Deloitte & Touche

Anvil Range Mining Complex
2005 Seepage Investigation at the Emergency Tailings Area

2005/06 - Task 20e

Prepared for

Deloitte & Touche Inc.

on behalf of

Faro Mine Closure Planning Office

Prepared by

SRK Consulting
Engineers and Scientists

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On behalf of

The Faro Mine Closure Planning Office

SRK Consulting (Canada) Inc.
Suite 800, 1066 West Hastings Street
Vancouver, B.C. V6E 3X2

Tel: 604.681.4196 Fax: 604.687.5532
E-mail: vancouver@srk.com Web site: www.srk.com

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Authors
Daniel Mackie, M.Sc.
Quinn Jordan-Knox, M.Sc.
Dr. Christoph Wels, Ph. D., M.Sc.

Reviewed by
Cam Scott, P.Eng.

Executive Summary

An assessment of groundwater and surface water flow and water quality conditions at the Emergency Tailings Area (ETA) indicates that significant contaminant load (up to 70 t/yr zinc) is reporting to the Faro Creek Canyon and Rose Creek valley. The contaminated seepage discharging from the ETA is a combination of surface flow originating as toe seepage from the Faro waste rock dumps) and groundwater flow through highly permeable alluvial sediments in the historic Faro Creek valley. The tailings stored in the ETA also contribute significantly to the contaminant loading. Therefore, a seepage interception system (SIS) will be required in the ETA, probably for an indefinite period of time.

Drilling and hydraulic testing indicates that bedrock is significantly (> 3 orders of magnitude) less transmissive than overburden in this area. In addition, groundwater in bedrock also shows significantly lower contaminant concentrations than observed in the overburden. As a result, the estimated contaminant loads associated with groundwater flow in bedrock are 3-4 orders of magnitude lower than the contaminant loads observed in the overburden soils. These initial loading estimates suggest that interception of groundwater flow in bedrock in the ETA area may not be required.

Pumping test results and scoping level numerical modeling indicate that groundwater pumping alone in the ETA will likely not provide the necessary level of capture. Instead, a Primary SIS, a monitoring system and an Adaptive Management Program are recommended. As a first step, the tailings should be removed from the ETA itself. The primary SIS, consisting of a cut-off wall with up gradient pumping wells should then be installed. Limited sections of permeable trench should be installed along the fence of pumping wells in areas with relatively low permeability materials (till). A monitoring system and an adaptive management plan should be implemented to allow seepage cature efficiency to be monitored and upgraded as necessary.

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1 Introduction and Scope of Work

This report presents results of the 2005/2006 hydrogeology program for the Emergency Tailings Area (ETA) as part of Task 20e – Continued Seepage Investigations. Seepage from the Faro waste rock dump, and the subsequent influence of tailings in the ETA itself, have been identified as a source of contamination to the Rose Creek Aquifer. As a result, impacts and potential mitigation measures have been investigated. Figure 1 shows the location of the study area.

The scope of work for Task 20e was described in a memorandum dated June 8, 2005 and included investigations in four areas: the Emergency Tailings Area (ETA), Zone 2 Pit area, the S-cluster area, and the Grum area. This report covers the ETA component. The primary objectives addressed herein are:

- Drilling and completion of two inclined bedrock drillholes with core logging, packer testing and completion as bedrock monitoring wells,
- Additional hydraulic testing of the pumping well installed in 2004,
- A detailed stream survey, and
- Development of recommendation for a collection system.

A brief review of background information is presented in Section 2. Descriptions of field program methodologies and results are presented in Section 3, including a hydrogeologic conceptual model for the ETA area. Contaminant loading estimates in groundwater and surface water are presented in Section 4. Section 5 describes options and recommendations for a seepage interception system.

2 Background

2.1 Initial Data Review

An “Initial Review of Groundwater Quality downstream of Faro, Grum and Vangorda WRDs, Yukon Territory”, by Robertson GeoConsultants Inc., dated July 14, 2004, is provided in Appendix A of the Preliminary Seepage Collection Options – Faro and Grum Waste Rock Dumps (SRK, 2006). Available groundwater quality data was reviewed and priorities for further work were assigned based on the observed trends in acid rock drainage (ARD) related contaminants, specifically, zinc and sulphate, as well as parameters such as pH and alkalinity. The following paragraphs summarize the findings relevant to the ETA.

Surface Seepage in Faro Creek Channel (X23)

Water quality has been monitored regularly since 1986 at station X23 where seepage from the Main Dump “daylights” year-round (Figure 2a and 2b). Sulphate concentrations increased from around 1,500 mg/L to more than 4,000 mg/L with spikes to above 6,000 mg/L. Zinc concentrations increased from around20 mg/L in the late 1980’s to around200-400 mg/L with spikes up to greater than 1,000 mg/L since about 2001. Total and dissolved iron concentrations show 10-100 fold increases since about 2001 (Figure 2b). Interception and treatment of surface seepage at this location was recommended.

Subsurface Seepage in Faro Creek Channel (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 increased from around 2,000 mg/L in 1996 to around 4,000 mg/L in 2003. Zinc increased from around2 mg/L to greater than100 mg/L in the same 8-year time span. Alkalinity ranged from 150-350 mg/L and pH 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.

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 had already been observed.

2.2 2004 Field Program

The recommendations of the initial data review provided a framework for developing the 2004 hydrogeological field investigation that is described in Preliminary Seepage Collection Options – Faro and Grum Waste Rock Dumps (SRK, 2006). The 2004 program included drilling, well installation, hydraulic testing, test pitting and geophysical surveying of targets based as prioritized by the initial review of groundwater quality. The final program also included reduction of all field data and the identification of preliminary seepage collection options. Preliminary costs were estimated and a preliminary preferred option was presented.

Analysis of water quality data at the ETA, from new (2004) drillholes, older (1996) drillholes and surface water, indicated that the tailings in the ETA are contributing significant contaminant load to the Rose Creek Valley tailings impoundment and underlying aquifer.

Hydraulic testing and measurements of surface flow suggested that approximately 6 l/s of highly contaminated water is discharging to the Rose Creek Valley. This water is likely a combination of seepage from the main Faro waste rock dump and mill area, both located up gradient from the ETA, and precipitation that falls directly on the ETA. Water quality is poorer at the downstream side of the ETA than on the upstream side, suggesting that the tailings in the ETA are contributing to the overall contaminant loading.

The report from the 2004 program recommended a seepage collection system consisting of a line of pumping wells located adjacent to the mine access road, combined with surface water collection sumps.

3 Field Investigation

3.1 Monitoring Well Drilling and Installation

Seven new monitoring wells were drilled in the ETA in 2005.Boreholes SRK05-ETA-BR1 and –BR2 were completed in bedrock as part of Task 22e to characterize potential bedrock groundwater flow. The remaining five (ETA05-01 to -05) were completed as part of a separate investigation of the ETA tailings, but were also utilised for the groundwater program.

Locations for all ETA monitoring wells are shown in Figure 1. Table 1 lists completion details for the 2005 monitoring wells, as well as the five previously existing 2004 monitoring wells. Borehole logs for all newly completed monitoring wells are provided in Appendix A.

Table 1: ETA Monitoring Well Summary

2005 Monitoring Wells	Easting	Northing	Total Depth (m)	Top of Casing Elevation (m.a.s.l.)	Screen Interval (m.b.g.s.)
ETA05-01	582953	6913851	9.1	1105.13	4.3-7.3
ETA05-02	582993	6913849	7.6	1105.06	5.0-7.5
ETA05-03	582975	6913808	9.0	1103.98	7.0-8.8
ETA05-04	583045	6913858	9.0	1105.4	6.7-9.0
ETA05-05	582977	6913856	7.5	1105.44	2.0-5.2
SRK05-ETA-BR1	582972	6913846	13.0	1105.21	9-12
SRK05-ETA-BR2	582987	6913825	23.6	1103.75	14.6-18.9
2004 Monitoring Wells					
SRK-04-04	582,977	6,913,837	11.9	1104.80	7.6 – 11.6
SRK04-3A	582,977	6,913,824	13.4	1104.55	10.4 – 11.9
SRK04-3B	582,977	6,913,824	13.4	1104.63	5.5 – 7.0
Historic Monitoring Wells					
P96-8A	577,050	6,911,223	~4.5	1109.39	1.0-4.5
P96-8B	577,050	6,911,223	~8.5	1109.48	5.5-8.5

The 2005 drilling program was conducted using two different drill types. A track mounted sonic drill owned and operated by SDS Sonic Drilling out of Calgary, Alberta, was used to drill shallow boreholes ETA05-01 through -05. A track-mounted Maxidrill coring drill, owned and operated by Midnight Sun Drilling of Whitehorse, Yukon, was used to drill the two deeper bedrock holes.

The sonic rig was equipped with a 4x6 system (4” core barrel and 6” casing) that allowed for continuous sampling in 10 foot runs (1 core barrel; approximately 3 metres) by advancing the core barrel using ultra-sonic vibrations. Casing is advanced over the core barrel to below the bit to keep the hole open during barrel retrieval. Water is only used during casing advancement to prevent heave between barrel and casing. Run samples are extruded into 4” diameter clear plastic sample bags for logging and grab sampling. Rods and casing were in imperial units and all units have been converted to metric. Final drillhole diameter was 152 mm (six-inches).

The Maxidrill was a combination reverse circulation / diamond drilling machine, but only the diamond drill component was employed. Alluvium was drilled with NW size casing (88.9 mm O.D.) and shoe to bedrock to stabilize the overburden. After casing was set into bedrock, NQ drillrods and drill bit (75.7 mm O.D.) were lowered through the casing for bedrock coring. Casing could not be set into bedrock in SRK05-ETA-BR1 because of coarse gravel or boulders. This borehole was terminated in the alluvium. SRK05-ETA-BR2 was successfully completed in bedrock.

All drillholes were logged. Packer injection tests were completed in bedrock during drilling of SRK05-ETA-BR2.

Piezometers in ETA05-01 to -05 were constructed with standard (Schedule 80), two-inch diameter, PVC components (solid and screen) installed through the Sonic drill-rods. Sand packs were emplaced around the PVC screens and then a grout seal poured to the surface. Depths of materials were measured during installation.

Piezometers in SRK05-ETA-BR1 and –BR2 were completed differently than the others. Sections of 2.5 cm (1”) PVC solid pipe and screen were installed through the Maxidrill drill rods to hole bottom. A rubber “shale trap” (funnel-shaped rubber seal with outer diameter of the drillhole) was fixed to the solid PVC above the screen zone. A bentonite grout (mix approximately ½ bag grout to 5 US gallons of water) was used to seal the well annulus above the shale trap. 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.

Two monitoring wells were developed using a peristaltic pump: SRK05-ETA-BR1 and SRK05-ETA-BR2. Water was pumped from the wells until field conductivity and pH readings stabilized, and at least three well volumes had been removed. Monitoring wells ETA05-01 through-05 have not been developed.

3.2 Hydrostratigraphy

The interpreted cross-sections shown in Figures 3 and 4 were developed using the borehole logs and results of a ground penetrating radar survey, which was conducted as part of the 2004 investigations. Cross-section locations are shown on Figure 1. The cross-sections show the primary geologic units identified in the ETA area, which from top to bottom are: tailings, natural soil consisting of either alluvium or till, and bedrock.

3.2.1 Tailings

The tailings vary in texture from gravel and sand to silt with lenses of visible pyrite-rich sand/gravel observed in drill-core. The tailings deposit is approximately 6.5m thick near the access road and appears to thin up-valley and towards the valley sides. Coarser materials (gravels) observed within the tailings deposit may represent waste rock placed onto the tailings surfaces after intermittent discharges to the ETA. These coarser units cannot be accurately delineated with the available data.

3.2.2 Alluvium and Till

The alluvium unit is dominantly comprised of coarse (sand and gravel sized) alluvium interpreted to have been deposited by the old Faro Creek near the mine access road, but is also interpreted to include some till of sandy or gravelly silt texture further up-valley (towards the Faro waste dumps) and towards the valley sides. The alluvial unit is interpreted to continue under the access road, sloping downwards with topography and is interpreted to vary between 2-6 m in thickness within the ETA. Fine grained (silt) till is assumed to blanket the adjacent hillsides bordering the ETA, but the distribution/thickness of alluvial and till deposits up-valley from the ETA is uncertain. Drill logs for P96-8, located up gradient of the ETA at the toe of the waste rock dump, indicate bedrock at approximately 8 m depth, overlain by coarse alluvial sand and gravel.

3.2.3 Bedrock

Bedrock in the ETA is characterised as phyllite, with a weathered zone ranging in thickness from 0.10 to 1.2 meters determined by the presence of iron staining on fractures in BR2. Drilling at most locations was terminated at the overburden-bedrock interface and did not provide detailed characterisation of weathered bedrock. The bedrock channel observed below the mine access road is interpreted to extend up-valley under the mine access road into the ETA to at least SRK04-4. The bedrock surface is interpreted to raise up-valley from the access road to the waste rock dumps and valley-sides.

Drilling at SRK05-ETA-BR2 was continued to a total depth of 23.6 m.b.g.s., intersecting approximately 12 meters of bedrock. Bedrock was characterised using standard geotechnical methods, including rock quality designation (RQD), solid core recovery (SCR) and fracture frequency (fractures/meter). Table 2 summarises bedrock characteristics.

Table 2: SRK05-ETA-BR2 Bedrock Characteristics

DEPTH		RUN LENGTH	RECOVERY		RQD		SCR		Fracture frequency (Joints/m)
FROM	TO								
(m)	(m)	(m)	(m)	(%)	(m)	(%)	(m)	(%)	
10.20	11.60	1.40	1.33	95.0	0.34	24.0	0.70	50.0	14.0
11.60	13.10	1.52	1.52	100.0	0.26	17.0	1.02	67.0	18.0
13.10	14.60	1.52	1.52	100.0	0.71	47.0	1.01	66.0	15.0
14.60	16.15	1.52	1.52	100.0	0.15	10.0	0.89	58.0	20.0
16.15	17.80	1.65	1.60	97.0	0.17	10.0	0.97	59.0	21.0
17.80	19.33	1.52	1.48	100.0	0.33	22.0	0.94	61.0	17.0
19.33	20.60	1.27	1.27	100.0	0.32	25.0	0.76	59.0	20.0
20.60	22.10	1.52	1.52	100.0	0.72	47.0	1.08	71.0	16.0
22.10	23.60	1.52	1.52	100.0	0.36	23.0	1.15	76.0	15.0

Bedrock in the ETA area is characterised as phyllite or schist, both of which have shown at least one relatively well developed foliation surface. The presence of foliation can complicate geotechnical and hydrogeological characterisation due to the inherent weakness, and subsequent “apparent” high fracture frequency that can result. Many breaks, if not most, are caused by the drilling process itself, which may cause the core to break along the foliation surface. Plate 1 shows drillcore from SRK05-ETA-BR2. The preferential fracture orientation parallel to foliation suggests that measured RQD and fracture frequency values are conservative and rock quality is likely better than observed in core.

Plate 1: Drillcore from SRK05-ETA-BR2

3.3 Hydrology

3.3.1 Methodology

Surface water and seepage flows, as well as water quality, were monitored in 2005 at multiple locations above and below the ETA (shown on Figure 1). As part of this program, the weir at monitoring station X23 was improved and an additional weir installed at the mouth of the Faro Creek canyonby Laberge Environmental Services (LES). Continuous recording water level data loggers were installed at each weir and calibrated to manual discharge measurement on each site visit to develop stage-discharge relationships. The resulting data were used to assess the hydrologic dynamics of the ETA area, and, using regional analysis, develop preliminary estimates of 100-year flood flows.

Appendix B includes memoranda prepared by LES describing the weir installation and periodic site visits. Appendix C provides a memorandum prepared by Mr. Pat Bryan on the regional analysis and flood estimates.

3.3.2 Manual Streamflow Surveys

Discharge measurements and water quality (SO_4, Zn-T and Fe-T) from the four stations along the Faro Creek channel (from X23 at the toe of the WRDs to the mouth of the Faro Creek Canyon) are summarised in Table 3. The following conclusions can be drawn with respect to streamflows and surface water quality in the ETA area:

- Toe seepage from the waste rock (FCS-1 at X23) occurs year-round with some decrease in seepage during winter baseflow; concentrations of sulphate, zinc and iron are highly elevated but have remained relatively steady during the period of observation;
- Surface runoff from the ETA area (FCS-2 at culvert) shows more variable flow than toe seepage up-gradient of the ETA area but concentrations of sulphate, zinc and iron are very similar to those observed in toe seepage up-gradient of the ETA area (except for a small decrease in total iron concentrations);
- Subsurface seepage from the ETA area (FCS-3 at downstream seepage face) flows year-round with flow estimates ranging from 2.3 – 4.8 L/s; water quality of this seepage is generally similar to that observed in the alluvial wells in the ETA area; iron concentrations in this seepage are consistently about one order of magnitude higher than in waste rock seepage entering (and leaving) the ETA area;
- Surface runoff at the mouth of the Faro Creek canyon (FCS-4) also flows year-round with flow rates ranging from 4.5 to 11.7 L/s (peak flows during snowmelt and/or storm events may be higher but have not yet been measured); the water quality represents a mixture of surface runoff and subsurface seepage from the ETA area with intermediate concentrations of total iron;
- The two most reliable flow surveys (May and October 2005) indicate that incremental gains in streamflow along the Faro Creek Canyon (between FCS-2/3 and FCS-4) are very small

(0.1 to 0.7 L/s) suggesting that there is little or no groundwater discharge along the Faro Creek canyon;

Table 3: Faro Creek Flow and Water Quality

Station ID	Date	Flow L/s	S04 mg/L	Zn-T mg/L	Fe-T mg/L
FCS-1 At toe of WRD	10-Apr-05	1.3	5,030	295	88.9
	13-May-05	4.6	no sample		
	18-Oct-05	1.2	6,200	477	157
	21-Nov-05	1.0	6,370	458	131
	19-Dec-05	0.6	5,920	516	180
	Average	**1.7**	**5,880**	**437**	**139**
FCS-2 At culvert below road	10-Apr-05	frozen	no sample		
	13-May-05	9.0	no sample		
	18-Oct-05	3.4	6,210	459	61.6
	21-Nov-05	>1.0	5,890	437	36.8
	19-Dec-05	frozen	no sample		
	Average	**n/a**	**6,050**	**448**	**49**
FCS-3 Seepage face below road	10-Apr-05	4.8	5,550	309	1,210
	13-May-05	2.6	no sample		
	18-Oct-05	3.1	6,570	222	1,120
	21-Nov-05	3.4	7,460	371	1,790
	19-Dec-05	2.3	7,030	430	1,990
	Average	**3.2**	**6,653**	**333**	**1,528**
FCS-4 Mouth of Canyon	10-Apr-05	6.6	4,170	174	801
	13-May-05	11.7	no sample		
	18-Oct-05	7.2	5,750	310	773
	21-Nov-05	5.4	5,610	266	940
	19-Dec-05	4.2	5,540	278	1,220
	Average	**7.1**	**5,268**	**257**	**934**

3.3.3 Streamflow Gauging

In September 2005, continuous monitoring of flow rates along the Faro Creek channel was initiated. For this purpose, the existing V-notch weir at monitoring stations FCS-1 (X23) was upgraded and a new V-notch weir was constructed at the mouth of the Faro Creek canyon (monitoring station FCS-4). Both weirs were equipped with a PT2X sensor/data logger to allow continuous monitoring of stage height. Rating curves were developed to convert the recorded stage height to streamflow (see Appendix B for details).

Figure 5 shows the observed flow rates between mid-October 2005 and mid-January 2006 at the two monitoring stations. Seepage flow at the toe of the WRD (at X23) has gradually decreased from about 1.3 L/s in mid-September 2005 to about 0.6 L/s in early January 2006. The occasional “spikes” are believed to be related to ice jams rather than runoff events.

Seepage flows at the mouth of the Faro Canyon (at FCS-4) have also gradually decreased from about 8 L/s in mid-September 2005 to 3.5 L/s in early January 2006. The observed sudden spikes in flow are believed to be a result of mill discharge into the ETA area (in mid-September 2005) or blockage of the weir due to ice build-up.

3.4 Hydraulic Testing

Hydraulic testing during the 2005 field program consisted of packer injection tests completed in SRK05-ETA-BR2 during drilling and, after completion of all monitoring wells, a 24-hour pumping test.

3.4.1 Packer Injection Testing

During drilling of SRK05-ETA-BR2, packer injection testing was completed in bedrock portions of the drillhole. Packer injection test equipment was provided by Midnight Sun Drilling, who conducted the tests under the supervision of SRK field staff. A wireline pneumatic packer system was used for testing, incorporating nitrogen-inflated packers sealing off the test interval below the drill rods, and injection of water under known pressure into the test zone using the drill water pump. A total of four packer tests were completed in SRK05-ETA-BR2, commencing close to the bottom of the surface casing at 10.2 meters below ground surface (m.b.g.s.). Details and test results are summarised in Table 4. Data sheets for packer tests are included in Appendix D-1

Table 4: Packer Testing Summary

Test No.	Test Interval (m.b.g.s.)	Weighted Average RQD (%)*	Hydraulic Conductivity (m/s)
1	11.7 – 15.0	30	1.3×10^{-8}
2	16.0 – 19.0	15	1.1×10^{-7}
3	19.1 – 23.6	32	$< 1.0 \times 10^{-8}$
4	12.0 – 23.6	25	4.3×10^{-8}

*Weighted Average RQD calculated by wieghting RQD % by run lengths

Despite the low RQD and high fracture frequency values determined for this rock (see Table 2), packer testing results suggest the bedrock has relatively low hydraulic conductivity values. This suggests that, overall, the observed bedrock fracturing is not indicative of actual subsurface conditions. In contrast, the highest hydraulic conductivity value corresponds to an area with the lowest RQD. It is difficult to determine the precise location of the more permeable fractures, but the packer testing data suggest that the bedrock may have zones with slightly higher hydraulic conductivities than intact bedrock. Nevertheless, even the highest observed hydraulic conductivity in bedrock in this borehole ($\sim 1 \times 10^{-7}$ m/s) is more than 3 orders of magnitudes lower than the hydraulic conductivity in the alluvial sediments overlying the bedrock (see below).

3.4.2 24-hour Pumping Test

Methodology

The pumping test was conducted by Aquatech of Whitehorse, Yukon, with field supervision by SRK staff. The test was completed using a submersible pump rated to greater than 4.7 L/s (75 USGPM). Pump flow rates were measured with an inline manometer attached to the discharge line, which was directed to the culvert passing underneath the mine access road, and from there down slope to the tailings impoundment, below the FCS4 Faro Creek Canyon monitoring station.

Prior to initiation of the pumping test, a step test was conducted in SRK04-4 to determine an appropriate test discharge rate. Pumping rates of 1.9, 3.2, 3.8 and 4.7 L/s (30, 50, 60 and 75 USgpm) were used over time intervals of 20 to 50 minutes and water level changes recorded. Water level data are shown on Figure 6. A test pumping rate of ~3.2 L/s (50 USgpm) was chosen as a rate for the 24-hour test.

A 24-hr constant rate pumping test was conducted on SRK-04-4 at an average rate of approximately 3.2 L/s (50 U.S.gpm) between 09:22 on October 2and 09:50 October 3. Water levels were recorded at 11 groundwater monitoring locations and two weirs on Faro Creek, one at FCS-1 (X23) and another at FCS-4 (discussed in Section 3.3). Visual observations were taken intermittently at the groundwater seep below the mine access road (station FCS3/X7) to determine if pumping resulted in a decrease of the seepage rate. Static groundwater levels were monitored immediately prior to the pumping test and are shown on Figure 7. Table 5 summarises the monitoring locations and measurement type.

Table 5: Monitoring Station Measurements

Station Type	Monitoring Station ID	Measurement Method
Groundwater Well	P96-8A	Water Level Tape
	P96-8B	M10 Level-logger / Water Level Tape
	SRK04-4	Water Level Tape
	SRK04-3A	M10 Level-logger / Water Level Tape
	SRK04-3B	Water Level Tape
	ETA-05-1	Water Level Tape
	ETA-05-2	Water Level Tape
	ETA-05-3	Water Level Tape
	ETA-05-4	M10 Level-logger / Water Level Tape
	ETA-05-5	Water Level Tape
	SRK-05-ETA-BR1	M10 Level-logger / Water Level Tape
	SRK-05-ETA-BR2	M10 Level-logger / Water Level Tape
Surface Water Weir	FCS1/X23	Datalogger
	FCS4	Datalogger

Results

The 24-hour pumping test was successfully completed without any significant interruption or pump breakdowns. Discharge data during the testing period is included in Appendix D-2. In general, water levels at groundwater monitoring stations did not reach steady-state or indicate intersection with aquifer boundaries. Water levels and flow at each of the weirs indicated no apparent changes related to the pumping test (Figures 8 and 9). Seepage from below the mine access road was not observed to noticeably change during the testing period (based on visual observations). Figure 10 shows drawdown immediately prior to termination of the test.

Aquifer properties were determined from drawdown and recovery data with standard analytical techniques using the Waterloo Hydrogeologic software AquiferTest V3.5 and V4. Table 6 summarises the estimated aquifer properties (T and S) inferred from the drawdown/recovery data observed in the pumping well and the various monitoring wells. The best fits of the analytical solution to the drawdown/recovery data are provided in Appendix D-3.

Table 6: Results of Hydraulic Analyses from Pumping Test at SRK04-4

Monitoring Well	Average Transmissivity (m^2/d)	Average Storativity	Comment
Wells screened in Alluvial Aquifer			
SRK-04-4	50.0	NA	Pumping Well, only recovery data used in analysis
SRK-04-3A	77.9	0.018	Monitoring well at 13 m distance; drawdown and recovery data used
ETA-05-2	52.2	0.013	Monitoring well at20 m distance; drawdown and recovery data used
ETA-05-3	93.0	0.012	Monitoring well at29 m distance; drawdown and recovery data used
SRK-05-ETA-BR1	62.4	0.014	Monitoring well at 10 m distance; drawdown and recovery data used
Average	**67.1**	**0.014**	Arithmetic Average

Note: only those wells screened in the alluvial aquifer were analysed; an interpretation of pump test response in wells screened in tailings and bedrock is considered questionable as modeling assumptions are not met

The results of the pump test can be summarized as follows:

- Aquifer transmissivity (T) was estimated to be approximately 67.1 m^2/d; assuming an average aquifer thickness of 4m this represents an average hydraulic conductivity (K) of approximately $2x10^{-4}$ m/s for the alluvial sediments.
- Aquifer storativity was estimated to be approximately 0.014; this estimate is significantly lower than typical values for an unconfined sand and gravel aquifer (0.1-0.2) and greater than typical values for confined aquifers (<0.001) suggesting leakage to the alluvial aquifer from the overlying tailings (semi-confined conditions).

- Wells screened across or within tailings showed drawdown and suggest potential for desaturation of the tailings.
- The bedrock monitoring well (SRK05-ETA-BR2) showed delayed but similar drawdown response to shallower wells screened within the aquifer (SRK05-ETA-BR1).

Note that packer testing in the bedrock borehole (SRK05-ETA-BR2) suggested an average hydraulic conductivity of 4.3×10^{-8} m/s for the bedrock in the ETA area. Assuming these packer test results are representative of the bedrock in the ETA area and further assuming a bedrock aquifer thickness of about 11.6m (equivalent to the testing interval), the bedrock would have a bulk transmissivity of 0.043 m^2/day, or approximately three to four orders of magnitude lower than the overburden materials.

3.5 Hydrogeologic Conceptual Model

Based on geologic data, hydraulic testing results and hydrology data, the ETA is interpreted to have three hydrostratigraphic units and a limited, but in certain areas direct, connection of groundwater with surface flow in the former Faro Creek channel. A summary of ETA hydrostratigraphy is as follows:

Unit 1 – Tailings: silt to gravel size tailings up to 6.5 meters thick, thinning up-valley and towards the valley sides, with coarser, gravel-size, waste rock interbeds. Tailings may represent a partially confining layer to the primary aquifer, which may desaturate during pumping. Coarse waste rock interbeds may represent preferential pathways within the tailings. Hydraulic conductivity unknown, but interpreted to be lower than primary aquifer unit.

Unit 2 – Primary Aquifer: sand to gravel size alluvium interpreted to be deposits of historic Faro Creek, with sandy or gravelly-silt till in up-valley sections of the ETA and along valley walls. Includes weathered bedrock where present. Alluvium thickness varies between 2-6 meters near the mine access road, but is uncertain up-valley.
Average transmissivity = 67 m^2/day (conductivity = 2×10^{-4} m/s); average storativity = 0.014.

Unit 3 – Bedrock: phyllitic bedrock is relatively minor aquifer unit only. Intermittent discrete fracturing present but with no known preferred orientation.
Average hydraulic conductivity = 4.3×10^{-8} m/s with higher zones (up to 1.1×10^{-7} m/s)

Review of available hydraulic gradient and stream flow data suggests that the Faro Creek channel gains significant flow from groundwater along its length. While the exact location of gaining or losing reaches is unknown, data suggests this occurs in the upper reaches, but below X23. Below the mine access road, Faro Creek does not appear to gain significantly from upwelling groundwater emanating from bedrock.

3.6 Water Quality

Tables 7 and 8 summarize selected groundwater quality data collected in 2005 from existing and newly installed monitoring wells in the ETA area. Complete water quality data is included in Appendix E. The following conclusions can be drawn about the groundwater quality in the ETA area:

- All groundwater samples exceed the CCME limit of 0.05 mg/l for Zinc
- Groundwater quality in the two up-gradient wells (P96-6A&B) showed significant variations over time suggesting variable contributions of (more dilute) surface water recharge;
- Concentrations of sulphate, zinc, and in particular iron were generally higher in alluvial wells located in the ETA area compared to those wells located up-gradient; furthermore, the highest concentrations of sulphate, zinc and iron were observed in the single well screened in tailings (SRK04-03B); these observations suggest that the ETA tailings represent a significant source of contaminant loading (in particular iron) to the Faro Creek seepage;
- The sample from the bedrock well, SRK05-ETA-BR2, had the lowest contaminant concentrations of all wells in the ETA. This information suggests that bedrock groundwater is significantly less affected by ARD seepage from the Faro mine site than groundwater in the alluvial aquifer;
- Contaminant concentrations in the pumping well decreased slightly with time during the pumping test. This result may indicate a declining influence of very poor quality waters leaking from overlying tailings.

Table 7: Monitoring Well Water Quality

ID	Date	Lab pH	Lab Conductivity (µS/cm)	SO4 (mg/L)	Zn (mg/L)	Fe (mg/L)
November 2005 Sampling						
SRK05-ETA-BR1	11/2005	5.42	9750	9250	681	3100
SRK05-ETA-BR2	11/2005	6.8	2040	1200	7.41	22.5
October 2005 SRK04-04 Pumping Test						
SRK04-4	10/2/2005	5.44	7630	7370	438	1950
October 2005 Sampling (Pre-Test)						
P96-8A	9/10/2005	6.50	6370	5040	604	0.061
P96-8B	9/10/2005	6.35	6620	4980	368	9.85
May 2005 Sampling						
SRK04- 04-04	5/5/2005	5.23	n/a	7080	350	1630
SRK04-03A	5/5/2005	5.87	n/a	5480	233	693
SRK04-03B	5/5/2005	3.72	n/a	16700	749	6610
P96- 8A	5/3/2005	6.76	197	71.2	1.67	0.064
P96- 8B	5/3/2005	7.01	5540	4520	173	0.22

Table 8: Pumping Well Water Quality during Test

ID	Date	Lab pH	Lab Conductivity (µS/cm)	SO4 (mg/L)	Zn (mg/L)	Fe (mg/L)
October 2005 SRK04-04 Pumping Test						
SRK04- 04-1HR	10/2/2005	4.84	8390	8100	461	2380
SRK04- 04-10HR	10/2/2005	5.34	7780	7460	447	2020
SRK04- 04-24HR	10/3/2005	5.39	7610	7460	444	1950
SRK04- 04-36HR*	10/3/2005	5.44	7630	7370	438	1950

*NOTE: SRK04-04-36HR is a duplicate sample of SRK04-04-24HR

Comparison of groundwater quality with surface water quality (Table 3) indicates that groundwater from monitoring wells completed in the aquifer unit is slightly more impacted than surface water quality, with the notable exception of SRK05-ETA-BR2, the bedrock monitoring well, which has significantly better water quality than that of the overlying alluvial aquifer or Faro Creek.

4 Assessment of Contaminant Sources and Loading

4.1 Contaminant Sources

4.1.1 Waste Rock Seepage

Waste rock seepage represents a significant contaminant source for ETA groundwater and surface water (Faro Creek). Two monitoring wells installed close to X23 in 1996 (P96-8A and 8B) show high concentrations of sulphate, zinc and other metals. Sulphate and zinc concentrations show similar trends to surface water quality at X23. Sulphate has increased from about 2,000 mg/L in 1996 to about 4,000 mg/L in 2003. Zinc has increased from about 2 mg/L to greater than 100 mg/L in the same 8-year time span.

4.1.2 ETA Tailings

Groundwater quality results from ETA monitoring wells indicate that the tailings also represent a significant source of contaminants (in particular iron) to the Faro Creek seepage. ETA wells have significantly higher concentrations than upstream wells and a well completed in the tailings (SRK04-3B) had the highest observed concentrations and lowest pH. Concentrations were also highest in the pumping well at early times, potentially when tailings leakage likely represented a larger proportion of discharged water.

4.1.3 Other Sources

The waste rock seepage at X23 represents only some of the seepage that enters the ETA. There are also intermittent flows from the waste rock north of X23 and from the mill area. Site staff also report that other wastes, such as the concentrate removed during thickener cleaning, have been introduced into the ETA. These wastes presumably remain mixed in with the tailings. No independent sampling of these sources has been completed; therefore, their contribution to contaminant loadings is not distinguishable from the contribution by tailings.

4.2 Contaminant Loading in Groundwater and Surface Water

4.2.1 Faro Creek and Alluvial Groundwater

Table 9 summarizes the observed surface water flows and calculated loads of sulphate, total zinc and total iron at the four sampling locations along the Faro Creek channel. The following conclusions can be drawn with respect to contaminant loading in surface water upstream and downstream of the ETA area:

- The contaminant load associated with surface runoff entering the ETA area (i.e. waste rock dump seepage reporting to X23) is generally much smaller (<25%) than the combined contaminant load discharging from the ETA area (in surface runoff and groundwater discharge combined);

- The contaminant load associated with surface runoff from the ETA area varies significantly (in relative and absolute terms), due to significant seasonal variations in both flow and contaminant concentrations (see table 3);
- Groundwater discharge along the seepage face downstream of the ETA area (immediately below the access road) represents the primary source of contaminant loading during winter baseflow and a significant source of loading during the remainder of the year;
- The total sulphate and zinc load discharging from the ETA area (at FCS-4) varies with flow conditions; for example, zinc loading ranged from 70 t/yr during the (wet) fall to 36 t/yr during the winter baseflow; the total iron load at FCS-4 remained surprisingly constant over time (~170 t/yr);
- During the October 2005 survey, the combined sulphate and zinc loads from FCS-2 and FCS-3 agreed very well with the observed total loads at FCS-4. The load estimates for the other surveys are considered too uncertain (in particular for FCS-2 due to freezing of the culvert) to allow similar mass balance calculations.

Table 9: ETA Surface Water and Seepage Loading, October 2004

Date	Station	Flow L/s	S04 Load t/yr	Zn Load t/yr	Fe Load t/yr
10-Apr-05	FCS-1	1.3	206	12.1	3.6
	FCS-2	frozen	0	0	0
	FCS-3	4.8	840	46.8	183
	FCS-4	6.6	868	36.2	167
18-Oct-05	FCS-1	1.15	225	17.3	5.7
	FCS-2	3.4	666	49.2	6.6
	FCS-3	3.1	642	21.7	109
	FCS-4	7.2	1306	70.4	176
21-Nov-05	FCS-1	1.01	203	14.6	4.2
	FCS-2	1.0 to 2.0	196 – 392	14 – 29	1.9 – 3.9
	FCS-3	3.4	800	39.8	192
	FCS-4	5.4	955	45.3	160
19-Dec-05	FCS-1	0.63	118	10.3	3.6
	FCS-2	frozen	0	0	0
	FCS-3	2.3	510	31.2	144
	FCS-4	4.2	734	36.8	162

🟨 Estimated range

4.2.2 Bedrock Groundwater

Table 10 presents loading estimates for the bedrock system, based on available data from SRK05-ETA-BR2. These estimates assume: the hydraulic gradient is the same as the overlying alluvial aquifer under static conditions (~0.064); a width of 200m (~50m wider than the interpreted alluvial system); and a thickness in bedrock of 20m (total area = 4000m^2). The maximum and minimum hydraulic conductivities from packer testing were used for calculations.

The estimated contaminant loads associated with groundwater flow in bedrock are 3-4 orders of magnitude lower than the contaminant loads observed in the alluvial aquifer (at FCS-3). The much lower contaminant loads are a result of the orders-of-magnitude lower bedrock permeability plus significantly lower contaminant concentrations.

Table 10: Groundwater Loading in Bedrock

	K (m/s)	Flux (m3/s)	Zn Concentration (mg/L)	SO4 Concentration (mg/L)	Zn Load (tonnes/yr)	SO4 Load (tonnes/yr)
1-min	$1.8x10^{-8}$	$4.6x10^{-3}$	7.41	1200	0.0011	0.1714
2-max	$1.1x10^{-7}$	$2.8x10^{-2}$	7.41	1200	0.0065	1.048

4.3 Contaminant Loading to Rose Creek Valley

The calculated loads at FCS4 are interpreted to represent most of the total load to Rose Creek Valley from the ETA. As discussed above, upstream loads from FCS2 and FCS3 balance very well with observed (combined) load at FCS4 and groundwater moving in the deeper bedrock is estimated to carry only a very small, even negligible load.

5 Conceptual Design of Seepage Interception System

The primary sources of contamination in the ETA are the up-gradient waste rock dumps, the mill area and the ETA tailings themselves. While removal of the ETA tailings is a feasible option for partial source control, the waste rock dumps and mill site will not likely be removed as part of the mine closure, though options to reduce infiltration through these areas and, subsequently, load from them, are being considered. Consequently, collection systems to intercept the main flow of contaminated groundwater will be required for an indefinite period of time.

This extended period of time will allow any capture system to be refined or upgraded. Various technologies installed in phases, as necessary, maximize the overall capture efficiency of the total system.

5.1 Assessment of Previous Design Concepts

SRK (2004) proposed a SIS consisting of a fence of pumping wells up-gradient of the mine access road for groundwater control, in combination with a sump for collection of Faro Creek surface water flows. As part of the 2005 investigation, further work was completed on assessing the viability of this option.

Utilising the additional data collected during the 2005 investigation, a scoping level numerical model was created for the ETA to determine the number of pumping wells that would be required for the recommended SIS. The numerical model was a 2-D, finite element model using the code Feflow, produced by WASY (WASY, 2006). An initial model was calibrated to steady-state static conditions and then run transiently for comparison with results of the 24-hour pumping test. This initial model was used to assess longer term interception using different combinations and positioning of pumping wells (see Appendix F for details).

The numerical modeling suggested that pumping wells alone would not provide adequate capture of contaminated groundwater passing through the ETA. A “stagnation point” or line beyond which the pumping wells had either no, or only a minimal, effect developed down-gradient of the fence of pumping wells, leading to bypass of some contaminated groundwater. The primary factor affecting the ability of the pumping wells to capture all groundwater was related to the limited available drawdown and elevation difference between the location of the pumping wells and the down-gradient seepage face. Complete capture could only be achieved by allowing drawdown in the pumping wells to go below the elevation of the seepage face, an operational measure that is not practical considering the local geology and the potential for “well fouling”, i.e. blinding of the well screen with iron precipitates, due to aeration of the well screen when water levels are drawn down significantly.

5.2 Recommended Approach

The approach recommended herein has three components:

1. Construction of a “Primary Seepage Interception System” that will be as effective as possible given the current understanding of the site conditions;
2. Installation of a monitoring system to assess performance of the Primary SIS; and
3. A series of contingency measures to be implemented according to a well-defined Adaptive Management Program.

5.2.1 Primary SIS

The primary seepage interception system will have groundwater and surface water collection components, which will be constructed after removal of the ETA tailings. Conceptual layout of the SIS is shown on Figure 11. Figure 12 shows two longitudinal cross-sections through the ETA including the proposed SIS.

Currently, a large volume of tailings are present (scoping estimate of >64,000 m^3) and it is assumed that tailings will be removed by hydraulic mining and or excavation (truck and shovel) with some additional materials cleanup required (~10,000-20,000 m^3). Once the tailings have been removed, a berm will be built out approximately 20 meters from the edge of the mine access road, into the ETA area, that would act as both a platform for construction of the interception system and support for the flood-retention structure.

Groundwater Interception

Groundwater will be intercepted using a combination of slurry cut-off wall and pumping wells upstream of the mine access road, constructed from the top of the berm. The slurry wall would be emplaced using trenching equipment and a soil-bentonite slurry, which would be keyed into weathered bedrock. Pumping wells would be installed up gradient of the cut-off wall. The pumping wells would be screened in the overburden soils and the underlying weathered bedrock. In areas where the overburden soils along the proposed alignment are comprised of lower permeability till material (in particular, close to the valley sides), a permeable trench would be installed down to bedrock using the same trenching equipment as the slurry-wall. In those areas, the pumping wells would be screened directly into this permeable trench and underlying weathered bedrock. In the central portions of the valley, near SRK04-4, where permeable alluvium has been identified during drilling, the permeable trench would likely not be required, but could be installed if deemed appropriate by field engineers.

Based on the results of our initial loading calculations, direct interception of groundwater flow in deeper bedrock (below weathered bedrock) using a grout curtain plus pumping wells screened in deeper bedrock would not be included in the primary SIS. However, these system components were included as optional components of the adaptive management plan. This is described further in Sections 5.2.2 and 5.2.3.

Based on the available hydraulic information, a well spacing of approximately 50m (between two neighbouring pumping wells) is proposed, requiring a total of 5 pumping wells (Figure 11). This spacing should provide some redundancy in the system to allow maintenance of individual pumping wells without complete system shutdown. The screening intervals of the pumping wells would be selected sufficiently below the water table to minimize aeration of the well screen during active pumping. Pumping wells would be outfitted with automatic controllers, including water level recorders and flow meters, to maintain a positive hydraulic gradient toward the up gradient side of the barrier and to provide information regarding total load captured. The system would be equipped with an alarm system to alert the operator if the system was malfunctioning (e.g. pump breakdown).

The proposed combination of a hydraulic barrier with a fence of pumping wells located up-gradient of the barrier provides a very high collection efficiency. The hydraulic barrier improves the hydraulics of the capture system (by essentially ponding the groundwater up-gradient for collection) and also provides a secondary containment in the case of temporary shut-down of the pumping system (e.g. due to power failure). One of the authors of this report recently designed, constructed and operated a similar hydraulic barrier system at a development site in North Vancouver, BC to prevent hydrocarbon contamination. This hydraulic barrier system was operated successfully for over three years with no detectable by-pass of contaminated groundwater (Wels, 2002).

Surface water collection in the ETA would have three components: (i) flood detention storage, (ii) collection of contaminated surface runoff (Faro Creek seepage), and (iii) bypass of clean run-off from surrounding areas.

Flood Detention Storage

Scoping level estimates indicate that removing the tailings and associated cleanup could provide 100,000 m^3 of storage behind the mine access road. This volume is estimated to be adequate to store pre-closure flood flows up to the 100-yr event and most post-closure flows (Appendix C). Only the estimated “long-duration” post-closure events, such as a 1-week 100-yr event (average 278 l/s), would exceed this storage. Flows greater than the 100-yr event, or long duration events that exceed storage, would be passed downstream via an emergency spillway.

Consequently, it is proposed that all pre-closure storm flows be stored in the ETA detention pond until they can be pumped to a water treatment plant or the Faro Pit. The interim water quality of the runoff flows post-closure (after cover construction) is unknown, but it is conservatively assumed that runoff water quality will initially remain poor and will continue to require treatment and storage in the ETA. Once runoff has sufficiently improved, it could be allowed to directly discharge to Faro Creek canyon (i.e. no storage). The mine access road, berm and cut-off wall are envisioned to hold back water in the ETA detention area. No assessment has been made regarding any geotechnical upgrades to the mine access road that may be required. The suitability of this structure will require assessment in the detailed design phase.

It should be noted that significant storage of flood water in the ETA over extended periods of time may temporarily compromise the performance of the groundwater SIS. The ponding of surface water would tend to increase the groundwater level on the up gradient side of the barrier for the period of ponding. In order to prevent this upstream mounding, the following control measures would be implemented:

- Provide adequate pumping capacity to reduce the pond height relatively quickly after a significant storm event; and/or

- Line the upstream face of the berm and the foot print area of the detention pond within a narrow corridor (say 20m distance) upstream of the berm using a synthetic liner (see Figures 11 and 12).

The final design of a flood-storage structure in the ETA will require integration with overall site water treatment plans. If the structure is to operate only as a short-term, emergency retention structure, with water pumped as quickly as possible to the treatment facility, the total volume of treatable water would increase substantially. Alternatively, if the ETA were designed such to provide medium-term flood water storage, the additional water could be directed to the treatment plant at a more constant rate. A third option would be to utilize a long term storage pond elsewhere, either in the Faro Pit or constructed elsewhere. Decision on how storage should be accommodated will have to be addressed after the final closure plan has been determined and will then include final sizing of pumps and pipelines.

Faro Creek Seepage Collection

Surface runoff in the historic Faro Creek channel (primarily seepage from the Faro waste rock dumps) will likely remain contaminated for the foreseeable future. Faro Creek water will be re-aligned towards a sump in the ETA, once tailings have been removed (see Figures 11 and 12). Water will be directed from the sump to the main pumping well discharge line, from which it will be directed to the water treatment plant.

Run-off Bypass

Currently, there is a component of the ETA catchment, located southeast of the ETA, which likely generates relatively clean run-off. A shallow ditch will be constructed along the southeast margin of the ETA to divert this water from entering the ETA. Water in this ditch would be directed past the mine access road and Faro Creek Canyon to a reasonable discharge location. Under closure conditions, when covers have been installed over waste rock dumps, the drainage ditch would be extended to allow capture of additional clean water prior to it entering the ETA area.

5.2.2 Initial Monitoring System

Both groundwater and surface water monitoring will continue for the duration of interception. Monitoring locations would be focused in four general areas: (i) up-gradient of the cut-off wall,

(ii) immediately down gradient of the cut-off wall, (iii) in the area of the seepage face below the access road and (iv) at the mouth of the Faro Creek Canyon. Monitoring station locations are shown on Figure 11. Combined with surface water monitoring stations, the multiple tiers of groundwater monitoring wells would allow for the assessment of SIS performance by observing different scale flow systems, from small scale in close proximity to the cut-off wall to larger scale between the ETA and the mouth of the Faro Creek Canyon. Monitoring stations would be used to provide assessment of system performance via four general parameters:

1. Groundwater gradients;
2. Groundwater quality;
3. Surface water discharge rate;
4. Surface water load.

All groundwater monitoring wells would be nested or multi-level, with zones in overburden, weathered bedrock and deeper bedrock (Figure 12). Packer testing would be conducted during installation to provide additional information regarding bedrock permeability. Monitoring wells located between the pumping wells up-gradient of the cut-off wall and immediately down gradient of the cut-off wall would be monitored to assess the hydraulic gradients created by the SIS. Vertical gradients in monitoring wells located immediately down gradient of the cut-off wall, as well as water levels from monitoring wells located between pumping wells, when combined with water quality data, would allow detection of underflow or other forms of cut-off wall bypass.

Note that downstream-directed gradients across the cut-off wall may still occur due to elevation differences and dewatering of the down gradient side, even if all groundwater was captured in the SIS. Hence, additional monitoring of groundwater quality in these wells (plus surface water monitoring at the seepage face, see below) will be required to assess system performance.

Three monitoring wells will be installed in bedrock in the upper Faro Creek Canyon, (i.e. immediately down gradient of the mine access road - see Figure 11 for location). During installation, packer tests will be carried out in the bedrock to assess the bedrock permeability and to assist with selection of the screening intervals. These monitoring wells will be used to monitor groundwater gradients and groundwater quality in downstream bedrock in response to system operation. Information from these monitoring wells, in conjunction with information from the bedrock wells completed immediately down gradient of the SIS, would be used to assess the potential for seepage by-pass in bedrock (see section 5.2.3).

A groundwater monitoring station would also be located at the mouth of the Faro Creek Canyon. This station would be used primarily to monitor absolute and relative water quality. Hydraulic gradient information would be obtained that could be used to further characterise the larger-scale flow system, but would not be an integral part of the monitoring system. While it may take considerable time for water quality at this location to improve, due to its proximity to the tailings impoundment and its current poor water quality, water quality is unlikely to worsen.

Surface water monitoring would include discharge rate and water quality at three of the four pre-SIS monitoring stations: FCS-1, FCS-3 and FCS-4. FCS-2, currently located on the downstream end of the culvert passing under the mine access road, would be deactivated once this culvert is blocked by the berm and cut-off wall. If the system is working properly, there should be no more discharge of seepage along the current seepage face monitored at FCS-3, except perhaps for some minor flow of “clean” groundwater from the surrounding areas. The presence of highly contaminated water at this location would indicate cut-off wall bypass. Monitoring at FCS-4 will provide a final check on seepage collection (groundwater and surface water combined). Assessment of load at FCS-4 will improve the understanding of contributions from the ETA area itself, which should not contribute significantly if the SIS is working properly, and from the relatively small catchment downstream of the ETA. Monitoring at FCS-1 (X23) would continue to improve understanding of the ETA hydrology and would detect potential improvement in water quality assuming covers are installed on the waste rock dumps. This information would be used to determine the timing for extension of the shallow runoff collection ditches to bypass relatively clean water around the ETA.

5.2.3 Adaptive Management Program

Performance of the Primary SIS would be assessed using surface water and groundwater data from the monitoring system. If surface water or groundwater parameters reach or surpass monitoring triggers, contingency measures would be implemented.

The monitoring triggers and contingency measures can be grouped into three main areas:

1. Area adjacent to the cut-off wall,
2. Down gradient of the cut-off wall (at seepage face), and
3. Mouth of Faro Creek Canyon.

In all areas, the first action upon reaching a monitoring trigger would be an investigation into the cause and determination of appropriate remedial steps. If trigger values are reached after these initial remedial action steps, then additional investigations or remedial actions would be taken as described below.

Area adjacent to cut-off wall

In this area, the monitoring system would consist primarily of multi-level groundwater monitoring wells, located both immediately up gradient and down gradient of the wall itself. Groundwater monitoring would include two components:

1. Hydraulic gradients
2. Groundwater concentrations

Hydraulic gradients would be monitored primarily between pumping wells and monitoring wells located on the up gradient side of the cut-off wall. Lack of adequate drawdown in water levels at these monitoring locations would suggest pump inefficiency or improper spacing. Remedial actions would include an investigation of the pumping system and repair or installation of additional pumping wells, as necessary.

In the event of a significant increase in groundwater contaminant concentrations from baseline levels, two responses are possible. If the initial investigation suggested edge bypass, additional pumping wells would be installed closer to the ends of the cut-off wall. If the investigation suggested that underflow through the bedrock system was occurring, options for grouting and/or pumping of the bedrock would be investigated.

Bedrock grouting could be completed along either of two alignments: immediately below the cut-off wall, or down gradient of the mine access road, where Faro Creek Canyon begins to narrow. At this time, there is insufficient bedrock data to provide a recommended option. Data should be collected in both locations during installation of the monitoring system. If the cut-off wall alignment were chosen, monitoring would continue as before. If the down gradient alignment were chosen, the interim collection sump would likely require upgrading to allow continued operation, but monitoring would continue as prior to the trigger, as described in the following.

Area down gradient of the cut-off wall (at seepage face)

Surface water and groundwater would be monitored in the vicinity of the seepage face in the Upper Faro Creek Canyon (near monitoring station FCS-3). The flow rate and water quality of seepage at this location (FCS-3) would be monitored as part of surface monitoring. If the SIS is working properly, there should be no surface flow at this monitoring station, besides local inputs from precipitation recharge. If contaminated seepage was identified, a remedial investigation would be conducted. Remedial actions could include, as necessary, repair or improvement of the pumping system or re-activation of the interim collection system. If seepage could be linked to underflow at the cut-off wall, an investigation into bedrock grouting options would be completed.

Groundwater monitoring would focus on water quality. If contaminant concentrations were observed to increase from baseline levels, an investigation would be completed. If surface seepage were not observed, changes in contaminant concentrations would likely be related to underflow. In this case, options for bedrock grouting would be investigated.

Area at mouth of Faro Creek Canyon

Both surface water and groundwater would be monitored at the mouth of the Faro Creek Canyon (at monitoring station FCS-4). Surface water monitoring would include water quality, discharge and load. If the SIS is working properly, there should be only minimal surface flow at this location, particularly during baseflow conditions. Surface water monitoring would include continued operation of the FCS-4 weir and datalogger. The trigger at this location would be the presence of contaminated seepage. If contaminated seepage were observed, an investigation of the upstream SIS would be completed. Remedial actions for upstream areas would be implemented as appropriate. If contaminated seepage were determined to be the result of upwelling groundwater, pumping wells could be installed in this area. Further measures would include bedrock grouting options, if appropriate, and/or secondary containment structures.

Groundwater quality would be monitored and compared to baseline values. The trigger for investigation and remedial action would be an increase above baseline conditions. Due to its location on the edge of the tailings impoundment and the current presence of contamination, improvements in water quality here are unlikely to occur for a significant period of time. In fact, it may even be possible that contaminant concentrations in groundwater (in particular in bedrock) may even increase before they decrease, even if the SIS is working as intended. A detailed investigation into the likely causes for any increase in contaminant concentrations at this location (including a comparison with up gradient system monitoring), and an assessment of the associated loading to the Rose Creek valley aquifer would be required before additional remedial action would be taken.

If such an investigation concluded that contamination could not be effectively intercepted at the up gradient SIS and that the contaminant load represented a risk to the downstream environment, a secondary groundwater interception system (e.g. consisting of a cut-off wall and/or pumping wells) would be installed at the mouth of Faro Creek canyon.

As a final contingency, if initial remedial actions at any or all monitoring areas do not provide adequate capture to protect the downstream aquatic environment, a secondary containment structure or capture system could be developed in or below the Faro Creek canyon.

5.3 Further Work

Additional design work should be completed on flood detention structure options at the ETA during the detailed design phase. The ability to design appropriate control structures for estimated flood discharge is limited by the relatively short and intermittent record of flow for the historic Faro Creek channel at FCS-1 (X23), uncertainty regarding actual volume of tailings and related materials that will be removed from the ETA and uncertainty about the final design and effectiveness of waste rock covers. Each of these items should be further assessed prior to final design.

Monitoring of Faro Creek flows should continue and improvements of flood hydrology completed. Uncertainty regarding volumes of water that could potentially be bypassed during a large flood event, and the consequent loading, will be decreased only by improvement in flood forecasting. As part of flood forecasting, an assessment of risks associated with bypass of excess flood waters should be completed.

Regardless of these uncertainties, the mine access road is likely to be needed to perform as a control structure to some degree. An assessment of what the access road may be used as, or what level of upgrading would be necessary, should be undertaken by a Professional Geotechnical Engineer.

Prior to additional work in the ETA area, a detailed ground survey should be conducted of the historic Faro Creek channel, focusing on the canyon and seepage face areas downstream of the mine access road.

Routine groundwater and surface water monitoring should continue to further develop baseline conditions for use with the Adaptive Management Program.

The interim collection sump will be installed in 2006/2007 and operated during summer months. Contaminant capture monitoring at this system should be used to improve the understanding of system dynamics and loading estimates. Water quality and discharge monitoring should occur at a location down-gradient of the interim collection sump to assess capture efficiency.

This report, **“2005/06 Task 20e - 2005 Seepage Investigation at the Emergency Tailings Area”**, has been prepared by SRK Consulting (Canada) Inc.

Daniel Mackie, M.Sc.

Dr. Christoph Wels, Ph. D., M.Sc.

Quinn Jordan-Knox, M.Sc.

Reviewed by

Cam Scott, P.Eng.

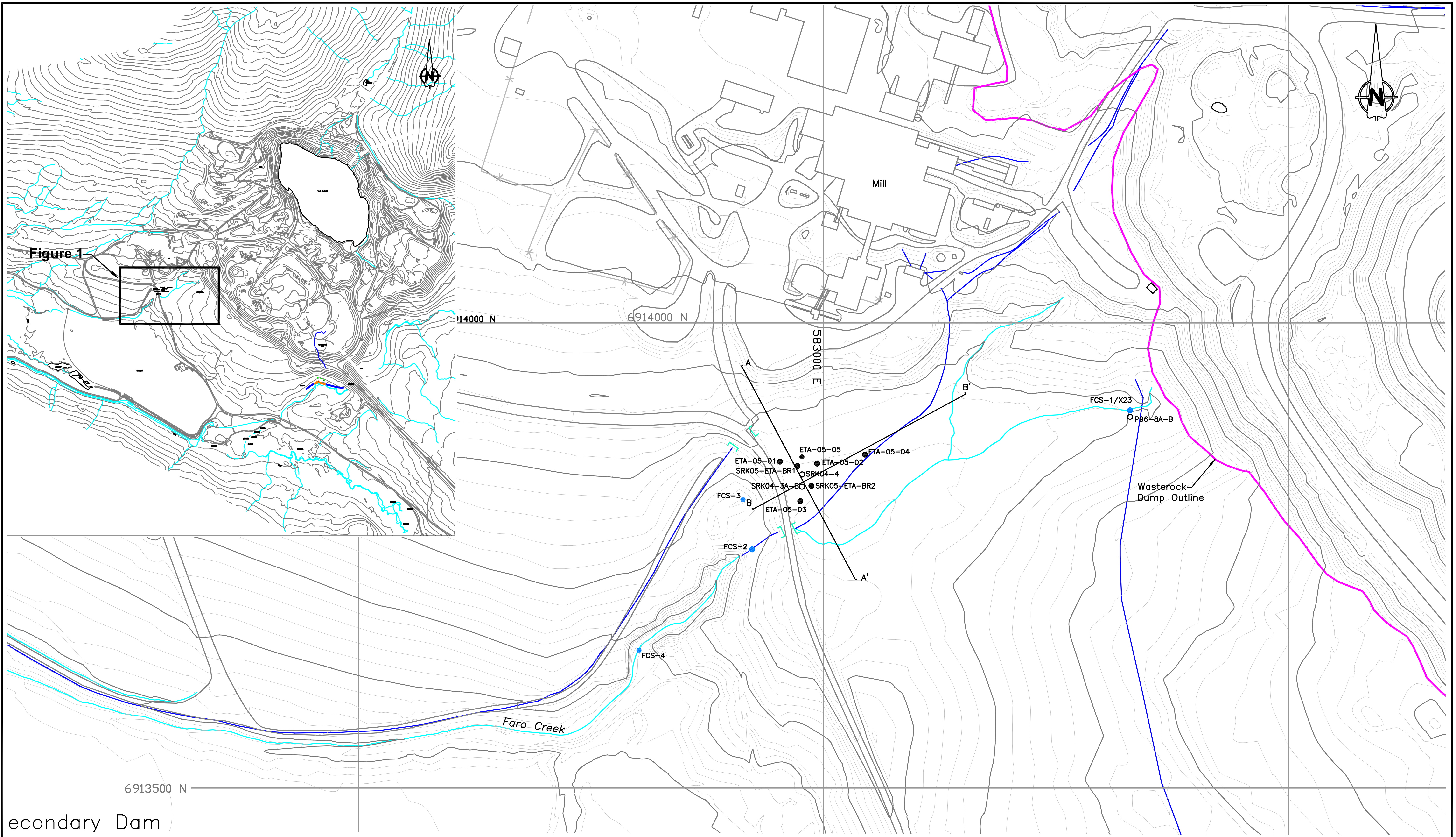
6 References

SRK, 2006 Preliminary Seepage Collection Options – Faro and Grum Waste Rock Dumps; prepared for Deloitte and Touche, Interim Receiver for Anvil Range Mining.

