Anvil Range Pit Lakes
Evaluation of In-Situ Treatment

2005/06 Task 20c

Prepared for:

DELOITTE & TOUCHE INC.

on behalf of the

FARO MINE CLOSURE PLANNING OFFICE

Prepared by:

SRK Consulting
Engineers and Scientists

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On behalf of

Faro Mine Closure Planning Office

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Executive Summary

Investigations undertaken in 2004 concluded that biological treatment should be continued in the Grum Pit lake during 2005. Since it is possible that biological treatment may be combined with conventional treatment at some time in the future, it was also recommended that the Faro Pit be fertilized, and that three to four fertilization programs be carried out in the Vangorda Pit to establish the response to biological treatment, if any, at more elevated metal concentrations.

This report provides presents and discusses the results from the 2005 biological treatment program.

Only a limited fertilization program was undertaken in the Faro Pit lake since the biomass was found to interfere with the performance of the Faro Mill lime water treatment system. Even though the fertilization program was limited, rapid algal growth was observed. Mass balance calculations indicated that between 45 and 60 tonnes of zinc were removed from the water column as a result of biological treatment. The estimated zinc removal rate ranged between 0.48 and 0.80 $g/m^2/day$ and was substantially better than expected.

The limnological assessment of the Faro Pit lake indicated that it was meromictic in 2004 and 2005. This is means that water at depth is likely to remain isolated from the surface layer water.

As in 2004, Grum Pit lake responded well to fertilization and excellent algal growth was achieved. The results, however, indicated that late summer fertilization was ineffective and nutrient uptake ceased by late August. Overall mass balance calculations for 2004 and 2005 indicated that about 12 tonnes of zinc in excess of the cumulative loading have been removed from the Grum Pit lake water column since commencement of biological treatment in 2004. The net zinc removal rate averaged about 0.31 $mg/m^2/day$ for the summer of 2005, which is similar to that observed during 2004.

The limonoligical assessment indicated that the Grum Pit lake mixes partially in spring and summer, possibly due to ongoing failure of the east wall. Nevertheless, the Grum Pit lake did not turn over in the fall and remained stratified under ice.

Fertilization of the Vangorda Pit lake was not undertaken due to the fact that a large volume of water had been removed and no suitable baseline condition could be established.

It is recommended that consideration be given to additional testing of the Faro Pit to assess the overall treatment capability of the pit lake. This can be decided on once a better understanding of the pit lake configuration is developed. Mass balance calculations however should be carried forward to verify the current baseline metal loadings to the pit.

Based on the zinc removal rates observed for the Grum Pit lake, it is recommended that the fertilization program be continued in 2006.

* * *

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1 Introduction

An assessment of the Faro, Vangorda and Grum Pit lakes completed in 2003 concluded that concentrations of contaminants in the water would trend towards levels that could be amenable to in situ biological treatment. As a result, in 2004, pit lake fertilization and limnocorral testing programs were carried out by Lorax Environmental Services Inc. in association with Laberge Environmental Services. Concurrently, an assessment of physical limnology was completed by Greg Lawrence and Associates and a source characterization program was completed by SRK Consulting.

The findings from pit lake fertilization program indicated that the pit lakes responded rapidly to fertilization with excellent phytoplankton growth occurring within two weeks of fertilization. Zinc removal by phytoplankton was demonstrated to the extent that total zinc concentrations in the near surface water were reduced to below 0.3 mg/L.

The physical limnology study suggests that the three pit lakes may be quite different due to the deep-water variability in conductivity amongst the lakes. It was also concluded that significant fresh water input may be occurring to the surface of the Grum Pit Lake though summer and early fall. The results indicated that under-ice conductivity-temperature-density (CTD) sampling from all three pit lakes would be required to complete stability assessments and determine the potential for permanent stratification to develop in the pit lakes. Ice samples would also be required to assess the amount of salts trapped in the ice, which would be indicative of the freshwater layer that would be formed during spring melt.

Source characterization indicated that the net zinc loadings to the Faro Pit lake are currently about 26,600 kg/year and are expected to decrease to about 17,100 kg/year. The annual removal rates by biological treatment are predicted to exceed both current and future loadings. Similarly for the Grum Pit, the estimated rates of zinc removal by biological treatment were shown to exceed the estimated annual loadings. However, the estimated net annual loadings to the Vangorda Pit lake were shown to exceed the estimated removal capacity for fully flooded conditions and indicated that biological treatment would not reduce zinc concentrations to acceptable levels.

As a result, the 2004 investigations concluded that biological treatment should be continued in the Grum Pit lake during 2005. Since it is possible that biological treatment may be combined with conventional treatment at some time in the future, it was also recommended that the Faro Pit be fertilized. Finally, it was recommended that three to four fertilization programs be carried out in the Vangorda Pit to establish the response to biological treatment, if any, at the more elevated metal concentrations in this pit lake.

This report provides an overview of the results form the 2005 biological treatment program.

2 Pit Lake Fertilization

2.1 Fertilization and Monitoring Program

The fertilization and monitoring of the pit lakes was undertaken by Laberge Environmental Services. A summary of actual sampling and monitoring schedule is provided in Table 2.1. The Vangorda Pit lake was not fertilized because of the planned pumping and treatment program. Fertilization of the Faro Pit was discontinued after 29 July because excess foaming in the lime treatment system interfered with hydroxide precipitate settlement in the sludge thickener system.

Fertilization entailed distribution by boat of about 7 drums (about 1400 L) of fertilizer to the Faro Pit lake and about 1.5 drums (320 L) to the Grum Pit lake.

Table 2.1 Summary of Pit Lake Fertilization and Monitoring Program for 2005

Date	Pit Lake	Fertilize	Field Parameters	Water Quality	Chlorophyll 'a'
08-Jun-05	Faro	Yes	Yes	Yes	-
	Grum	Yes	Yes	Yes	Yes
	Vangorda	-	Yes	Yes	-
22-Jun-05	Faro	Yes	-	-	-
	Grum	Yes	-	-	-
	Vangorda	-	-	-	-
29-Jun-05	Faro	Yes	-	-	-
	Grum	Yes	-	-	-
	Vangorda	-	-	-	-
06-Jul-05	Faro	-	Yes	Yes	Yes
	Grum	Yes	Yes	Yes	Yes
	Vangorda	-	-	-	-
13-Jul-05	Faro	-	-	-	-
	Grum	Yes	-	-	-
	Vangorda	-	-	-	-
20-Jul-05	Faro	-	-	-	-
	Grum	Yes	-	-	-
	Vangorda	-	-		
03-Aug-05	Faro	-	Yes	Yes	Yes
	Grum	Yes	Yes	Yes	Yes
	Vangorda	-	-	-	-
17-Aug-05	Faro	-	-	-	-
	Grum	Yes	-	-	-
	Vangorda	-	-	-	-
31-Aug-05	Faro	-	-	-	-
	Grum	Yes	-	-	-
	Vangorda	-	-	-	-
14-Sep-05	Faro	-	Yes	Yes	Yes
	Grum	-	Yes	Yes	Yes
	Vangorda	-	Yes	Yes	Yes

Field parameters included measurement of pH, temperature, total dissolved solids (TDS), conductivity and dissolved oxygen at various depths in the pit lakes. The depth sampling stations that were adopted included 0.1 m, 1 m, 3 m, 5 m, 10 m, 15 m and 30 m in all three pits. Additional stations at 40 m were established in the Grum and the Vangorda pit lakes, whereas the Faro Pit lake was also sampled at depths of 60 m and 80 m.

Complete field parameter results are provided in Appendix A and analytical results for the water quality samples are provided in Appendix B. The results are discussed in the following sections respectively for each of the pit lakes.

2.2 Faro Pit Lake

The in situ monitoring results indicated a thermocline in the Faro Pit lake at a depth of about 5 m below surface. A maximum surface water temperature of about 16^{o}C was measured in July. The physical stability of the pit lake is discussed in Section 3.

2.2.1 Algal Growth

Dissolved orthophosphate concentrations in general were at or below the detection limit, even during the period that the pit lake was fertilized. In contrast, as shown in Figure 2-1, ammonia-N was present in the pit lake prior to commencement of fertilization, and appears to have increased in the surface layer (down to a depth of about 15 m).

The chlorophyll ‘a’ depth profiles for the Faro Pit lake are illustrated in Figure 2-2. As noted previously, the Faro Pit lake was fertilized only three times between June 8 and June 29. Nonetheless, the pit lake responded well to fertilization with a rapid increase in chlorophyll ‘a’ as indicated for the July 6 depth profile. The chlorophyll ‘a’ concentration had increased to in excess of 50 µg/L at a depth of 5 m below the water surface. The observed profile also suggests that the biomass had settled rapidly from the surface layer. This explains why the Faro Mill lime water treatment system was affected, since the drawpoint for the treatment plant is located at about 5 to 6 m below the water surface.

By early August, the biomass had further settled from the water column and was marginally elevated at a depth of 30 m and below. By the end of the summer, as reflected in the September 14 data, the biomass had almost completely settled from the water column.

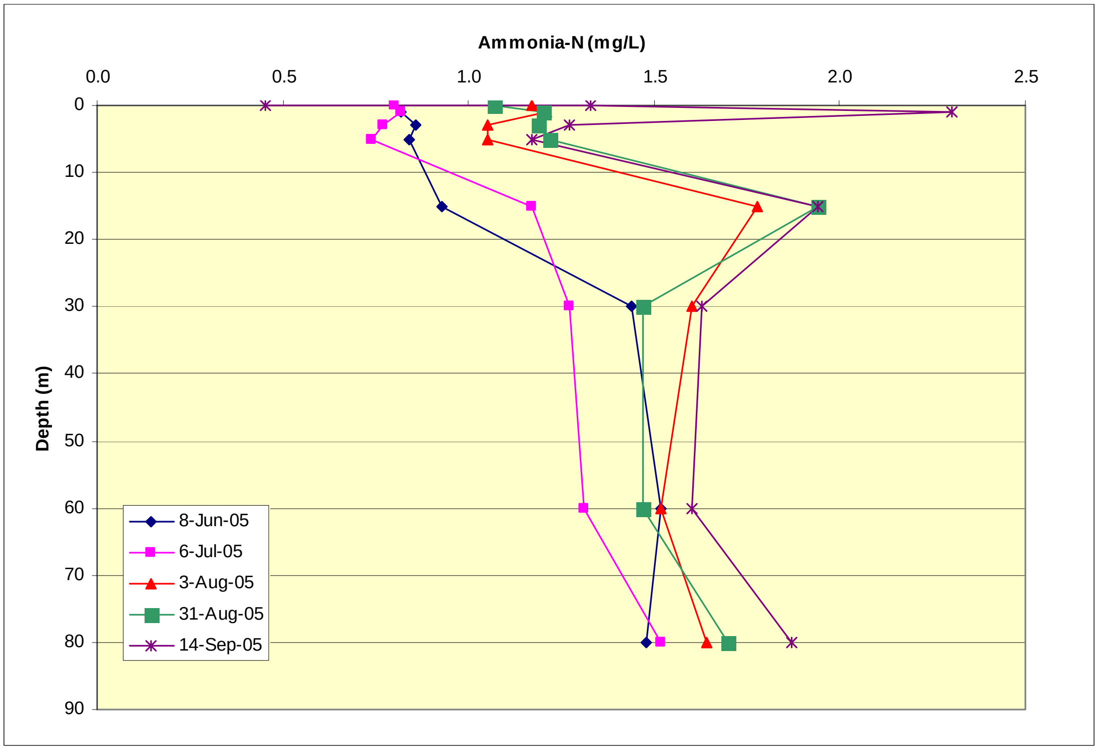

Figure 2-1 Ammonia-N Depth Profiles Measured in the Faro Pit Lake

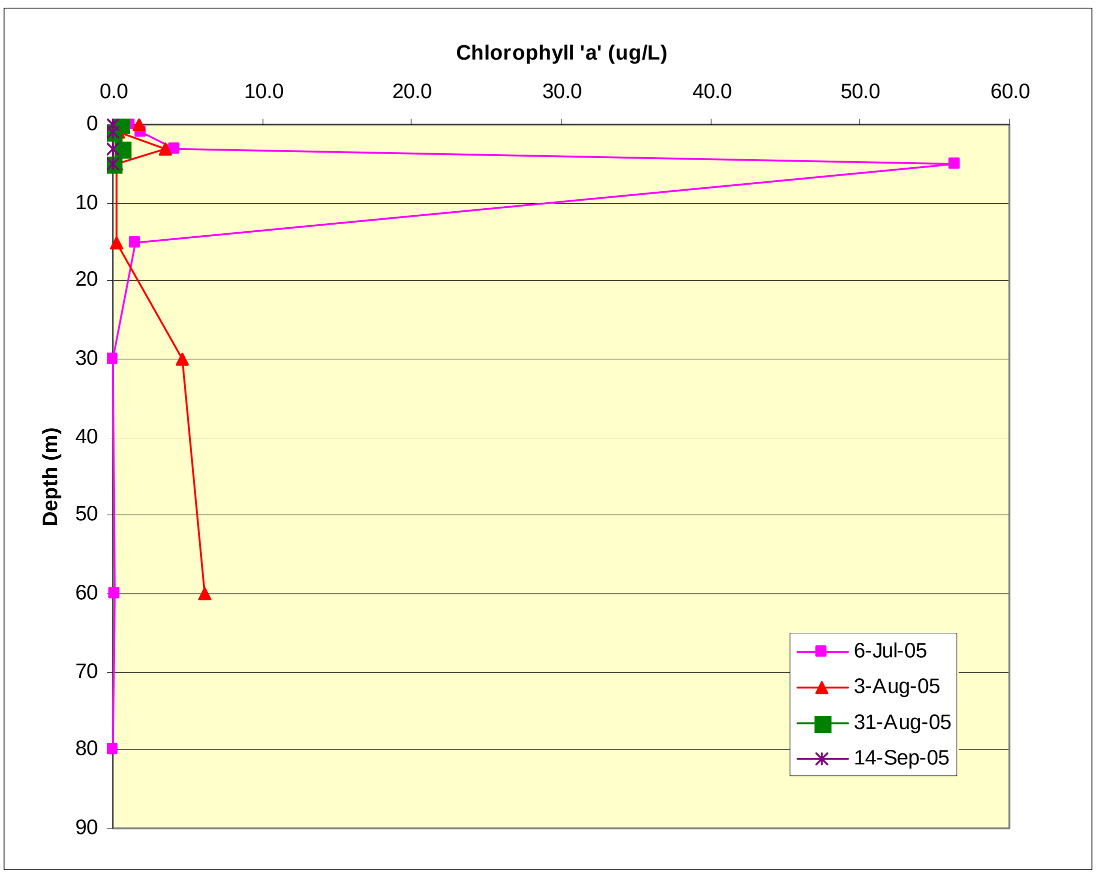

Figure 2-2 Chlorophyll 'a' Depth Profiles Measured in the Faro Pit Lake

2.2.2 Zinc Concentrations

Depth profiles for total zinc concentrations are shown in Figure 2-3. As observed in the 2004 and preceding monitoring results, a chemocline exists in the Faro Pit lake at a depth between 15 and 30 m below surface. Above this depth, zinc concentrations are elevated whereas, below this depth, the zinc concentration is almost constant at about 2.5 to 3 mg/L. Most significantly, the results show that total zinc was removed from the near-surface water during and subsequent to fertilization. Comparing the June 8 concentration profile with that of July 6 shows that the near-surface water concentration decreased by about 2 mg/L whereas there was a slight increase in the concentration at a depth of about 5 m. The change in the zinc concentration profile coincides with the chlorophyll ‘a’ concentration profile for July 6 shown in Figure 2-2, indicating that zinc is removed by the settling biomass. This is consistent with the 2004 test program observations.

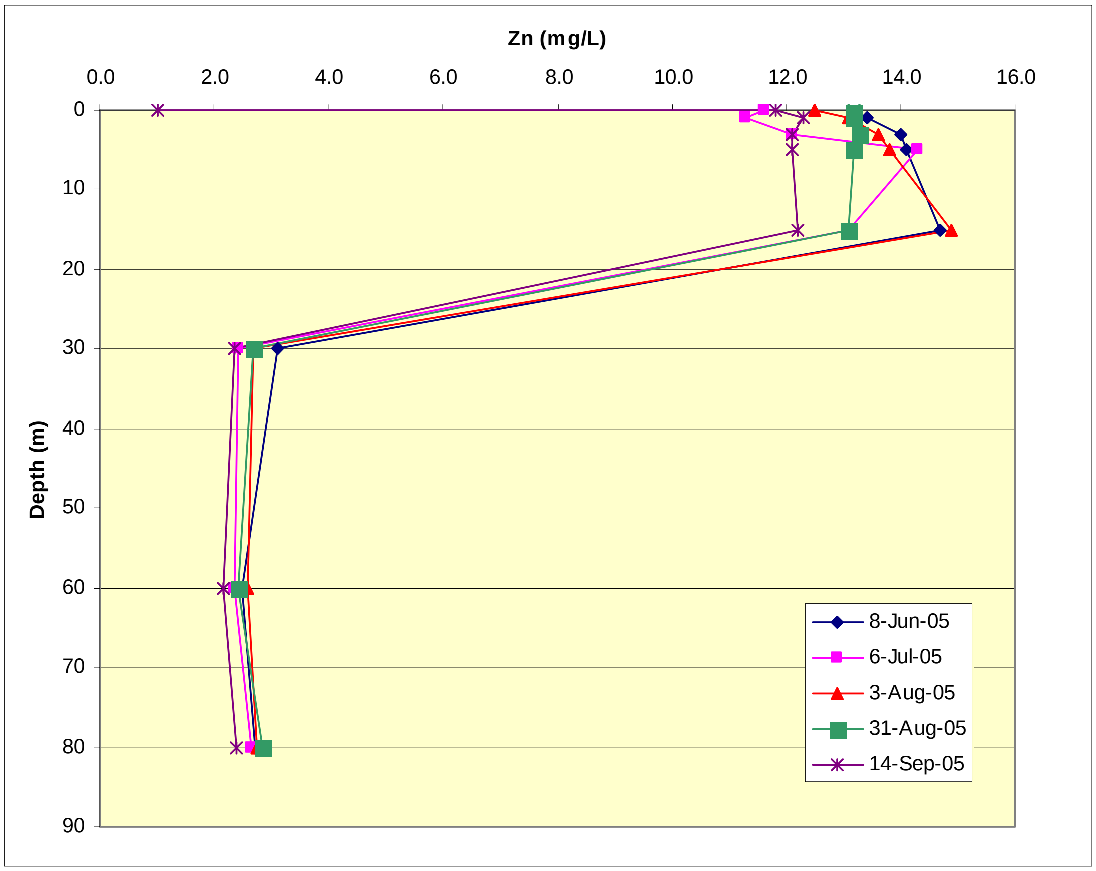

Figure 2-3 Total Zinc Concentration Depth Profiles Measured in the Faro Pit Lake

Time series plots of total zinc concentrations at various depth in the pit lake are shown in Figure 2-4. The results clearly illustrate the removal of zinc from the near-surface water subsequent to fertilization of the pit lake, as evidenced in the profiles at depths of 1 m and 3 m. The results subsequent to July 6, however, have been influenced by the draw-down effect of pumping for treatment, and may also have been impacted by near-surface mixing processes. Nonetheless, the results indicate a concentration convergence toward the end of summer, with a clear decrease over time.

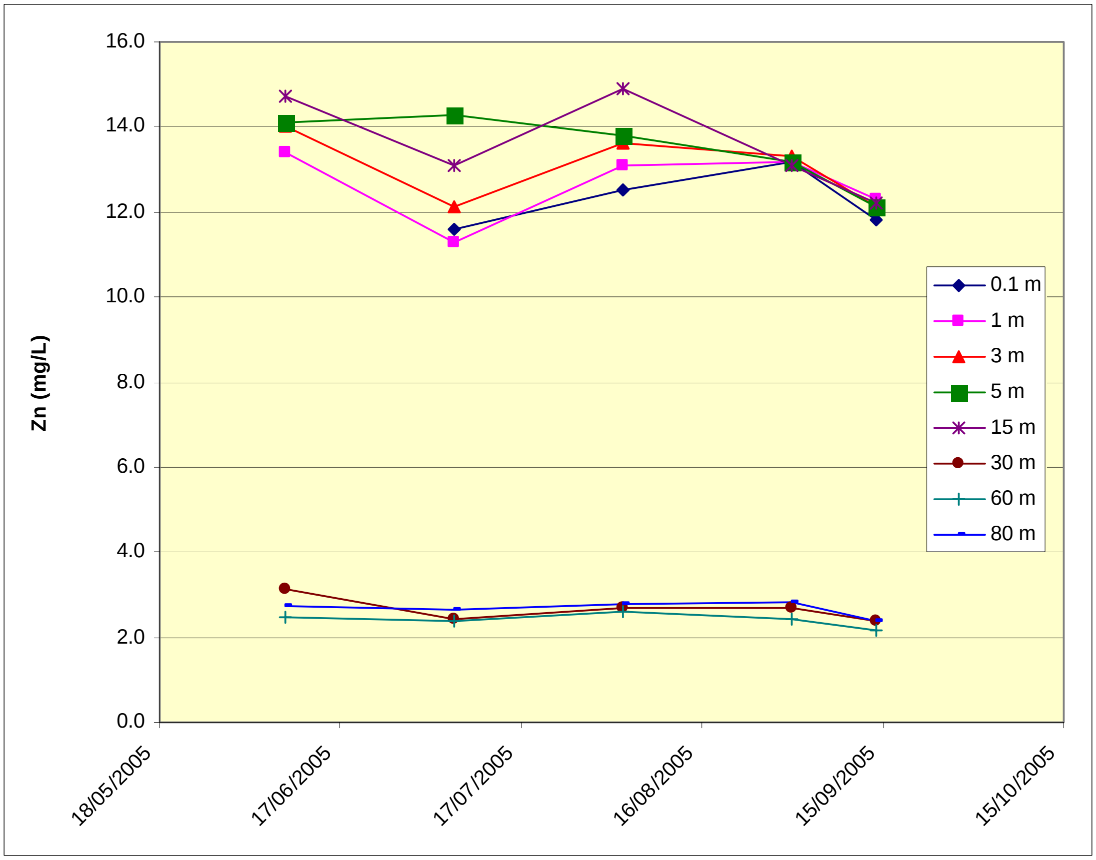

Figure 2-4 Total Zinc Concentration Time Series Plots at Various Depths

Zinc removal as a result of fertilization was assessed by calculating overall mass balances for the pit lake. The zinc inventory in the pit lake would be affected by water inflow from surface runoff and wall rock seepage, freshwater from direct precipitation, discharge from the Zone 2 Pit and from water abstracted for treatment. The effects of these inflows were assessed as part of the post closure water quality assessment that was completed by SRK. That report, provided in Appendix D, suggests that current annual zinc loading to the Faro Pit lake is about 24 tonnes per year from waste rock seepage and wall rock loadings. The majority of the loading however is expected to occur from the wall rocks.

Mass balance calculations presented in Appendix D indicate that in June of 2004, the pit lake contained about 150 tonnes of zinc. Similar calculations were completed for the current monitoring results, however, it should be noted that the current study had fewer samples to indicate the depth profile than the 2004 results. Calculations for mass balance are therefore not directly comparable. Even though the inventory estimate for 2004 would be more accurate, the inventory estimate was recalculated on the same sample frequency as for the current study to allow a direct comparison with the results for the current investigation. The change in inventory rather than the absolute number is more critical to allow an assessment of the factors that impacted the pit lake. On the latter basis, the zinc inventory was estimated to be about 219 tonnes.

Since monitoring commenced only in June (i.e. after spring freshet), it is possible that the majority of loadings from wall rock and waste rock seepage had already entered the pit lake. Therefore, potential loadings from the wall and waste rock were not included in the initial calculations. These results are summarised in Table 2.2. Compared to June 2004, the pit lake inventory had increased from about 219 to 261 tonnes, a net increase of about 42 tonnes for 2004. This is almost double the estimated current annual zinc loading of 24 tonnes presented in Appendix D.

The results in Table 2.2 furthermore suggest a net removal of about 36 tonnes of zinc. The sulphate inventory, however, increased by more than 600 tonnes, whereas a small loss of sodium from the water column is indicated. The ‘loss’ is likely within the accuracy of the calculation.

The significant increase in the sulphate concentration indicates that the runoff and seepage inflow to the pit lake cannot be discounted as a source. Therefore, the calculations were repeated by including the estimated wall rock and seepage loadings derived in the 2004 assessment. The results are shown in Table 2.3. The sulphate inventory is still shown to increase by about 365 tonnes. This may suggest that the current estimate for sulphate loading from the wall rock and waste rock seepage has been underestimated. As before, the sodium inventory is shown to decrease marginally. In contrast, if the additional zinc loading is included in the calculations, the estimated removal achieved by biological treatment increases to about 62 tonnes.

Table 2.2 Summary of Faro Pit Lake Mass Balance Calculations Excluding Wall Rock Loadings

Component	Volume m^3	Zn (T)		SO4		Na	
		Conc. (mg/L)	Mass (tonne)	Conc. (mg/L)	Mass (tonne)	Conc. (mg/L)	Mass (tonne)
Year start (Jun 8)	35,872,000	7.3	261	655	23,490	28	998
Zone 2 Pit	101,000	115	12	3120	315	2	0.2
Runoff Inflow	1,180,000	-	-	-	-	-	-
Outflow Treated	1,620,000	14.3	23	567	919	19.98	32
Year end (Sep 14)	34,892,000	6.1	214	675	23,551		964
Net Gain / (Loss)			**-36**		**664**		**-2**

Table 2.3 Summary of Faro Pit Lake Mass Balance Calculations Including Wall Rock and Waste Rock Loadings

Component	Volume m^3	Zn (T)		SO4		Na	
		Conc. (mg/L)	Mass (tonne)	Conc. (mg/L)	Mass (tonne)	Conc. (mg/L)	Mass (tonne)
Year start (Jun 8)	35,872,000	7.3	261	655	23,490	28	998
Zone 2 PIT	101,000	115	12	3,120	315	2	0.2
Runoff Inflow	1,180,000	22.8	26	254	300	12.4	14.6
Outflow Treated	1,620,000	14.3	23	567	919	19.98	32
Year end (Sep 14)	34,892,000	6.1	214	675	23,551		964
Net Gain / (Loss)			**-62**		**364**		**-16**

It should also be noted that the change in inventory from June 2004 (estimated at about 165 tonnes) to June 2005 (261 tonnes) suggests that the annual zinc loading may be substantially higher than previous estimates.

2.2.3 Summary

In summary, the limited fertilization undertaken in the Faro Pit lake effected rapid algal growth. The monitoring results furthermore suggest a correlation between algal settling and zinc removal from the water column.

Mass balance calculations indicate that between 45 and 60 tonnes of zinc have likely been removed from the water column as a result of the algal bloom induced by fertilization. The estimated net removals correspond to zinc removal rates of between 0.48 and 0.80 $g/m^2/day$. These rates correspond well with the estimated removal rates of 0.45 to 0.78 $g/m^2/day$ determined for the Grum Pit lake during the 2004 assessment. However, considering the limited fertilization program these removal rates are exceptional.

2.3 Grum Pit Lake

In situ monitoring results indicated that a thermocline developed in the Grum Pit lake at a depth of between 5 and 10 m below the water surface. A maximum surface water temperature of about 17°C was measured in July. The physical stability of the pit lake is discussed in Section 3.

2.3.1 Nutrients

Depth concentration profiles for dissolved orthophosphate-P and total phosphate-P are shown in Figure 2-5 and Figure 2-6, respectively. As shown, orthophosphate was consumed throughout summer, however, by fall the uptake ceased and its concentration increased due to late-season fertilization. Total phosphate-P concentrations increased in the surface layer throughout the open water as a result of the continuous fertilization. The water column at depth also showed a net increase in the total phosphate-P concentration. These results suggest that there may currently be sufficient phosphorus present in the water column to allow algal growth as soon as open water occurs. The results further suggest that late summer/fall fertilization is ineffective since orthophosphate uptake had ceased.

