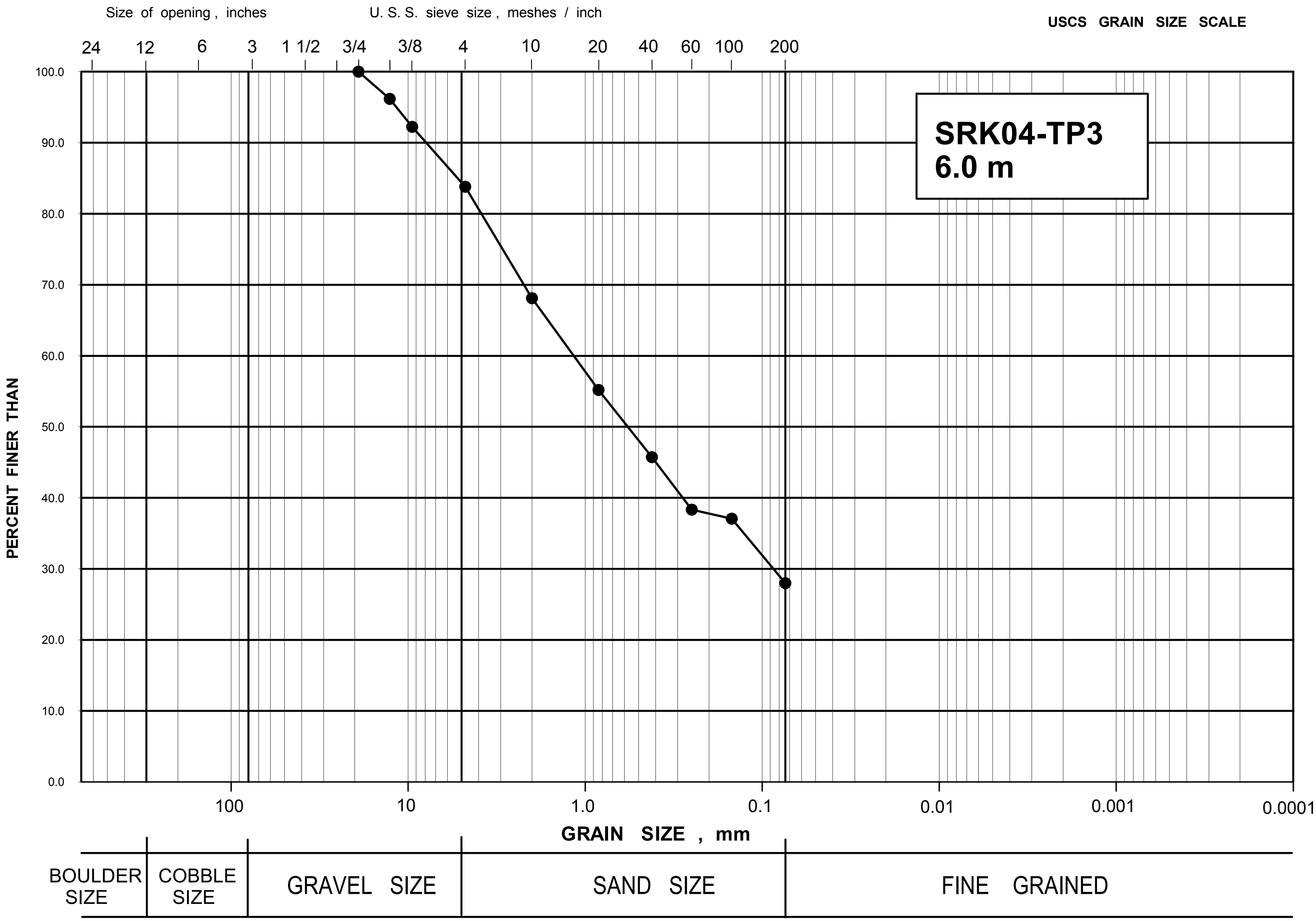
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP3
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	6.0m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	131.8
Total weight	497.4	Wash Sieve (Y/N)	Y	Weight after wash	88.7
Total Wt -#4	416.9	Total Wt of -#4 sieved	131.8	Pan Weight	0.9

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	0.0	0.0			0.0	19.1	100.0
1/2"	19.1	3.8			3.8	12.7	96.2
3/8"	19.5	3.9			3.9	9.50	92.2
#4	41.9	8.4			8.4	4.76	83.8
#10			24.7	18.7	15.7	2.00	68.1
#20			20.3	15.4	12.9	0.84	55.2
#40			14.9	11.3	9.5	0.42	45.7
#60			11.6	8.8	7.4	0.25	38.3
#100			2.0	1.5	1.3	0.149	37.1
#200			14.3	10.8	9.1	0.074	28.0
-200			44.0	33.4	28.0		

REMARKS :



Project No. 04-1416-040
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Date 10/27/04

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GRAIN SIZE DISTRIBUTION

Figure

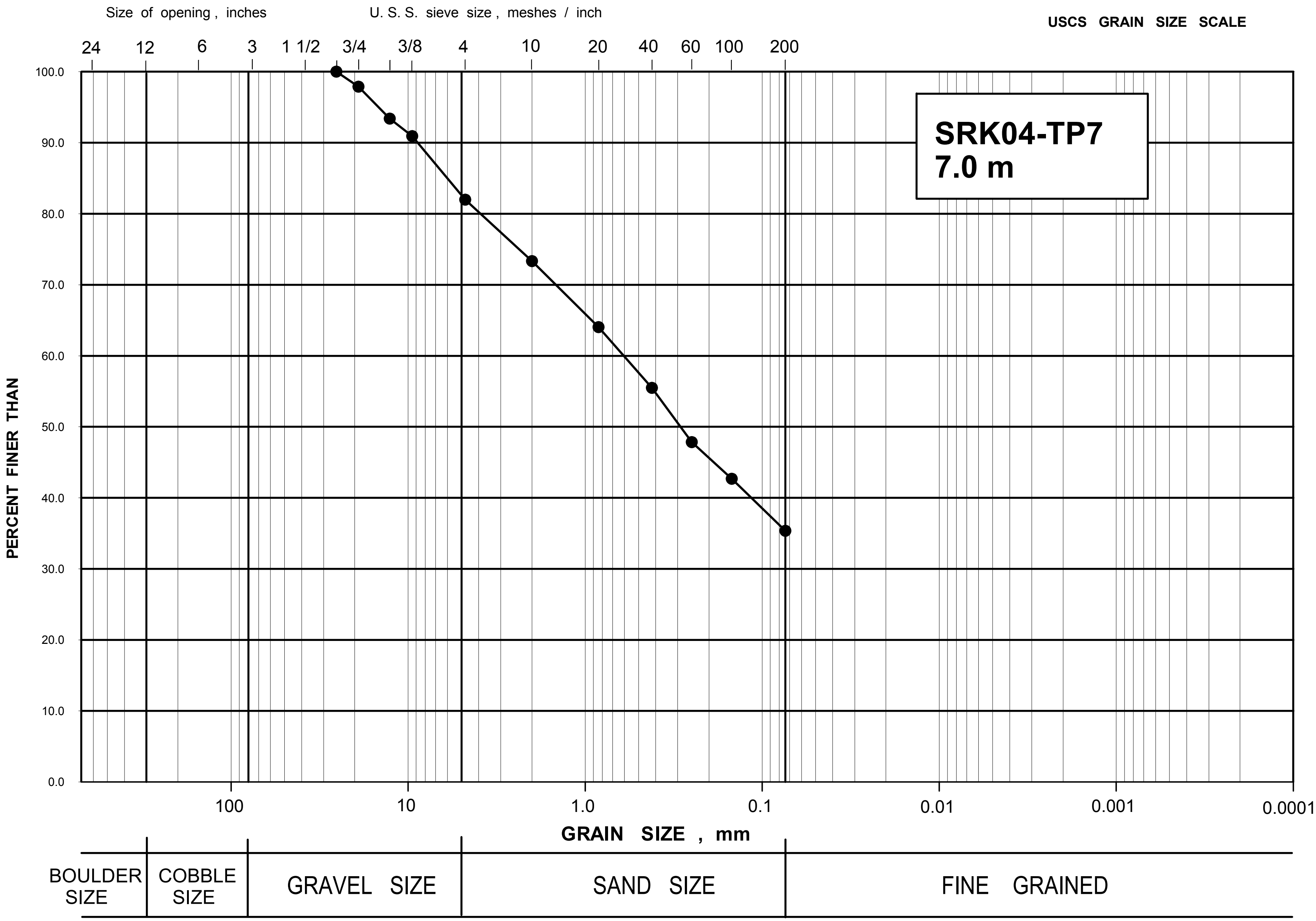
SIEVE ANALYSIS

Project No.	04-1416-040	Client	SRK	Borehole	SRK04-TP7
Sch#	215	Project	Lab Testing	Sample	
Lab Work	TM	Location	Vancouver	Depth	7m

1st SIEVING +#4		2nd SIEVING -#4		Wash Sieving - #4	
Weight before sieving		Quarter - #4 (Y/N)	Y	Weight before wash	79.5
Total weight	420.1	Wash Sieve (Y/N)	Y	Weight after wash	46.1
Total Wt -#4	344.4	Total Wt of -#4 sieved	79.5	Pan Weight	0.9

Sieve (USS)	Weight Retained	% Retained	Weight Retained	% Retained	% Retained of Total	Diameter (mm)	% Passing
12"	0.0	0.0			0.0	304.8	100.0
6"	0.0	0.0			0.0	152.4	100.0
3"	0.0	0.0			0.0	76.2	100.0
1 1/2 "	0.0	0.0			0.0	38.1	100.0
1"	0.0	0.0			0.0	25.4	100.0
3/4"	8.8	2.1			2.1	19.1	97.9
1/2"	19.0	4.5			4.5	12.7	93.4
3/8"	10.3	2.5			2.5	9.50	90.9
#4	37.6	9.0			9.0	4.76	82.0
#10			8.4	10.6	8.7	2.00	73.3
#20			9.0	11.3	9.3	0.84	64.0
#40			8.3	10.4	8.6	0.42	55.5
#60			7.4	9.3	7.6	0.25	47.8
#100			5.0	6.3	5.2	0.149	42.7
#200			7.1	8.9	7.3	0.074	35.4
-200			34.3	43.1	35.4		

REMARKS :



Project No. 04-1416-040
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Date 10/27/04