WASY, 2006 FEFLOW Interactive Graphics-based Finite Element Simulation System for Subsurface Flow and Transport Processes, WASY Institute for Water Resources Planning and Systems Research Ltd., Berlin, Germany.

Wels, C. 2002 Use of Waterloo Barrier in Progressive Reclamation of Hydrocarbon Plume, Paper published in Proceedings of the 55th Canadian Geotechnical Conference, Niagara Falls, Ontario, October 20-23, 2002.

Figures



File Ref: 2006 Acad drawings\ FARO SITE PLAN-updated-DM.dwg

LEGEND

- ● 2005 Groundwater Monitoring Well
- ○ Other Groundwater Monitoring Well
- ● Faro Creek Monitoring Station
- — Pipeline

50 0 100 200 300 feet

25 0 50 100 150 Metres

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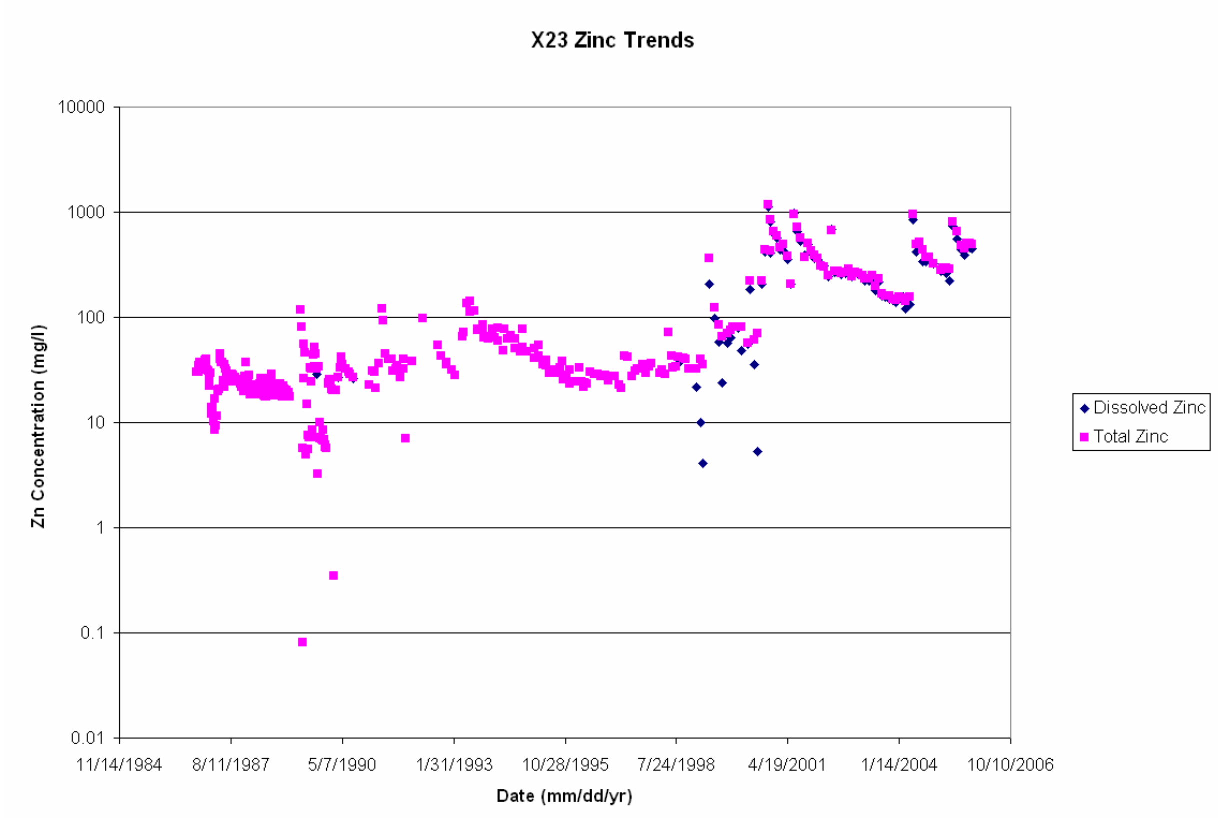
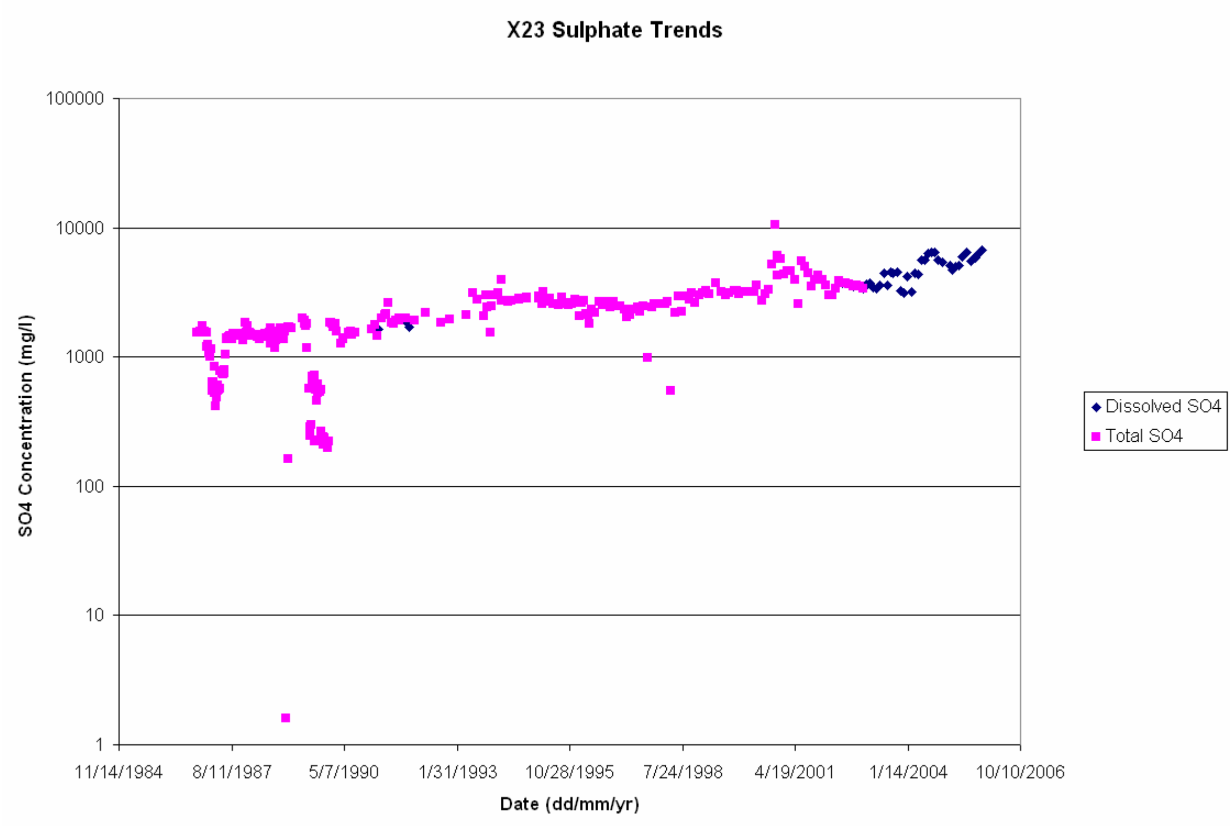
FARO MINE SITE ETA

SITE LOCATION MAP

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Feb. 2006	QJK	1





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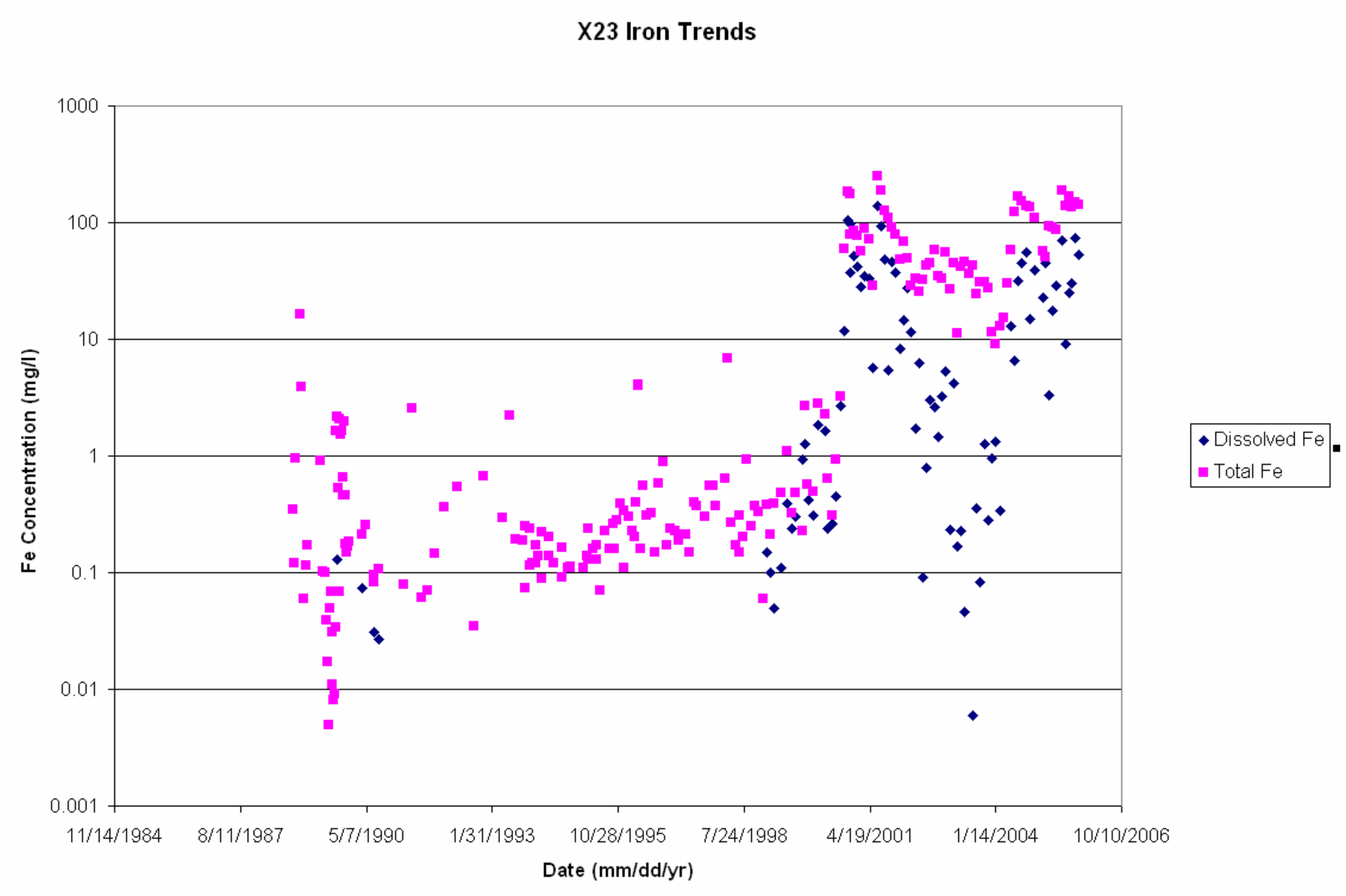
Task 20e – Continue Seepage Investigations

Historical Water Quality at X23

PROJECT: 1CD003.073	DATE: April 2006	APPROVED:	FIGURE: 2a



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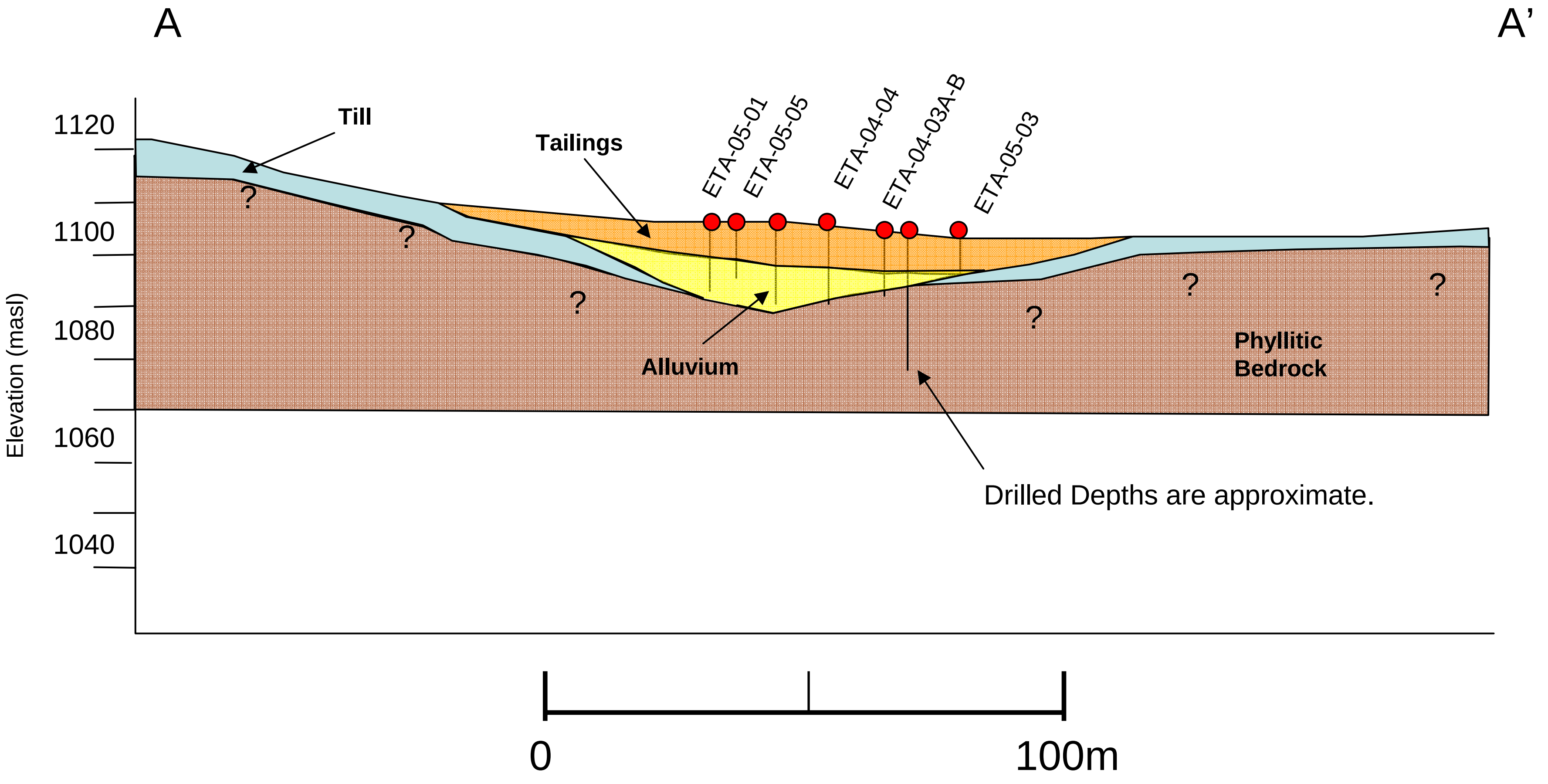
Task 20e – Continue Seepage Investigations

Historical Water Quality at X23

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.073	April 2006		**2b**



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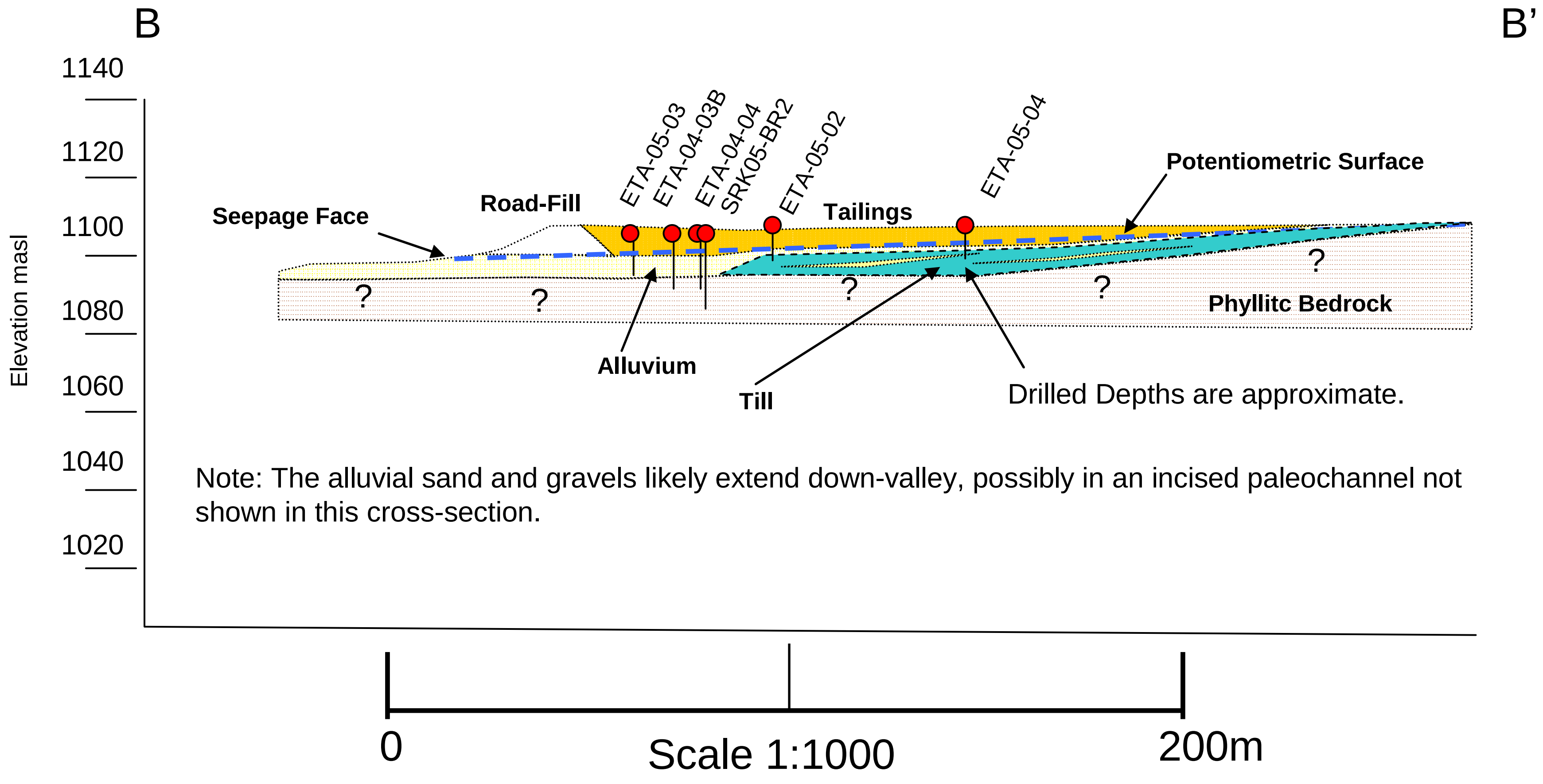
Task 20e – Continue Seepage Investigations

Cross-section A – A'

PROJECT:	DATE:		FIGURE:
1CD003.73	April 2006		3



Drilled Depths are approximate.

Note: The alluvial sand and gravels likely extend down-valley, possibly in an incised paleochannel not shown in this cross-section.

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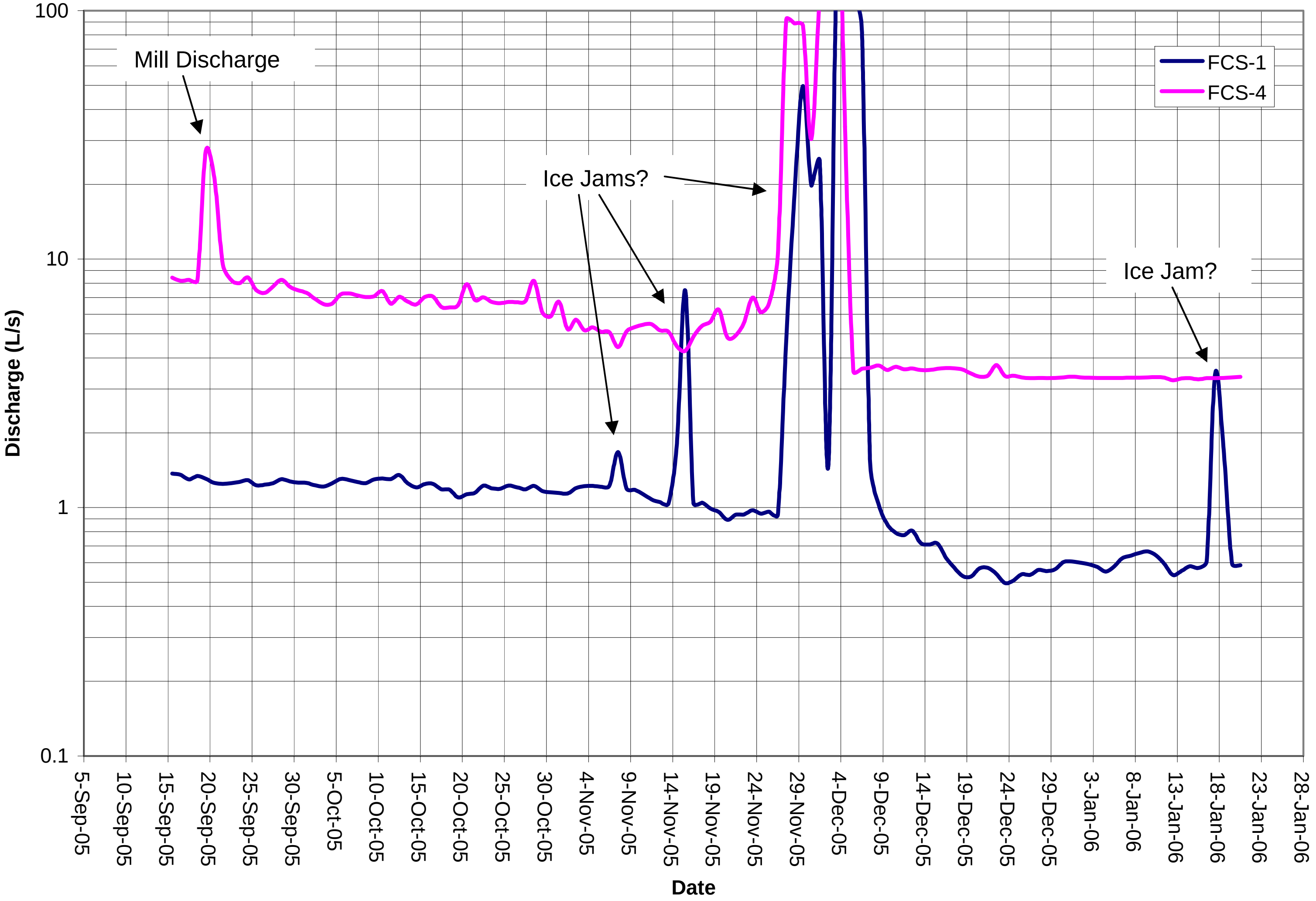
Cross-Section B – B’

PROJECT:	DATE:		FIGURE:
1CD003.73	April 2006		4



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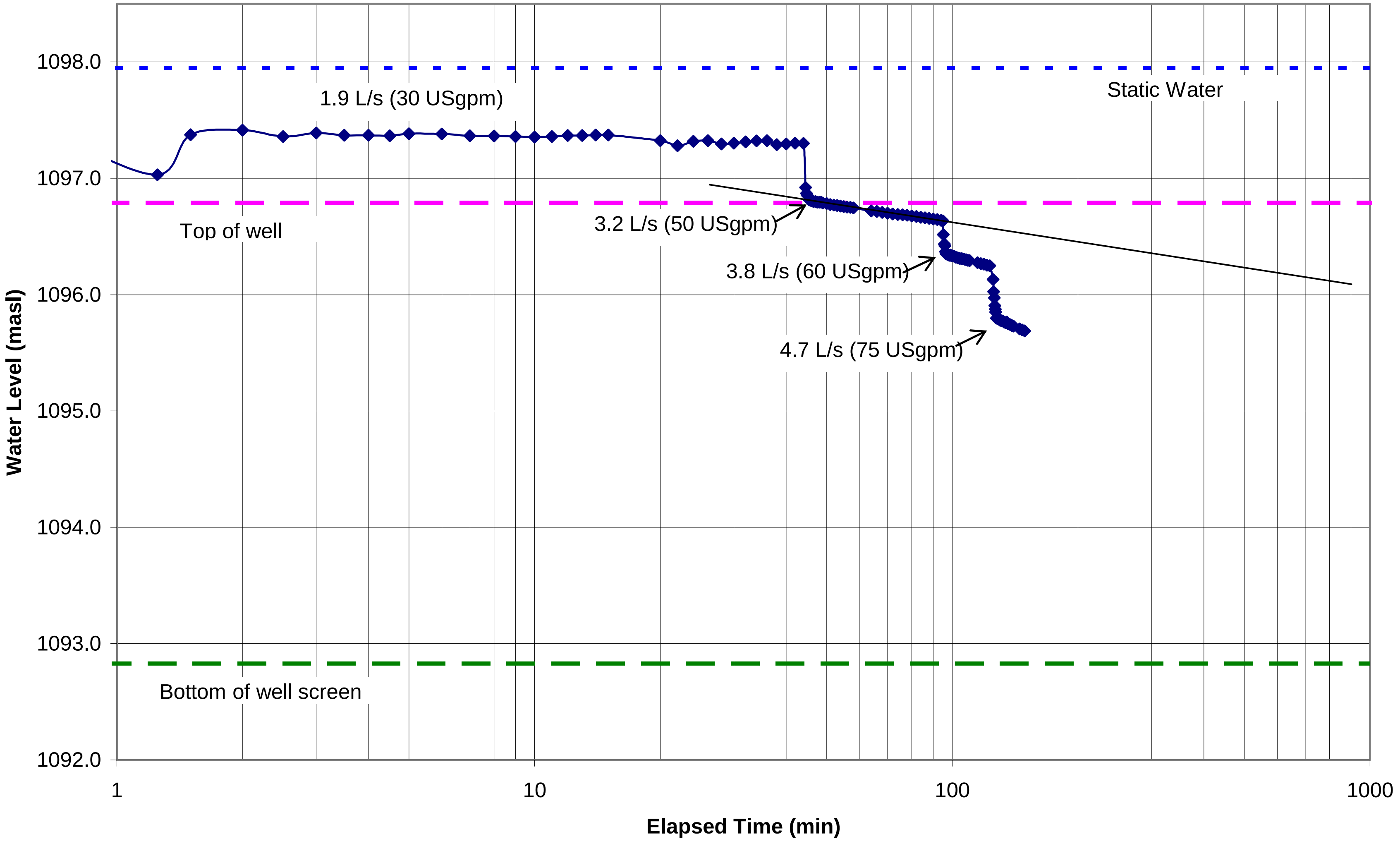
Task 20e – Continue Seepage Investigations

FCS-1 and FCS-4 Weir Discharge Data

PROJECT:	DATE:		FIGURE:
1CD003.73	April 2006		**5**



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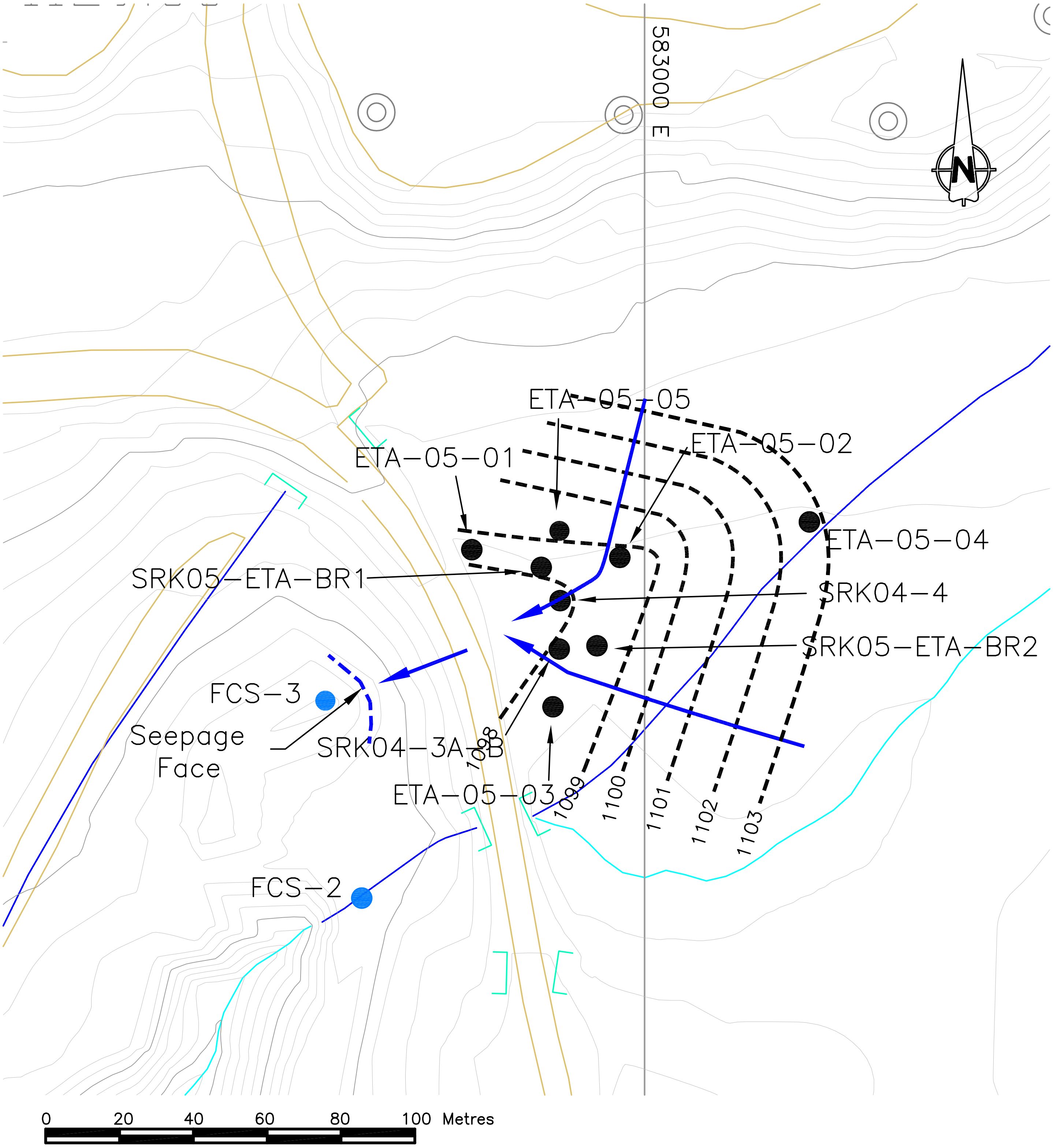
Task 20e – Continue Seepage Investigations

SRK04-4 Step Test Results

PROJECT:	DATE:		FIGURE:
1CD003.73	April 2006		**6**



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

● Groundwater Monitoring Well

– – – – Hydraulic head Contour

← Groundwater Flow Line

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Task 20e - Continue Seepage Investigation

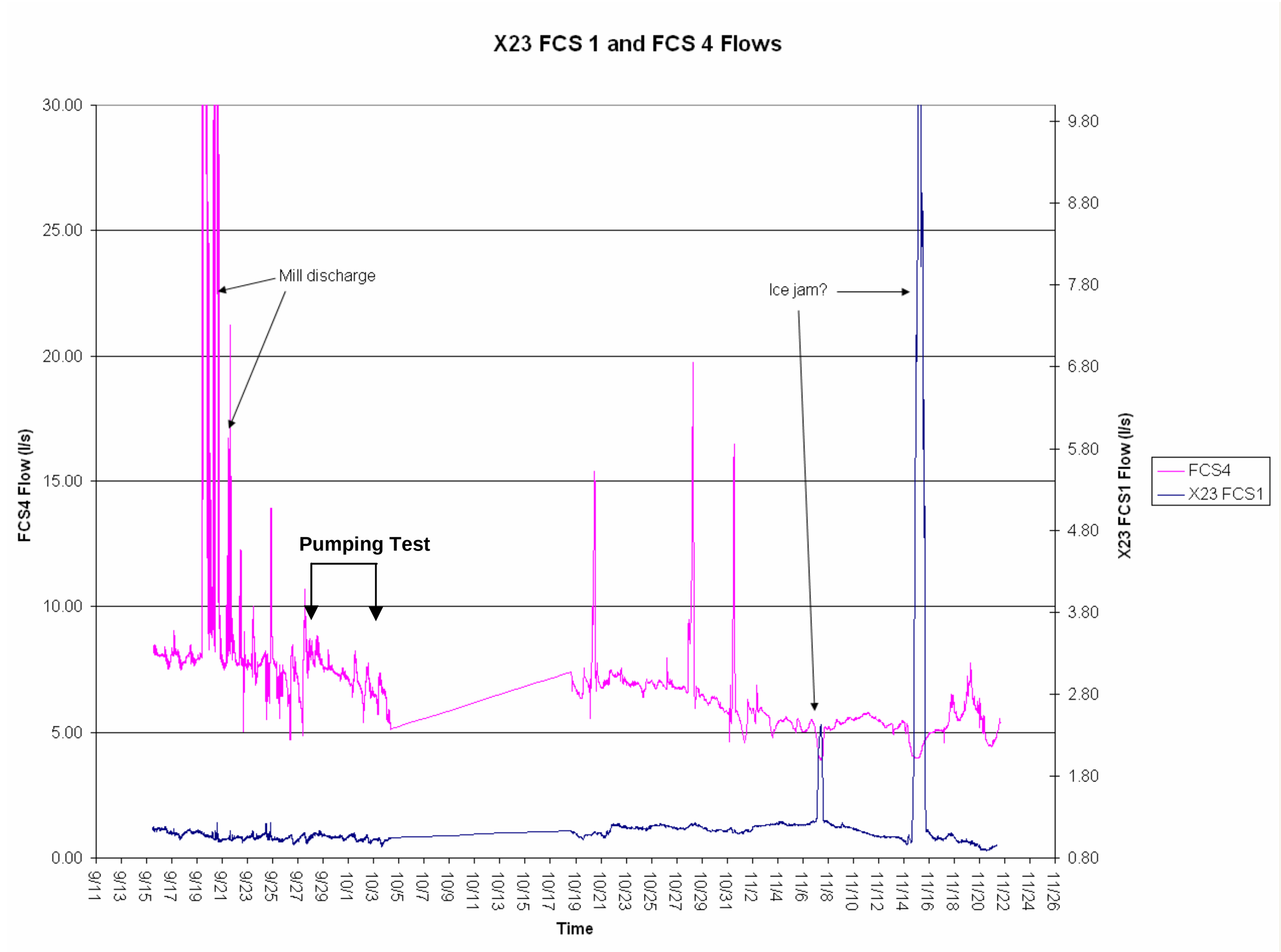
Static Groundwater Levels

SRK JOB NO.: 1CD003.073

FILE NAME: \2006 Acad drawings\FARO SITE PLAN-ETA-QJK.dwg

Faro Mine Site

DATE:	APPROVED:	FIGURE:
April 06	QJK	7



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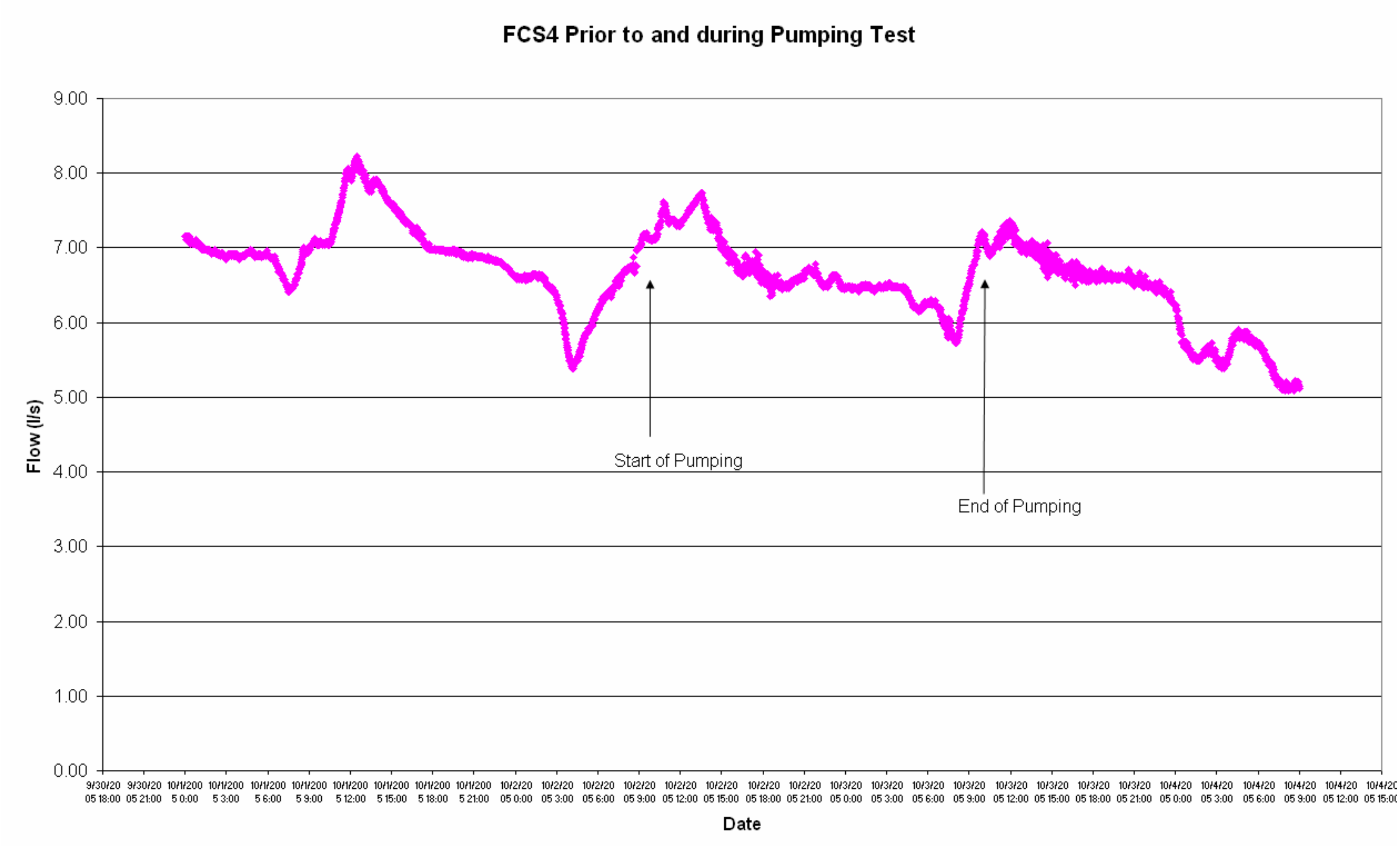
Task 20e – Continue Seepage Investigations

ETA Surface Flows in Faro Creek

PROJECT:	DATE:		FIGURE:
1CD003.73	April 2006		8



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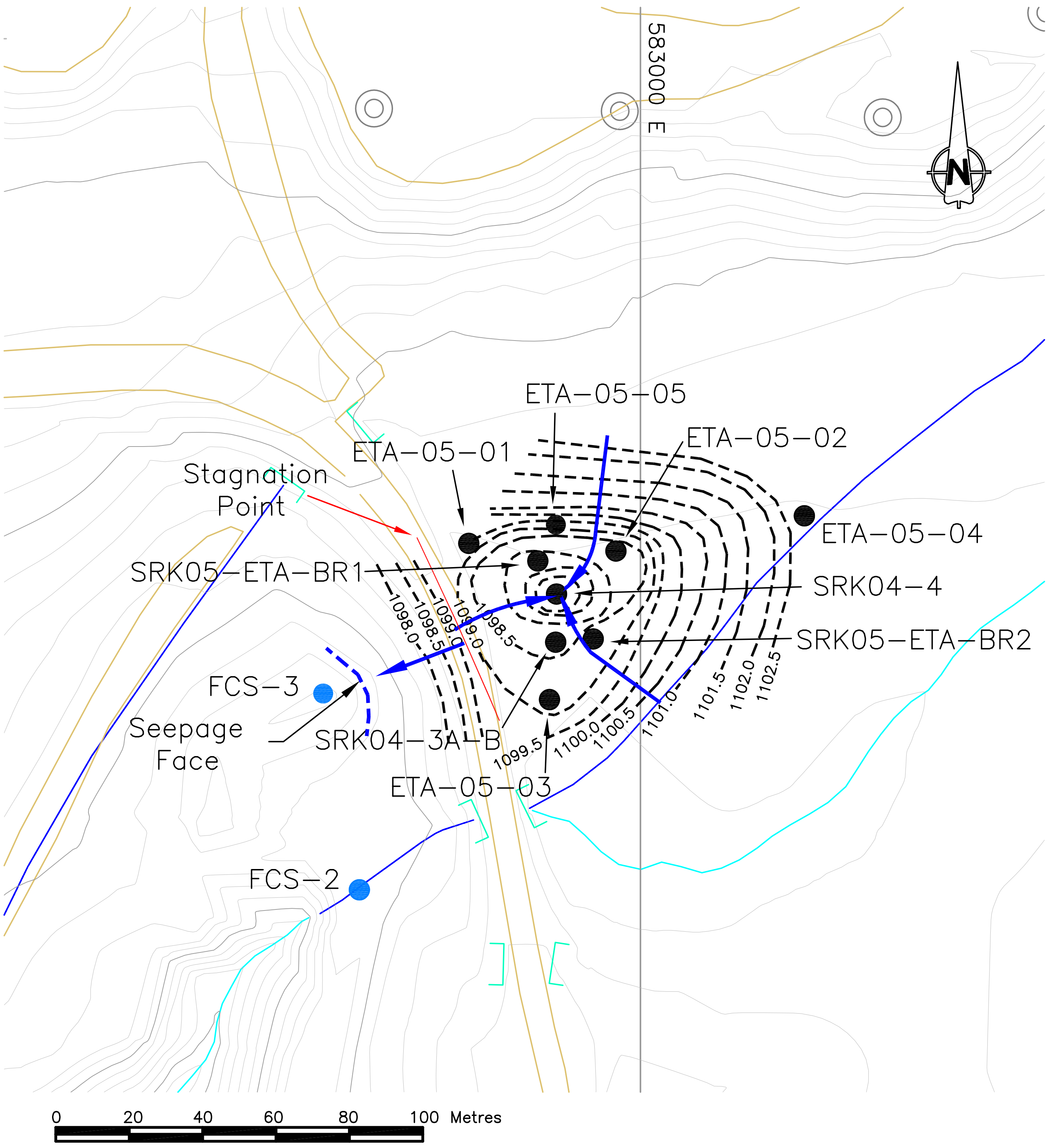
Task 20e – Continue Seepage Investigations

Faro Creek Flows at FCS4 during Pumping Test at SRK04-4

PROJECT:	DATE:		FIGURE:
1CD003.73	April 2006		9



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

●	Groundwater Monitoring Well
– – – –	Hydraulic head Contour
←	Groundwater Flow Line

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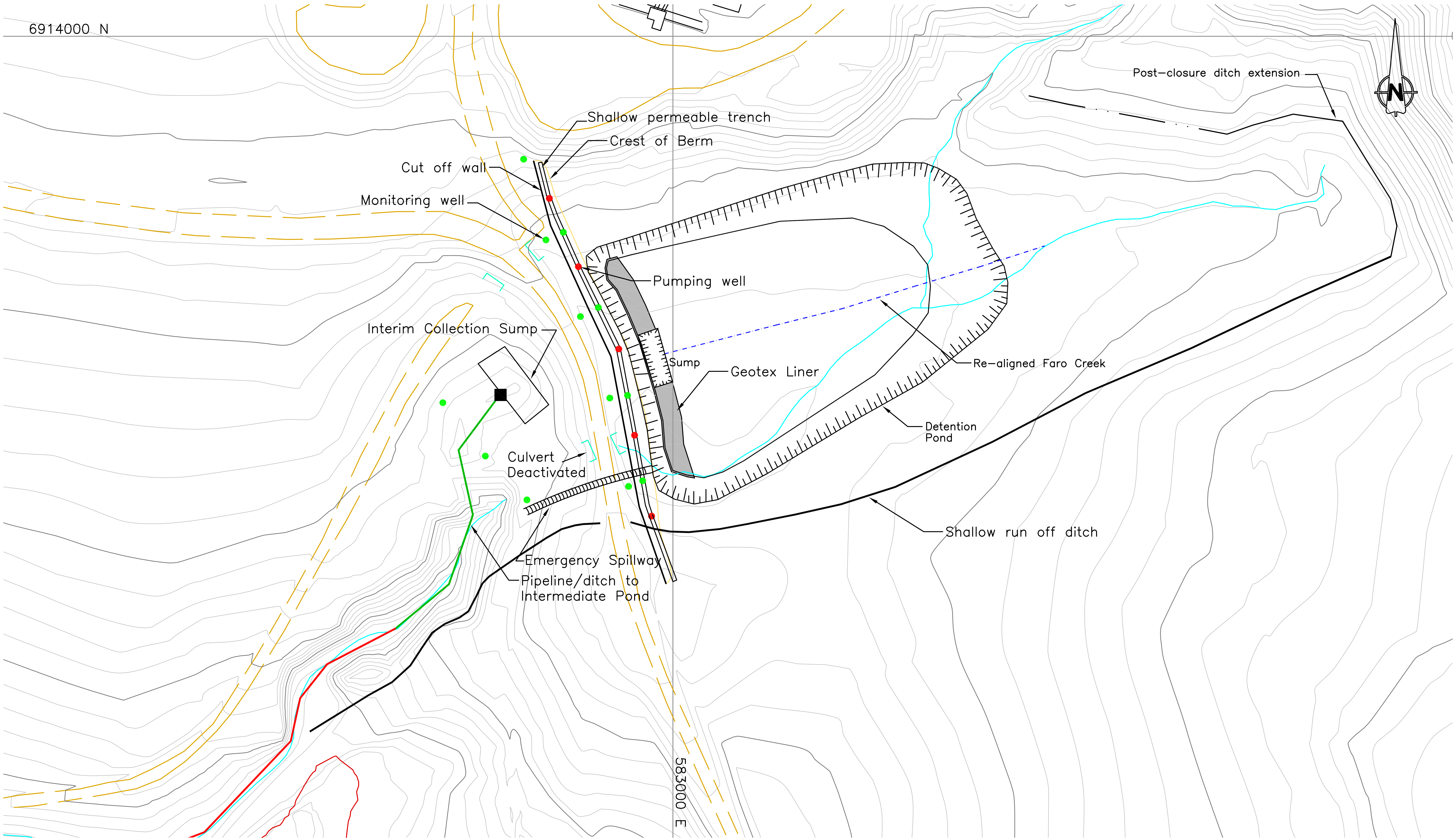
Task 20e - Continue Seepage Investigation

Groundwater Levels at end of Pumping

Faro Mine Site

SRK JOB NO.: 1CD003.073
FILE NAME: \2006 Acad drawings\ FARO SITE PLAN–ETA–QJK.dwg

DATE: April 06
APPROVED: QJK
FIGURE: 10



10 0 20 40 60 Metres
1:2000

SRK CONSULTING
Faro Mine, Yukon
Map Scale:1:20,000
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
● Monitoring Well
● Pumping Well
— Pipeline

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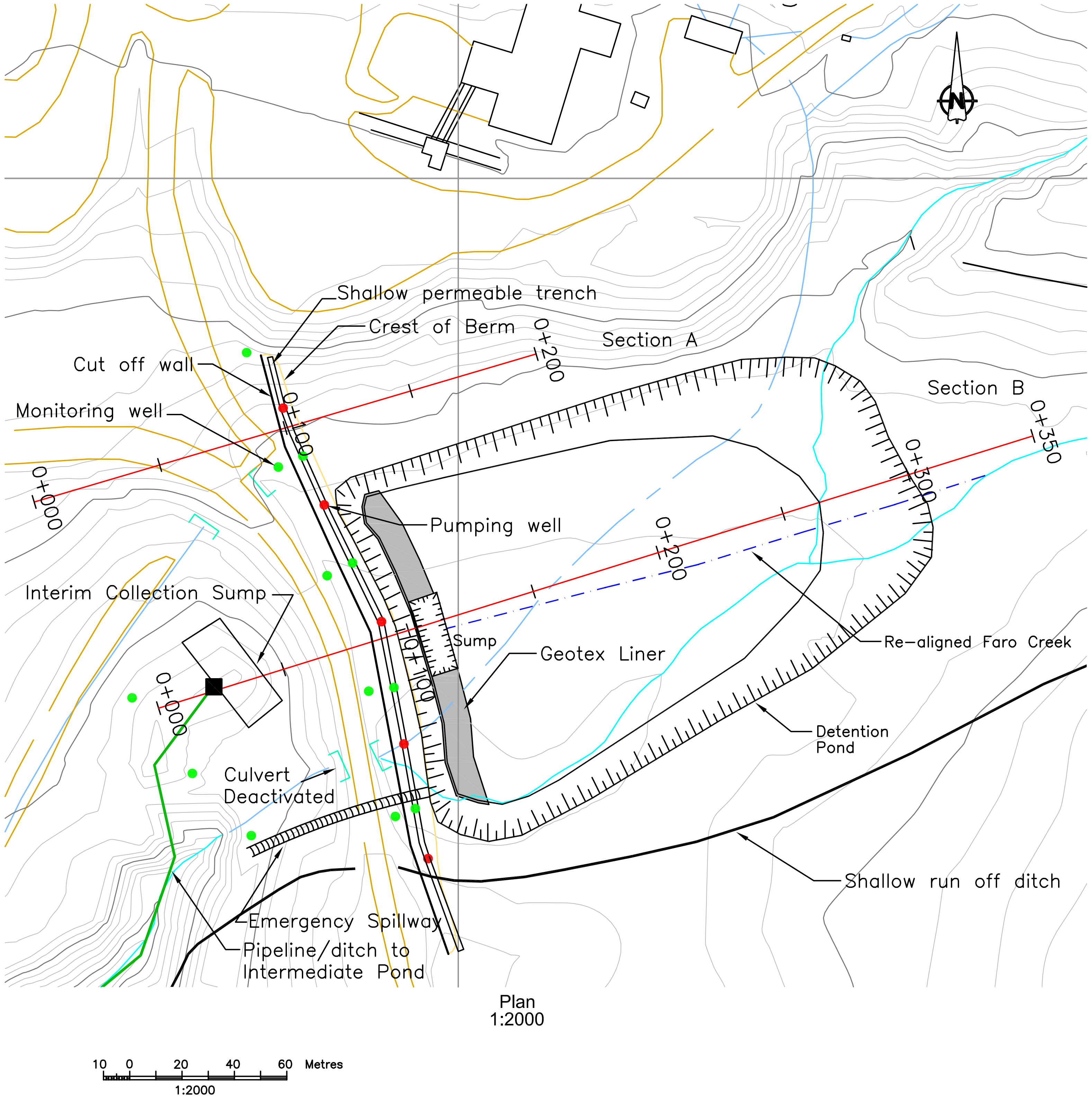
Task 20e - Continue Seepage Investigation

Conceptual Design
of ETA SIS

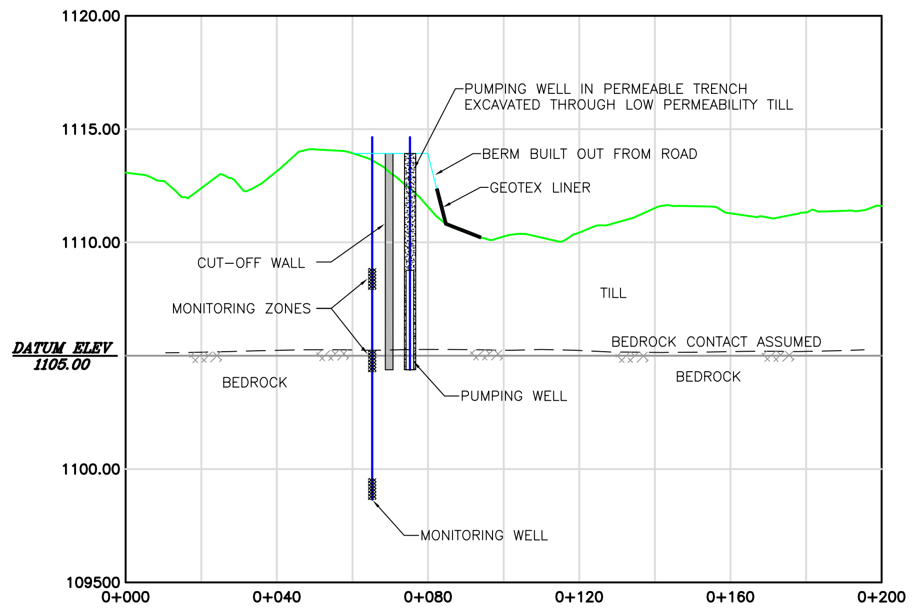
SRK JOB NO.: 1CD003.073
FILE NAME: \2006 Acad drawings\ 2006 FARO SITE PLAN–LDD.dwg

Faro Mine Site

DATE:	APPROVED:	FIGURE:
April 06	DM	11

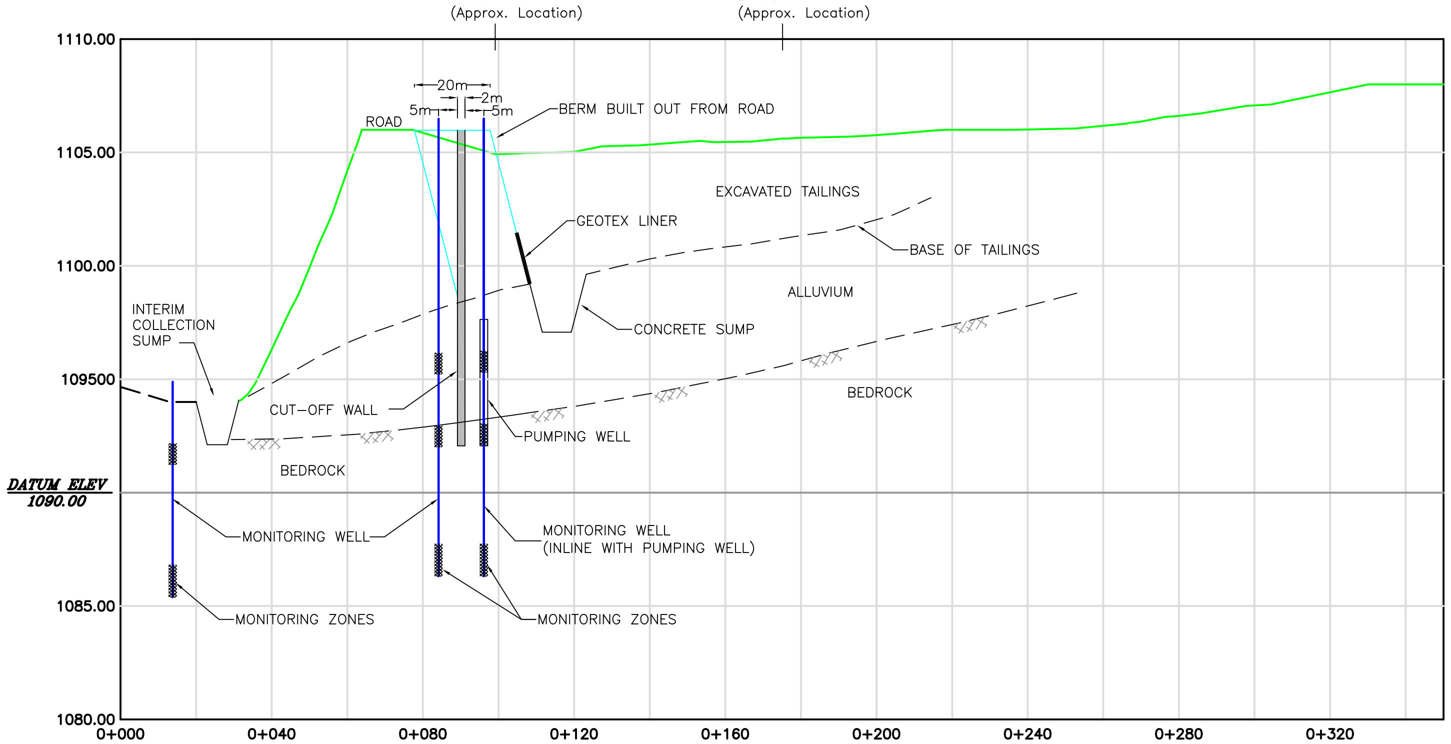


Plan
1:2000



Section A
1:2000 vertcal scale 6x Exag.

NOTE: MONITORING WELLS
PROJECTED TO SECTIONS



Section B
1:2000 vertcal scale 6x Exag.