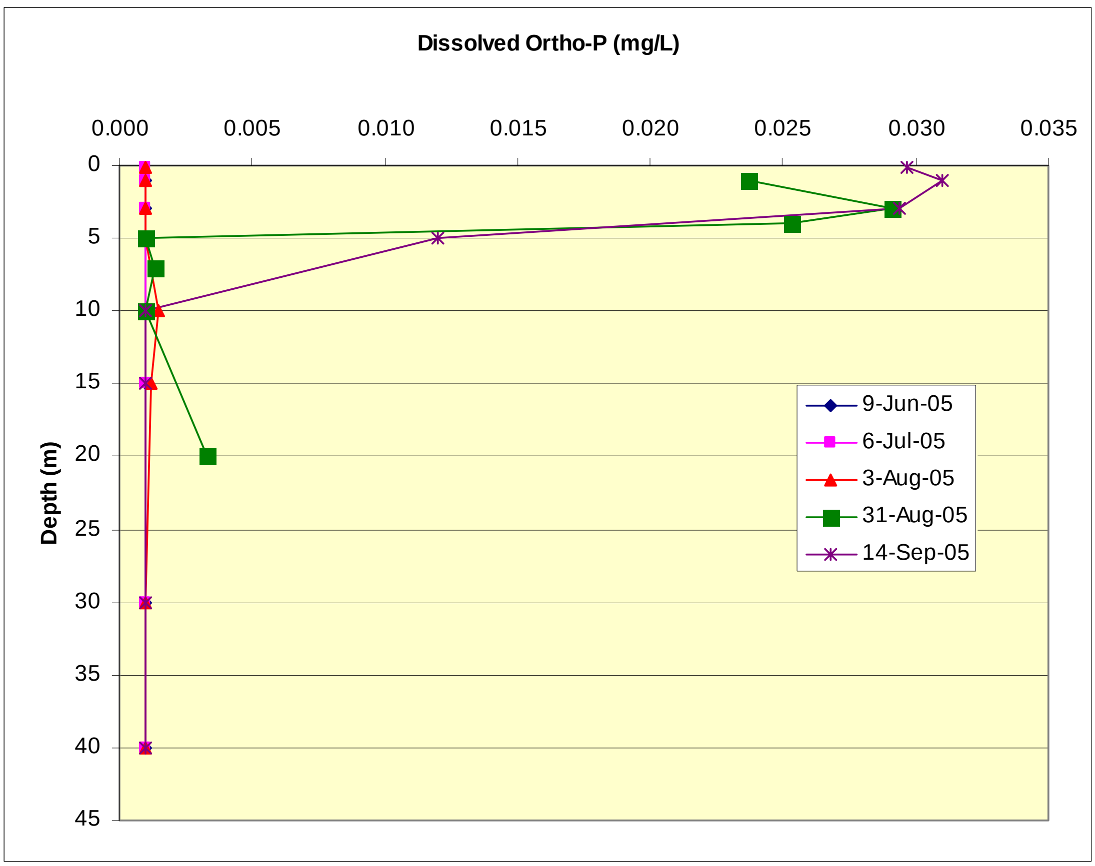

Figure 2-5 Dissolved Orthophosphate-P in the Grum Pit Water Column

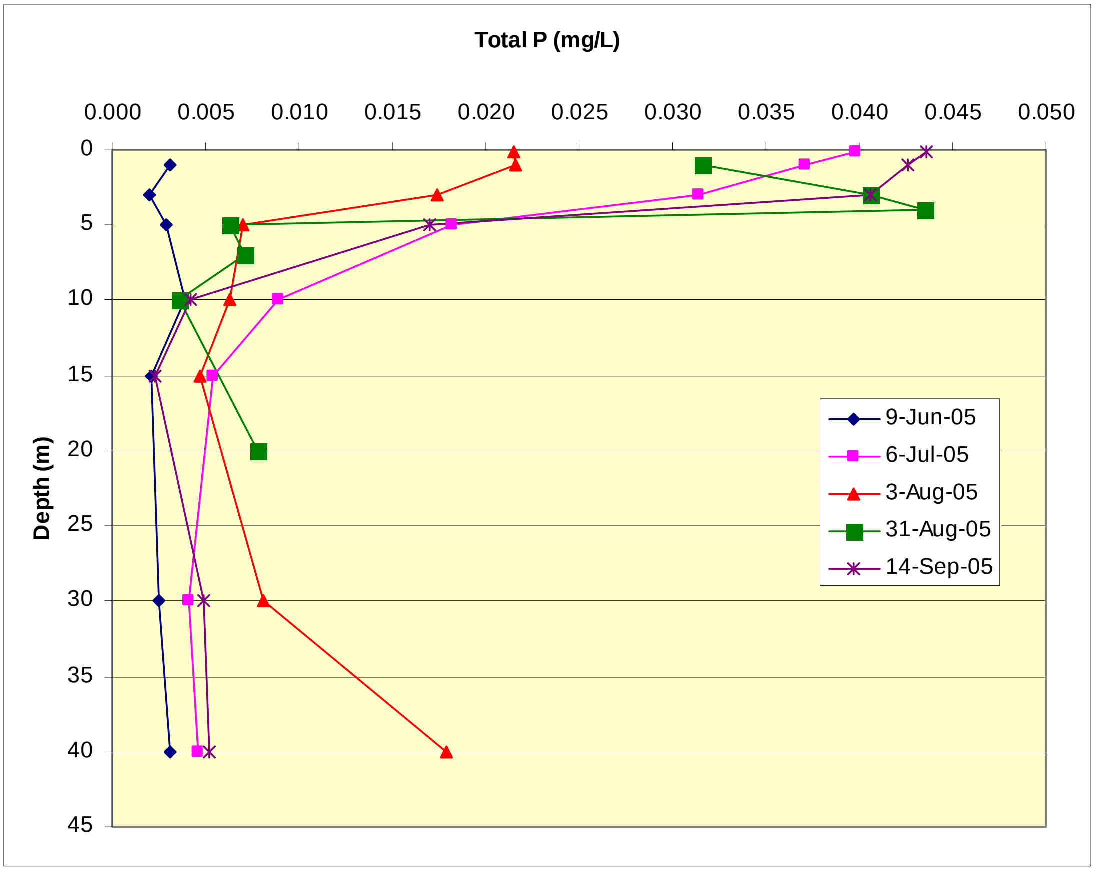

Figure 2-6 Dissolved Orthophosphate-P in the Grum Pit Water Column

Depth profiles for ammonia-N concentrations in the Grum Pit lake water column are shown in Figure 2-7. As noted for orthophosphate-P, ammonia-N uptake ceased in the late summer to early fall again confirming that late summer fertilization does not provide additional algal growth since reduced sunlight is likely to limit growth late in the season.

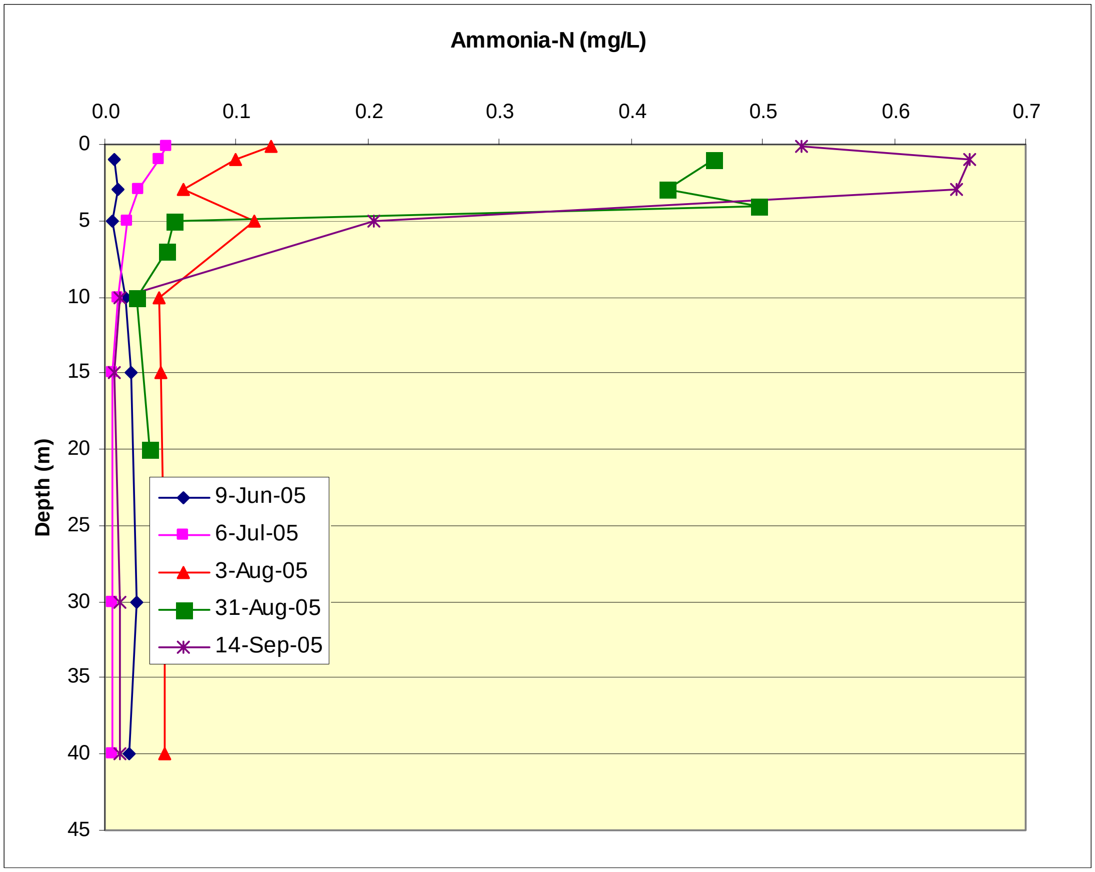

Figure 2-7 Ammonia-N Concentration Profiles in the Grum Pit Water Column

2.3.2 Algal Growth

Rapid growth with high algal densities was achieved in the Grum Pit lake as illustrated by the chlorophyll 'a' depth profiles measured in the pit lake shown in Figure 2-8. Maximum concentrations of up to 30 µg/L were observed during 2005 as compared to a maximum concentration of about 17 µg/L observed in 2004. The peak concentrations however were lower than observed for the Faro Pit lake. The reason may be lower light exposure in the Grum Pit compared to the Faro Pit lake, due to the higher sidewalls and smaller size of the Grum Pit lake.

The results shown in Figure 2-8 further suggest that multiple blooms occurred during July and early August. Note that no data were available for June. The results further indicate that, by the end of August, essentially most of the growth had been lost (settled) from the water column, and fertilization likely was not beneficial beyond this time. This is consistent with the observed lack of nutrient uptake during this late summer – early fall period.

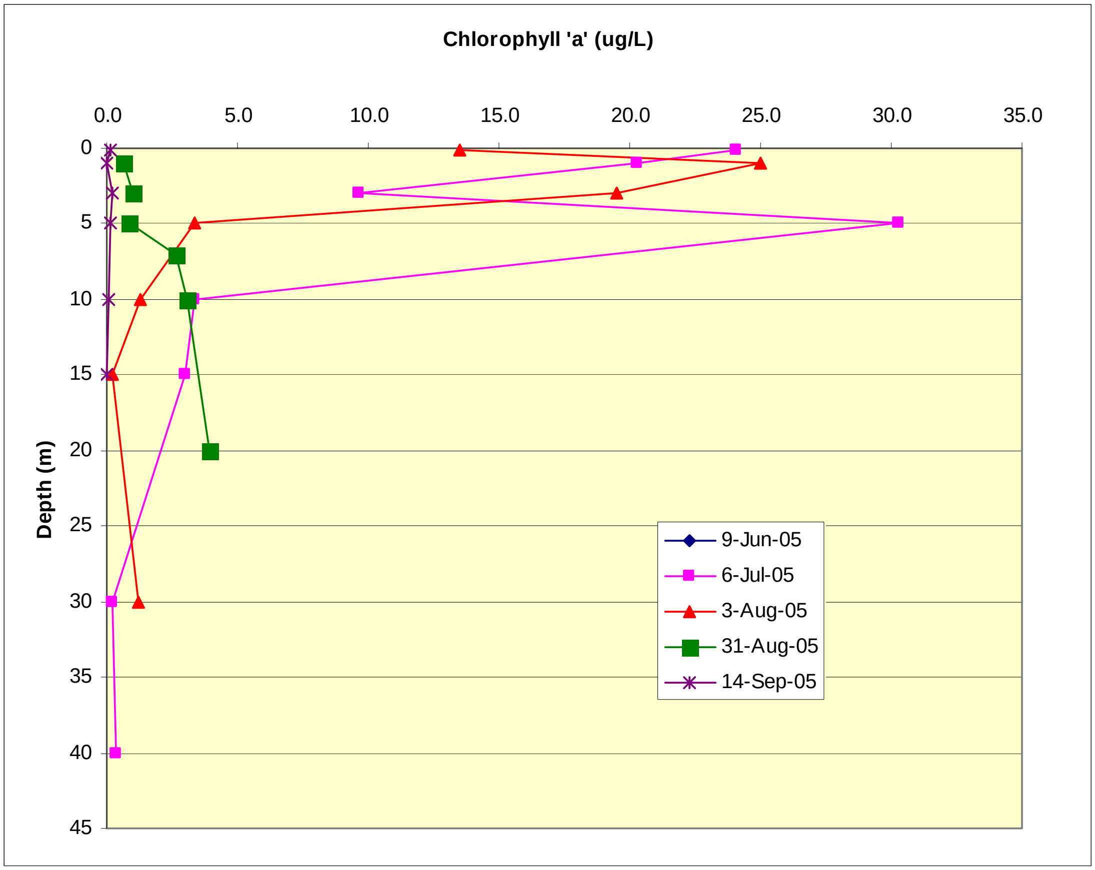

Figure 2-8 Chlorophyll ‘a’ Depth Profiles Measured in the Faro Pit Lake

2.3.3 Zinc Concentrations

Depth profiles of total zinc concentrations in Grum Pit lake are shown in Figure 2-9. Removal of total zinc from the surface layer (above the thermocline) is clearly evident from the decrease in the zinc concentration over time. The lowest surface zinc concentration of 0.1 mg/L was observed on August 3; thereafter a marginal increase in the surface concentration was observed. However, it should be noted that the zinc concentration at greater depth decreased, which suggests that mixing of the near-surface layer with deeper water was occurring during this time. The in situ monitoring indicated that the thermocline was eroded subsequent to August 3, which supports a ‘down-mixing mechanism for the observed increase in the zinc concentration in the near-surface water.

A direct comparison of the 2005 zinc concentration profiles with those of 2004 is provided in Figure 2-10. The figure shows profiles at the beginning and end of each summer season. The profiles indicate that zinc concentrations have decreased both in the near-surface and at depth. The decrease at depth may be a result of down-mixing with the ‘treated’ cleaner surface water, or, possibly as a result of sulphate reduction followed by sulphide mineral precipitation that may be occurring at depth.

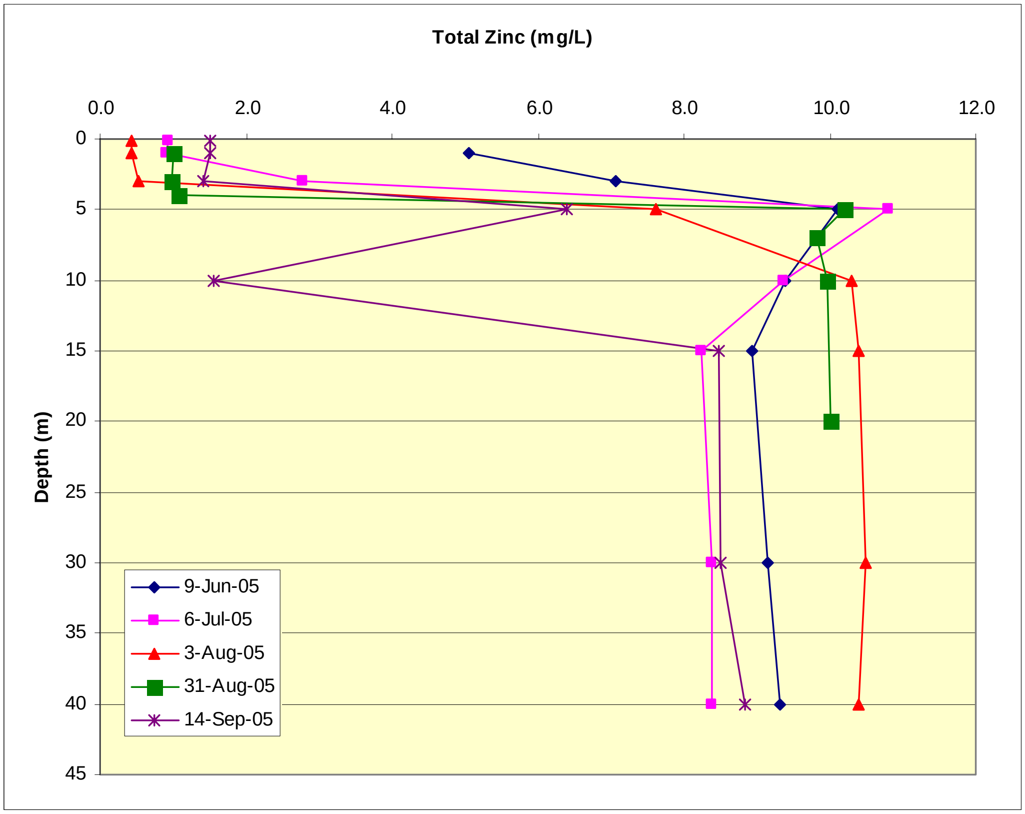

Figure 2-9 Grum Pit Zinc Concentration Profiles as a Function of Depth

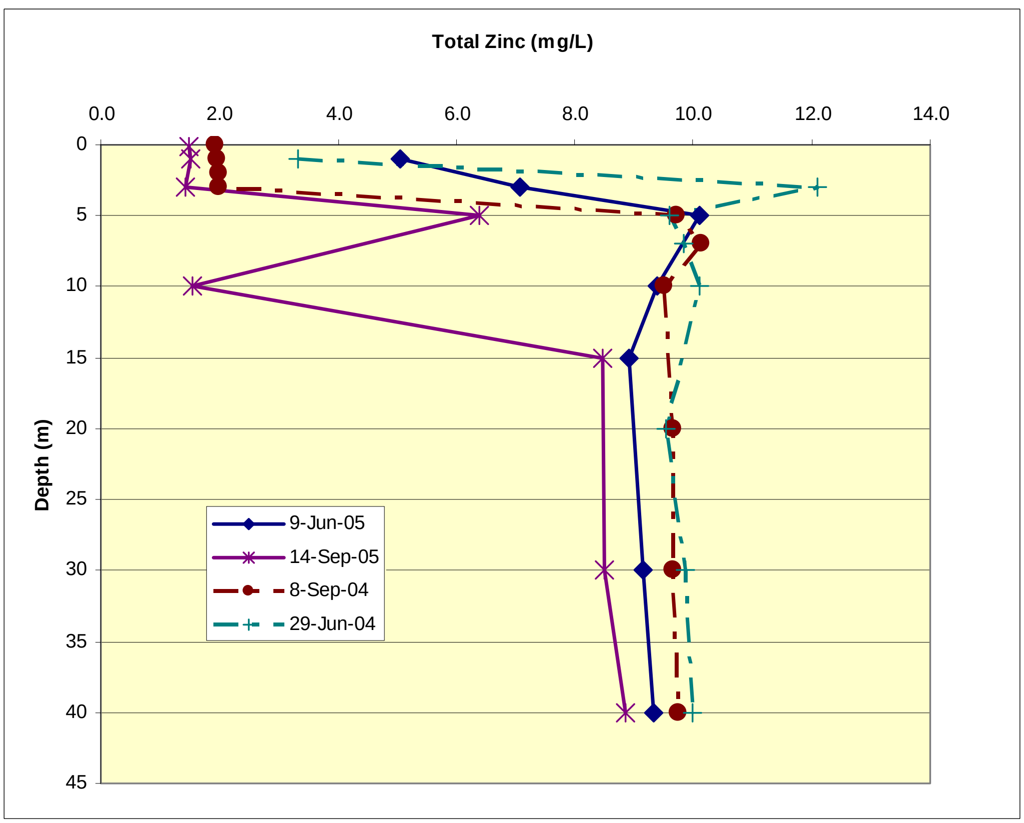

Figure 2-10 Comparison of 2004 and 2005 Zinc Concentration Profiles

In the 2004 assessment, metal removal was estimated from the change in the surface layer water quality only, since a significant proportion of the algae remained suspended at the end of the season. In the current assessment, the volume curve was used to establish the change in total and dissolved zinc inventory in the lake, as a whole, from the commencement of biological treatment in 2004. The results are summarised in Table 2.4. The table shows the mass of total and dissolved zinc contained in the pit lake. The net change shown in the table indicates net removals (negative values) or net gains (positive values) relative to the total inventory contained in June of 2004.

As shown, even though net removal of zinc occurred from the surface layer of the lake, there was a net increase in the total zinc inventory toward the end of the 2004 season. The inventory at the end of 2004 increased by as much as 11 tonnes, which suggests that the total loading to the pit lake may be in excess of this value. It also suggests that previous estimates of the total loading to the pit lake may be low. Nonetheless, the results indicate that a net removal of about 12 tonnes of zinc has occurred since the beginning of 2004. This is inclusive of the annual loading (i.e. the cumulative annual loadings plus about 12 tonnes already present prior to commencement of treatment were removed). The overall trend in the zinc inventory is illustrated in Figure 2-11 which clearly shows the net decrease of the zinc in the pit lake water column over time. It is also noted that the high zinc loading that was observed toward the end of 2004 did not occur in 2005.

Table 2.4 Estimated Inventory of Total and Dissolved Zinc Contained in the Grum Pit Lake

Date	Inventory (tonne)		* Net Change (tonne)	
	T Zn	D Zn	T Zn	D Zn
29/06/2004	39.0	39.0		
14/07/2004	42.2	40.6	3.3	1.5
28/07/2004	30.6	33.9	-8.3	-5.1
11/08/2004	37.9	36.9	-1.0	-2.1
25/08/2004	46.4	46.0	7.4	7.0
8/09/2004	50.2	49.4	11.2	10.4
9/06/2005	35.2	-	-3.8	-
6/07/2005	31.6	30.7	-7.3	-8.4
3/08/2005	36.2	-	-2.8	-
31/08/2005	26.2	-	-12.8	-
14/09/2005	26.7	28.7	-12.3	-10.3

Note : * Negative values indicate removal and positive values indicate net gain; removals relative to inventory on 29/06/2004. T Zn and D Zn refers to total zinc and dissolved zinc.

As shown in Figure 2-11, some zinc removal occurred during the winter of 2004/05. One possible reason for the reduction in the zinc inventory is that the quiescent conditions under ice could have promoted settling of the suspended algae, which may have sorbed additional zinc as it settled to the bottom of the pit. Alternatively, under-ice conditions would have led to anoxic conditions and it is possible that sulphate reduction may have occurred. Secondary sulphide mineralization may have contributed to the net removal observed.

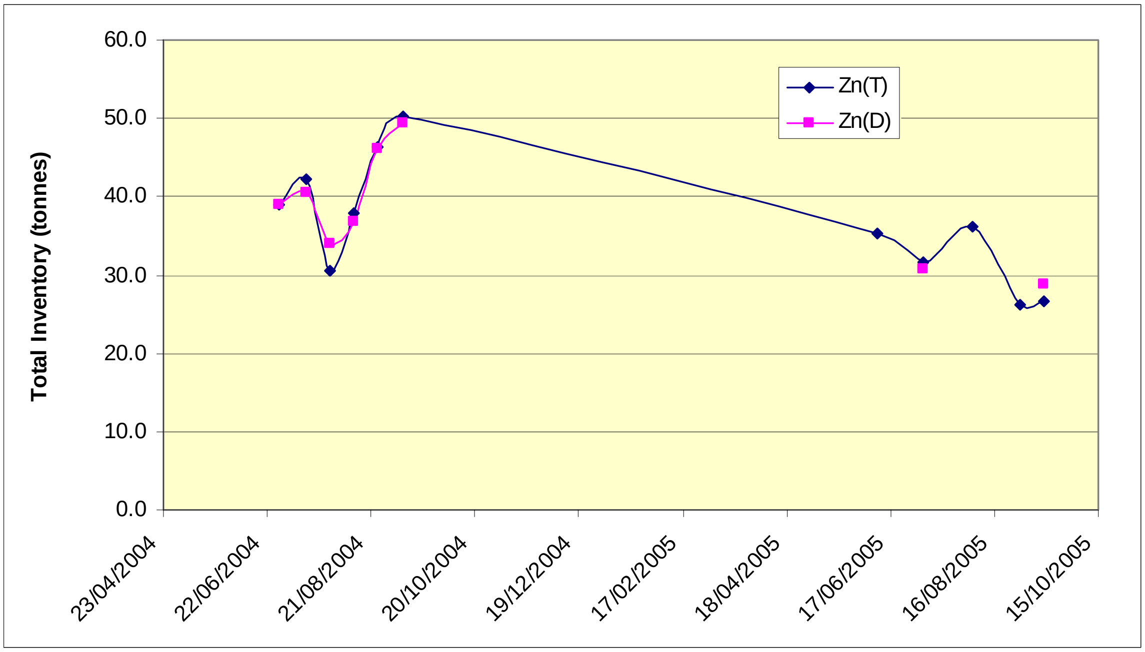

Figure 2-11 Net Change in the Zinc Inventory of the Grum Pit Lake with Time

Considered in isolation, the net zinc removal achieved during the summer of 2005 equated to about 35.2-26.7=8.5 tonnes. This is equal to an average removal rate of about 0.31 $g/m^2/day$ (exclusive of any additional loading to the pit lake), which is similar to the rate observed during 2004. Note that the actual removal rate will be in excess of this rate since the additional zinc that would have entered and been removed from the pit lake during this period is not included in the calculation.

Currently about 27 tonnes of zinc still remain in the pit lake, which suggests that if the biological treatment performance achieved in 2005 is sustained, most of the zinc could be removed from water column in about three to four consecutive years of treatment. This would be well in advance of the time expected to fill the pit. However as noted above, the ongoing loading may be more substantial than previously estimated. Irrespective, the loading is expected to decrease as the water level in the pit rises and a greater proportion of the sulphidic wall rocks are inundated. Consequently, the time to completely treat the pit lake may be somewhat longer than originally estimated.

2.3.4 Summary

The results indicate that the Grum Pit lake again responded well to fertilization and that excellent algal growth was achieved in 2005. However, it is noted that late summer fertilization was ineffective and that nutrient uptake ceased by late August. The fertilization program should in future be terminated by mid-August to limit the net build-up of nutrients in the water column.

Overall mass balance calculations for 2004 and 2005 suggest that zinc loadings to the Grum Pit lake may have been underestimated in the past. Nonetheless, the overall mass balance indicates a net decrease of about 12 tonnes of zinc since biological treatment commenced in 2004.

The mass balance calculations further indicated a net removal of zinc occurred during the winter of 2004/05. While the mechanism is not yet understood, the winter removal may be as a result of either additional zinc sorption as dead biomass settles from the water column, or, as a result of secondary sulphide mineralization (due to sulphate reduction).

During the summer of 2005, about 8.5 tonnes of zinc were removed from the water column. This equates to an average removal rate of about 0.31 $mg/m^2/day$, which is similar to that observed during 2004. The net rate, however, is somewhat lower than that observed for the Faro Pit lake.

2.4 Vangorda Pit Lake

Since the Vangorda Pit lake was not fertilized, and a large volume of water was abstracted for treatment, it was not possible to derive overall mass balance calculations to assess net loadings to the pit lake. No further assessment of the 2005 data was undertaken, but the September 2005 results can be used as baseline reference for assessing future changes in the water quality.

3 Physical Limnology

3.1 Introduction

A climate station was established on the raft that was floated on the Grum Pit lake. As well, conductivity-temperature-density (CTD) profiles of the Grum Pit were monitored during the open water summer period. CTD profiles were also obtained for the Faro and Vangorda Pit lakes. These results were reviewed by Lawrence and Associates, who commented on the stability of the pit lake systems. Their report is provided in Appendix C and is summarised briefly below.

3.2 Data Collection

CTD profiles were collected each time that water samples were obtained (see Table 2.1). Three different profiling instruments were used, including a Seabird 19plus, an Applied Microsystems StdPlus 638 CTD, and a YSI 600SQ profiler (primarily used to collect dissolved oxygen data).

Samples for water chemistry collected from discrete depths were analysed for specific conductance, pH, and chemical constituents by ALS in Vancouver (see Appendix B). Ice samples consisted of cuttings from an entire sampling hole, without breaking through to water. Ice chips were placed in clean wide mouth bottles and poured into sampling bottles once melted, and submitted for analysis.