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GRAIN SIZE DISTRIBUTION

Figure

Appendix F
Preliminary Water Quality Data

S1a

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/23/2004	0:00	M			<0.0010	<0.20	185	<0.020	<0.020	<0.10	<0.0050	562
9/23/2004	12:06	M	em, mg									

S1b

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/23/2004	0:00	M			<0.00025	<0.050	114	<0.0050	0.025	<0.10	<0.0050	197
9/23/2004	12:08	M	em, mg	went dry almost immediately, had to sample water from tubing								

S2a

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/23/2004	0:00	M			<0.0025	<0.50	178	<0.050	<0.020	<0.10	<0.0050	518
9/23/2004	12:12	M	em, mg									

S2b

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/23/2004	0:00	M			<0.00050	<0.10	75.6	<0.010	0.045	<0.10	<0.0050	602
9/23/2004	12:10	M	em, mg	brown, v. silty								

S3

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/23/2004	0:00	M			<0.0010	<0.20	170	<0.020	0.023	<0.10	<0.0050	455
9/23/2004	12:20	M	em, mg									

P96-7

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/29/2004	15:22	M	mg, as	dry @ 14.2								

P96-8a

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/24/2004	0:00	M			<0.0050	<1.0	141	<0.10	<0.060	<0.30	<0.015	471
9/24/2004	8:57	M	em, toos	new tubing								

P96-8b

Date collected	Time collected	Class	Sampler ID	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/24/2004	0:00	M			<0.0050	<1.0	255	<0.10	<0.040	<0.20	<0.010	545
9/24/2004	8:58	M	em, toos	clear, rusty colour								

P96-9

Date collected	Time collected	Class	Comments	AG-D	AL-D	ALK-T	AS-D	BA-D	B-D	BE-D	CA-D
9/24/2004	0:00	M		<0.00050	<0.10	483	<0.010	0.077	<0.10	<0.0050	378
9/24/2004	12:48	M	brown, slightly silty, new tubing								

S1a

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/23/2004	0.0094	0.012		5330	<0.010	<0.020	<0.030	4250	<0.00020	0.133	691	43.3	<0.020	29.7
9/23/2004			1.325											

S1b

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/23/2004	0.00032	<0.0025		1400	<0.0025	<0.0050	0.033	733	<0.00020	<0.050	58.6	0.125	<0.0050	41.2
9/23/2004			0.666											

S2a

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/23/2004	0.0166	<0.025		5500	<0.025	<0.050	1.72	4280	<0.00020	0.134	726	58.1	<0.050	31.6
9/23/2004			1.345											

S2b

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/23/2004	0.00262	0.014		3270	<0.0050	<0.010	97.2	2750	<0.00020	<0.050	304	20	<0.010	19.9
9/23/2004			1.134											

S3

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/23/2004	<0.0010	0.036		5360	<0.010	<0.020	2.06	3990	<0.00020	0.135	692	47	<0.020	29.7
9/23/2004			1.39											

P96-7

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/29/2004			2.825											

P96-8a

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/24/2004	0.179	0.074		6010	<0.050	<0.10	<0.090	4460	<0.00020	0.2	798	85.8	<0.10	56.1
9/24/2004			1.038											

P96-8b

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/24/2004	0.053	0.711		6320	<0.050	<0.10	1.95	4880	<0.00020	0.15	854	75.7	<0.10	52.6
9/24/2004			1.67											

P96-9

Date collected	CD-D	CO-D	COND-F	COND-L	CR-D	CU-D	FE-D	HARD	HG-D	LI-D	MG-D	MN-D	MO-D	NA-D
9/24/2004	0.00097	<0.0050		2760	<0.0050	<0.010	<0.030	1890	<0.00020	<0.050	231	0.094	<0.010	12.4
9/24/2004			1135											

S1a

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/23/2004	1.08	<0.020		7.48	<0.010		<0.020	4540		<0.050	<0.0040	0.008	<0.030			92.7
9/23/2004			6.22						3					100	4.35	

S1b

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/23/2004	<0.025	<0.0050		7.86	<0.0025		<0.0050	760		<0.050	<0.0010	<0.0010	<0.030			0.109
9/23/2004			6.4						4.8						3.95	

S2a

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/23/2004	1.45	<0.050		7.34	<0.025		<0.050	4610		<0.050	<0.010	<0.010	<0.030			124
9/23/2004			6.07						3.8					24	4.69	

S2b

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/23/2004	0.235	<0.010		7.18	<0.0050		<0.010	2370		<0.050	<0.0020	<0.0020	<0.030			29.6
9/23/2004			6.43						3.8					7	4.85	

S3

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/23/2004	0.71	<0.020		7.31	<0.010		<0.020	4560		<0.050	<0.0040	<0.0040	<0.030			86.7
9/23/2004			5.97						6.1					40	3.63	

P96-7

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/29/2004			7.76						1.64					14.2	5.75	

P96-8a

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/24/2004	1.47	<0.10		7.09	<0.050		<0.10	5120		<0.15	<0.020	<0.020	<0.090			447
9/24/2004			6.12						6.8					57	2.91	

P96-8b

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SB-T	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/24/2004	1.03	<0.10		7.05	<0.050		<0.10	5560		<0.10	<0.020	<0.020	<0.060			263
9/24/2004			6.28						6.6					85	2.82	

P96-9

Date collected	NI-D	PB-D	PH-F	PH-L	SB-D	SE-D	SO4-T	TEMP-F	TI-D	TL-D	U-D	V-D	VOLUME-I	WL-M	ZN-D
9/24/2004	<0.050	<0.010		7.83	<0.0050	<0.010	1500		<0.050	<0.0020	0.0299	<0.030			0.0176
9/24/2004			6.77					7					70	5.7	

40692 Water Analysis
Gartner Lee Ltd.
U8724
9/28/2004
10/11/2004

RESULTS OF ANALYSIS

Sample ID	SRK04-5B	SRK04-5A	SRK04-4	SRK04-3A	SRK04- 03B
Date Sampled	9/25/2004	9/25/2004	9/25/2004	9/25/2004	9/24/2004
Time Sampled					
ALS Sample ID	80	81	82	83	105
Nature	Water	Water	Water	Water	Water
Physical Tests					
Conductivity (uS/cm)	450	459	8910	6600	14900
Hardness CaCO3	185	198	3340	3690	3780
pH	8.31	8.34	5.11	5.64	3.84
Dissolved Anions					
Alkalinity-Total CaCO3	138	140	32.8	45.7	8.1
Sulphate SO4	100	108	9840	6480	18000
Dissolved Metals					
Aluminum D-Al	<0.010	<0.010	2.2	<1.0	4.3
Antimony D-Sb	0.00088	0.00068	<0.050	<0.050	<0.10
Arsenic D-As	0.0120	0.0079	<0.10	<0.10	<0.20
Barium D-Ba	0.058	0.046	<0.10	<0.040	<0.20
Beryllium D-Be	<0.0050	<0.0050	<0.025	<0.010	<0.050
Boron D-B	<0.10	<0.10	<0.50	<0.20	<1.0
Cadmium D-Cd	<0.000050	<0.000050	0.0194	0.0165	<0.010
Calcium D-Ca	51.1	54.2	484	479	470
Chromium D-Cr	<0.00050	<0.00050	<0.050	<0.050	<0.10
Cobalt D-Co	<0.00050	<0.00050	0.611	0.602	0.43
Copper D-Cu	<0.0010	<0.0010	<0.10	<0.10	<0.20
Iron D-Fe	0.316	0.272	2990	1080	6600
Lead D-Pb	<0.0010	<0.0010	0.16	<0.10	0.60
Lithium D-Li	<0.050	<0.050	<0.25	0.14	<0.50
Magnesium D-Mg	14.1	15.3	517	605	631
Manganese D-Mn	0.069	0.063	54.1	51.3	77.3
Mercury D-Hg	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Molybdenum D-Mo	0.0236	0.0186	<0.10	<0.10	<0.20
Nickel D-Ni	<0.0050	<0.0050	0.82	0.92	<1.0
Selenium D-Se	<0.0010	<0.0010	<0.10	<0.10	<0.20
Silver D-Ag	<0.000050	<0.000050	<0.0050	<0.0050	<0.010
Sodium D-Na	18.6	17.7	64	55.5	64
Thallium D-Tl	<0.00020	<0.00020	<0.020	<0.020	<0.040
Titanium D-Ti	<0.050	<0.050	<0.25	<0.10	<0.50
Uranium D-U	0.00727	0.00489	<0.020	<0.020	<0.040
Vanadium D-V	<0.030	<0.030	<0.15	<0.060	<0.30
Zinc D-Zn	0.0154	0.0081	478	376	870

Appendix G
Preliminary Geophysical Survey Results

AURORA GEOSCIENCES LTD.
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MEMORANDUM

To: Daniel MacKie, P.Geo.
Cam Scott, P.Geo.
SRK Consulting Engineers and Scientists Ltd.