Faro Mine, Yukon
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 Vancouver	Deloitte & Touche	Task 20e - Continue Seepage Investigation
		ETA SIS Schematic Cross Sections
SRK JOB NO.: 1CD003.073	Faro Mine Site	DATE: April 06
FILE NAME: \2006 Acad drawings\ 2006 FARO SITE PLAN-LDD.dwg		APPROVED: DM
		FIGURE: 12

Appendix A

Borehole Drill Logs

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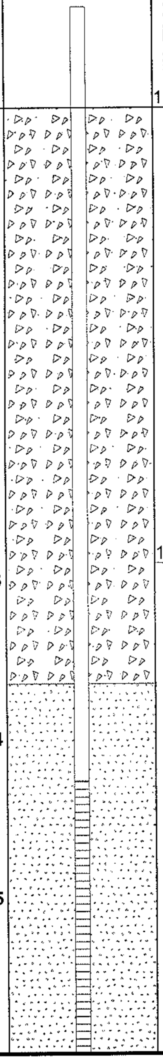
BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913851.00 N 582953.00 E **DATUM:**

BOREHOLE: ETA-05-01
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon



DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	STRATIGRAPHY DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
		1104.49	Natural ground surface								
		0.00	Sand, gravelly, little fines.		1				0 Light brown, slightly moist sand mixed with dark gray discrete pods. Surface has subangular gravel.		
					2				0.152000 Dark grey to black, fresh sulphides (sand), no oxidation, moist (sl.).		
					3				0.305000 Light yellowish brown gravelly sand, anulgar gravel, slightly moist, gravel up to 2cm.		
	1									1	
5				SGF	4				0.610000 Dark grey Sx sand, some lenses up to 20cm with more fines, fresh Py (sand). Bottom of unit has more Py sand, less fines. Slightly moist.		
	2									2	
					5				2.134000 Brownish orange, gravelly sand. Silt, moist to very moist. Angular gravel (20%) up to 3cm. No fresh Sx observed.		
		1101.59									
10	3	2.90	Gravel, silty, sandy.						2.896000 Mottled white/orange/grey/brown zone, dry to slightly moist, silty sandy gravel (ang., up to full core diam. (4")). Lenses full of visible Py up to 20cm. Dry to sl. moist.	3	
	4									4	
15					6						
	5									5	

X:\06 REFERENCE MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:20hrs

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913851.00 N 582953.00 E **DATUM:**

BOREHOLE: ETA-05-01
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		TYPE OF SAMPLER	
☒	Remoulded	DC	Diamond core barrel
▨	Undisturbed	GS	Grab sample
■	Lost	SS	Split spoon
◧	Rock core		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
	7		1097.18 7.32				■				7	
25	8			Sand, gravelly, silty.		7	■			7.315000 Original ground. Peat layer ~ 5cm, coarse fibrous. Smells like diesel.	8	
30	9		1095.35 9.14			8	■			7.620000 Dark chl green to olive green gravelly silty sand, moist to wet, mottled rusty zone at 8.53m. Smells like diesel from 7.62-8.53m.	9	
35	10 11			END OF BOREHOLE							10 11	

X:\06 REFERENCE MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:20hrs

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BOREHOLE LOG

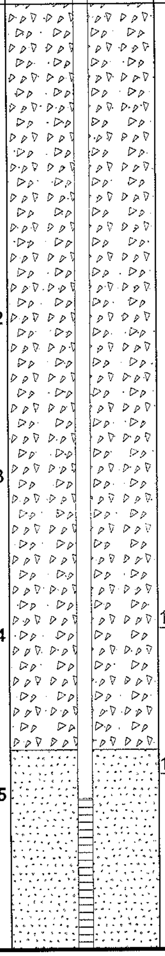
PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913849.00 N 582993.00 E **DATUM:**

BOREHOLE: ETA-05-02
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

WELL DETAILS & WATER LEVEL - m



STRATIGRAPHY

ELEVATION - m	DEPTH - m	DESCRIPTION
1104.23		Natural ground surface
	0.00	Tailings
1100.27	3.96	Sandy gravel
1099.35	4.88	Till

SAMPLES

TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION
1	■			0 Light brown gravelly sand, dry angular - subangular gravel; ETA surface material
2	■			0.300000 Yellowish gray moist tailings, 95% fresh, sandy silt, vertical black and orange laminations
3	■			1.200000 Yellowish brown sand (tailings), very slightly moist, 5% loosely cemented, no silt.
4	■			3.000000 Dark gray tailings sand, little to no silt, moist. WL appeared to be at 4.0m.
5	■			4.300000 Mixed tailings and organics.
6	■			4.500000 Sandy gravel, light brown, subangular - subrounded, moist.
7	■			5.500000 Olive green till, silty sandy gravel, moist, diesel smell.

DEPTH - ft	DEPTH - m
5	1
10	2
15	3
	4
	5

LABORATORY and IN SITU TESTS

X:\06 REFERENCE MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:20hrs

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913849.00 N 582993.00 E **DATUM:**

BOREHOLE: ETA-05-02
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
						8	■			6.500000 Coarse sand with gravel, no silt.		
	7					9	■			6.700000 Wet till, silty sandy gravel, light orange, brown.	7	
25			1096.63 7.60	END OF BOREHOLE								
	8										8	
	9										9	
30												
	10										10	
35												
	11										11	

X:\06_REFERENCE_MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:20hrs

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913808.00 N 582975.00 E **DATUM:**

BOREHOLE: ETA-05-03
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			0.00	Natural ground surface								
			0.00	Tailings		1	■			0 Dry gravel, subangular, 40% sand, orange.		
	1					2	■			0.400000 Yellowish brown coarse tailings, <5% angular gravel mixed in, dry to slightly moist.	1	
5	2					3	■			1.500000 Dark gray fresh tailings, silt with 5% sand, wet.	2	
10 15	3 4 5					4	■			3.000000 Yellowish gray tailings sand, fresh, wet, very little silt.	3 4 5	
						5	■			5.250000 Wet silt (tailings-fresh) as from 1.5-3m.		

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913808.00 N 582975.00 E **DATUM:**

BOREHOLE: ETA-05-03
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			-6.71 6.71	Sand/ gravel		6	■			6.750000 Fibrous peat.		
	7					7	■			6.780000 Coarse sandy gravel with silt; light brown, wet. Angular-subrounded gravel.	7	
25							■			7.500000 Dark chl green till, gravelly sandy silt, moist, angular gravel chips to 3cm diam.		
	8		-7.92 7.92	Till		8	■				8	
			-8.53 8.53	Bedrock		9	■			8.400000 Looks like bedrock. Powder rock flour and chips that look like quartzite - siliceous.		
30	9		-9.00 9.00	END OF BOREHOLE							9	
	10										10	
35												
	11										11	

X:\06_REFERENCE_MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:21hrs

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913858.00 N 583045.00 E **DATUM:**

BOREHOLE: ETA-05-04
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

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: RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			1104.51	Natural ground surface								
			0.00	Tailings		1	■			0 Pale orangeytan silty gravel; streaks of yellow and orangey silt.		
5	1					2	■			0.200000 Fine to medium sand tailings. Transitions from orange at top through brownish orange, yellowish. Gray, brownish yellow with depth. Moist.	1	
10	2 3 4					3	■			1.700000 Uniform yellowish dark gray fresh medium sand tailings, moist.	2 3 4	
15	5		1099.94 4.57	Tailings/OVB contact		4	■			4.500000 Run was lost. Driller says cobble layer prevented any recovery. Transition from tailings to overburden occurred over this interval. Driller thinks overburden starts at 6m. Based on drill response.	5	

X:\06_REFERENCE_MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:21hrs

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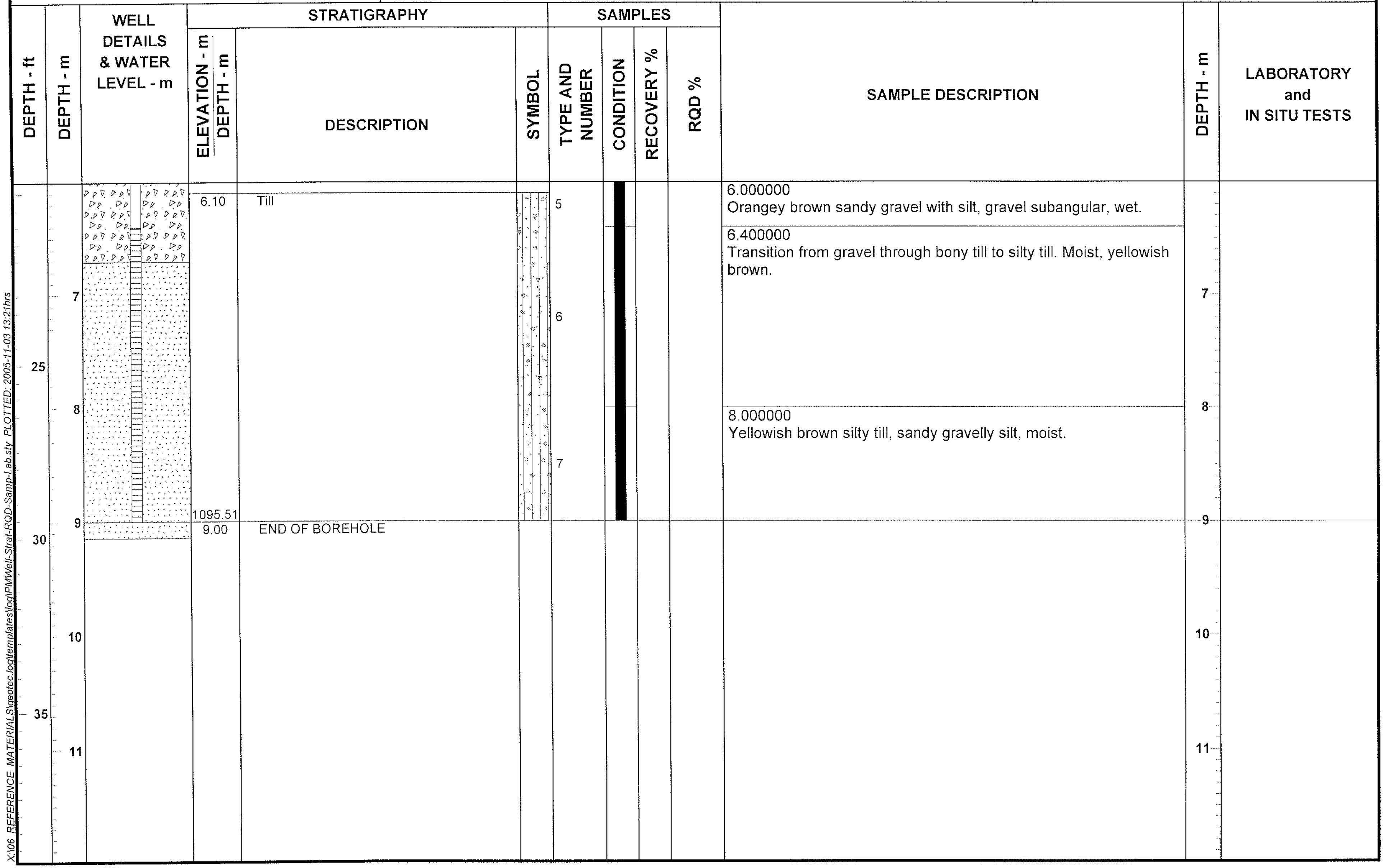
BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 TO
DIP: **AZIMUTH:**
COORDINATES: 6913858.00 N 583045.00 E **DATUM:**

BOREHOLE: ETA-05-04
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		TYPE OF SAMPLER	
☒	Remoulded	DC	Diamond core barrel
▨	Undisturbed	GS	Grab sample
■	Lost	SS	Split spoon
◨	Rock core		



DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m / DEPTH - m	STRATIGRAPHY DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	SAMPLES CONDITION	SAMPLES RECOVERY %	SAMPLES RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			6.10	Till		5	■			6.000000 Orangey brown sandy gravel with silt, gravel subangular, wet.		
						6	■			6.400000 Transition from gravel through bony till to silty till. Moist, yellowish brown.		
						7	■			8.000000 Yellowish brown silty till, sandy gravelly silt, moist.		
			1095.51 9.00	END OF BOREHOLE								

X:\06 REFERENCE MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:21hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

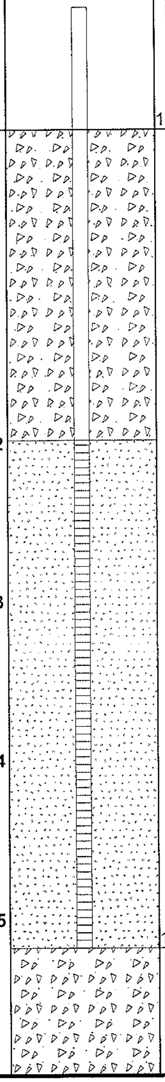
PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913856.00 N 582977.00 E **DATUM:**

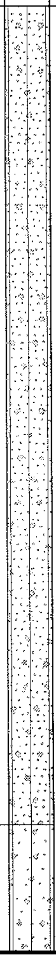
BOREHOLE: ETA-05-05
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

WELL DETAILS & WATER LEVEL - m





DEPTH - ft: 5, 10, 15
DEPTH - m: 1, 2, 3, 4, 5

ELEVATION - m DEPTH - m	STRATIGRAPHY DESCRIPTION	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
1104.66	Natural ground surface							
0.00	Tailings	1	■			0 Tan sandy gravel, dry to slightly moist, subangular - subrounded gravel		
		2	■			0.5 Yellowish, brown tailings, fine sand with silt, moist. Isolated orangey-brown clasts.		
		3	■			0.700000 Granite cobble, stuck in bit. Lost 0.7-1.5m. Driller indicated that it felt like moist tailings as from 0.5-0.7m.	1	
		4	■			1.500000 Moist silty fine sand tailings, yellowish brown.		
		5	■			1.700000 Tan sandy gravel as from 0-0.5m.	2	
		6	■			2.000000 Yellowish brown fine to medium sand tailings, slightly moist, little to no fines.	3	
		7	■			3.800000 Tailings as above - transition to yellowish gray in colour.	4 5	
1099.48 5.18	Peat, original ground	8	■			5.200000 Dark gray to black organics and silt. Moist.		
		9	■			5.400000 Tan to light brown fine to medium sand with silt, moist.		

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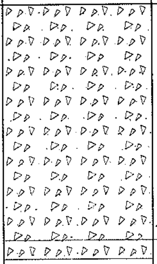
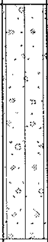
BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-15 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6913856.00 N 582977.00 E **DATUM:**

BOREHOLE: ETA-05-05
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY			SAMPLES				SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %			
	7					10	■			6.200000 Chl green silty sandy gravel, moist. Particles subrounded to subangular. Becomes sandier towards end of borehole.	7	
25			1097.16 7.50	END OF BOREHOLE								
	8										8	
30	9										9	
	10										10	
35	11										11	

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BOREHOLE LOG

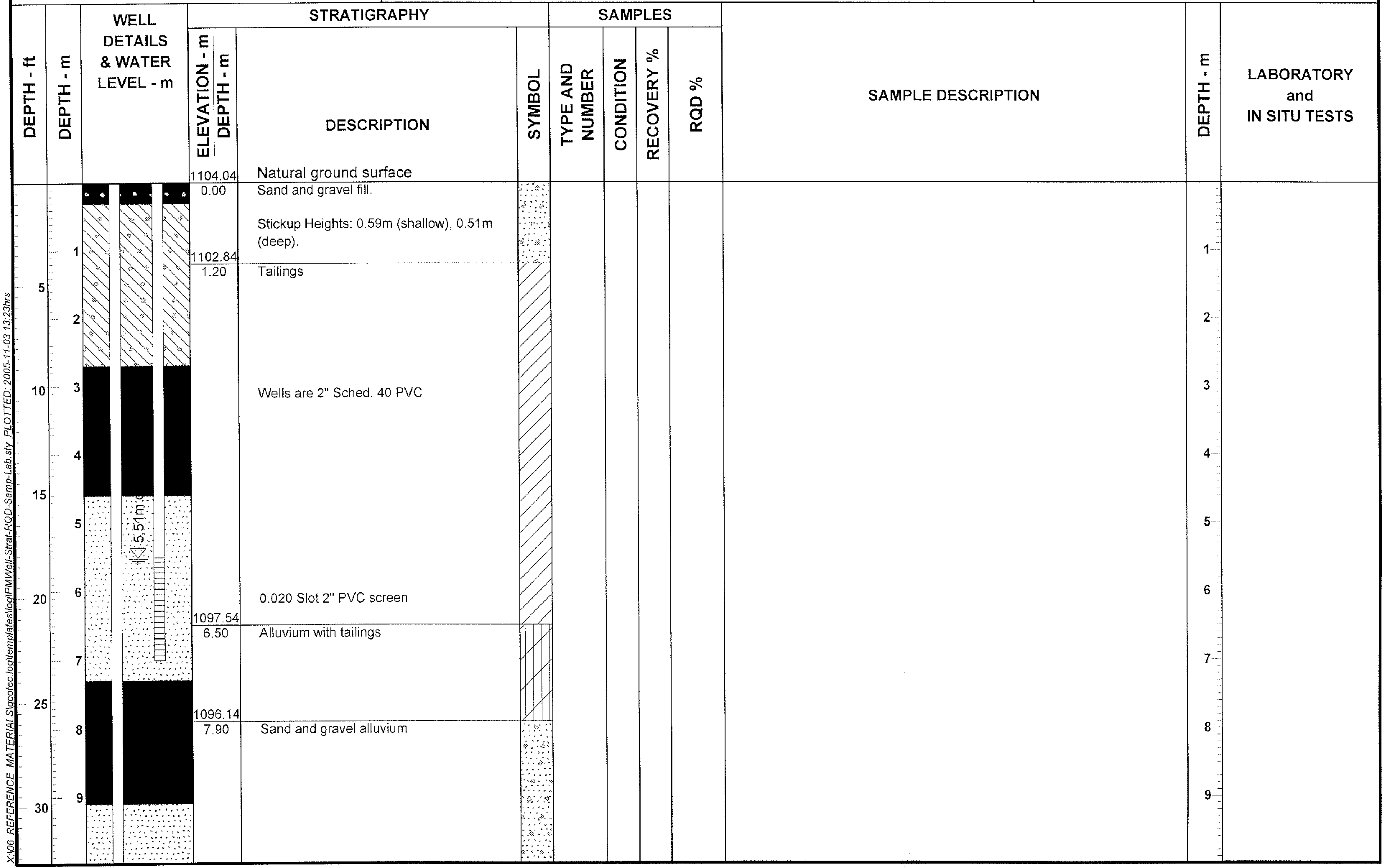
PROJECT: Faro Mine Seepage Investigation
LOCATION: Emergency Tailings Area
FILE No: FARO (1CD003.053)
BORING DATE: 2004-08-30 **TO** 2004-09-01
DIP: 90.00 **AZIMUTH:**
COORDINATES: 6913824.47 N 582977.28 E **DATUM:**

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

SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Rock core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon



ELEVATION - m / DEPTH - m	DESCRIPTION
1104.04	Natural ground surface
0.00	Sand and gravel fill. Stickup Heights: 0.59m (shallow), 0.51m (deep).
1102.84 1.20	Tailings Wells are 2" Sched. 40 PVC 0.020 Slot 2" PVC screen
1097.54 6.50	Alluvium with tailings
1096.14 7.90	Sand and gravel alluvium

X:\06 REFERENCE MATERIALS\geotec.log\templates\log\PMWell-Strat-RQD-Samp-Lab.sty PLOTTED: 2005-11-03 13:23hrs

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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: 2 **OF** 2
DRILL TYPE: Odex 6"
DRILL: Air Rotary
CASING: 6"

SAMPLE CONDITION		TYPE OF SAMPLER	
☒	Remoulded	DC	Diamond core barrel
▨	Undisturbed	GS	Grab sample
■	Lost	SS	Split spoon
◨	Rock core		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY			SAMPLES				SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %			
35	11		1093.34 10.70	Weathered bedrock, sand and gravel. Actual start of weathered zone ambiguous. 2" Sched. 40 PVC screen							11	
40	12 13		1092.14 11.90	Bedrock	■						12 13	
45 50 55 60 65	14 15 16 17 18 19		1090.64 13.40	END OF BOREHOLE							14 15 16 17 18 19	

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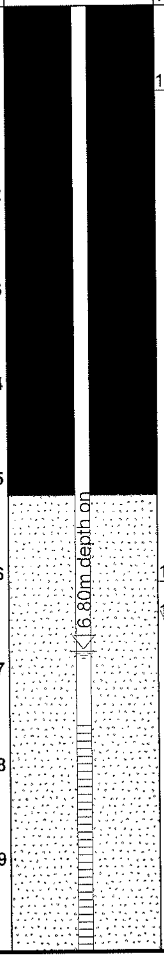
BOREHOLE LOG

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"

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon



DEPTH - ft	DEPTH - m	ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
		1104.29	Natural ground surface								
		0.00	Fill Well Stickup Height: 0.51m	▦							
	1	1103.38 0.91	Tailings Half bag of sand added to top of natural fill	▨						1	
5	2									2	
10	3									3	
	4									4	
15	5									5	
20	6	1098.19 6.10	Alluvium with Tailings							6	
		1097.89 6.40	Alluvium Sand in well is natural sandpack. 0.13m Steel to PVC casing adaptor 3.96m of Stainless Steel Screen; 2x20 slot at bottom, 1x10 slot at top Natural Sandpack	░							
	7									7	
25	8									8	
30	9									9	

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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:**

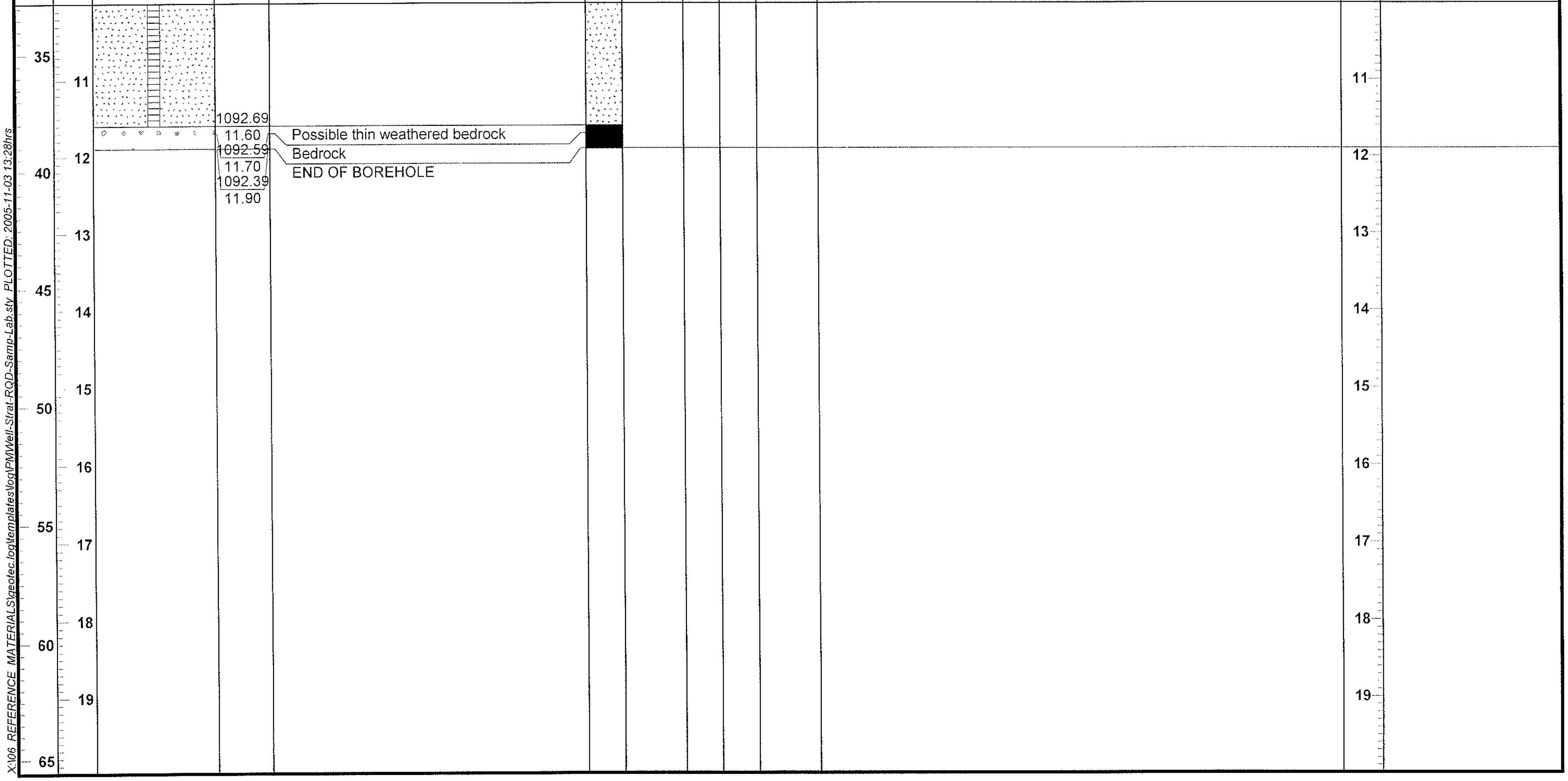
BOREHOLE: SRK04-04
PAGE: 2 **OF** 2
DRILL TYPE: ODEX 6"
DRILL: Air Rotary
CASING: 6"

SAMPLE CONDITION
☒ Remoulded
▨ Undisturbed
■ Lost
◧ Rock core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			1092.69 11.60	Possible thin weathered bedrock								
			1092.59 11.70	Bedrock								
			1092.39 11.90	END OF BOREHOLE								



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BOREHOLE LOG

PROJECT:
LOCATION: ETA area
FILE No: FARO (1CD003.73)
BORING DATE: TO
DIP: **AZIMUTH:**
COORDINATES: N E **DATUM:**

BOREHOLE: SRK05-ETA-BR1
PAGE: 1 **OF** 1
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	TYPE OF SAMPLER	LABORATORY AND IN SITU TESTS	
☒ Remoulded	DC Diamond core barrel	C Consolidation	Ku Thermal conductivity Unfrozen (W / m°C)
▨ Undisturbed	GS Grab sample	D Bulk density (kg/m3)	Kf Thermal conductivity Frozen (W / m°C)
■ Lost	SS Split spoon	Dr Specific gravity	PS Particle size analysis
◧ Core		Ksat Saturated hydraulic cond. (cm/s)	

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 100120
			0.00 0.00	tailings							
			-5.50 5.50	cobbles & gravels. Alluvium. recovered granite fragments mixed with binded, metamorphic rock (green, grey), drillers forgot to line the core barrel and had to pressure the core out, which was expelled onto the ground. Fragment at the drill bit was granite.							
			-6.40 6.40 -7.00	coarse gravel and granite cobbles. Alluvium. Recovery 50% still alluvium							
			13.00 -13.00 0.00	drilled down to 13m, still alluvium. Granite boulders from 11.74m approx. END OF BOREHOLE							

DEPTH - ft: 5 10 15 20 25 30 35 40 45 50 55 60 65
DEPTH - m: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-09-25 **TO** 2005-09-28
DIP: **AZIMUTH:**
COORDINATES: 6913846.00 N 582972.00 E **DATUM:**

BOREHOLE: SRK05-ETA-BR2
PAGE: 1 **OF** 4
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

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: RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
			1103.15	Natural ground surface								
5 10 15	1 2 3 4 5		0.00	Tailings, fine to coarse sand, some fine gravel.		1	■			0 Tailings and fine to coarse sand and some fine gravel.	1 2 3 4 5	
			1097.45 5.70	Tailings; alluvium			■			5.700000		

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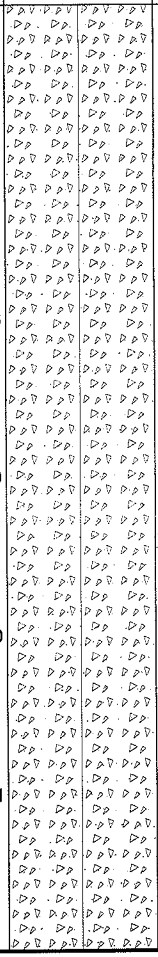
BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-09-25 **TO** 2005-09-28
DIP: **AZIMUTH:**
COORDINATES: 6913846.00 N 582972.00 E **DATUM:**

BOREHOLE: SRK05-ETA-BR2
PAGE: 2 **OF** 4
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

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: RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
							■			Tailings; alluvium		
	7										7	
						2	■					
25												
	8										8	
	9										9	
30												
			1093.70 9.45	Bedrock: Schist, some quartz lenses.						9.450000 Bedrock		
						3	■					
	10										10	
										10.200000 Schist; sheared/crushed zone ~11.18m (3.8cm thick)		
35												
						4	■	95	24			
	11										11	
							■			11.600000		

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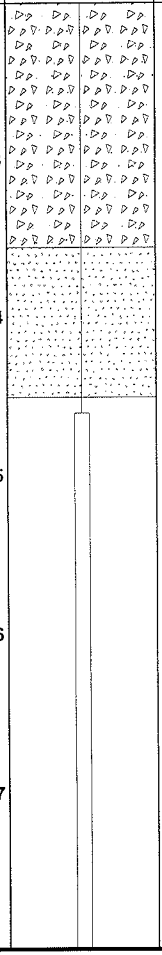
BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-09-25 **TO** 2005-09-28
DIP: **AZIMUTH:**
COORDINATES: 6913846.00 N 582972.00 E **DATUM:**

BOREHOLE: SRK05-ETA-BR2
PAGE: 3 **OF** 4
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
▮	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon



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 RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
40 45	13 14					5	▮	100	17		13	
						6	▮	100	47	13.100000 Sheared/crushed zone ~14.33m, 2.5cm thick.	14	k = 1.32E-08
50	15 16					7	▮	100	10	14.600000 Sheared/crushed zone 15.24-15.39m. Weathered zone at 16.15m.	15 16	
55	17					8	▮	97	10	16.150000 Schist with quartz lenses, up to 5cm thick. +/- vertical joint ~1.46m	17	k = 1.10E-07
							▮			17.799999		k = 4.33E-08

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BOREHOLE LOG

PROJECT:
LOCATION: ETA Area
FILE No: FARO (1CD003.73)
BORING DATE: 2005-09-25 **TO** 2005-09-28
DIP: **AZIMUTH:**
COORDINATES: 6913846.00 N 582972.00 E **DATUM:**

BOREHOLE: SRK05-ETA-BR2
PAGE: 4 **OF** 4
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Rock core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

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 RQD %	SAMPLE DESCRIPTION	DEPTH - m	LABORATORY and IN SITU TESTS
60						9		100	22			
	19									19.330000	19	
65	20					10		100	25		20	
	21									20.600000	21	
70						11		100	47			k = 1.00E-08
	22									22.100000	22	
75	23					12		100	23		23	
			1079.55 23.60	END OF BOREHOLE								

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Appendix B

Laberge Environmental Services Memorandums

Laberge
ENVIRONMENTAL SERVICES

Memorandum

To:	Dan Mackie	SRK	Christoph Wells	RGC	September 4, 2005
Copies:	Deloitte, GLL, RGC, BGC, Faro Project Office, Water Resources				
From:	Ken Nordin	LES			

Re: Installation of Weirs in the Emergency Tailings Area (ETA)

This is a brief description of two weir installations in the ETA; at X_23 and in the Faro Creek canyon at FCS_4.

X_23 Old Waste Rock Dump Seep near remnant Faro Creek channel

A one foot rectangular weir was replaced with a 90^0 V-notch weir on August 30, 2005 using a 235 CAT excavator. The bulkhead was made by the welding shop at the Faro mine site.

Old rectangular weir at X_23

replacement 90^0 weir September 1, 2005

Two sumps were dug upstream of the head pond and a small berm was placed upstream to help trap sediment. The weir was tested on September 2nd, using two different containers for volumetric measurements, and using the standard weir formula Q= 1362.9 ($H^{2.5}$).

26 L container = 0.6 L/sec
9.6 L container = 0.59 L/sec
Formula (H=0.045m) = 0.59 L/sec
A staff gauge was installed as shown, and adjusted to read 0.045m (H).

FCS_4 Remnant Faro Creek Channel at end of Canyon

A standard 90^0 V-notch weir was installed in the Faro Creek channel at the end of the canyon on August 30, 2005 using a 235 CAT excavator. The bulkhead was made by the welding shop at the Faro mine site.

Weir at bottom of Faro Creek canyon

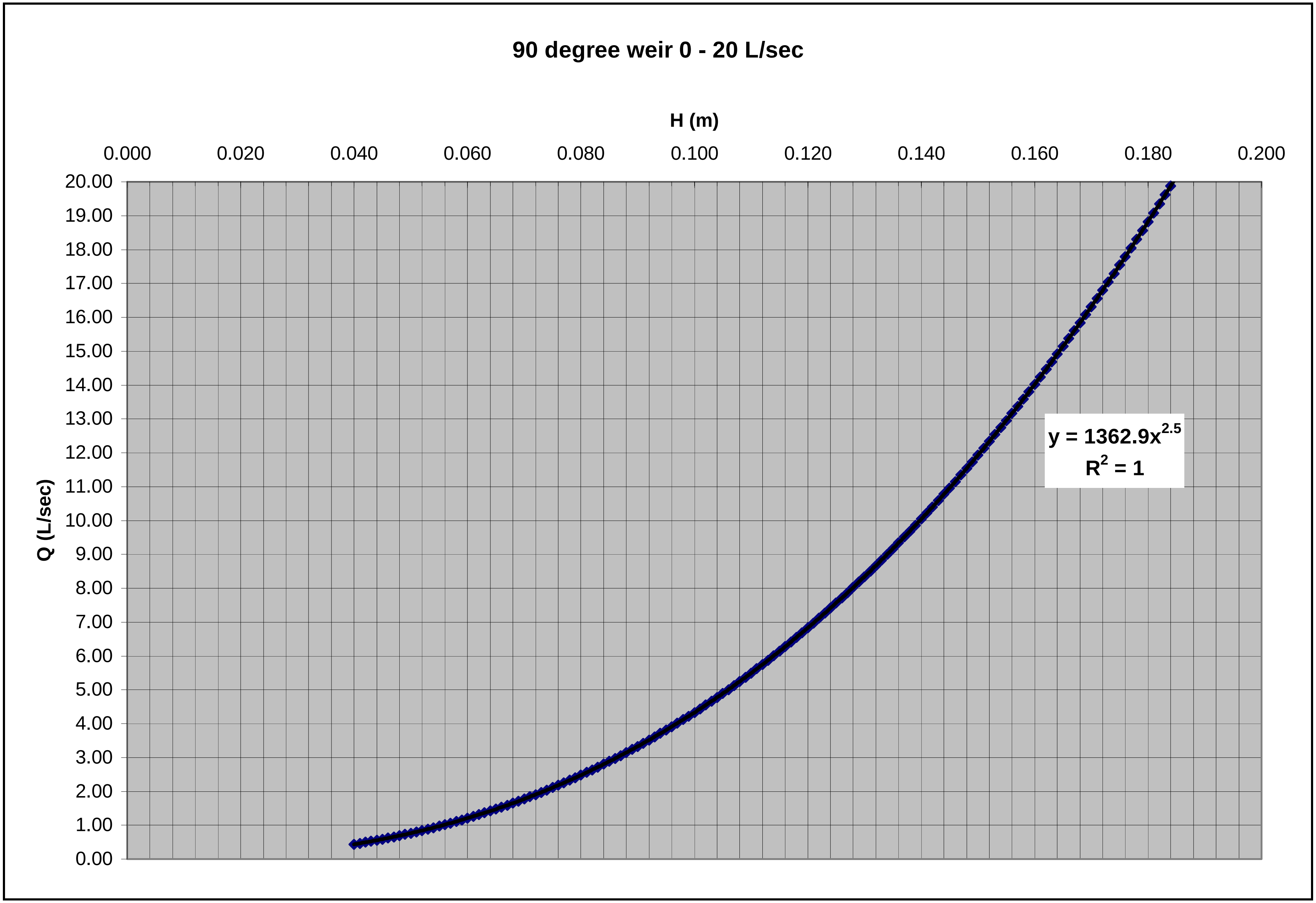
The weir was tested on September 2nd, using a container for volumetric measurements, and using the standard weir formula Q L/sec = 1362.9 ($H^{2.5}$).
9.6 L container = 7.62 L/sec
Formula (H=0.125m) = 7.56 L/sec
A staff gauge was installed as shown, and adjusted to read 0.125 m (H).

The head on a standard 90^0 weir (H) is to be measured as a depth above the elevation of the crest or vertex of the notch. H should be measured at a distance upstream of four times the maximum H expected. In practice, H can be measured closer to the bulkhead. One way to measure H at the notch is to use a set square or thin ruler and measure H just upstream of the plate.

Provided conditions for a standard weir are met, a rating table or curve can be used with the formula above. Standard weirs must have a sharp edge, 90 degree angle, close to zero approach velocity, free falling nappe, and be level and plumb. A rating table and chart follow which can be used for any standard 90 degree V-notch weir. The chart covers low level discharges up to 20 L/sec.

Rating Table for Standard 90 degree V-notch Weir where Q (L/sec) =1362.9H^2.5

H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec
0.030	0.21	0.073	1.97	0.108	5.25	0.143	10.59	0.178	18.30	0.223	32.15	0.258	46.29
0.035	0.31	0.074	2.04	0.109	5.37	0.144	10.77	0.179	18.56	0.224	32.52	0.259	46.74
0.040	0.44	0.075	2.11	0.110	5.49	0.145	10.96	0.180	18.82	0.225	32.88	0.260	47.20
0.041	0.47	0.076	2.18	0.111	5.62	0.146	11.15	0.181	19.08	0.226	33.25	0.270	51.87
0.042	0.49	0.077	2.25	0.112	5.75	0.147	11.34	0.182	19.35	0.227	33.61	0.280	56.80
0.043	0.52	0.078	2.33	0.113	5.88	0.148	11.54	0.183	19.62	0.228	33.99	0.290	62.01
0.044	0.56	0.079	2.40	0.114	6.01	0.149	11.73	0.184	19.88	0.229	34.36	0.300	67.49
0.045	0.59	0.080	2.48	0.115	6.14	0.150	11.93	0.185	20.16	0.230	34.74	0.310	73.26
0.046	0.62	0.081	2.56	0.116	6.27	0.151	12.13	0.186	20.43	0.231	35.12	0.320	79.31
0.047	0.66	0.082	2.64	0.117	6.41	0.152	12.33	0.187	20.70	0.232	35.50	0.330	85.65
0.048	0.69	0.083	2.72	0.118	6.55	0.153	12.54	0.188	20.98	0.233	35.88	0.340	92.29
0.049	0.73	0.084	2.80	0.119	6.69	0.154	12.74	0.189	21.26	0.234	36.27	0.350	99.23
0.050	0.77	0.085	2.88	0.120	6.83	0.155	12.95	0.190	21.55	0.235	36.66	0.360	106.47
0.051	0.80	0.086	2.97	0.121	6.97	0.156	13.16	0.191	21.83	0.236	37.05	0.370	114.02
0.052	0.84	0.087	3.06	0.122	7.12	0.157	13.37	0.192	22.12	0.237	37.44	0.380	121.88
0.053	0.89	0.088	3.15	0.123	7.26	0.158	13.59	0.193	22.41	0.238	37.84	0.390	130.06
0.054	0.93	0.089	3.24	0.124	7.41	0.159	13.80	0.194	22.70	0.239	38.24	0.400	138.55
0.055	0.97	0.090	3.33	0.125	7.56	0.160	14.02	0.195	22.99	0.240	38.64	0.410	147.38
0.056	1.02	0.091	3.42	0.126	7.72	0.161	14.24	0.196	23.29	0.241	39.04	0.420	156.53
0.057	1.06	0.092	3.52	0.127	7.87	0.162	14.46	0.197	23.58	0.242	39.45	0.430	166.01
0.058	1.11	0.093	3.61	0.128	8.03	0.163	14.69	0.198	23.89	0.243	39.85	0.440	175.83
0.059	1.16	0.094	3.71	0.129	8.18	0.164	14.91	0.199	24.19	0.244	40.27	0.450	185.99
0.060	1.21	0.095	3.81	0.130	8.34	0.165	15.14	0.200	24.49	0.245	40.68	0.500	242.04
0.061	1.26	0.096	3.91	0.131	8.50	0.166	15.37	0.201	24.80	0.246	41.10		
0.062	1.31	0.097	4.01	0.132	8.67	0.167	15.60	0.202	25.11	0.247	41.52		
0.063	1.36	0.098	4.12	0.133	8.83	0.168	15.84	0.203	25.42	0.248	41.94		
0.064	1.42	0.099	4.22	0.134	9.00	0.169	16.08	0.204	25.57	0.249	42.36		
0.065	1.47	0.100	4.33	0.135	9.17	0.170	16.32	0.205	26.05	0.250	42.79		
0.066	1.53	0.101	4.44	0.136	9.34	0.171	16.56	0.206	26.37	0.251	43.22		
0.067	1.59	0.102	4.55	0.137	9.51	0.172	16.80	0.207	26.69	0.252	43.65		
0.068	1.65	0.103	4.66	0.138	9.69	0.173	17.04	0.208	27.02	0.253	44.08		
0.069	1.71	0.104	4.78	0.139	9.86	0.174	17.29	0.209	27.34	0.254	44.52		
0.070	1.78	0.105	4.89	0.140	10.04	0.175	17.54	0.210	27.67	0.255	44.96		
0.071	1.84	0.106	5.01	0.141	10.22	0.176	17.79	0.211	28.00	0.256	45.40		
0.072	1.90	0.107	5.13	0.142	10.40	0.177	18.05	0.222	31.79	0.257	45.85		


90 degree weir 0 - 20 L/sec
H (m)
0.000
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.160
0.180
0.200
Q (L/sec)
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
y = 1362.9x^2.5
R^2 = 1

Laberge
ENVIRONMENTAL SERVICES

Memorandum

To: Christoph Wels RGC, Dan Mackie SRK October 23, 2005
Copies: Deloitte, GLL, Faro Project Office, Water Resources
From: Ken Nordin LES

Re: Installation of Weir at FCS_5 and Initial Monitoring of Faro Creek Seepage Losses

This is a brief description of the results of the project ***Additional Monitoring of Faro Creek Seepage Losses*** for October 2005.

X_23 FCS_1 Old Waste Rock Dump Seep near remnant Faro Creek channel

A one foot rectangular weir was replaced with a 90^0 V-notch weir on August 30, 2005 using a 235 CAT excavator. The bulkhead was made by the welding shop at the Faro mine site. Two sumps were dug upstream of the head pond and a small berm was placed upstream to help trap sediment. The weir was tested on September 2nd, using two different containers for volumetric measurements, and using the standard weir formula $Q= 1362.9 (H^{2.5})$. A staff gauge was installed and adjusted to read (H). On September 15, 2005 a PT2X sensor/logger was installed. At 11:30 AM the measured H over the notch was 0.059 m. On October 18, 2005 the datalogger was downloaded. The data was sent to RGC and SRK in Excel format on October 21.

FCS_4 Remnant Faro Creek Channel at end of Canyon

A standard 90^0 V-notch weir was installed in the Faro Creek channel at the end of the canyon on August 30, 2005 using a 235 CAT excavator. The bulkhead was made by the welding shop at the Faro mine site. A staff gauge was installed and adjusted to read (H). On September 15, 2005 a PT2X sensor/logger was installed. At 13:37 the measured H over the notch was 0.130 m. On October 18, 2005 the datalogger was downloaded. The data was sent to RGC and SRK in Excel format on October 21.

FCS_5 Old Tailings dam decant X_1 at end of ditch

A standard 90^0 V-notch weir was installed near the old decant formerly known as X_1 on October 18, 2005. A chart pac data logger and PS9800 pressure transducer were installed temporarily while waiting for the INW PT2X sensor/logger. Then installation consists of a 1/4 "metal weir bulkhead with 30 mil polypropylene liner and earth embankments. The 235 CAT excavator was used to build the installation. The bulkhead was made by the welding shop at the Faro mine site. The installation was provided with a pressure sensor and datalogger which had been deployed at X_14 for the summer. A dedicated INW PT2X sensor/logger is on order and will be installed in November.

Rating Table

Provided conditions for a standard weir are met, a rating table or curve can be used with the formula above. Standard weirs must have a sharp edge, 90 degree angle, close to zero approach velocity, free falling nappe, and be level and plumb. On September 3, a rating table was supplied with a memo on the ETA weirs. There was a transcription error in the table (the coefficient 136***9.2*** was used instead of 136***2.9***). A corrected rating table and chart are included.

Results of measurements at recording stations

The following is a summary of discharge measurements taken to date. An Excel file of containing the downloaded data from FCS_1 and FCS_4 was forwarded to RGC and SRK on October 21, 2005.

FCS_1 or X_23

Date/Time	H (m)	Q (L/sec	Sensor (m)	Offset (m)	comment
Aug 30 11:00	0.045	0.585			fmla
Aug 30 11:00		0.6			Site bucket 26 L
Aug 30 11:00		0.59			LES bucket 9.6 L
Sept 15 11:32	0.059	1.15			fmla
Sept 15 11:32		1.14	.2478	.1888	21.5 L bucket
Oct 3 07:30?	0.061	1.25	.2450?		fmla
Oct 18 13:35	0.059	1.15	.2443	.1853	fmla
Oct 18 13:35		1.15			20.5 L in dedicated bucket

FCS_4 Faro Creek Canyon

Date/Time	H (m)	Q (L/sec	Sensor (m)	Offset (m)	comment
Sept 1 16:00	0.125	7.56			fmla
Sept 1 16:00		7.62			9.6 L bucket
Sept 15 15:30	0.130	8.30	.2394	.1091	fmla
Sept 15 15:30		8.6			9.6 L bucket
Oct 3 07:30?	0.115	6.11	.2219	.1069	fmla
Oct 18 15:23	0.123	7.23	.2291	.1061	fmla
Oct 18 15:30		7.17			21.0 L dedicated bucket

Results of initial survey ETA/Faro Creek seepage

The following table shows the results of discharge measurements taken during the October 18 initial survey of stations FCS_1 through to FCS_7 in L/sec. Scanned pages of field notes, site photos and the ALS chain of custody forms are also included. Measurements at each of the weir sites were made using the formula for a standard 90^0 V-notch weir, and compared with volumetric measurements at the same time. Volumetric measurements were made using a calibrated bucket. In most cases five trials were made with the lowest and highest result discarded and the remaining three measurements averaged to determine the rate of flow. A portable 90^0 V-notch weir box was used at FCS_6. It should be noted that this device reached a maximum head of 0.094 m before the containment dam broke, and that there was some seepage through this dam (difficult to estimate but likely less than 5% of the flow).

Station ID	Location	October 2005 DD/Time	Trial 1	Trial 2	Cond. *u*S/cm	pH	TDS mg/L
Reach 3							
FCS1	WRD seepage in old Faro Creek channel (at X23)	18/13:35	1.15[v]	1.15[w]	4230	6.21	2060
FCS2	surface seepage discharging below road (below road at culvert)	18/14:30	3.39[v]		4890	7.47	2200
FCS3	subsurface seepage discharging at seepage face below road (at X7) (w/ organic smell)	18/15:00	3.12[v]		5010	6.07	2390
FCS4	combined seepage below confluence of X7 and X23 (at mouth of Faro Creek canyon)	18/15:23	7.23[w]	7.17[v]	4610	6.82	2120
FCS5	Seepage flow at end of diversion ditch (prior to discharge into Interm. Impoundment) new weir installed Oct.18	18/16:00	6.38[w]	6.28[v]	4350	6.02	1940
FCS5		19/16:45	6.11[w]				
FCS6	Seepage flow appr. Halfway towards Interm. Pond. Station established and flagged Oct 18. Q by portable weir box	18/18:00	3.71[wb]		4840	5.02	2200
FCS7	seepage flow near pond (but u/s of inflow from Guardhouse Creek) Station established and flagged Oct 18	18/17:30	2.7[efa]		5220	3.51	2360
GHC	Guardhouse Creek before discharge into Intermediate Impoundment (at road)	18/1730	5[e]				

[e] estimated, judgmental

[efa] estimated velocity float x area

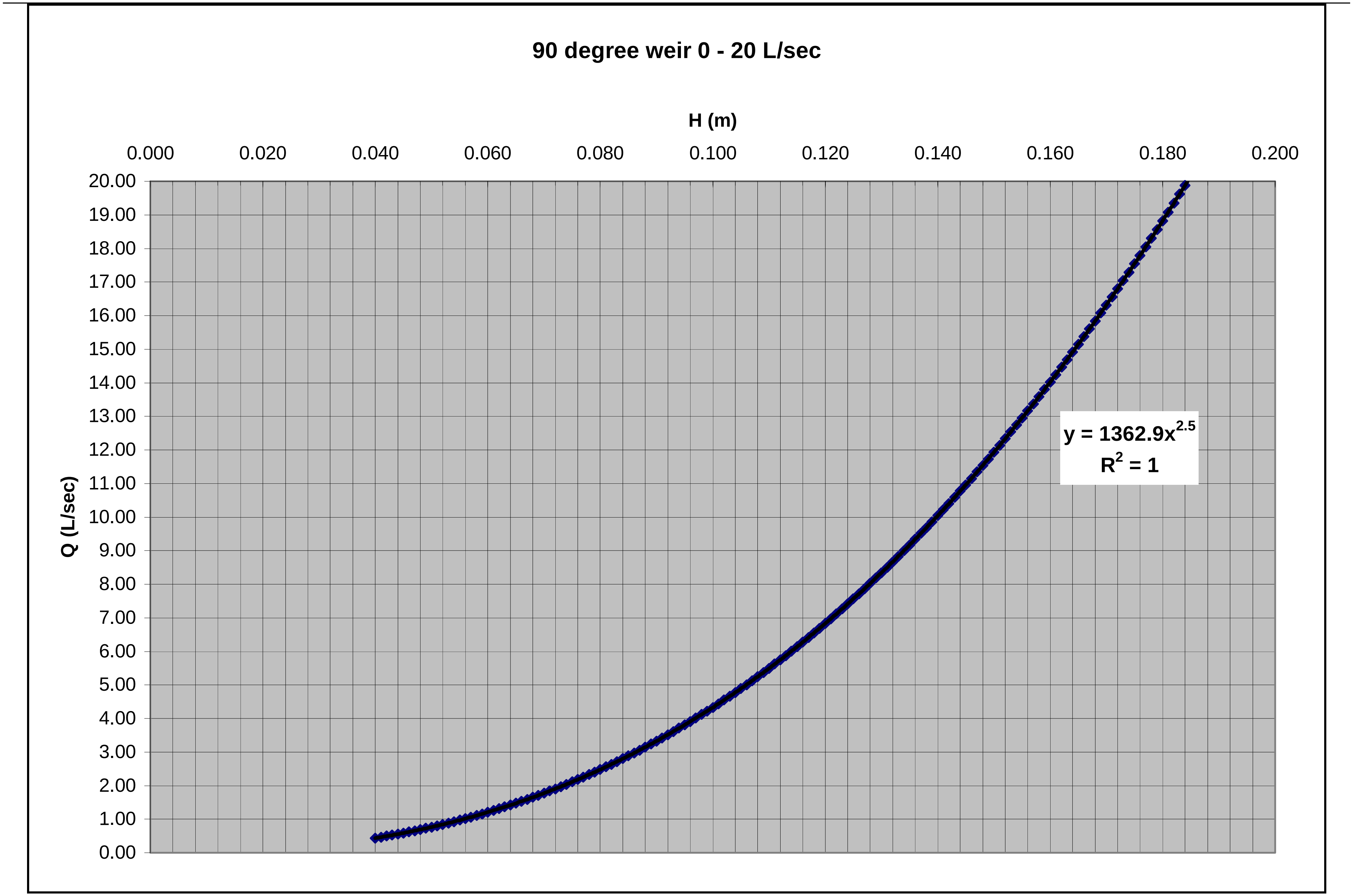
[v] volumetric (average trials time to fill calibrated bucket)

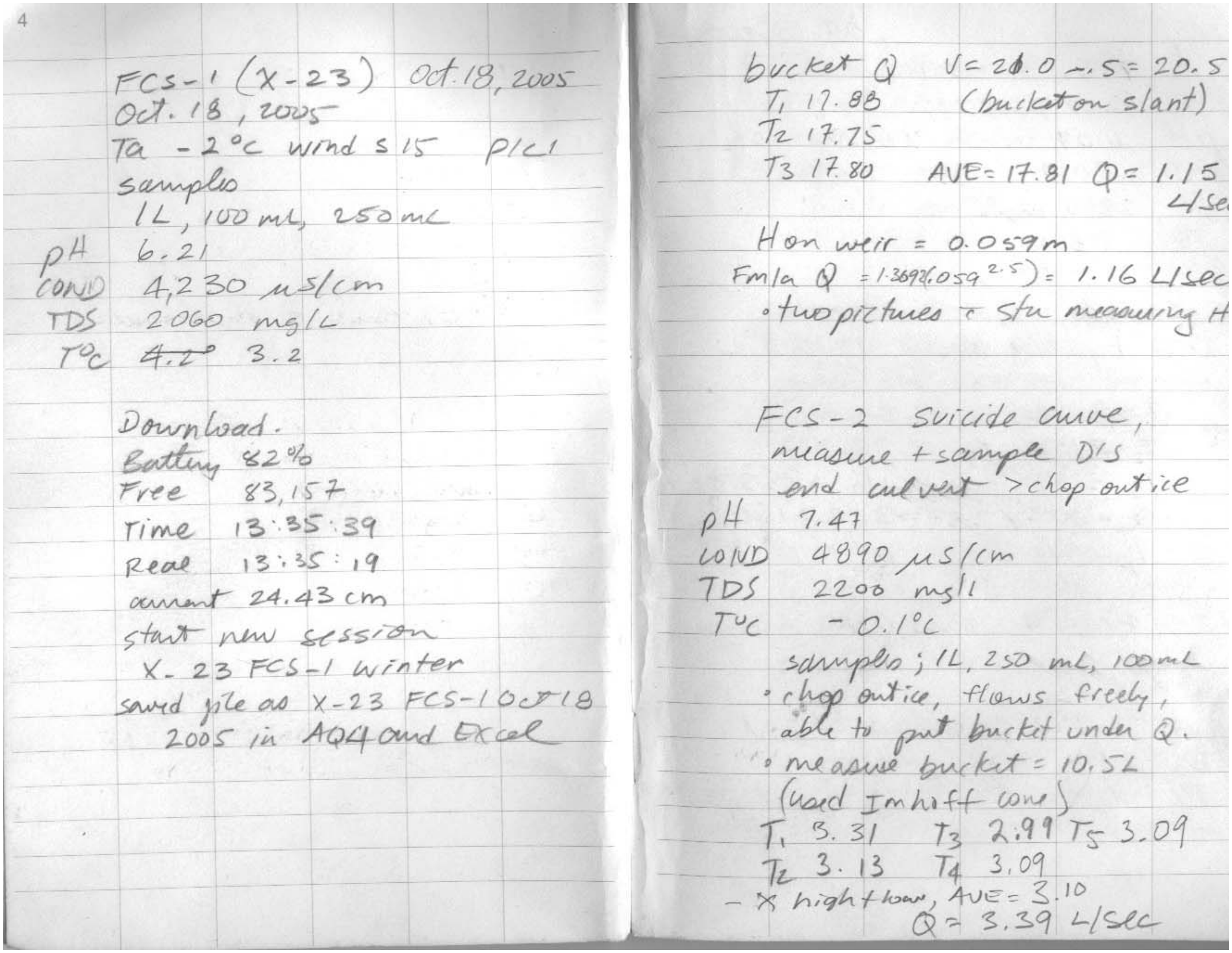
[w] weir

[wb] portable weir box

(Corrected) Rating Table for Standard 90 degree V-notch Weir where Q (L/sec) =1362.9H^2.5

H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec
0.030	0.21	0.073	1.96	0.108	5.22	0.143	10.54	0.178	18.22	0.223	32.01	0.258	46.08
0.035	0.31	0.074	2.03	0.109	5.35	0.144	10.72	0.179	18.48	0.224	32.37	0.259	46.53
0.040	0.44	0.075	2.10	0.110	5.47	0.145	10.91	0.180	18.73	0.225	32.73	0.260	46.98
0.041	0.46	0.076	2.17	0.111	5.59	0.146	11.10	0.181	19.00	0.226	33.09	0.270	51.63
0.042	0.49	0.077	2.24	0.112	5.72	0.147	11.29	0.182	19.26	0.227	33.46	0.280	56.54
0.043	0.52	0.078	2.32	0.113	5.85	0.148	11.48	0.183	19.53	0.228	33.83	0.290	61.72
0.044	0.55	0.079	2.39	0.114	5.98	0.149	11.68	0.184	19.79	0.229	34.20	0.300	67.18
0.045	0.59	0.080	2.47	0.115	6.11	0.150	11.88	0.185	20.06	0.230	34.58	0.310	72.92
0.046	0.62	0.081	2.54	0.116	6.25	0.151	12.08	0.186	20.34	0.231	34.95	0.320	78.95
0.047	0.65	0.082	2.62	0.117	6.38	0.152	12.28	0.187	20.61	0.232	35.33	0.330	85.26
0.048	0.69	0.083	2.70	0.118	6.52	0.153	12.48	0.188	20.89	0.233	35.72	0.340	91.87
0.049	0.72	0.084	2.79	0.119	6.66	0.154	12.68	0.189	21.17	0.234	36.10	0.350	98.77
0.050	0.76	0.085	2.87	0.120	6.80	0.155	12.89	0.190	21.45	0.235	36.49	0.360	105.98
0.051	0.80	0.086	2.96	0.121	6.94	0.156	13.10	0.191	21.73	0.236	36.88	0.370	113.49
0.052	0.84	0.087	3.04	0.122	7.09	0.157	13.31	0.192	22.01	0.237	37.27	0.380	121.32
0.053	0.88	0.088	3.13	0.123	7.23	0.158	13.52	0.193	22.30	0.238	37.66	0.390	129.46
0.054	0.92	0.089	3.22	0.124	7.38	0.159	13.74	0.194	22.59	0.239	38.06	0.400	137.92
0.055	0.97	0.090	3.31	0.125	7.53	0.160	13.96	0.195	22.88	0.240	38.46	0.410	146.70
0.056	1.01	0.091	3.40	0.126	7.68	0.161	14.18	0.196	23.18	0.241	38.86	0.420	155.81
0.057	1.06	0.092	3.50	0.127	7.83	0.162	14.40	0.197	23.48	0.242	39.26	0.430	165.25
0.058	1.10	0.093	3.59	0.128	7.99	0.163	14.62	0.198	23.78	0.243	39.67	0.440	175.02
0.059	1.15	0.094	3.69	0.129	8.15	0.164	14.84	0.199	24.08	0.244	40.08	0.450	185.14
0.060	1.20	0.095	3.79	0.130	8.30	0.165	15.07	0.200	24.38	0.245	40.49	0.500	240.93
0.061	1.25	0.096	3.89	0.131	8.47	0.166	15.30	0.201	24.69	0.246	40.91		
0.062	1.30	0.097	3.99	0.132	8.63	0.167	15.53	0.202	24.99	0.247	41.32		
0.063	1.36	0.098	4.10	0.133	8.79	0.168	15.77	0.203	25.30	0.248	41.74		
0.064	1.41	0.099	4.20	0.134	8.96	0.169	16.00	0.204	25.62	0.249	42.17		
0.065	1.47	0.100	4.31	0.135	9.13	0.170	16.24	0.205	25.93	0.250	42.59		
0.066	1.53	0.101	4.42	0.136	9.30	0.171	16.48	0.206	26.25	0.251	43.02		
0.067	1.58	0.102	4.53	0.137	9.47	0.172	16.72	0.207	26.57	0.252	43.45		
0.068	1.64	0.103	4.64	0.138	9.64	0.173	16.97	0.208	26.89	0.253	43.88		
0.069	1.70	0.104	4.75	0.139	9.82	0.174	17.21	0.209	27.22	0.254	44.31		
0.070	1.77	0.105	4.87	0.140	10.00	0.175	17.46	0.210	27.54	0.255	44.75		
0.071	1.83	0.106	4.99	0.141	10.17	0.176	17.71	0.211	27.87	0.256	45.19		
0.072	1.90	0.107	5.10	0.142	10.36	0.177	17.96	0.222	31.65	0.257	45.63		