The Onset Hobo Water Temp Pro was used at depths of 1, 2, 3, 5, 7, 10, 15, 20, 30, and 40 m from surface, for various periods of continuous monitoring of the Grum Pit lake water column temperature. Stream temperatures were also recorded for the Faro and Grum creeks.

Grum meteorological station recorded wind speed, wind direction, air temperature and solar radiation on the raft at Grum pit.

3.3 Summary of Results

The data suggest that the Faro, Vangorda and Grum Pit lakes are meromictic, but these pit lakes showed a range of behaviour, with varying degrees of deep water isolation.

The Faro Pit lake showed little change in water temperature and conductivity below 20 m, suggesting highly isolated deep water during the study period. The deep water showed little change from June 2004 to June 2005, with temperature steady to ± 0.05ºC and conductivity within ± 5 µS/cm. The presence of dissolved iron indicates the absence of dissolved oxygen which is also consistent with isolated deep water.

In contrast, the deep water of the Grum Pit lake is least isolated, possibly from mixing generated by failure of the east wall of till which is showing active creep. The decrease in deep conductivity from February 2005 to June 2005 is consistent with partial mixing of fresh water to depth. Another unusual feature of the Grum Pit lake is the absence of a chemocline below the surface layer. In fact, the temperature and conductivity profiles below the summer surface layer are remarkably uniform and suggestive of vertical mixing. However, despite the additional spring and summer mixing, the temperature data indicated that Grum did not turn over in the fall. Grum mixed deeper than 7 m but not to 10 m during the fall of 2004.

The Vangorda Pit-lake has the highest salt content at depth yet the deep water shows some seasonal change. The reasons for these changes are not clear.

3.4 Conclusions

The Faro Pit lake showed the most isolated deep water with only small changes in deep water temperature and conductivity and the absence of dissolved oxygen. This suggests that the Faro Pit lake was meromictic in 2004 and 2005.

The Grum Pit lake showed signs of partial mixing in spring and summer possibly due to ongoing failure of the east wall. Oxygen is possibly present in the deep water in summer. Nevertheless, the Grum Pit lake did not turn over in fall and remained stratified under ice.

The Vangorda Pit lake showed considerable changes over time for unknown reasons. These changes may be a result of ground water inflow or the relatively large influence of inflows to (runoff and seepage) and outflows from (pumping) the pit lake.

4 Conclusions and Recommendations

4.1 Conclusions

The conclusions from the 2005 biological treatment program for the Anvil Range Pit Lakes can be summarised as follows.

4.1.1 Faro Pit lake

The limited fertilization undertaken in the Faro Pit lake effected rapid algal growth. Mass balance calculations indicated that between 45 and 62 tonnes of zinc were removed from the water column as a result. The estimated zinc removal rate ranged between 0.48 and 0.80 $g/m^2/day$. These rates correspond well with the removal rates of 0.45 to 0.78 $g/m^2/day$ determined for the Grum Pit lake during the 2004 assessment, and are substantially better than expected for the limited fertilization program. Biological treatment in the Faro Pit lake therefore appears to be very promising.

The biomass generated in the pit lake however appeared to be the cause of excess foaming in the lime water treat system, preventing effective settling of the hydroxide precipitates generated by lime treatment. While this was not verified specifically, fertilization was the only change that could have induced this effect on the water treatment system. One possible explanation is the high pH to which the water is treated; the elevated pH may result in the breakdown of algal cell walls that could result in the release of proteins and other organic substances that could cause a stable froth to form. Unless water for treatment can be withdrawn from a much deeper horizon in the water column, biological treatment does not appear to be compatible with conventional lime treatment.

Mass balance calculations for the pit lake further suggest that the metal loadings to the pit lake may be higher than have previously been estimated.

The limnological assessment indicated that the Faro Pit lake was meromictic in 2004 and 2005. This means that water at depth is likely to remain isolated from the surface layer water.

4.1.2 Grum Pit Lake

The Grum Pit lake, as in 2004, responded well to fertilization and excellent algal growth was achieved in 2005. However, late summer fertilization was ineffective and nutrient uptake ceased by late August. It is therefore concluded that future fertilization programs should be terminated by mid-August to limit the net build-up of nutrients in the water column.

Overall mass balance calculations for 2004 and 2005 suggest that zinc loadings to the Grum Pit lake may have been underestimated in the past. Nonetheless, the overall mass balance indicates that about 12 tonnes of zinc in excess of the cumulative loading since commencement of biological treatment in 2004 have been removed from the water column.

Net zinc removal was observed for the winter of 2004/05. While the mechanism has not been identified, the winter removal may be as a result of either additional zinc sorption as dead biomass settle from the water column, or, as a results of secondary sulphide mineralization (due to sulphate reduction).

The summer of 2005 zinc net removal rate averaged about 0.31 mg/m^2/day, which is similar to that observed during 2004. The net rate however is somewhat lower than that observed for the Faro Pit lake.

The limonoligcial assessment indicated that the Grum Pit lake mixes partially in spring and summer, possibly due to ongoing failure of the east wall. Nevertheless the Grum Pit lake did not turn over in fall and remained stratified under ice.

4.1.3 Vangorda Pit Lake

The large volume of water abstracted from the Vangorda Pit lake precluded the derivation of an overall mass balance for the pit lake. The September 2005 results can however be used as a baseline reference for assessing future changes in the pit lake water quality.

The limnological assessment of the Vangorda Pit lake showed considerable changes over time. Theses changes may be a result of ground water inflow or the relatively large influence of inflows to (runoff and seepage) and outflows from (pumping) the pit lake.

4.2 Recommendations

4.2.1 Faro Pit Lake

On the basis of the observed performance of the 2005 fertilization, it is recommended that consideration be given to continuing the fertilization of the Faro Pit lake. Continuation of the fertilization program however will be practical only if the water balance for the pit will permit this since the results for 2005 indicated that the water is not compatible with the current lime treatment strategy. Current site constraints however preclude biological treatment of the Faro Pit lake in 2006. An assessment during 2007 may be considered however that would require that the pit lake level be drawn down substantially during 2006. Considering additional treatment requirements that under consideration for 2006, including the Intermediate Pond water, it is unlikely that sufficient draw-down of the pit will be possible. It is therefore recommended that alternative testing, which may include supplemental limnocorrals, be considered at a later date once a better understanding of the pit lake configuration has been developed.

The apparent effect of biological treatment should be verified and the possible cause(s) be identified to ensure that any consideration of biological treatment in conjunction with conventional treatment will be possible. (The interference observed for the Faro Mill treatment system may be consequence of its particular equipment utilization and configuration).

Because of the potential for utilizing the Faro Pit lake as an ancillary biological treatment system it is recommended that the pit lake limnology continue to be studied. It is also recommended that a dedicated Seabird CTD instrument be acquired for this purpose. It is also recommended by Greg Lawrence and Associates that under-ice profiling be carried out before ice-break-up. We concur with this recommendation.

As noted, mass balance calculations suggest that overall loadings to the pit are higher than previously predicted. It is noted that 2005 was an exceptionally wet year and the elevated loadings may have been a direct consequence. It is therefore recommended that profiling of the pit lake be undertaken at regular intervals during 2006 and mass balance calculations be completed to verify overall loadings. Should the calculated loadings continue to exceed the estimated loadings, the discrepancies between the predicted and actual loadings should be corrected in the modelling.

4.2.2 Grum Pit Lake

Based on the observed performance of biological treatment of the Grum Pit lake, it is recommended that the fertilization program be continued in 2006. It is, however, recommended that fertilization be terminated by mid-August to prevent the build-up of nutrients in the pit lake water column.

Mixing of the water column will, in the longer term, benefit biological treatment of the pit lake. Clearly there remain unresolved issues with respect to the mechanisms that are causing partial mixing in the pit lake. It is therefore recommended that the limnology of the pit lake continue to be investigated in 2006, including specifically, under-ice profiling prior to ice-break-up in accordance with the recommendation by Greg Lawrence and Associates.

As noted for the Faro Pit lake, the higher than predicted loadings to the pit lake may have been a consequence of exceptionally wet conditions. It is therefore recommended that mass balance calculations be completed for 2006 to verify overall loadings. Should the calculated loadings continue to exceed the estimated loadings, the discrepancies between the predicted and actual loadings should be corrected in the modelling.

4.2.3 Vangorda Pit Lake

At this time, it is not foreseen that the Vangorda Pit lake will be utilized as an ancillary treatment system. Fertilization of this pit lake is therefore not recommended. However, it is recommended that the water column water quality profile for this lake be monitored to enable an assessment of current contaminant loadings to the pit lake. Monitoring should be undertaken on a monthly basis commencing at open water conditions and should be continued to September 2006.

This report, **"Anvil Range Pit Lakes, Evaluation of In situ Treatment - 2005/06 Task20c"**, has been prepared by SRK Consulting (Canada) Inc.

John Chapman, P.Eng.
Principal

Cam Scott, P.Eng.
Principal

5 References

SRK Consulting, 2004, *Anvil Range Pit Lakes, Assessment of Post Closure Conditions*. Prepared for Deloitte and Touche Inc., January 2004.

Appendix A

In Situ Field Parameters

INSITU DATA FOR GRUM PIT, SUMMER OF 2005

Week #	Date	Station		pH	Temp oC	TDS mg/L	Cond.mS/cm	D.O. mg/L	Secchi (m)
1	2005-06-08	GP_1	1	8.08	14.2	448	930	6.8	1.9
1	2005-06-08	GP_3	3	7.99	11.8	460	960	7.4	
1	2005-06-08	GP_5	5	7.86	7.1	476	1014	8.4	
1	2005-06-08	GP_10	10	7.77	5.5	480	1023	7.2	
1	2005-06-08	GP_15	15	7.79	5.5	475	1025	7.4	
1	2005-06-08	GP_30	30	7.78	5.5	480	1016	7.3	
1	2005-06-08	GP_40	40	7.83	5.5	477	1014	7.2	
3	2005-06-22								0.75
4	2005-06-29								0.4
5	2005-07-06	GP_0.1	0.1	9.18	17.2	426	883	12.5	0.4
5	2005-07-06	GP_1	1	9.26	17.5	432	893	10.2	
5	2005-07-06	GP_3	3	8.71	14.0	445	918	10.5	
5	2005-07-06	GP_5	5	8.15	9.4	464	980	10.3	
5	2005-07-06	GP_10	10	7.74	6.8	465	994	9.7	
5	2005-07-06	GP_15	15	7.54	6.0	467	1002	10.4	
5	2005-07-06	GP_30	30	7.45	4.9	471	1020	10.8	
5	2005-07-06	GP_40	40	7.40	4.9	476	1022	11.6	
6	2005-07-13			9.05	16.1	351	809		0.5
7	2005-07-20								0.5
9	2005-08-03	GP_0.1	0.1	9.21	13.7	396	822	11.9	0.55
9	2005-08-03	GP_1	1	9.34	13.1	401	837	9.7	
9	2005-08-03	GP_3	3	8.28	12.5	409	853	8.6	
9	2005-08-03	GP_5	5	7.94	8.8	468	988	7.2	
9	2005-08-03	GP_10	10	7.68	5.8	472	1019	7.4	
9	2005-08-03	GP_15	15	7.59	5.2	476	1027	7.5	
9	2005-08-03	GP_30	30	7.54	5.5	476	1027	7.7	
9	2005-08-03	GP_40	40	7.53	5.4	477	1028	7.6	
11	2005-08-17								1.0
13	2005-08-31	GP_0.1		No instruments were available on Aug 31/05					1.2
13	2005-08-31	GP_1							
13	2005-08-31	GP_3							
13	2005-08-31	GP_5							
13	2005-08-31	GP_10							
13	2005-08-31	GP_15							
13	2005-08-31	GP_30							
13	2005-08-31	GP_40							
15	2005-09-14	GP_0.1	0.1	8.68	8.9	438	928	*	0.95
15	2005-09-14	GP_1	1	8.70	8.9	437	923		
15	2005-09-14	GP_3	3	8.71	9.1	436	923		
15	2005-09-14	GP_5	5	8.15	8.6	481	1015		
15	2005-09-14	GP_10	10	7.65	6.0	491	1053		
15	2005-09-14	GP_15	15	7.54	4.9	497	1076		
15	2005-09-14	GP_30	30	7.44	4.9	505	1081		
15	2005-09-14	GP_40	40	7.44	4.9	499	1073		

* Dissolved oxygen profiles were done with a YSI 600 SQ profiler and are included in another file.

INSITU DATA FOR FARO PIT, SUMMER OF 2005

Week #	Date	Station	Depth	pH	Temp oC	TDS mg/L	Cond.mS/cm	D.O. mg/L	Secchi (m)
1	2005-06-09	FP_1	1	7.53	12.0	521	1087	8.9	4.7
1	2005-06-09	FP_3	3	7.54	10.9	524	1096	9.1	
1	2005-06-09	FP_5	5	7.46	10.7	527	1100	7.8	
1	2005-06-09	FP_15	15	7.18	5.4	561	1200	8.5	
1	2005-06-09	FP_30	30	6.87	5.4	643	1370	6.0	
1	2005-06-09	FP_60	60	6.80	5.4	654	1373	5.9	
1	2005-06-09	FP_80	80	6.81	5.4	668	1418	5.7	
3	2005-06-22								7.2
4	2005-06-29	NOTE: This was the last day that the Faro Pit was fertilized.							1.9
5	2005-07-06	FP_0.1	0.1	7.88	15.9	512	1061	11.5	1.0
5	2005-07-06	FP_1	1	8.09	15.7	512	1060	8.8	
5	2005-07-06	FP_3	3	8.08	14.7	513	1063	8.4	
5	2005-07-06	FP_5	5	7.82	13.4	521	1077	8.2	
5	2005-07-06	FP_15	15	7.14	5.3	558	1094	10.0	
5	2005-07-06	FP_30	30	6.75	4.6	638	1370	6.9	
5	2005-07-06	FP_60	60	6.70	4.6	646	1378	6.5	
5	2005-07-06	FP_80	80	6.51	4.6	673	1439	6.5	
7	2005-07-20								2.9
9	2005-08-03	FP_0.1	0.1	6.58	12.3	510	1062	6.9	4.5
9	2005-08-03	FP_1	1	7.44	12.2	512	1066	6.5	
9	2005-08-03	FP_3	3	7.63	12.2	513	1064	6.5	
9	2005-08-03	FP_5	5	7.66	12.3	515	1070	6.5	
9	2005-08-03	FP_15	15	7.27	6.0	543	1163	7.3	
9	2005-08-03	FP_30	30	6.89	5.1	625	1344	6.5	
9	2005-08-03	FP_60	60	6.80	5.5	630	1354	6.3	
9	2005-08-03	FP_80	80	6.71	5.4	654	1401	6.2	
11	2005-08-17								5.8
13	2005-08-31	FP_1	1	No instruments were available on Aug 31/05					4.7
13	2005-08-31	FP_3	3						
13	2005-08-31	FP_5	5						
13	2005-08-31	FP_15	15						
13	2005-08-31	FP_30	30						
13	2005-08-31	FP_60	60						
13	2005-08-31	FP_80	80						
15	60 m	FP_0.1	0.1	7.58	10.1	542	1139	*	3.6
15	2005-09-14	FP_1	1	7.63	9.8	543	1138		
15	2005-09-14	FP_3	3	7.66	9.6	541	1135		
15	2005-09-14	FP_5	5	7.62	9.6	540	1133		
15	2005-09-14	FP_15	15	7.35	4.9	569	1224		
15	2005-09-14	FP_30	30	6.97	4.3	647	1397		
15	2005-09-14	FP_60	60	6.77	4.2	661	1429		
15	2005-09-14	FP_80	80	6.73	4.2	687	1483		

* Dissolved oxygen profiles were done with a YSI 600 SQ profiler and are included in another file.

INSITU DATA FOR VANGORDA PIT, SUMMER OF 2005

Week #	Date	Station	pH	Temp oC	TDS mg/L	Cond.mS/cm	D.O. mg/L	Secchi (m)
1	2005-06-09	VP_1	7.00	14.0	578	1188	8.2	1.3
1	2005-06-09	VP_3	5.85	8.2	804	1674	4.7	
1	2005-06-09	VP_5	5.86	6.5	848	1786	5.7	
1	2005-06-09	VP_15	5.96	6.2	880	1847	5.7	
1	2005-06-09	VP_30	5.96	5.8	909	1922	5.9	
1	2005-06-09	V_40	5.95	5.2	935	1970	5.6	
15	2005-09-14	VP-0.1	6.33	8.2	844	1753	*	0.4
15	2005-09-14	VP_1	6.40	8.5	839	1753		
15	2005-09-14	VP_3	6.94	7.1	924	1916		
15	2005-09-14	VP_5	5.91	4.9	941	2010		
15	2005-09-14	VP_15	5.91	4.8	958	2040		
15	2005-09-14	VP_20	5.90	4.6	959	2050		
15	2005-09-14	V_30	5.92	4.6	957	2050		

Note: Total depth on Sept 14/05 was 33m so sampled at 20 m and 30 m.

* Dissolved oxygen profiles were done with a YSI 600 SQ profiler and are included in another file.

Appendix B
Pit Lake Water Quality Monitoring Results

Faro Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	1	3	5	15	30	60	80
Sample ID	FP-1 FARO PIT @1m	FP-3 FARO PIT @3m	FP-5 FARO PIT @5m	FP-15 FARO PIT @15m	FP-30 FARO PIT @30m	FP-60 FARO PIT @60m	FP-80 FARO PIT @80m
Date Sampled	8/06/2005	8/06/2005	8/06/2005	8/06/2005	8/06/2005	8/06/2005	8/06/2005
Time Sampled	14:45	15:00	15:08	15:15	15:20	15:30	15:45
ALS Sample ID	1	2	3	4	5	6	7
Nature	Water	Water	Water	Water	Water	Water	Water
Physical Tests							
Conductivity (uS/cm)	1160	1160	1170	1260	1410	1430	1480
pH	7.60	7.73	7.80	7.42	7.34	7.32	7.29
Total Suspended Solids	<3.0	<3.0	<3.0	<3.0	36.6	44.6	49.3
Dissolved Anions							
Alkalinity-Total CaCO3	103	101	106	110	101	105	73.0
Sulphate SO4	546	544	558	608	688	708	733
Nutrients							
Ammonia Nitrogen N	0.820	0.860	0.840	0.930	1.44	1.52	1.48
Nitrate Nitrogen N	0.257	0.193	0.200	0.192	<0.050	<0.050	<0.050
Nitrite Nitrogen N	0.014	<0.010	0.014	0.015	<0.010	<0.010	0.011
Dissolved ortho-Phosphate P	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate P	<0.0020	<0.0020	<0.0020	<0.0020	0.0069	<0.060	<0.060
Total Metals							
Aluminum T-Al	0.0262	0.0324	0.0353	0.0200	0.0192	0.0114	0.0129
Antimony T-Sb	0.00156	0.00165	0.00164	0.00167	<0.00020	<0.00020	<0.00020
Arsenic T-As	0.00024	0.00023	0.00022	0.00024	0.00091	0.00217	0.00172
Barium T-Ba	0.0165	0.0168	0.0167	0.0168	0.0155	0.0167	0.0164
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.0139	0.0144	0.0144	0.0150	0.00048	0.00013	0.00015
Calcium T-Ca	147	135	135	138	185	202	193
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0442	0.0460	0.0466	0.0474	0.0335	0.0326	0.0309
Copper T-Cu	0.0172	0.0183	0.0184	0.0168	0.00728	<0.0016	<0.0014
Iron T-Fe	0.154	0.167	0.185	0.136	16.1	21.4	22.2
Lead T-Pb	0.00219	0.00260	0.00251	0.00140	0.00132	0.00094	0.00122
Lithium T-Li	0.050	0.051	0.051	0.054	0.063	0.066	0.065
Magnesium T-Mg	64.3	59.4	58.8	58.6	65.3	72.1	69.0
Manganese T-Mn	2.38	2.47	2.48	2.76	3.42	3.54	3.65
Molybdenum T-Mo	0.00257	0.00258	0.00262	0.00280	0.00384	0.00333	0.00284
Nickel T-Ni	0.0989	0.103	0.106	0.106	0.0717	0.0681	0.0719
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	7.5	6.9	6.9	7.1	12.0	13.6	12.3
Selenium T-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon T-Si	3.03	2.78	2.77	2.63	2.50	2.80	2.70
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	21.3	19.6	19.5	19.7	31.3	35.4	32.0
Strontium T-Sr	0.470	0.486	0.491	0.510	0.535	0.561	0.609
Thallium T-Tl	0.00064	0.00065	0.00067	0.00069	0.00024	0.00024	0.00024
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00275	0.00288	0.00293	0.00291	0.00282	0.00369	0.00464
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	13.4	14.0	14.1	14.7	3.12	2.48	2.73
Dissolved Metals							
Aluminum D-Al							
Antimony D-Sb							
Arsenic D-As							
Barium D-Ba							
Beryllium D-Be							
Bismuth D-Bi							
Boron D-B							
Cadmium D-Cd							
Calcium D-Ca							
Chromium D-Cr							
Cobalt D-Co							
Copper D-Cu							
Iron D-Fe							
Lead D-Pb							
Lithium D-Li							
Magnesium D-Mg							
Manganese D-Mn							
Molybdenum D-Mo							
Nickel D-Ni							
Phosphorus D-P							
Potassium D-K							
Selenium D-Se							
Silicon D-Si							
Silver D-Ag							
Sodium D-Na							
Strontium D-Sr							
Thallium D-Tl							
Tin D-Sn							
Titanium D-Ti							
Uranium D-U							
Vanadium D-V							
Zinc D-Zn							
Organic Parameters							
Chlorophyll a (a,b)							

Faro Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	15	30	60	80
Sample ID	FP-0.1m Faro Pit Sur	FP-1 Faro Pit @1m	FP-3 Faro Pit @3m	FP-5 Faro Pit @5m	FP-15 Faro Pit @15m	FP-30 Faro Pit @30m	FP-60 Faro Pit @60m	FP-80 Faro Pit @80m
Date Sampled	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005
Time Sampled	10:20	10:30	10:45	11:00	11:20	11:30	11:50	12:15
ALS Sample ID	1	2	3	4	5	6	7	8
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	1160	1160	1160	1170	1250	1400	1420	1470
pH	7.16	7.24	7.33	6.81	6.94	6.94	6.88	6.84
Total Suspended Solids	<3.0	<3.0	<3.0	4.8	<3.0	27.5	30.8	32.1
Dissolved Anions								
Alkalinity-Total CaCO3	97.2	96.1	101	101	105	97.6	97.4	108
Sulphate SO4	583	575	592	575	725	735	743	778
Nutrients								
Ammonia Nitrogen N	0.800	0.820	0.770	0.740	1.17	1.27	1.31	1.52
Nitrate Nitrogen N	0.420	0.379	0.362	0.315	0.201	5.66	<0.025	<0.025
Nitrite Nitrogen N	0.0086	0.0090	0.0078	0.0095	0.0087	0.137	0.0158	0.0086
Dissolved ortho-Phosphate P	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate P	0.0052	0.0052	0.0090	0.0113	0.0050	<0.0060	<0.0060	<0.0020
Total Metals								
Aluminum T-Al	<0.0050	<0.0050	<0.0050	0.0070	0.0117	0.0108	0.0085	0.0080
Antimony T-Sb	0.00141	0.00136	0.00135	0.00140	0.00150	<0.00020	<0.00020	<0.00020
Arsenic T-As	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00106	0.00181	0.00126
Barium T-Ba	0.0175	0.0169	0.0169	0.0169	0.0169	0.0165	0.0155	0.0164
Beryllium T-Be	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Boron T-B	<0.050	<0.050	<0.050	<0.050	<0.050	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00511	0.00522	0.00626	0.0122	0.0165	0.00077	0.00035	0.00022
Calcium T-Ca	137	139	139	136	158	189	201	202
Chromium T-Cr	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0475	0.0467	0.0463	0.0467	0.0475	0.0309	0.0301	0.0316
Copper T-Cu	0.00384	0.00392	0.00416	0.00704	0.00974	0.00462	0.00166	0.00118
Iron T-Fe	<0.030	<0.030	<0.030	0.032	0.081	20.0	22.7	25.6
Lead T-Pb	0.00094	0.00108	0.00088	0.00141	0.00129	0.00058	0.00064	0.00088
Lithium T-Li	0.048	0.050	0.050	0.049	0.054	0.059	0.059	0.066
Magnesium T-Mg	61.2	61.3	61.7	60.3	66.7	66.3	69.8	68.8
Manganese T-Mn	2.43	2.37	2.34	2.40	2.60	3.17	3.17	3.60
Molybdenum T-Mo	0.00273	0.00260	0.00235	0.00267	0.00260	0.00347	0.00291	0.00272
Nickel T-Ni	0.109	0.105	0.105	0.107	0.105	0.0657	0.0648	0.0736
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	9.0	9.2	8.9	8.7	10.8	15.1	15.7	15.4
Selenium T-Se	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Silicon T-Si	3.04	3.11	3.11	3.30	3.19	2.79	2.95	3.03
Silver T-Ag	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000020	<0.000020	<0.000020
Sodium T-Na	21.0	21.3	21.0	20.3	24.6	33.3	33.4	33.5
Strontium T-Sr	0.488	0.470	0.463	0.473	0.470	0.485	0.490	0.585
Thallium T-Tl	0.00070	0.00069	0.00066	0.00066	0.00066	0.00025	0.00024	0.00026
Tin T-Sn	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00292	0.00288	0.00282	0.00270	0.00285	0.00322	0.00359	0.00484
Vanadium T-V	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Zinc T-Zn	11.6	11.3	12.1	14.3	13.1	2.41	2.36	2.66
Dissolved Metals								
Aluminum D-Al	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Antimony D-Sb	0.00142	0.00143	0.00137	0.00146	0.00150	<0.00020	<0.00020	<0.00020
Arsenic D-As	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00089	0.00140	0.00059
Barium D-Ba	0.0170	0.0170	0.0164	0.0164	0.0165	0.0159	0.0154	0.0156
Beryllium D-Be	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Bismuth D-Bi	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Boron D-B	<0.050	<0.050	<0.050	<0.050	<0.050	<0.020	<0.020	<0.020
Cadmium D-Cd	0.00094	0.00099	0.00075	0.00116	0.00146	<0.00010	<0.00010	<0.00010
Calcium D-Ca	139	139	140	143	153	191	192	192
Chromium D-Cr	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Cobalt D-Co	0.0470	0.0469	0.0450	0.0447	0.0466	0.0308	0.0304	0.0306
Copper D-Cu	0.00187	0.00202	0.00171	0.00115	0.00161	0.00042	0.00035	0.00037
Iron D-Fe	<0.030	<0.030	<0.030	<0.030	<0.030	19.7	20.8	23.3
Lead D-Pb	0.00040	0.00045	0.00033	0.00050	<0.00025	<0.00010	<0.00010	<0.00010
Lithium D-Li	0.050	0.050	0.047	0.047	0.053	0.056	0.058	0.064
Magnesium D-Mg	62.3	61.3	62.0	63.1	64.6	67.0	64.6	64.9
Manganese D-Mn	2.38	2.39	2.29	2.30	2.60	3.13	3.15	3.51
Molybdenum D-Mo	0.00250	0.00253	0.00243	0.00246	0.00265	0.00329	0.00294	0.00257
Nickel D-Ni	0.107	0.108	0.104	0.103	0.106	0.0656	0.0649	0.0705
Phosphorus D-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium D-K	9.0	9.0	8.9	9.4	10.9	15.6	14.9	14.8
Selenium D-Se	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Silicon D-Si	2.97	2.97	3.03	3.50	3.20	2.84	2.81	2.87
Silver D-Ag	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000020	<0.000020	<0.000020
Sodium D-Na	21.1	21.1	20.9	21.7	24.8	34.2	31.7	32.7
Strontium D-Sr	0.477	0.480	0.450	0.455	0.468	0.477	0.499	0.565
Thallium D-Tl	0.00070	0.00068	0.00067	0.00066	0.00069	0.00024	0.00023	0.00024
Tin D-Sn	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020
Titanium D-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium D-U	0.00289	0.00294	0.00265	0.00256	0.00282	0.00301	0.00345	0.00459
Vanadium D-V	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Zinc D-Zn	11.2	11.2	11.1	13.4	12.3	2.36	2.35	2.52
Organic Parameters	FP-0.1 Faro Pit Surfa	FP-1 Faro Pit @1m	FP-3 Faro Pit @3m	FP-5 Faro Pit @5m	FP-15 Faro Pit @15m	FP-30 Faro Pit @30m	FP-60 Faro Pit @60m	FP-80 Faro Pit @80m
Chlorophyll a (a,b)	1.19	1.93	4.13	56.4	1.50	0.047	0.087	0.01