Date: 28 Oct 04

From: Mike Power

Re: Faro Mine - Geophysical Survey - Preliminary results

Per your request, this memorandum is a preliminary report on the Faro Mine geophysical survey program conducted for SRK Consulting Engineers and Scientists Ltd. earlier this month. The survey program was conducted between October 7 - 18 and the data processing and interpretation are underway but not complete. This report summarizes the work to date.

a. **Survey sites.** Geophysical surveys were performed at the following sites:

Vangorda Creek	Line GPR-1
Grum Pit	Line GPR-2 Line GPR-3 Line SL-1 (seismic refraction)
Vangorda Pit	Line GPR-4 Line GPR-5 Line SL-2 (seismic refraction)
Faro Rock Dump	Line SL-3 (seismic refraction)
Old Faro Creek	Line GPR-6

The field crew surveyed the line locations during the course of the geophysical surveys and final line location plots will be prepared once we have received a base drawing upon which to plot them.

b. Crew and equipment. The surveys were conducted by the following personnel:

Mike Power, P.Geoph.	Crew chief
Dave Hildes, Ph.D.	Geophysicist
Raanan Bodzin	Technician

The crew was equipped with the following instruments and ancillary equipment:

<u>Seismograph:</u>		Geometrics Strataview R-48 digital engineering seismograph (s/n 75162)
<u>Seismic equipment:</u>	1 -	24 channel cable w/ 10 m takeouts
	1 -	Bison HVB-1 high voltage seismic blaster / trigger
	29 -	Mark Products 40Hz vertical component geophones
	2 -	Type 6 explosives magazines
	1 -	Impulse laser range finder / digital clinometer & level
	1 -	Blasting wire, spool & winder
	4 -	VHF radios & chargers
<u>GPR system:</u>	1 -	RAMAC GPR (s/n 4679) w/ controller, Tx and Rx consoles
	1 -	50 MHz dipole antenna assembly
	1 -	25 MHz dipole antenna assembly
	1 -	50 MHz rough terrain antenna (s/n 12095)
	1 -	Hip chain trigger
	1 -	External monitor / computer controller
	6-	Li ion battery packs, chargers
	1-	Reflex processing and interpretation software package
<u>Other:</u>	2 -	1.8 Ghz laptop computers
	1-	Trimble Geoexplorer I differential GPS receiver
	1 -	1Ton 4x4 GMC truck
	1 -	Electronic and general repair tools

c. Seismic survey specifications. The seismic refraction surveys were conducted according to the following specifications:

Channels:	24
Receiver spacing:	5 m
Receivers:	single phone at each receiver station
Sampling:	0.250 ms
Record length:	256 ms
Pre-acquisition filters:	500 Hz high cut
Storage format:	SEG-Y digital file & paper shot record copy.
Shot spacing:	2 - 120 m off either end of the receiver array
	2 - 5 m off either end of the receiver array
	1 - mid-spread, offset 5 m left or right of line to clear the cable
Energy source:	High explosives (Dyno-Nobel Powerfrac™) initiated with StaticMaster seismic detonators. Single blast at each shot point.
Topography:	As provided by YES or surveyed with laser range finder, supplemented by DGPS receiver

The survey lines below the Faro Rock Dump and the GPR line across Old Faro Creek were put in by Yukon Engineering Services prior to the geophysical crew's arrival. The remainder of the lines were put in by either the geophysical crew or by Aurora line cutters working with them. The geophysical crew surveyed the topography on all the lines. Shots located off the seismic lines (ie. end of line shots) were surveyed with the laser range finder, recording the horizontal and vertical distances from a known station on the seismic line to the blast point.

Source effort varied depending upon distance from the reading array and the difficulty encountered in producing clear records. Off-end shots typically required from 25 to 30 1"x8" sticks of powder while a 10 stick charge was used for the shots at the centres of the arrays. Charges were stemmed where fine material was present but this was avoided in many situations were rocks or gravel was the only available material.

d. Data processing & interpretation. A full description of the refraction seismic data processing and interpretation will follow with the final report. The data was interpreted using an automated delay time method incorporating surface topography and lateral phone and shot offsets, if applicable[1]. The Rimrock Geophysics SIP interpretation program takes as input the first breaks and all available shot and array geometry information. The interpreter determines the number of layers present in the data by inspection of the time - distance (T-X) curves and through velocity analysis of the T-X curves. The interpreter then assigns each arrival to a layer based on his analysis of the T-X curves. The output consists of scattergrams showing the subsurface reflection points along each of the layer boundaries and a best fit line through the point set. A good solution will show a minimum of scatter about the best fit line delineating the layer boundary. It is an inherent property of refraction solutions that 2 layer cases will produce much tighter scatter plots than 3 or more layer cases.

The following procedures were used to interpret the seismic refraction data. First, the first arrivals on the shot records were picked with Interpex Ltd.'s IXSeg2SegY semi-automated shot record analysis program. Picks were exported and formatted for entry into the SIP processing package. Topographic survey data was processed in spreadsheets, checked for accuracy using the fixed cable length constraint and available independent elevation data, and then entered into the interpretation package. The Faro Rock Dumpdata was fit to a three layer case as there were 3 distinct segments in the T-X curves and this estimation is consistent with what might be encountered in the geological section. In most settings, overburden contains an uppermost dry layer (V_1 layer), a water saturated layer beneath (V_2 layer) and finally bedrock with a yet faster velocity (V_3). After layer assignment and initial interpretation runs, layer assignments were adjusted to minimize the scatter of refraction points around the best fit solution for each layer boundary. This forward modelling is an iterative process where the interpreter may have to repeatedly adjust his picks and recheck the shot records to improve the quality of the final solution. Final output including T-X plots and depth sections showing the location of the layer boundaries and the refraction point scatter are appended to this preliminary report. A more comprehensive summary of each inversion will follow with the final report.

---

[1]Scott, J.H. (1973) Seismic refraction modeling by computer. Geophysics Vol. 38, No. 2.

e. Preliminary results - seismic refraction surveys. At this time, only the preliminary results from the Faro Rock Dump are available; these are contained in Appendix A. For each spread (ie. each 115 m geophone array), a T-X plot and a model section is provided. The orientation of the local horizontal coordinate systems shown in the sections is constrained by the spread layout but the geographic orientation of the lines is also indicated on each section. The elevations shown in the model depth sections are elevations above mean sea level in metres referenced to the elevations provided by YES or to elevations determined with differential GPS measurements by the survey crew.

The Faro Rock Dump line is sketched in Figure 1 (above) and consists of three separate 115 m spreads, numbered sequentially from east to west. Line inflections occur at each spread boundary. Offset shots were placed in-line with each spread (ie. off in the bush and not along the adjacent spreads) and shot locations were surveyed in relative to the last phones on the spread. All spreads overlapped the adjacent spread (s) by one phone.

The data in each case best fit a three layer model and the velocities used in the inversions are summarized below:

Spread	V_1 (m/s)	V_2 (m/s)	V_3 (m/s)
1	597	1562	3075
2	354	1500	3637
3	564	1562	4281

The uppermost layer (V_1) has a velocity expected of dry, relatively unconsolidated material. The middle layer velocity is in the range expected for water saturated overburden. The velocity of the lowermost layer is in the range expected for bedrock in this area on Spread 3; it is anomalously slow on the other two spreads, particularly on Spread 1. The boundary between layers 2 and 3 (the lowermost boundary in each model) is tentatively interpreted to be bedrock. The available bedrock geology maps for the immediate area of the seismic line will be consulted to clarify this interpretation. The scatter in depth points about the best-fit layer boundary can be taken as a qualitative indication of the quality of goodness-of-fit in the final solution. It is an inevitable feature of the inversion process that the scatter of points below lower boundaries is substantially greater than the scatter of points about the upper layer boundaries.

The spreads were inverted separately and the mis-tie between the lines is important in assessing the validity of the final solutions. The mis-tie in elevation between Spreads 1 and 2 at Station 24 is 3.0 m and the mis-tie between Spreads 2 and 3 at Station 47 is 4.6 m. Seismic refraction surveys are typically accurate to $\pm$ 10%; consequently the difference between the two end-points could be as much as 20% of the total depth. Given the average depth of 20 to 30 m, a maximum discrepancy of 4 to 6 m could be anticipated. Consequently, the mis-ties, while larger than hoped, are within the bounds of expected error.

f. GPR survey specifications. The GPR survey at the Old Faro Creek line was conducted according to the following specifications:

Centre Frequency:	50 MHz and 25 MHz
Station spacing:	20 cm
Time window:	700 ns after groundwave first arrival
Sampling interval:	1.25 ns per sample
Antenna separation:	2.0 m (4.0 m - 25 MHz) maintained using a rope between antenna pullers
Triggering:	Automated chainbox (Hipchain)
Line location:	The apparent horizontal distance at which each surveyed control line picket was encountered was recorded manually and used in the data processing to register the lines.

g. GPR data processing. A full description of the data processing procedures will follow in the final report. In brief, the following data processing steps and algorithms were applied to the raw data to produce the final radargrams:

1. Geometric registration of radar traces to topographic survey points.
2. Dewow
3. Drift correction and reset time zero to remove short wavelength static variations caused by variable antenna spacing.
4. Spherical & exponential gain.
5. Time varying gain to boost reflections in the region of interest.
6. Band-pass filtering
7. Spiking deconvolution
8. Velocity analysis of diffraction hyperbolas
9. Depth section production

Band pass filtering, spherical & exponential gain and spiking deconvolution were omitted in some cases where these steps were not considered useful in improving the quality of the final images.

h. GPR survey results. Raw radargrams (not interpreted) are appended to this report as JPEG files for the Old Faro Creek line. The following notes describe the processing applied to each radargram:

1. Geometric registration - Warped GPR local coordinates onto fixed surveyed points P4 through P99.
2. Trace kills - Set bad traces to zero.
3. Drift removal - Flattened times of first maximum arrival
4. Reset time zero - Subtracted 10 ns from flattened data
5. Dewow - Used 20 ns time window
6. Gain - Applied time varying gain, then a scaled window gain using 70-100 ns time window
7. Depth conversion - Inserted static shift based on two way travel time

through overburden. Average overburden velocity of 0.14 m/ns used based on diffraction hyperbola analysis

Fully interpreted radargrams will be included in the final report.