90 degree weir 0 - 20 L/sec
H (m)
0.000
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.160
0.180
0.200
Q (L/sec)
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
y = 1362.9x^2.5
R^2 = 1



4

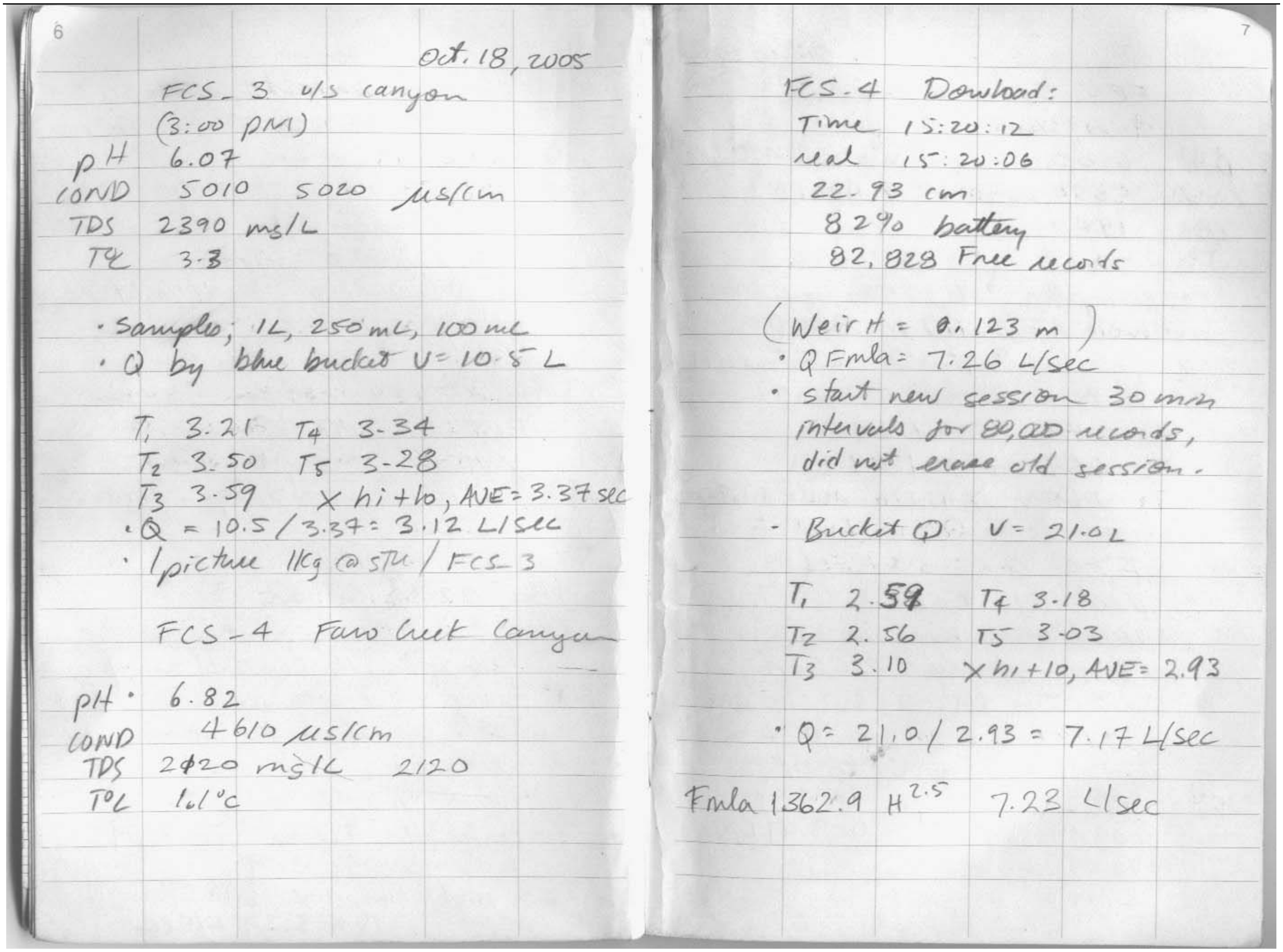
FCS-1 (X-23) Oct. 18, 2005
Oct. 18, 2005
Ta -2°C wind S 15 P/C1
samples
1L, 100 mL, 250 mL
pH 6.21
COND 4,230 μS/cm
TDS 2060 mg/L
T°C ~~4.2°~~ 3.2

Download.
Battery 82%
Free 83,157
Time 13:35:39
Real 13:35:19
current 24.43 cm
start new session
X-23 FCS-1 winter
saved file as X-23 FCS-1 Oct 18
2005 in AQ4 and Excel

bucket Q V = 21.0 - .5 = 20.5
T_1 17.88 (bucket on slant)
T_2 17.75
T_3 17.80 AVE = 17.81 Q = 1.15
L/se

H on weir = 0.059m
Fmla Q $= 1.369(.059^{2.5}) =$ 1.16 L/sec
- two pictures $\bar{c}$ Stu measuring H

FCS-2 Suicide curve,
measure + sample D/S
end culvert > chop out ice
pH 7.47
COND 4890 μS/cm
TDS 2200 mg/l
T°C -0.1°C
samples; 1L, 250 mL, 100 mL
- chop out ice, flows freely,
able to put bucket under Q.
- measure bucket = 10.5L
(used Imhoff cone)
T_1 3.31 T_3 2.99 T_5 3.09
T_2 3.13 T_4 3.09
- X high + low, AVE = 3.10
Q = 3.39 L/sec



6

Oct. 18, 2005

FCS-3 u/s canyon
(3:00 pM)
pH 6.07
COND 5010 5020 µs/cm
TDS 2390 mg/L
T°C 3.3

- Samples; 1L, 250 mL, 100 mL
- Q by blue bucket V= 10.5 L

T_1 3.21 T_4 3-34
T_2 3.50 T_5 3-28
T_3 3.59 × hi + lo, AVE= 3.37 sec

- Q = 10.5 / 3.37 = 3.12 L/sec
- 1 picture 1Kg @ STU / FCS-3

FCS-4 Faro Creek Canyon

pH · 6.82
COND 4610 µs/cm
TDS 2020 mg/L 2120
T°C 1.1°C

7

FCS.4 Dowload:
Time 15:20:12
real 15:20:06
22.93 cm
82% battery
82,828 Free records

(Weir H = 0.123 m)

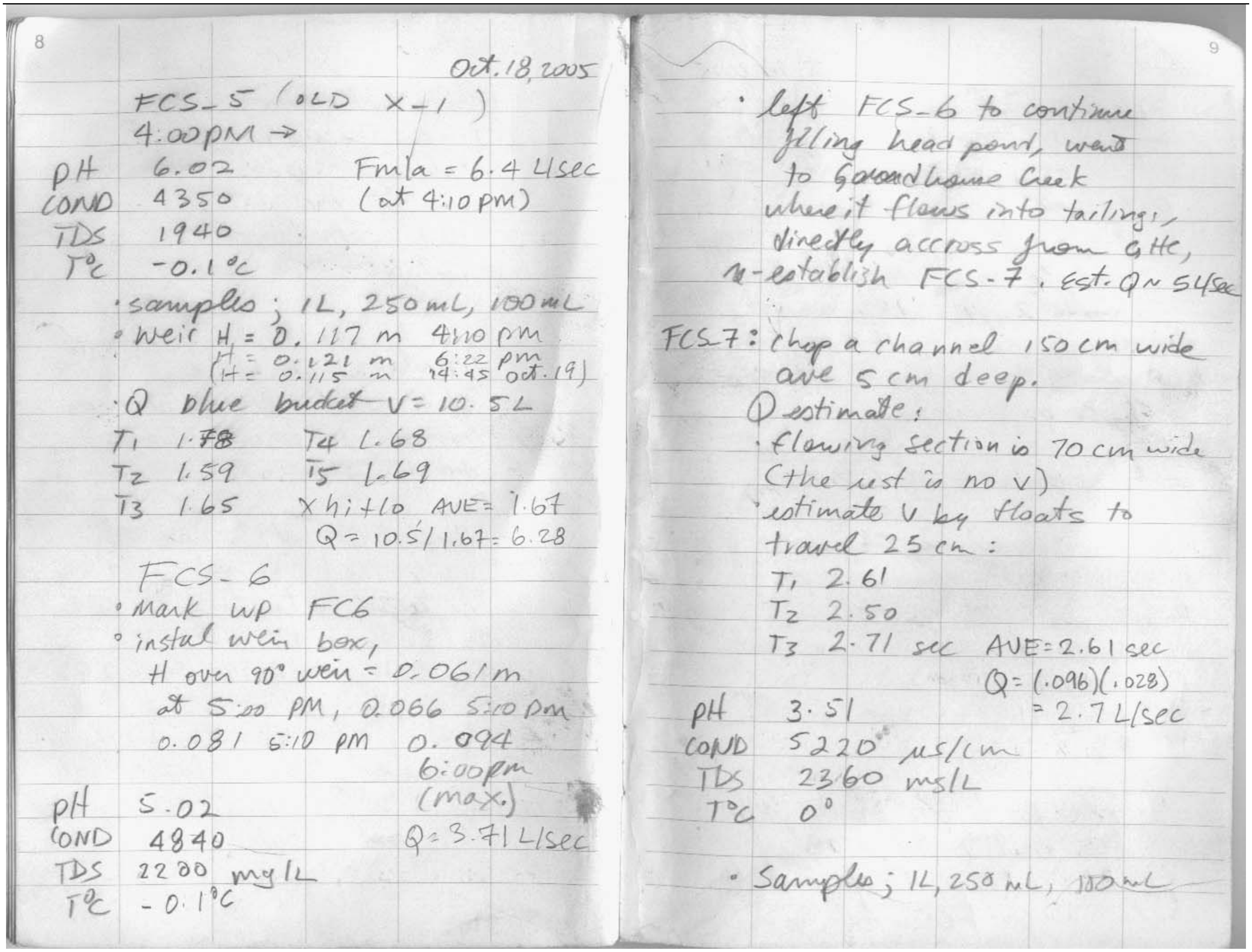
- Q Fmla= 7.26 L/sec
- start new session 30 min intervals for 80,000 records, did not erase old session.

- Bucket Q V= 21.0 L

T_1 2.59 T_4 3.18
T_2 2.56 T_5 3-03
T_3 3.10 × hi + lo, AVE= 2.93

- Q= 21.0 / 2.93 = 7.17 L/sec

Fmla 1362.9 $H^{2.5}$ 7.23 L/sec



Oct. 18, 2005

FCS_5 (OLD X-1)
4:00pm →

pH 6.02 Fmla = 6.4 L/sec
COND 4350 (at 4:10 pm)
TDS 1940
T°C -0.1 °C

- samples; 1L, 250 mL, 100 mL
- Weir H_1 = 0.117 m 4:10 pm
  H = 0.121 m 6:22 pm
  (H = 0.115 m 14:45 oct. 19)
- Q blue bucket V = 10.5 L

T_1 1.78 T_4 1.68
T_2 1.59 T_5 1.69
T_3 1.65 x hi + lo AVE = 1.67
Q = 10.5 / 1.67 = 6.28

FCS-6

- Mark wp FC6
- instal weir box,
  H over 90° weir = 0.061 m
  at 5:00 PM, 0.066 5:10 pm
  0.081 5:10 pm 0.094 6:00pm (max.)

pH 5.02
COND 4840 Q = 3.71 L/sec
TDS 2200 mg/L
T°C -0.1°C

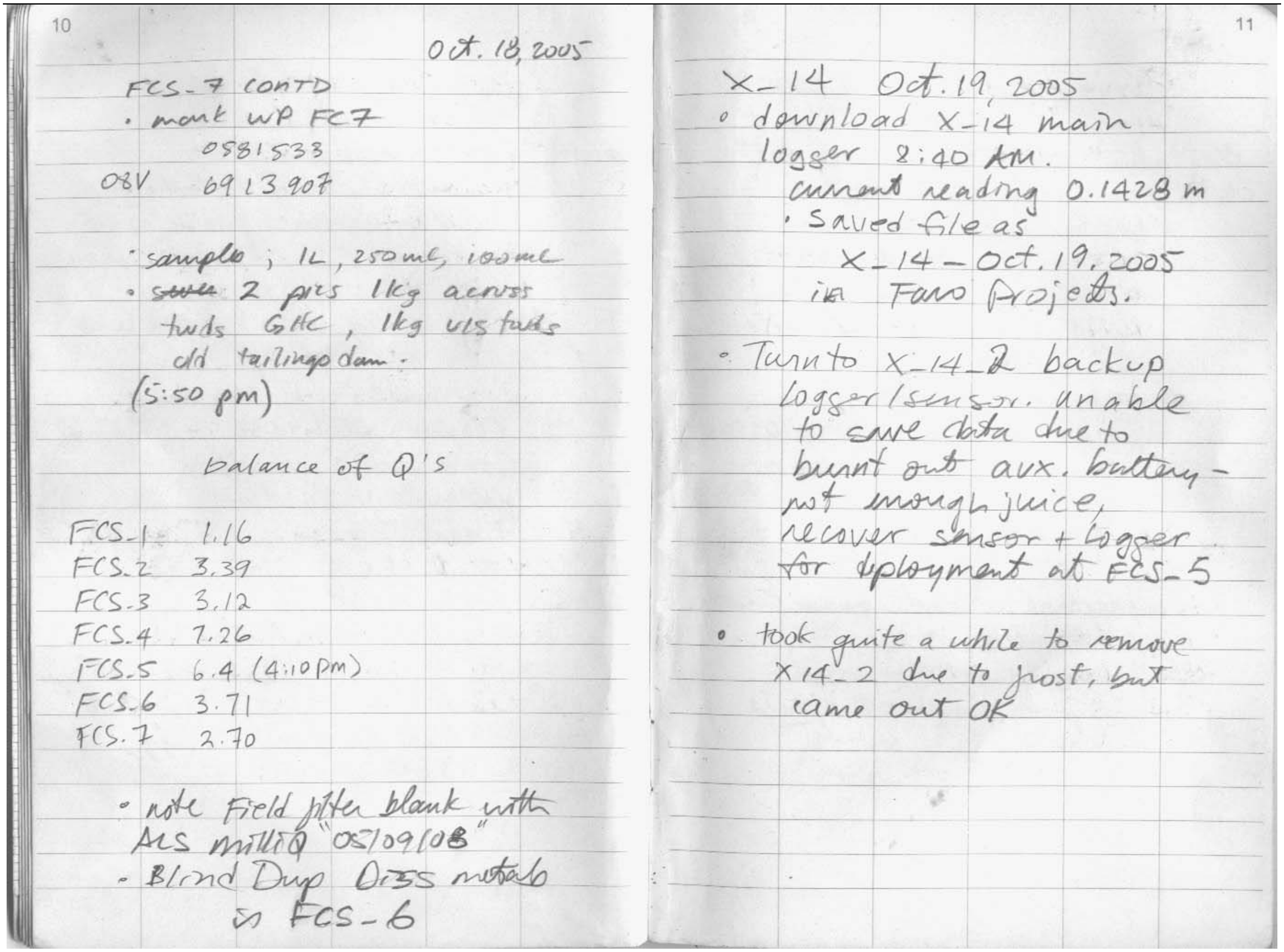
- left FCS-6 to continue filling head pond, went to Guardhouse Creek where it flows into tailings, directly accross from GHC, re-establish FCS-7. Est. Q ~ 5 L/sec

FCS-7: chop a channel 150 cm wide ave 5 cm deep.
Q estimate:
- flowing section is 70 cm wide (the rest is no v)
- estimate v by floats to travel 25 cm:

T_1 2.61
T_2 2.50
T_3 2.71 sec AVE = 2.61 sec
Q = (.096)(.028)
= 2.7 L/sec

pH 3.51
COND 5220 µs/cm
TDS 2360 mg/L
T°C 0°

- Samples; 1L, 250 mL, 100 mL



Oct. 18, 2005

FCS-7 CONTD

· mark WP FC7

0581533

08V 6913907

· samples; 1L, 250mL, 100mL

· [illegible] 2 pits 1kg across

twds GHC, 1kg u/s tails

old tailings dam.

(5:50 pm)

balance of Q's

FCS-1	1.16
FCS.2	3.39
FCS.3	3.12
FCS.4	7.26
FCS.5	6.4 (4:10pm)
FCS.6	3.71
FCS.7	2.70

· note Field filter blank with ALS milliQ "05/09/08"

· Blind Dup Diss metals

is FCS-6

X-14 Oct. 19, 2005

· download X-14 main logger 8:40 AM.

current reading 0.1428 m

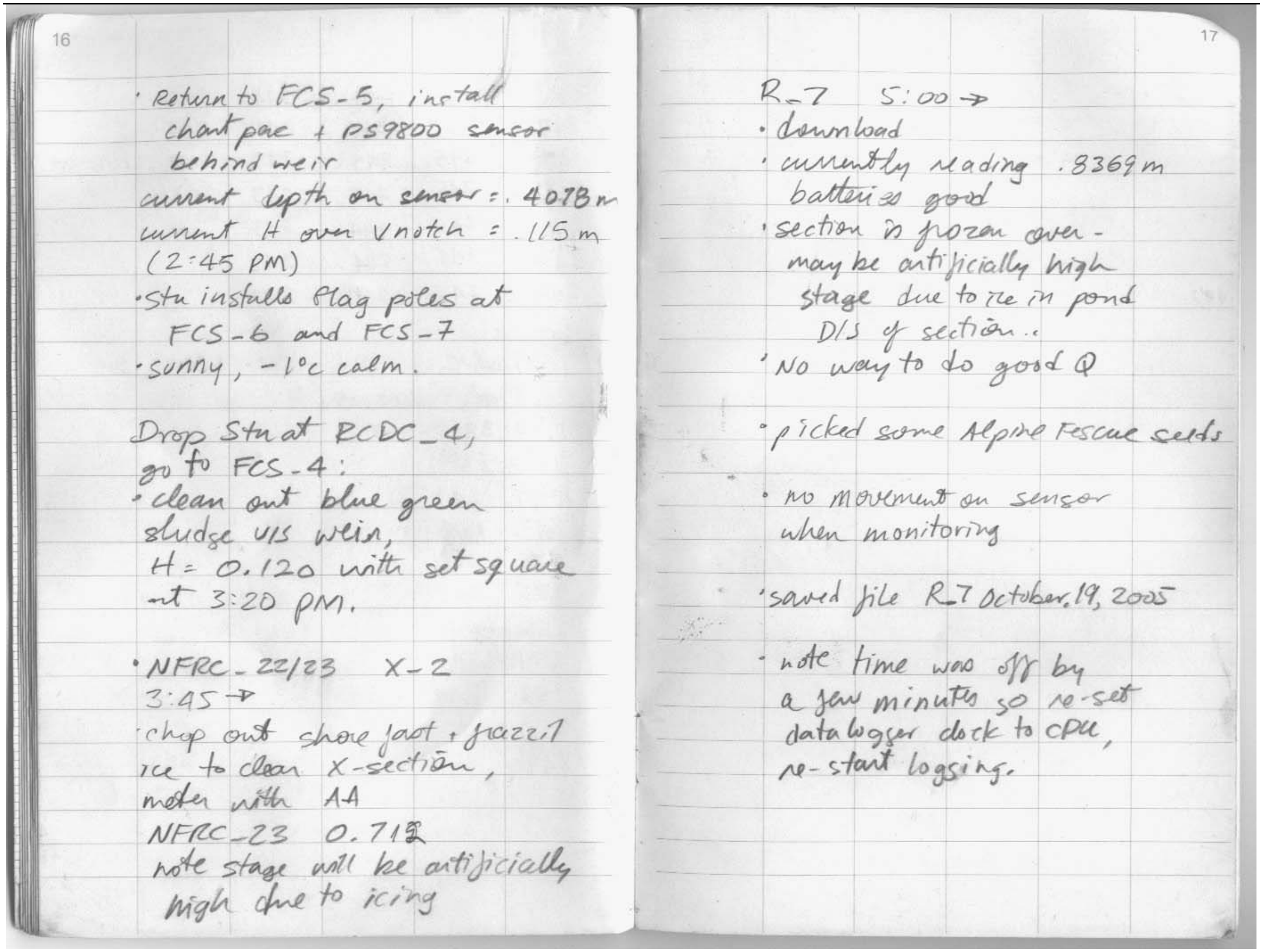
· Saved file as

X-14-Oct. 19. 2005

in Faro Projects.

· Turn to X-14-2 backup logger/sensor. unable to save data due to burnt out aux. battery - not enough juice, recover sensor + logger for deployment at FCS-5

· took quite a while to remove X14-2 due to frost, but came out OK



- Return to FCS-5, install chart pac + PS9800 sensor behind weir

current depth on sensor = .4078 m
current H over V notch = .115 m
(2:45 PM)

- Stu installs flag poles at FCS-6 and FCS-7
- sunny, -1°c calm.

Drop Stu at RCDC_4,
go to FCS-4:

- clean out blue green sludge U/S weir,
  H = 0.120 with set square at 3:20 PM.

- NFRC-22/23 X-2
  3:45 →

- chop out shore fast + frazzil ice to clean X-section,
  meter with AA
  NFRC-23 0.712
  note stage will be artificially high due to icing

R_7 5:00 →

- download
- currently reading .8369 m
  batteries good
- section is frozen over - may be artificially high stage due to ice in pond D/S of section..
- No way to do good Q

- picked some Alpine Fescue seeds

- no movement on sensor when monitoring

- saved file R_7 October, 19, 2005

- note time was off by a few minutes so re-set datalogger clock to cpu, re-start logging.

FCS_1 Oct 18.05

FCS_2 Oct.18.05

FCS_3 Oct.18.05

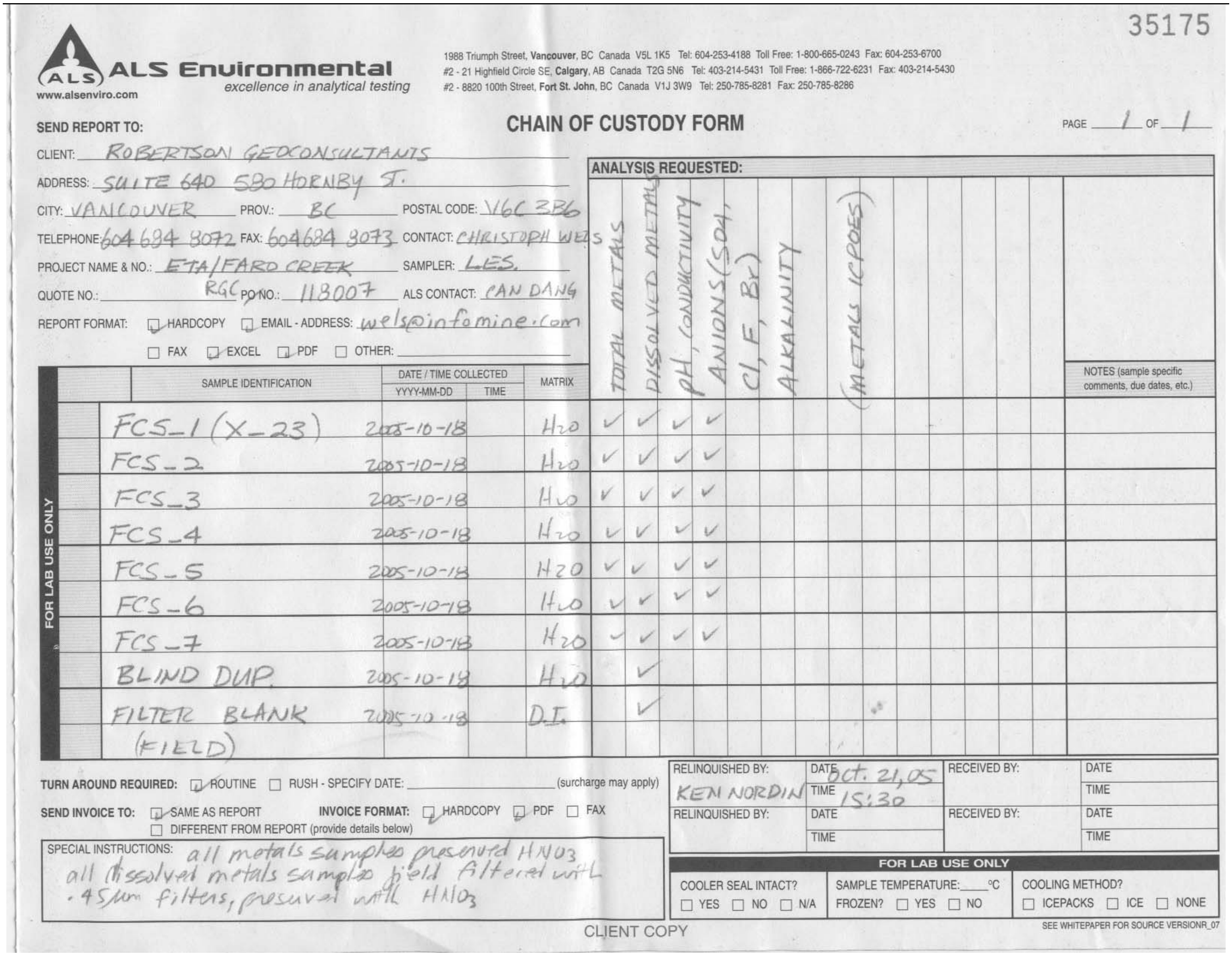
FCS_4 Oct.18.05. Note high water mark on bank.

FCS_6 portable weir box

FCS_6 looking across portable weir

FCS_7 looking across towards Guardhouse Creek

FCS_7 looking upstream towards old tailings dam Oct.18.05



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CHAIN OF CUSTODY FORM

PAGE 1 OF 1

SEND REPORT TO:

CLIENT: ROBERTSON GEOCONSULTANTS
ADDRESS: SUITE 640 580 HORNBY ST.
CITY: VANCOUVER PROV.: BC POSTAL CODE: V6C 3B6
TELEPHONE: 604 684 8072 FAX: 604684 8073 CONTACT: CHRISTOPH WELS
PROJECT NAME & NO.: ETA/FARO CREEK SAMPLER: L.E.S.
QUOTE NO.: RGC PO NO.: 118007 ALS CONTACT: CAN DANG
REPORT FORMAT: ☑ HARDCOPY ☑ EMAIL - ADDRESS: wels@infomine.com
☐ FAX ☑ EXCEL ☑ PDF ☐ OTHER:

ANALYSIS REQUESTED:

SAMPLE IDENTIFICATION	DATE / TIME COLLECTED YYYY-MM-DD	TIME	MATRIX	TOTAL METALS	DISSOLVED METALS	pH, CONDUCTIVITY	ANIONS (SO4, Cl, F, Br)	ALKALINITY	(METALS ICPOES)	NOTES (sample specific comments, due dates, etc.)
FCS_1 (X-23)	2005-10-18		H2O	✓	✓	✓	✓			
FCS_2	2005-10-18		H2O	✓	✓	✓	✓			
FCS_3	2005-10-18		H2O	✓	✓	✓	✓			
FCS_4	2005-10-18		H2O	✓	✓	✓	✓			
FCS_5	2005-10-18		H2O	✓	✓	✓	✓			
FCS_6	2005-10-18		H2O	✓	✓	✓	✓			
FCS_7	2005-10-18		H2O	✓	✓	✓	✓			
BLIND DUP.	2005-10-18		H2O		✓					
FILTER BLANK (FIELD)	2005-10-18		D.I.		✓					

FOR LAB USE ONLY

TURN AROUND REQUIRED: ☑ ROUTINE ☐ RUSH - SPECIFY DATE: (surcharge may apply)

SEND INVOICE TO: ☑ SAME AS REPORT ☐ DIFFERENT FROM REPORT (provide details below)
INVOICE FORMAT: ☑ HARDCOPY ☑ PDF ☐ FAX

RELINQUISHED BY: KEN NORDIN	DATE Oct. 21, 05 TIME 15:30	RECEIVED BY:	DATE TIME
RELINQUISHED BY:	DATE TIME	RECEIVED BY:	DATE TIME

SPECIAL INSTRUCTIONS: all metals samples preserved HNO3
all dissolved metals samples field filtered with .45µm filters, preserved with HNO3

FOR LAB USE ONLY
COOLER SEAL INTACT? ☐ YES ☐ NO ☐ N/A
SAMPLE TEMPERATURE: ____°C FROZEN? ☐ YES ☐ NO
COOLING METHOD? ☐ ICEPACKS ☐ ICE ☐ NONE

CLIENT COPY

SEE WHITEPAPER FOR SOURCE VERSIONR_07

Laberge
ENVIRONMENTAL SERVICES

Memorandum

To: Christoph Wels RGC, Dan Mackie SRK January 5, 2006
Copies: Deloitte, GLL, Faro Project Office
From: Ken Nordin LES

Re: Additional Monitoring of Faro Creek Seepage Losses

This is a brief description of the results of the project ***Additional Monitoring of Faro Creek Seepage Losses*** for December 2005. All sites were accessed by skidoo – FCS_2 and FCS_7 were frozen solid and FCS_5 was heavily affected by icing.

FCS_1 WRD seepage in old Faro Creek channel (at X23)

FCS_1 was visited at 12:30 PM. There was a thin ice cover over the notch and water was flowing freely underneath. H over the notch was 0.045m (0.59 L/sec). Bucket discharge was approximately 0.67 L/sec. We tried to download the PT2X sensor but the computer and battery were frozen (air temp. -20^0 C).

FCS_2 Downstream of access road at suicide curve

The entire culvert barrel was filled with ice. There was still some wet areas downstream of the culvert so some seepage was likely still reporting trough the or under the ice although there was not a confined flow or any place to collect a sample.

FCS_2 downstream of the road December 19, 2005

FCS_3 Subsurface seepage discharging at seepage face below road (at X7)

Again, conditions were favourable for sampling and reliable volumetric measurements at this site. Discharge was 2.3 L/sec.

FCS_4 Combined seepage at the mouth of Faro Creek Canyon

Things looked frozen soild at this site, but proved otherwise. The V-notch was flowing freely uner 0.5 m of bright orange ice. H over the notch was hard to meaure, but was about 10 cm (4.3 L/sec). Discharge by bucket was 4.7 L/sec. The PT2X sensor was not downloaded due to dead computer.

0.5m ice cover; water flowing over notch freely

FCS_4 looking downstream Dec 19, 2005

FCS_4 at weir looking upstream

FCS_5 Old Tailings dam decant X_1 at end of ditch

This site began to ice up in early December. By December 19 a thick accumulation had built up directly over the weir. Water was still flowing around the left hand side, some of which was spilling out onto the old tailings. A channel was cut to allow free flow around the left side. We chopped out the V-notch and found it frozen solid. The PT2X sensor could not be downloaded. The communication cable was re-set on a higher pole to make sure it would not be inundated by ice. The flow around the bulkhead was estimated with a bucket at 2.5 L/sec.


FCS_5 glacier


Looking upstream


Some flow onto old tailings


Channel cut left side


Channel downstream of FCS_5


new pole to suspend cable FCS_5

FCS_6 Seepage flow approximately halfway towards Intermediate pond

This site was heavily iced up but there was free water on the sides of the frozen channel. We were able to collect samples without difficulty but there was no way to estimate the flow. There was definitely some free flowing water.

FCS_6 site Dec 19 2005

FCS_7 seepage flow near pond (but u/s of inflow from Guardhouse Creek)
This site was white, indicating that it was still frozen solid as it was in November.

Results of measurements at recording stations
The following is a summary of discharge measurements taken to date at the recording sites
.

FCS_1 or X_23

Date/Time	H (m)	Q (L/sec	Sensor (m)	Offset (m)	comment
Aug 30 11:00	0.045	0.585			fmla
Aug 30 11:00		0.6			Site bucket 26 L
Aug 30 11:00		0.59			LES bucket 9.6 L
Sept 15 11:32	0.059	1.15			fmla
Sept 15 11:32		1.14	.2478	.1888	21.5 L bucket
Oct 3 07:30?	0.061	1.25	.2450?		fmla
Oct 18 13:35	0.059	1.15	.2443	.1853	fmla
Oct 18 13:35		1.15			20.5 L in dedicated bucket
Nov 21 10:00		1.05			About 19.5 L in the dedicated bucket – can't make the bucket level
Nov 21 10:00	0.055	0.97	.2390	.1840	fmla
Dec 19 12:30	0.045	0.59			Fmla, computer frozen, not downloaded
Dec 19 12:30		0.67			Site bucket (19 L fill)

FCS_4 Faro Creek Canyon

Date/Time	H (m)	Q (L/sec	Sensor (m)	Offset (m)	comment
Sept 1 16:00	0.125	7.56			fmla
Sept 1 16:00		7.62			9.6 L bucket
Sept 15 15:30	0.130	8.30	.2394	.1091	fmla
Sept 15 15:30		8.6			9.6 L bucket
Oct 3 07:30?	0.115	6.11	.2219	.1069	fmla
Oct 18 15:23	0.123	7.23	.2291	.1061	fmla
Oct 18 15:30		7.17			21.0 L dedicated bucket
Nov 21 16:30		5.4			About 20 L in dedicated bucket – can't get bucket level
Nov 21 16:30	0.109	5.35	0.2155	.1065	fmla
Dec 19 13:30	0.1	4.3			fmla
Dec 19 13:30		4.7			Bucket, 19L. Not downloaded

FCS_5 near old X_1 at end of ditch from Faro Creek Canyon

Date/Time	H (m)	Q (L/sec	Sensor (m)	Offset (m)	comment
Oct 18 14:30	0.115	6.11	0.4028	.2878	fmla
Nov 21 16:30		4.5			11.75 L bucket, fills fast
Nov 21 16:30	0.094	3.7	0.359	.2650	fmla
Dec 19 16:00	0	2.5			Flow reporting around left side of bulkhead. V-notch frozen solid

Copies of field notes and chain of custody forms follow. If you have any questions contact the undersigned anytime.

Ken Nordin
Laberge Environmental Services

Station ID	Location	December 2005 DD/Time	Trial 1	Trial 2	*Cond. *u*S/cm	pH	*TDS mg/L
Reach 3							
FCS1	WRD seepage in old Faro Creek channel (at X23)	19/12:30	0.67^v	0.59^w	4160	6.05	1910
FCS2	Culvert chock full, backing up upstream of road, still some wet spots below but no way to get samples or flow						
FCS3	subsurface seepage discharging at seepage face below road (at X7) (w/ organic smell)	19/14:30	2.3^v		5120	5.88	2540
FCS4	combined seepage below confluence of X7 and X23 (at mouth of Faro Creek canyon)	19/13:30	4.3^w	4.7^v	4100	5.85	1880
FCS5	Seepage flow at end of diversion ditch (prior to discharge into Interm. Impoundment) new weir installed Oct.18. Iced up Dec 19	19/16:00		2.5^v	3590	5.84	1640
FCS6	Seepage flow appr. Halfway towards Interm. Pond. Station established and flagged Oct 18. Q by portable weir box. Iced up Dec 19, negligible flow	19/16:30	<0.1^e		4170	3.88	2080
FCS7	seepage flow near pond (but u/s of inflow from Guardhouse Creek) Station established and flagged Oct 18. still frozen Dec 19	19/16:4	nil		na	na	na
GHC	Guardhouse Creek before discharge into Intermediate Impoundment (at road)						

*Orion conductivity meter 115A+

^{e} estimated, judgmental

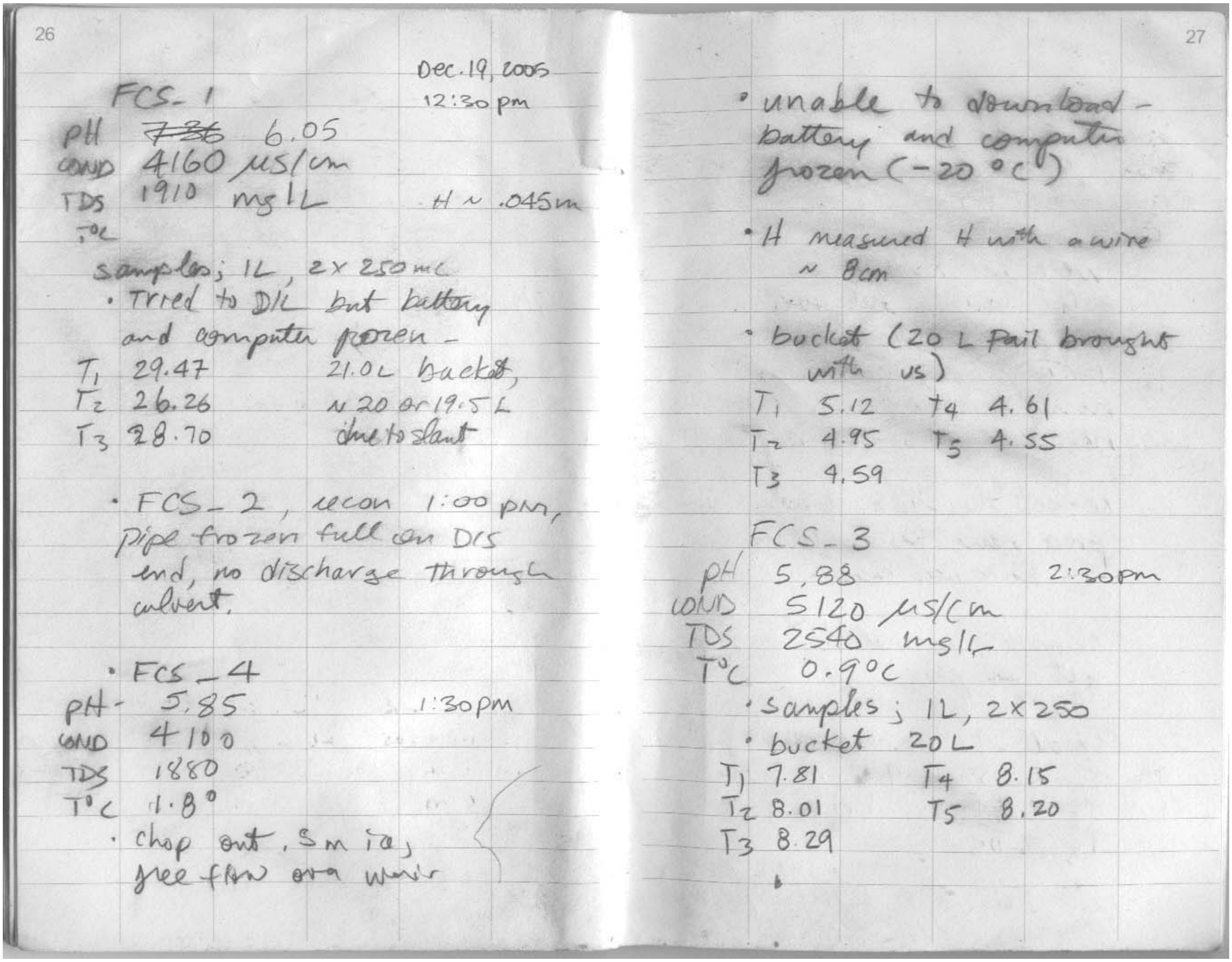
^{v} volumetric (average trials time to fill calibrated bucket)

^{w} weir

Note conductivity readings suspect – when checked at guesthouse later they were off-scale

(Corrected) Rating Table for Standard 90 degree V-notch Weir where Q (L/sec) =1362.9H^2.5

H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec	H (m)	L/sec
0.030	0.21	0.073	1.96	0.108	5.22	0.143	10.54	0.178	18.22	0.223	32.01	0.258	46.08
0.035	0.31	0.074	2.03	0.109	5.35	0.144	10.72	0.179	18.48	0.224	32.37	0.259	46.53
0.040	0.44	0.075	2.10	0.110	5.47	0.145	10.91	0.180	18.73	0.225	32.73	0.260	46.98
0.041	0.46	0.076	2.17	0.111	5.59	0.146	11.10	0.181	19.00	0.226	33.09	0.270	51.63
0.042	0.49	0.077	2.24	0.112	5.72	0.147	11.29	0.182	19.26	0.227	33.46	0.280	56.54
0.043	0.52	0.078	2.32	0.113	5.85	0.148	11.48	0.183	19.53	0.228	33.83	0.290	61.72
0.044	0.55	0.079	2.39	0.114	5.98	0.149	11.68	0.184	19.79	0.229	34.20	0.300	67.18
0.045	0.59	0.080	2.47	0.115	6.11	0.150	11.88	0.185	20.06	0.230	34.58	0.310	72.92
0.046	0.62	0.081	2.54	0.116	6.25	0.151	12.08	0.186	20.34	0.231	34.95	0.320	78.95
0.047	0.65	0.082	2.62	0.117	6.38	0.152	12.28	0.187	20.61	0.232	35.33	0.330	85.26
0.048	0.69	0.083	2.70	0.118	6.52	0.153	12.48	0.188	20.89	0.233	35.72	0.340	91.87
0.049	0.72	0.084	2.79	0.119	6.66	0.154	12.68	0.189	21.17	0.234	36.10	0.350	98.77
0.050	0.76	0.085	2.87	0.120	6.80	0.155	12.89	0.190	21.45	0.235	36.49	0.360	105.98
0.051	0.80	0.086	2.96	0.121	6.94	0.156	13.10	0.191	21.73	0.236	36.88	0.370	113.49
0.052	0.84	0.087	3.04	0.122	7.09	0.157	13.31	0.192	22.01	0.237	37.27	0.380	121.32
0.053	0.88	0.088	3.13	0.123	7.23	0.158	13.52	0.193	22.30	0.238	37.66	0.390	129.46
0.054	0.92	0.089	3.22	0.124	7.38	0.159	13.74	0.194	22.59	0.239	38.06	0.400	137.92
0.055	0.97	0.090	3.31	0.125	7.53	0.160	13.96	0.195	22.88	0.240	38.46	0.410	146.70
0.056	1.01	0.091	3.40	0.126	7.68	0.161	14.18	0.196	23.18	0.241	38.86	0.420	155.81
0.057	1.06	0.092	3.50	0.127	7.83	0.162	14.40	0.197	23.48	0.242	39.26	0.430	165.25
0.058	1.10	0.093	3.59	0.128	7.99	0.163	14.62	0.198	23.78	0.243	39.67	0.440	175.02
0.059	1.15	0.094	3.69	0.129	8.15	0.164	14.84	0.199	24.08	0.244	40.08	0.450	185.14
0.060	1.20	0.095	3.79	0.130	8.30	0.165	15.07	0.200	24.38	0.245	40.49	0.500	240.93
0.061	1.25	0.096	3.89	0.131	8.47	0.166	15.30	0.201	24.69	0.246	40.91		
0.062	1.30	0.097	3.99	0.132	8.63	0.167	15.53	0.202	24.99	0.247	41.32		
0.063	1.36	0.098	4.10	0.133	8.79	0.168	15.77	0.203	25.30	0.248	41.74		
0.064	1.41	0.099	4.20	0.134	8.96	0.169	16.00	0.204	25.62	0.249	42.17		
0.065	1.47	0.100	4.31	0.135	9.13	0.170	16.24	0.205	25.93	0.250	42.59		
0.066	1.53	0.101	4.42	0.136	9.30	0.171	16.48	0.206	26.25	0.251	43.02		
0.067	1.58	0.102	4.53	0.137	9.47	0.172	16.72	0.207	26.57	0.252	43.45		
0.068	1.64	0.103	4.64	0.138	9.64	0.173	16.97	0.208	26.89	0.253	43.88		
0.069	1.70	0.104	4.75	0.139	9.82	0.174	17.21	0.209	27.22	0.254	44.31		
0.070	1.77	0.105	4.87	0.140	10.00	0.175	17.46	0.210	27.54	0.255	44.75		
0.071	1.83	0.106	4.99	0.141	10.17	0.176	17.71	0.211	27.87	0.256	45.19		
0.072	1.90	0.107	5.10	0.142	10.36	0.177	17.96	0.222	31.65	0.257	45.63		



Dec. 19, 2005
12:30 pm

FCS_1
pH ~~7.36~~ 6.05
COND 4160 µS/cm
TDS 1910 mg/L
T°C

H ~ .045 m

samples; 1L, 2 x 250 mL
- Tried to D/L but battery and computer frozen –

T_1 29.47
T_2 26.26
T_3 28.70

21.0 L bucket,
~ 20 or 19.5 L
due to slant

- FCS_2, recon 1:00 pm, pipe frozen full on D/S end, no discharge through culvert.

- FCS_4

pH - 5.85
COND 4100
TDS 1880
T°C 1.8°

1:30 pm

- chop out, 5 m ice, free flow over weir

- unable to download – battery and computer frozen (−20 °C)
- H measured H with a wire ~ 8 cm
- bucket (20 L pail brought with us)

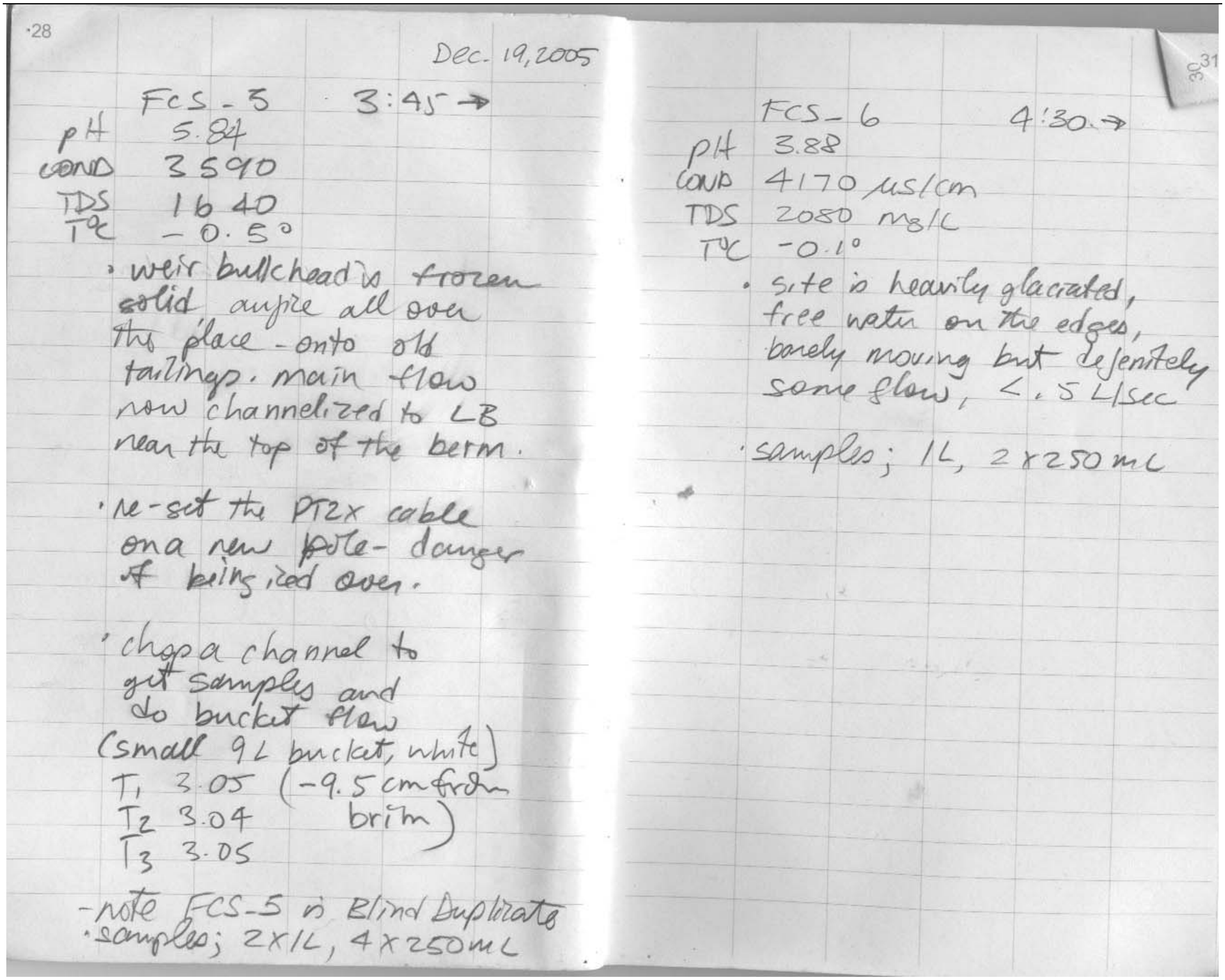
T_1 5.12 T_4 4.61
T_2 4.95 T_5 4.55
T_3 4.59

FCS_3
pH 5.88
COND 5120 µS/cm
TDS 2540 mg/L
T°C 0.9°C

2:30 pm

- samples; 1L, 2 x 250
- bucket 20 L

T_1 7.81 T_4 8.15
T_2 8.01 T_5 8.20
T_3 8.29



Dec. 19, 2005

FCS - 5 3:45 →

pH 5.84
COND 3590
TDS 1640
T°C - 0.5°

- weir bulkhead is frozen solid aufice all over the place - onto old tailings. main flow now channelized to LB near the top of the berm.
- re-set the PT2X cable on a new pole - danger of being iced over.
- chop a channel to get samples and do bucket flow (small 9L bucket, white)

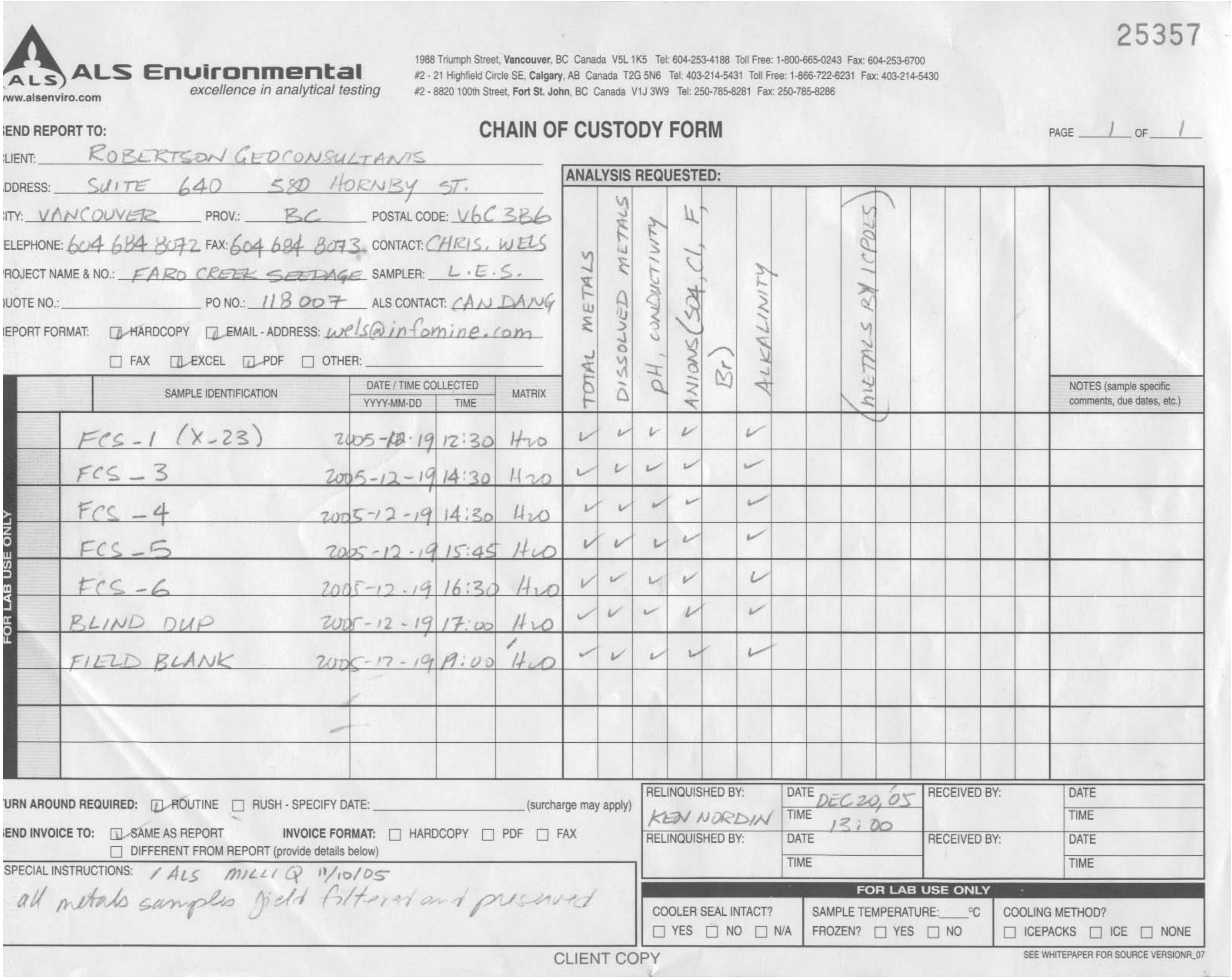
T1 3.05 (-9.5 cm from
T2 3.04 brim)
T3 3.05

-note FCS-5 is Blind Duplicate
- samples; 2X1L, 4X250mL

FCS - 6 4:30 →

pH 3.88
COND 4170 uS/cm
TDS 2080 mg/L
T°C -0.1°

- site is heavily glaciated, free water on the edges, barely moving but defenitely some flow, < .5 L/sec
- samples; 1L, 2x250 mL



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#2 - 8820 100th Street, **Fort St. John**, BC Canada V1J 3W9 Tel: 250-785-8281 Fax: 250-785-8286

CHAIN OF CUSTODY FORM

PAGE 1 OF 1

END REPORT TO:

LIENT: ROBERTSON GEOCONSULTANTS
DDRESS: SUITE 640 580 HORNBY ST.
ITY: VANCOUVER PROV.: BC POSTAL CODE: V6C 3B6
ELEPHONE: 604 684 8072 FAX: 604 684 8073 CONTACT: CHRIS. WELS
ROJECT NAME & NO.: FARO CREEK SEEPAGE SAMPLER: L.E.S.
UOTE NO.: PO NO.: 118 007 ALS CONTACT: CAN DANG
EPORT FORMAT: ☑ HARDCOPY ☑ EMAIL - ADDRESS: wels@infomine.com
☐ FAX ☑ EXCEL ☑ PDF ☐ OTHER:

ANALYSIS REQUESTED:

SAMPLE IDENTIFICATION	DATE / TIME COLLECTED		MATRIX	TOTAL METALS	DISSOLVED METALS	pH, CONDUCTIVITY	ANIONS (SO4, Cl, F,	Br)	ALKALINITY			(METALS BY ICPOES)						NOTES (sample specific comments, due dates, etc.)
	YYYY-MM-DD	TIME																
FCS-1 (X-23)	2005-12-19	12:30	H_2O	✓	✓	✓	✓		✓									
FCS_3	2005-12-19	14:30	H_2O	✓	✓	✓	✓		✓									
FCS-4	2005-12-19	14:30	H_2O	✓	✓	✓	✓		✓									
FCS_5	2005-12-19	15:45	H_2O	✓	✓	✓	✓		✓									
FCS-6	2005-12-19	16:30	H_2O	✓	✓	✓	✓		✓									
BLIND DUP	2005-12-19	17:00	H_2O	✓	✓	✓	✓		✓									
FIELD BLANK	2005-12-19	19:00	H_2O	✓	✓	✓	✓		✓									

FOR LAB USE ONLY

URN AROUND REQUIRED: ☑ ROUTINE ☐ RUSH - SPECIFY DATE: (surcharge may apply)
END INVOICE TO: ☑ SAME AS REPORT **INVOICE FORMAT:** ☐ HARDCOPY ☐ PDF ☐ FAX
☐ DIFFERENT FROM REPORT (provide details below)

SPECIAL INSTRUCTIONS: 1 ALS MILLI Q 11/10/05
all metals samples field filtered and preserved

RELINQUISHED BY:	DATE	RECEIVED BY:	DATE
KEN NORDIN	DEC 20, 05		
	TIME 13:00		TIME
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FOR LAB USE ONLY

COOLER SEAL INTACT? ☐ YES ☐ NO ☐ N/A
SAMPLE TEMPERATURE: ____°C
FROZEN? ☐ YES ☐ NO
COOLING METHOD? ☐ ICEPACKS ☐ ICE ☐ NONE

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Appendix C

ETA Flood Hydrology

Estimation of a Design Hydrograph for the Proposed ARD Collection System at the Emergency Tailings Area - DRAFT

1 Introduction

Mine drainage in the old Faro Creek channel below the Main Waste Dump contains elevated metal and sulphate concentrations. Owing to a steady increase in the sulphate concentrations since about 1998, it has been recognized that this drainage may pose a significant risk to the environment long before permanent closure measures can be implemented at the mine. To minimize the impact of this drainage over the short term, a plan has been proposed to collect the drainage and treat it at new water treatment plant. Implementation of this plan will require the development of a collection system, comprising a dam constructed in the old Faro Creek channel, pumps and a pipeline to the new water treatment plant. This memorandum summarizes the hydrological information used as the basis for sizing of the collection system.