Faro Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	15	30	60	80
Sample ID	FP_0.1	FP_1	FP_3	FP_5	FP_15	FP_30	FP_60	FP_80
Date Sampled	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005
Time Sampled	14:35	14:47	14:55	15:00	15:17	15:23	15:32	15:44
ALS Sample ID	1	2	3	4	5	6	7	8
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	1140	1140	1140	1140	1230	1370	1390	1440
pH	7.45	7.69	7.78	7.81	7.66	7.41	7.24	7.25
Total Suspended Solids	<3.0	<3.0	<3.0	<3.0	<3.0	36.7	32.0	36.7
Dissolved Anions								
Alkalinity-Total CaCO3	101	95.2	97.5	56.8	104	110	107	112
Sulphate SO4	558	562	561	557	605	691	699	733
Nutrients								
Ammonia Nitrogen N	1.17	1.21	1.05	1.05	1.78	1.60	1.52	1.64
Nitrate Nitrogen N	0.334	0.351	0.348	0.341	0.181	<0.0050	0.0066	<0.0050
Nitrite Nitrogen N	0.0061	0.0062	0.0063	0.0063	0.0060	0.0016	0.0024	0.0022
Dissolved ortho-Phosphate P	<0.0010	<0.0010	0.0019	0.0044	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate P	0.0025	0.0046	0.0060	0.0101	0.0027	0.0037	0.0048	0.0037
Total Metals								
Aluminum T-Al	0.0119	0.0137	0.0140	0.0140	0.0147	0.0108	0.0129	0.0128
Antimony T-Sb	0.00138	0.00140	0.00140	0.00142	0.00142	<0.00020	<0.00020	<0.00020
Arsenic T-As	<0.00020	<0.00020	<0.00020	0.00020	0.00022	0.00102	0.00168	0.00110
Barium T-Ba	0.0161	0.0163	0.0164	0.0164	0.0161	0.0158	0.0159	0.0160
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00302	0.00315	0.00315	0.00313	0.00968	0.00110	0.00051	0.00035
Calcium T-Ca	138	135	137	135	146	175	191	199
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0433	0.0453	0.0461	0.0472	0.0494	0.0319	0.0324	0.0317
Copper T-Cu	0.00423	0.00445	0.00472	0.00463	0.00527	0.00243	0.00093	0.00060
Iron T-Fe	0.062	0.063	0.064	0.063	0.058	17.4	20.9	24.0
Lead T-Pb	0.00184	0.00282	0.00224	0.00252	0.00191	0.00114	0.00144	0.00135
Lithium T-Li	0.049	0.052	0.052	0.054	0.058	0.063	0.066	0.068
Magnesium T-Mg	63.0	62.5	62.8	61.6	62.9	63.1	69.2	71.7
Manganese T-Mn	2.36	2.49	2.56	2.60	2.99	3.49	3.59	3.80
Molybdenum T-Mo	0.00236	0.00247	0.00249	0.00259	0.00270	0.00348	0.00304	0.00266
Nickel T-Ni	0.0959	0.0997	0.103	0.104	0.107	0.0651	0.0667	0.0715
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	6.9	6.8	6.9	6.7	7.8	13.4	13.0	12.7
Selenium T-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon T-Si	2.94	2.90	2.93	2.87	2.72	2.39	2.67	2.79
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	19.6	19.4	19.8	18.9	21.5	33.5	32.6	32.1
Strontium T-Sr	0.480	0.504	0.514	0.521	0.539	0.525	0.566	0.617
Thallium T-Tl	0.00067	0.00069	0.00070	0.00070	0.00073	0.00025	0.00026	0.00026
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00224	0.00234	0.00237	0.00239	0.00307	0.00330	0.00379	0.00472
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	12.5	13.1	13.6	13.8	14.9	2.68	2.58	2.76
Dissolved Metals								
Aluminum D-Al								
Antimony D-Sb								
Arsenic D-As								
Barium D-Ba								
Beryllium D-Be								
Bismuth D-Bi								
Boron D-B								
Cadmium D-Cd								
Calcium D-Ca								
Chromium D-Cr								
Cobalt D-Co								
Copper D-Cu								
Iron D-Fe								
Lead D-Pb								
Lithium D-Li								
Magnesium D-Mg								
Manganese D-Mn								
Molybdenum D-Mo								
Nickel D-Ni								
Phosphorus D-P								
Potassium D-K								
Selenium D-Se								
Silicon D-Si								
Silver D-Ag								
Sodium D-Na								
Strontium D-Sr								
Thallium D-Tl								
Tin D-Sn								
Titanium D-Ti								
Uranium D-U								
Vanadium D-V								
Zinc D-Zn								
Organic Parameters	FP_0.1	FP_1	FP_3	FP_5	FP_7	FP_10	FP_15	
Chlorophyll a (a,b)	1.79	0.396	3.51	0.306	0.222	4.59	6.20	

Faro Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	15	30	60	80
Sample ID	FP_ SURFACE	FP_1	FP_3	FP_5	FP_15	FP_30	FP_60	FP_80
Date Sampled	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005
Time Sampled	15:15	16:00	16:15	16:22	16:35	16:49	17:15	17:45
ALS Sample ID	1	2	3	4	5	6	7	8
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	1140	1140	1140	1140	1230	1360	1380	1440
pH	7.27	7.46	7.57	7.69	7.51	7.34	7.16	7.02
Total Suspended Solids	<3.0	<3.0	<3.0	3.3	<3.0	60	30.6	37.6
Dissolved Anions								
Alkalinity-Total CaCO3	102	101	99.8	102	110	104	107	118
Sulphate SO4	569	582	567	573	631	712	724	761
Nutrients								
Ammonia Nitrogen N	1.07	1.20	1.19	1.22	1.94	1.47	1.47	1.70
Nitrate Nitrogen N	0.356	0.410	0.365	0.371	0.197	<0.025	<0.025	<0.025
Nitrite Nitrogen N	0.0308	0.0255	0.0159	0.0091	0.0167	0.0067	0.0060	0.0082
Dissolved ortho-Phosphate P	<0.0010	0.0072	<0.0010	<0.0010	<0.0010	0.0016	0.0017	0.0017
Total Phosphate P	0.0025	0.0112	0.0021	<0.0020	<0.0020	0.0157	0.0026	0.0034
Total Metals								
Aluminum T-Al	0.0109	0.0155	0.0118	0.0107	0.0069	0.0088	0.0096	0.0205
Antimony T-Sb	0.00126	0.00135	0.00138	0.00132	0.00112	<0.00020	<0.00020	<0.00020
Arsenic T-As	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00092	0.00162	0.00136
Barium T-Ba	0.0153	0.0159	0.0155	0.0156	0.0145	0.0155	0.0150	0.0166
Beryllium T-Be	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Boron T-B	<0.050	<0.050	<0.050	<0.050	<0.050	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00313	0.00324	0.00323	0.00328	0.00408	0.00087	0.00029	0.00016
Calcium T-Ca	144	142	143	135	146	173	180	202
Chromium T-Cr	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0426	0.0420	0.0435	0.0431	0.0429	0.0302	0.0290	0.0322
Copper T-Cu	0.00423	0.00464	0.00442	0.00433	0.00132	<0.0020	<0.0010	<0.0010
Iron T-Fe	0.162	0.183	0.160	0.148	0.039	17.4	19.9	24.8
Lead T-Pb	0.00264	0.00373	0.00278	0.00265	0.00105	0.00074	0.00067	0.00284
Lithium T-Li	0.049	0.049	0.047	0.050	0.054	0.063	0.064	0.072
Magnesium T-Mg	66.0	64.2	63.0	59.6	60.0	60.7	62.1	70.1
Manganese T-Mn	2.22	2.19	2.25	2.24	2.50	3.18	3.17	3.72
Molybdenum T-Mo	0.00217	0.00219	0.00223	0.00212	0.00214	0.00317	0.00269	0.00264
Nickel T-Ni	0.0941	0.0955	0.0963	0.0969	0.0945	0.0630	0.0617	0.0744
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	7.7	7.4	7.3	7.0	8.2	12.0	12.5	13.2
Selenium T-Se	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Silicon T-Si	3.22	3.15	3.16	2.95	2.74	2.47	2.55	2.91
Silver T-Ag	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000020	<0.000020	<0.000020
Sodium T-Na	21.9	21.4	20.8	19.9	22.3	30.4	31.2	33.8
Strontium T-Sr	0.478	0.475	0.483	0.485	0.483	0.522	0.541	0.661
Thallium T-Tl	0.00063	0.00062	0.00062	0.00062	0.00058	0.00022	0.00022	0.00023
Tin T-Sn	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00195	0.00193	0.00192	0.00196	0.00240	0.00319	0.00374	0.00515
Vanadium T-V	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020
Zinc T-Zn	13.2	13.2	13.3	13.2	13.1	2.69	2.43	2.84
Dissolved Metals								
Aluminum D-Al								
Antimony D-Sb								
Arsenic D-As								
Barium D-Ba								
Beryllium D-Be								
Bismuth D-Bi								
Boron D-B								
Cadmium D-Cd								
Calcium D-Ca								
Chromium D-Cr								
Cobalt D-Co								
Copper D-Cu								
Iron D-Fe								
Lead D-Pb								
Lithium D-Li								
Magnesium D-Mg								
Manganese D-Mn								
Molybdenum D-Mo								
Nickel D-Ni								
Phosphorus D-P								
Potassium D-K								
Selenium D-Se								
Silicon D-Si								
Silver D-Ag								
Sodium D-Na								
Strontium D-Sr								
Thallium D-Tl								
Tin D-Sn								
Titanium D-Ti								
Uranium D-U								
Vanadium D-V								
Zinc D-Zn								
Organic Parameters	FP_ SURFACE	FP_1	FP_3	FP_5				
Chlorophyll a (a,b)	0.507	0.01	0.657	0.027				

Faro Pit - 2005 Monitoring Results

RESULTS OF ANALYSIS

Depth (m)	0.05	0.1	1	3	5	15	30	60	80
Sample ID	FP_ SURFACE	FP-0.1	FP-1	FP-3	FP-5	FP-15	FP-30	FP-60	FP-80
Date Sampled	31/08/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005
Time Sampled	10:15	19:00	19:07	19:12	19:16	19:25	19:40	19:55	20:15
ALS Sample ID	9	1	2	3	4	5	6	7	8
Nature	Water	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests									
Conductivity (uS/cm)	899	1180	1180	1180	1190	1250	1390	1410	1460
pH	8.41	6.69	6.86	7.03	7.12	7.20	7.32	7.22	7.14
Total Suspended Solids	7.1	<3.0	<3.0	<3.0	<3.0	<3.0	31.2	34.5	39.8
Dissolved Anions									
Alkalinity-Total CaCO3	124	90.0	93.4	96.7	107	97.7	83.4	90.0	93.2
Sulphate SO4	412	569	570	572	572	632	711	720	761
Nutrients									
Ammonia Nitrogen N	0.453	1.33	2.30	1.27	1.17	1.94	1.63	1.60	1.87
Nitrate Nitrogen N	1.01	0.344	0.351	0.346	0.349	0.199	<0.025	<0.025	<0.025
Nitrite Nitrogen N	0.0098	0.0052	0.0052	0.0051	0.0054	0.0093	0.0075	0.0056	0.0051
Dissolved ortho-Phosphate P	0.0363	<0.0010	<0.0010	<0.0010	<0.0010	0.0085	0.0026	0.0029	0.0027
Total Phosphate P	0.0540	<0.0020	<0.0020	<0.0020	<0.0020	0.0086	0.0031	0.0040	0.0038
Total Metals									
Aluminum T-Al	0.0700	0.0179	0.0143	0.0105	0.0100	0.0068	0.0079	0.0092	0.0138
Antimony T-Sb	0.00520	0.00133	0.00147	0.00145	0.00142	0.00134	<0.00020	<0.00020	<0.00020
Arsenic T-As	0.00087	0.00023	0.00025	0.00021	0.00021	<0.00020	0.00128	0.00163	0.00154
Barium T-Ba	0.0317	0.0160	0.0173	0.0165	0.0162	0.0167	0.0156	0.0155	0.0182
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00077	0.00346	0.00351	0.00340	0.00345	0.00284	0.00073	0.00024	0.00022
Calcium T-Ca	98.0	153	152	147	154	164	188	203	205
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0136	0.0429	0.0449	0.0446	0.0445	0.0454	0.0307	0.0301	0.0307
Copper T-Cu	0.00140	0.00493	0.00537	0.00499	0.00478	<0.0020	<0.0018	<0.0012	<0.0012
Iron T-Fe	0.124	0.224	0.243	0.216	0.230	0.072	18.6	21.7	23.8
Lead T-Pb	0.00168	0.00261	0.00403	0.00283	0.00286	0.00115	0.00067	0.00072	0.00289
Lithium T-Li	0.023	0.047	0.050	0.049	0.047	0.053	0.059	0.060	0.065
Magnesium T-Mg	64.4	67.6	67.4	65.4	68.0	67.2	65.5	68.9	68.1
Manganese T-Mn	0.189	2.36	2.49	2.49	2.46	2.84	3.36	3.45	3.77
Molybdenum T-Mo	0.00332	0.00234	0.00244	0.00238	0.00235	0.00251	0.00337	0.00286	0.00267
Nickel T-Ni	0.112	0.0952	0.0994	0.0991	0.0980	0.0994	0.0630	0.0624	0.0705
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	2.2	7.7	7.6	7.4	7.8	9.1	12.3	13.4	13.0
Selenium T-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon T-Si	2.48	3.27	3.28	3.18	3.32	3.00	2.60	2.77	2.81
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	9.6	21.3	20.9	20.4	21.3	24.1	29.8	32.0	31.1
Strontium T-Sr	0.607	0.470	0.492	0.487	0.487	0.496	0.503	0.525	0.604
Thallium T-Tl	0.00119	0.00066	0.00067	0.00066	0.00067	0.00064	0.00023	0.00023	0.00021
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00402	0.00200	0.00211	0.00209	0.00202	0.00256	0.00329	0.00369	0.00504
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	1.01	11.8	12.3	12.1	12.1	12.2	2.37	2.15	2.40
Dissolved Metals									
Aluminum D-Al		<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Antimony D-Sb		0.00140	0.00139	0.00139	0.00136	0.00138	<0.00020	<0.00020	<0.00020
Arsenic D-As		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Barium D-Ba		0.0159	0.0160	0.0161	0.0161	0.0158	0.0149	0.0145	0.0137
Beryllium D-Be		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth D-Bi		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron D-B		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium D-Cd		0.00337	0.00348	0.00353	0.00361	<0.00010	<0.00010	<0.00010	<0.00010
Calcium D-Ca		151	148	149	147	161	194	192	209
Chromium D-Cr		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt D-Co		0.0438	0.0445	0.0441	0.0443	0.0451	0.0312	0.0305	0.0306
Copper D-Cu		0.00289	0.00300	0.00295	0.00295	<0.00060	<0.00040	<0.00040	<0.00060
Iron D-Fe		<0.030	<0.030	<0.030	<0.030	<0.030	1.70	1.71	1.96
Lead D-Pb		0.00014	0.00024	0.00016	0.00016	<0.00010	<0.00010	<0.00010	<0.00010
Lithium D-Li		0.047	0.046	0.047	0.047	0.051	0.058	0.059	0.064
Magnesium D-Mg		66.7	65.1	65.7	64.3	64.7	67.1	65.3	69.2
Manganese D-Mn		2.45	2.49	2.50	2.48	2.90	3.54	3.59	3.83
Molybdenum D-Mo		0.00231	0.00230	0.00242	0.00237	0.00243	0.00017	<0.00010	<0.00010
Nickel D-Ni		0.101	0.101	0.102	0.103	0.103	0.0675	0.0658	0.0731
Phosphorus D-P		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium D-K		7.6	7.4	7.5	7.3	8.9	12.7	12.4	12.9
Selenium D-Se		<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon D-Si		3.23	3.13	3.17	3.09	2.88	2.32	2.28	2.46
Silver D-Ag		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium D-Na		20.8	20.2	20.5	20.2	23.4	31.3	30.2	30.6
Strontium D-Sr		0.493	0.506	0.513	0.508	0.519	0.544	0.568	0.650
Thallium D-Tl		0.00064	0.00063	0.00062	0.00061	0.00060	0.00021	<0.00020	<0.00020
Tin D-Sn		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium D-Ti		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium D-U		0.00187	0.00188	0.00192	0.00193	0.00239	0.00114	0.00122	0.00157
Vanadium D-V		<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc D-Zn		12.1	12.4	12.6	12.5	12.4	2.00	1.84	2.04
Organic Parameters	FP- SURFACE	FP-1	FP-3	FP-5	FP-7				
Chlorophyll a (a,b)	0.0006	0.0006	0.0006	0.0006	0.0006	-		-	-

Grum Pit - 2005 Monitoring Results

RESULTS OF ANALYSIS

Depth (m)	1	3	5	10	15	30	40
Sample ID	GP-1 GRUM PIT @	GP-3 GRUM PIT @	GP-5 GRUM PIT @	GP-10 GRUM PIT @	GP-15 GRUM PIT @	GP-30 GRUM PIT @	GP-40 GRUM PIT @
Date Sampled	9/06/2005	9/06/2005	9/06/2005	9/06/2005	9/06/2005	9/06/2005	9/06/2005
Time Sampled	11:40	11:50	12:00	12:10	12:15	23:30	12:45
ALS Sample ID	8	9	10	11	12	13	14
Nature	Water	Water	Water	Water	Water	Water	Water
Physical Tests							
Conductivity (uS/cm)	1000	1030	1080	1070	1070	1070	1030
pH	8.07	8.07	7.99	7.99	8.00	8.11	8.01
Total Suspended Solids	3.3	3.9	4.6	3.9	<3.0	11.3	<3.0
Dissolved Anions							
Alkalinity-Total CaCO3	157	164	187	172	179	176	172
Sulphate SO4	408	421	435	437	433	440	436
Nutrients							
Ammonia Nitrogen N	0.0067	0.0100	0.0053	0.0153	0.0200	0.0240	0.0180
Nitrate Nitrogen N	0.958	0.989	1.03	1.07	1.10	1.12	1.11
Nitrite Nitrogen N	0.015	0.014	<0.010	<0.010	<0.010	<0.010	<0.010
Dissolved ortho-Phosphate P	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Phosphate P	0.0031	0.002	0.0029	0.0039	0.0021	0.0025	0.0031
Total Metals							
Aluminum T-Al	0.0331	0.0353	0.0340	0.0261	0.0216	0.0291	0.0217
Antimony T-Sb	0.00602	0.00697	0.00772	0.00758	0.00751	0.00772	0.00786
Arsenic T-As	0.00069	0.00073	0.00077	0.00106	0.00097	0.00145	0.00213
Barium T-Ba	0.0410	0.0442	0.0460	0.0461	0.0458	0.0466	0.0474
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00525	0.00585	0.00668	0.00673	0.00656	0.00678	0.00674
Calcium T-Ca	114	122	127	126	125	123	119
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0206	0.0231	0.0251	0.0245	0.0240	0.0250	0.0256
Copper T-Cu	0.00140	0.00173	0.00322	0.00350	0.00324	0.00328	0.00326
Iron T-Fe	0.050	0.053	0.044	0.038	0.042	0.087	0.132
Lead T-Pb	0.00128	0.00155	0.00157	0.00173	0.00119	0.00147	0.00135
Lithium T-Li	0.022	0.025	0.025	0.024	0.025	0.025	0.025
Magnesium T-Mg	66.8	70.8	72.0	71.3	70.0	68.9	66.0
Manganese T-Mn	0.387	0.438	0.500	0.489	0.487	0.505	0.528
Molybdenum T-Mo	0.00312	0.00330	0.00345	0.00333	0.00345	0.00346	0.00369
Nickel T-Ni	0.173	0.195	0.215	0.209	0.207	0.213	0.220
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	2.3	2.4	2.5	2.5	2.5	2.2	2.4
Selenium T-Se	<0.0020	<0.0020	<0.0020	0.0020	<0.0020	0.0020	<0.0020
Silicon T-Si	2.67	2.91	3.07	3.02	2.96	2.95	2.81
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	9.0	9.8	10.3	10.4	10.2	9.2	9.7
Strontium T-Sr	0.691	0.750	0.780	0.772	0.775	0.784	0.814
Thallium T-Tl	0.00093	0.00103	0.00094	0.00095	0.00094	0.00102	0.00100
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00423	0.00396	0.00517	0.0126	0.00862	0.00873	0.00922
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	5.05	7.07	10.1	9.38	8.93	9.15	9.32
Dissolved Metals							
Aluminum D-Al							
Antimony D-Sb							
Arsenic D-As							
Barium D-Ba							
Beryllium D-Be							
Bismuth D-Bi							
Boron D-B							
Cadmium D-Cd							
Calcium D-Ca							
Chromium D-Cr							
Cobalt D-Co							
Copper D-Cu							
Iron D-Fe							
Lead D-Pb							
Lithium D-Li							
Magnesium D-Mg							
Manganese D-Mn							
Molybdenum D-Mo							
Nickel D-Ni							
Phosphorus D-P							
Potassium D-K							
Selenium D-Se							
Silicon D-Si							
Silver D-Ag							
Sodium D-Na							
Strontium D-Sr							
Thallium D-Tl							
Tin D-Sn							
Titanium D-Ti							
Uranium D-U							
Vanadium D-V							
Zinc D-Zn							
Organic Parameters							
Chlorophyll a (a,b)							

Footnotes:

Grum Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	10	15	30	40
Sample ID	GP-0.1 Grum Surfa	GP-1 Grum Pit @ 1	GP-3 Grum Pit @3r	GP-5 Grum Pit @5r	GP-10 Grum Pit @1	GP-15 Grum Pit @1	GP-30 Grum Pit @3	GP-40 Grum Pit @4
Date Sampled	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005	6/07/2005
Time Sampled	15:00	15:10	15:15	15:30	15:50	16:05	16:45	17:00
ALS Sample ID	9	10	11	12	13	14	15	16
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	970	972	1010	1050	1060	1060	1060	1060
pH	8.40	8.64	8.32	7.82	7.66	7.66	7.68	7.68
Total Suspended Solids	6.8	8.1	6.1	4.1	<3.0	<3.0	<3.0	<3.0
Dissolved Anions								
Alkalinity-Total CaCO3	152	152	169	174	173	171	167	183
Sulphate SO4	430	416	415	459	457	453	453	448
Nutrients								
Ammonia Nitrogen N	0.0470	0.0413	0.0250	0.0170	0.0100	<0.0050	<0.0050	<0.0050
Nitrate Nitrogen N	0.821	0.816	1.10	1.15	1.27	1.28	1.28	1.27
Nitrite Nitrogen N	0.0126	0.0134	0.0141	0.0096	0.0060	0.0059	0.0058	<0.0050
Dissolved ortho-Phosphate P	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Phosphate P	0.0398	0.0371	0.0314	0.0182	0.0089	0.0054	0.0041	0.0046
Total Metals								
Aluminum T-Al	0.0207	0.0264	0.0126	0.0187	0.0176	0.0096	0.0112	0.0112
Antimony T-Sb	0.00584	0.00582	0.00605	0.00740	0.00773	0.00754	0.00747	0.00760
Arsenic T-As	0.00044	0.00045	0.00048	0.00055	0.00093	0.00101	0.00198	0.00262
Barium T-Ba	0.0430	0.0429	0.0415	0.0457	0.0459	0.0447	0.0446	0.0448
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00280	0.00268	0.00466	0.00761	0.00711	0.00666	0.00676	0.00677
Calcium T-Ca	111	113	118	117	122	127	131	117
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0196	0.0193	0.0207	0.0255	0.0251	0.0240	0.0246	0.0244
Copper T-Cu	0.00069	0.00109	0.00086	0.00169	0.00250	0.00269	0.00257	0.00249
Iron T-Fe	<0.040	0.036	0.047	0.050	<0.030	0.037	0.142	0.179
Lead T-Pb	0.00091	0.00092	0.00128	0.00144	0.00130	0.00131	0.00134	0.00146
Lithium T-Li	0.023	0.022	0.023	0.026	0.025	0.026	0.025	0.026
Magnesium T-Mg	65.0	65.5	67.9	65.6	67.8	70.5	71.1	66.2
Manganese T-Mn	0.296	0.289	0.342	0.503	0.493	0.477	0.488	0.492
Molybdenum T-Mo	0.00338	0.00327	0.00325	0.00386	0.00336	0.00326	0.00336	0.00324
Nickel T-Ni	0.161	0.156	0.171	0.217	0.216	0.209	0.213	0.216
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	3.1	3.1	3.3	3.2	3.3	3.5	3.5	3.2
Selenium T-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon T-Si	2.33	2.37	2.72	3.42	3.22	3.32	3.37	3.10
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	10.2	10.1	10.6	10.8	10.9	11.4	11.7	10.9
Strontium T-Sr	0.658	0.648	0.633	0.719	0.715	0.707	0.714	0.721
Thallium T-Tl	0.00109	0.00107	0.00117	0.00105	0.00099	0.00098	0.00107	0.00115
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00446	0.00442	0.00368	0.00248	0.0104	0.00923	0.00939	0.00944
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	0.943	0.919	2.78	10.8	9.37	8.24	8.39	8.38
Dissolved Metals								
Aluminum D-Al	0.0054	<0.0020	<0.0020	0.0097	<0.0020	0.0030	<0.0020	<0.0020
Antimony D-Sb	0.00601	0.00583	0.00606	0.00756	0.00749	0.00738	0.00728	0.00729
Arsenic D-As	0.00037	0.00033	0.00034	0.00034	0.00073	0.00075	0.00061	0.00066
Barium D-Ba	0.0425	0.0414	0.0416	0.0442	0.0444	0.0439	0.0434	0.0430
Beryllium D-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth D-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron D-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium D-Cd	0.00152	0.00082	0.00353	0.00674	0.00689	0.00665	0.00669	0.00666
Calcium D-Ca	115	112	113	118	120	125	116	119
Chromium D-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt D-Co	0.0188	0.0179	0.0210	0.0242	0.0240	0.0240	0.0240	0.0236
Copper D-Cu	0.00050	0.00025	0.00034	0.00658	0.00139	0.00213	0.00199	0.00181
Iron D-Fe	<0.030	<0.030	<0.030	0.063	<0.030	<0.030	<0.030	<0.030
Lead D-Pb	0.00043	0.00020	0.00047	0.00181	0.00063	0.00073	<0.00010	<0.00010
Lithium D-Li	0.022	0.021	0.024	0.025	0.025	0.025	0.025	0.025
Magnesium D-Mg	67.4	65.8	65.0	67.3	66.7	68.3	67.2	67.5
Manganese D-Mn	0.269	0.248	0.338	0.477	0.476	0.477	0.480	0.475
Molybdenum D-Mo	0.00337	0.00324	0.00340	0.00334	0.00321	0.00329	0.00330	0.00333
Nickel D-Ni	0.155	0.147	0.175	0.207	0.204	0.207	0.209	0.206
Phosphorus D-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium D-K	3.2	3.1	3.2	3.3	3.2	3.4	3.2	3.3
Selenium D-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon D-Si	2.34	2.23	2.46	3.45	3.17	3.25	3.05	3.11
Silver D-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium D-Na	10.6	10.3	10.4	11.2	10.7	11.1	11.0	11.0
Strontium D-Sr	0.667	0.642	0.658	0.695	0.697	0.704	0.711	0.697
Thallium D-Tl	0.00110	0.00105	0.00116	0.00100	0.00094	0.00096	0.00105	0.00110
Tin D-Sn	<0.00020	<0.00020	<0.00020	0.00058	<0.00020	<0.00020	<0.00020	<0.00020
Titanium D-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium D-U	0.00445	0.00431	0.00380	0.00263	0.00999	0.00922	0.00923	0.00915
Vanadium D-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc D-Zn	0.431	0.144	1.90	10.7	8.98	8.19	8.19	8.06
Organic Parameters	GP-0.1 Grum Surfa	GP-1 Grum Pit @ 1	GP-3 Grum Pit @3r	GP-5 Grum Pit @5r	GP-10 Grum Pit @1	GP-15 Grum Pit @1	GP-30 Grum Pit @3	GP-40 Grum Pit @4
Chlorophyll a (a,b)	24.1	20.3	9.65	30.3	3.34	2.99	0.196	0.333