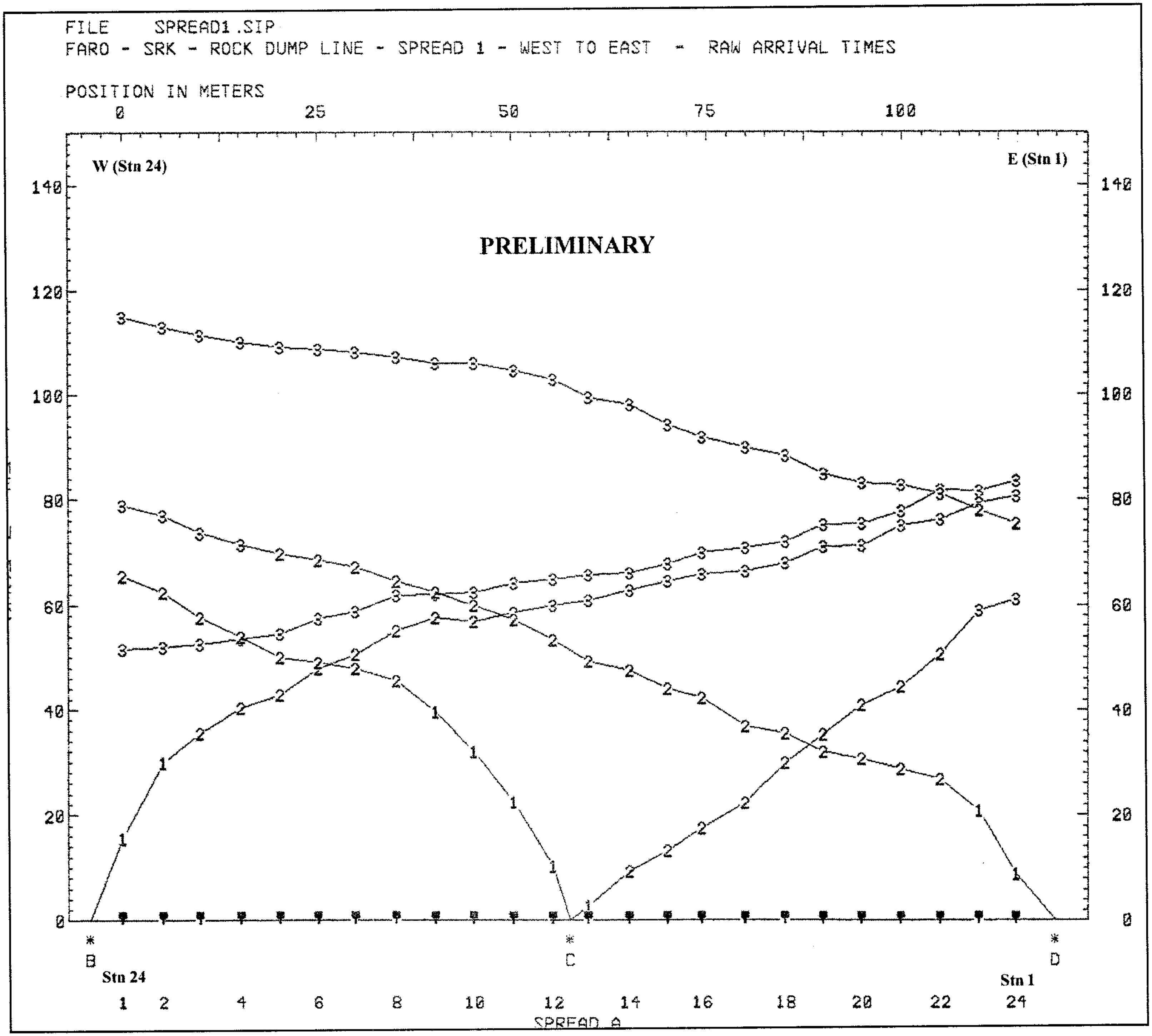
Respectfully submitted,
AURORA GEOSCIENCES LTD.

Mike Power
Digitally signed by Mike Power
DN: cn=Mike Power, c=US
Date: 2004.10.28 12:56:36 -07'00'
Validity unknown

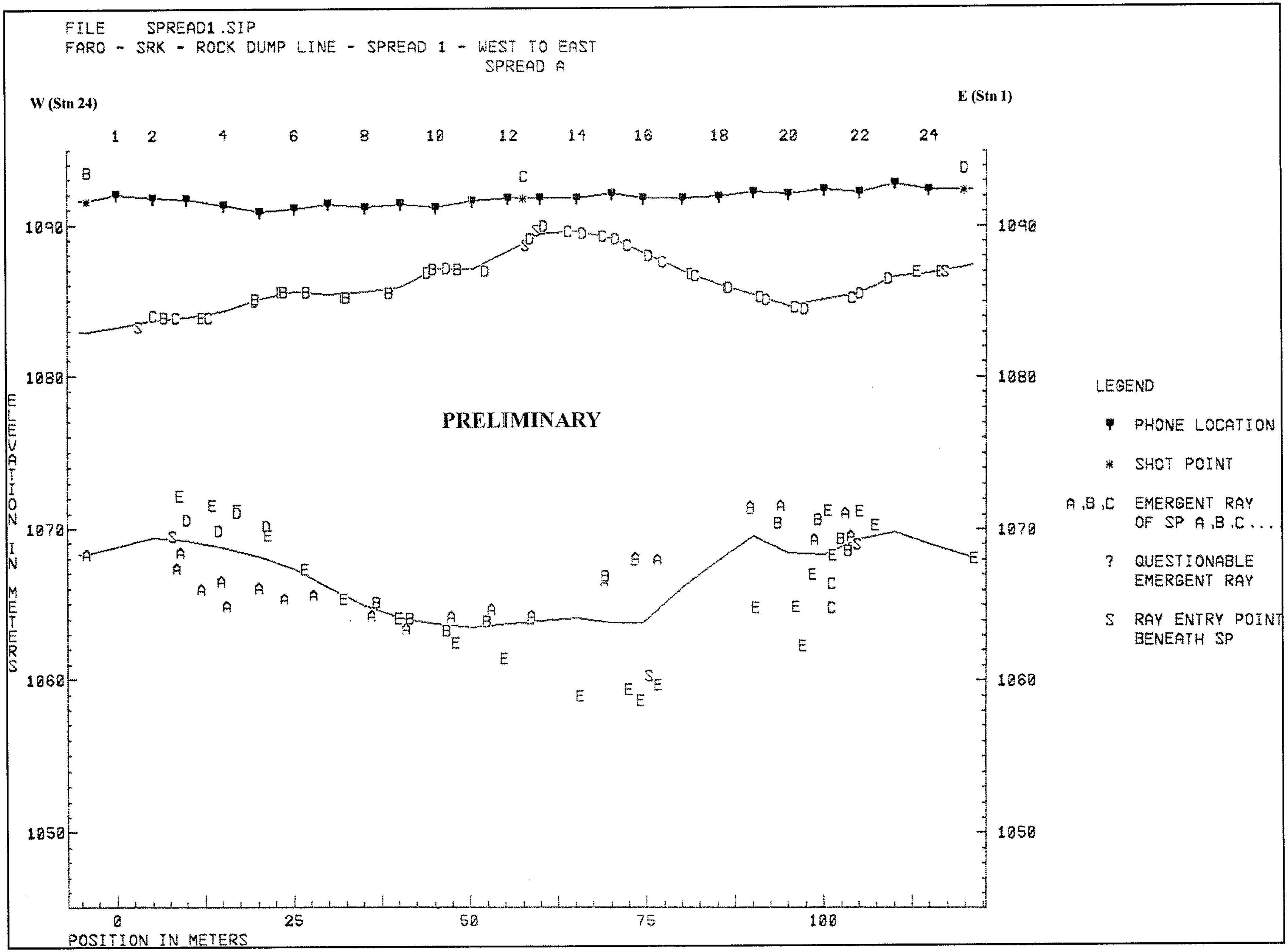
Mike Power, M.Sc., P.Geoph.
Geophysicist

/attach.