Figure 1 shows key information that was assembled to help estimate design flows for the proposed collection system. It is a map of the pre-mining topography with the following pieces of information superimposed on it:

1) the locations of the two water quality monitoring sites within the old Faro Creek channel, one at the toe of the Main Dump (X23) and the other near the outlet of the Faro Creek canyon (X7);
2) outlines of the waste dumps around the perimeter of the Main Pit (excluding the Faro Valley Waste Dump);
3) outline of the lake within the Main Pit;
4) the course of the Faro Creek prior to development of the mine;
5) location of the Emergency Tailings Area (ETA); and,
6) the outline of the approximate area contributing flows to the old Faro Creek channel under present-day conditions.

The dam for the proposed collection system would be located near the downstream end of the ETA, or just above Station X7. The deposited tailings within the ETA would probably have to be removed to develop an adequate volume of storage for the collection system.

The catchment boundary outlined on Figure 1 was based on pre-mining topography rather than the surface topography of the waste dumps. Pre-mining topography generally provides an accurate basis for predicting where seepage from a waste dump will emerge (i.e., at points where the toes of waste dumps intersect stream channels). Following from this observation, the pre-mining topography was judged to also be useful for outlining the catchment area contributing to the proposed dam (after allowance was made for the effect of excavating the open pit). The tacit assumption in using pre-mining topography for this purpose is that percolation through a waste dump is primarily a vertical process and the underlying original ground is where the percolated water is forced to move laterally. The catchment outlined on Figure 1 suggests that Station X7, and hence the proposed dam, controls an area of about 1.8 km^2.

The adopted design event for the proposed collection system was an extremely wet year with a return period of 100 years. The estimation of such an event was not a straightforward exercise for the following reasons:

1) the records of flow within the old Faro Creek channel are sparse, with continuous monitoring of flow only being established in September 2005;
2) owing to a large drainable porosity, the waste dumps have considerable, but unquantified, capacity to attenuate the runoff response from the catchment of the proposed dam;
3) there is uncertainty as to the true size of the drainage area that will be controlled by the proposed dam (e.g., it is unknown whether pre-mining or existing surface topography provides a better indication of the location of drainage divides) ; and,
4) there is uncertainty in the true long-term average yield generated by the waste dumps. Evaporation from the waste dumps may be enhanced relative to undisturbed catchments because of heat generated by oxidation within the waste dumps. In addition, the lack of vegetation on the waste dumps may allow a loss of snowpack due to wind re-distribution.

Taking the complications outlined above into consideration, a procedure was developed to estimate the 100-year hydrograph for the proposed collection system. The procedure was broken down into two broad tasks. The first involved using regional streamflow records to infer what the 100-year hydrograph would look like at Station X7 if no waste dumps existed within the station's catchment (i.e., a condition representative of the largely undisturbed catchments that are measured by the regional streamflow gauging stations). The second task entailed modifying the hydrograph developed in the first task so that it reflected the significant storage attenuation caused by the waste dumps. This second task relied heavily on the available flow measurements made thus far at X23 and X7. The two tasks are described below under separate headings.

2 Flood Hydrology of Typical Streams

The proposed collection system will include a reservoir to temporarily store a portion of incoming flood flows for subsequent pumping to the mill for treatment during periods of low flow. To determine an adequate size for the reservoir, an understanding must be developed of the volumes of water associated with the flood. With this in mind, this section uses regional streamflow gauging data to infer what the 100-year hydrograph would look like at the proposed dam, but without the attenuation benefits caused by storage within the waste dumps. As mentioned above, the influence of the waste dumps on the flood hydrology will be examined in the next section of the memorandum. The developed hydrograph spans a full calendar year and is based on a daily time step.

The volume characteristics of local floods were estimated using a technique known as Regional Analysis. This technique involved developing empirical relationships that could be used to transpose the flood data from regional streamflow gauging stations to the site of the proposed dam. Application of the Regional Analysis entailed six steps.

The first step was the assembly of regional data. Emphasis was placed on finding streamflow gauging stations that had long periods of record and that were located on small drainage areas. To maximize the amount of data available from which to choose, a search was made of the networks of streamflow gauging stations operated by three government agencies: Water Survey of Canada (WSC), Environment Yukon (EY) and United States Geological Survey (USGS). The search for data in the WSC and EY networks extended over the entire Yukon Territory south of latitude 65°. The search within the USGS network was limited to the eastern central region of Alaska. Examination of the three networks revealed a total of 15 stations that could potentially be useful in characterizing the flood hydrology of the collection system. Table 1 provides details of these stations, including length of record, drainage area, mean annual runoff and the name of the authority that operated the station.

The second step entailed a statistical analysis of the assembled records. From each streamflow record, a total of 12 annual series were extracted. All of the series had one characteristic in common: they contained a list of the highest discharge in each year. The differences in the 12 annual series related to the period over which the highest discharge was defined. These periods were 1, 2, 3, 5, 7, 10, 15, 30, 60, 90, 183 and 365 consecutive days. Each of these annual series was fitted to a theoretical frequency distribution to estimate the average flood flow rate for a return period of 100 years. This meant a total of 180 fittings were undertaken (i.e., 15 stations x 12 annual series per station). Table 1 summarizes the results obtained from performing this step. To facilitate comparison of the floods generated by the widely different catchment sizes, the flood values in Table 1 are expressed as unit discharges in units of L/s/km^2 (i.e., the absolute flood discharge was divided by the contributing catchment area). The extraction of the annual series and the fitting of frequency distributions were performed using a suite of hydrological programs developed by the USGS (viz., ANNIE4.1, IOWDM4.1 and SWSTAT4.1).

The third step involved examining the data for trends that could form the basis for transposing the regional data to the minesite. For peak instantaneous floods, there is a tendency for the unit flood discharge to exhibit an inverse relationship with catchment area (i.e., unit flood discharge increases with decreasing catchment area). It was suspected that this inverse relationship may also apply to peak daily average flows and perhaps even longer durations. Figures 2 and 3 were prepared to test the flood data for such scale effects. These figures show a total of 12 plots of unit flood discharge vs. catchment area, one for each of the durations given in Table 1. Examination of these 12 plots revealed that unit discharge is virtually independent of catchment area for all 12 durations, at least over the range of catchment areas (13.7 km^2 to 7250 km^2) represented by the data in Table 1. This observation suggested that there was no need to adjust the unit flood values from large catchments to make them representative of the floods on small minesite catchments.

Having discovered that scale effects are minimal for durations of a day and longer, a search was undertaken to identify another independent variable that might help explain the variation in unit flood values. This search identified mean annual runoff (MAR) as a potential variable, particularly for the longer durations. Figures 4 and 5 were developed to explore the relationship between unit flood discharge and MAR. Again, a total of 12 plots are presented on these figures, one for each duration. Examination of these plots revealed that MAR is a poor predictor of flood values for short durations up to 5 days, a fair predictor for durations between 7 and 15 days, and a good predictor for durations of 30 days and longer. On the basis of this observation, it was decided to use the observed relationships between flood discharge and MAR to help estimate flood magnitudes at the minesite. To facilitate application of the relationships, a linear regression was fitted to the data set of each duration (see red lines on the plots). A text box on each plot expresses the relationship as an equation. To provide a means of making conservative flood estimates, envelope curves were also drawn on the plots that encompass all the data points (see blue lines).

The fourth step in developing the Regional Analysis was to estimate the MAR of the catchment of the proposed collection dam. This was accomplished using an empirical relationship developed during preparation of the 1996 Integrated Comprehensive Abandonment Plan for the Anvil Range Mine Complex. Figure 6 is a reproduction of this relationship. It examines the relationship between MAR and the elevational characteristics of the catchment that generated the runoff. The variable used as a measure of catchment elevation was the median elevation, which is the contour that divides a catchment into halves. Given a median elevation of about 1160 m, the catchment of the proposed collection dam has an estimated MAR of 205 mm. For a catchment area of 1.8 km^2, this is equivalent to a long-term average flow of 11.7 L/s.

The fifth step involved estimating short and long duration flood flows for the proposed collection dam on old Faro Creek, but without accounting for the benefit of storage attenuation caused by the dumps. Using the estimated MAR of 205 mm, each of the plots on Figures 4 and 5 were entered to provide estimates of the 100-year flood magnitude for durations from 1 to 365 days. In recognition of the scatter in the plots, two values were extracted from each plot, one based on the best-fit linear regression and the other on the envelope curve. Table 2 summarizes all the flood values extracted from the plots, all expressed in normalized units of $L/s/km^2$.

The sixth and final step entailed constructing 100-year hydrographs from the flood values assembled in Table 2. This was primarily a process of splitting the long duration flood flows presented in Table 2 into daily values. For example, Table 2 indicates the flood flows for one day and two consecutive days are 189 and 169 $L/s/km^2$, respectively. This means the flood would comprise one day with an average flow of 189 $L/s/km^2$ and a second day with an average flow of 149 $L/s/km^2$ (i.e., 2 x 169 – 189 = 149). By repeating this process for the remaining long duration flows, a set of 365 daily values were computed from the flood information presented in Table 2. In most cases, this resulted in multiple days with the same discharge rate. For example, Table 2 provides flow values for periods of 5 and 7 consecutive days of 123 and 107 $L/s/km^2$, respectively. As a result, the 6th and 7th highest flow days during the year were assumed to experience the same flow rate of 67 $L/s/km^2$ (i.e., (7 x 107 – 5 x 123) / 2 = 67).

Two hydrographs were constructed, one based on the "best estimate" values of unit discharge and the other on the "conservative estimate" values. Figure 7 graphically portrays the resulting two hydrographs. Significant features of the hydrographs are as follows:

- the hydrographs possess a daily time step and cover the period from January 1 to December 31;
- the peak daily discharge occurs on June 1 (based on the approximate average date on which the peak is observed to occur at streamflow gauging stations in the region);
- the unit flood values presented in Table 2 were multiplied by 1.8 km^2 to obtain absolute discharge rates representative of a typical stream with the same drainage area as the proposed collection dam; and,
- the hydrographs were given a "symmetrical" shape.

To create the "symmetrical" shape, the flow rate was made to progressively increase towards the peak and then progressively decrease away from it. This was accomplished by placing the daily flows, from largest to smallest, in an alternating pattern about the peak. Accordingly, the largest daily flow was assigned to June 1, second largest to May 31, the third largest to June 2, the fourth largest on May 30, etc. Beyond the 60th largest flow, this placement pattern was modified to create a skewed appearance to the hydrograph to approximate the shape of natural hydrographs in the region.

The 100-year "best estimate" hydrograph has a daily average peak of 341 L/s, which corresponds to an equivalent depth of 16 mm/d spread uniformly over the 1.8 km^2 catchment. The similar numbers for the 100-year "conservative estimate" hydrograph are 585 L/s and 28 mm/d. The 100-year "best estimate" and "conservative estimate" hydrographs have annual average flows of 22 L/s and 30 L/s, respectively. As a comparison, the long-term average yield from the collection dam catchment is estimated to be about 11.7 L/s (as computed above in Step 4).

The hydrographs presented in Figure 7 are approximations of what a 100-year wet year might look like on a "typical", natural stream with a 1.8 km^2 catchment. Flows measured at X23 and X7 suggest that the hydrology of the old Faro Creek is more subdued than a typical stream in the region. The next section describes how the estimated hydrograph for a typical stream was modified to represent conditions within the old Faro Creek channel.

3 Effect of Waste Dumps on Flood Hydrology

Figure 8 shows a plot of all known flow measurements made at the toe of the Main Waste Dump (Station X23) since 1987 (excluding the data collected at the recently established Station FCS-1). To provide a comparison with a "typical" stream in the region, the corresponding flow record for Vangorda Creek (EY Station 29BC003) has been superimposed on this plot. As the Vangorda Creek station is operated only during the open water season, missing data were patched using a correlation with another regional streamflow gauging station (WSC Station 09BA001). Comparison of the X23 and Vangorda Creek records demonstrates that the runoff response in the old Faro Creek channel is very subdued. Baseflows in the winter are high and peaks during the spring freshet are comparatively small.

The subdued nature of the runoff response in the old Faro Creek channel can almost certainly be attributed to the waste dumps that occupy much of the catchment. As described in the introduction, the mouth of Faro Creek canyon (near Station X7) controls a drainage area of about 1.8 km^2 (see Figure 1). The volume of waste rock overlying this catchment area is approximately 43 million m^3, corresponding to an average dump height of 24 m. If the average moisture content of this dump was, say, 10% by mass, then the water contained in the dump would represent an equivalent depth of 3 m. With an estimated average yield from the dump of 0.2 m per year, the average retention time in the dump works out to be about 15 years. A retention time of this order is adequate to explain the subdued nature of the runoff response in the old Faro Creek channel.

A partial validation check of the X23 flow record was made by creating a scatter diagram with the coincidental Vangorda Creek flows (see bottom plot on Figure 8). The main aim of this diagram was to check the reasonableness of the largest flow on record (29 L/s on June 9, 1992). The scatter diagram indicates that this value is indeed plausible, as it corresponds with a high flow in Vangorda Creek. Examination of other regional data provides additional support for this conclusion. At the WSC station on Ross River, the average flow in June 1992 was exceptionally high; only one other June in the station’s 42 year record has experienced a higher flow.

Besides serving as a consistency check, the scatter diagram provided some insight into the nature of the runoff response in the old Faro Creek channel. During average and dry years, the runoff response has a very strong groundwater character. During wetter years, such as 1992, a faster runoff component is also evident, possibly due to the temporary initiation of shallow groundwater flow or saturated overland flow.

The subdued nature of the X23 flow record suggests that flood hydrographs created for typical streams (as shown on Figure 7) probably overestimate the magnitude of flood discharges in the old Faro Creek channel, particularly for shorter durations of up to say 15 days. Because of this, a method was sought to modify the flood hydrographs estimated in Section 2 so they would be more representative of actual conditions below the waste dumps. The basic requirement of the method was it had to account for the storage attenuation within the waste dumps. One option would be to employ a common technique used in hydrological models to simulate lag and attenuation of runoff within a catchment, namely: cascading linear reservoirs. However, this method was rejected because the available flow data at the proposed dam site was judged to be insufficient to calibrate the technique. In recognition of the limited database, a simplified method was adopted. The basic premise of the method was that the 100-year flood hydrograph in the old Faro Creek could be represented as a mix of a typical stream response and a perfectly regulated system. The former response was estimated in Section 2. The latter response assumes that the system has so much internal storage that the outflows from the system are nearly constant year-round.

The adopted method for accounting for storage attenuation within the waste dumps required calibration. Figure 9 graphically illustrates the calibration process. The data used for the calibration comprised flow measurements collected at a new gauging station (FCS-4) located near Station X7 and the proposed collection dam. The first flow measurement at this site was made in the fall of 2004. In September 2005, a triangular weir was established and an automated water level recorder installed. Blue box symbols on Figure 9 represent the 7 direct discharge measurements made at FCS-4 during 2005. The solid blue line represents the hourly flows computed from the water level measurements made at FCS-4. For the purpose of the calibration, the flow measurements made at FCS-4 during 2005 were used to roughly represent the long-term average flows from the waste dump. However, there is some evidence that these flows may actually represent higher-than-average conditions. For instance, the total precipitation measured at the Whitehorse Airport during the 2005 water year (October 2004 to September 2005) was 139% of normal.

The red line on Figure 9 shows the first attempt at reproducing the average flows at the proposed dam site. The key assumptions behind the construction of this line are as follows:

- the pre-mining topography provides a reliable basis for determining the drainage area controlled by the proposed collection dam (1.8 km^2);
- the regional relationship between MAR and catchment median elevation provides a reliable estimate of the average yield generated by the waste dumps (205 mm);
- the Main and Northwest Waste Dumps have reached a steady-state moisture content so that there is no longer any net storage of water within the dumps; and,
- the shape of the seasonal runoff distribution can be approximated as being 50% of a typical streamflow distribution and 50% of a perfectly regulated distribution.

Figure 10 graphically illustrates the mechanics of constructing the red line. The average monthly flows measured at a WSC station on Tay River were used to represent the average distribution of a “typical” stream.

The flows represented by the red line on Figure 9 lie considerably above the measured flows at Station FCS-4 during 2005, and this is despite that fact that 2005 may have experienced greater-than-average flows from the dumps. After examining the underlying assumptions associated with development of the red line, the following potential reasons were hypothesized for the overestimation:

1) the true drainage area controlled by site FCS-4 could be less than determined using the pre-mining topography;
2) the true yield of Station FCS-4’s catchment could be less than estimated by the regional relationship between MAR and median elevation, particularly if waste dumps act to enhance evaporation losses above what is observed within natural catchments;

3) the moisture storage within the waste dump may not have reached a steady state; or,
4) some portion of the catchment yield may be flowing in the ground below Station FCS-4.

Much of the uncertainties outlined above can be addressed after a longer flow record has been measured at FCS-4. In the meantime, it was decided to recognize these uncertainties by defining ranges in which the true average monthly flows at FCS-4 would fall. The red line on Figure 9 was adopted as the upper limit on the true average flows. For a lower limit, the following assumptions were made:

- the drainage area remains the same as used for the red line, or 1.8 km^2;
- the catchment yield is 100 mm, or roughly half the value estimated by the regional relationship between MAR and elevation; and,
- the distribution of flows can be approximated as being 30% of a typical stream distribution and 70% of a perfectly regulated distribution.

The orange line on Figure 9 represents this lower limit.

The analysis presented on Figure 9 explored ways of accounting for the storage attenuation caused by the waste dumps during average (or near average) flow conditions. The understanding of the waste dump hydrology gained from preparing Figure 9 was used in developing 100-year hydrographs for the proposed collection dam. Figure 11 presents the results. As was done for average flows, upper and lower limits are presented that are estimated to contain the true 100-year hydrograph at the site. The upper limit is based on the same assumptions used in developing the red line on Figure 9 (i.e., MAR = 205 mm, drainage area = 1.8 km^2 and a 50:50 weighting of a typical streamflow hydrograph and a perfectly regulated hydrograph). Similarly, the lower limit is based on the same assumptions used to define the orange line (MAR = 100 mm, drainage area = 1.8 km^2 and a 30:70 weighting). In both cases, the 100-year hydrograph for a typical stream is represented by the “best estimate” hydrograph developed in Section 2 (see Figure 7).

The “high estimate” 100-year hydrograph has a daily peak of 182 L/s and an annual average flow of 22 L/s. The similar values for the “low estimate” hydrograph are 114 L/s and 16 L/s.

Table 1 Estimated 100-Year Floods at Regional Streamflow Gauging Stations

Streamflow Gauging Station		Length of Record (years)	Drainage Area (km^2)	Mean Annual Runoff (mm)	Authority [c]	Average discharge in $L/s/km^2$ for the following number of consecutive days [d]:											
ID No.	Name					1	2	3	5	7	10	15	30	60	90	183	365
10AB003	King Creek at km 20.9 Nahanni Range Road	12	13.7	290	WSC	150	126	112	101	93	86	77	72	63	52	30	16
29AB006	Upper Wolf Creek [a]	9	14.5	179	EY	325	257	197	150	122	103	85	68	56	47	31	16
15344000	King Creek near Dome Creek	7	15.2	100	USGS	114	112	110	100	91	73	65	41	21	13	9	5
15535000	Caribou Creek near Chatanika	15	23.8	200	USGS	169	140	115	89	72	69	65	58	42	34	22	13
15439800	Boulder Creek near Central	20	81.0	131	USGS	257	246	199	151	132	112	89	60	43	31	15	8
29BC003	Vangorda Creek at Faro Townsite Road [a]	22	91.2	235	EY	149	134	113	96	85	72	71	61	43	32	20	11
09AD002	Sidney Creek at km 46 South Canol Road	11	372	350	WSC	231	200	173	141	126	116	103	86	62	50	29	18
10AA002	Tom Creek at km 34.9 Robert Campbell Highway	18	435	218	WSC	105	103	102	100	97	90	82	76	57	51	29	16
09AG003	South Big Salmon River below Livingstone Creek	14	515	246	WSC	198	175	157	132	112	100	84	72	53	43	25	15
09AA012	Wheaton River near Carcross [a]	49	875	285	WSC	107	105	101	92	88	81	70	56	44	37	24	13
15511000	Little Chena River near Fairbanks [b]	37	963	199	USGS	256	242	226	189	154	123	94	58	38	29	21	11
09BB001	South MacMillan River at km 407 Canol Road	22	997	624	WSC	216	216	205	187	173	169	151	126	103	79	47	25
09EA004	North Klondike River near the mouth	29	1100	379	WSC	159	145	135	124	113	104	97	82	64	51	32	18
15484000	Salcha River near Salchaket [b]	56	5618	261	USGS	285	239	217	179	152	131	107	77	52	44	29	15
09BA001	Ross River at Ross River [a]	41	7250	293	WSC	113	111	109	103	97	88	81	72	52	39	22	13

Notes: a) The daily streamflow records of these four stations were patched prior to them being fitted to frequency distributions. Estimates were only made for short gaps and/or missing periods during winter. Years with substantial periods of missing data during the open water season were not included in the flood frequency analysis.

b) For each station and each duration, the annual series of flood data were fitted to a theoretical frequency distribution (Log-Pearson Type III or 3-parameter lognormal) to estimate the magnitude of the 100-year flood discharge. A visual inspection revealed a good fit to the data sets for all but a few of the stations. For the Salcha River and Little Chena River, the fit was only fair for durations from 1 to 30 days because of the existence of a high outlier.

c) WSC = Water Survey of Canada; EY = Environment Yukon; USGS = United States Geological Survey

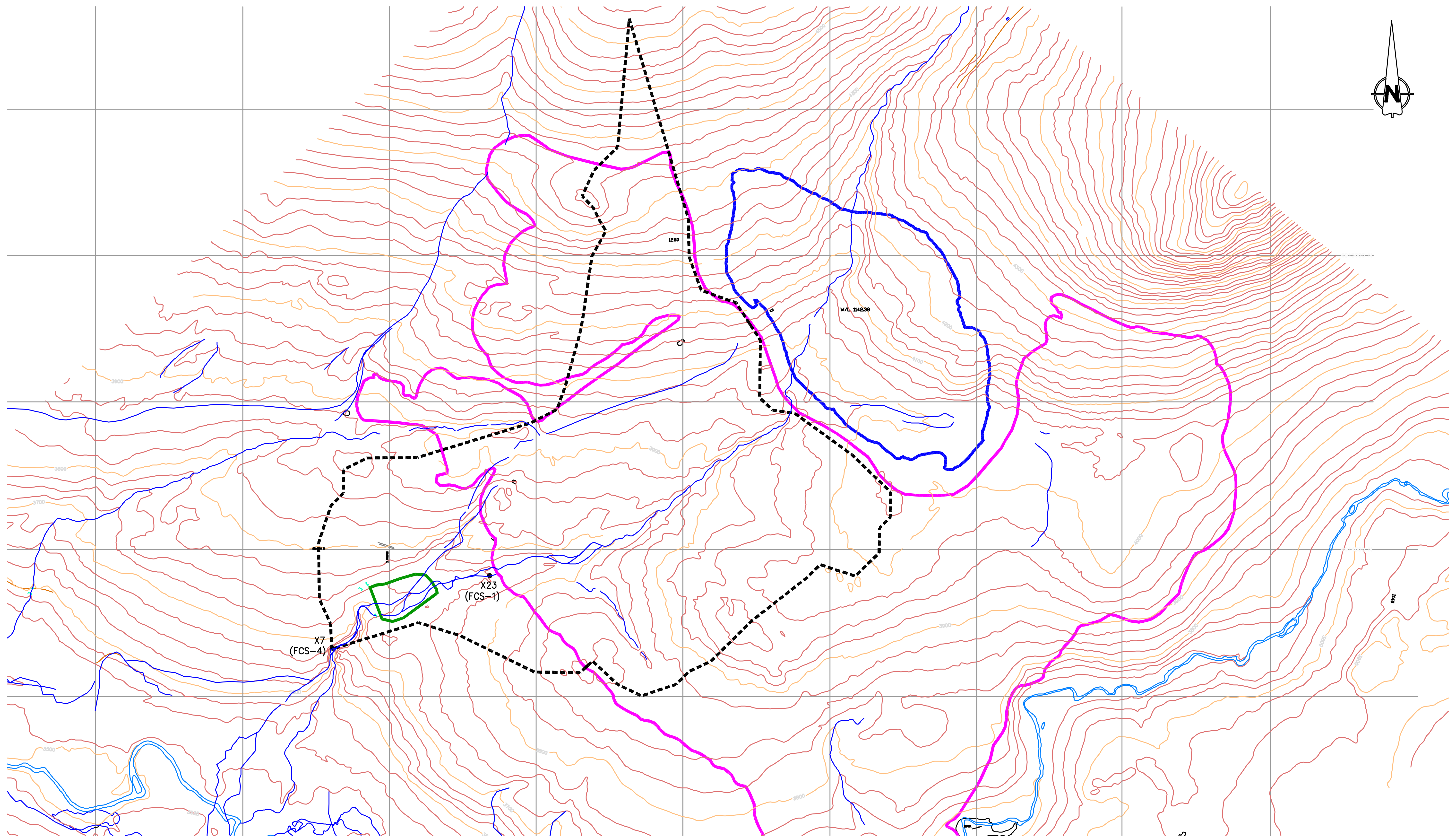
d) To facilitate comparisons of the flood values for the widely differing catchment areas, the flood values in this table have been expressed as unit discharges in units of $L/s/km^2$ (i.e., the absolute flood discharges have been divided by the contributing catchment areas).

Table 2 Estimated 100-Year Flood Hydrograph for a Typical Stream at the Minesite

Method of Estimation [a]	Average discharge in L/s/km^2 for the following number of consecutive days [b]:											
	1	**2**	**3**	**5**	**7**	**10**	**15**	**30**	**60**	**90**	**183**	**365**
Linear regression fitted to trend between flood discharge and MAR	189	169	148	123	107	93	80	62	45	36	22	12
Envelope curve on trend between flood discharge and MAR	325	258	226	190	155	124	99	74	59	50	33	17

Notes: a) The estimate based on linear regression is designated as being the "best estimate" hydrograph. The other is designated as being the "conservative estimate" hydrograph.

b) These unit flood estimates are for a stream with a mean annual runoff (MAR) of 205 mm.



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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

🟩 ETA Outline
🟪 Waste Dump Outline
🟦 Lake (Main Pit)
■ ■ ■ Station X7/FS4 Catchment Boundary

SRK Consulting
Engineers and Scientists

Deloitte
& Touche

Task 20e – Continue Seepage Investigation

Approximate Catchment Area
of Station X7 Superimposed on
Pre–Mining Topography

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Feb., 2006	PB	1

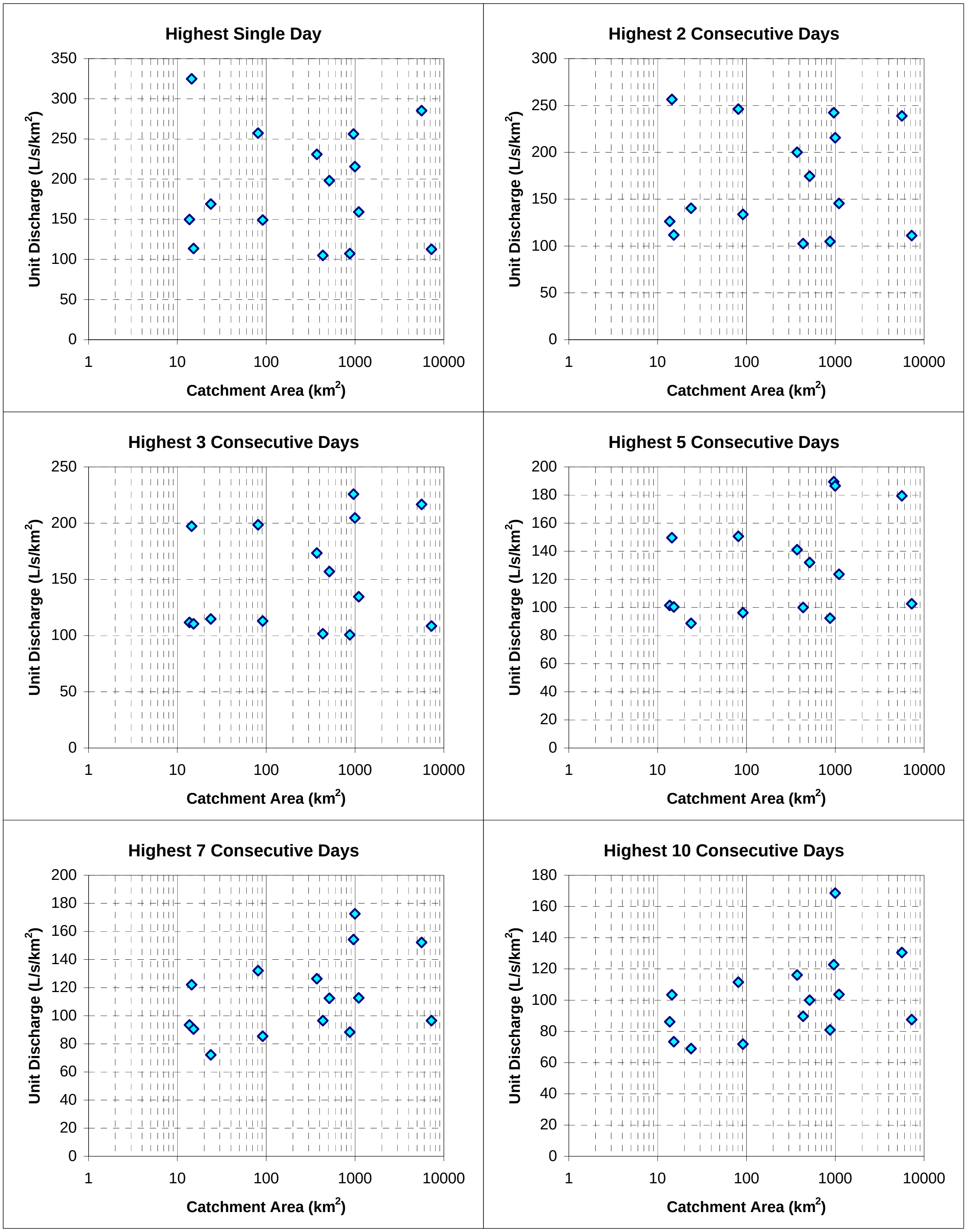


Figure 2: Magnitude of 100-year Flood vs. Catchment Area (1 to 10 Day Durations)

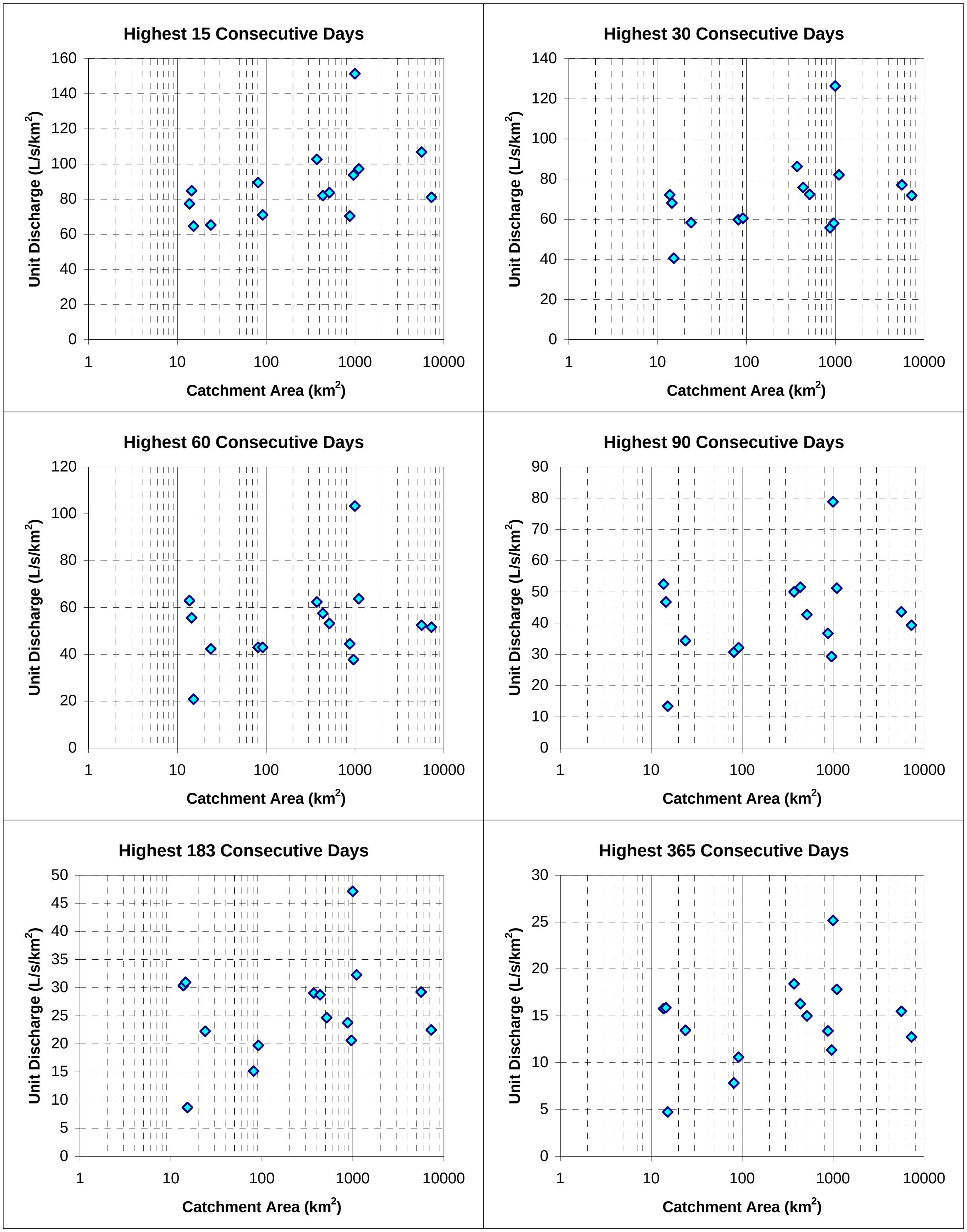


Figure 3: Magnitude of 100-year Flood vs. Catchment Area (15 to 365 Day Durations)

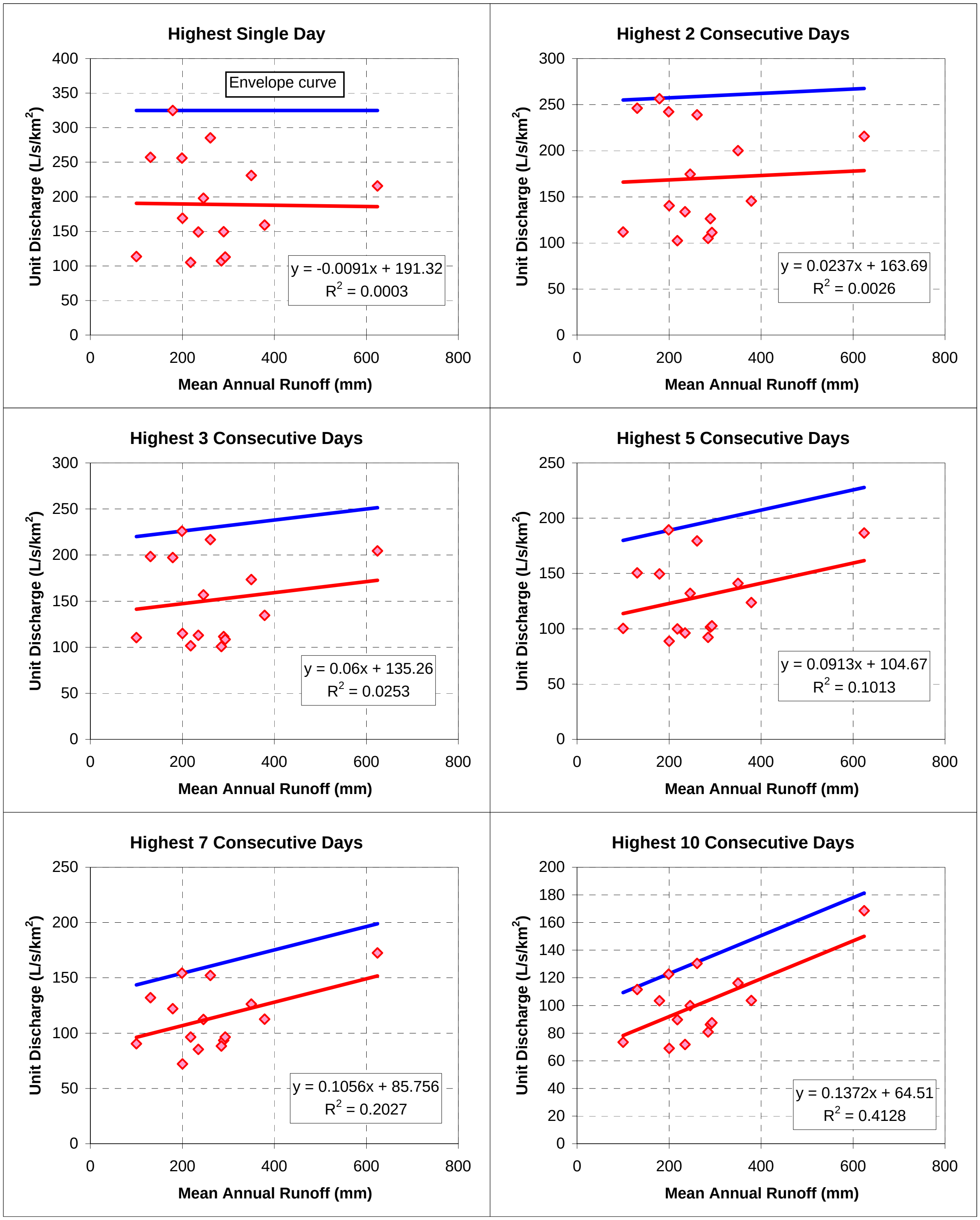
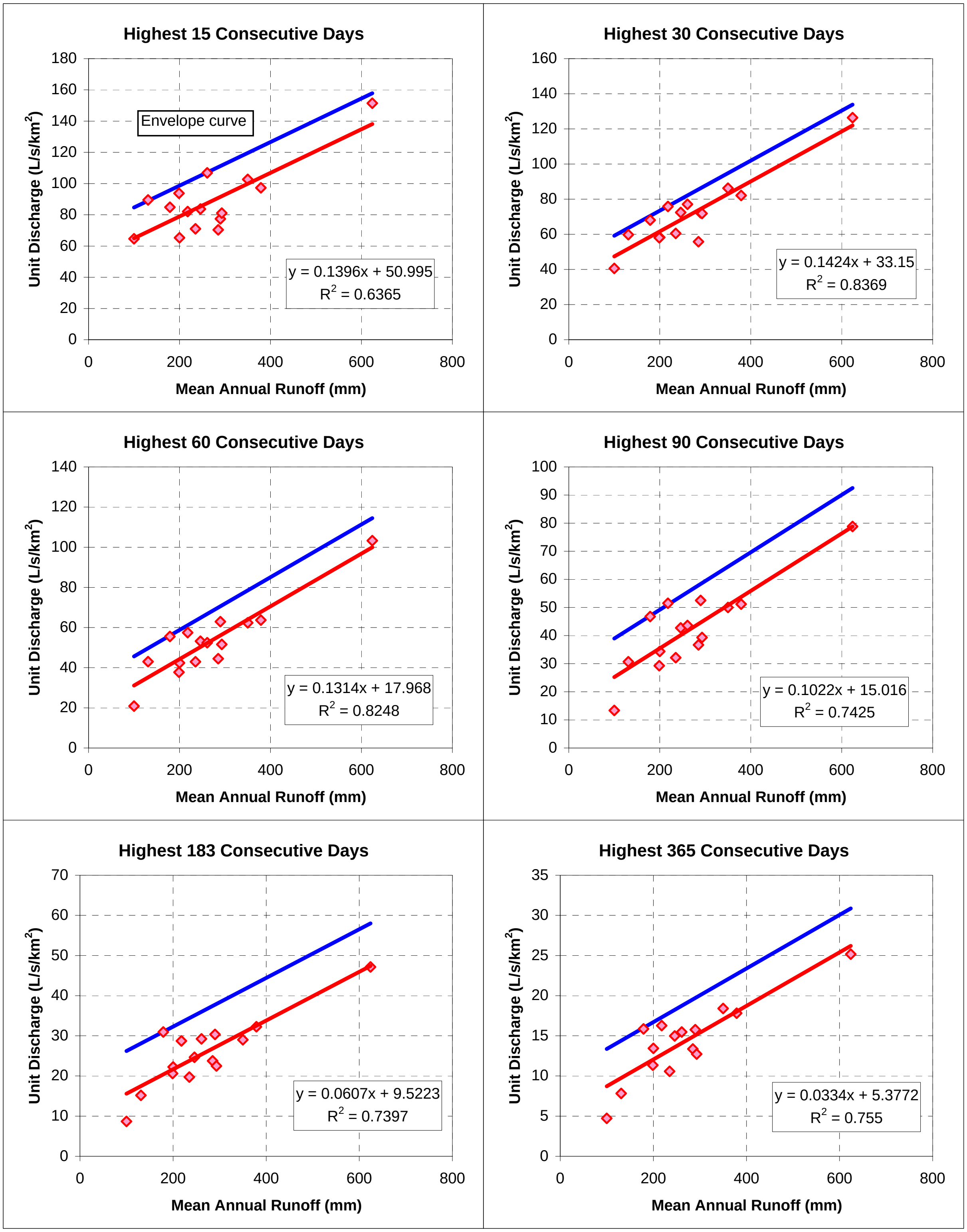


Figure 4: Magnitude of 100-Year Flood vs. Mean Annual Runoff (1 to 10 Day Durations)



Highest 15 Consecutive Days

Highest 30 Consecutive Days

Highest 60 Consecutive Days

Highest 90 Consecutive Days

Highest 183 Consecutive Days

Highest 365 Consecutive Days

Figure 5: Magnitude of 100-Year Flood vs. Mean Annual Runoff (15 to 365 Day Durations)

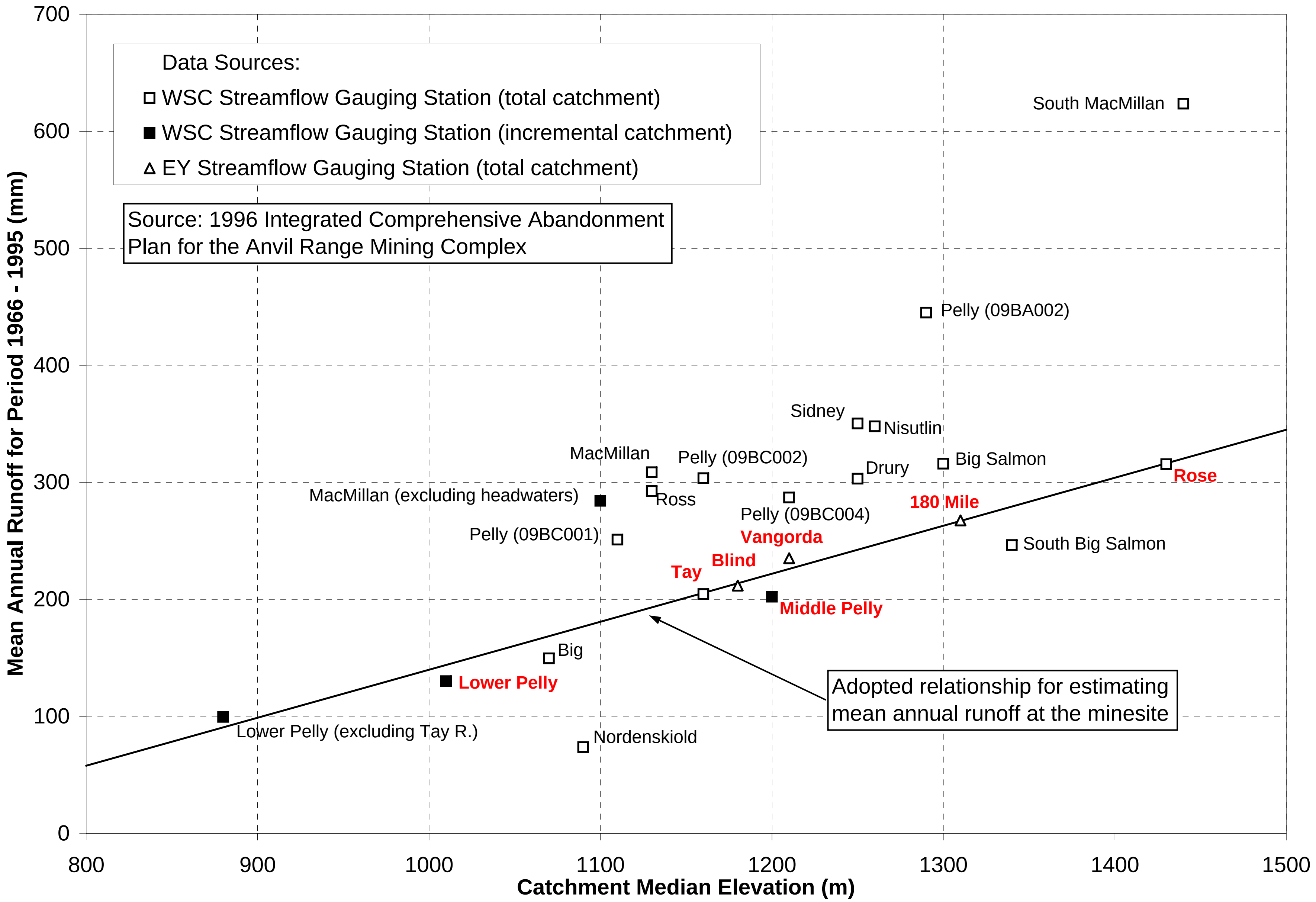
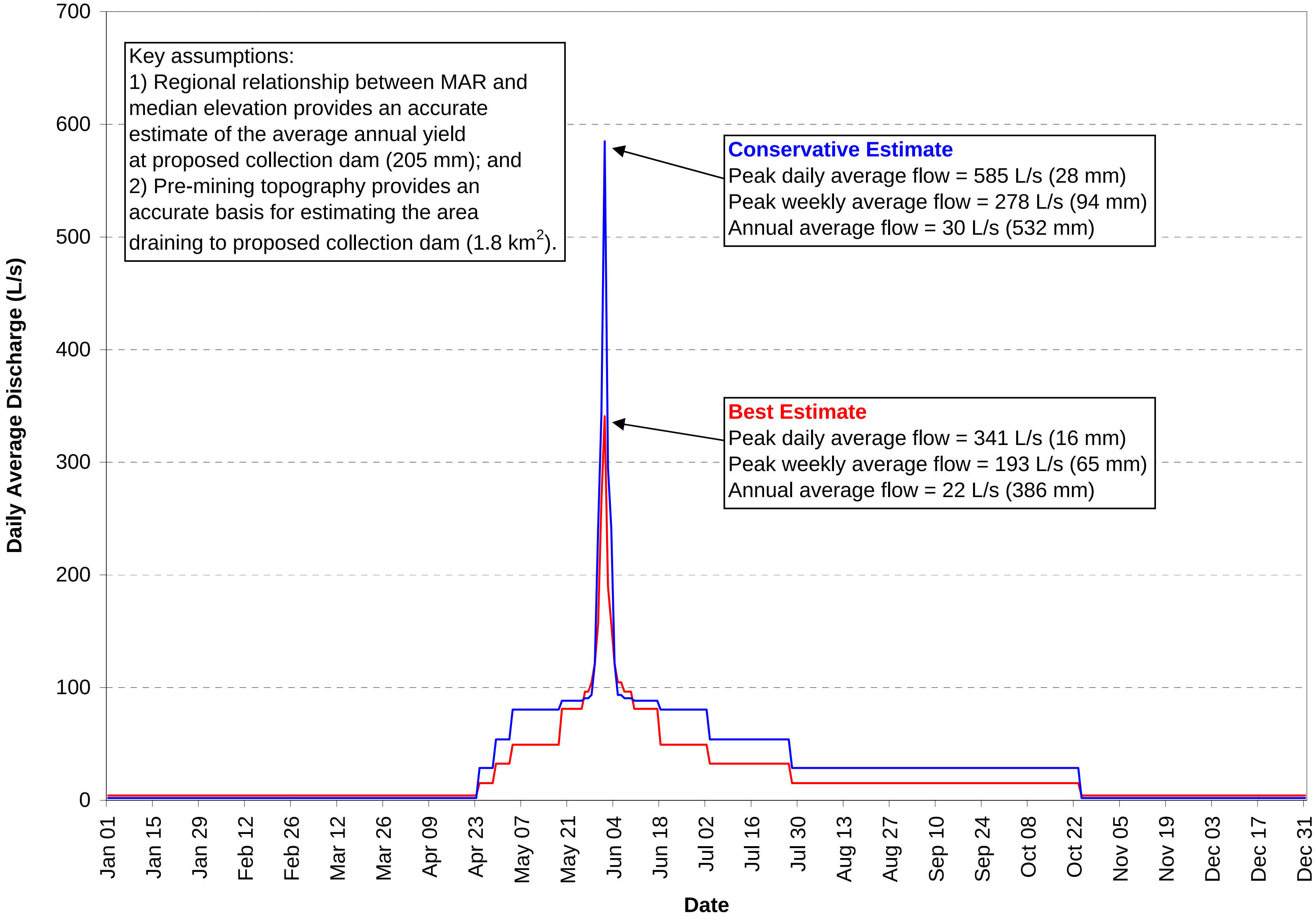


Figure 6: Regional Relationship Between Mean Annual Runoff and Catchment Median Elevation



Key assumptions:
1) Regional relationship between MAR and median elevation provides an accurate estimate of the average annual yield at proposed collection dam (205 mm); and
2) Pre-mining topography provides an accurate basis for estimating the area draining to proposed collection dam (1.8 km^2).

Conservative Estimate
Peak daily average flow = 585 L/s (28 mm)
Peak weekly average flow = 278 L/s (94 mm)
Annual average flow = 30 L/s (532 mm)

Best Estimate
Peak daily average flow = 341 L/s (16 mm)
Peak weekly average flow = 193 L/s (65 mm)
Annual average flow = 22 L/s (386 mm)

Figure 7: Estimated 100-Year Flood Hydrograph at Proposed Collection Dam (without allowance for effect of waste dumps)

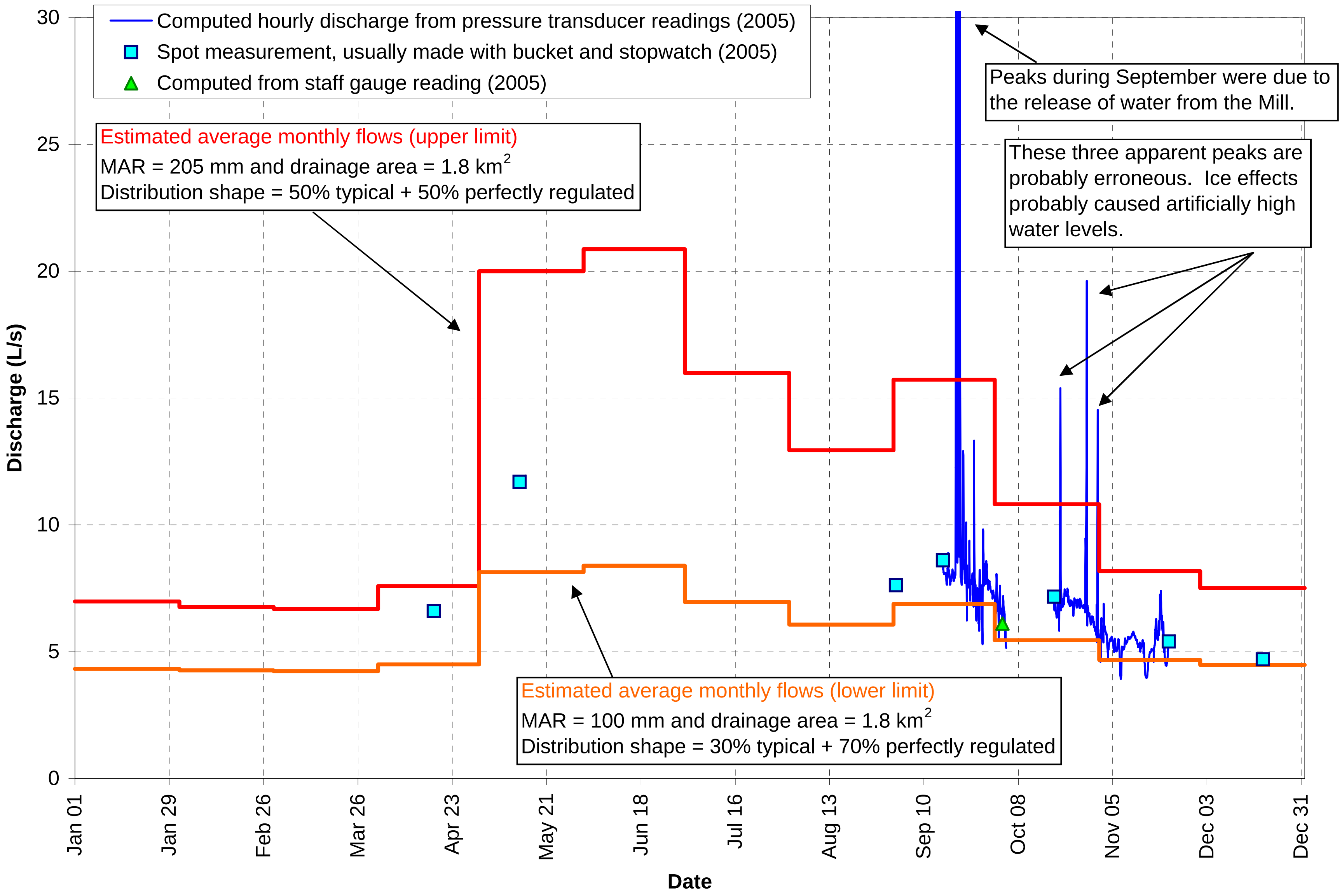
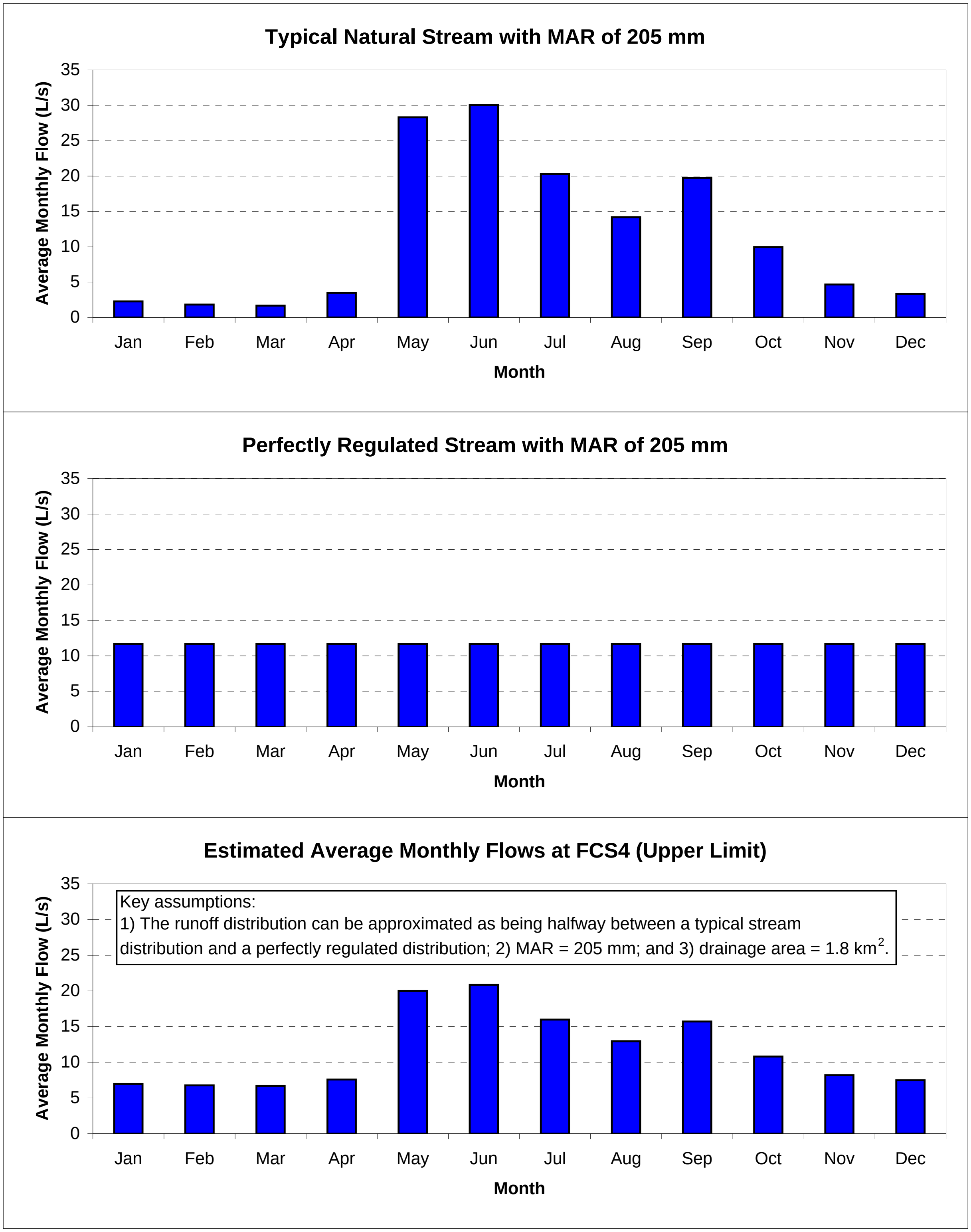


Figure 9: Comparison of Estimated Average Flows and Observed Flows at FCS4


Typical Natural Stream with MAR of 205 mm

Perfectly Regulated Stream with MAR of 205 mm

Estimated Average Monthly Flows at FCS4 (Upper Limit)

Key assumptions:
1) The runoff distribution can be approximated as being halfway between a typical stream distribution and a perfectly regulated distribution; 2) MAR = 205 mm; and 3) drainage area = 1.8 km^2.