Footnotes:

Grum Pit - 2005 Monitoring Results

RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	10	15	30	40
Sample ID	GP_0.1	GP_1	GP_3	GP_5	GP_10	GP_15	GP_30	GP_40
Date Sampled	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005	3/08/2005
Time Sampled	10:00	10:08	10:18	10:28	10:38	10:48	11:00	11:08
ALS Sample ID	9	10	11	12	13	14	15	16
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	897	894	897	1040	1050	1050	1050	1060
pH	8.72	8.80	8.80	7.97	7.93	7.95	7.98	7.50
Total Suspended Solids	10.7	9.3	9.3	4.0	<3.0	<3.0	4.7	9.3
Dissolved Anions								
Alkalinity-Total CaCO3	113	108	117	171	174	173	176	178
Sulphate SO4	407	405	401	436	439	432	433	433
Nutrients								
Ammonia Nitrogen N	0.127	0.0993	0.0600	0.114	0.0407	0.0427	0.0453	0.0453
Nitrate Nitrogen N	0.616	0.621	0.664	1.08	1.20	1.16	1.15	1.14
Nitrite Nitrogen N	0.0014	0.0013	0.0020	0.0057	0.0041	0.0038	0.0041	0.0045
Dissolved ortho-Phosphate P	0.001	0.001	0.001	0.001	0.0015	0.0012	0.001	0.001
Total Phosphate P	0.0215	0.0216	0.0174	0.0070	0.0063	0.0047	0.0081	0.0179
Total Metals								
Aluminum T-Al	0.0630	0.0551	0.0672	0.0363	0.0151	0.0139	0.0674	0.0961
Antimony T-Sb	0.00513	0.00514	0.00497	0.00747	0.00832	0.00835	0.00833	0.00845
Arsenic T-As	0.00069	0.00069	0.00067	0.00092	0.00155	0.00170	0.00222	0.00248
Barium T-Ba	0.0257	0.0254	0.0249	0.0462	0.0498	0.0494	0.0498	0.0511
Beryllium T-Be	<0.00050	<0.00050	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.00050	<0.00050	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.010	<0.010	<0.010	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.000562	0.000598	0.000713	0.00579	0.00781	0.00755	0.00746	0.00786
Calcium T-Ca	97.1	95.5	96.5	121	128	127	128	130
Chromium T-Cr	<0.00050	<0.00050	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0153	0.0153	0.0147	0.0242	0.0256	0.0258	0.0261	0.0262
Copper T-Cu	0.00096	0.00133	0.00091	0.00143	0.00188	0.00202	0.00198	0.00216
Iron T-Fe	0.084	0.083	0.089	0.117	0.097	0.117	0.226	0.320
Lead T-Pb	0.000837	0.000964	0.000940	0.00168	0.00136	0.00149	0.00166	0.00204
Lithium T-Li	0.0243	0.0239	0.0234	0.026	0.027	0.028	0.027	0.028
Magnesium T-Mg	69.1	68.2	68.3	69.4	72.5	71.5	74.2	73.9
Manganese T-Mn	0.218	0.222	0.223	0.484	0.531	0.530	0.546	0.556
Molybdenum T-Mo	0.00344	0.00339	0.00324	0.00358	0.00364	0.00361	0.00359	0.00374
Nickel T-Ni	0.123	0.121	0.119	0.206	0.228	0.227	0.231	0.230
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	2.2	2.2	2.2	2.3	2.4	2.5	2.6	2.5
Selenium T-Se	0.0017	0.0019	0.0016	<0.0020	<0.0020	0.0021	<0.0020	0.0022
Silicon T-Si	2.35	2.31	2.31	2.83	3.00	2.95	3.05	3.09
Silver T-Ag	<0.000010	<0.000010	<0.000010	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	9.2	9.1	9.1	9.4	10.2	10.3	10.4	10.2
Strontium T-Sr	0.582	0.587	0.567	0.739	0.792	0.796	0.810	0.821
Thallium T-Tl	0.00114	0.00114	0.00111	0.00116	0.00108	0.00109	0.00114	0.00114
Tin T-Sn	<0.00010	<0.00010	<0.00010	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00384	0.00383	0.00366	0.00512	0.00980	0.00989	0.00986	0.00991
Vanadium T-V	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	0.421	0.427	0.526	7.62	10.3	10.4	10.5	10.4
Dissolved Metals								
Aluminum D-Al								
Antimony D-Sb								
Arsenic D-As								
Barium D-Ba								
Beryllium D-Be								
Bismuth D-Bi								
Boron D-B								
Cadmium D-Cd								
Calcium D-Ca								
Chromium D-Cr								
Cobalt D-Co								
Copper D-Cu								
Iron D-Fe								
Lead D-Pb								
Lithium D-Li								
Magnesium D-Mg								
Manganese D-Mn								
Molybdenum D-Mo								
Nickel D-Ni								
Phosphorus D-P								
Potassium D-K								
Selenium D-Se								
Silicon D-Si								
Silver D-Ag								
Sodium D-Na								
Strontium D-Sr								
Thallium D-Tl								
Tin D-Sn								
Titanium D-Ti								
Uranium D-U								
Vanadium D-V								
Zinc D-Zn								
Organic Parameters	GP_0.1	GP_1	GP_3	GP_5	GP_7	GP_10	GP_15	
Chlorophyll a (a,b)	13.5	25.0	19.5	3.35	1.25	0.220	1.18	

Footnotes:

Grum Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	1	3	4	5	7	10	20	40
Sample ID	GP_1	GP_3	GP_40	GP_5	GP_7	GP_10	GP_20	GP_40
Date Sampled	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005	31/08/2005
Time Sampled	10:30	10:40	12:10	10:55	11:15	11:30	11:45	12:10
ALS Sample ID	10	11	16	12	13	14	15	16
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	901	898	904	1040	1030	1040	1040	904
pH	8.51	8.55	8.48	7.82	7.83	7.34	7.60	8.48
Total Suspended Solids	6.4	5.7	5.7	<3.0	5.7	<3.0	6.4	5.7
Dissolved Anions								
Alkalinity-Total CaCO3	120	118	120	185	178	176	180	120
Sulphate SO4	410	413	411	443	443	442	449	411
Nutrients								
Ammonia Nitrogen N	0.463	0.427	0.497	0.0520	0.0473	0.0247	0.0347	0.497
Nitrate Nitrogen N	0.005	1.01	0.998	1.25	1.27	1.29	1.26	0.998
Nitrite Nitrogen N	0.0087	0.0096	0.0096	0.0044	0.0061	0.0104	0.0092	0.0096
Dissolved ortho-Phosphate P	0.0237	0.0291	0.0253	0.001	0.0013	0.001	0.0033	0.0253
Total Phosphate P	0.0316	0.0406	0.0435	0.0063	0.0071	0.0036	0.0078	0.0435
Total Metals								
Aluminum T-Al	0.0397	0.0514	0.0283	0.0308	0.0280	0.0165	0.0757	0.0283
Antimony T-Sb	0.00516	0.00509	0.00536	0.00653	0.00645	0.00659	0.00681	0.00536
Arsenic T-As	0.00090	0.00087	0.00093	0.00088	0.00086	0.00135	0.00160	0.00093
Barium T-Ba	0.0313	0.0304	0.0322	0.0429	0.0424	0.0426	0.0434	0.0322
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00083	0.00077	0.00084	0.00331	0.00366	0.00624	0.00630	0.00084
Calcium T-Ca	99.3	100	102	133	139	137	127	102
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0137	0.0129	0.0142	0.0238	0.0232	0.0229	0.0237	0.0142
Copper T-Cu	0.00127	0.00116	0.00124	0.00102	0.00099	0.00129	0.00118	0.00124
Iron T-Fe	0.076	0.081	0.068	0.106	0.099	0.115	0.213	0.068
Lead T-Pb	0.00159	0.00139	0.00156	0.00186	0.00159	0.00157	0.00138	0.00156
Lithium T-Li	0.023	0.022	0.025	0.025	0.024	0.026	0.026	0.025
Magnesium T-Mg	65.0	66.5	64.5	72.6	75.7	73.0	68.8	64.5
Manganese T-Mn	0.189	0.179	0.199	0.489	0.475	0.480	0.513	0.199
Molybdenum T-Mo	0.00331	0.00323	0.00340	0.00305	0.00292	0.00295	0.00293	0.00340
Nickel T-Ni	0.112	0.106	0.117	0.208	0.202	0.202	0.206	0.117
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	2.2	2.3	2.3	2.7	2.8	2.9	2.6	2.3
Selenium T-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon T-Si	2.46	2.54	2.44	3.34	3.45	3.29	3.11	2.44
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000023	<0.000020
Sodium T-Na	9.4	9.8	9.5	11.4	11.7	11.3	10.7	9.5
Strontium T-Sr	0.610	0.583	0.628	0.779	0.763	0.780	0.801	0.628
Thallium T-Tl	0.00119	0.00116	0.00122	0.00105	0.00104	0.00106	0.00110	0.00122
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00386	0.00373	0.00390	0.00753	0.00788	0.00906	0.00898	0.00390
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	0.996	0.976	1.08	10.2	9.82	9.96	10.0	1.08
Dissolved Metals								
Aluminum D-Al	-	-	-	-	-	-	-	-
Antimony D-Sb								
Arsenic D-As								
Barium D-Ba								
Beryllium D-Be								
Bismuth D-Bi								
Boron D-B								
Cadmium D-Cd								
Calcium D-Ca								
Chromium D-Cr								
Cobalt D-Co								
Copper D-Cu								
Iron D-Fe								
Lead D-Pb								
Lithium D-Li								
Magnesium D-Mg								
Manganese D-Mn								
Molybdenum D-Mo								
Nickel D-Ni								
Phosphorus D-P								
Potassium D-K								
Selenium D-Se								
Silicon D-Si								
Silver D-Ag								
Sodium D-Na								
Strontium D-Sr								
Thallium D-Tl								
Tin D-Sn								
Titanium D-Ti								
Uranium D-U								
Vanadium D-V								
Zinc D-Zn								
Organic Parameters	GP_ SURFACE	GP_1		GP_3	GP_5	GP_7	GP_10	
Chlorophyll a (a,b)	0.639	1.01		0.847	2.64	3.06	3.91	

Footnotes:

Grum Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	10	15	30	40
Sample ID	GP-0.1	GP-1	GP-3	GP-5	GP-10	GP-15	GP-30	GP-40
Date Sampled	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005
Time Sampled	11:45	12:07	12:14	12:20	12:27	12:31	12:45	13:15
ALS Sample ID	9	10	11	12	13	14	15	16
Nature	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests								
Conductivity (uS/cm)	938	937	945	1060	1080	1070	1070	1070
pH	7.93	7.97	8.07	7.79	7.61	7.66	7.68	7.72
Total Suspended Solids	3.8	3.8	<3.0	5.2	4.5	3.2	6.5	7.8
Dissolved Anions								
Alkalinity-Total CaCO3	128	123	127	173	171	209	182	193
Sulphate SO4	403	403	402	428	439	440	441	441
Nutrients								
Ammonia Nitrogen N	0.530	0.657	0.647	0.204	0.0107	0.0067	0.0107	0.0107
Nitrate Nitrogen N	1.16	1.15	1.15	1.22	1.33	1.29	1.28	1.29
Nitrite Nitrogen N	0.0134	0.0145	0.0142	0.0099	0.0021	0.0011	0.0021	0.0019
Dissolved ortho-Phosphate P	0.0297	0.0310	0.0294	0.0120	0.001	0.001	0.001	0.001
Total Phosphate P	0.0436	0.0426	0.0406	0.0170	0.0042	0.0023	0.0049	0.0052
Total Metals								
Aluminum T-Al	0.0476	0.0501	0.0487	0.0585	<0.0020	0.0711	0.137	0.156
Antimony T-Sb	0.00554	0.00553	0.00527	0.00651	0.00694	0.00697	0.00684	0.00704
Arsenic T-As	0.00103	0.00101	0.00095	0.00082	0.00041	0.00157	0.00188	0.00215
Barium T-Ba	0.0335	0.0338	0.0323	0.0422	0.0480	0.0431	0.0442	0.0458
Beryllium T-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth T-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron T-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium T-Cd	0.00107	0.00116	0.00109	0.00312	0.00489	0.00618	0.00621	0.00640
Calcium T-Ca	106	102	98.1	128	131	129	125	120
Chromium T-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt T-Co	0.0140	0.0143	0.0137	0.0217	0.0150	0.0226	0.0229	0.0235
Copper T-Cu	0.00136	0.00144	0.00125	0.00110	<0.00060	0.00120	0.00123	0.00134
Iron T-Fe	0.104	0.094	0.093	0.132	<0.030	0.223	0.346	0.371
Lead T-Pb	0.00180	0.00196	0.00181	0.00247	0.00025	0.00136	0.00157	0.00166
Lithium T-Li	0.022	0.023	0.022	0.024	0.024	0.024	0.023	0.024
Magnesium T-Mg	65.6	62.7	60.9	68.8	70.6	69.0	67.0	64.1
Manganese T-Mn	0.224	0.231	0.213	0.479	0.524	0.520	0.537	0.559
Molybdenum T-Mo	0.00345	0.00350	0.00324	0.00327	0.00381	0.00308	0.00308	0.00314
Nickel T-Ni	0.115	0.117	0.110	0.184	0.108	0.196	0.195	0.203
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	2.4	2.2	2.2	2.6	2.6	2.5	2.4	2.3
Selenium T-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon T-Si	2.56	2.47	2.36	3.10	3.06	3.09	3.09	2.98
Silver T-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium T-Na	9.3	8.5	8.6	10.0	11.0	10.4	10.3	9.7
Strontium T-Sr	0.583	0.590	0.559	0.707	0.855	0.727	0.729	0.756
Thallium T-Tl	0.00121	0.00123	0.00116	0.00116	0.00110	0.00108	0.00111	0.00115
Tin T-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00408	0.00408	0.00385	0.00445	0.00377	0.00875	0.00882	0.00916
Vanadium T-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc T-Zn	1.50	1.52	1.42	6.39	1.56	8.47	8.50	8.85
Dissolved Metals								
Aluminum D-Al	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Antimony D-Sb	0.00513	0.00531	0.00537	0.00612	0.00665	0.00713	0.00699	0.00709
Arsenic D-As	0.00064	0.00069	0.00069	0.00042	0.00029	0.00047	0.00048	0.00050
Barium D-Ba	0.0321	0.0326	0.0328	0.0408	0.0463	0.0447	0.0434	0.0437
Beryllium D-Be	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth D-Bi	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron D-B	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Cadmium D-Cd	0.00081	0.00075	0.00077	0.00261	0.00622	0.00651	0.00637	0.00639
Calcium D-Ca	100	96.5	96.8	124	133	128	123	114
Chromium D-Cr	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt D-Co	0.0133	0.0137	0.0137	0.0214	0.0201	0.0238	0.0233	0.0236
Copper D-Cu	<0.0010	<0.0010	<0.0010	<0.0010	<0.00060	<0.0010	<0.0010	<0.0010
Iron D-Fe	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead D-Pb	0.00029	0.00032	0.00035	0.00053	<0.00010	<0.00010	<0.00010	0.00029
Lithium D-Li	0.021	0.021	0.021	0.023	0.023	0.023	0.022	0.023
Magnesium D-Mg	61.1	60.0	59.9	65.5	70.2	68.0	65.6	61.2
Manganese D-Mn	0.196	0.197	0.200	0.469	0.544	0.555	0.560	0.580
Molybdenum D-Mo	0.00337	0.00350	0.00356	0.00325	0.00351	0.00333	0.00325	0.00328
Nickel D-Ni	0.111	0.115	0.116	0.187	0.157	0.214	0.209	0.213
Phosphorus D-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium D-K	2.2	<2.0	2.1	2.5	2.6	2.5	2.4	2.2
Selenium D-Se	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon D-Si	2.30	2.23	2.25	2.86	3.07	2.94	2.84	2.65
Silver D-Ag	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Sodium D-Na	8.5	8.0	8.2	9.7	10.9	10.5	10.2	9.2
Strontium D-Sr	0.604	0.615	0.624	0.754	0.840	0.799	0.790	0.812
Thallium D-Tl	0.00113	0.00111	0.00117	0.00109	0.00105	0.00111	0.00112	0.00114
Tin D-Sn	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium D-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium D-U	0.00395	0.00397	0.00392	0.00420	0.00144	0.00931	0.00916	0.00915
Vanadium D-V	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Zinc D-Zn	1.18	1.19	1.24	6.44	2.07	9.28	9.17	9.29
Organic Parameters	GP-0.1	GP-1	GP-3	GP-5	GP-7	GP-10		
Chlorophyll a (a,b)	0.136	0.0006	0.240	0.152	0.0416	0.0335		

Footnotes:

Vangorda Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	1	3	5	15	30	40
Sample ID	VP-1 VGDA PIT @1m	VP-3 VGDA PIT @3m	VP-5 VGDA PIT @5m	VP-15 VGDA PIT @15m	VP-30 VGDA PIT @30m	VP-40 VGDA PIT @40m
Date Sampled	9/06/2005	9/06/2005	9/06/2005	9/06/2005	9/06/2005	9/06/2005
Time Sampled	17:00	17:10	17:15	17:20	17:30	17:40
ALS Sample ID	15	16	17	18	19	20
Nature	Water	Water	Water	Water	Water	Water
Physical Tests						
Conductivity (uS/cm)	1320	1880	2000	2070	2140	2140
pH	7.49	7.17	6.86	6.44	5.90	5.82
Total Suspended Solids	4.6	22.9	41.9	56.9	61.9	66.9
Dissolved Anions						
Alkalinity-Total CaCO3	24.8	42.0	18.0	13.2	10.4	10.7
Sulphate SO4	732	1130	1220	1290	1330	1360
Nutrients						
Ammonia Nitrogen N	0.180	0.420	0.470	0.500	0.590	0.550
Nitrate Nitrogen N	0.184	0.055	<0.050	<0.050	<0.050	<0.050
Nitrite Nitrogen N	<0.010	<0.010	<0.010	0.015	<0.010	<0.010
Dissolved ortho-Phosphate P	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphate P	0.0038	<0.0060	<0.030	<0.030	<0.030	<0.030
Total Metals						
Aluminum T-Al	0.036	0.068	0.056	0.077	0.214	0.271
Antimony T-Sb	<0.0020	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050
Arsenic T-As	<0.0020	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050
Barium T-Ba	0.0510	0.0347	0.0278	0.0254	0.0284	0.0310
Beryllium T-Be	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025
Bismuth T-Bi	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025
Boron T-B	<0.20	<0.20	<0.20	<0.20	<0.50	<0.50
Cadmium T-Cd	0.0746	0.0909	0.0979	0.105	0.127	0.129
Calcium T-Ca	156	237	252	240	250	248
Chromium T-Cr	<0.010	<0.010	<0.010	<0.010	<0.025	<0.025
Cobalt T-Co	0.376	0.590	0.666	0.699	0.784	0.789
Copper T-Cu	0.0692	0.132	0.120	0.237	0.439	0.445
Iron T-Fe	0.428	4.81	18.4	24.0	37.7	46.8
Lead T-Pb	0.0115	0.0107	0.0052	0.0045	0.0421	0.0432
Lithium T-Li	<0.10	<0.10	<0.10	<0.10	<0.25	<0.25
Magnesium T-Mg	66.7	93.2	99.9	97.8	106	101
Manganese T-Mn	23.0	33.0	37.1	39.5	43.8	43.9
Molybdenum T-Mo	<0.0010	<0.0010	<0.0010	<0.0010	<0.0025	<0.0025
Nickel T-Ni	0.373	0.572	0.630	0.648	0.719	0.706
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	<2.0	2.5	3.0	2.7	2.8	3.5
Selenium T-Se	<0.020	<0.020	<0.020	<0.020	<0.050	<0.050
Silicon T-Si	2.46	2.99	3.18	3.06	3.32	3.31
Silver T-Ag	<0.00020	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050
Sodium T-Na	3.0	4.6	5.3	4.7	4.8	5.9
Strontium T-Sr	0.803	1.14	1.21	1.23	1.36	1.34
Thallium T-Tl	<0.0020	0.0020	0.0022	0.0023	<0.0050	<0.0050
Tin T-Sn	<0.0020	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00059	0.00043	0.00034	0.00036	0.00060	0.00074
Vanadium T-V	<0.020	<0.020	<0.020	<0.020	<0.050	<0.050
Zinc T-Zn	74.0	109	124	131	149	149
Dissolved Metals						
Aluminum D-Al						
Antimony D-Sb						
Arsenic D-As						
Barium D-Ba						
Beryllium D-Be						
Bismuth D-Bi						
Boron D-B						
Cadmium D-Cd						
Calcium D-Ca						
Chromium D-Cr						
Cobalt D-Co						
Copper D-Cu						
Iron D-Fe						
Lead D-Pb						
Lithium D-Li						
Magnesium D-Mg						
Manganese D-Mn						
Molybdenum D-Mo						
Nickel D-Ni						
Phosphorus D-P						
Potassium D-K						
Selenium D-Se						
Silicon D-Si						
Silver D-Ag						
Sodium D-Na						
Strontium D-Sr						
Thallium D-Tl						
Tin D-Sn						
Titanium D-Ti						
Uranium D-U						
Vanadium D-V						
Zinc D-Zn						
Organic Parameters						
Chlorophyll a (a,b)						

Vangorda Pit - 2005 Monitoring Results
RESULTS OF ANALYSIS

Depth (m)	0.1	1	3	5	10	20	30
Sample ID	VP-0.1	VP-1	VP-3	VP-5	VP-10	VP-20	VP-30
Date Sampled	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005	14/09/2005
Time Sampled	15:20	15:30	15:38	15:42	15:46	15:50	16:00
ALS Sample ID	17	18	19	20	21	22	23
Nature	Water	Water	Water	Water	Water	Water	Water
Physical Tests							
Conductivity (uS/cm)	1880	1870	2060	2130	2150	2150	2150
pH	7.05	7.00	6.65	5.32	5.36	5.37	5.38
Total Suspended Solids	10.5	10.5	38.5	47.2	45.2	43.2	45.8
Dissolved Anions							
Alkalinity-Total CaCO3	12.8	12.8	9.0	8.1	8.2	7.2	7.8
Sulphate SO4	1190	1200	1370	1420	1420	1420	1430
Nutrients							
Ammonia Nitrogen N	0.490	0.460	0.590	0.640	0.620	0.630	0.590
Nitrate Nitrogen N	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrite Nitrogen N	<0.010	0.013	<0.010	0.016	0.019	0.010	0.011
Dissolved ortho-Phosphate P	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0010
Total Phosphate P	<0.0020	0.0029	0.0020	0.0024	0.0027	0.0032	0.0022
Total Metals							
Aluminum T-Al	0.023	0.030	0.027	<0.050	<0.050	<0.050	<0.050
Antimony T-Sb	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050
Arsenic T-As	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050
Barium T-Ba	0.0193	0.0208	0.0165	0.0137	0.0153	0.0164	0.0148
Beryllium T-Be	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.025
Bismuth T-Bi	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.025
Boron T-B	<0.20	<0.20	<0.20	<0.50	<0.50	<0.50	<0.50
Cadmium T-Cd	0.0854	0.0914	0.107	0.110	0.114	0.124	0.116
Calcium T-Ca	240	245	255	255	271	280	281
Chromium T-Cr	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.025
Cobalt T-Co	0.491	0.517	0.683	0.719	0.761	0.801	0.742
Copper T-Cu	0.0063	0.0073	0.0745	0.124	0.0903	0.0992	0.0899
Iron T-Fe	3.37	3.52	31.8	40.7	49.4	45.3	40.3
Lead T-Pb	0.0096	0.0114	0.0100	0.0056	0.0180	0.0208	0.0223
Lithium T-Li	<0.10	<0.10	<0.10	<0.25	<0.25	<0.25	<0.25
Magnesium T-Mg	86.9	89.7	104	104	109	113	110
Manganese T-Mn	31.3	32.8	40.8	41.3	44.6	47.0	43.4
Molybdenum T-Mo	<0.0010	<0.0010	<0.0010	<0.0025	<0.0025	<0.0025	<0.0025
Nickel T-Ni	0.443	0.466	0.616	0.644	0.691	0.733	0.666
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium T-K	2.7	2.6	2.9	3.1	3.6	3.3	3.0
Selenium T-Se	<0.020	<0.020	<0.020	<0.050	<0.050	<0.050	<0.050
Silicon T-Si	2.38	2.45	3.28	3.35	3.53	3.62	3.45
Silver T-Ag	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00050
Sodium T-Na	5.4	5.4	5.4	5.3	6.7	5.8	5.0
Strontium T-Sr	1.17	1.25	1.18	1.23	1.31	1.38	1.28
Thallium T-Tl	0.0022	0.0023	0.0023	<0.0050	<0.0050	<0.0050	<0.0050
Tin T-Sn	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050
Titanium T-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium T-U	0.00023	0.00034	0.00027	<0.00050	<0.00050	<0.00050	<0.00050
Vanadium T-V	<0.020	<0.020	<0.020	<0.050	<0.050	<0.050	<0.050
Zinc T-Zn	87.8	91.7	122	127	137	145	134
Dissolved Metals							
Aluminum D-Al	<0.020	<0.020	<0.020	<0.050	<0.050	<0.050	<0.050
Antimony D-Sb	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050
Arsenic D-As	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050
Barium D-Ba	0.0152	0.0146	0.0145	0.0125	0.0116	0.0114	0.0112
Beryllium D-Be	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.025
Bismuth D-Bi	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.025
Boron D-B	<0.20	<0.20	<0.20	<0.50	<0.50	<0.50	<0.50
Cadmium D-Cd	0.0935	0.0899	0.115	0.120	0.116	0.117	0.111
Calcium D-Ca	251	238	270	260	279	293	272
Chromium D-Cr	<0.010	<0.010	<0.010	<0.025	<0.025	<0.025	<0.025
Cobalt D-Co	0.502	0.494	0.698	0.735	0.748	0.727	0.722
Copper D-Cu	0.0074	0.0071	0.0642	0.109	0.0717	0.0765	0.0747
Iron D-Fe	0.437	0.396	16.3	18.8	20.7	22.2	19.6
Lead D-Pb	<0.0010	<0.0010	<0.0010	<0.0025	<0.0025	<0.0025	<0.0025
Lithium D-Li	<0.10	<0.10	<0.10	<0.25	<0.25	<0.25	<0.25
Magnesium D-Mg	92.9	85.1	108	105	113	117	107
Manganese D-Mn	32.8	32.5	42.8	44.1	44.2	43.5	42.8
Molybdenum D-Mo	<0.0010	<0.0010	<0.0010	<0.0025	<0.0025	<0.0025	<0.0025
Nickel D-Ni	0.469	0.461	0.646	0.686	0.682	0.670	0.659
Phosphorus D-P	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium D-K	2.8	2.5	3.2	3.0	3.3	3.5	3.1
Selenium D-Se	<0.020	<0.020	<0.020	<0.050	<0.050	<0.050	<0.050
Silicon D-Si	2.45	2.24	3.26	3.22	3.43	3.63	3.24
Silver D-Ag	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00050
Sodium D-Na	5.7	5.2	5.9	5.3	6.0	6.1	5.2
Strontium D-Sr	1.29	1.27	1.32	1.33	1.33	1.30	1.30
Thallium D-Tl	0.0021	0.0022	0.0023	<0.0050	<0.0050	<0.0050	<0.0050
Tin D-Sn	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050
Titanium D-Ti	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium D-U	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00050
Vanadium D-V	<0.020	<0.020	<0.020	<0.050	<0.050	<0.050	<0.050
Zinc D-Zn	94.0	92.5	133	139	138	136	134
Organic Parameters	VP-0.1	VP-1	VP-3				
Chlorophyll a (a,b)	0.0309	0.00396	<0.00060	-	-	-	-

Appendix C

Limnology Assessment

Report Prepared by Greg Lawrence and Associates (January 2006)

Physical Limnology of the Faro Site Pit-Lakes, 2004 & 2005

Prepared by:

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INTRODUCTION

This report examines data from 2004 and 2005 from the Faro, Grum and Vangorda pit-lakes to determine the circulation in these water bodies. The data collection was overseen by SRK Consulting. In 2005 data collection was conducted in conjunction with a fertilization experiment designed by Lorax Environmental. In both 2004 and 2005, data collection was conducted by Laberge Environmental Consultants.