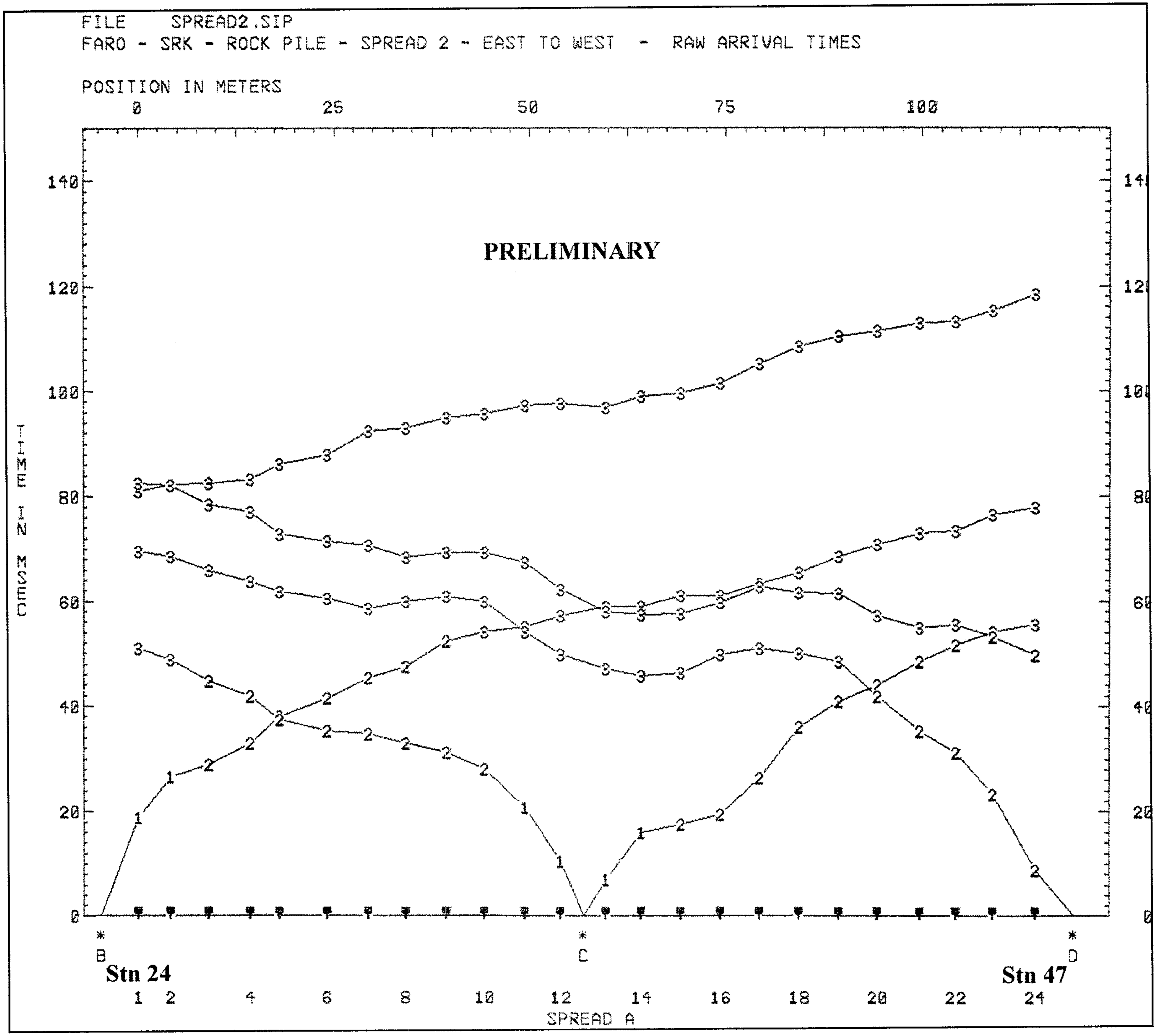
APPENDIX A. SEISMIC REFRACTION RESULTS - FARO ROCK DUMP LINE



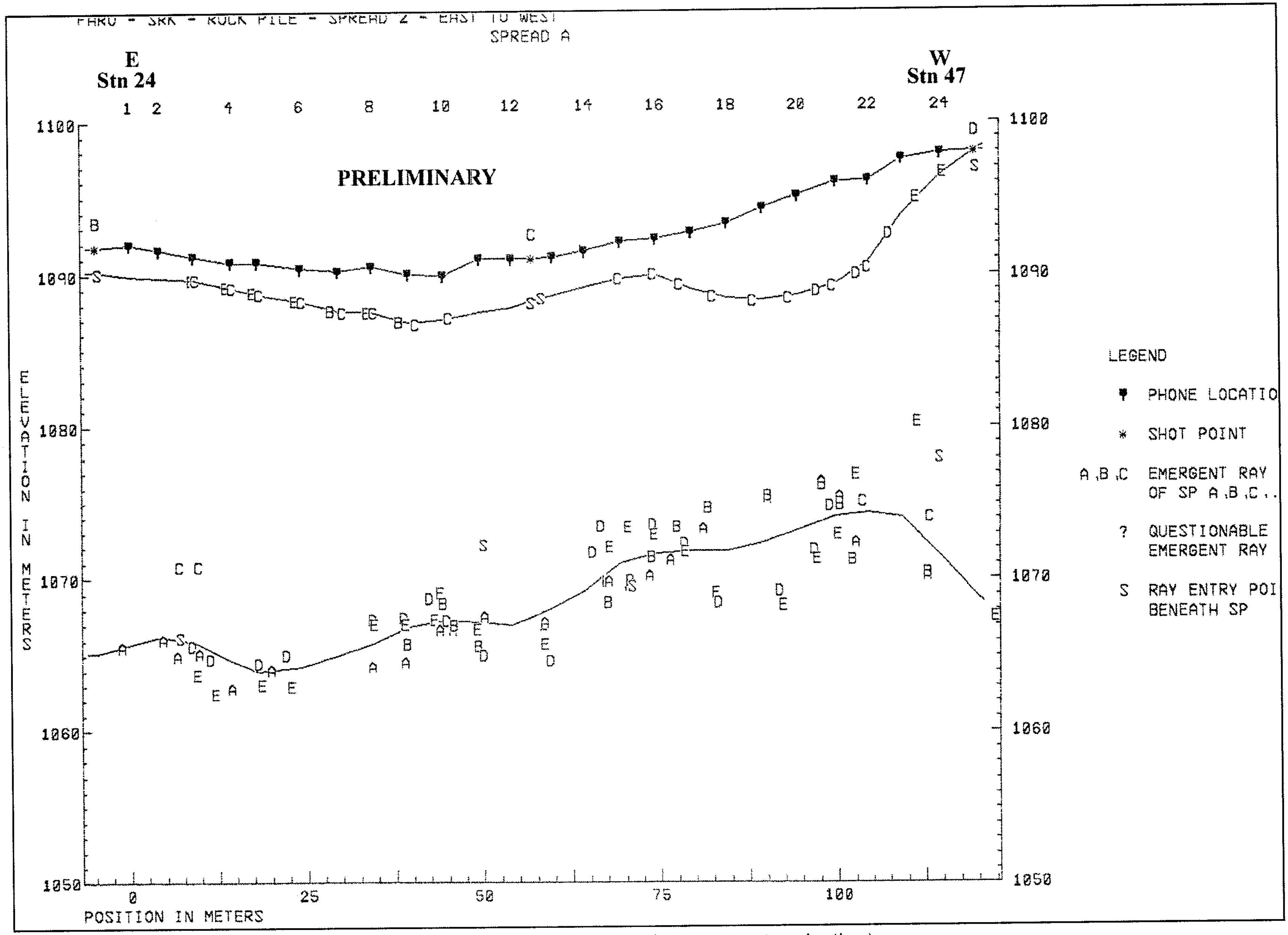
Faro Rock Dump Line - Spread 1 (eastern spread) - T-X curves



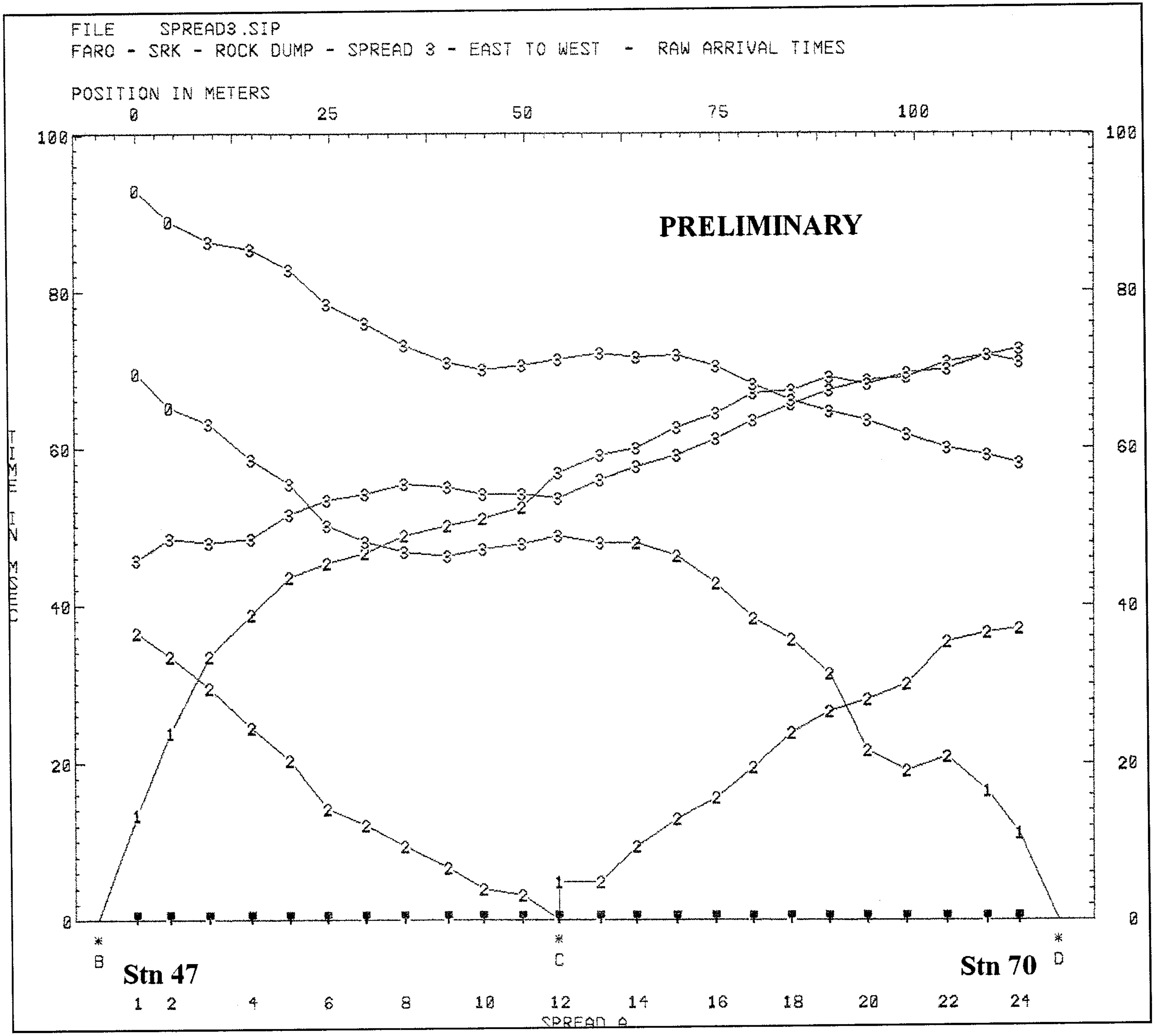
Faro Rock Dump Line - Spread 1 (eastern spread) - Inversion model (west to east)



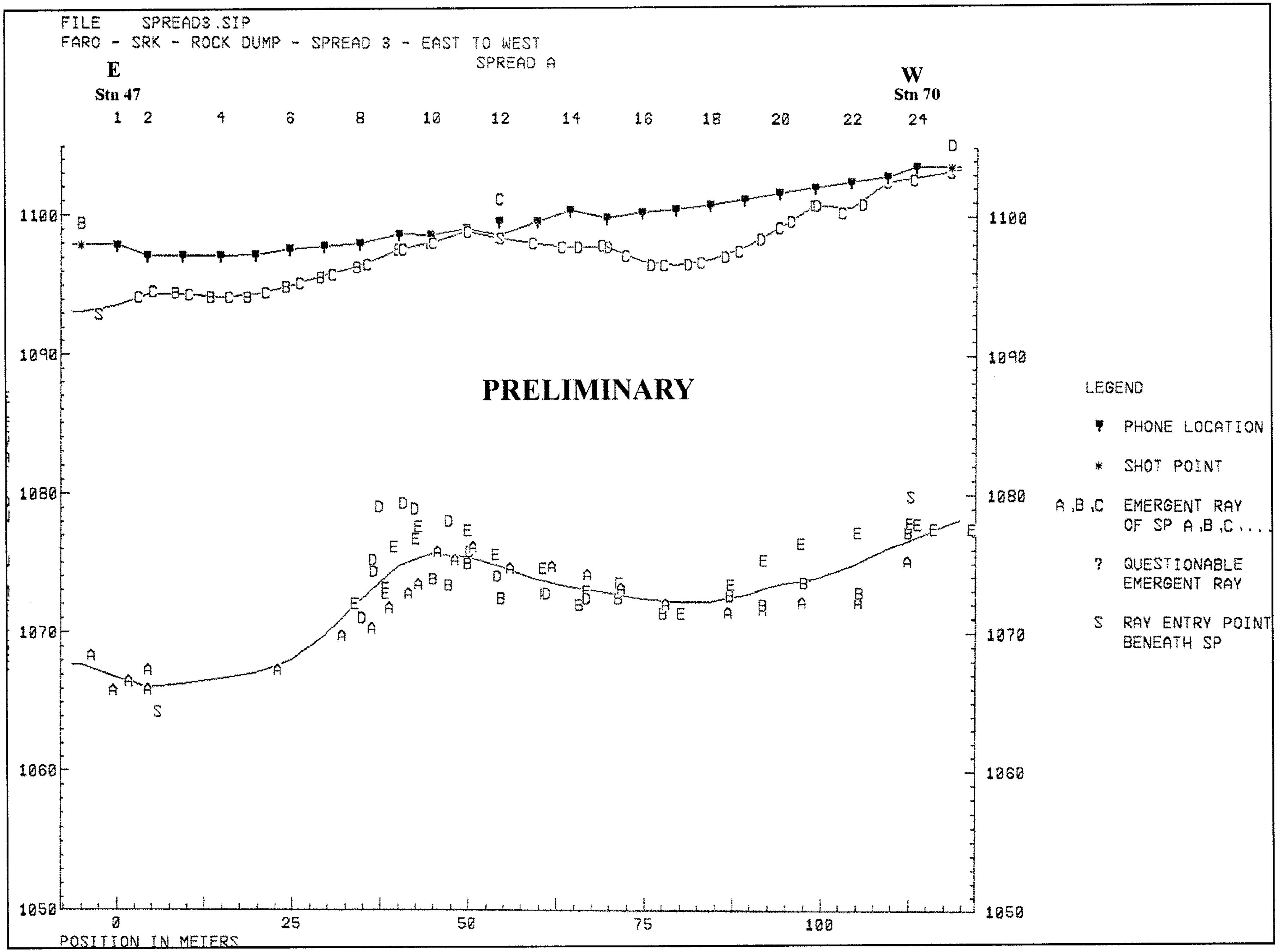
Faro Rock Dump Line - Spread 2 (central spread) - T-X curves