Figure 10: Method Used to Estimate Average Seasonal Runoff Distribution at FCS4

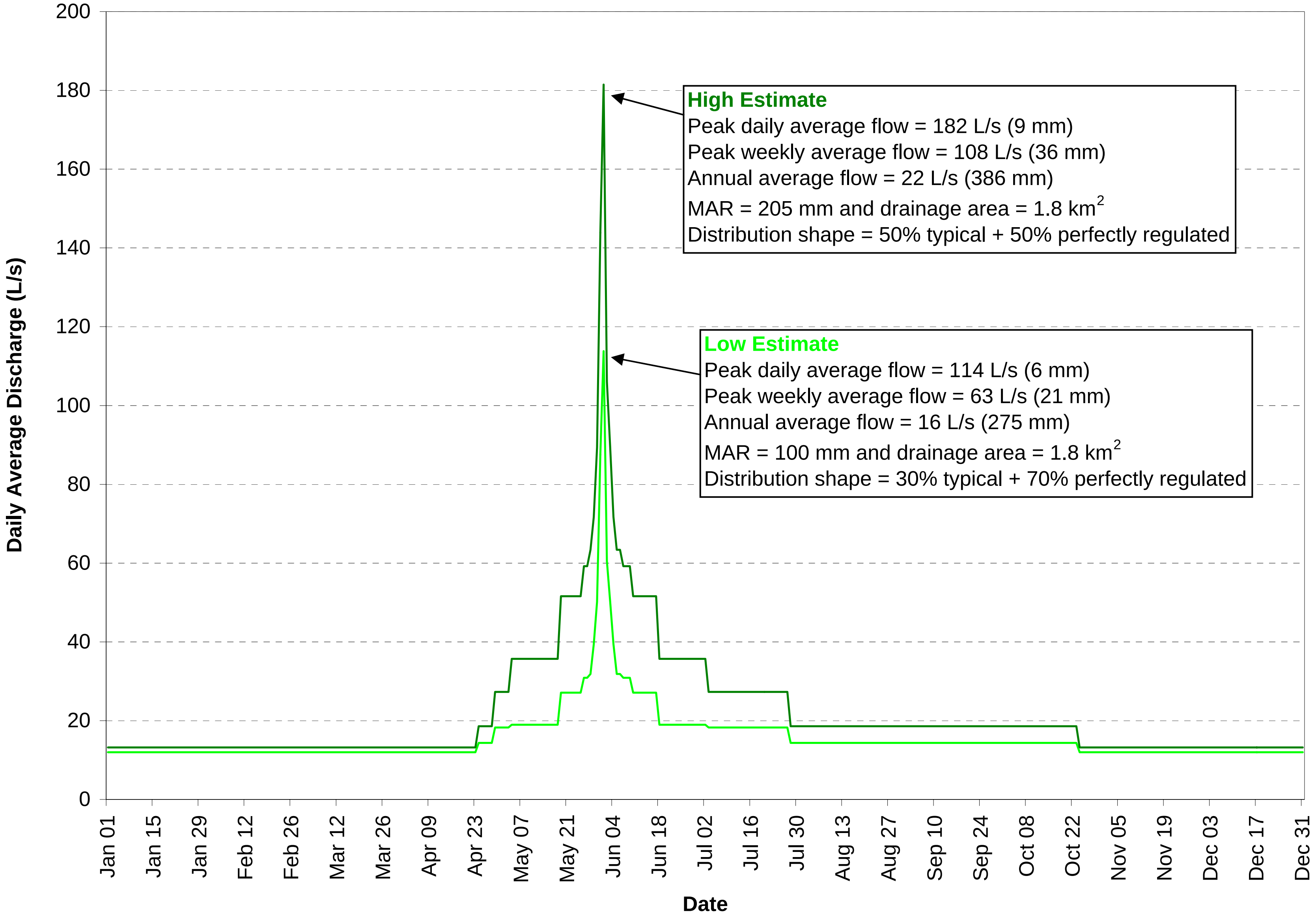


Figure 11: Estimated 100-Year Flood Hydrograph at Proposed Collection Dam (with allowance for effect of waste dumps)

Appendix D

Hydraulic Testing Results

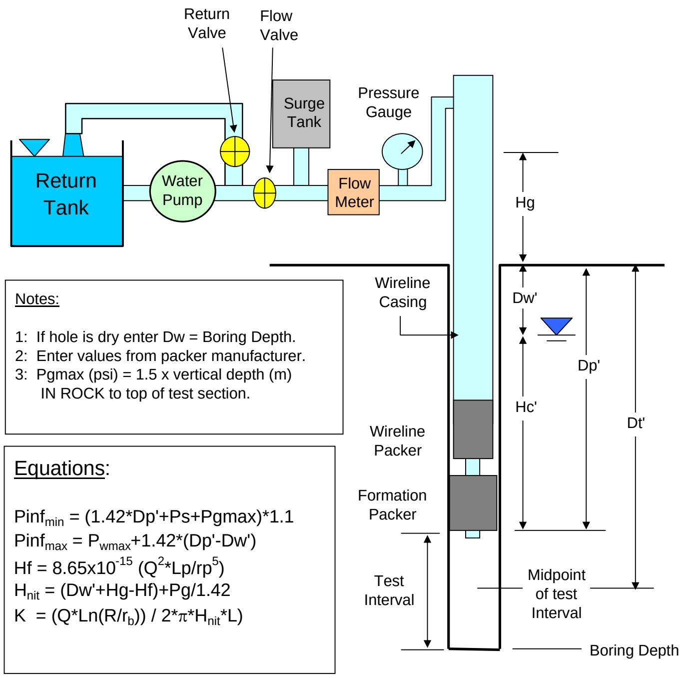
Appendix D-1

Packer Testing Data Sheets

SRK Consulting
Engineers and Scientists

PACKER INJECTION TEST

Project:	Faro Task 20e	**Test Interval (m):**	11.7	to	15.0	**Boring Nº:**	SRK05-ETA-BR2
Northing:		**Date:** 27-Sep-05	**Start Time:**	12:13		**Test Nº:**	1
Easting:			**End Time:**	12:43		**Boring Depth (m):**	15.0
GS Elevation:						**Supervisor:**	MP



Notes:

1: If hole is dry enter Dw = Boring Depth.
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:

$Pinf_{min} = (1.42*Dp'+Ps+Pgmax)*1.1$

$Pinf_{max} = P_{wmax}+1.42*(Dp'-Dw')$

$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$

$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$

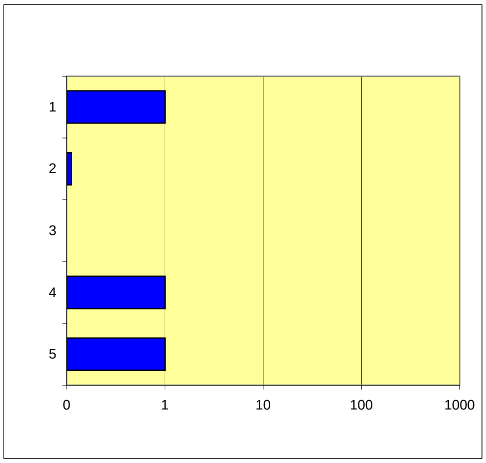
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L$

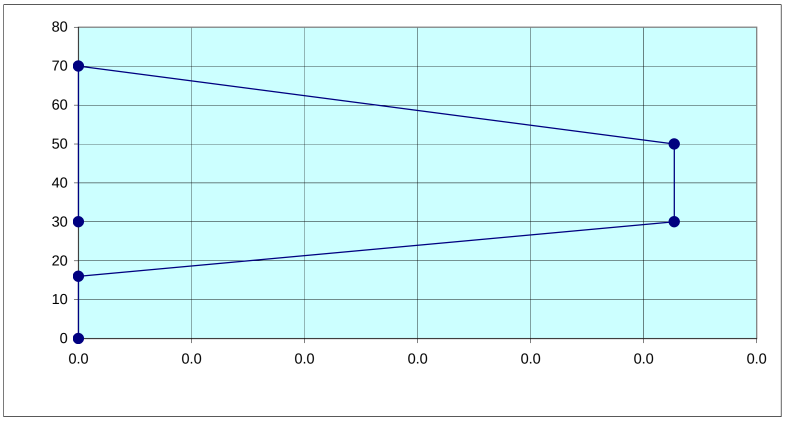
Dw	Measured depth of static water level (1)	5.3	m
Dp	Measured depth to packer	**11.7**	m
Dt	Measured depth to midpoint of test	**13.4**	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	**5.3**	m
Dp'	Vertical depth to packer	**11.7**	m
Dt'	Vertical depth to midpoint of test	**13.4**	m
Ps	Packer stretch pressure (2)	50	psi
Pwmax	Maximum packer working pressure (2)	290	psi
Pgmax	Maximum injection gauge pressure (3)	35	psi
Pinfmin	**Minimum packer inflation pressure**	**112**	psi
Pinfmax	**Maximum packer inflation pressure**	**299**	psi
Hg	Gauge height	1.2	m
Lp	Length of discharge pipe	6.00	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0195	m
R	Radius of influence (10 m is standard value)	10	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.038	m
L	Length of test section	**3.3**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bars
which is approximately 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement	**Q (gpm)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	16	30	50	70	30
1	0.0000	0.0001	0.0001	0.0000	0.0000
2	0.0000		0.0001	0.0000	0.0000
3	0.0000			0.0000	0.0000
4	0.0000				0.0000
5	0.0000				0.0000
Qavg (gpm)	0.00	0.03	0.03	0.00	0.00
Q_{avg} (m^3/day)	0.00	0.14	0.14	0.00	0.00
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	17.8	27.6	41.7	55.8	27.6
K (m/day)	0.0E+00	1.4E-03	9.3E-04	0.0E+00	0.0E+00
K (m/sec)	0.00E+00	1.62E-08	1.07E-08	0.00E+00	0.00E+00
Lugeons	0.00	0.11	0.07	0.00	0.00





Field Observations

Flow measurements approaching maximum resolution of guage

Slight changes in total flow observed during two increasing steps

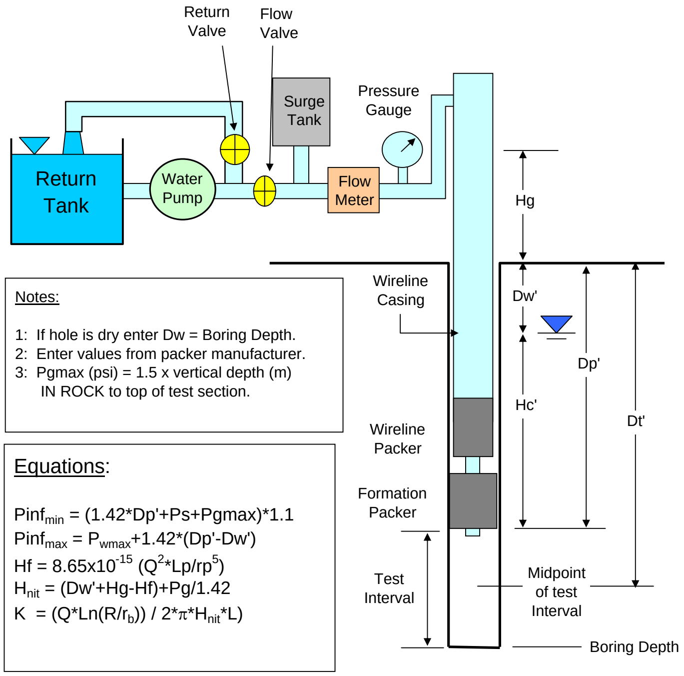
Interpretation of Results

VERY LOW FLOW DURING STEPS 2 AND 3 SUGGESTS VERY LOW K. CALCULATED K VALUE IS LIKELY THE MAXIMUM K FOR THIS INTERVAL.

SRK Consulting
Engineers and Scientists

PACKER INJECTION TEST

Project:	Faro Task 20e	**Test Interval (m):**	16.0	to	19.0	**Boring Nº:**	SRK05-ETA-BR2
Northing:		**Date:** 27-Sep-05	**Start Time:**	17:03		**Test Nº:**	2
Easting:			**End Time:**	18:06		**Boring Depth (m):**	19.0
GS Elevation:						**Supervisor:**	MP



Notes:

1: If hole is dry enter Dw = Boring Depth.
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:

$Pinf_{min} = (1.42*Dp'+Ps+Pgmax)*1.1$

$Pinf_{max} = P_{wmax}+1.42*(Dp'-Dw')$

$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$

$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$

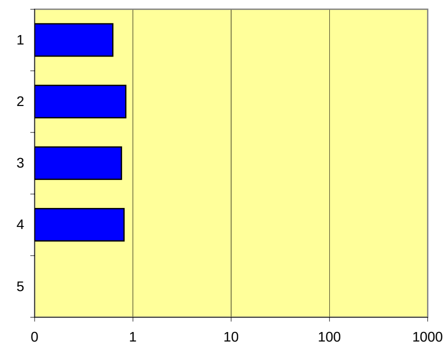
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

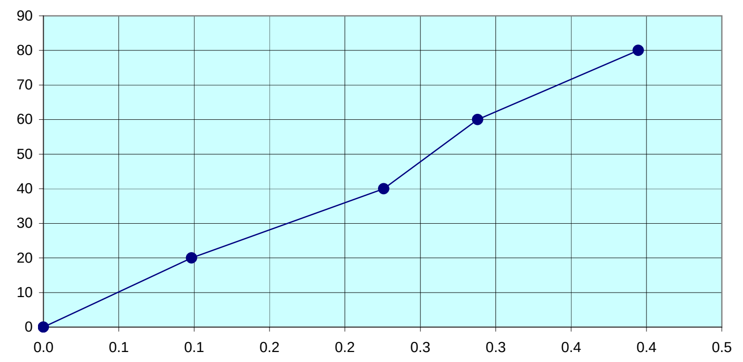
Dw	Measured depth of static water level (1)	5.0	m
Dp	Measured depth to packer	**16.0**	m
Dt	Measured depth to midpoint of test	**17.5**	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	**5.0**	m
Dp'	Vertical depth to packer	**16.0**	m
Dt'	Vertical depth to midpoint of test	**17.5**	m
Ps	Packer stretch pressure (2)	50	psi
Pwmax	Maximum packer working pressure (2)	290	psi
Pgmax	Maximum injection gauge pressure (3)	35	psi
Pinfmin	**Minimum packer inflation pressure**	**118**	psi
Pinfmax	**Maximum packer inflation pressure**	**306**	psi
Hg	Gauge height	1.2	m
Lp	Length of discharge pipe	6.00	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0195	m
R	Radius of influence (10 m is standard value)	10	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.038	m
L	Length of test section	**3.0**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bars
which is approximately 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement	**Q (gpm)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	20	40	60	80	
1	0.0003	0.0010	0.0013	0.0016	
2	0.0005	0.0009	0.0010	0.0016	
3	0.0003	0.0008	0.0012	0.0015	
4	0.0004	0.0008	0.0010	0.0014	
5	0.0004	0.0008	0.0010	0.0014	
Qavg (gpm)	0.10	0.23	0.29	0.39	
Q_{avg} (m^3/day)	0.54	1.23	1.57	2.16	
Hf (m)	0.00	0.00	0.00	0.00	
Hnit (m)	20.3	34.4	48.5	62.5	
K (m/day)	7.8E-03	1.1E-02	9.6E-03	1.0E-02	
K (m/sec)	9.06E-08	1.23E-07	1.11E-07	1.18E-07	
Lugeons	0.62	0.85	0.76	0.81	





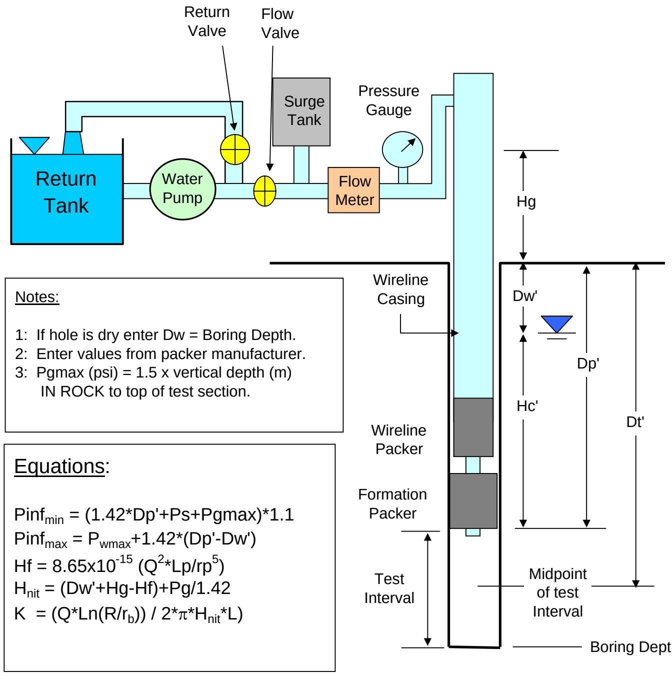
Field Observations

Interpretation of Results

SRK Consulting
Engineers and Scientists

PACKER INJECTION TEST

Project:	Faro Task 20e	**Test Interval (m):**	16.0	to 19.0	**Boring Nº:**	SRK05-ETA-BR2
Northing:		**Date:** 27-Sep-05	**Start Time:**	17:03	**Test Nº:**	2
Easting:			**End Time:**	18:06	**Boring Depth (m):**	19.0
GS Elevation:					**Supervisor:**	MP



Notes:

1: If hole is dry enter Dw = Boring Depth.
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m)
IN ROCK to top of test section.

Equations:

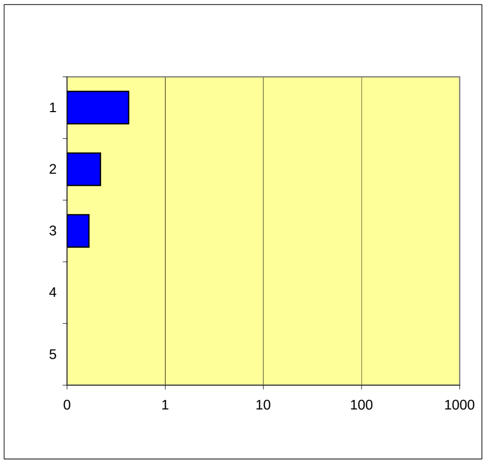
$Pinf_{min} = (1.42*Dp'+Ps+Pgmax)*1.1$
$Pinf_{max} = P_{wmax}+1.42*(Dp'-Dw')$
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

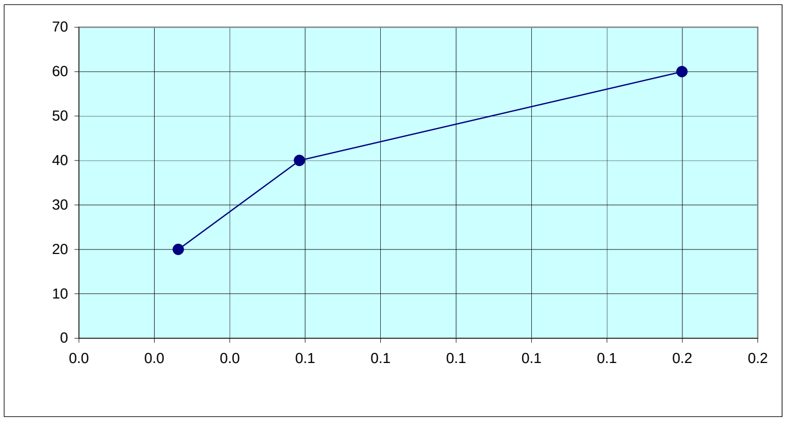
Dw	Measured depth of static water level (1)	5.0	m
Dp	Measured depth to packer	16.0	m
Dt	Measured depth to midpoint of test	17.5	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	5.0	m
Dp'	Vertical depth to packer	16.0	m
Dt'	Vertical depth to midpoint of test	17.5	m
Ps	Packer stretch pressure (2)	50	psi
Pwmax	Maximum packer working pressure (2)	290	psi
Pgmax	Maximum injection gauge pressure (3)	35	psi
Pinfmin	**Minimum packer inflation pressure**	118	psi
Pinfmax	**Maximum packer inflation pressure**	306	psi
Hg	Gauge height	1.2	m
Lp	Length of discharge pipe	6.00	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0195	m
R	Radius of influence (10 m is standard value)	10	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.038	m
L	Length of test section	3.0	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bars
which is approximately 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement	**Q (gpm)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	60	40	20		
1	0.0004	0.0001	0.0001		
2	0.0007	0.0002	0.0001		
3	0.0007	0.0003	0.0001		
4	0.0006	0.0003			
5	0.0007	0.0003			
Qavg (gpm)	0.16	0.06	0.03		
Q_{avg} (m^3/day)	0.87	0.32	0.14		
Hf (m)	0.00	0.00	0.00		
Hnit (m)	48.5	34.4	20.3		
K (m/day)	5.3E-03	2.8E-03	2.1E-03		
K (m/sec)	6.17E-08	3.18E-08	2.43E-08		
Lugeons	0.42	0.22	0.17		





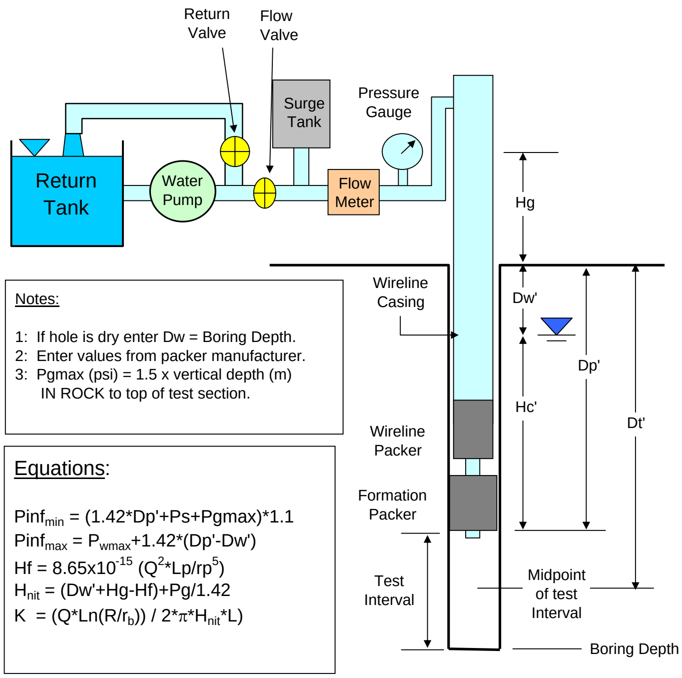
Field Observations

Interpretation of Results

SRK Consulting
Engineers and Scientists

PACKER INJECTION TEST

Project:	Faro Task 20e	**Test Interval (m):**	12.0	to	23.6	**Boring Nº:**	SRK05-ETA-BR2
Northing:		**Date:** 28-Sep-05	**Start Time:**	14:26		**Test Nº:**	3
Easting:			**End Time:**	15:15		**Boring Depth (m):**	23.6
GS Elevation:						**Supervisor:**	MP



Notes:

1: If hole is dry enter Dw = Boring Depth.
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m)
IN ROCK to top of test section.

Equations:

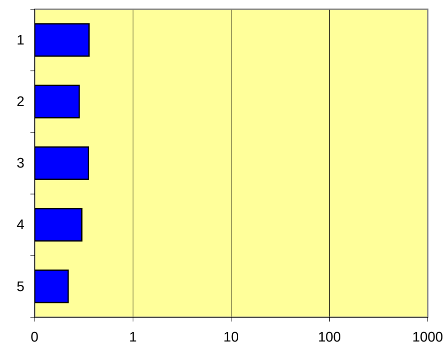
$Pinf_{min} = (1.42*Dp'+Ps+Pgmax)*1.1$
$Pinf_{max} = P_{wmax}+1.42*(Dp'-Dw')$
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

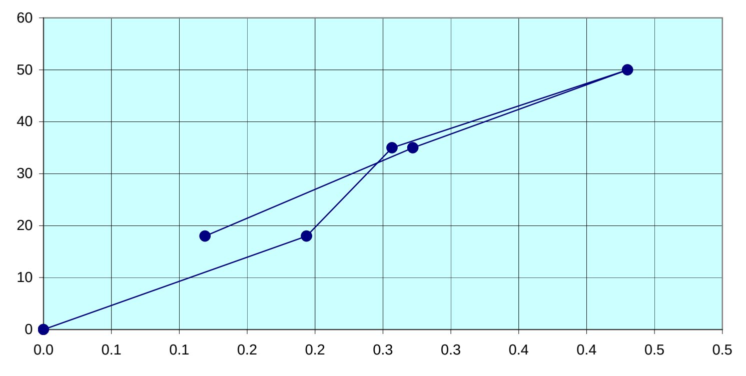
Dw	Measured depth of static water level (1)	4.2	m
Dp	Measured depth to packer	**12.0**	m
Dt	Measured depth to midpoint of test	**17.8**	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	**4.2**	m
Dp'	Vertical depth to packer	**12.0**	m
Dt'	Vertical depth to midpoint of test	**17.8**	m
Ps	Packer stretch pressure (2)	50	psi
Pwmax	Maximum packer working pressure (2)	290	psi
Pgmax	Maximum injection gauge pressure (3)	35	psi
Pinfmin	**Minimum packer inflation pressure**	**112**	psi
Pinfmax	**Maximum packer inflation pressure**	**301**	psi
Hg	Gauge height	1.2	m
Lp	Length of discharge pipe	6.00	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0195	m
R	Radius of influence (10 m is standard value)	10	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.038	m
L	Length of test section	**11.6**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bars
which is approximately 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement	**Q (gpm)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	18	35	50	35	18
1	0.0006		0.0017	0.0011	0.0005
2	0.0008	0.0009	0.0016	0.0010	0.0005
3	0.0007	0.0010	0.0016	0.0010	0.0003
4	0.0008	0.0010			0.0005
5	0.0008	0.0010			0.0005
Qavg (gpm)	0.19	0.26	0.43	0.27	0.12
Q_{avg} (m^3/day)	1.06	1.40	2.35	1.49	0.65
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	18.1	30.0	40.6	30.0	18.1
K (m/day)	4.5E-03	3.6E-03	4.4E-03	3.8E-03	2.7E-03
K (m/sec)	5.18E-08	4.13E-08	5.12E-08	4.38E-08	3.18E-08
Lugeons	0.36	0.28	0.35	0.30	0.22





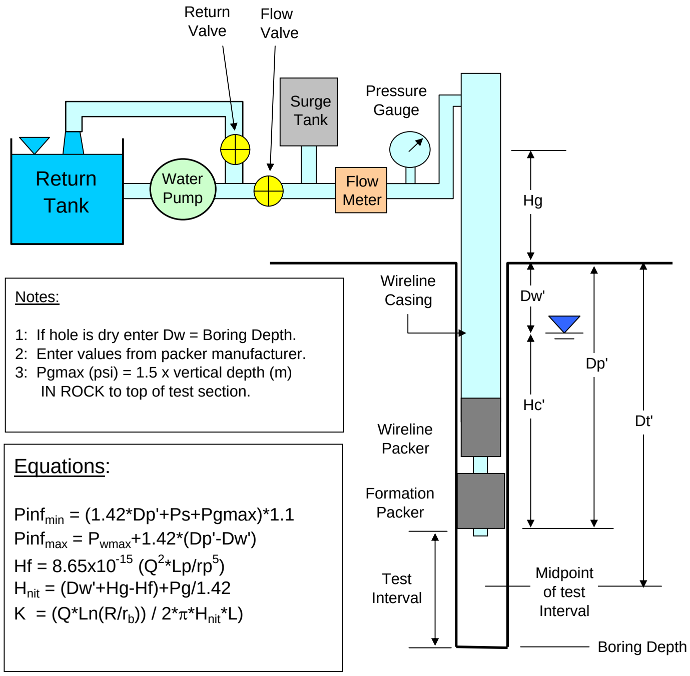
Field Observations

Interpretation of Results

SRK Consulting
Engineers and Scientists

PACKER INJECTION TEST

Project:	Faro Task 20e	**Test Interval (m):**	19.1	to	23.6	**Boring Nº:**	SRK05-ETA-BR2
Northing:		**Date:** 28-Sep-05	**Start Time:**	12:43		**Test Nº:**	4
Easting:			**End Time:**	13:02		**Boring Depth (m):**	23.6
GS Elevation:						**Supervisor:**	MP



Notes:

1: If hole is dry enter Dw = Boring Depth.
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:

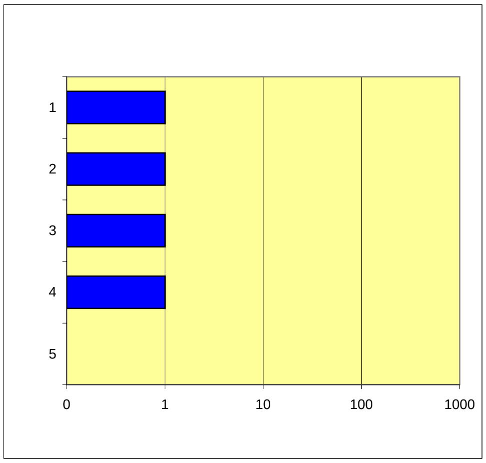
$Pinf_{min} = (1.42*Dp'+Ps+Pgmax)*1.1$
$Pinf_{max} = P_{wmax}+1.42*(Dp'-Dw')$
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Dw	Measured depth of static water level (1)	4.2	m
Dp	Measured depth to packer	**19.1**	m
Dt	Measured depth to midpoint of test	**21.4**	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	**4.2**	m
Dp'	Vertical depth to packer	**19.1**	m
Dt'	Vertical depth to midpoint of test	**21.4**	m
Ps	Packer stretch pressure (2)	50	psi
Pwmax	Maximum packer working pressure (2)	290	psi
Pgmax	Maximum injection gauge pressure (3)	35	psi
Pinfmin	**Minimum packer inflation pressure**	**123**	psi
Pinfmax	**Maximum packer inflation pressure**	**311**	psi
Hg	Gauge height	1.2	m
Lp	Length of discharge pipe	6.00	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0195	m
R	Radius of influence (10 m is standard value)	10	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.038	m
L	Length of test section	**4.5**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:

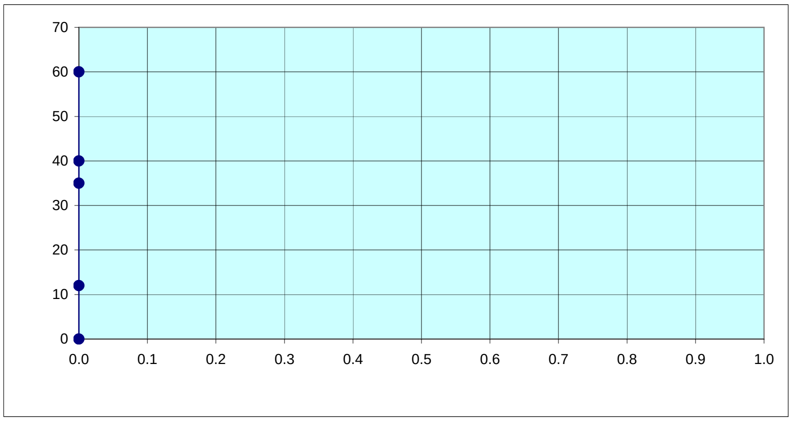
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bars
which is approximately 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement	**Q (gpm)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	12	35	40	60	
1	0.00	0.00	0.00	0.00	
2	0.00	0.00	0.00	0.00	
3	0.00	0.00	0.00	0.00	
4	0.00	0.00	0.00	0.00	
5	0.00	0.00	0.00	0.00	
Qavg (gpm)	0.00	0.00	0.00	0.00	
Q_{avg} (m^3/day)	0.0	0.0	0.0	0.0	
Hf (m)	0.00	0.00	0.00	0.00	
Hnit (m)	13.9	30.0	33.6	47.7	
K (m/day)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
K (m/sec)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Lugeons	0.00	0.00	0.00	0.00	



Field Observations

NO FLOW



Interpretation of Results

VERY LOW K ROCK

Appendix D-2

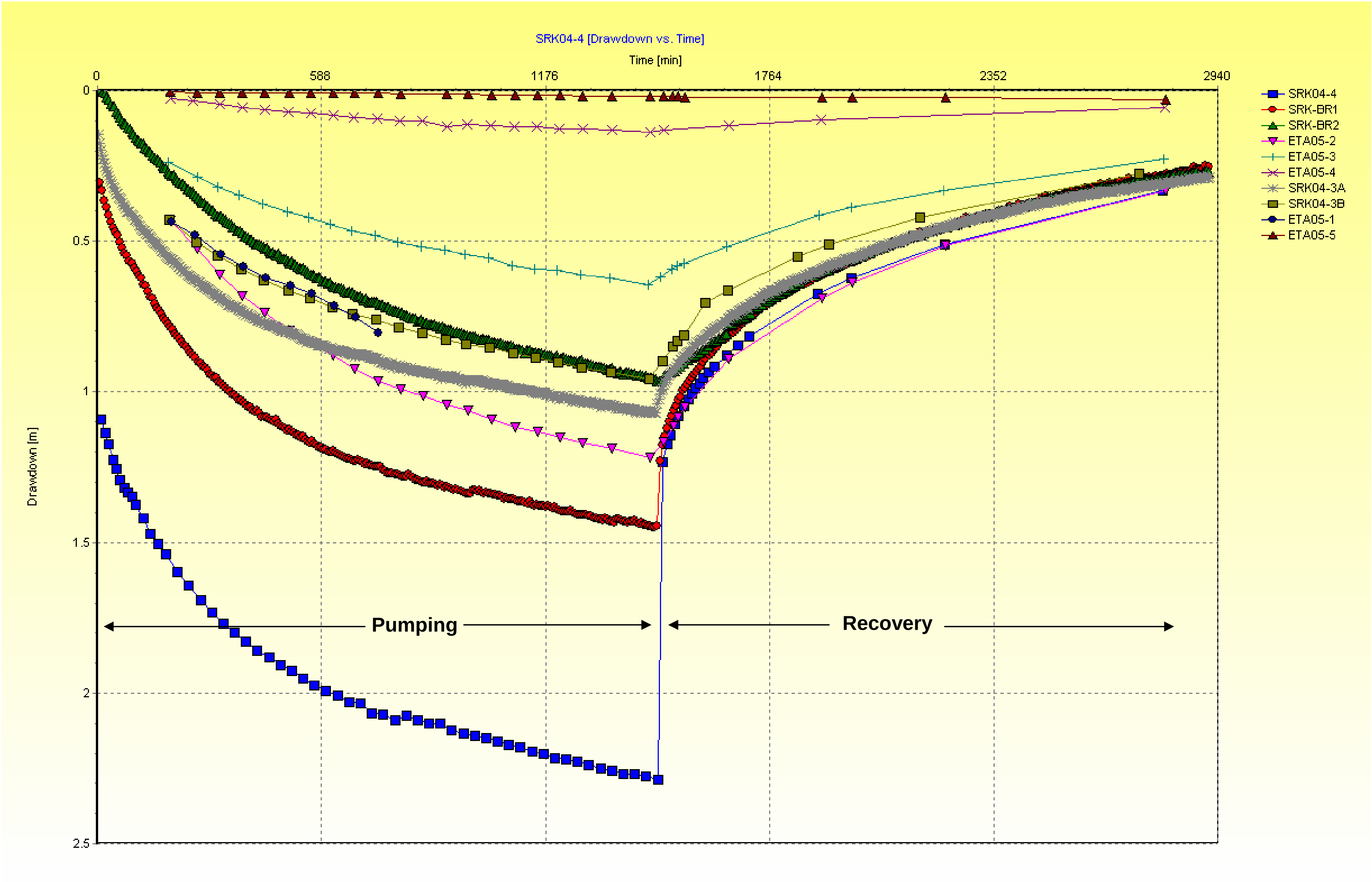
Pumping Test Discharge Data

Well No:	SRK 04-04 (Pumping Well)
Static WL: 9.05h	6.904m
Date: October 2, 2005	Start at 9.22h

Elapsed Time (minutes)	Manometer Reading	Caculated Flow (USgpm)	
0.25	7.155		
1	7.915	53	
0.45	7.91	51	
1.5	7925	51	
1.75	7.865	50	
2	7.94	52	
2.5	8.05	56	
3.5		96	??
4	8.025	53	
4.5	8.04	53	
5	8.025	52	
6	7.98	50	
7	7.98	50	
8	7.984	50	
9	7.99	50	
10	7.997	50	
12	8.006	50	
14	8.016	50	
16	8.024	49	
18	8.033	49	
20	8.042	49	
25	8.06	49	
30	8.077	49	
40	8.13	50	
46	[8.145]	[50]	
50	8.16	50	
60	8.195	50	
70	8.222	50	
80	8.236	50	
90	8.251	50	
100	8.278	50	
120	8.322	50	
140	8.735	50	
160	8.41	50	
180	8.443	50	some uncertainty
210	8.502	50	
240	8.546	50	
270	8.597	51	Flow oscillating between 50-51 gpm
300	8.635	50	
334	8.672	50	
360	8.733	50	
390	8.733	50	
420	8.762	50	
450	8.785	50	
480	8.81	50	
510	8.829	50	
540	8.858	50	
570	8.877	51	
600	8.897	51	
630	8.914	51	
660	8.933	51	
690	8.94	51	
720	8.97	51	
750	8.976	51	
780	8.996	51	
810	8.981	51	
840	8.944	50	
870	9.005	50	
900	9.007	50	
930	9.027	50	
960	9.04	50	
990	9.045	50	
1020	9.054	50	
1050	9.065	50	
1080	9.076	50	
1110	9.085	50	
1140	9.097	50	
1170	3.107	50	
1200	9.12	50	
1230	9.124	50	
1260	9.133	50	
1290	9.144	50	
1320	9.153	50	
1350	9.163	50	
1380	9.172	50	
1410	9.172	49	
1440	9.179		
AVERAGE		50.96	

Appendix D-3

24-Hour Pumping Test Drawdown Data and Interpretations



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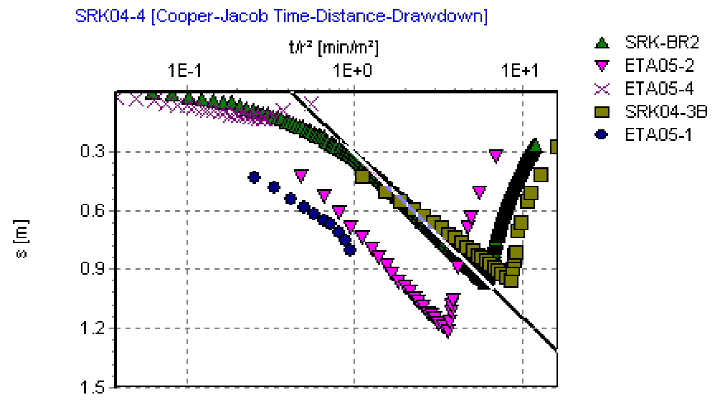
ETA SRK04-4 Pumping Test – Faro Mine

Drawdown vs. Time for All Monitoring Wells

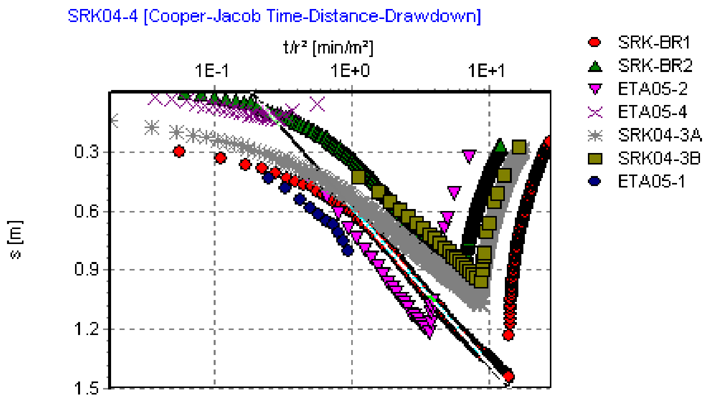
PROJECT: 1CD003.73	DATE: Feb 2006	APPROVED: QJK	FIGURE: **D-2a**

SRK05-ETA-BR2



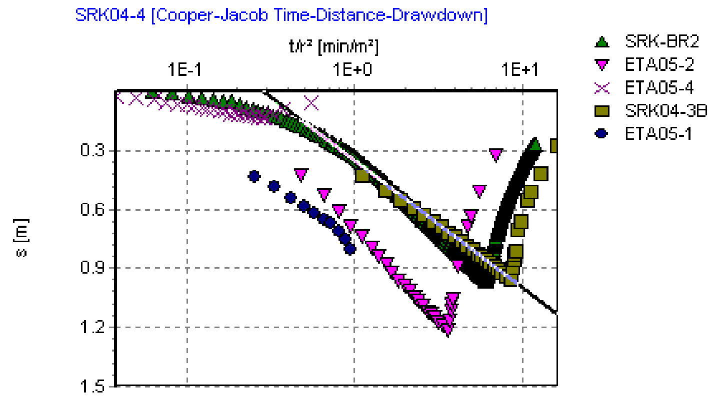
Transmissivity: 5.99E+1m²/d Storativity: 3.96E-2

SRK05-ETA-BR1



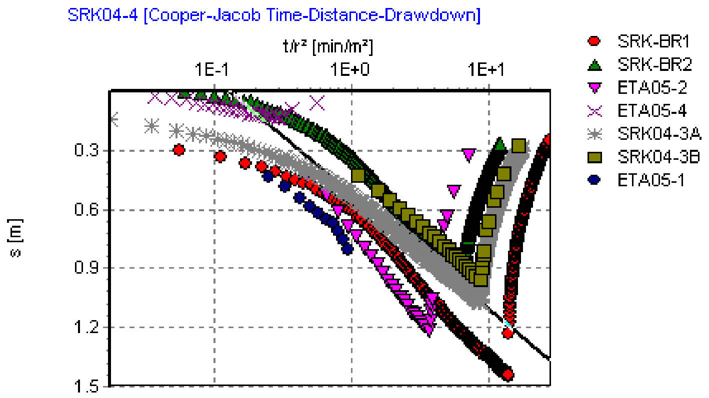
Transmissivity: 6.25E+1m²/d Storativity: 1.83E-2

SRK04-3B



Transmissivity: 7.74E+1m²/d Storativity: 3.42E-2

SRK04-3A



Transmissivity: 8.47E+1m²/d Storativity: 1.72E-2

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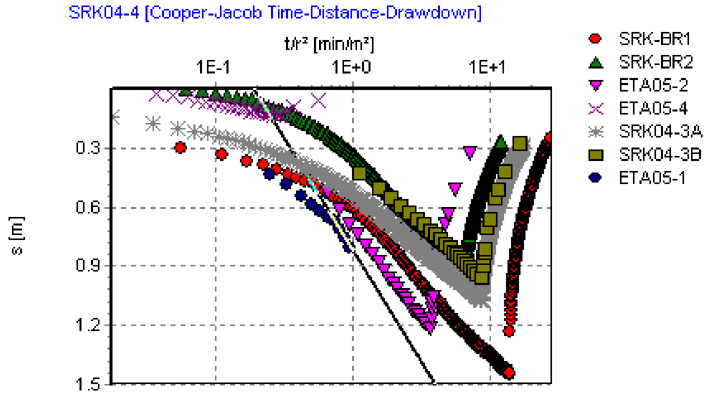
ETA SRK04-4 Pumping Test – Faro Mine

Cooper-Jacob Analyses

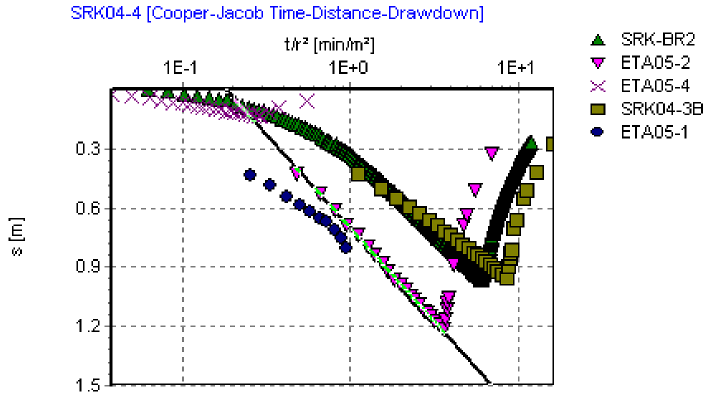
PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.73	Feb 2006	QJK	**D-2b**

ETA05-1



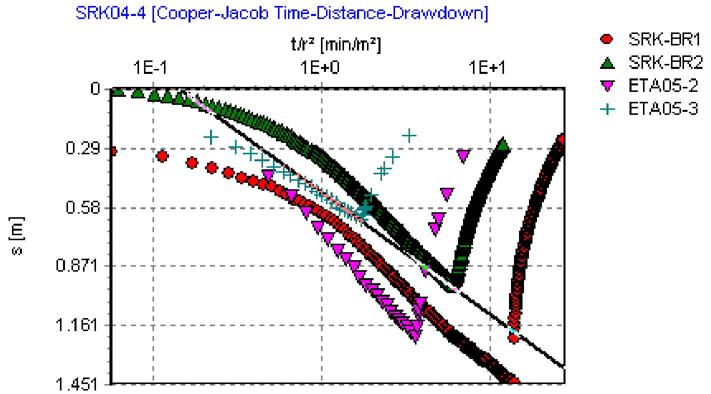
Transmissivity: 4.40E+1m²/ d Storativity: 1.30E-2

ETA05-2



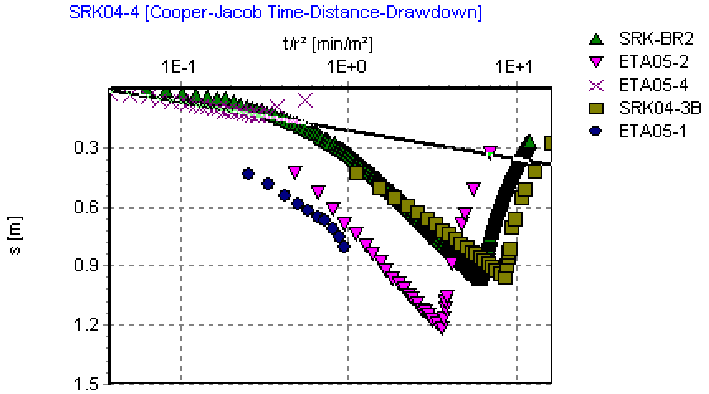
Transmissivity: 5.28E+1m²/ d Storativity: 1.51E-2

ETA05-3



Transmissivity: 8.32E+1m²/ d Storativity: 1.86E-2

ETA05-4



Transmissivity: 3.53E+2m²/ d Storativity: 1.74E-2

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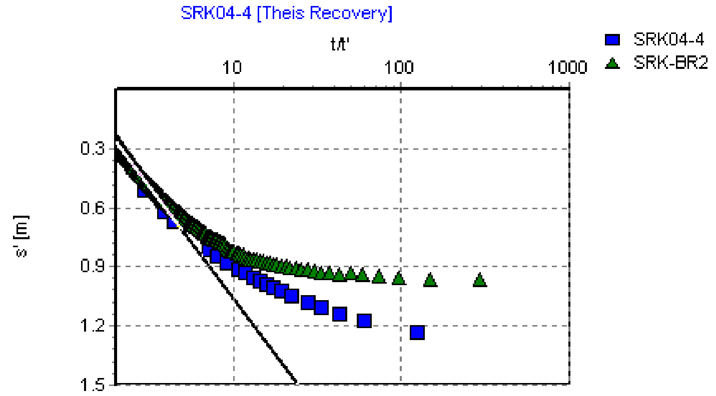
ETA SRK04-4 Pumping Test – Faro Mine

Cooper-Jacob Analyses

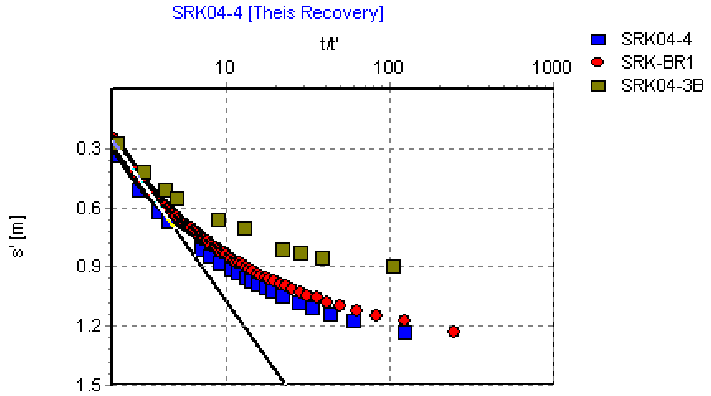
PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.73	Feb 2006	QJK	D-2c

SRK05-ETA-BR2



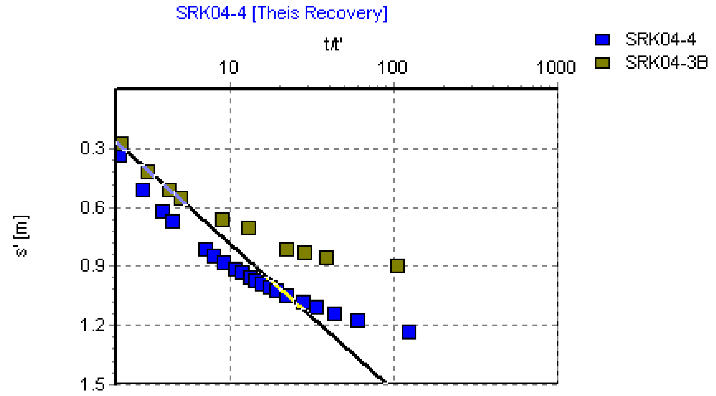
Transmissivity: 4.39E+1m^2/ d

SRK05-ETA-BR



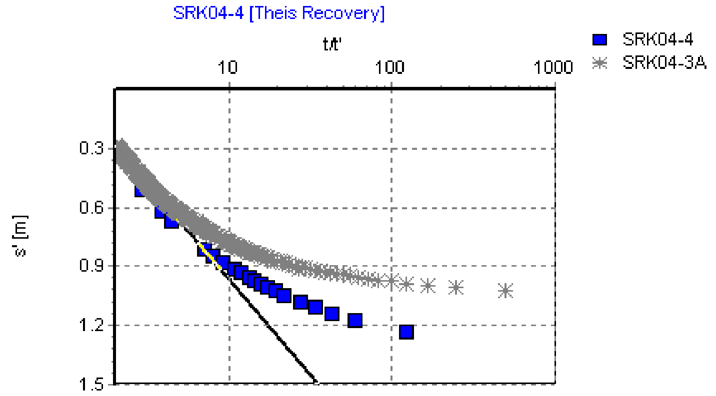
Transmissivity: 4.27E+1m^2/ d

SRK04-3B



Transmissivity: 6.70E+1m^2/ d

SRK04-3A



Transmissivity: 5.11E+1m^2/ d

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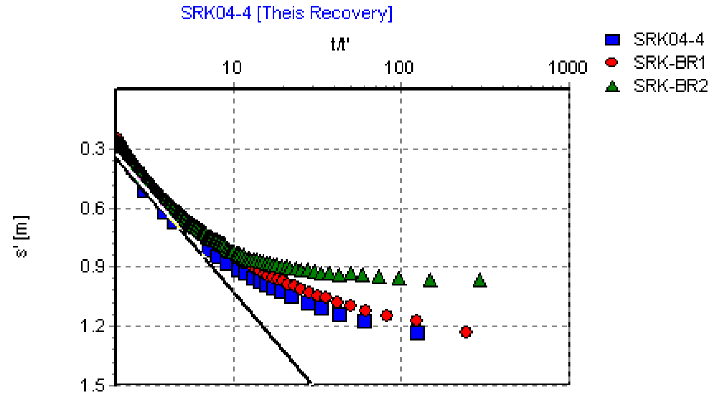
ETA SRK04-4 Pumping Test – Faro Mine

Theis Recovery Analyses

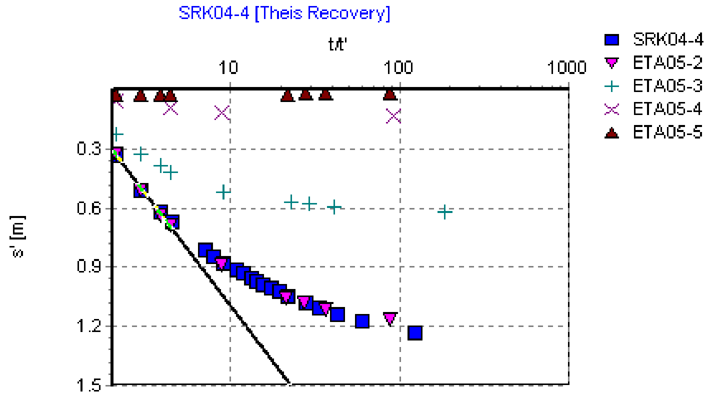
PROJECT: 1CD003.73	DATE: Feb 2006	APPROVED: QJK	FIGURE: D-2d

SRK04-4



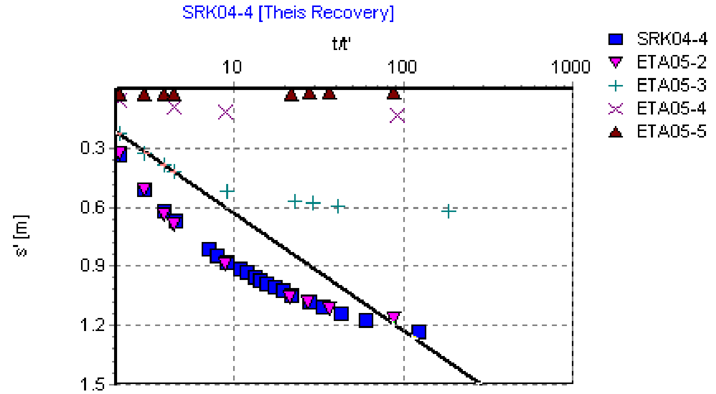
Transmissivity: 5.00E+1m^2/ d

ETA05-2



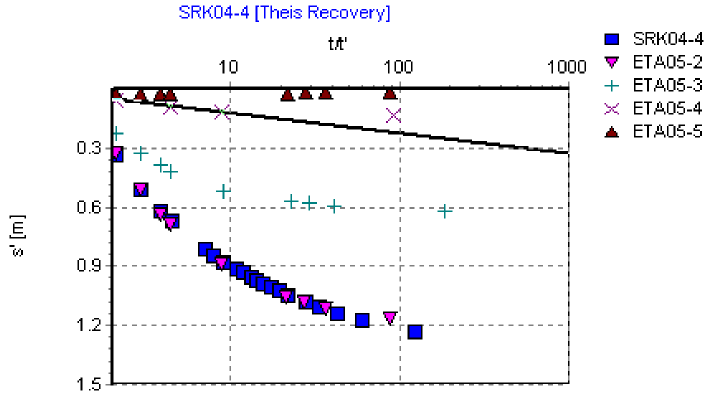
Transmissivity: 4.44E+1m^2/ d

ETA05-3



Transmissivity: 8.41E+1m^2/ d

ETA05-4



Transmissivity: 4.92E+2m^2/ d

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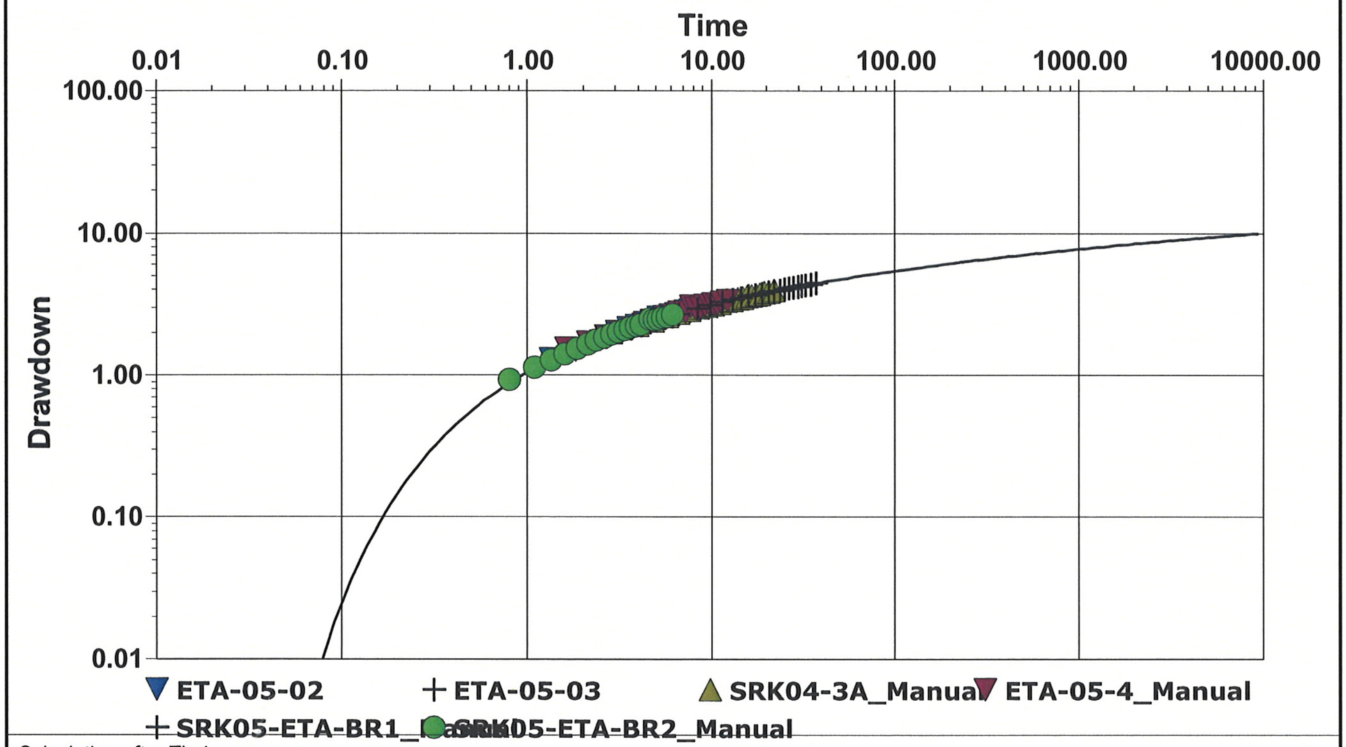
ETA SRK04-4 Pumping Test – Faro Mine