Of particular interest is whether or not the pit-lakes are meromictic, that is permanently stratified with a fresher layer capping more saline water at depth. While most temperate lakes turns over in spring and fall, in a water body that is permanently stratified, wind mixing is not sufficient to overcome the salinity-driven density difference between the upper and lower layers. This results in isolation of the lower water. While this isolation provides the opportunity to isolate deleterious materials at depth, breakdown of the stratification could result in discharge of low-quality water to the environment. As a result, it is important to assess the circulation and stability of these pit-lakes based on field observations.

DATA COLLECTION

CTD profiles CTD (conductivity-temperature-depth) profiles were collected and sampling dates are given in Appendix 1. Three different profiling instruments were used:

- a Seabird 19plus CTD was used from June 2004 to June 2005,
- an Applied Microsystems StdPlus 638 CTD was used for July-September, 2005 (as a Seabird profiler was not available for rental), and
- additional casts with a YSI 600SQ profiler were taken on September 14, 2005 (primarily used to collect dissolved oxygen data).

Of particular importance is pit-lake salinity, measured by conductivity. The conductivity data is evaluated in Appendix 2. We conclude that:

- the Seabird 19plus conductivity is accurate to 0.5% assuming that the deep water in Faro pit remains unchanged,
- the Applied Microsystems CTD conductivity shows increasing drift and distortion over the summer and is erroneous, reason unknown, and
- the conductivity of the YSI is 3% high.

Chemistry Samples from discrete depths were analyzed for specific conductance, pH, and chemical constituents by ALS, Vancouver. Sampling dates are given in Appendix 1. At times samples were analyzed for total metals only or dissolved metals only; at other times they were analyzed for both (Appendix 1). Ice samples consisted of cuttings from an entire sampling hole, without breaking through to water (K. Nordin, pers. comm.) Ice chips were placed in clean wide mouth bottles and poured into sampling bottles once melted.

Dissolved oxygen While oxygen data was collected it does not appear to be reliable; the absence of oxygen is inferred from the presence of dissolved iron (Appendix 3).

Grum mooring A line with internally recording temperature instruments was deployed from the raft in Grum pit. The Onset Hobo Water Temp Pro was used at depths of 1, 2, 3, 5, 7, 10, 15, 20, 30, and 40 m from surface. The period of record is as follows:

29Jun2004 - 09Sep2004(upload) - 26Nov2004(memory full), and
10Jun2005 - 06Jul2005(upload) – 14Sep2005(upload) – ongoing.

Grum meteorological station Wind speed, wind direction, air temperature and solar radiation were collected from Aug 12, 2004 by an Onset weather station on the raft at Grum pit.

Creek temperature Record of stream temperature for Faro and Grum creeks was collected from June 29 to Nov 26, 2004 and for Vangorda Creek from June 29 to Sept 9, 2004.

Additional data include pit-lake levels, pumping records and a shore based meteorological station; these have not been assessed.

RESULTS

The data suggests that Faro, Vangorda and Grum are meromictic, but these pit-lakes show a range of behaviour, with varying degrees of deep water isolation. Faro pit-lake shows very little change in water temperature and conductivity below 20 m suggesting highly isolated deep water during the study period. In contrast, the deep water of Grum pit is least isolated, possibly from mixing generated by failure of the east wall of till which shows active creep (SRK 2004c). Vangorda pit-lake has the highest salt content at depth yet the deep water shows some seasonal change the origins of which are not clear. The evolution of these pit-lakes will be discussed below.

Because of the differences between the pits it will be helpful to have a clear idea of what would be expected from an undisturbed or ‘baseline’ pit-lake. A schematic of baseline circulation is given in Figure 1. The depths, conductivity and temperature values are meant to be illustrative rather than specific to any given pit-lake.

The baseline pit-lake has two main layers (Fig 1):

- **monimolimnion**, the isolated deep water that does not mix to the surface, and
- **mixolimnion,** which mixes at some point every year.

The **chemocline** is the boundary between the mixolimnion and the monimolimnion.

During spring and summer, the mixolimnion consists of two parts: a warm, less saline surface layer overlying colder water of intermediate salinity (Fig 1a,b). In spring the surface layer of ice-melt and runoff is shallow. This shallow surface layer is generally kept well mixed by wind. In fall, the surface layer cools and wind mixes the surface layer down (Fig 1c,d). In winter, salt expelled from ice at the surface induces thermohaline convection in the mixolimnion (Fig 1e,f).

The depth to which the wind mixes the surface layer in fall may vary. In some situations fall wind may not mix the entire depth of the mixolimnion: e.g. the surface layer might only extend to 15 m at the time ice forms on the surface. Then, under ice, the thermohaline convection could deepen the top layer to 20m. In other years, the wind may extent the surface layer to the top of the monimolimnion by the time ice forms.

In some years, wind or thermohaline convection may be strong enough to erode the chemocline deeper; in other years mixing may not be as deep and the level of the chemocline could get shallower. Also important will be the ice thickness, with increased thermohaline convection generated by thicker ice.

We can speculate that expelled salts may act in different ways. Beside causing convection below where the salt is formed (Fig 2, Case A), the expelled salt may also, for example, pool to the sides. This pooling of saline water would lead to sinking gravity currents which could erode the chemocline (Case B) and even intrude into the monimolimnion (Case C).

In spring, ice melt and runoff re-stratifies the mixolimnion. Note that the water in the base of the mixolimnion (3-20 m) remains cold (Fig 1a), a remnant of the winter cooling at this depth (cf. Fig 1e).

Also helpful in interpreting the field data is a consideration of levels of turbulent mixing. Turbulent mixing is enhanced by energy sources (such as wind) and inhibited by density gradients (such as the chemocline). Mixing ranges from highest to lowest as follows:

- the surface layer is relatively well mixed by wind, as evidenced by relatively uniform vertical profiles of temperature and conductivity;
- thermohaline convection occurs as salt is expelled from the ice cover and overcomes the reverse temperature stratification under the ice;
- low levels of mixing occur in regions of low energy input and moderate density gradients, e.g. within the monimolimnion;
- very little mixing occurs across sharp density interfaces, such as the chemocline.

Faro

Faro is the largest of the Anvil Range pit-lakes; the dimensions of Faro pit-lake, both current and ultimate, are given in Table 1. In both 2004 and 2005, Faro pit was pumped from mid-May to mid-September. Pumping reduced the summer water level by approximately 1 m in 2004 and 2 m in 2005.

Table 1 Pit-lake characteristics

PIT	FARO	GRUM	VANGORDA
Current water level	1142	1185	1089
Current water level variation	~3m, pumped		pumped
Current max. depth (m)	~90	~50	~50
Current area (m^2)	510,000	95,000	59,000
Current volume (m^3)	~30x10^6	~2x10^6	~1x10^6
Runoff with diversions (without creeks) (m^3/yr), SRK 2004c	5.9x10^4		2.4x10^6
Bulk retention time (yrs)	50 yr		0.4 yr
Ultimate water level (m ASL)	1158 (no dam*)	1230	1130
Increase in water level (m)	16	45	41
Ultimate max. depth (m)	~105	~95	~90
Ultimate area** (m^2)	596,000	266,000	144,000
Ultimate volume (m^3), SRK 2004c	38x10^6	9x10^6	5.8x10^6
Runoff without diversions (with creeks) (m^3), SRK 2004c	5.5x10^6	3.2x10^5	7.8x10^6
Bulk retention time (yrs)	7 yr	28 yr	0.7 yr

* Faro with plug dam "constructed across the southeast pit ramp to increase flood elevation and thus the residence time in the pit" (SRK, 2004c, p17): ultimate elevation 1173 m ASL; area 780,000 m^2; volume 49x10^6 m^3.

** As given by data used in Lawrence and Pieters, 2003. Note, while SRK, 2004c gives similar ultimate area for Faro and Grum, it gives the ultimate area of Vangorda as slightly larger, 170,000 m^2.

Figure 3 shows the Seabird CTD profiles for 2004 and 2005. These profiles suggest the circulation is similar to that sketched above. In both June 2004 and 2005, the pit lake had a warm, slightly fresher surface layer about 6 m deep (Fig 3c,d). Between 6 and 20 m, Faro had cold water of intermediate conductivity. Note the temperature in this layer reaches a minimum of 3.6 ºC at 17 m, a relict of winter.

The evolution of the Faro surface layer in the summer of 2005 can be inferred from the Applied Microsystems CTD temperature profiles (Fig 4). (The conductivity data of the Applied Microsystems CTD was erroneous, Appendix 2). As expected, the surface layer deepens and cools through late summer and early fall. Below the surface layer, the temperature minimum at 17 m remains, though the minimum temperature increases from 3.8 ºC to 4.0 ºC as a result of very low level transport of heat.

Figure 5 shows temperature and corrected conductivity for the YSI for September 14, 2004. The surface layer is now 8 m deep. Note that pumping of water from Faro will have an impact on the surface structure. At this time, the surface water temperature is still 10 C; the thermistor chain on Grum pit (below) indicates that ice-on does not occur until mid October.

At the end of January, 2005, the ice thickness was 0.3 m and was reported clear. Ice thickness, conductivity and salt exclusion are given in Table 2. Ice thickness was significantly less than expected for time of year (Ken Nordin, pers. comm.). Approximately 70% of the salt was excluded.

Table 2 Ice thickness, conductivity and percentage salt exclusion

	Faro	Grum	Vangorda
Ice thickness (cm)	40, 44, 42	50, 51, 50	44, 44
Snow depth (cm)	30, 32, 30	32, 30, 30	35, 36
Ice conductivity (µS/cm)	317	520	295
Conductivity at 1m (µS/cm)	1200	1650	973
Percentage salt exclusion	74%	68%	70%

The chemocline occurs at 20 m and the monimolimnion (below 20 m) is about 4.5 ºC and has a conductivity that increases steadily from 1400 µS/cm to just over 1600 µS/cm at depth (Fig 3). The deep water shows very little change from June 2004 to June 2005 with temperature steady to ± 0.05ºC (Fig 3e) and conductivity within ± 5 µS/cm (Fig 3f). This suggests a high degree of isolation of the Faro deep water. The presence of dissolved iron indicates the absence of dissolved oxygen (Appendix 3), also consistent with isolated deep water.

Grum

In both June 2004 and 2005, Grum pit had a warm surface layer 2 – 2.5 m thick (Fig 6). However, this June surface layer does not appear to be fresh enough. The conductivity of the surface layer roughly accounts for ice-melt but, unlike Faro and Vangorda, does not show the effect of freshet runoff. This might happen if the volume of freshet runoff was low or if the runoff had a high conductivity. However, this is not likely the case as the conductivity profiles for the remainder of the summer show significant fresh water input (Fig 6d).

An alternative explanation for the shallow and relatively saline surface layer right after ice-off could be partial spring overturn e.g. partial mixing of the surface layer into the deep water as the surface layer warmed through 4 ºC. The decrease in deep conductivity from February 2005 to June 2005 is consistent with partial mixing of fresh water to depth. Unfortunately, moored temperature data were not available during spring 2004 because instrument memory was full; data from spring 2005 may shed light on the ice-off period.

Another unusual feature of Grum is the absence of a chemocline below the surface layer. In fact, the temperature and conductivity profiles below the summer surface layer are remarkably uniform (Fig 6e,f), and suggestive of vertical mixing. The profiles are similar to those from the Equity Main Zone pit-lake (near Houston, B.C.), where sludge discharge to the pit resulted in uniform deep water profiles (Pieters et al, 2005).

In addition, the deep water temperature increased from 4.55 to 4.75 ºC over the summer in 2004 (Fig 6e) and increased from 4.4 to 4.7 ºC over the summer in 2005 (Fig 7), which also suggests some turbulent mixing with the surface layer. Temperature inversions in the Jul 6, 13 and 20, 2005 temperature profiles (Fig 7c) are also suggestive of ongoing mixing.

However, the deep conductivity *increased* over the summer of 2005, which is not consistent with simple mixing with a less saline surface layer. The increase of conductivity is 1.5%, larger than our inferred conductivity accuracy of about 0.5% based on Faro deep water. We will return to this after discussing the moored temperature data.

That some disturbance is occurring in the deep water of Grum is confirmed by the moored temperature data (Figs 8 and 9). Note the rising 6, 8 and10 ºC isotherms from July 18-24, 2004 (days 231-237, Fig 8c) and especially July 11-25, 2005 (days 558-572, Fig 9c). These isotherms suggest injection of water to ~5m or mixing from 5 m down.

Plotting the deep temperature for both years (Fig 10) confirms this picture and shows an increased rate of deep water warming during the two July periods. There is notable disturbance on July 18, 2004 suggestive of a rock fall.

The absence of dissolved iron and the relatively high oxygen profile in September 2005 (Appendix 3) suggest replenishment of dissolved oxygen in the deep water.

To summarize, we have the possibility of partial spring overturn along with elevated, episodic mixing throughout the summer. The most likely explanation is the gradual failure of the east wall composed of till. Slumping could occur either from the surface, or occur as a subsurface subsidence. To further evaluate this possibility would require an estimate of the volume of material involved.

During mining, the east wall was subject to a large dewatering program in an attempt to stabilize the slope. Currently, the east wall has a surface water inflow of order of 5 L/s (Ken Nordin, pers. comm.). In June 2004, after 6 days of dry weather, this inflow was sampled 150 m above the lake surface, was estimated as 1 L/s and had a conductivity of 341 µS/cm (SRK 2004c). A second sample in the till had trace volume and conductivity of 1097 µS/cm. It is clear that water plays an important role in the till wall, but not clear what the ultimate salt content of this water might be. There may also be other sources of conductivity to the deep part of Grum, such as ground water.

However, despite the additional spring and summer mixing, the temperature data indicate that Grum did not turn over in the fall: Grum mixed deeper than 7m but not to 10 m during the fall of 2004 (Fig 8 and 10). This is consistent with the CTD profile of February 1, 2005 when the surface layer extended to 8 m. The deep conductivity continued to rise between September, 2004 and February, 2005. During this time deep temperature decreased slowly, consistent with the presence of colder water above. Ice thickness on Grum was similar to that on Faro and showed a similar percentage of excluded salt.

Vangorda

Vangorda is the smallest and most saline of the Anvil Range pit-lakes and has a very short bulk retention time (Table 1). Vangorda is used to store seepage runoff and the Vangorda water level is maintained by pumping to a treatment plant.

CTD profiles from Vangorda pit are shown in Figure 11. In June 2004 Vangorda had a significant fresh water cap, 2 m deep. A second density interface at 20 m is suggestive of a chemocline.

From June 2004 to February 2005 the surface layer deepened to only 5 m. However, during this time the deep conductivity increased by 7%; the lab conductivity from the bottle samples show a similar increase (not shown). The deep water of Vangorda shows little gradient in conductivity, unlike Faro. The presence of dissolved iron suggests the absence of dissolved oxygen in the Vangorda deep water (Appendix 3). These deep water changes could result from saline ground water inflows. The changes in Vangorda deep water may also reflect its small residence time.

CONCLUSIONS

While the pit lakes are stratified they show a range of behaviour:

- Faro shows the most isolated deep water with only very small changes in deep water temperature and conductivity and the absence of dissolved oxygen. This suggests Faro is meromictic in 2004 and 2005.
- Grum shows signs of partial mixing in spring and summer possibly due to ongoing failure of the east wall. Oxygen is possibly present in the Grum deep water in summer. Nevertheless Grum does not turn over in fall and remains stratified under ice.
- Vangorda changes considerably over time for unknown reasons. It may result from ground water inflow or result from the relatively large influence of inflow and outflows as reflected in its short residence time.

RECOMMENDATIONS

1. We highly recommend that the project use a Seabird CTD. The cost of purchase is modest ($US 8,200) compared to the cost to collect and analyze the data. There is enough going on in these pit-lakes that it is impossible to infer their behaviour from poor quality data. We feel strongly that collection and analysis of this data is only worthwhile if the data is reliable.

   Some explanation is warranted for our insistence on a Seabird CTD. Water profilers have been developed by two somewhat separate communities. The first is water treatment, hydrology and inland waters (e.g. Hydrolab and YSI). These instruments are typically compact to allow for well sampling, feature multiple sensors as standard (e.g. pH and redox potential) and are generally of modest accuracy in temperature and conductivity. The second community is oceanography (e.g. Seabird, Guildline, Applied Microsystems) where the tendency has been to develop high temperature and conductivity accuracy for distinguishing subtle but important changes in the ocean. However, oceanographers have generally considered only water with conductivity higher than about 2 PSU (C25 >3800 μS/cm). Generally, speaking oceanographic conductivity sensors do *not* work well in low conductivity water and experience high noise in this region. However, in order to simplify calibration, Seabird designed its conductivity cell to have a fixed point at zero conductivity and as a result it displays relatively high accuracy, high stability and low noise in the fresh water range. This decision has provided a major step forward for those working in inland waters and makes Seabird the instrument of choice.

2. We recommend under-ice Seabird CTD profiles be taken in all three pit-lakes. This is important to assessing the changes that took place since the summer, assessing both the impact of fall wind-mixing and thermohaline convection due to salt excluded from the ice-cover. During this sampling trip we would recommend
   - -examining ice bore holes for white and black ice,
   - -collect ice conductivity samples of white and black ice as needed, and
   - -measure ice thickness.

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FIGURE CAPTIONS

Figure 1. Schematic of pit-lake circulation showing temperature and conductivity for (a,b) spring, (c,d) fall and (e,f) winter. Note the depth values along with temperature and conductivity levels are chosen to be illustrative only.

Figure 2. Schematic of potential effects of salt expelled from surface ice: (A) salt expulsion can drive thermohaline convection or (B) salt can pool horizontally and drive density currents, and (C) if strong enough these density currents could intrude into the monimolimnion.

Figure 3. Temperature and conductivity profiles from a Seabird CTD profiler in Faro, 2004 & 2005. The same profiles are shown three times: (a,b) full scale (a,b), shown in reduced depth scale to zoom on the surface layer and (c,d) shown on reduced temperature and conductivity scales to zoom on the deep part of the profiles.

Figure 4. Temperature of Faro for Summer 2005, from the Applied Microsystems CTD.

Figure 5. YSI temperature and conductivity profiles for Faro, September 14, 2005.

Figure 6. Temperature and conductivity profiles from a Seabird CTD profiler in Grum, 2004 & 2005.

Figure 7. Temperature profiles for Grum, Summer 2005.

Figure 8. Wind and moored temperature data for Grum, 2004. The temperature chain was uploaded on September 15, causing a spike in temperature.

Figure 9. Wind and moored temperature data for Grum, 2005. The temperature chain was uploaded on July 6, causing a spike in temperature. After July 6, the data is shifted as the temperature chain was redeployed about 0.6 m high.

Figure 10. Deep temperature in Grum (a) 2004 and (b) 2005. A spike in temperature spike was created by upload on 14 Sept 2004 and 6 July 2005.

Figure 11. Temperature and conductivity profiles from a Seabird CTD profiler in Vangorda, 2004 & 2005.

Figure 1 Schematic of Pit−Lake Circulation

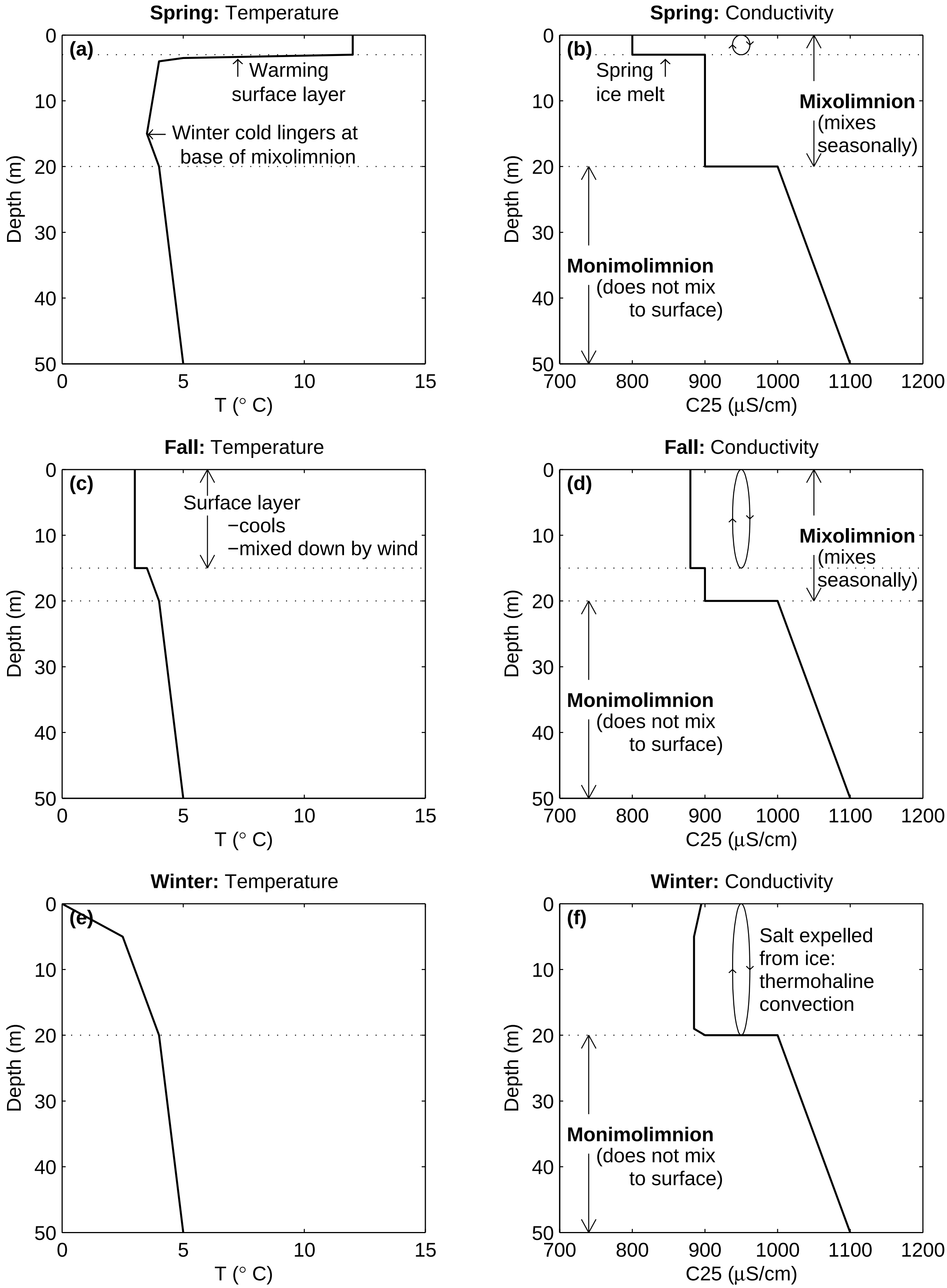


Figure 2. Schematic of plunging salt expelled from ice
A. thermohaline convection
B. horizontal pooling with density current
C. plunging into mixolimnion