Faro Rock Dump Line - Spread 2 (central spread) - Inversion model (east to west projection)

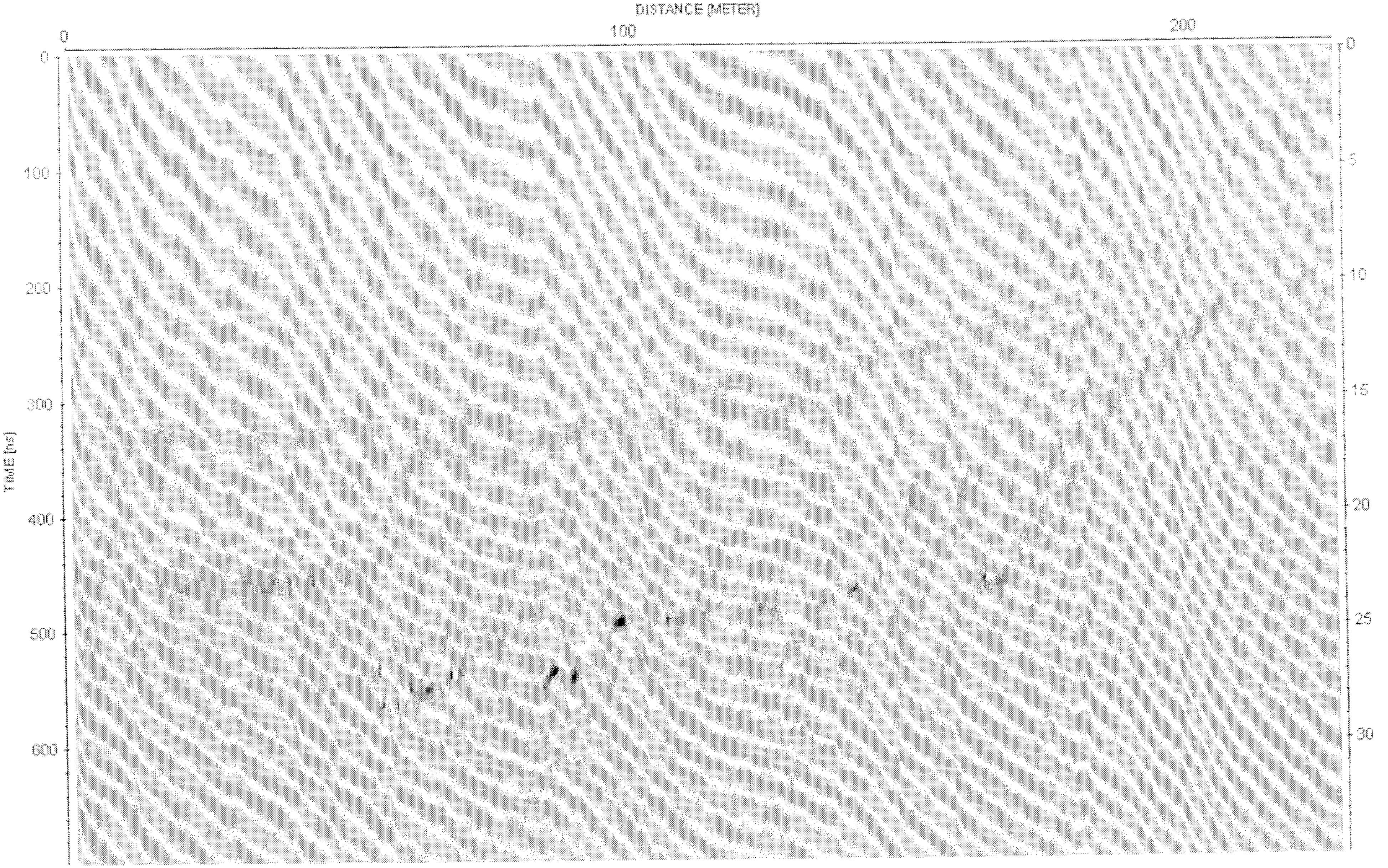


Faro Rock Dump Line - Spread 3 (western spread) - T-X curves

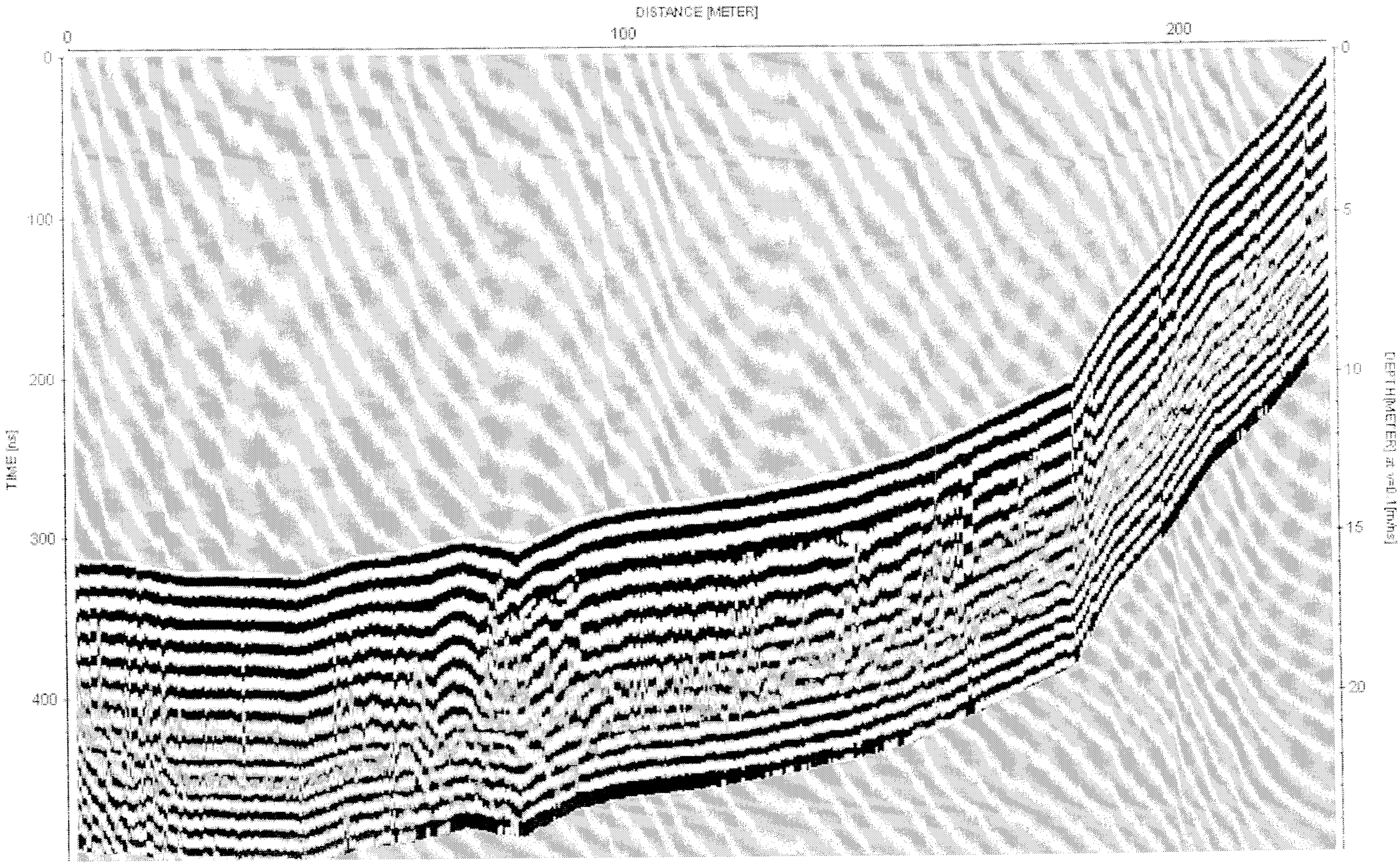


Faro Rock Dump Line - Spread 3 (western spread) - Inversion model (east to west projection)