Theis Recovery Analyses

PROJECT: 1CD003.73	DATE: Feb 2006	APPROVED: QJK	FIGURE: **D-2e**

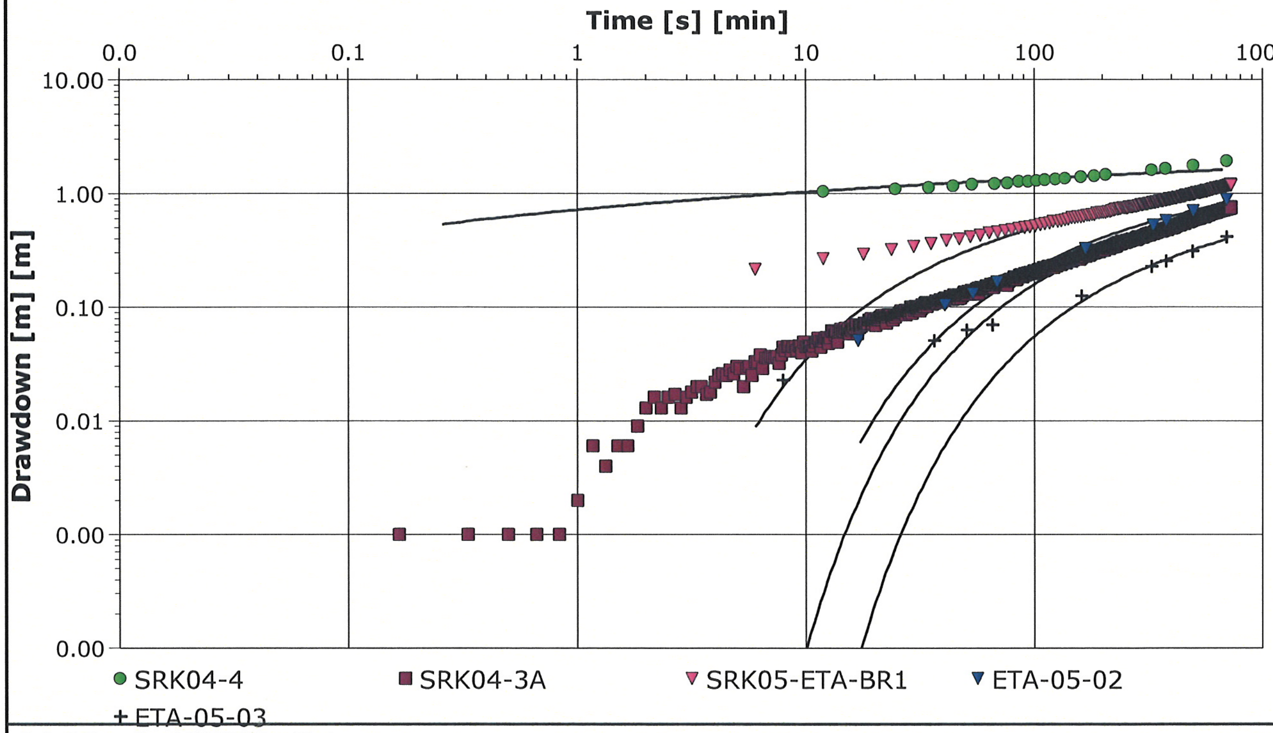
Location: Faro Mine	Pumping Test: ETA 24-hour pumping	Pumping well: SRK04-4
Test conducted by: Mauro Prado		Test date: 10/3/2005
Analysis performed by:	Theis	Date: 10/17/2005
Aquifer Thickness: 4.00 m	Discharge rate: 50 [U.S. gal/min]	



Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
ETA-05-02	5.05×10^{1}	1.26×10^{1}	1.26×10^{-2}	20.0	
ETA-05-03	1.00×10^{2}	2.50×10^{1}	9.80×10^{-3}	29.07	
SRK04-3A_Manual	7.48×10^{1}	1.87×10^{1}	2.01×10^{-2}	13.0	
ETA-05-4_Manual	3.54×10^{2}	8.84×10^{1}	5.75×10^{-3}	71.17	
SRK05-ETA-BR1_Manual	5.89×10^{1}	1.47×10^{1}	1.50×10^{-2}	10.3	
SRK05-ETA-BR2_Manual	5.16×10^{1}	1.29×10^{1}	3.45×10^{-2}	15.62	
Average	1.15×10^{2}	2.87×10^{1}	1.63×10^{-2}		

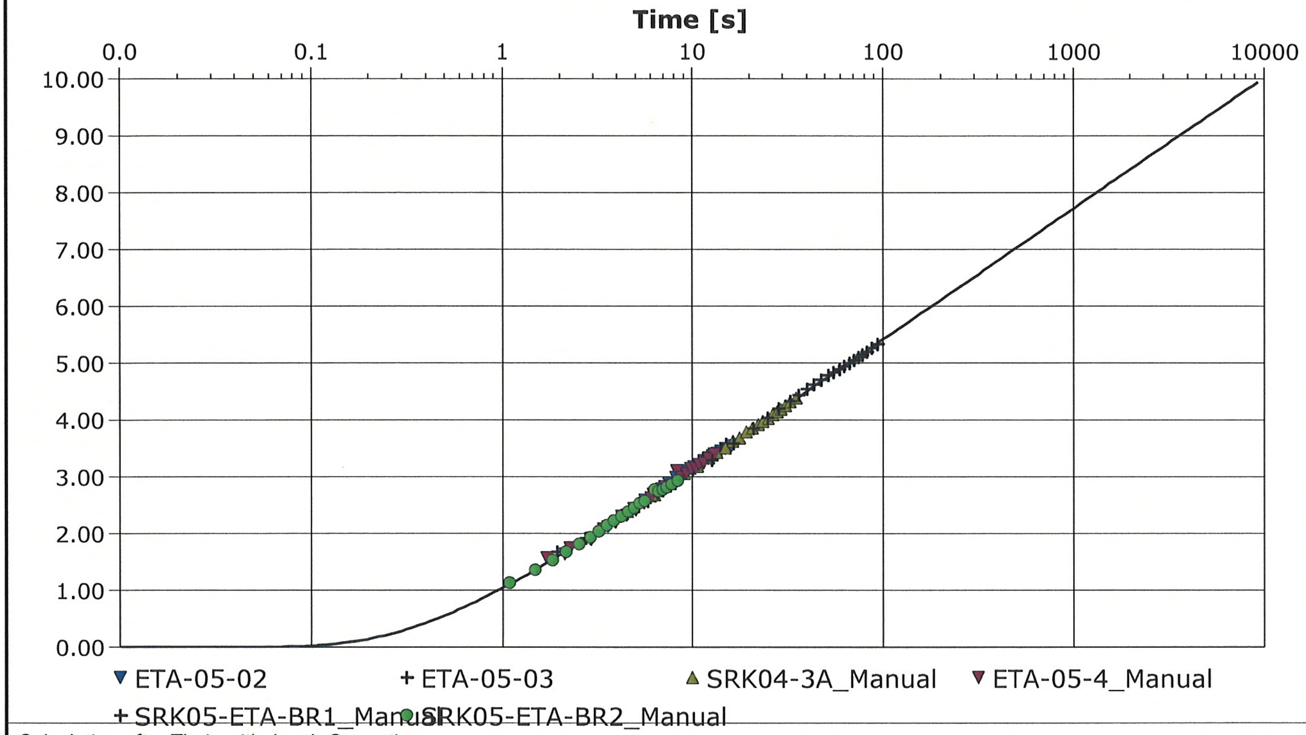
Location: Faro Mine	Pumping Test: ETA 24-hour pumping	Pumping well: SRK04-4
Test conducted by: Mauro Prado		Test date: 10/3/2005
Analysis performed by:	Theis recovery	Date: 10/26/2005
Aquifer Thickness: 4.00 m	Discharge rate: 50 [U.S. gal/min]	



Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
SRK04-4	1.58 × 10^2	3.96 × 10^1	5.00 × 10^{-1}	0.05	
SRK04-3A	5.84 × 10^1	1.46 × 10^1	6.03 × 10^{-2}	13.0	
SRK05-ETA-BR1	6.39 × 10^1	1.60 × 10^1	2.48 × 10^{-2}	10.3	
ETA-05-02	5.70 × 10^1	1.43 × 10^1	1.90 × 10^{-2}	20.0	
ETA-05-03	8.06 × 10^1	2.02 × 10^1	2.75 × 10^{-2}	29.07	
Average	8.36 × 10^1	2.09 × 10^1	1.26 × 10^{-1}		

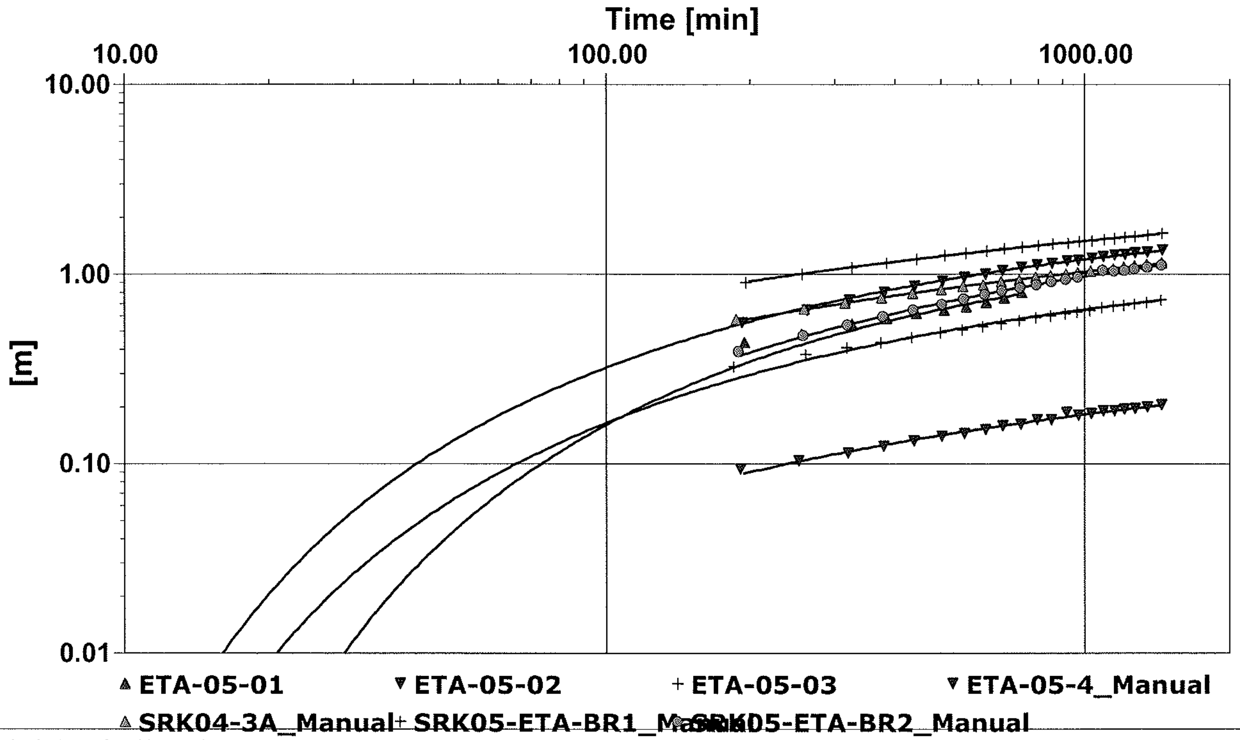
Location: Faro Mine	Pumping Test: ETA 24-hour pumping	Pumping well: SRK04-4
Test conducted by: Mauro Prado		Test date: 10/3/2005
Analysis performed by:	Theis with Jacob Correction	Date: 10/26/2005
Aquifer Thickness: 4.00 m	Discharge rate: 50 [U.S. gal/min]	



Calculation after Theis with Jacob Correction

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	P	Radial distance to PW [m]
ETA-05-02	6.91×10^{1}	1.73×10^{1}	1.08×10^{-2}	1.26×10^{3}	20.0
ETA-05-03	1.17×10^{2}	2.92×10^{1}	9.18×10^{-3}	1.00×10^{6}	29.07
SRK04-3A_Manual	9.70×10^{1}	2.43×10^{1}	1.64×10^{-2}	1.96×10^{2}	13.0
ETA-05-4_Manual	3.69×10^{2}	9.22×10^{1}	5.66×10^{-3}	1.54×10^{2}	71.17
SRK05-ETA-BR1_Manual	8.88×10^{1}	2.22×10^{1}	9.04×10^{-3}	1.53×10^{2}	10.3
SRK05-ETA-BR2_Manual	6.61×10^{1}	1.65×10^{1}	3.27×10^{-2}	1.06×10^{2}	15.62
Average	1.34×10^{2}	3.36×10^{1}	1.40×10^{-2}	1.67×10^{5}	

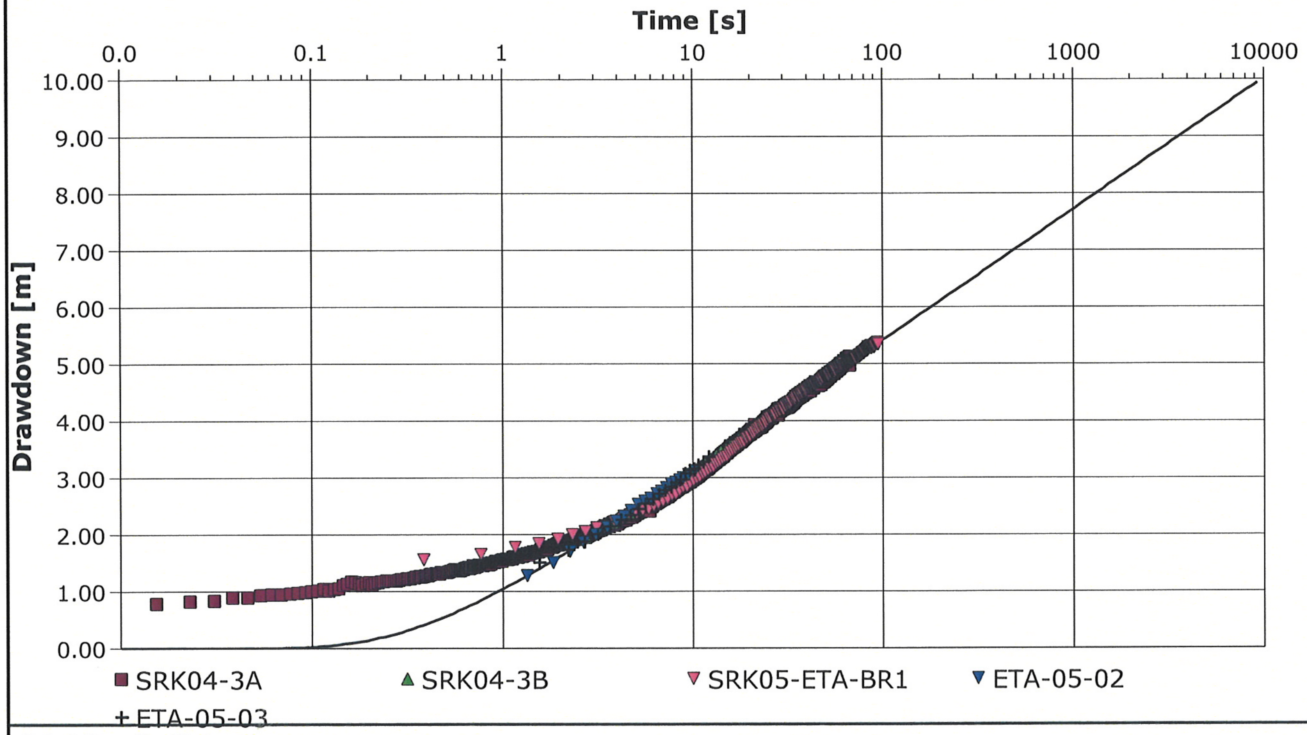
Location: Faro Mine	Pumping Test: ETA 24-hour pumping	Pumping well: SRK04-4
Test conducted by: Mauro Prado		Test date: 10/3/2005
Analysis performed by:	Hantush	Date: 10/28/2005
Aquifer Thickness: 4.00 m	Discharge rate: 50 [U.S. gal/min]	



Calculation after Hantush

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Hydr. resistance [min]	Radial distance to PW [m]
ETA-05-01	4.43×10^{1}	1.11×10^{1}	1.21×10^{-2}	2.10×10^{5}	27.78
ETA-05-02	4.43×10^{1}	1.11×10^{1}	1.30×10^{-2}	3.33×10^{5}	20.0
ETA-05-03	8.06×10^{1}	2.02×10^{1}	1.21×10^{-2}	5.00×10^{5}	29.07
ETA-05-4_Manual	3.53×10^{2}	8.83×10^{1}	5.75×10^{-3}	1.67×10^{8}	71.17
SRK04-3A_Manual	7.48×10^{1}	1.87×10^{1}	2.01×10^{-2}	1.67×10^{8}	13.0
SRK05-ETA-BR1_Manual	5.89×10^{1}	1.47×10^{1}	1.50×10^{-2}	1.67×10^{8}	10.3
SRK05-ETA-BR2_Manual	5.16×10^{1}	1.29×10^{1}	3.45×10^{-2}	1.67×10^{8}	15.62
Average	1.01×10^{2}	2.53×10^{1}	1.61×10^{-2}	9.54×10^{7}	

Location: Faro Mine	Pumping Test: ETA 24-hour pumping	Pumping well: SRK04-4
Test conducted by: Mauro Prado		Test date: 10/3/2005
Analysis performed by:	Theis semi-log	Date: 10/28/2005
Aquifer Thickness: 4.00 m	Discharge rate: 50 [U.S. gal/min]	



Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
SRK04-3A	9.47 × 10^1	2.37 × 10^1	8.44 × 10^{-3}	13.0	
SRK04-3B	8.01 × 10^1	2.00 × 10^1	2.28 × 10^{-2}	13.0	
SRK05-ETA-BR1	7.20 × 10^1	1.80 × 10^1	7.35 × 10^{-3}	10.3	
ETA-05-02	5.05 × 10^1	1.26 × 10^1	1.26 × 10^{-2}	20.0	
ETA-05-03	1.00 × 10^2	2.50 × 10^1	9.80 × 10^{-3}	29.07	
Average	7.95 × 10^1	1.99 × 10^1	1.22 × 10^{-2}		

Appendix E

Water Quality

Sample ID	X23														
Date Sampled	1/12/2004	2/16/2004	3/15/2004	4/14/2004	5/14/2004	6/14/2004	7/12/2004	8/9/2004	9/13/2004	10/12/2004	11/14/2004	5/9/2005	6/20/2005	7/25/2005	8/22/2005
Time Sampled															
Nature															
Physical Tests															
Field Conductivity															
Lab Conductivity (uS/cm)			6990	4180	6100	8190	7150	9900	9290	9460	8040	7550	11500	6300	7150
Hardness CaCO3			4210	4150				3980		4023	4290	3840	4660	4300	4970
pH															
pH F		7	7	6.9	6	6.5	6.5	6.7	6.4			6	6.4	6.6	6.7
Dissolved Anions															
Acidity (to pH 8.3) CaCO3															
Alkalinity-Total CaCO3															
Bromide Br															
Chloride Cl															
Fluoride F															
Sulphate SO4	4190	3163	4440	4390	5610	5590	6370	6490	6500	5630	5380	5910	6510	5500	5800
Total Metals															
Aluminum T-Al	<0.001	0.005	0.009	0.14	9.38	0.063	0.012	0.012	0.017	0.009	0.029	8.15	0.04	0.009	<0.005
Antimony T-Sb	<0.002	<0.002	<0.001	<0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic T-As	0.012	0.013	0.002	<0.03	0.022	0.004	0.004	0.002	0.002	0.002	0.003	0.019	0.004	0.002	0.005
Barium T-Ba	0.015	0.014	0.015	0.005	0.023	0.021	0.02	0.016	0.016	0.015	0.019	0.021	0.017	0.016	0.016
Beryllium T-Be	0.0007	0.0005	<0.001	<0.003	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001
Bismuth T-Bi	<0.01	<0.01	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron T-B	0.11	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium T-Cd	0.0172	0.0164	0.015	0.02	1.2	0.16	0.104	0.083	0.058	0.06	0.064	0.847	0.211	0.134	0.132
Calcium T-Ca	655.6	611.8	608	564	382	550	508	490	460	472	483	444	495	469	578
Chromium T-Cr	<0.001	0.005	0.001	<0.01	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001
Cobalt T-Co	0.396	0.365	0.4	0.36	1.43	1.14	0.91	0.8	0.81	0.77	0.86	1.16	1.08	0.87	1.07
Copper T-Cu	0.039	0.039	0.021	0.03	10.6	0.26	0.12	0.085	0.075	0.046	0.035	6.8	0.14	0.078	0.063
Iron T-Fe	9.026	12.849	15.3	30.2	58.4	123	169	151	139	137	110	86.7	190	140	167
Lanthanum T-La	<0.001	<0.001													
Lead T-Pb	0.019	0.011	<0.001	<0.03	0.19	0.008	0.003	0.003	0.005	0.003	0.002	0.11	0.005	0.003	0.002
Lithium T-Li			0.011		0.19	0.21	0.19	0.15	0.15	0.14	0.22	0.17	0.21	0.18	0.22
Magnesium T-Mg	745.7	707.4	654	665	577	681	647	668	690	697	749	662	832	760	854
Manganese T-Mn	46.209	42.319	57.6	49.2	65.3	75.5	73.8	70.8	65.8	66.9	64.1	73.4	83.8	69.9	89
Mercury T-Hg	<0.0001	<0.0001	<0.00002	<0.00002	0.00004	<0.00002		<0.00002	<0.00002	<0.00002	<0.00002	0.00004	<0.00002	<0.00002	<0.00002
Molybdenum T-Mo	0.03	0.034	<0.0005	<0.02	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel T-Ni	0.408	0.45	0.54	0.54	1.72	1.47	1.15	1	0.99	0.94	1.04	1.47	1.31	1.05	1.21
Phosphorus T-P															
Potassium T-K	27.4	25.1	16.1	14.3	12.9	16	16.2	13.9	14.5	15.3	22.7	12.8	14.7	13.9	16.8
Selenium T-Se	<0.005	<0.005	0.009	0.0077	0.053	0.017	0.014	0.011	0.008	0.007	0.015	0.027	0.017	0.01	0.018
Silicon T-Si			16.2	7.49	20.2	17.9	16.4	16.7	18.4	16.4	30.2	19.5	18.7	17	17.4
Silver T-Ag	0.0049	0.0021	<0.00025	<0.01	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	0.0009	<0.00025	<0.00025	<0.00025	<0.00025
Sodium T-Na	63.5	55.7	59.2	55.8	33.7	57.5	47.9	47	51.3	55.8	81.5	37.3	51.1	47.8	60.1
Strontium T-Sr	4.017	3.542	3.69	3.37	2.33	3.35	3.58	3.46	3.6	3.35	3.32	2.45	3.55	3.37	4.09
Sulfur T-S	1472.9	1319.4													
Tellurium T-Te			<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium T-Tl	<0.002	<0.002	0.0011		0.0019	0.0017	0.0016	0.0013	0.0014	0.0015	0.0016	0.0019	0.0017	0.0015	0.0017
Thorium T-Th			0.001		0.003	<0.0005	<0.0005	<0.0005	<0.0005	0.001	<0.0005	0.0025	<0.0005	<0.0005	<0.0005
Tin T-Sn	<0.002	<0.002	<0.001	<0.03	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Titanium T-Ti	<0.001	0.003	0.002	<0.005	0.002	0.001	0.001	0.001	<0.001	<0.001	0.005	0.001	<0.001	<0.001	0.001
Tungsten T-W	<0.03	<0.03													
Uranium T-U			0.017		0.038	0.009	0.012	0.011	0.013	0.016	0.018	0.032	0.0091	0.01	0.013
Vanadium T-V	0.004	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc T-Zn	155.508	152.852	141	158	964	498	512	438	375	372	327	808	655	480	449
Dissolved Metals															
Aluminum D-Al	<0.001	0.005	<0.005	0.13	0.4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.58	0.006	<0.005	<0.005
Antimony D-Sb	<0.002	<0.002	<0.001	<0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic D-As	0.013	0.013	0.002	<0.03	0.011	0.003	0.003	0.002	0.002	0.001	0.003	0.005	0.003	0.002	0.004
Barium D-Ba	0.013	0.013	0.013	<0.001	0.021	0.016	0.015	0.013	0.013	0.014	0.018	0.018	0.014	0.015	0.012
Beryllium D-Be	0.0007	0.0004	<0.001	<0.003	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Bismuth D-Bi	<0.01	<0.01	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron D-B	0.1	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium D-Cd	0.0156	0.0155	0.013	<0.01	1.16	0.131	0.083	0.07	0.05	0.054	0.052	0.734	0.177	0.121	0.104
Calcium D-Ca	648.4	651.7	532	499	343	458	433	379	410	465	455	397	433	434	458
Chromium D-Cr	0.002	0.003	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt D-Co	0.387	0.389	0.35	0.320	1.340	0.95	0.77	0.67	0.75	0.73	0.82	1.06	0.91	0.8	0.85
Copper D-Cu	0.009	0.027	0.005	<0.02	6.56	0.052	0.03	0.014	0.01	0.006	0.006	4.08	0.027	0.034	0.012
Iron D-Fe	1.341	0.339	<0.01	<0.01	13.1	6.6	31.9	45	55.2	14.8	38.9	28.9	69.9	9.02	25.2
Lanthanum D-La	<0.001	<0.001													
Lead D-Pb	0.013	0.015	<0.001	<0.03	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Lithium D-Li			0.1		0.18	0.15	0.16	0.12	0.13	0.14	0.18	0.16	0.17	0.16	0.18
Magnesium D-Mg	717	758.3	579	614	512	587	560	530	638	695	711	572	692	689	687
Manganese D-Mn	44.714	43.355	49.9	44.4	57.6	62.3	64.2	59	59.9	65.5	63.4	64.5	70.1	64.3	69.2
Mercury D-Hg	<0.0001	<0.0001	<0.00002	<0.00002			<0.00002								
Molybdenum D-Mo	0.03	0.035	<0.0005	<0.02	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel D-Ni	0.403	0.478	0.47	0.46	1.62	1.21	0.94	0.83	0.9	0.87	1.03	1.34	1.1	0.96	0.95
Phosphorus D-P															
Potassium D-K	26	27.5	14	12.8	12.3	11.6	12.3	10.2	12.8	14.5	18.1	11.4	11.5	12	13.1
Selenium D-Se	<0.005	<0.005	0.007	0.0068	0.049	0.014	0.013	0.01	0.008	0.007	0.014	0.023	0.015	0.009	0.016
Silicon D-Si			12.9	5.7	15.7	11.1	11.3	11.7	12.2	11.6	16.8	15	12.3	12.8	10.2
Silver D-Ag	0.0049	0.0029	<0.00025	<0.01	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	0.0005	<0.00025	<0.00025	<0.00025	<0.00025
Sodium D-Na	60.4	60.8	52.8	50	33	42.6	38.5	37.5	47.4	53.5	68.4	33.7	42.3	43	47.8
Strontium D-Sr	3.771	3.814	3.2	3.01	2.32	2.72	3.03	2.64	3.23	3.19	3.16	2.36	3.02	3.11	3.25
Sulfur D-S	1477.8	1408.1													
Tellurium D-Te			<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium D-Tl	<0.002	<0.002	0.001		0.0017	0.0012	0.0011	0.0009	0.0012	0.0013	0.0012	0.0016	0.0012	0.0012	0.0013
Thorium D-Th			0.0007		0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Tin D-Sn	0.002	<0.002	<0.001	<0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium D-Ti	<0.001	<0.001	<0.001	<0.005	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tungsten D-W	<0.03	<0.03													
Uranium D-U			0.014		0.0087	0.0011	0.0018	0.0016	0.0048	0.0019	0.0055	0.0084	0.0014	0.0039	0.0014
Vanadium D-V	0.003	0.002	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc D-Zn	148.651	157.429	121	134	857	417	446	338	340	351	326	732	562	440	391
Nutrients															

Sample ID	SRK04- 04	SRK04-04 (1HR, 10HR, 24HR, 36HR) during Ptest (36-hr is dup)				SRK04-03A	SRK04-03B	P96-8A		P96-8B	
Date Sampled	5/5/2005	10/2/2005	10/2/2005	10/3/2005	10/3/2005	5/5/2005	5/5/2005	5/3/2005	9/10/2005	5/3/2005	9/10/2005
Time Sampled	10:45	10:20	19:20	9:20	10:00	10:48	11:00	16:35	16:55	16:35	17:00
Nature	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests											
Field Conductivity											
Lab Conductivity (uS/cm)		8390	7780	7610	7630			197	6370	5540	6620
Hardness CaCO3	3810					3970	3890	94.4	4240	3770	4080
pH	5.23	4.84	5.34	5.39	5.44	5.87	3.72	6.76	6.5	7.01	6.35
pH F											
Dissolved Anions											
Acidity (to pH 8.3) CaCO3		4640	4400	4890	4280						
Alkalinity-Total CaCO3	63.6	67.3	95.4	93.5	108	91	61.7	12.4	108	214	131
Bromide Br											
Chloride Cl		<50	<50	<50	<50						
Fluoride F											
Sulphate SO4	7080	8100	7460	7460	7370	5480	16700	71.2	5040	4520	4980
Total Metals											
Aluminum T-Al		2.32	1.84	1.62	1.67						
Antimony T-Sb		<0.010	<0.010	<0.010	<0.010						
Arsenic T-As		<0.010	<0.010	<0.010	<0.010						
Barium T-Ba		0.0137	0.0121	0.0120	0.0121						
Beryllium T-Be		<0.050	<0.050	<0.050	<0.050						
Bismuth T-Bi		<0.050	<0.050	<0.050	<0.050						
Boron T-B		<1.0	<1.0	<1.0	<1.0						
Cadmium T-Cd		0.0278	0.0243	0.0279	0.0248						
Calcium T-Ca		520	511	538	527						
Chromium T-Cr		<0.050	<0.050	<0.050	<0.050						
Cobalt T-Co		0.651	0.643	0.644	0.647						
Copper T-Cu		0.025	0.034	0.024	0.025						
Iron T-Fe		2410	2020	1980	1940						
Lanthanum T-La											
Lead T-Pb		0.0689	0.0737	0.0517	0.0531						
Lithium T-Li		<0.50	<0.50	<0.50	<0.50						
Magnesium T-Mg		562	540	558	544						
Manganese T-Mn		66.3	67.0	66.1	65.6						
Mercury T-Hg											
Molybdenum T-Mo		<0.0050	<0.0050	<0.0050	<0.0050						
Nickel T-Ni		0.782	0.801	0.795	0.795						
Phosphorus T-P		<0.90	<0.90	<0.90	<0.90						
Potassium T-K		11.4	11.4	11.8	11.4						
Selenium T-Se		<0.10	<0.10	<0.10	<0.10						
Silicon T-Si		17.1	16.4	16.6	16.3						
Silver T-Ag		<0.0010	<0.0010	<0.0010	<0.0010						
Sodium T-Na		71.0	76.8	88.0	86.2						
Strontium T-Sr		3.93	4.05	4.21	4.16						
Sulfur T-S											
Tellurium T-Te											
Thallium T-Tl		<0.010	<0.010	<0.010	<0.010						
Thorium T-Th											
Tin T-Sn		<0.010	<0.010	<0.010	<0.010						
Titanium T-Ti		<0.030	<0.030	<0.030	<0.030						
Tungsten T-W											
Uranium T-U		0.0074	0.0072	0.0070	0.0074						
Vanadium T-V		<0.10	<0.10	<0.10	<0.10						
Zinc T-Zn		469	451	450	444						
Dissolved Metals											
Aluminum D-Al	1.4	2.06	1.72	1.60	2.70	<1.0	4.3	0.029	<1.0	<0.50	<1.0
Antimony D-Sb	<0.050	<0.010	<0.010	<0.010	<0.010	<0.050	<0.050	0.00110	<0.050	<0.025	<0.050
Arsenic D-As	<0.10	<0.010	<0.010	<0.010	<0.010	<0.10	<0.10	<0.0010	<0.10	<0.050	<0.10
Barium D-Ba	<0.040	0.0115	0.0113	0.0118	0.0118	<0.040	<0.40	0.042	<0.040	<0.10	<0.040
Beryllium D-Be	<0.010	<0.050	<0.050	<0.050	<0.050	<0.010	<0.10	<0.0050	<0.010	<0.025	<0.010
Bismuth D-Bi		<0.050	<0.050	<0.050	<0.050						
Boron D-B	<0.20	<1.0	<1.0	<1.0	<1.0	<0.20	<2.0	<0.10	<0.20	<0.50	<0.20
Cadmium D-Cd	0.0151	0.0242	0.0246	0.0260	0.0246	0.0066	<0.0050	0.000901	0.220	0.0410	0.0970
Calcium D-Ca	457	516	517	526	532	454	459	25.6	456	424	431
Chromium D-Cr	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.00050	<0.050	<0.025	<0.050
Cobalt D-Co	0.500	0.631	0.648	0.642	0.627	0.349	0.225	<0.00050	0.312	0.395	1.69
Copper D-Cu	<0.10	0.022	0.025	0.024	0.023	<0.10	<0.10	0.0044	<0.10	<0.050	<0.10
Iron D-Fe	1630	2380	2020	1950	1950	693	6610	0.064	0.061	0.22	9.85
Lanthanum D-La											
Lead D-Pb	<0.10	0.0058	0.0235	0.0509	0.0510	<0.10	0.16	<0.0010	<0.10	<0.050	<0.10
Lithium D-Li	<0.10	<0.50	<0.50	<0.50	<0.50	<0.10	<1.0	<0.050	0.26	<0.25	0.20
Magnesium D-Mg	649	558	546	546	551	690	666	7.39	752	659	730
Manganese D-Mn	56.0	64.6	65.5	65.2	64.1	49.7	72.9	0.014	98.7	49.0	90.7
Mercury D-Hg	<0.00020					<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Molybdenum D-Mo	<0.10	<0.0050	<0.0050	<0.0050	<0.0050	<0.10	<0.10	<0.0010	<0.10	<0.050	<0.10
Nickel D-Ni	0.72	0.778	0.778	0.787	0.761	0.60	<0.50	0.0108	1.70	0.69	1.40
Phosphorus D-P		<0.90	<0.90	<0.90	<0.90						
Potassium D-K		11.5	11.4	11.2	11.6						
Selenium D-Se	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.0010	<0.10	<0.050	<0.10
Silicon D-Si		16.9	16.4	16.3	16.4						
Silver D-Ag	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0050	<0.000050	<0.0050	<0.0025	<0.0050
Sodium D-Na	60.5	70.4	77.1	86.3	86.5	58.8	66	<2.0	54.9	53	58.6
Strontium D-Sr		3.83	4.06	4.16	4.05						
Sulfur D-S											
Tellurium D-Te											
Thallium D-Tl	<0.020	<0.010	<0.010	<0.010	<0.010	<0.020	<0.020	<0.00020	<0.020	<0.010	<0.020
Thorium D-Th											
Tin D-Sn		<0.010	<0.010	<0.010	<0.010						
Titanium D-Ti	<0.10	<0.030	<0.030	<0.030	<0.030	<0.10	<1.0	<0.050	<0.10	<0.25	<0.10
Tungsten D-W											
Uranium D-U	<0.020	0.0061	0.0066	0.0074	0.0067	<0.020	<0.020	<0.00020	<0.020	<0.010	<0.020
Vanadium D-V	1.07	<0.10	<0.10	<0.10	<0.10	0.507	3.81	<0.030	0.078	0.17	<0.20
Zinc D-Zn	350	461	447	444	438	233	749	1.67	604	173	368
Nutrients											

Sample ID	FCS-1				FCS-2			FCS-3				FCS-4		
Date Sampled	10/20/2004	4/17/2005	7/1/2005	10/18/2005	10/20/2004	7/1/2005	10/18/2005	10/20/2004	4/17/2005	7/1/2005	10/18/2005	10/20/2004	4/17/2005	10/18/2005
Time Sampled														
Nature				Water										
Physical Tests														
Field Conductivity	6470	5240	4610	4230	7810	3850	4890	7410	5710	5120	5010	7080	5190	4610
Lab Conductivity (uS/cm)	6320	6110		6990			6990	7470	6920		8400	6900	5770	6780
Hardness CaCO3														
pH				6.37			6.55				5.17			5.45
pH F	6.71		6.7	6.21	6.5	5.78	7.47	5.96		5.58	6.07	6.69		6.82
Dissolved Anions														
Acidity (to pH 8.3) CaCO3														
Alkalinity-Total CaCO3				111			120				60.0			57.0
Bromide Br				<1.0			<1.0				<1.0			<1.0
Chloride Cl				13			14				<10			15
Fluoride F				0.43			<0.40				0.55			<0.40
Sulphate SO4	5580	5030.0		6200			6210	5790	5550.0		6570	5490	4170	4860
Total Metals														
Aluminum T-Al				<0.40			0.58				1.53			7.00
Antimony T-Sb				<0.40			<0.40				<0.60			<0.40
Arsenic T-As				<0.40			<0.40				<0.60			<0.40
Barium T-Ba				<0.020			0.026				<0.030			0.049
Beryllium T-Be				<0.010			<0.010				<0.015			<0.010
Bismuth T-Bi				<0.40			<0.40				<0.60			<0.40
Boron T-B				<0.20			<0.20				<0.30			<0.20
Cadmium T-Cd				0.102			0.112				<0.030			0.047
Calcium T-Ca				496			493				279			477
Chromium T-Cr				<0.020			<0.020				<0.030			<0.020
Cobalt T-Co				0.972			0.748				0.290			0.471
Copper T-Cu				0.036			0.030				<0.060			<0.050
Iron T-Fe	123	88.9		157			61.6	1650	1210		1120	572	801	773
Lanthanum T-La														
Lead T-Pb				<0.10			0.30				<0.15			0.26
Lithium T-Li				0.199			0.216				0.078			0.145
Magnesium T-Mg				881			928				309			626
Manganese T-Mn				90.4			104				37.7			69.3
Mercury T-Hg														
Molybdenum T-Mo				<0.060			<0.060				<0.090			<0.060
Nickel T-Ni				1.12			1.27				0.33			0.69
Phosphorus T-P				<0.60			<0.60				<0.90			<0.60
Potassium T-K				16.7			18.2				6.9			14.2
Selenium T-Se				<0.40			<0.40				<0.60			<0.40
Silicon T-Si				7.57			10.3				8.80			13.4
Silver T-Ag				<0.020			<0.020				<0.030			<0.020
Sodium T-Na				60.6			64.4				87.4			98.5
Strontium T-Sr				3.67			3.88				2.12			3.31
Sulfur T-S														
Tellurium T-Te														
Thallium T-Tl				<0.40			<0.40				<0.60			<0.40
Thorium T-Th														
Tin T-Sn				<0.060			<0.060				<0.090			<0.060
Titanium T-Ti				<0.020			<0.020				<0.030			<0.020
Tungsten T-W														
Uranium T-U														
Vanadium T-V				<0.060			<0.060				<0.090			<0.060
Zinc T-Zn	371	295		477			459	309	309		222	319	174	310
Dissolved Metals														
Aluminum D-Al				<0.40			<0.40				<0.60			<0.40
Antimony D-Sb				<0.40			<0.40				<0.60			<0.40
Arsenic D-As				<0.40			<0.40				<0.60			<0.40
Barium D-Ba				<0.020			<0.020				<0.030			<0.020
Beryllium D-Be				<0.010			<0.010				<0.015			<0.010
Bismuth D-Bi				<0.40			<0.40				<0.60			<0.40
Boron D-B				<0.20			<0.20				<0.30			<0.20
Cadmium D-Cd				0.096			0.111				<0.030			0.045
Calcium D-Ca				493			499				283			482
Chromium D-Cr				<0.020			<0.020				<0.030			<0.020
Cobalt D-Co				0.965			0.755				0.292			0.478
Copper D-Cu				<0.020			<0.020				<0.060			<0.050
Iron D-Fe		34.4		119			44.7		1090		1090		604	670
Lanthanum D-La														
Lead D-Pb				<0.10			<0.10				<0.15			<0.10
Lithium D-Li				0.199			0.219				0.073			0.153
Magnesium D-Mg				876			936				314			635
Manganese D-Mn				90.4			105				37.3			70.6
Mercury D-Hg														
Molybdenum D-Mo				<0.060			<0.060				<0.090			<0.060
Nickel D-Ni				1.11			1.28				0.33			0.69
Phosphorus D-P				<0.60			<0.60				<0.90			<0.60
Potassium D-K				16.8			18.4				6.8			14.5
Selenium D-Se				<0.40			<0.40				<0.60			<0.40
Silicon D-Si				6.74			9.60				7.97			9.53
Silver D-Ag				<0.020			<0.020				<0.030			<0.020
Sodium D-Na				61.2			64.2				87.2			104
Strontium D-Sr				3.51			3.94				2.09			3.33
Sulfur D-S														
Tellurium D-Te														
Thallium D-Tl				<0.40			<0.40				<0.60			<0.40
Thorium D-Th														
Tin D-Sn				<0.060			<0.060				<0.090			<0.060
Titanium D-Ti				<0.020			<0.020				<0.030			<0.020
Tungsten D-W														
Uranium D-U														
Vanadium D-V				<0.060			<0.060				<0.090			<0.060
Zinc D-Zn		278		470			462		291		219		150	309
Nutrients														

Appendix F

Scoping Level Numerical Model Results

SRK Consulting
Engineers and Scientists

Steffen, Robertson and Kirsten (Canada) Inc.
Suite 800 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: 604.681.4196
Fax: 604.687.5532

Revised Technical Memo

To: Faro – Groundwater Group
Date: February 28, 2006
cc:
From: Quinn Jordan-Knox, SRK
Christoph Wels, RGC
Subject: Results of ETA Scoping Simulations
Project #: 1CD003.073 Task 20e

A review of water quality data from the Emergency Tailings Area (ETA) by RGC and subsequent investigations by RGC and SRK indicated that highly contaminated groundwater and surface water are discharging to Rose Creek Valley (Preliminary Seepage Collection Options, SRK, 2005). This water is likely a combination of seepage from the main Faro waste rock dump and the mill area, and precipitation infiltrating through tailings present in the ETA. Initial results suggested that the ETA tailings likely contribute to the overall contaminant loading, in particular with respect to iron.

The 2005 report recommended a seepage collection system consisting of a line of pumping wells adjacent to the mine access road, combined with surface water collection sumps. Further works were undertaken in 2005 to increase the understanding of groundwater flow in the ETA to improve design and costing of the collection system. If further work indicates that groundwater collection above the road is difficult, an alternative seepage and surface water collection system will be necessary below the road.

A conference call was held on November 10th, 2005, to provide an update on the status of work on various 2005 studies at Faro, including the Emergency Tailings Area (ETA). Preliminary analyses were discussed and next steps identified to complete the project, focussing on information that will be critical for identifying and evaluating closure alternatives in the next few months. Major preliminary results of 2005 ETA investigations were:

- Results of a 24 hr pumping test of SRK04-4 indicated that hydraulic barriers were not intersected; all monitoring wells showed drawdown.
- The seepage face flow on the downstream side of the access road did not show a noticeable change (based on visual assessments and continuous flow monitoring at the mouth of the Faro Creek canyon) during the pumping test. ETA groundwater flow is thought to be connected to the seepage face but reasons for the lack of reduction in seepage during pumping were unclear.
- Flow and loading estimates along Faro Creek appeared to balance with the exception of iron. Zinc load estimates at FCS4 in Faro Creek were approximately 71 tonnes/yr

During the November 10 conference call, a number of issues were identified for further consideration:

1. Do numerical simulations support the conclusion that it is feasible to collect contaminated groundwater in the ETA with a pumping well system?
2. Do simulations indicate that the 24 hr pumping test should have cut-off seepage below the access road and if not, why?
3. What is the estimated capture efficiency for groundwater collection within the ETA?
4. Should the tailings be removed to reduce the contaminant load to the aquifer (particularly iron) and improve the operation of pumping system (reduce operation costs).

This memo describes the construction of a groundwater flow model for the ETA area and summarizes results of numerical scoping simulations of groundwater flow in the ETA and potential groundwater capture scenarios for the collection of groundwaters at the mine access road. The numerical model was constructed to provide a tool for testing conceptual model assumptions and potential capture systems. Scoping simulation results are discussed with respect to the above identified issues.

BACKGROUND

The geologic conceptual model for the ETA has been updated using geologic and geophysical data from the 2004 and 2005 field programs. Figures 1 and 2 are location maps for the site. Figures 3 and 4 are cross-sections showing the primary aquifer unit, overlying tailings deposit, and underlying bedrock surface.

- The aquifer is primarily comprised of coarse (sand and gravel sized) alluvium deposited by the old Faro Creek near the main access road but is also interpreted to include some Till of sandy or gravelly silt texture further up-valley (towards the Faro waste dumps) and towards the valley sides.
- The distribution/thickness of alluvial and till deposits up-valley from the ETA is uncertain. The alluvial unit is interpreted to continue under the access road, sloping downwards with topography.
- The tailings vary in texture from gravel and sand to silt with lenses of visible pyrite-rich sand/gravel observed in drill-core. The tailings deposit is approximately 6.5m thick near the access road and thins up-valley and towards the valley sides.
- Coarser materials within the tailings deposit may represent mine wastes (waste rock) being placed onto the tailings surfaces after intermittent discharges to the ETA. These coarser waste layers may represent preferential pathways in the tailings unit but cannot be accurately delineated with the available data.
- The tailings are interpreted to represent a partially confining layer to the alluvial aquifer (where tailings are fine sand/silt-size) which may desaturate during pumping in the alluvial aquifer.
- The narrow bedrock channel observed below the main access road is interpreted to extend up-valley under the mine access road into the ETA to approximately SRK04-4. The bedrock surface is interpreted to rise up-valley from the access road to the waste rock dumps and valley-sides.
- Fine grained (silt) Till is assumed to blanket the adjacent hillsides bordering the ETA

Significant uncertainty exists regarding the distribution and thickness of alluvial and till deposits up-valley where there is little geologic data. Preferential pathways in coarser till units or thicker alluvial sediments may exist but cannot be accurately defined with the available data.

Hydraulic properties for the aquifer were estimated by analyses of the 2005 24-hr pumping test using analytical techniques:

- Aquifer transmissivity (T) was estimated to be approximately 66 m^2/d, with an average hydraulic conductivity (K) of 2×10^{-4} m/s. These estimates are based on a new analysis of the 24hr pump test data.
- Aquifer storativity was estimated to be approximately 0.02; this estimate is significantly greater than typical values for confined aquifers (<0.001) suggesting the influence of leakage to the alluvial aquifer (semi-confined conditions).
- Drawdown curves for several wells screened in the aquifer and the overlying tailings suggest leakage from the tailings to the aquifer, indicating the potential for complete desaturation of the tailings
- Seepage from below the mine access road was not observed to change significantly during the 24 hour pumping test
- The bedrock monitoring well (SRK05-ETA-BR2) showed delayed but similar drawdown response to shallower wells screened within the aquifer (SRK05-ETA-BR1).

Table 1 summarizes selected groundwater quality data collected in 2005 from existing and newly installed monitoring wells in the ETA area. The following conclusions can be drawn about the groundwater quality in the ETA area:

- All groundwater samples exceed the CCME limit of 0.05 mg/l for Zinc

- Groundwater quality in the two up-gradient wells (P96-6A&B) showed significant variations over time suggesting variable contributions of (more dilute) surface water recharge;
- Concentrations of sulphate, zinc, and in particular iron were generally higher in alluvial wells located in the ETA area compared to those wells located up-gradient; furthermore, the highest concentrations of sulphate, zinc and iron were observed in the single well screened in tailings (SRK04-03B); these observations suggest that the ETA tailings represent a significant source of contaminant loading (in particular iron) to the Faro Creek seepage;
- The sample from the bedrock well, SRK05-ETA-BR2, had the lowest contaminant concentrations of all wells in the ETA. This information suggests that bedrock groundwater is less affected by ARD seepage from the Faro mine site than alluvial groundwater;
- Lower concentrations in the bedrock sample may indicate that deeper groundwaters are less contaminated than shallow groundwaters. Bedrock hydraulic conductivities estimated from packer tests in SRK05-BR2 were low (10^{-7} – 10^{-8} m/s) and suggest that bedrock groundwater fluxes are also low. Consequently, bedrock groundwaters may not be critical for collection (i.e. bypass of deep groundwaters may have lower impact to receiving environment than shallower alluvial groundwaters).

Table 1 Monitoring Well Water Quality

ID	Date	Lab pH	Lab Conductivity (µS/cm)	SO4 (mg/L)	Zn (mg/L)	Fe (mg/L)
November 2005 Sampling						
SRK05-ETA-BR1	11/2005	5.42	9750	9250	681	3100
SRK05-ETA-BR2	11/2005	6.8	2040	1200	7.41	22.5
October 2005 SRK04-04 Pumping Test						
SRK04-4	10/2/2005	5.44	7630	7370	438	1950
October 2005 Sampling (Pre-Test)						
P96-8A	9/10/2005	6.50	6370	5040	604	0.061
P96-8B	9/10/2005	6.35	6620	4980	368	9.85
May 2005 Sampling						
SRK04- 04-04	5/5/2005	5.23		7080	350	1630
SRK04-03A	5/5/2005	5.87		5480	233	693
SRK04-03B	5/5/2005	3.72		16700	749	6610
P96- 8A	5/3/2005	6.76	197	71.2	1.67	0.064
P96- 8B	5/3/2005	7.01	5540	4520	173	0.22

Surface water samples were taken repeatedly in 2005 at four stations along the Faro Creek channel (from X23 at the toe of the WRDs to the mouth of the Faro Creek Canyon). Table 2 summarizes the concentrations of selected constituents (SO4, Zn-T and Fe-T) observed in these surveys. The measured streamflows at each station are also shown for reference. The following conclusions can be drawn with respect to streamflows and surface water quality in the ETA area:

- Toe seepage from the WRDs (FCS-1 at X23) occurs year-round with some decrease in seepage during winter baseflow; concentrations of sulphate, zinc and iron are highly elevated but have remained relatively steady during the period of observation;
- Surface runoff from the ETA area (FCS-2 at culvert) shows more variable flow than toe seepage up-gradient of the ETA area but concentrations of sulphate, zinc and iron are very similar to those observed in toe seepage up-gradient of the ETA area (except for a small decrease in total iron concentrations);

- Subsurface seepage from the ETA area (FCS-3 at downstream seepage face) flows year-round with flow estimates ranging from 2.3 – 4.8 L/s; water quality of this seepage is generally similar to that observed in the alluvial wells in the ETA area; iron concentrations in this seepage are consistently about one order of magnitude higher than in WRD seepage entering (and leaving) the ETA area;
- Surface runoff at the mouth of the Faro Creek Canyon (FCS-4) also flows year-round with flow rates ranging from 4.5 to 11.7 L/s (peak flows during snowmelt and/or heavy precipitation events may be higher but have not yet been measured); the water quality represents a mixture of surface runoff and subsurface seepage from the ETA area with intermediate concentrations of total iron;
- The two most reliable flow surveys (May and October 2005) suggest that incremental gains in streamflow along the Faro Creek Canyon (between FCS-2/3 and FCS-4) are very small (0.1 to 0.7 L/s) suggesting only a very small, if any, groundwater discharge along the Faro Creek canyon; this hypothesis is supported by loading calculations for October 2005 (see below).

Table 2: Surface Water Quality

Station ID	Date	Flow L/s	S04 mg/L	Zn-T mg/L	Fe-T mg/L
FCS-1 At toe of WRD	10-Apr-05	1.3	5,030	295	88.9
	13-May-05	4.6	no sample		
	18-Oct-05	1.2	6,200	477	157
	21-Nov-05	1.0	6,370	458	131
	19-Dec-05	0.6	5,920	516	180
	Average	**1.7**	**5,880**	**437**	**139**
FCS-2 At culvert below road	10-Apr-05	frozen	no sample		
	13-May-05	9.0	no sample		
	18-Oct-05	3.4	6,210	459	61.6
	21-Nov-05	>1.0	5,890	437	36.8
	19-Dec-05	frozen	no sample		
	Average	**n/a**	**6,050**	**448**	**49**
FCS-3 Seepage face below road	10-Apr-05	4.8	5,550	309	1,210
	13-May-05	2.6	no sample		
	18-Oct-05	3.1	6,570	222	1,120
	21-Nov-05	3.4	7,460	371	1,790
	19-Dec-05	2.3	7,030	430	1,990
	Average	**3.2**	**6,653**	**333**	**1,528**
FCS-4 Mouth of Canyon	10-Apr-05	6.6	4,170	174	801
	13-May-05	11.7	No sample		
	18-Oct-05	7.2	5,750	310	773
	21-Nov-05	5.4	5,610	266	940
	19-Dec-05	4.5	5,540	278	1,220
	Average	**7.1**	**5,268**	**257**	**934**

Table 3 summarises the observed surface water flows and calculated loads of sulphate, total zinc and total iron at the four sampling locations along the Faro Creek channel. The following conclusions can be drawn with respect to contaminant loading in surface water upstream and downstream of the ETA area:

- The contaminant load associated with surface runoff entering the ETA area is generally much smaller (<25%) than the combined contaminant load discharging from the ETA area (in surface runoff and seepage flow combined);
- The contaminant load associated with surface runoff from the ETA area varies significantly (in relative and absolute terms), mainly due to the large variability in flow;
- Subsurface seepage discharging downstream of the ETA area represents the primary source of contaminant loading during winter baseflow and a significant source of loading during the remainder of the year;
- The total sulphate and zinc load discharging from the ETA area (at FCS-4) varies with flow conditions; for example, zinc loading ranged from 70 t/yr during the (wet) fall to 36 t/yr during the winter baseflow; the total iron load at FCS-4 remained surprisingly constant over time (~170 t/yr);

- During the October 2005 survey, the combined sulphate and zinc loads from FCS-2 and FCS-3 agreed very well with the observed total loads at FCS-4. The load estimates for the other surveys are considered too uncertain (in particular for FCS-2 due to freezing of the culvert) to allow similar mixing calculations.

Table3: ETA Surface Water and Seepage Flow and Zinc Loading, October 2004

Date	Station	Flow L/s	S04 Load t/yr	Zn Load t/yr	Fe Load t/yr
10-Apr-05	FCS-1	1.3	206	12.1	3.6
	FCS-2	frozen	0	0	0
	FCS-3	4.8	840	46.8	183
	FCS-4	6.6	868	36.2	167
18-Oct-05	FCS-1	1.15	225	17.3	5.7
	FCS-2	3.4	666	49.2	6.6
	FCS-3	3.1	642	21.7	109
	FCS-4	7.2	1306	70.4	176
21-Nov-05	FCS-1	1.01	203	14.6	4.2
	FCS-2	1.0 to 2.0	196 – 392	14 – 29	1.9 – 3.9
	FCS-3	3.4	800	39.8	192
	FCS-4	5.4	955	45.3	160
19-Dec-05	FCS-1	0.63	118	10.3	3.6
	FCS-2	frozen	0	0	0
	FCS-3	2.3	510	31.2	144
	FCS-4	4.5	786	39.5	173

🟨 Estimated range

A summary of conceptual groundwater flow in the ETA is as follows:

- Under static conditions groundwater generally flows from the north-east to the south-west with converging flow towards the seepage face below the access road.
- The converging flow potentially indicates the presence of a bedrock paleochannel extending beneath the road into the ETA. The bedrock channel is assumed to have been filled with coarse waste rock during the construction of the access road.
- Groundwater is discharging into the current Faro Creek alignment along much of its length in the ETA, resulting in the increase of flow between stations (Table 3).
- The observed groundwater discharge from the ETA area, as measured by FCS-3 at the seepage face below the access road, ranges from 2.3 to 4.8 l/s. The October survey suggests that this station captures most, if not all, groundwater moving through the alluvial aquifer in the ETA area

- Groundwater seepage from ETA is year-round as indicated by measurements made as recently as mid-December 2005 by Laberge Environment, with flow decreasing during winter;
- After pumping SRK04-4 for 24-hrs, groundwater flows is generally towards the pumping well, but has not yet captured flow discharging at the seepage face.
- Uncertainty exists whether the aquifer will act as a confined aquifer with significant leakage from the tailings, or as an unconfined aquifer with the tailings draining completely during extended pumping.

CONCEPTUAL GROUNDWATER COLLECTION SYSTEM

A conceptual groundwater collection system was presented in ***Preliminary Seepage Collection Options, SRK, 2004***. This design was used to provide the basis for scoping simulations of ETA groundwater capture. A brief summary of the concept used for simulations is as follows:

- Three pumping wells installed adjacent to the main access road at the south-western edge of the ETA
- Each well to have variable speed pumps, with a potential capacity between 0.93 and 2.84 l/s (15-45 USGPM or 55-275 m^3/d).
- Well are to be screened within aquifer sediments only and potentially 1-2 meters below the top of the aquifer. The water levels within the wells are not to be drawn to the screens to limit oxidation on the screens.
- For simulations purposes, the top of the well screens has been set to 1097 masl, above the estimated elevation of the seepage face at approximately 1096.5 masl. This configuration assumes that the aquifer and bedrock surface are dipping to the south-west.

SCOPING SIMULATIONS

Two numerical groundwater models were constructed for the ETA to conduct scoping level simulations for (i) confined conditions and (ii) unconfined conditions. The purpose of these scoping simulations was to test conceptual model assumptions and provide further information on the issues of:

- potential hydraulic barriers to collecting groundwater,
- lack of seepage flow cut-off during 24hr pumping test, and
- scoping level estimates of capture efficiency.

Model Construction

The model extents, mesh, and observation wells were the same for both the confined and unconfined models and are shown in Figures 1 and 5. The models were 2-D simulations due to the limited information available regarding surficial geology and bedrock topography away from the ETA wells.

The choice of 2-D simulations allows for a simple geologic conceptual model commensurate with geologic uncertainty but has drawbacks for calculating transient model heads from pumping. The 2-D confined model simulations assume the aquifer sediments remain saturated during pumping and do not receive significant leakage from the overlying tailings. The 2-D unconfined simulations allow for desaturation of the aquifer but do not allow for additional leakage from the overlying tailings.

It is recognized that neither model may represent actual aquifer conditions (i.e. a semi-confined aquifer with leakage from the overlying tailings). Nevertheless, these model simulations should be sufficient to provide a scoping level test of assumptions and insight on identified issues. It was assumed that the access road was constructed of coarse waste rock placed and thus not a barrier to flow in the model.

Model Calibration

The models were first run steady-state and adjusted to static conditions (pre-pumping) observed on October 1st, 2005. Next, the 24 hr pump test at SRK04-4 was simulated using the initial model and the resulting calculated head/drawdown compared to observed end-of-pumping conditions. The simulated water levels were compared to observed levels in ETA monitoring wells screened in aquifer sediments (SRK04-4, ETA05-2, ETA05-04, ETA05-3, SRK04-3A). ETA monitoring wells screened in tailings (ETA05-1, ETA05-5, SRK04-3B) or bedrock (SRK05-ETA-BR2) were not used for comparison. The distant monitoring well below the waste rock dump, P968A/B, was also not used.

Calibrated confined model transmissivities and recharge are shown in Tables 5 and 6.