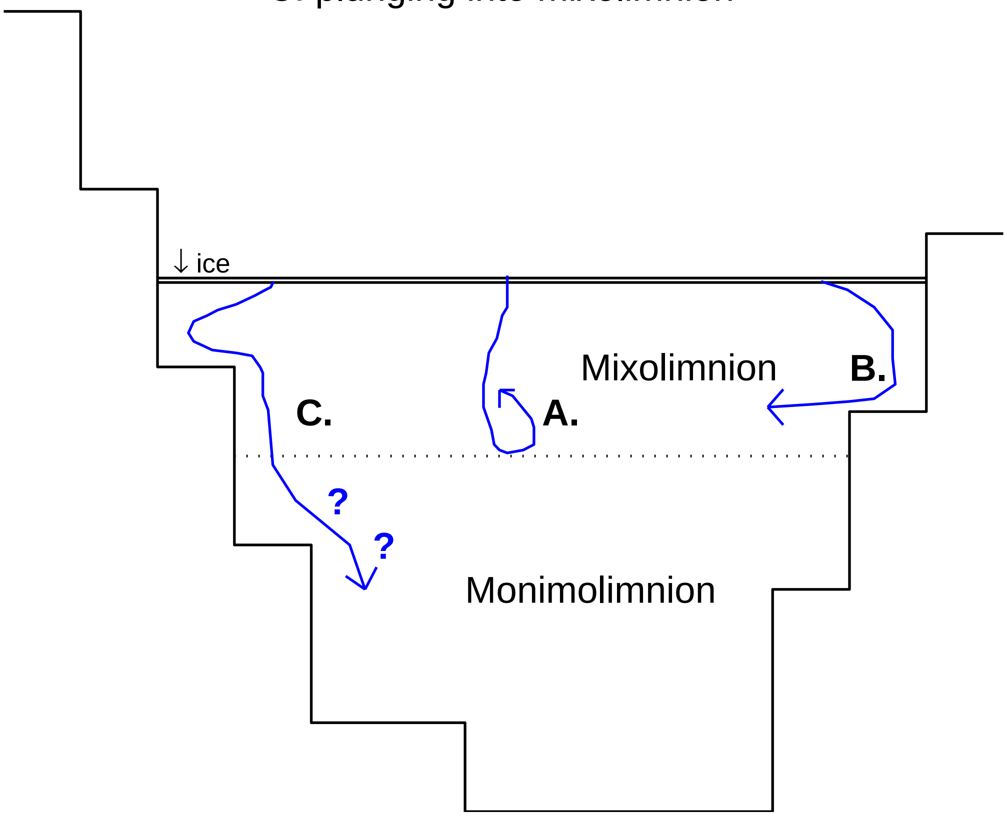


Figure 3 Faro Seabird Temperature and Conductivity Profiles, 2004 & 2005

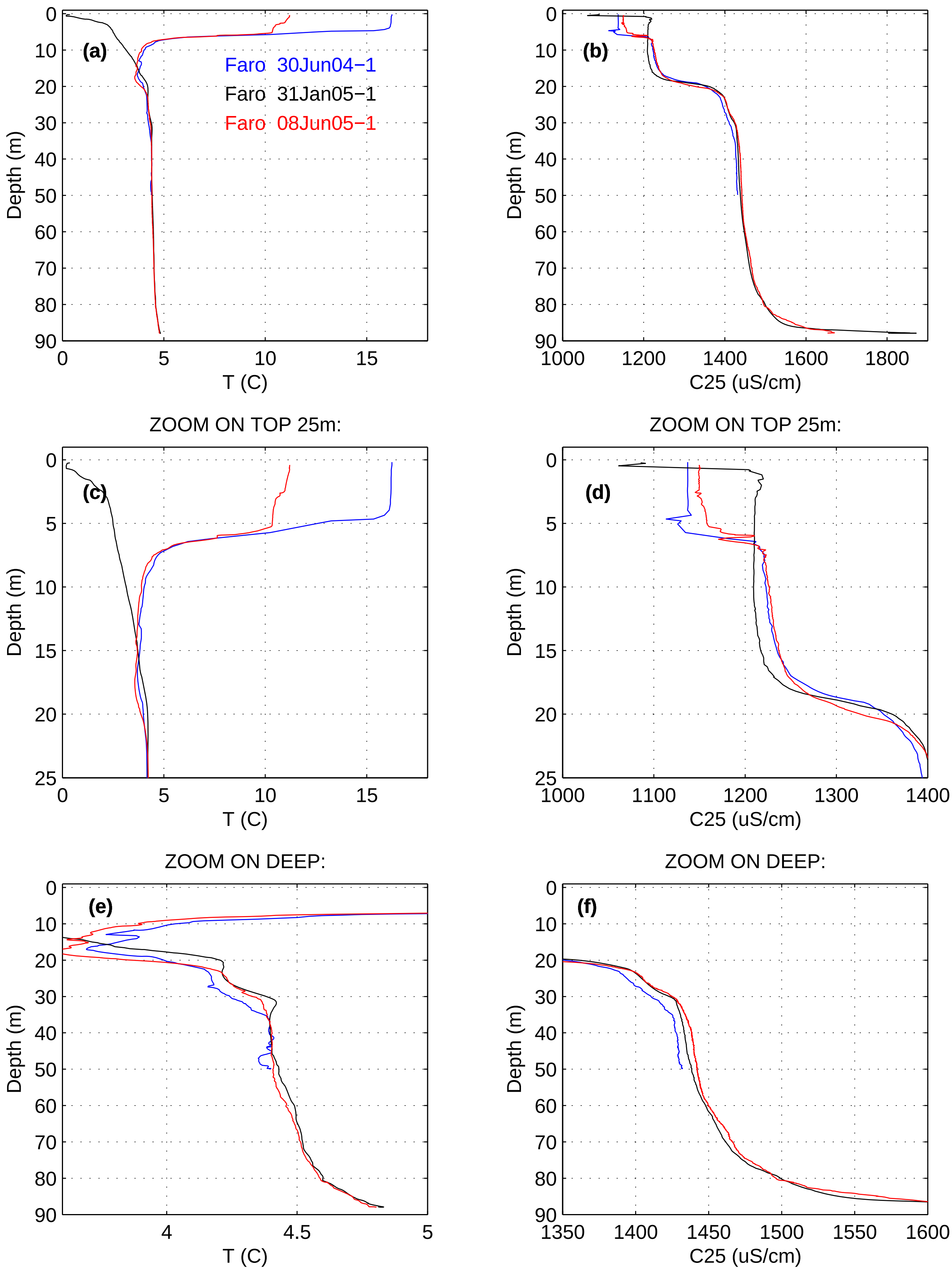


Figure 4 Faro Temperature Profiles, Summer 2005

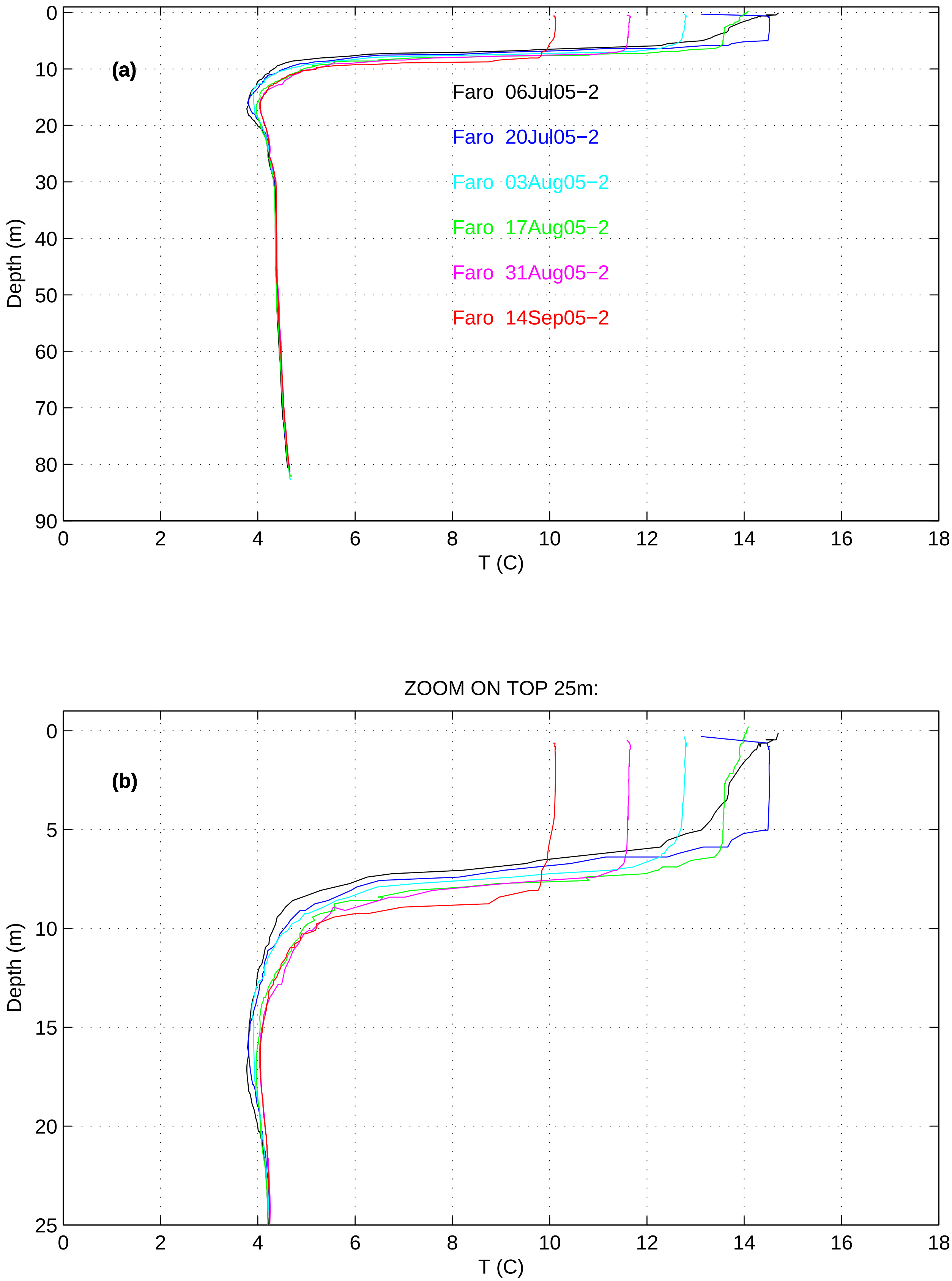


Figure 5 Faro YSI Temperature and Conductivity Profiles, September 2005

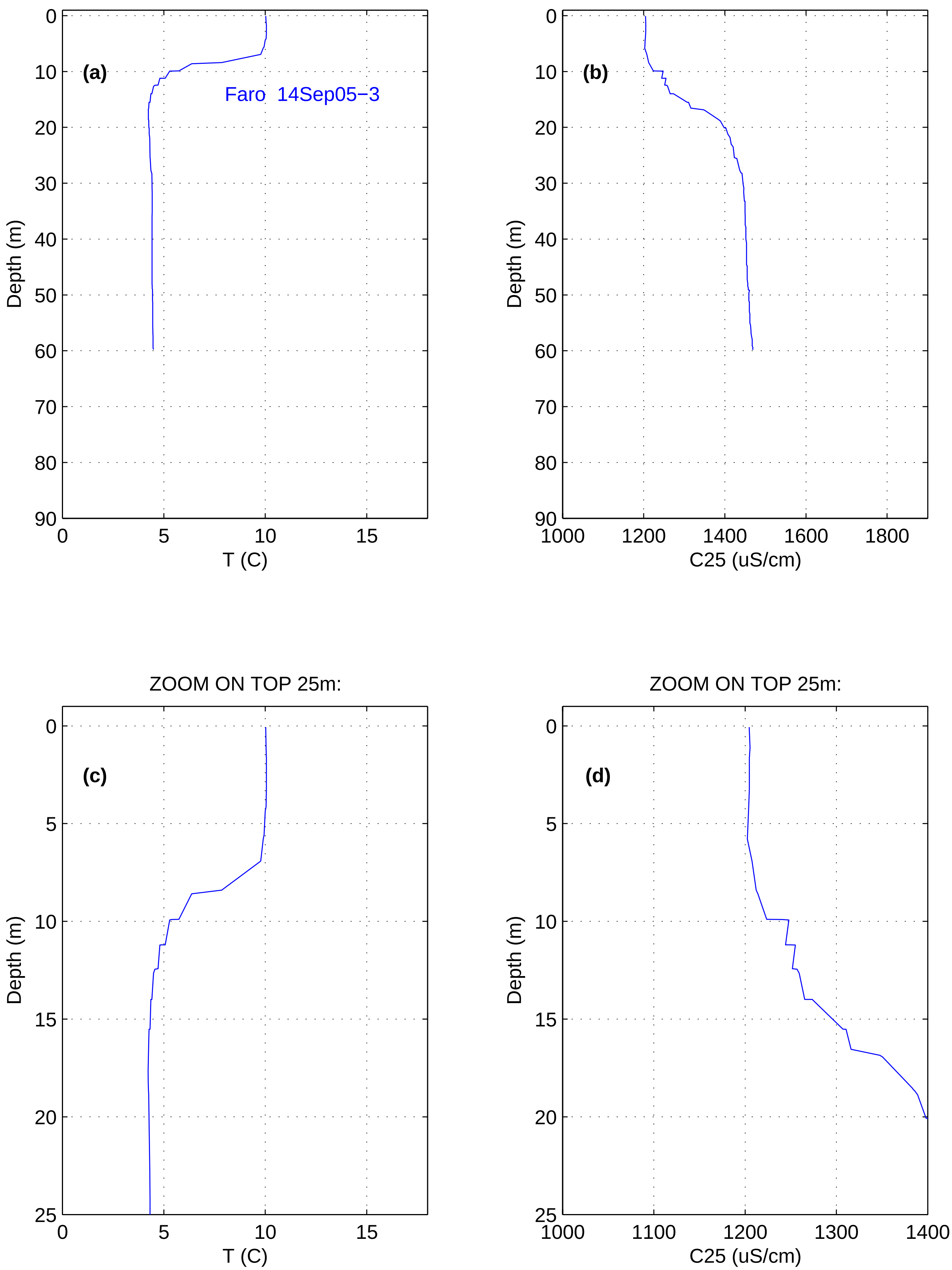


Figure 6 Grum Seabird Temperature and Conductivity Profiles, 2004 & 2005

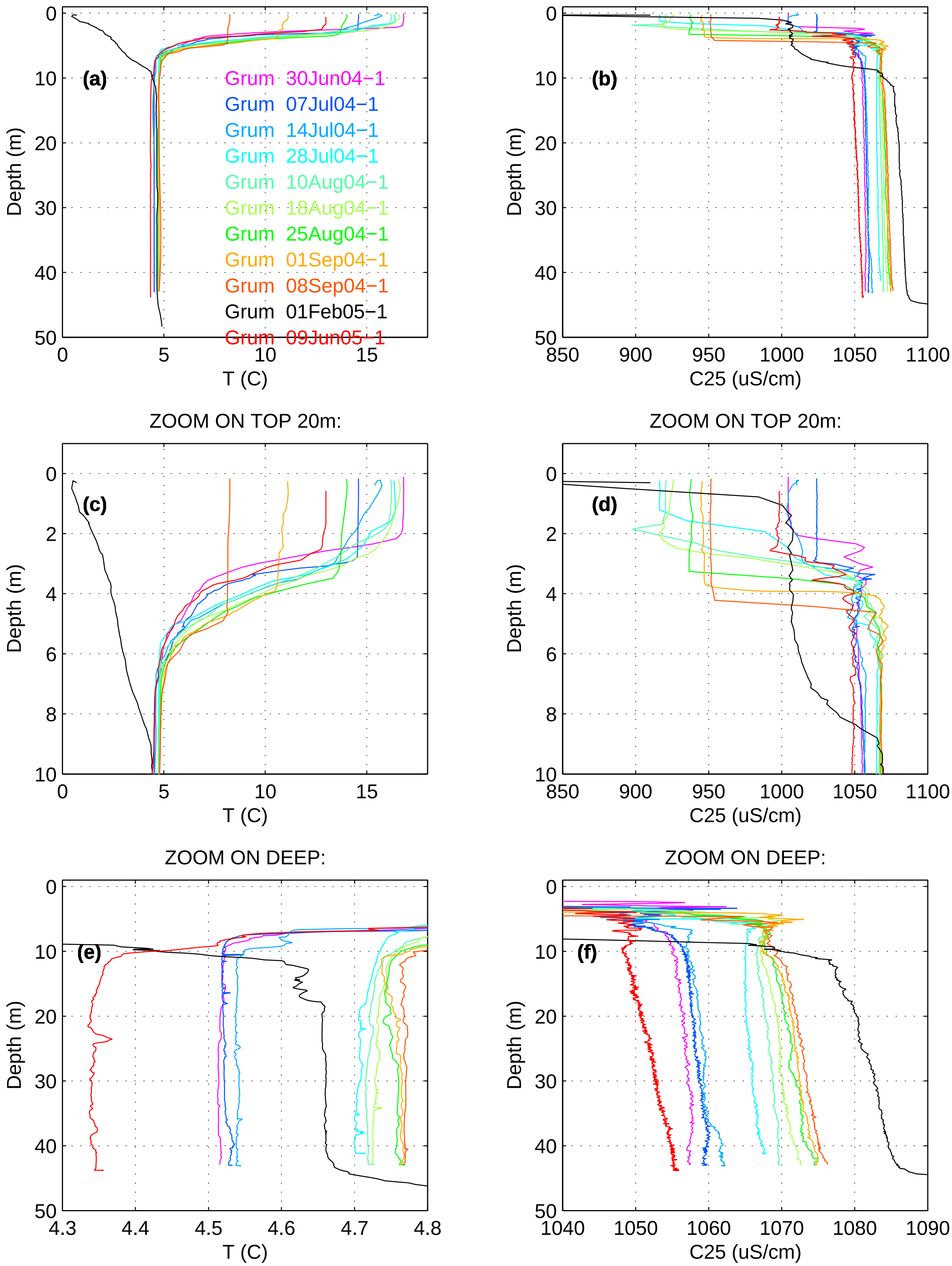


Figure 7 Grum Temperature, Summer 2005

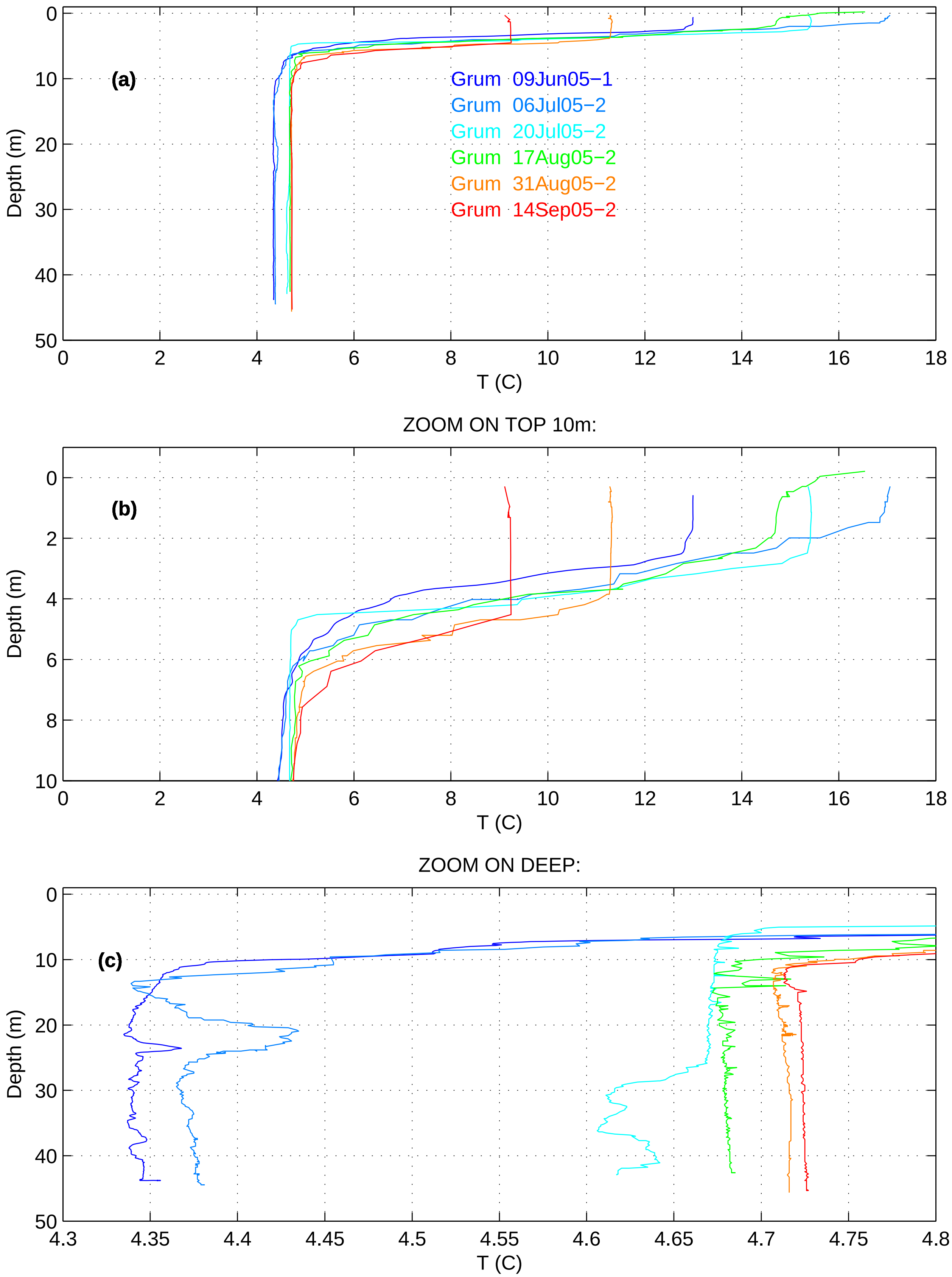


Figure 8. Grum Wind Speed and Water Temperature,**2004**

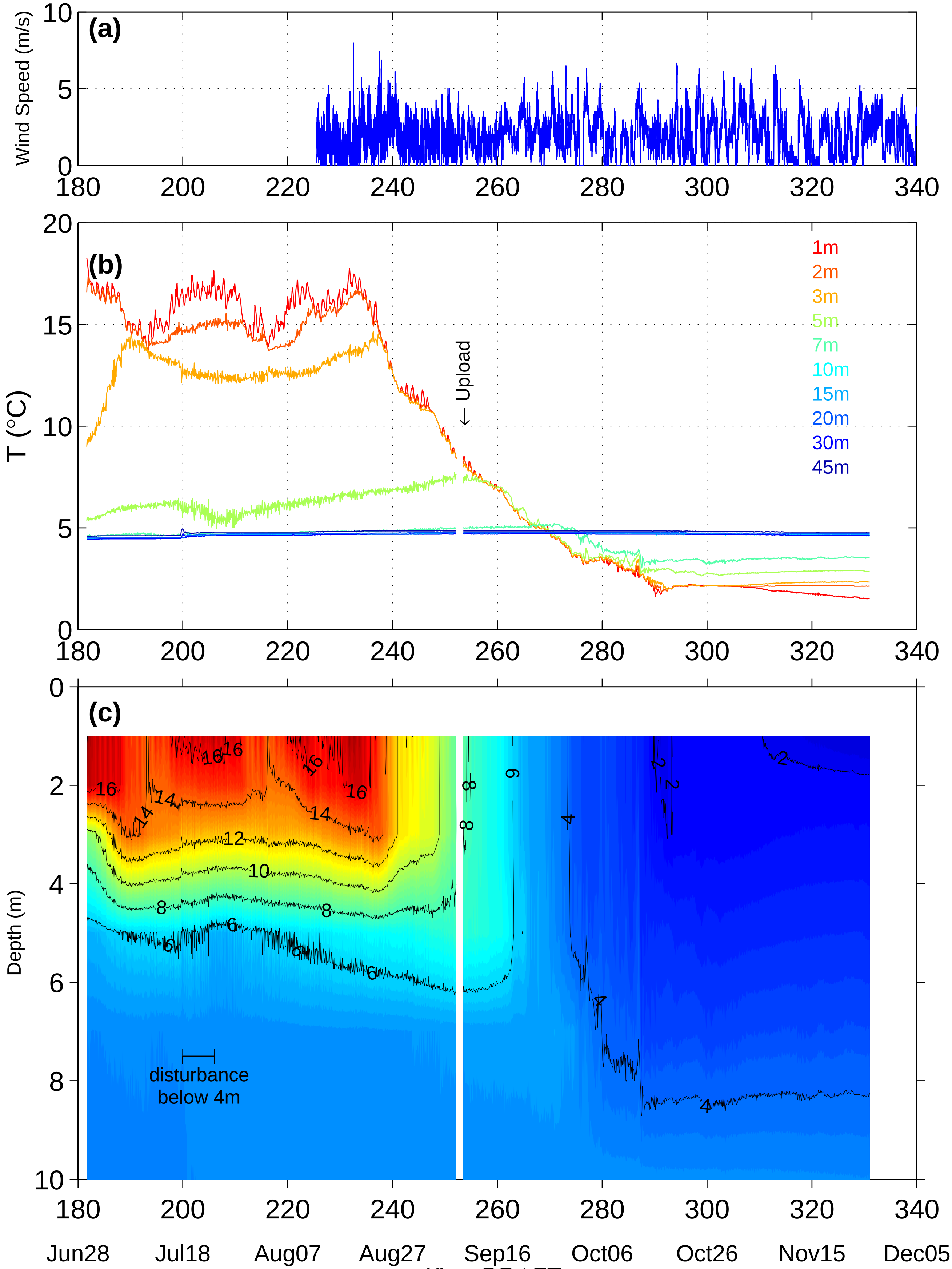
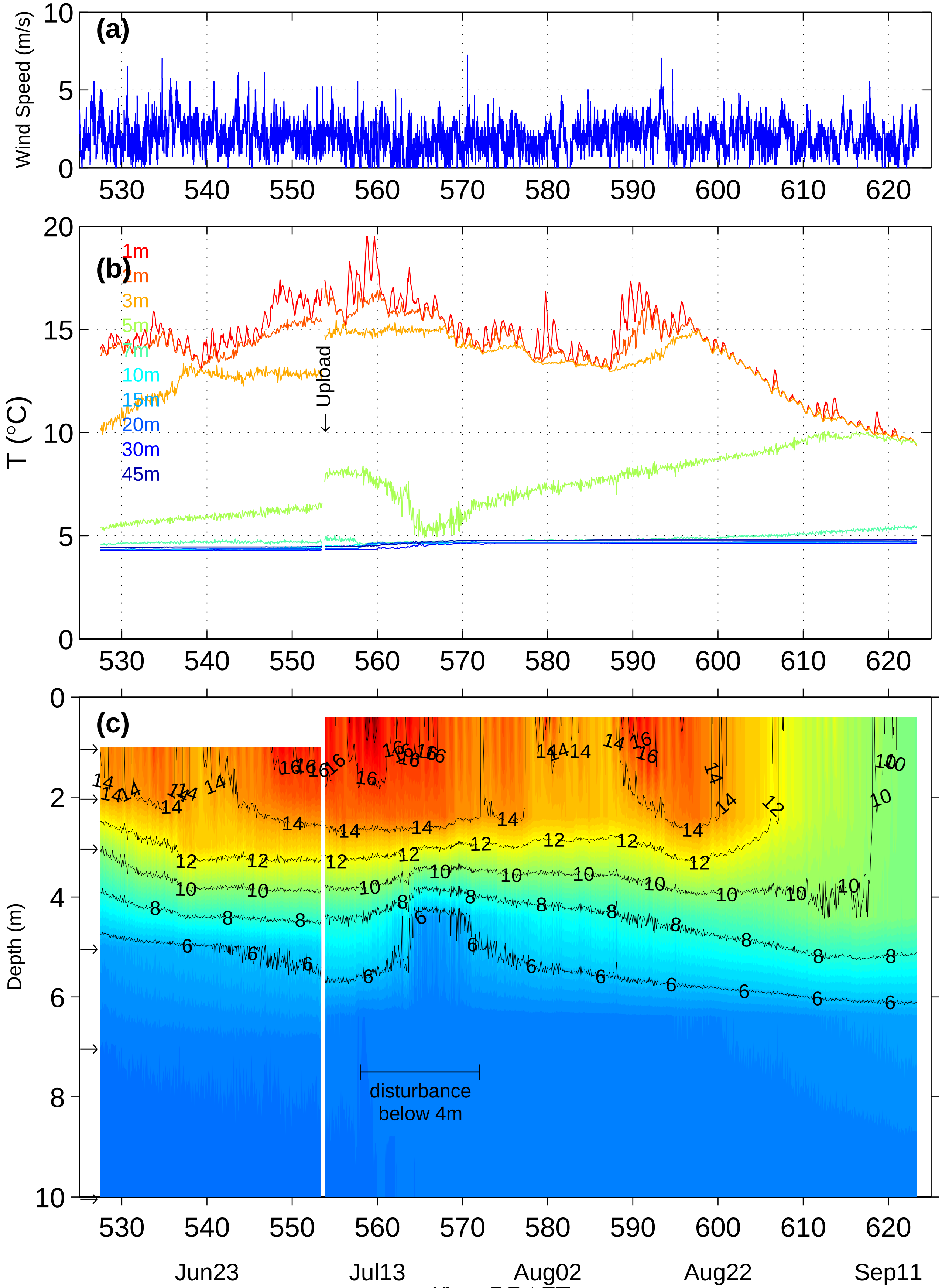


Figure 9. Grum Wind Speed and Water Temperature,**2005**



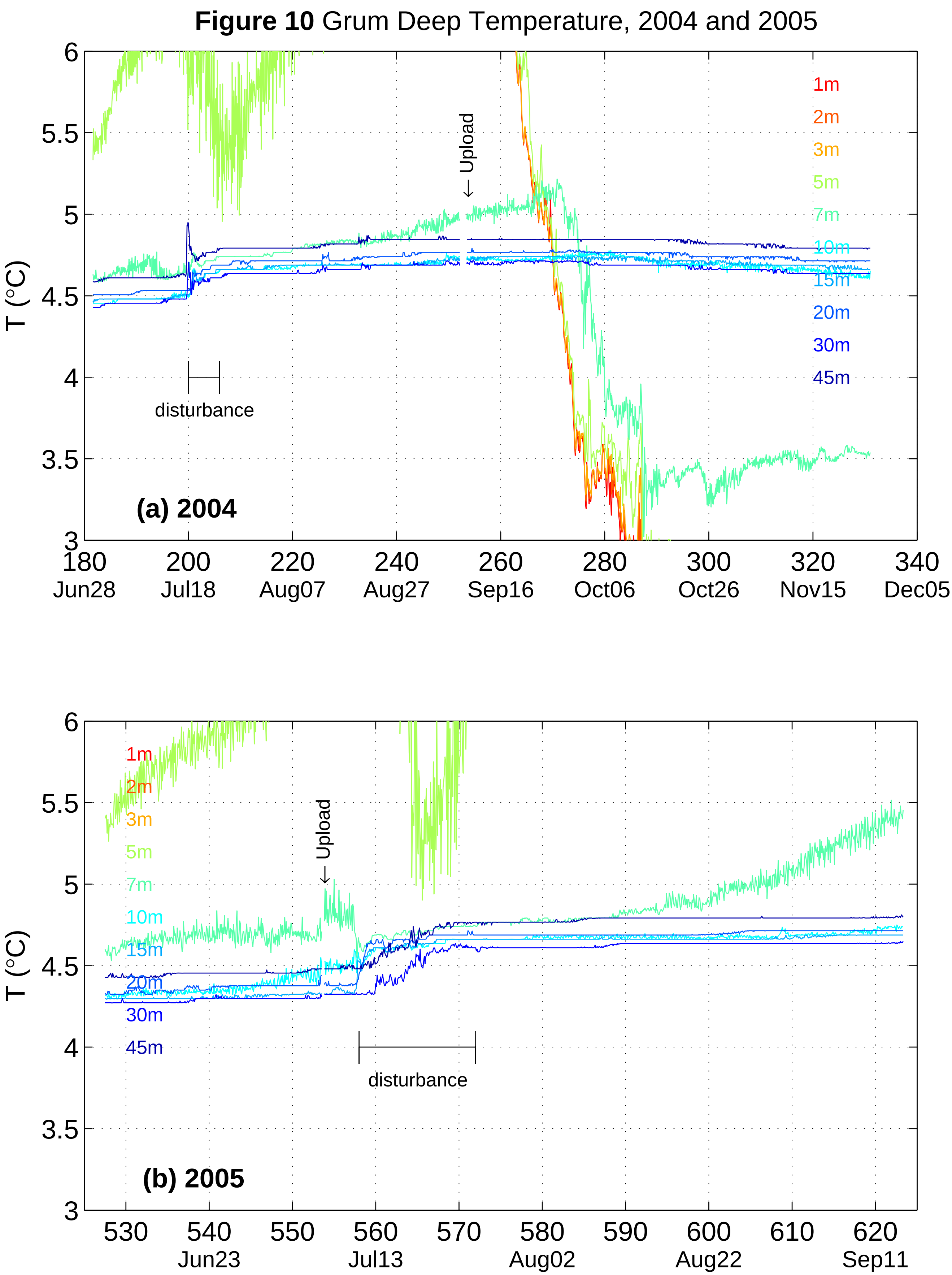
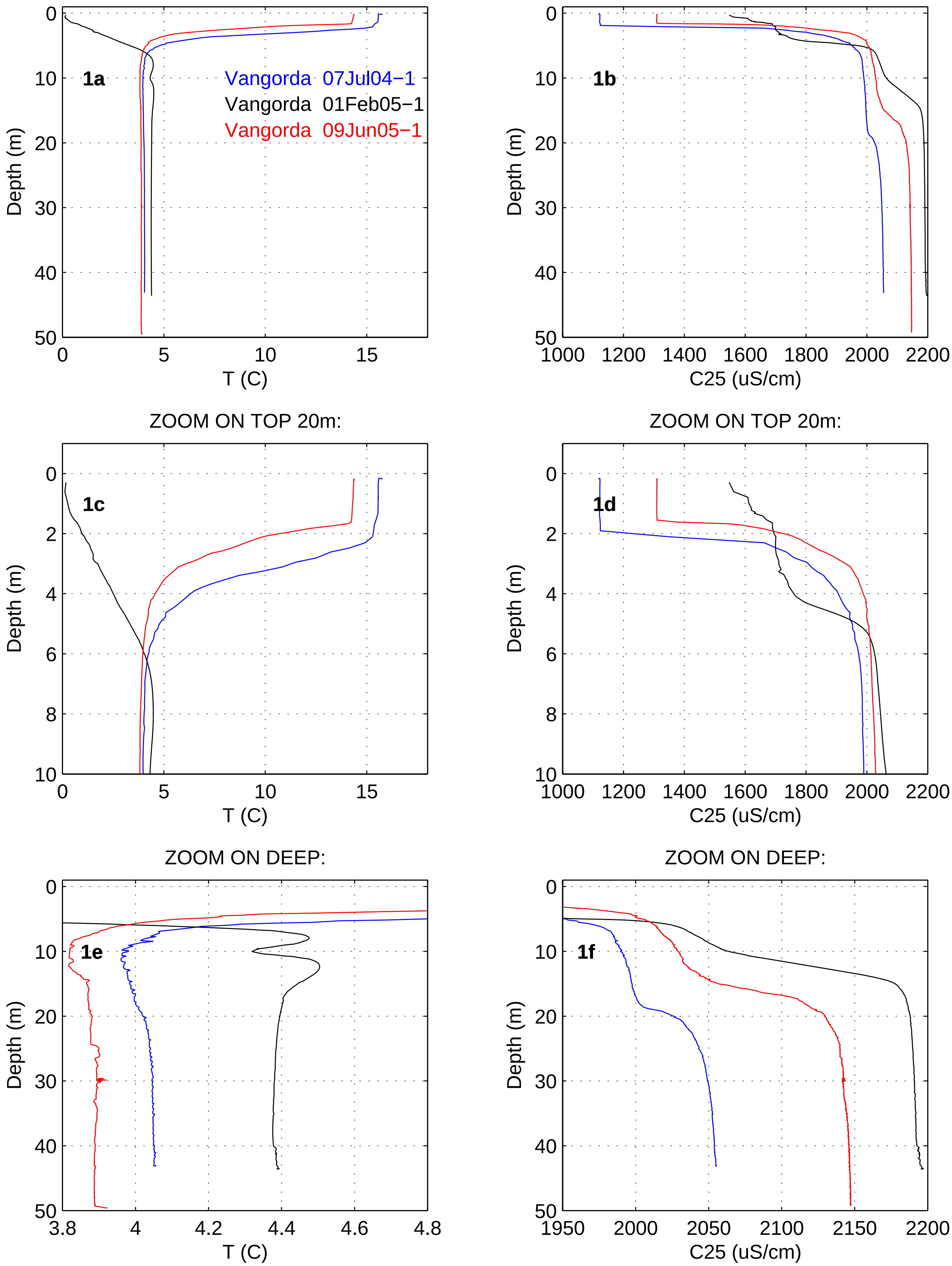