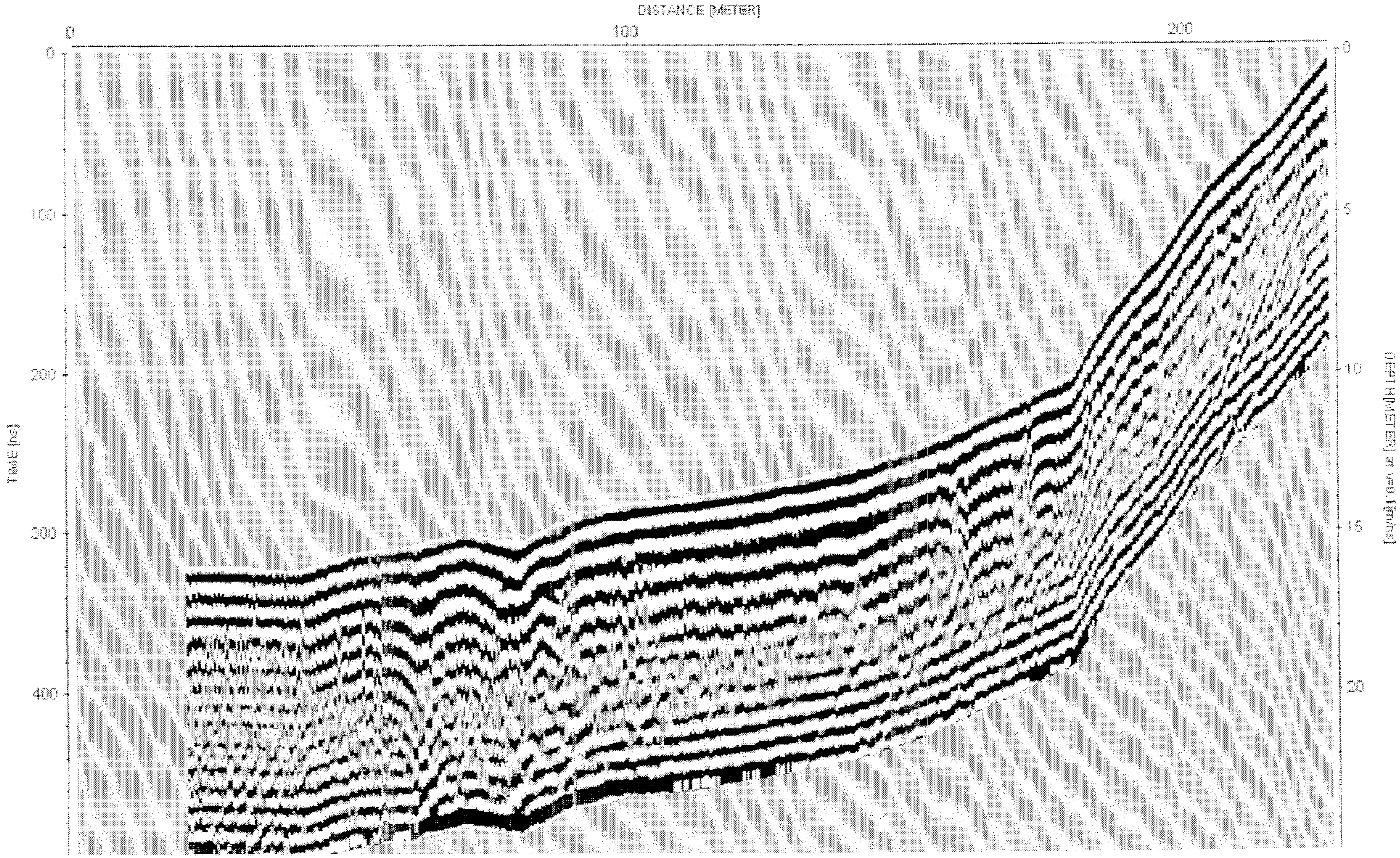
GPR, Old Faro Creek, 25MHz



GPR, Old Faro Creek, 50 MHz, Northbound



GPR, Old Faro Creek, 50 MHz, Southbound



Appendix H
Option Costs

ETA Option 1

Cost Estimate for Pumping Wells (2), Seepage Collection Sump and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
1		**General**					
	1.1	Mob/Demob (Contractor)	l.s.		0		
	1.2	Room and Board(Inspector)	days	20	150	3,000	
	1.3	Airfare (Inspector)	l.s.	1	1,000	1,000	
	1.4	Transportation(Inspector)	days	20	150	3,000	
	1.5	Survey	days	10	1,000	10,000	
		Sub-Total					**$17,000**
2		**Site Supervison**					
	2.1	Inspector	hrs	100	70	7,000	
		Sub-Total					**$7,000**
3		**Seepage Collection Ditches**					
	3.1	Excavation of Soil	cu.m	2537	8	20,296	
	3.2	Supply and Place Rip-Rap	cu.m	98	20	1,960	
	3.3	Supply and Place non woven Filter fabric	cu.m	465	4	1,860	
	3.4	Supply, haul and place 150mm HDPE Insulated Pipe	lin.m	352	100	35,200	
	3.5	Place backfill	cu.m	1584	4	6,336	
	3.6	Supply and Place HDPE Manhole	ea	6000	1	6,000	
		Sub-Total					**$71,652**
4		**Pumping System**					
	4.1	Mob/Demob	ls	1	6,000	6,000	
	4.2	Drilling (lump sum per 12 m hole)[1]	ls	2	21,070	42,140	
	4.3	Pump Installation and Setup	ea.	2	10,000	20,000	
	4.4	Development & Testing	ea.	2	5,000	10,000	
	4.5	Piping	lin m	100	10	1,000	
	4.6	Electrical Pump Controls and Housing	ea	2	15,000	30,000	
	4.7	Heating?				0	
		Sub-Total					**$109,140**
5A		**Piping to Faro Pit**					
	5.1	Manholes/junctions	ea	4	6,000	24,000	
	5.2	Excavation	cu.m	9200	8	73,600	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	2050	100	205,000	
	5.4	Backfilling[2]	cu.m	9200	4	36,800	
	5.5	Heating?				0	
	5.6	Pumping Booster	ea	1	20,000	20,000	
		Sub-Total					**$359,400**
5B		**Piping to Faro Canyon Treatment Plant**					
	5.1	Manholes/junctions	ea	3	6,000	18,000	
	5.2	Excavation	cu.m	1800	8	14,400	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	400	100	40,000	
	5.4	Backfilling[2]	cu.m	1800	4	7,200	
	5.5	Road Excavation	cu.m				
	5.6	Heating?				0	
		Sub-Total					**$79,600**
5C		**Piping to Treatment Plant near Intermediate Dam**					
	5.1	Manholes/junctions	ea	6	6,000	36,000	
	5.2	Excavation	cu.m	13635	8	109,080	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	3030	100	303,000	
	5.4	Backfilling[2]	cu.m	13635	4	54,540	
	5.5	Road Excavation	cu.m				
	5.6	Heating?				0	
		Sub-Total					**$502,620**
Piping Option 5A							
		Total costs					$564,192
		Contingency (20%)					$112,838
		Total estimated cost					**$677,030**
Piping Option 5B							
		Total costs					$284,392
		Contingency (20%)					$56,878
		Total estimated cost					**$341,270**
Piping Option 5C							
		Total costs					$707,412
		Contingency (20%)					$141,482
		Total estimated cost					**$848,894**

[1]Drill costs are taken from $18,900 per hole drilling (based on two days per hole incl. development with a jet tool) and a final $2,170 charge for 0.5 days per hole on the hypothetical 5th day of drilling.
[2]Excavation and backfill volumes based on 3m deep x 1.5m wide x (length of line)

NOTE **SHADED SECTIONS INDICATE PRELIMINARY NUMBERS ONLY**

ETA Option 1
Annual Operating Cost Estimate for Pumping Wells, Seepage Collection Ditches and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
A1		**Electrical Power Supply**					
	A1.1	Submersible Power Requirement (maximum)	KWhr/yr	70084	0.13	9110.92	
		Sub-Total					**$9,111**
A2		**General Maintenance**					
	A2.1	Inspection	days	44	150	6600	
	A2.2	Sump Clearing	days	2	250	500	
		Sub-Total					**$7,100**
Piping Option 5A							
		Sump Clearing	days	7	$250	$1,750	
		Pumping Booster Power Cost/yr	KWhr/yr	70000	$0.13	$9,100	
		Sub-Total					**$10,850**
		Total costs					$27,061
		Contingency (20%)					$5,412
		Total estimated cost					**$32,473**
Piping Option 5B							
		Sump Clearing	days	5	$250	$1,250	
		Sub-Total					**$1,250**
		Total costs					$17,461
		Contingency (20%)					$3,492
		Total estimated cost					**$20,953**
Piping Option 5C							
		Sump Clearing	days	10	$250	$2,500	
		Sub-Total					**$2,500**
		Total costs					$18,711
		Contingency (20%)					$3,742
		Total estimated cost					**$22,453**

ETA Option 2
Cost Estimate for Pumping Wells (3), Seepage Collection Sump and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
1		**General**					
	1.1	Mob/Demob (Contractor)	l.s.		0		
	1.2	Room and Board(Inspector)	days	20	150	3,000	
	1.3	Airfare (Inspector)	l.s.	1	1,000	1,000	
	1.4	Transportation(Inspector)	days	20	150	3,000	
	1.5	Survey	days	10	1,000	10,000	
		Sub-Total					**$17,000**
2		**Site Supervison**					
	2.1	Inspector	hrs	100	70	7,000	
		Sub-Total					**$7,000**
3		**Seepage Collection System**					
	3.1	Excavation of Soil	cu.m	635.5	8	5,084	
	3.2	Supply and Place Rip-Rap	cu.m	65	20	1,300	
	3.3	Supply and Place non woven Filter fabric	sq.m	309.5	4	1,238	
	3.4	Place backfill	cu.m	0	4	0	
		Sub-Total					**$7,622**
4		**Pumping System**					
	4.1	Mob/Demob	ls	1	6,000	6,000	
	4.2	Drilling (lump sum per 12 m hole)[1]	ls	3	21,070	63,210	
	4.3	Pump Installation and Setup	ea.	3	10,000	30,000	
	4.4	Development & Testing	ea.	3	5,000	15,000	
	4.5	Piping	lin m	115	10	1,150	
	4.6	Electrical Controls and Protective Housing (shack construction)	ea	3	15,000	45,000	
	4.7	Heating?				0	
		Sub-Total					**$160,360**
5A		**Piping to Faro Pit**					
	5.1	Manholes/junctions	ea	5	6,000	30,000	
	5.2	Excavation	cu.m	9200	8	73,600	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	2050	100	205,000	
	5.4	Backfilling[2]	cu.m	9200	4	36,800	
	5.5	Pumping Booster	ea	1	20,000	20,000	
	5.6	Heating?				0	
		Sub-Total					**$365,400**
5B		**Piping to Faro Canyon Treatment Plant**					
	5.1	Manholes/junctions	ea	2	6,000	12,000	
	5.2	Excavation	cu.m	1800	8	14,400	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	400	100	40,000	
	5.4	Backfilling[2]	cu.m	1800	4	7,200	
	5.5	Road Excavation/backfill for Pipe Install	cu.m				
	5.6	Heating?				0	
		Sub-Total					**$73,600**
5C		**Piping to Treatment Plant at Intermediate Dam**					
	5.1	Manholes/junctions	ea	7	6,000	42,000	
	5.2	Excavation	cu.m	13635	8	109,080	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	3030	100	303,000	
	5.4	Backfilling[2]	cu.m	13635	4	54,540	
	5.5	Road Excavation/backfill for Pipe Install	cu.m				
	5.6	Heating?				0	
		Sub-Total					**$508,620**
Piping Option 5A							
		Total costs					$557,382
		Contingency (20%)					$111,476
		Total estimated cost					**$668,858**
Piping Option 5B							
		Total costs					$265,582
		Contingency (20%)					$53,116
		Total estimated cost					**$318,698**
Piping Option 5C							
		Total costs					$700,602
		Contingency (20%)					$140,120
		Total estimated cost					**$840,722**