Table 4 Confined Model Transmissivities

Parameter	**Description**	**Transmissivity**
T_1	Fine grained till blanket on hillsides	1.15 x 10^{-6} m^2/s
T_2	Till, sand, and gravel sediments	4.63 x 10^{-4} m^2/s
T_3	Sand and gravel sediments in ETA	6.94 x 10^{-4} m^2/s
T_4	Bedrock paleochannel filled with coarse waste rock	185 x 10^{-4} m^2/s

Table 5 Confined Model Recharge Distribution

Parameter	**Description**	**Recharge**
R_1	Hillsides, low infiltration	30 mm
R_2	Valley sediments	450 mm
R_3	Valley sediments in ETA, including potential leakage from pipeline	900 mm

Table 6 Unconfined Model Transmissivities

Parameter	**Description**	**Transmissivity**
K_1	Fine grained till blanket on hillsides	1.0 x 10^{-5} m/s
K_2	Till, sand, and gravel sediments	1.0 x 10^{-4} m^2/s
K_3	Sand and gravel sediments in ETA	2.5 x 10^{-4} m^2/s
K_4	Bedrock paleochannel filled with coarse waste rock	50 x 10^{-4} m^2/s

Table 7 Unconfined Model Recharge Distribution

Parameter	**Description**	**Recharge**
R_1	Hillsides, low infiltration	30 mm
R_2	Valley and ETA sediments	450 mm

Model storage storativity was as follows:

- 0.002 for all areas for confined simulations
- 0.05 for ETA and 0.02 for surrounding areas for unconfined simulations

Model boundary conditions were as follows:

- Constant heads were set at ~2m below topography along most of model boundary
    - Heads were constrained by flux to only allow outflow from the south-west boundary below the access road, heads were set at the estimated elevation of the seepage face of 1096.5 masl.
- Transfer boundary along Faro Creek with water levels set approximately at current elevation and maximum inflow/outflow rate l/s per unit length of creek.
- The calibrated stead-state model was run transiently for 24 hours while pumping SRK04-4 at 244 m^3/d (45 USGPM).

Model Predictions

Once calibrated, the numerical models were used to simulate various pumping scenarios over a year of pumping. The number of wells, pumping rates, and locations were varied to increase capture efficiency (reduce ETA groundwater bypassing wells).

Capture efficiency was generally defined as the reduction in groundwater flow through the ETA from static conditions to pumping conditions. This flow was measured in simulations as the net flux past the boundary line indicated in Figure 5. This net flux reduction was then compared for the various pumping scenarios.

Results of Scoping-Level Simulations

Steady-State

Both the confined and unconfined models reasonably simulated steady-state conditions in the ETA (Figure 6).

Results of confined steady-state simulations were as follows:

- Calculated heads were within approximately 0.4 m of observed heads with the exception of the up-valley well, ETA05-4. The root-mean squared (RMS) error was 0.25 m, excluding ETA05-4 and 0.89 m with the 05-4 well.
- Calculated flux from the model was ~3.5 l/s (~304 m^3/d), with most of that coming from flux through the ETA (3 l/s). The total flux is similar to observed seepage at FCS3 (Table 3).
- The observed pattern of converging heads could not be simulated without the presence of a high Transmissivity paleochannel extending into the ETA.

Table 8 Static Conditions: Calculated Heads and Residuals

ETA Monitoring Well	Calculated Head (masl)	Observed Head (masl)	Residual Head (masl)
SRK04-4	1098.15	1098.18	-0.02
ETA05-2	1098.95	1098.77	0.18
SRK05-ETA-BR1	1098.03	1098.31	-0.28
ETA05-3	1098.32	1098.55	-0.23
SRK04-3A	1098.06	1098.45	-0.38
ETA05-4	1100.87	1102.97	-2.10

Results of unconfined steady-state simulations were as follows:

- Calculated heads were within approximately 0.5 m of observed heads. The RMS error was 0.36 m for all wells.
- Calculated flux from the model was 6 l/s (518 m^3/d), with most of that coming from flux through the ETA (5.65 l/s). The total flux was significantly greater than the observed seepage at FCS3 during moderate to low flow conditions (typical for the October 1 survey) but similar to previous broad estimates of groundwater flux (*Faro Seepage Collection Options Report, SRK, 2004* and *Discussion Memo: Preliminary ETA Results, SRK, 2005)*.
- The observed pattern of converging heads could not be simulated without the presence of a high hydraulic conductivity paleochannel extending into the ETA.

Transient

The confined model reasonably simulated overall drawdown after 24-hrs of pumping SRK04-4, and was considered suitable for scoping level analyses of groundwater capture (Figure 7). The confined model over-predicted the drawdown in the pumping well and under-predicted the observed drawdown in the observations

wells. Leakage from the overlying tailings (not simulated) is the likely cause for this inconsistency between predicted and observed drawdown with distance from the pumping well.
The unconfined model was less successful in simulating drawdown, resulting in higher RMS (0.7) due to insufficient drawdown at most observation wells (Figure 7).

Results of confined transient simulations were as follows:

- The overall RMS of calculated vs. observed drawdown was 0.41 m, sufficient for scoping simulations of capture.
- The model overpredicted the actual pumping level by 0.7 m and underpredicted the drawdown in the surrounding aquifer levels (between 0.03 – 0.3m)
- The calculated flux leaving the model (at the downstream seepage face) was reduced to 1.9 l/s but was not cut-off. A stagnation point occurred between the pumping well and the seepage face limiting the capture of seepage.
- Simulated storativity (0.002) was less than determined from pumping tests (0.02) as the model could not simulate vertical leakage.

Table 8 24-Hr Pumping Test Heads Comparison to Confined Simulations

ETA Monitoring Well	**Calculated Drawdown (m)**	**Observed Drawdown (m)**	**Residual Drawdown (m)**
SRK04-4	3.30	2.572	0.73
ETA05-2	1.28	1.339	-0.06
SRK05-ETA-BR1	1.31	1.618	-0.31
ETA05-3	0.82	0.731	0.09
SRK04-3A	1.14	1.173	-0.03
ETA05-4	0.80	0.178	0.62

▨ excluded from calculation of RMS

<u>Capture Simulations</u>
The confined model was used to simulate capture from several extraction wells installed above the access road. Results of the “steady-state” (year-long) capture simulations were as follows (Figures 8-10):

- The use of 3 pumping well (at a pumping rate of 2.84 l/s each) with the top of screen set 0.5m above the seepage face elevation (1097 vs. 1096.5 masl) captured only about ~1/3 of groundwater flow through the ETA.
- A stagnation point occurred between the pumping wells and the seepage face due to the limited drawdown.
- Capture efficiency did not increase with increasing pumping rate as pumping durations at low rates were still limited by screen elevation (wells turned off in model when maximum allowable drawdown reached).
- Adding incrementally more extraction wells with similar screen elevations only moderately improved capture efficiency (2/3 of flow, Figure 9). Simulations of 7 and 9 wells (2.84 l/s each) still had significant bypass (~1/3 of flow). The capture efficiency was primarily controlled by the limited allowable drawdown in the pumping wells and the position of the pumping level and seepage face elevation (Figure 10).
- Effective capture (>90%) occurred only when pumping levels were able to drop to the same or below the elevation of the downstream seepage face. Due to the sloping bedrock surface and aquifer it is expected to be difficult to drop the aquifer water levels to/below the seepage face elevation (Figure 11).
- The assumed presence of a paleochannel extending beneath the access road focussed bypassing groundwater to the seepage face by acting as a drain. Thus the existence of a paleochannel would

reduce capture efficiency of any upstream collection system, but could improve efficiency of downstream collection below the access road.

DISCUSSION

Scoping simulations have been carried out to test conceptual model assumptions and provide further information on:

- potential hydraulic barriers to collecting groundwater,
- lack of seepage flow cut-off during 24hr pumping test, and
- scoping level estimates of capture efficiency.

The confined model reasonably simulated observed conditions in the ETA and was used to simulate capture of groundwater above the access road. The following conclusions are drawn from the simulations:

- The limited available drawdown (<2.5m) for any potential ETA groundwater pumping system above the access road may result in poor capture (i.e. bypass in the order of 10% or greater). The pumping wells will likely be unable to drawdown aquifer levels to/below the seepage face on a continuous basis and thus may not cut off groundwater discharge to Faro Creek below the access road.
- There is a significant potential for continued “on-off” cycling of pumps (due to the limited available drawdown) which further increases the potential for groundwater bypass to Faro Creek.
- Attempts to draw groundwater levels further into the aquifer may expose a portion of the well screens to the atmosphere, likely resulting in iron oxidation (“well fouling”) of the exposed screens, these conditions can be expected to cause difficulties with well maintenance (well efficiency, pump failure, etc.).
- Simulations also suggest that the presence of a paleochannel (or similar high permeability zone) beneath the access road may provide a means to concentrate seepage to a small discharge zone (seepage face). Such a paleochannel would further complicate upstream groundwater collection and facilitate groundwater bypass of the wells. Contrastingly, this focussed seepage would improve capture efficiency for a seepage collection system installed below the access road.
- Simulations suggest that groundwater discharge at the seepage face should have decreased but not cut-off completely during the 24-hr pumping. This simulated reduction in flux is likely because the model does not allow for leakage from tailings, which would supply additional water to the pumping well. It is interpreted that a stagnation point developed between the pumping well and the seepage face.

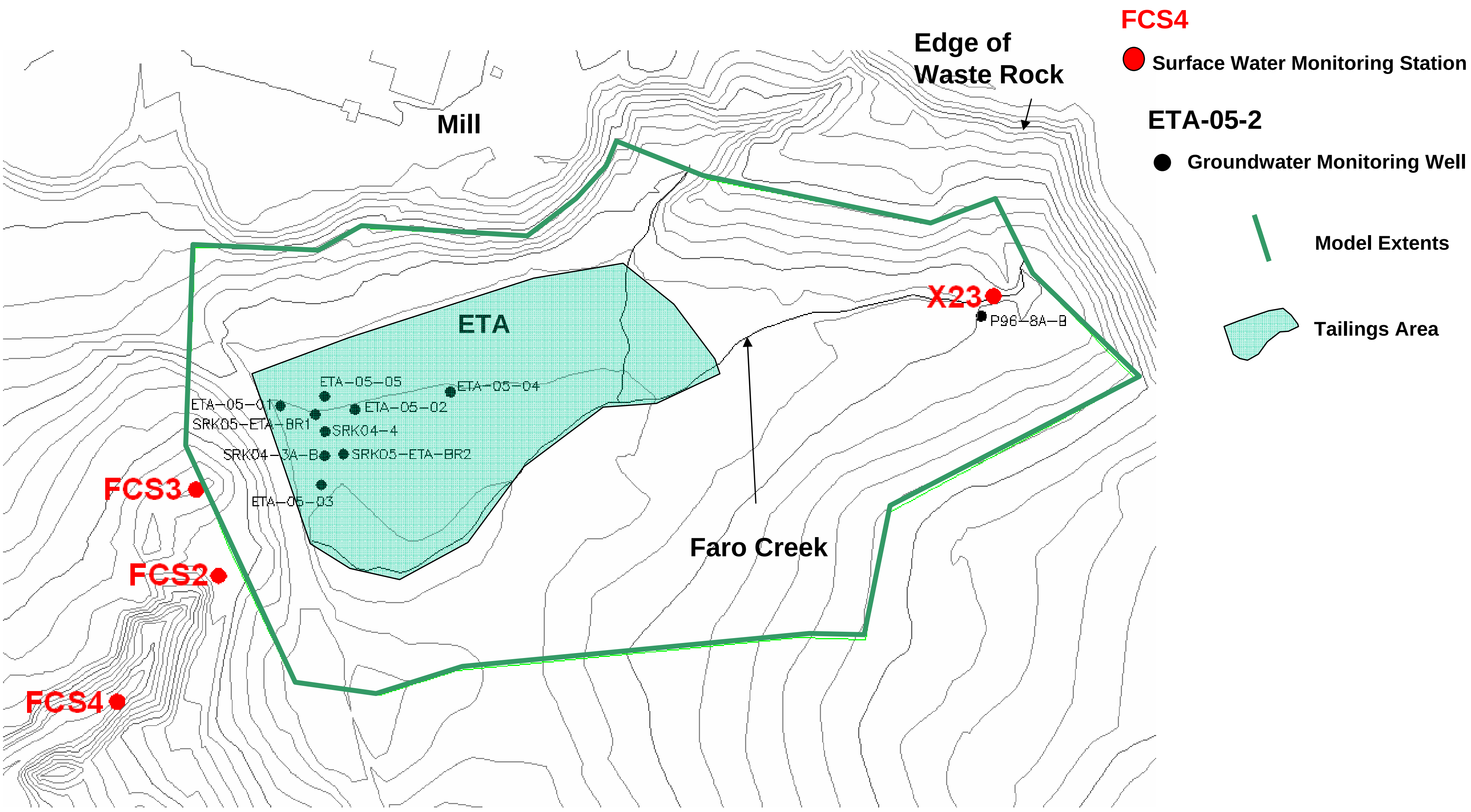
In summary, scoping simulations indicate that the position of the seepage face below expected pumping levels due to limited available drawdown represents a significant impediment to an effective groundwater capture by active pumping. The balance of flows and load estimates indicates that most seepage is accounted for in FCS2 and FSC3. Based on the available information, it therefore appears that seepage and surface collection immediately below the road in heated sumps is likely more effective than a groundwater pumping system.

RECOMMENDATIONS

The following preliminary recommendations are made regarding the capture of contaminated groundwater from the ETA:

- A combined seepage and surface water collection system of sumps should be designed below the main access road near FCS2/3 (Figure 12). This system would likely capture the majority of groundwater and base flows from the ETA and allow for easier maintenance of installations.
- Further detailed flow and load surveys should be conducted along Faro Creek to determine where groundwater is discharging to/receiving from Faro Creek. This data will assist determination of potential variability (and inconsistency) of flows/loads.

- Further modelling to simulate groundwater conditions in 3-dimensions is not recommended due to limited geologic data up-valley and similar difficulty of seepage face elevation control.
- A simple test of the sump concept could be conducted by collecting all flows at FCS2/3 and pumping/bypassing them downstream of FCS4. Flows would then be monitored at FCS4 to estimate potential bypass.
- Additional drainage ditches and sumps could be installed within the ETA (e.g. base of WRD) to control surface drainage and thereby reduce downstream seepage collection and prevent contaminated flows from entering Faro Creek.



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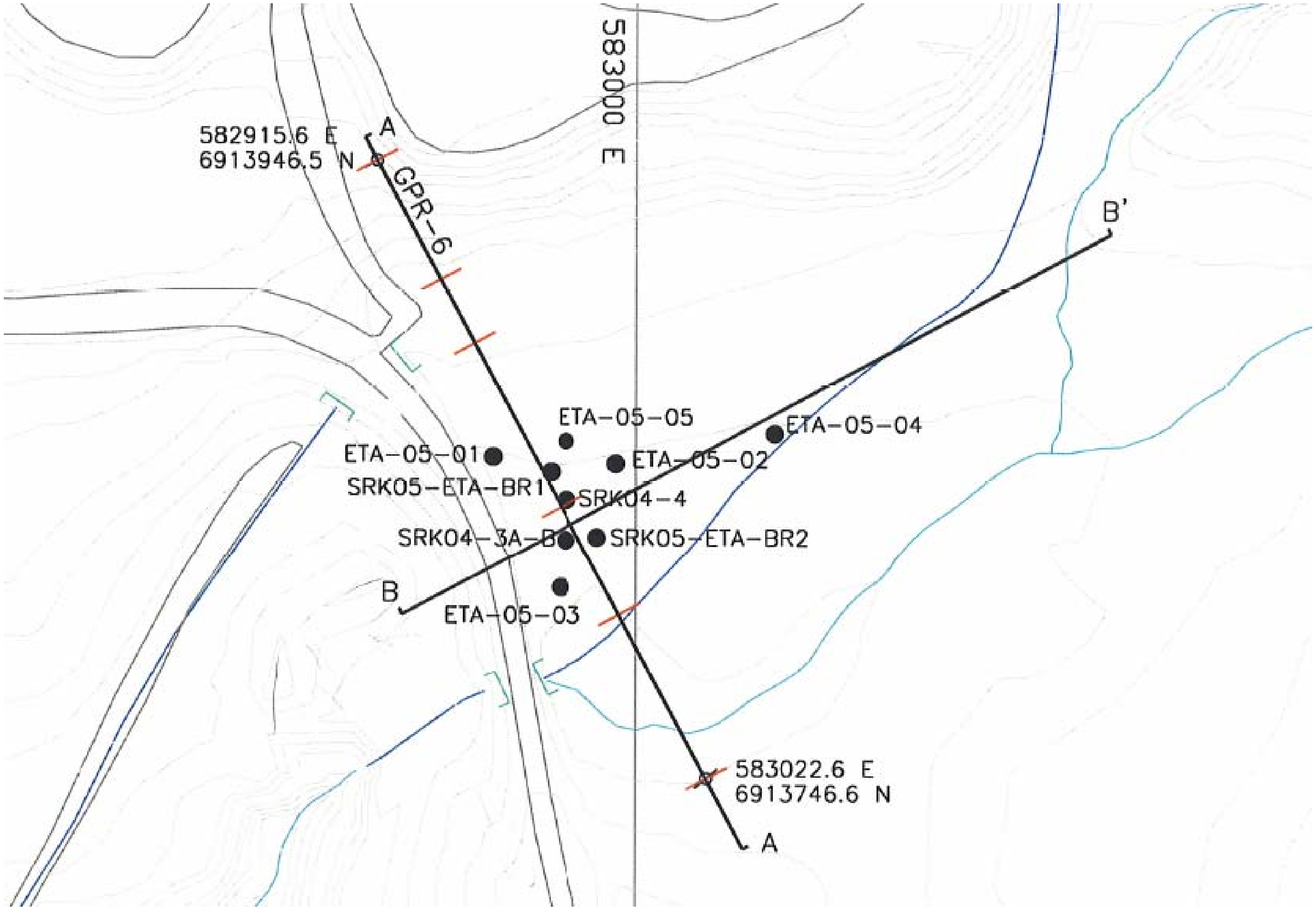
Simulation of Seepage Collection Options – Faro Mine

Location Map and Numerical Model Extents

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.73	Jan 2006		1



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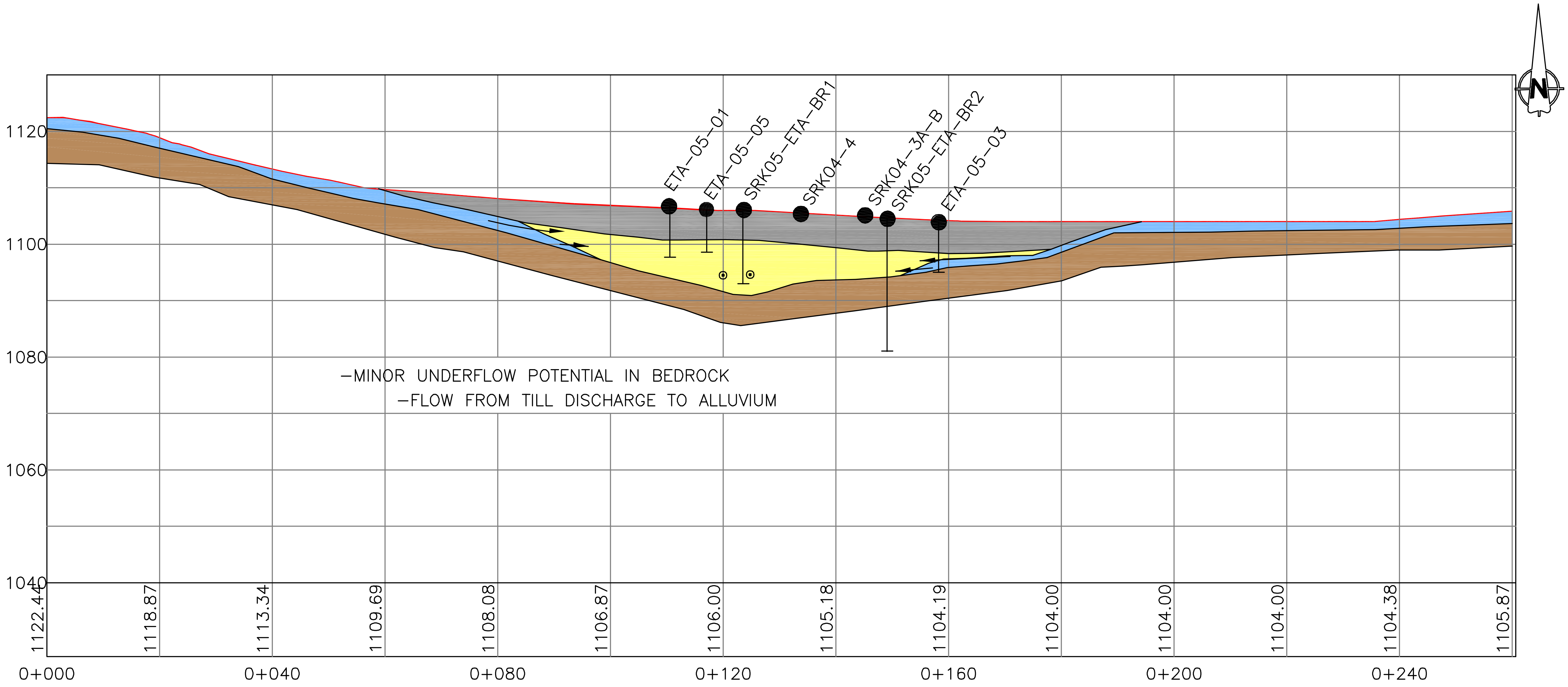
Simulation of Seepage Collection Options – Faro Mine

Locations of ETA Monitoring Wells and X-Sections

PROJECT: 1CD003.73	DATE: Jan 2006	APPROVED:	FIGURE: 2



–MINOR UNDERFLOW POTENTIAL IN BEDROCK
–FLOW FROM TILL DISCHARGE TO ALLUVIUM

SECTION A–A'
1:750

LEGEND

🟥 ROAD FILL
▨ COARSE TAILINGS
🟨 SAND & GRAVEL ALLUVIUM
🟦 TILL, COMPACT COARSE SAND & GRAVEL TO SILT
🟫 PHYLLITIC BEDROCK
→ GROUNDWATER FLOW ARROW

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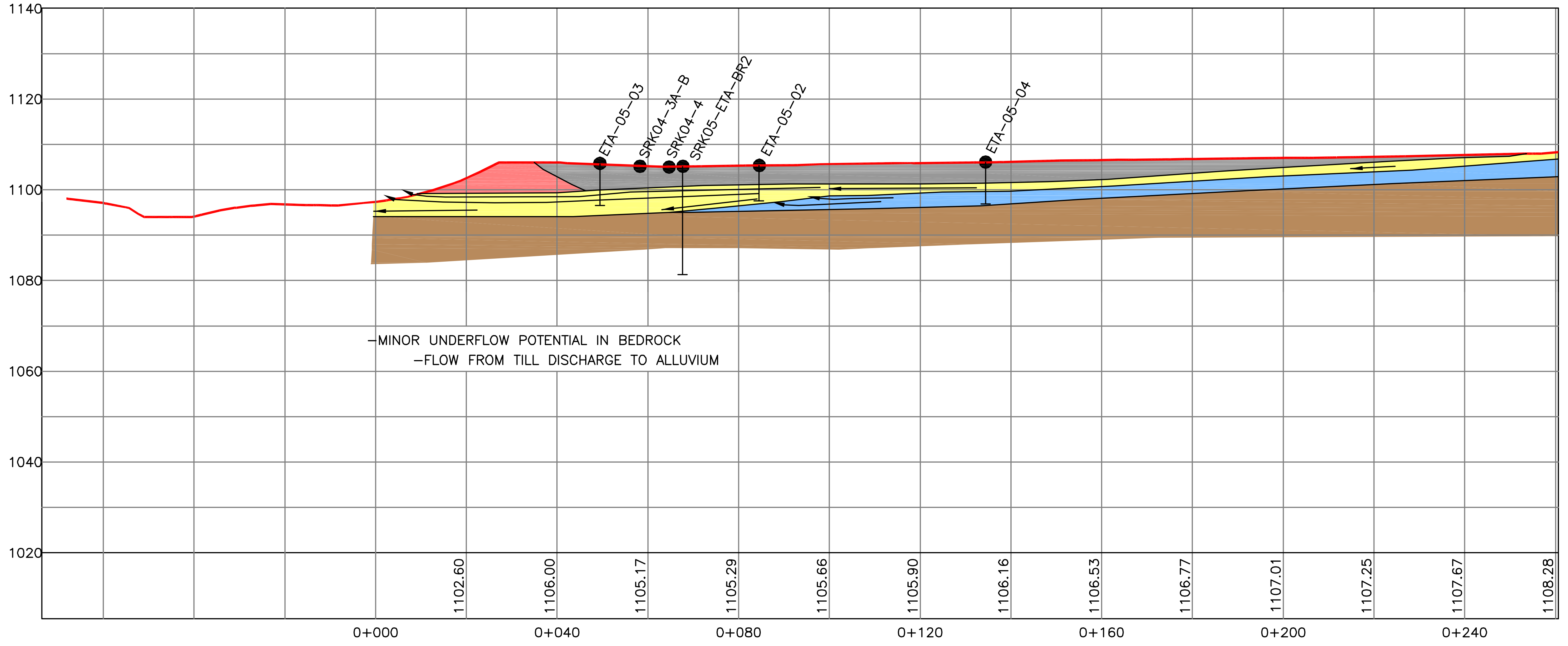
FARO MINE SITE ETA

Section A–A'

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Feb., 2006	QJK	3

File Ref: 2003-FARO SITE PLAN 1-UPDATED-DM.DWG



SECTION B–B'

SCALE: 1:1000

LEGEND

🟥 ROAD FILL

⬛ COARSE TAILINGS

🟨 SAND & GRAVEL ALLUVIUM

🟦 TILL, COMPACT COARSE SAND & GRAVEL TO SILT

🟫 PHYLLITIC BEDROCK

→ GROUNDWATER FLOW ARROW

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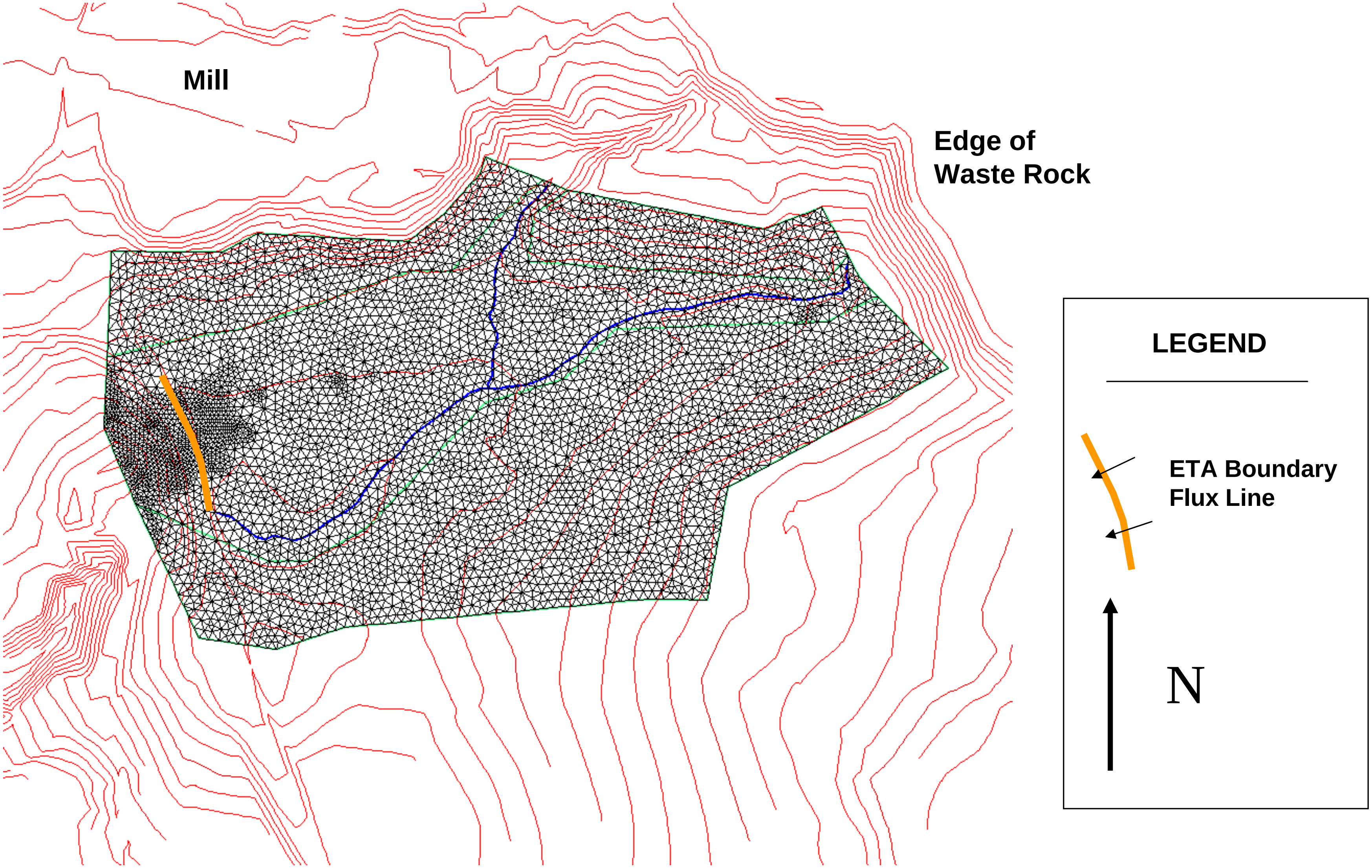
FARO MINE SITE ETA

Section B–B'

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Feb., 2006	QJK	4

File Ref: 2003-FARO SITE PLAN 1-UPDATED-DM.DWG



Simulation of Seepage Collection Options – Faro Mine

Numerical Model Mesh and ETA Flux Line

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PROJECT:	DATE:	APPROVED:	FIGURE:
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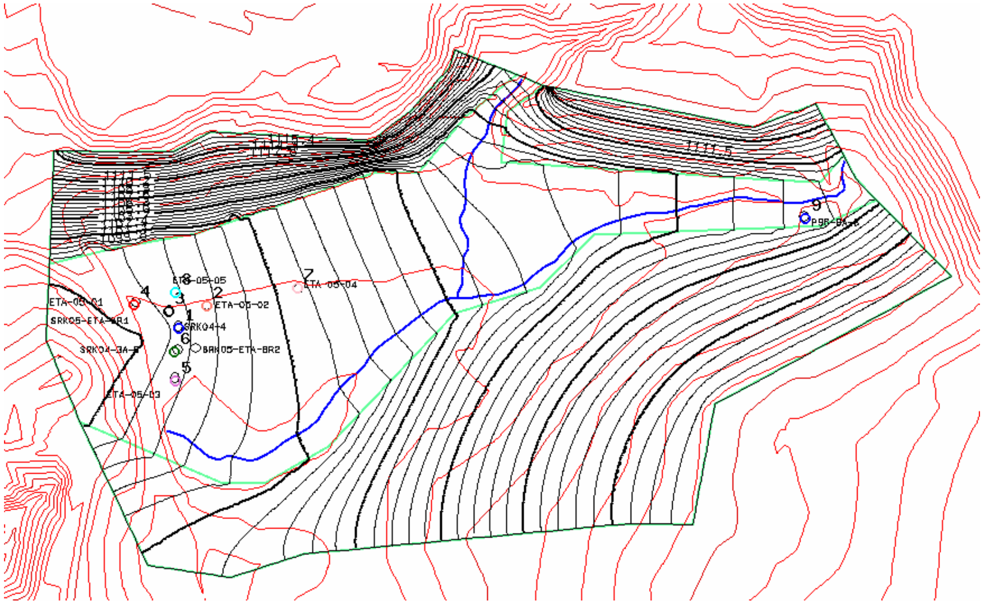
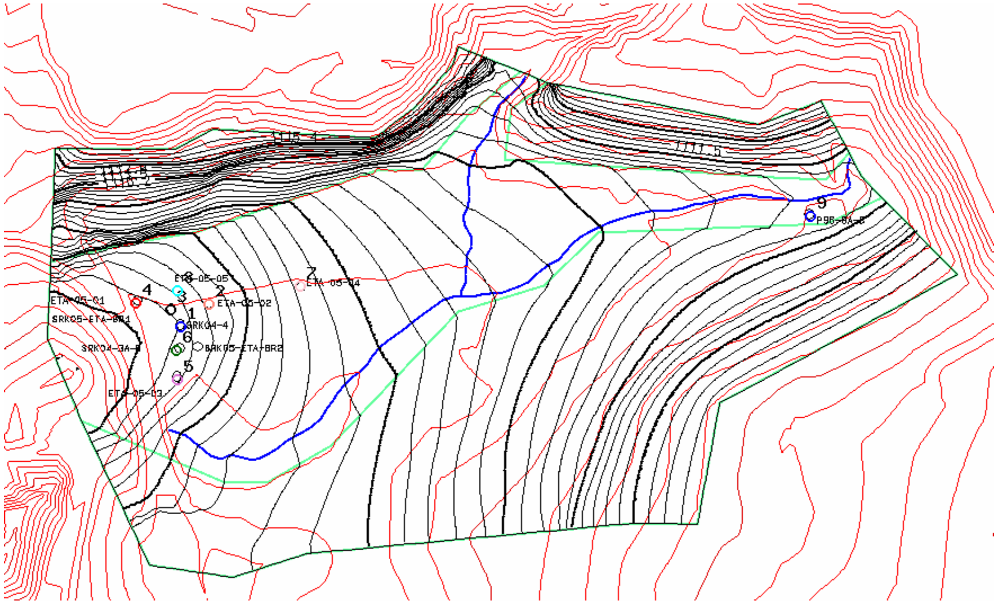


Confined Simulation: RMS = 0.89m
RMS=0.25 without ETA-05-4



Unconfined Simulation: RMS = 0.36m

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Simulation of Seepage Collection Options – Faro Mine

Static Conditions- Hydraulic Heads

PROJECT:	DATE:	APPROVED:	FIGURE:
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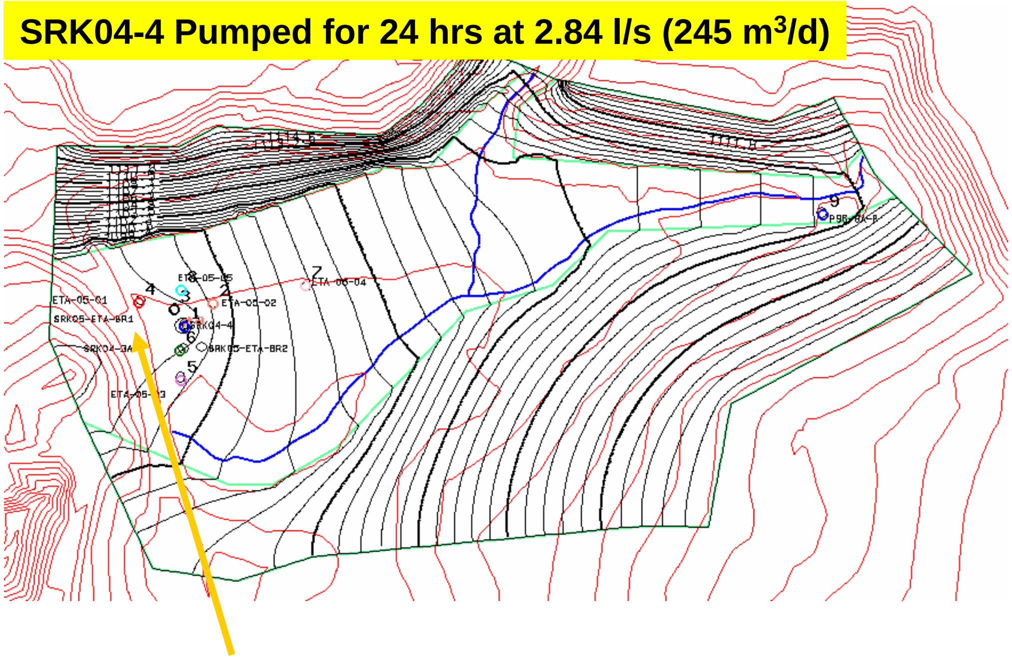
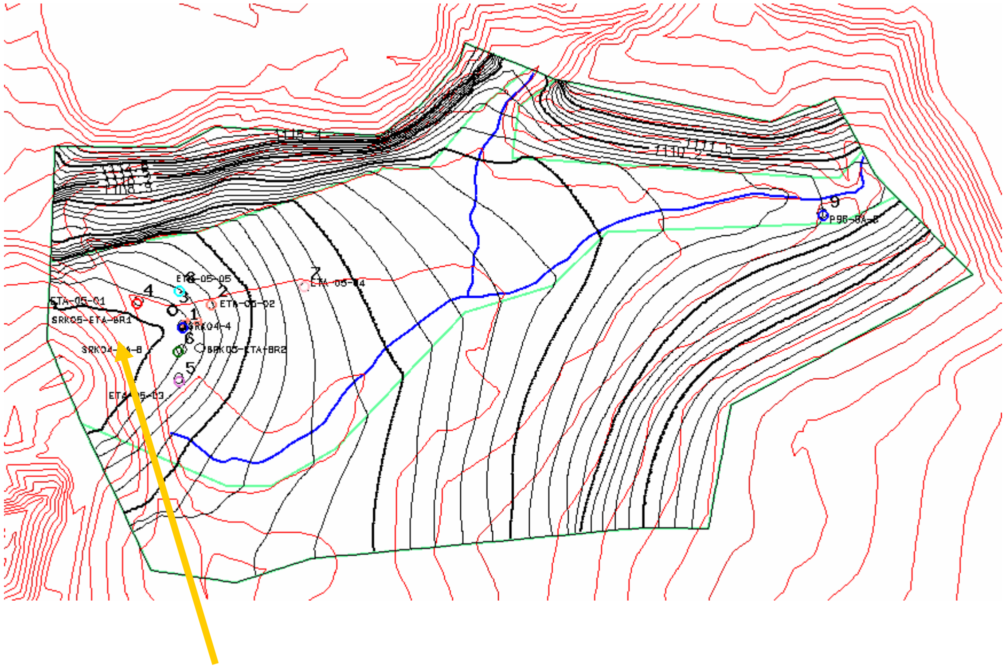
SRK04-4 Pumped for 24 hrs at 2.84 l/s (245 m^3/d)



Stagnation point



Stagnation point

Confined Simulation: RMS = 0. 41m. This model was considered sufficient for scoping simulations of capture.

Unconfined Simulation: RMS = 0.7m. This model was not used for scoping simulations of capture

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Simulation of Seepage Collection Options – Faro Mine

Post-Pumping Conditions-Hydraulic Heads

PROJECT:	DATE:	APPROVED:	FIGURE:
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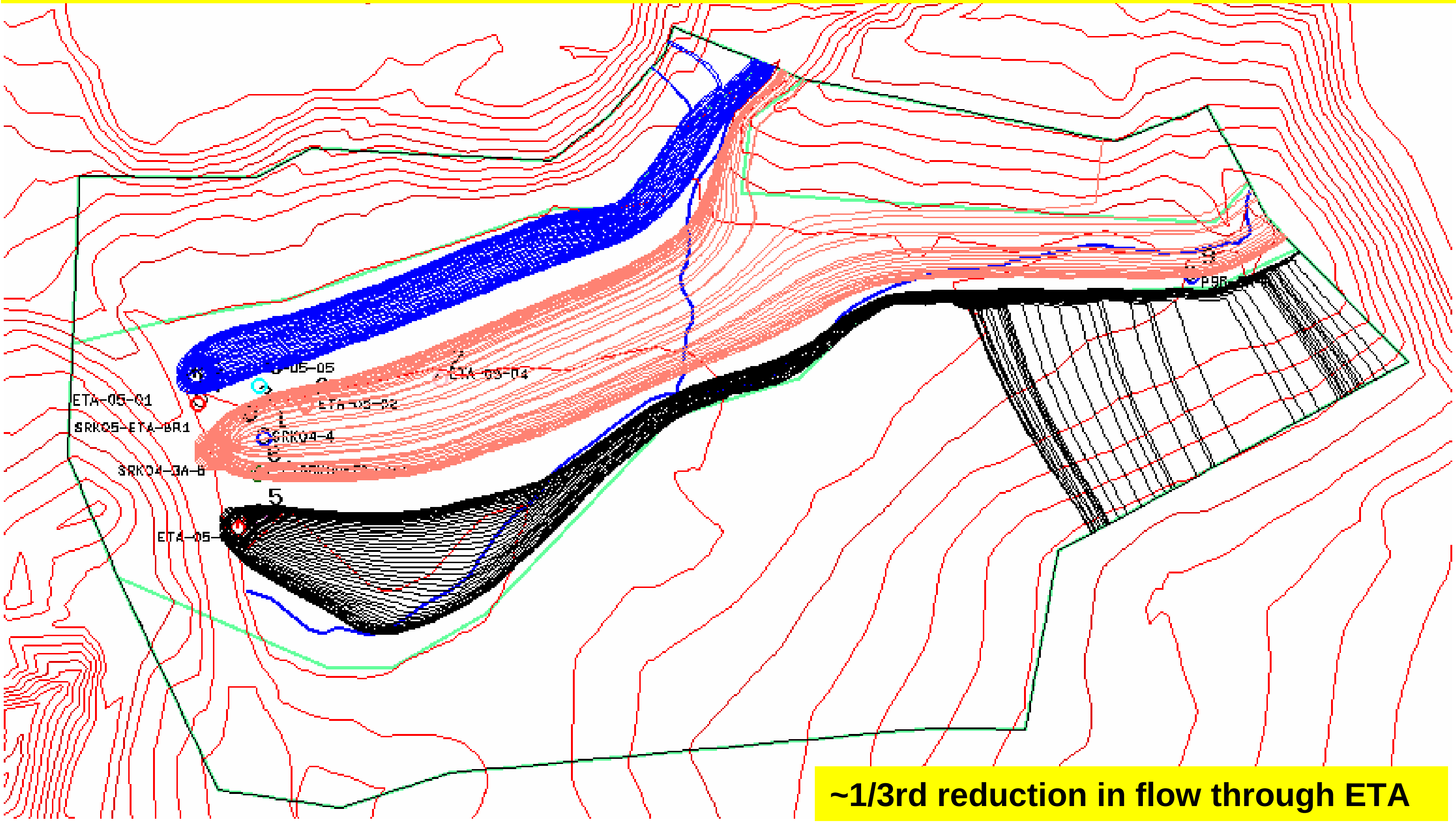
3 wells with pumping level set at 1097 masl. Seepage face set at 1096.5 masl.



~1/3rd reduction in flow through ETA

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Simulation of Seepage Collection Options – Faro Mine

Confined Capture Simulations: 3 Pumping Wells Scenario

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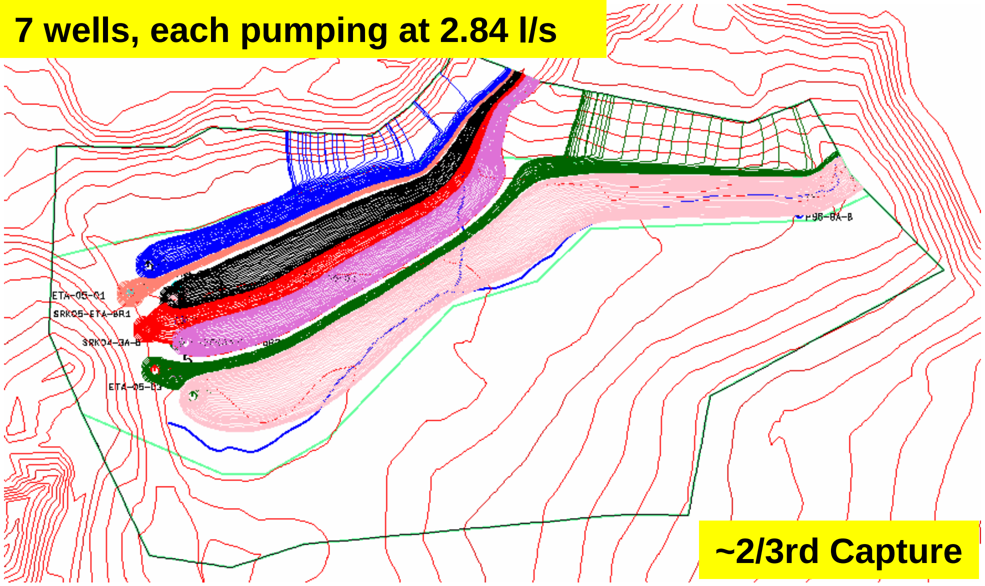
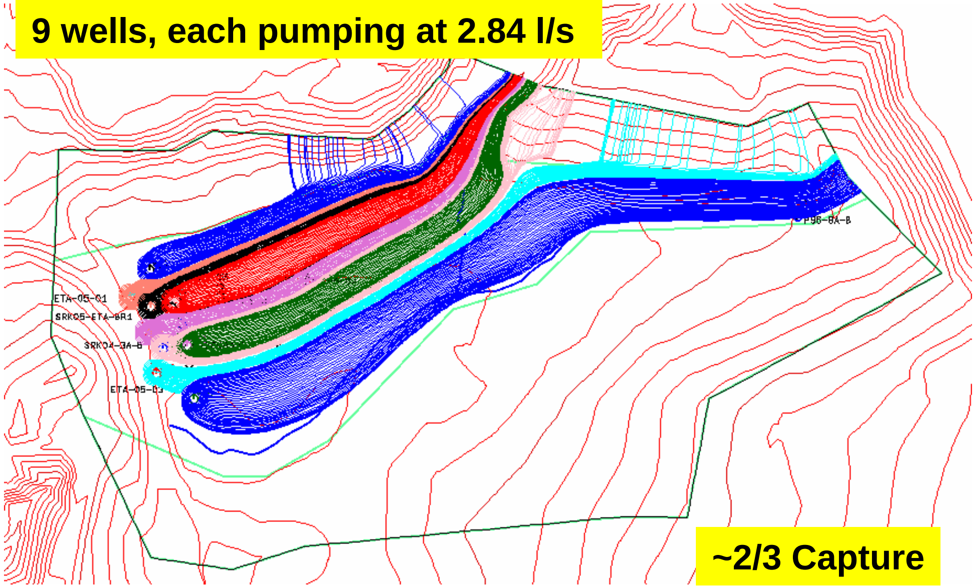


7 wells, each pumping at 2.84 l/s

~2/3rd Capture



9 wells, each pumping at 2.84 l/s

~2/3 Capture

In this scenario all well screens are set at 1097 masl, 0.5 m above seepage face.

While capture zones appear to cover most of the ETA, significant bypass occurs when wells are forced to cycle on/off with fluctuating water levels.

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Simulation of Seepage Collection Options – Faro Mine

Confined : Iterative capture, low available drawdown

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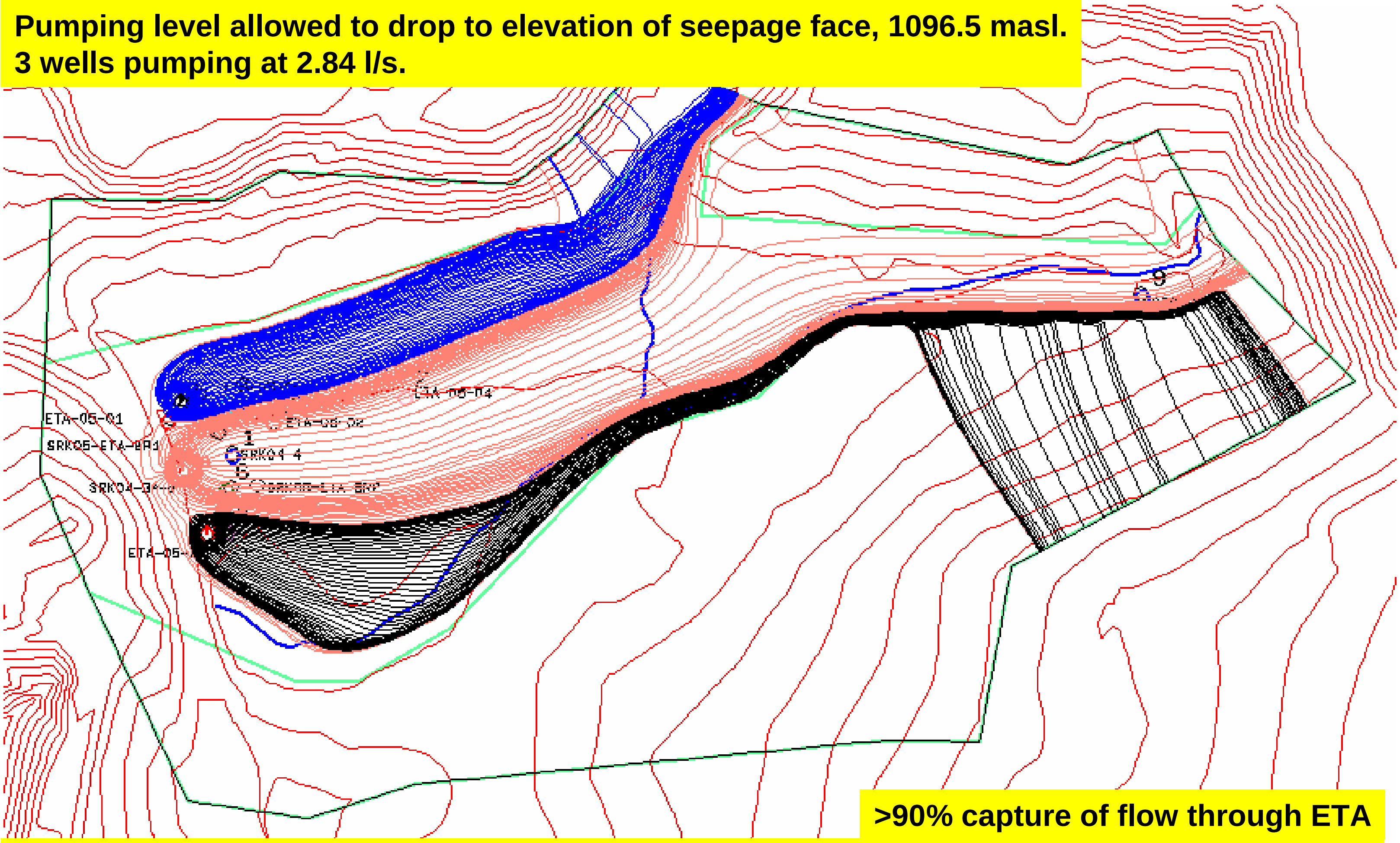

Pumping level allowed to drop to elevation of seepage face, 1096.5 masl.
3 wells pumping at 2.84 l/s.

>90% capture of flow through ETA

This scenario is considered unrealistic due to expected large difficulties in drawing water levels down to seepage face elevation.

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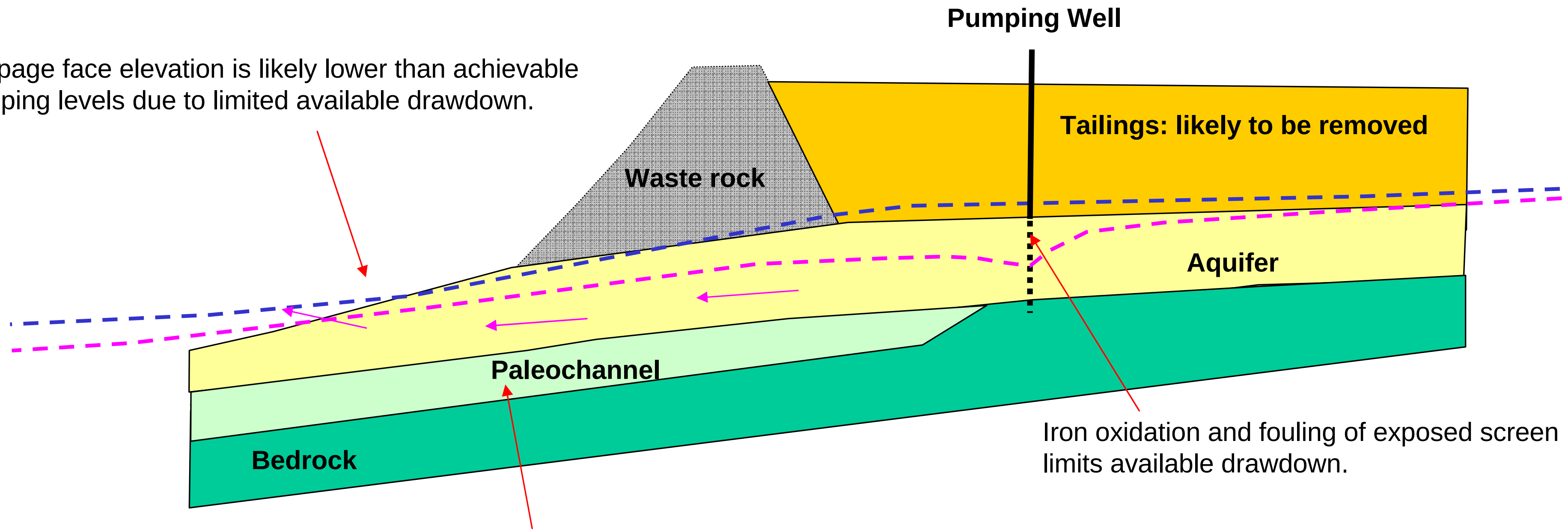
Simulation of Seepage Collection Options – Faro Mine

Confined Capture Simulations: Sensitivity to Screen Elevation

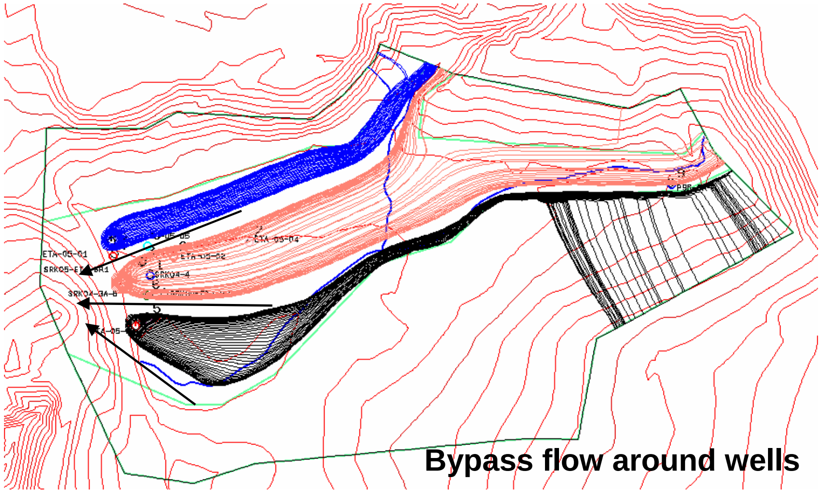
PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.73	Jan 2006		10



Seepage face elevation is likely lower than achievable pumping levels due to limited available drawdown.

Iron oxidation and fouling of exposed screen limits available drawdown.

Paleochannel may focus drainage of ETA groundwaters to the seepage face.



Bypass flow around wells

- - - Pre-pumping level

- - - Post-pumping level

→ Post-groundwater flow

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Simulation of Seepage Collection Options – Faro Mine

Schematic of hydraulic barrier to capture from limited drawdown

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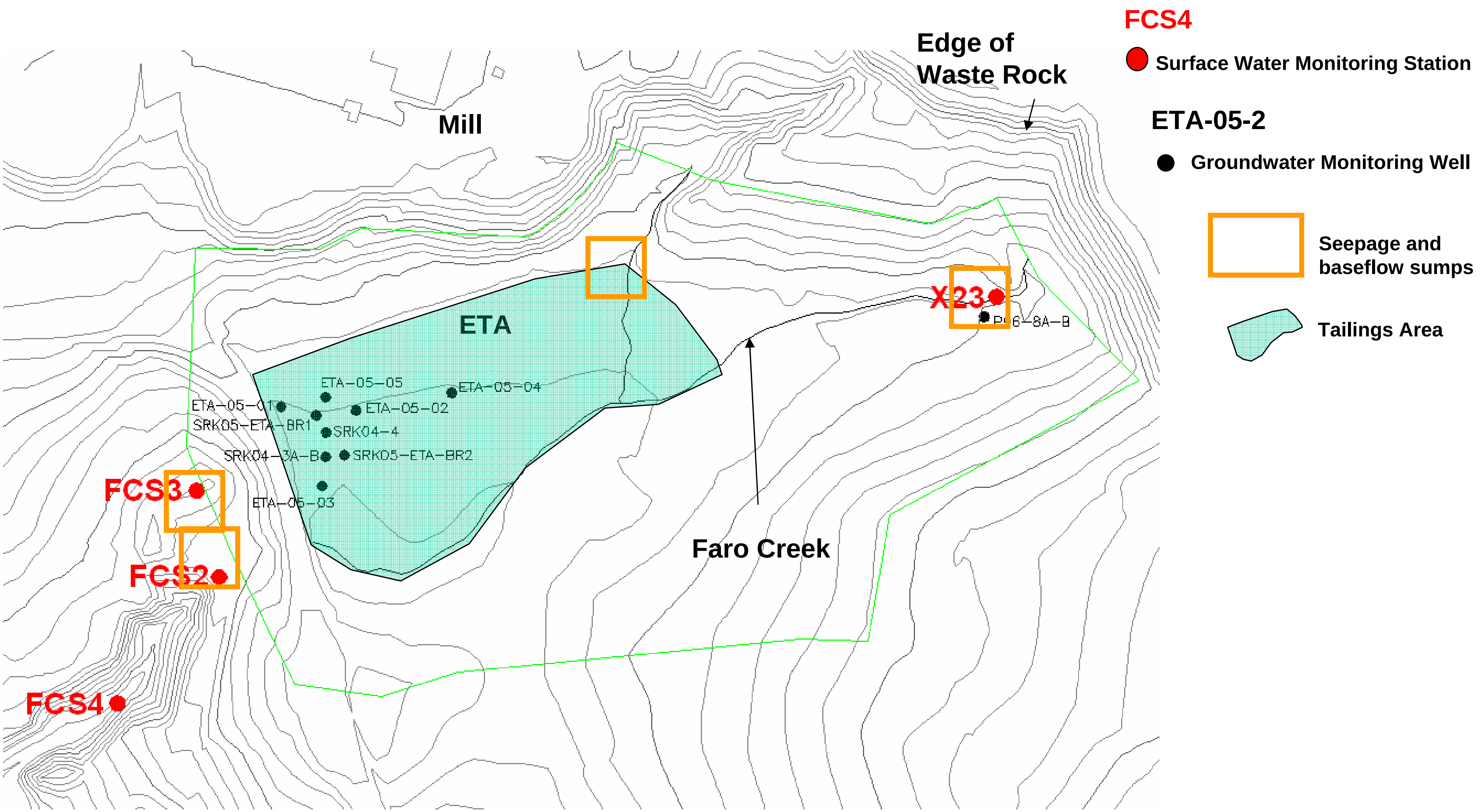

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Simulation of Seepage Collection Options – Faro Mine

Seepage and Baseflow Collection Sumps

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