[1]Drill costs are taken from $18,900 per hole drilling (based on two days per hole incl. development with a jet tool) and a final $2,170 charge for 0.5 days per hole on the hypothetical 7th day of drilling.
[2]Excavation and backfill volumes based on 3m deep x 1.5m wide x (length of line)

NOTE **SHADED SECTIONS INDICATE PRELIMINARY NUMBERS ONLY**

ETA Option 2
Annual Operating Cost Estimate for Pumping Wells, Seepage Collection Ditches and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
A1		**Electrical Power Supply**					
	A1.1	Submersible Power Requirement (maximum)	KWhr/yr	105120	0.13	13665.6	
	A1.3	Heating?	KWhr/yr	0	0.13	0	
		Sub-Total					**$13,666**
A2		**General Maintenance**					
	A2.1	Inspection	days	44	150	6600	
	A2.2	Sump Clearing	days	5	250	1250	
		Sub-Total					**$7,850**
Piping Option 5A							
		Sump Clearing	days	7	$250	$1,750	
		Pumping Booster Power Cost/yr	KWhr/yr	70000	$0.13	$9,100	
		Sub-Total					**$10,850**
		Total costs					$32,366
		Contingency (20%)					$6,473
		Total estimated cost					**$38,839**
Piping Option 5B							
		Sump Clearing	days	5	$250	$1,250	
		Sub-Total					**$1,250**
		Total costs					$22,766
		Contingency (20%)					$4,553
		Total estimated cost					**$27,319**
Piping Option 5C							
		Sump Clearing	days	10	$250	$2,500	
		Sub-Total					**$2,500**
		Total costs					$24,016
		Contingency (20%)					$4,803
		Total estimated cost					**$28,819**

ETA Option 3
Cost Estimate for Pumping Wells (2), Seepage Collection Sump and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
1		**General**					
	1.1	Mob/Demob (Contractor)	l.s.		0		
	1.2	Room and Board(Inspector)	days	20	150	3,000	
	1.3	Airfare (Inspector)	l.s.	1	1,000	1,000	
	1.4	Transportation(Inspector)	days	20	150	3,000	
	1.5	Survey	days	10	1,000	10,000	
		Sub-Total					**$17,000**
2		**Site Supervison**					
	2.1	Inspector	hrs	100	70	7,000	
		Sub-Total					**$7,000**
3		**Seepage Collection Sump**					
	3.1	Excavation of Soil	cu.m	2160	8	17,280	
	3.2	Supply and Place Prefabricated HDPE Manholes	ea.	1	20	20	
	3.3	Sump Pump	ea.	1	20,000	20,000	
	3.4	Pumping Booster Power Cost /yr	KWhr/yr		0.13	0	
		Sub-Total					**$37,300**
4		**Pumping System**					
	4.1	Mob/Demob	ls	1	6,000	6,000	
	4.2	Drilling (lump sum per 12 m hole)[1]	ls	2	21,070	42,140	
	4.3	Pump Installation and Setup	ea.	2	10,000	20,000	
	4.4	Development & Testing	ea.	2	5,000	10,000	
	4.5	Piping	lin m	50	10	500	
	4.6	Electrical Controls and Protective Housing (shack construction)	ea	2	15,000	30,000	
		Sub-Total					**$102,640**
5A		**Piping to Faro Pit**					
	5.1	Manholes/junctions	ea	3	6,000	18,000	
	5.2	Excavation	cu.m	3938	8	31,504	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	210	100	21,000	
	5.4	Backfilling[2]	cu.m	3938	4	15,752	
	5.5	Pumping Booster					
	5.6	Heating?				0	
		Sub-Total					**$86,256**
5B		**Piping to Faro Canyon Treatment Plant**					
	5.1	Manholes/junctions	ea	5	6,000	30,000	
	5.2	Excavation	cu.m	10170	8	81,360	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	2185	100	218,500	
	5.4	Backfilling[2]	cu.m	10170	4	40,680	
	5.5	Road Excavation	cu.m				
	5.6	Heating?	KWhr/yr		0.13	0	
		Sub-Total					**$370,540**
5C		**Piping to Treatment Plant at Intermediate Dam**					
	5.1	Manholes/junctions	ea	6	6,000	36,000	
	5.2	Excavation	cu.m	13455	8	107,640	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	2450	100	245,000	
	5.4	Backfilling[2]	cu.m	13455	4	53,820	
	5.5	Road Excavation	cu.m				
	5.6	Heating?	KWhr/yr		0.13	0	
		Sub-Total					**$442,460**
Piping Option 5A							
		Total costs					$250,196
		Contingency (20%)					$50,039
		Total estimated cost					**$300,235**
Piping Option 5B							
		Total costs					$534,480
		Contingency (20%)					$106,896
		Total estimated cost					**$641,376**
Piping Option 5C							
		Total costs					$606,400
		Contingency (20%)					$121,280
		Total estimated cost					**$727,680**

[1]Drill costs are taken from $18,900 per hole drilling (based on two days per hole incl. development with a jet tool) and a final $2,170 charge for 0.5 days per hole on the hypothetical 5th day of drilling.
[2]Excavation and backfill volumes based on 3m deep x 1.5m wide x (length of line)

NOTE **SHADED SECTIONS INDICATE PRELIMINARY NUMBERS ONLY**

ETA Option 3
Annual Operating Cost Estimate for Pumping Wells, Seepage Collection Ditches and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
A1		**Electrical Power Supply**					
	A1.1	Submersible Power Requirement (maximum)	KWhr/yr	70084	0.13	9110.92	
	A1.3	Heating?	KWhr/yr	0	0.13	0	
		Sub-Total					**$9,111**
A2		**General Maintenance**					
	A2.1	Inspection	days	44	150	6600	
	A2.2	Sump Clearing	days	2	250	500	
		Sub-Total					**$7,100**
Piping Option 5A							
		Sump Clearing	days	7	$250	$1,750	
		Pumping Booster Power Cost/yr	KWhr/yr	70000	$0.13	$9,100	
		Sub-Total					**$10,850**
		Total costs					$27,061
		Contingency (20%)					$5,412
		Total estimated cost					**$32,473**
Piping Option 5B							
		Sump Clearing	days	5	$250	$1,250	
		Sub-Total					**$1,250**
		Total costs					$17,461
		Contingency (20%)					$3,492
		Total estimated cost					**$20,953**
Piping Option 5C							
		Sump Clearing	days	10	$250	$2,500	
		Sub-Total					**$2,500**
		Total costs					$18,711
		Contingency (20%)					$3,742
		Total estimated cost					**$22,453**

NFRC Option 1
Capital Cost Estimate for Pumping Wells, Seepage Collection Ditches and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
1		**General**					
	1.1	Mob/Demob (Contractor)	l.s.		0		
	1.2	Room and Board(Inspector)	days	20	150	3,000	
	1.3	Airfare (Inspector)	l.s.	1	1,000	1,000	
	1.4	Transportation(Inspector)	days	20	150	3,000	
	1.5	Survey	days	10	1,000	10,000	
		Sub-Total					**$17,000**
2		**Site Supervison**					
	2.1	Inspector	hrs	100	70	7,000	
		Sub-Total					**$7,000**
3		**Seepage Collection System**					
	3.1	Excavation of Soil	cu.m	4302	8	34,416	
	3.2	Place backfill	cu.m	4302	20	86,040	
		Sub-Total					**$120,456**
4		**Pumping System**					
	4.1	Mob/Demob (assume included with ETA area)	l.s.	0	6,000	0	
	4.2	Drilling (lump sum per 7 m hole)[1]	ea.	3	15,000	45,000	
	4.3	Pump Installation and Setup	ea.	3	10,000	30,000	
	4.4	Development & Testing	ea.	3	5,000	15,000	
	4.5	Piping	lin m	168	10	1,680	
	4.6	Electrical Controls and Protective Housing (shack construction)	ea	3	15,000	45,000	
		Sub-Total					**$136,680**
5A		**Piping to Main Junction**					
	5.1	Manholes/junctions	ea	2	6,000	12,000	
	5.2	Excavation	cu.m	8255	8	66,040	
	5.3	Supply, haul and place 150mm HDPE Insulated Pipe	lin m	1805	100	180,500	
	5.4	Backfilling[2]	cu.m	8255	4	33,020	
	5.5	Heating?	lin m			0	
	5.6	Pumping Booster	ea	1	20,000	20,000	
		Sub-Total					**$311,560**
		Sub-Total					**$592,696**
		Contingency (20%)					$118,539
		Total estimated cost					**$711,235**

[1]Drill costs are taken from $15.214 per hole drilling (based on two days per hole)
[2]Excavation and backfill volumes based on 3m deep x 1.5m wide x (length of line)

NOTE **SHADED SECTIONS INDICATE PRELIMINARY NUMBERS ONLY**

NFRC Option 1

Annual Operating Cost Estimate for Pumping Wells, Seepage Collection Ditches and Pipeline

Item No.	Subtask	Work item description	Units	Quantity	Unit cost (CAD$)	Cost (CAD$)	Total Cost (CAD$)
A1		**Electrical Power Supply**					
	A1.1	Submersible Power Requirement (maximum)	KWhr/yr	105120	0.13	13665.6	
	A1.2	Booster Power Requirement (maximum)	KWhr/yr	7165	0.13	931.45	
	A1.3	Heating?	KWhr/yr	0	0.13	0	
		Sub-Total					**$14,597**
A2		**General Maintenance**					
	A2.1	Inspection	days	44	150	6600	
	A2.2	Sump Clearing	days	4	250	1000	
		Sub-Total					**$7,600**
		Sub-Total					**$22,197**
		Contingency (20%)					$4,439
		Total estimated cost					**$26,636**