Figure 10 Grum Deep Temperature, 2004 and 2005
T (°C)
Upload
disturbance
(a) 2004
1m
2m
3m
5m
7m
10m
15m
20m
30m
45m
180
200
220
240
260
280
300
320
340
Jun28
Jul18
Aug07
Aug27
Sep16
Oct06
Oct26
Nov15
Dec05
(b) 2005
530
540
550
560
570
580
590
600
610
620
Jun23
Jul13
Aug02
Aug22
Sep11

Figure 11 Vangorda Seabird Temperature and Conductivity Profiles, 2004 & 2005



APPENDIX 1
DATA SUMMARY

Table A1.1 Timeline of CTD profiles and chemistry sampling

GRUM	FARO	VANGORDA
	Mar94CTD*** 11Mar94 CHEM (TM,DM, 1,15,30m)	
	6Oct96 CTD*** 6Oct96 CHEM (TM, 0,45m)	
	Jul98 CTD*** 30Jul98 CHEM (TM 0,3,40m)	
	Jul99 CTD*** 15Jul99 CHEM (TM,DM 1,40m)	
	11Jan00 CHEM (TM,DM 1,15,30m)	
	21Mar00 CTD*** 23Mar00 CHEM (TM,DM 5,25m)	
	Apr03 CTD*** shallow	
8Aug03 CTD*** 2x 8Aug03 CHEM 2x (TM,DM 5,10,20,30,40m)	9Aug03 CTD*** 2x 9Aug03 CHEM (TM,DM 5,10,15,58m; (TM,DM 2,10,25,60m)	
Summer: weekly nutrient addition		8Jun05 Flume fails and part of Vangorda Cr. to pit
29Jun04 CTD(SBE) 29Jun04 CHEM (TM,DM, No C25 1,3,5,7,10,20,30,40m)	30Jun04 CTD(SBE) 30Jun04 CHEM (TM, No DM, NoC25 1,5,10,15,20,25,30,40m)	
7Jul04 CTD(SBE)		7JUL04 CTD(SBE) 7JUL04 CHEM (TM,DM, No C25 1,3,5,10,20,30,40m)
14Jul04 CTD(SBE) 14Jul04 CHEM (TM,DM,C25, z as above)		
28Jul04 CTD(SBE) 29Jul04 CHEM (TM,DM, NoC25 z as above)		
10Aug04 CTD(SBE) 11Aug04 CHEM		

(z as above)		
18Aug04 CTD(SBE)		
25Aug04 CTD(SBE) 25Aug04 CHEM (TM,DM C25 z as above)		
1Sep04 CTD(SBE)		
8Sep04 CTD(SBE) 8Sep04 CTD(SBE) 8Sep04 CHEM 2x (TM,DM z as above)		
9Sep04 HWTP upload		
26Nov04 HWTP memory fills		
1feb05 CTD(SBE) 1feb05 CHEM (DM, ice,1,5,15,48m)	31Jan05 CTD(SBE) 31Jan05 CHEM (DM, ice 1 5 15 87m)	1feb05 CTD(SBE) 31Jan05 CHEM (DM ice,1,5,15,47m)
Summer: nutrient addition	Summer part: nutrient addn	
8Jun05 CTD(SBE) 9Jun05 CHEM (TM 1,3,5,10,15,30,40m) 10Jul05 HWTP upload	9Jun05 CTD(SBE) 8Jun05 CHEM (TM 1,2,3,5,15,30,60,80m)	9Jun05 CTD (SBE) 9Jun05 CHEM (TM 1,3,5,15,30,40m)
6Jul05 CTD(AM) 6Jul05 CHEM (TM,DM) 6Jul05 HWTP upload	5Jul05 CTD(AM) 6Jul05 CTD (AM) 6 Jul05 CHEM (TM,DM**)	
13Jul05 CTD (AM)		
20Jul05 CTD(AM)	20Jul05 CTD(AM)	
3Aug05 CTD(AM) 3Aug05 CHEM (TM*)	3AUG05 CTD(AM) 3 AUG05 CHEM (TM**)	
17Aug05 CTD(AM)	17Aug05 CTD(AM)	
31Aug05 CTD(AM) 31Aug05 CHEM (TM 1,3,4,5,7,10,20m)	31Aug05 CTD(AM) 31Aug05 CHEM (TM**)	
14Sep05 CTD(AM) 14Sep05 CTD(YSI) 14Sep05 CHEM(TM,DM*) 14Sep05 HWTP upload	14Sep05 CTD(AM) 14Sep05 CTD(YSI) 2x 14Sep05 CHEM (TM,DM**)	14Sep05 CTD(AM) 14Sep05 CTD(YSI) 14Sep05 CHEM (TM,DM 1,3,5,10,20,30m)

*2005 Grum Chem (0),1,3,5,10,15,30,40
** 2005 Vangorda Chem 0,1,3,5,15,30,60,80m
*** Profiler unknown

Abbreviations:

TM-Total metals DM-Dissolved metals
SBE-Seabird 19plus
AM-Applied Microsystems StdPlus 638
YSI-YSI600QS
HWTP-Hobo Water Temp Pro temperature loggers

APPENDIX 2
CONDUCTIVITY CALIBRATION

The conductivity at 25 ºC (also known as specific conductance) is a measure of the salinity. Meromixis requires a salinity difference to maintain stability and salinity is an indicator of changes in the pit-lake water column. For these reasons it is important to establish the accuracy of the conductivity data. In what follows we compare the CTD (conductivity-temperature-depth) profiler conductivity with the conductivity of water samples drawn from specific depths. All laboratory measurements were done by ALS.

For 2004-2005, three different CTD profilers were used:

1. June 2004-June 2005 Seabird 19plus SN 4621
2. July-September 2005 Applied Microsystems StdPlus 638
3. September 2005 YSI 600

2004 Seabird Data From June 2004 to June 2005 profiles were collected with a Seabird SBE19plus (SN 4621), Appendix 1.

The Seabird and laboratory data are compared for two reasons: to evaluate the character of the laboratory data and to check that the Seabird and laboratory data are consistent. To look at the laboratory data, Fig A2.1a-f compares Seabird conductivity (line) to laboratory bottle data (circles). (Laboratory conductivity of bottle samples was not measured in June 2004). While the Seabird and laboratory data are generally consistent, the laboratory data shows both considerable scatter within a profile as well as varying offsets from one survey to the next. Laboratory data is typically considered to be accurate to 1%; however, this and experience with other data sets suggests the accuracy is closer to 2-3%.

To check if the laboratory and Seabird data are consistent, the difference between the Seabird and laboratory conductivity is shown in Fig A2.1g. The error bars represent the difference between the minimum and maximum conductivity one meter around the sample depth: high error bar suggests the sample was collected in a conductivity gradient. No trend is evident, which indicates that the Seabird and laboratory data are consistent to within the coarse accuracy of the laboratory data.

Unfortunately the Seabird did not undergo calibration in a laboratory calibration bath at the start and end of the 2004-05 sampling seasons. From our experience on other sites, it is possible to establish accuracies of <0.1% for a Seabird 19plus by comparison to a bench salinometer.

However, the accuracy of the Seabird can be constrained by the field data, assuming that the deep water of Faro remains undisturbed. Note that from June 2004 to June 2005, the deep temperature of Faro pit did not change significantly. In addition the deep conductivity varied by only +/- 5 µS/cm. For the purpose of this report we will assume that the conductivity of the Faro deep water has not changed, suggesting that the accuracy of the Seabird is approximately +/- 0.5%.

2005 YSI600 Data In September 2005 profiles were collected using a YSI 600 (Appendix 1). These profiles were collected primarily for oxygen but temperature and conductivity were also measured. Figure A2.2a shows the YSI conductivity profiles (lines) and the laboratory bottle data (circles). The difference is shown in Fig. A2.2b and shows a clear trend: the YSI data is ~3% higher than the laboratory data. To correct the YSI data, a line was fit to the difference in Fig A 2.2b. This linear correction is then applied to the YSI data and corrected YSI profiles are plotted in Fig A.2.2c. Some difference remains and whether this represents instrument or laboratory variability is not known. Note the YSI600QS has a specified temperature accuracy of only +/- 0.15 ºC and conductivity accuracy of only +/- 0.5%.

2005 Applied Microsystems StdPlus 638 CTD Profiles were collected with an Applied Microsystems CTD from July to September 2005 (Appendix 1). Figure A2.3a-d shows the conductivity profiles (line) with concurrent laboratory bottle data (circles). The CTD show a large drift in profiler conductivity over the summer. As will be seen, the correction is not simply a drifting cell constant as the shape of the profiles do not match those of the laboratory data.

The difference between the laboratory and profiler conductivity is plotted by survey in Figure A2.3e along with linear trend lines. For the last survey, in September, the difference is follows a curve (red circles, Fig A2.3e): both a linear fit (not shown) and second order fit (shown) were tried. The trend lines from A2.3f were used to correct the Applied Microsystems data: corrected profiles are shown in Figure A2.4. While the absolute values are closer, it is clear that the profile shape is distorted. The distortion appears to increase through the summer. Various other corrections were tried but none produced meaningful data. We conclude that the CTD conductivity data is incorrect for reasons unknown and this conductivity data has not been further used.

Figure A2.1 Comparison of 2004 SBE and Laboratory Conductivity

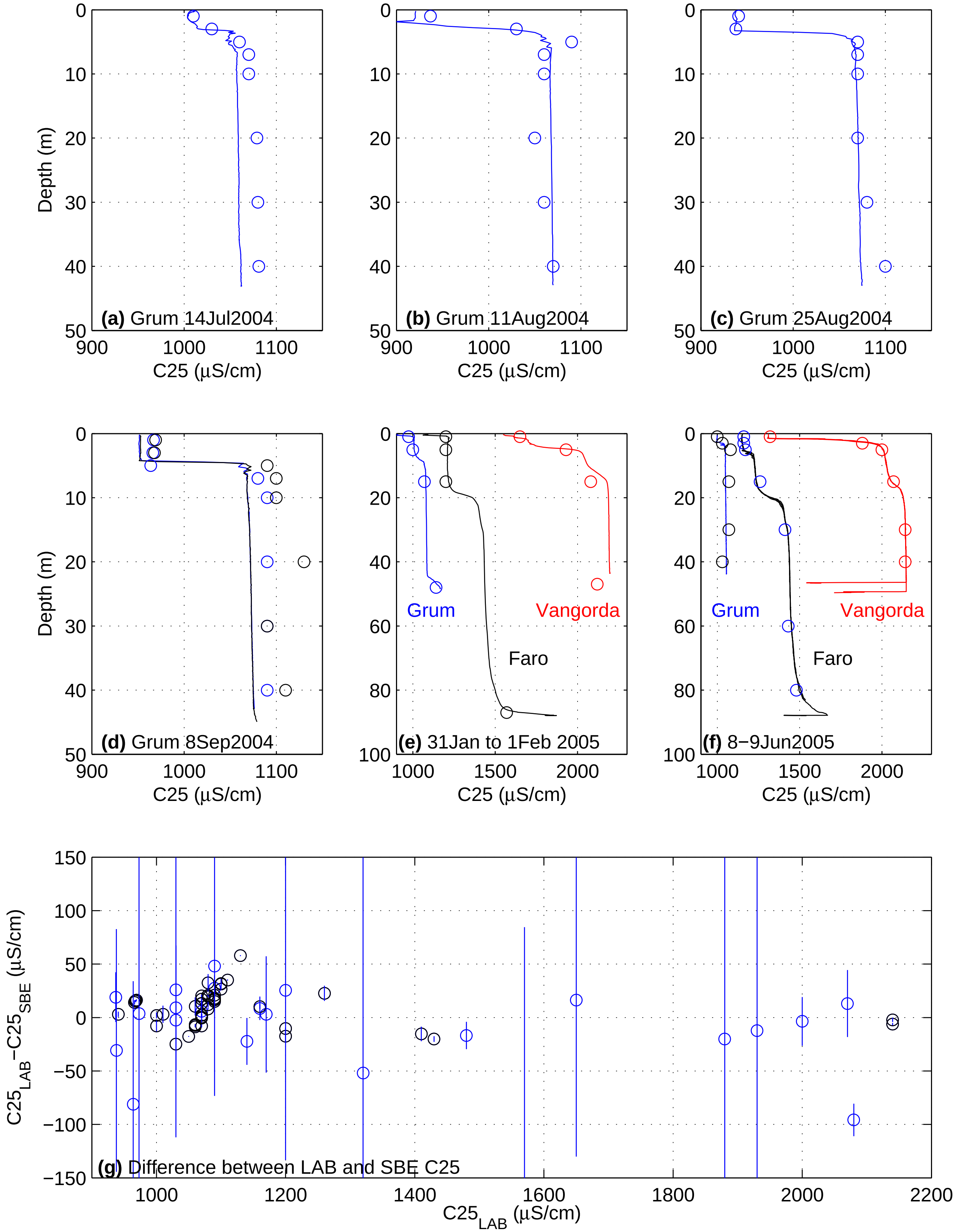


Figure A2.2 Comparison of 14Sep2005 YSI and Laboratory Conductivity

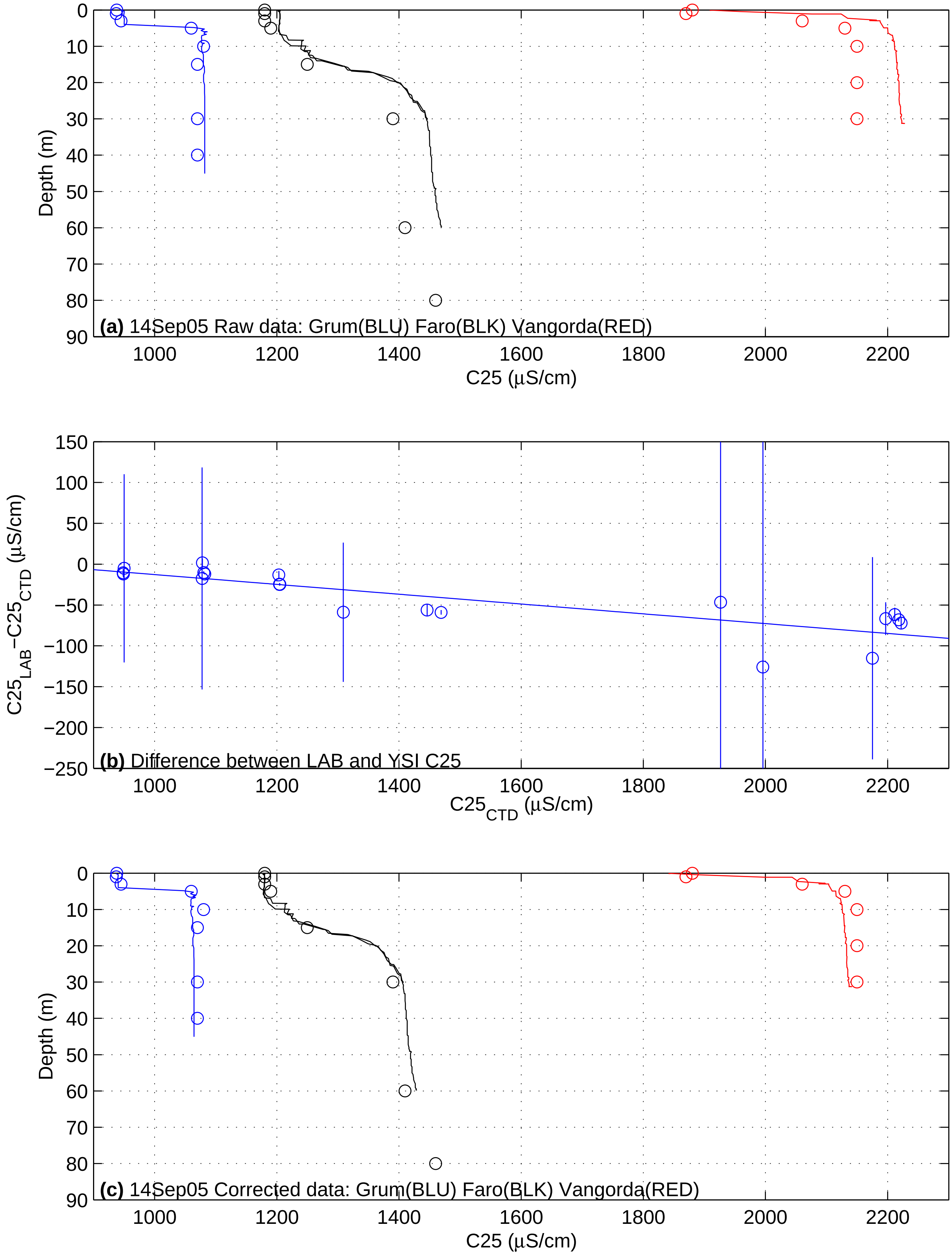


Figure A2.3 Comparison of 2005 StdPlus 638 (line) and Laboratory (o) conductivity

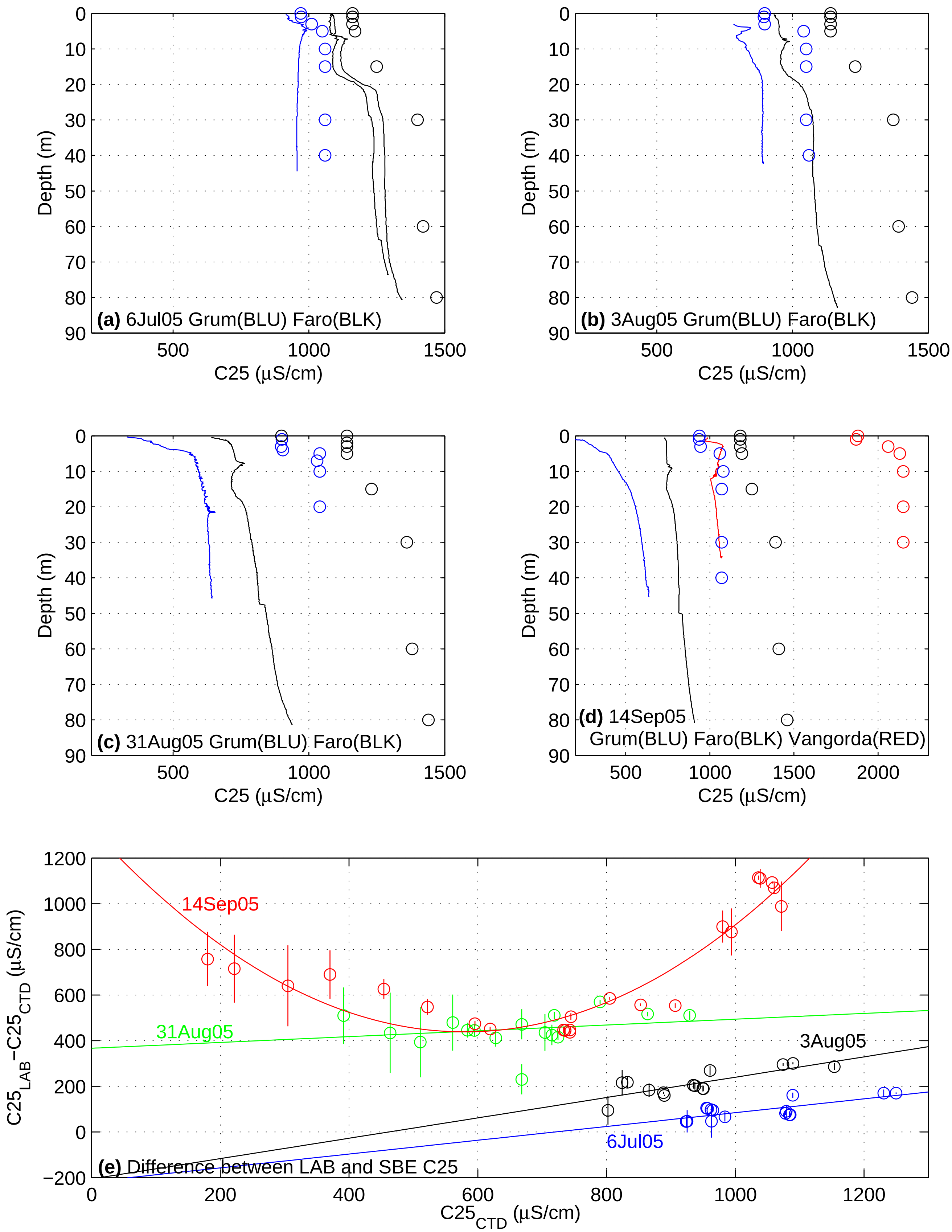
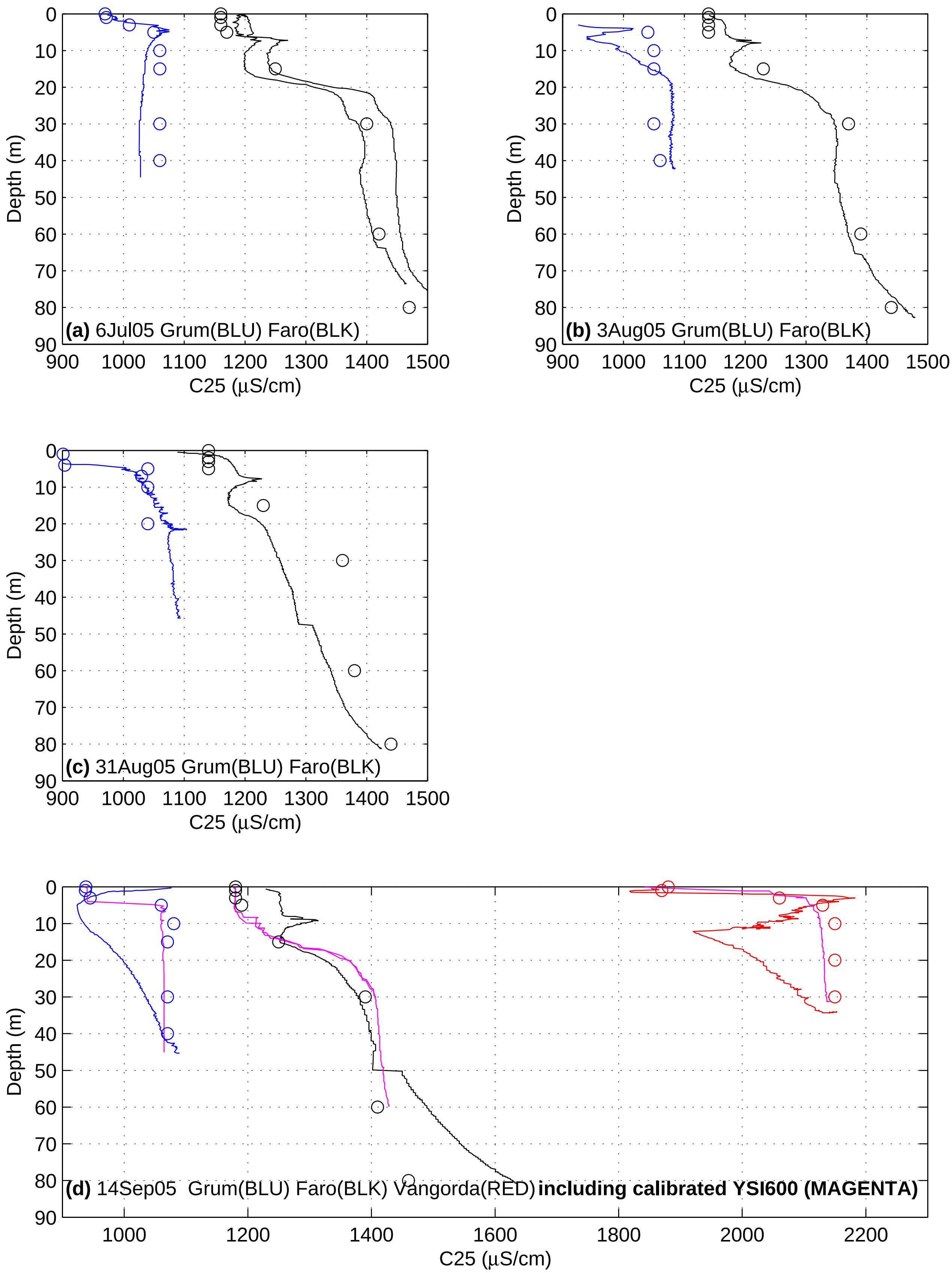


Figure A2.4 Calibration of 2005 StdPlus 638 CTD conductivity
Calibrated CTD(line), Laboratory C25(o)



APPENDIX 3
DISOLVED OXYGEN

In 2004, sample water was collected by tubing and a peristaltic pump and in 2005 it was collected with a Van Dorn sampler. During most sampling trips, water was transferred to a beaker and dissolved oxygen was measured using a hand-held probe. While this method is known to be unreliable, it was used to provide relative oxygen data (Ken Nordin, pers. comm.).

The dissolved oxygen data for 2005 are plotted in Figure A3.1. While data collected by the hand-held probe are generally higher near the surface, the deep values range around 6 mg/L. The YSI showed lower levels of dissolved oxygen in September 2004, with lower values in Faro and Vangorda than in Grum.

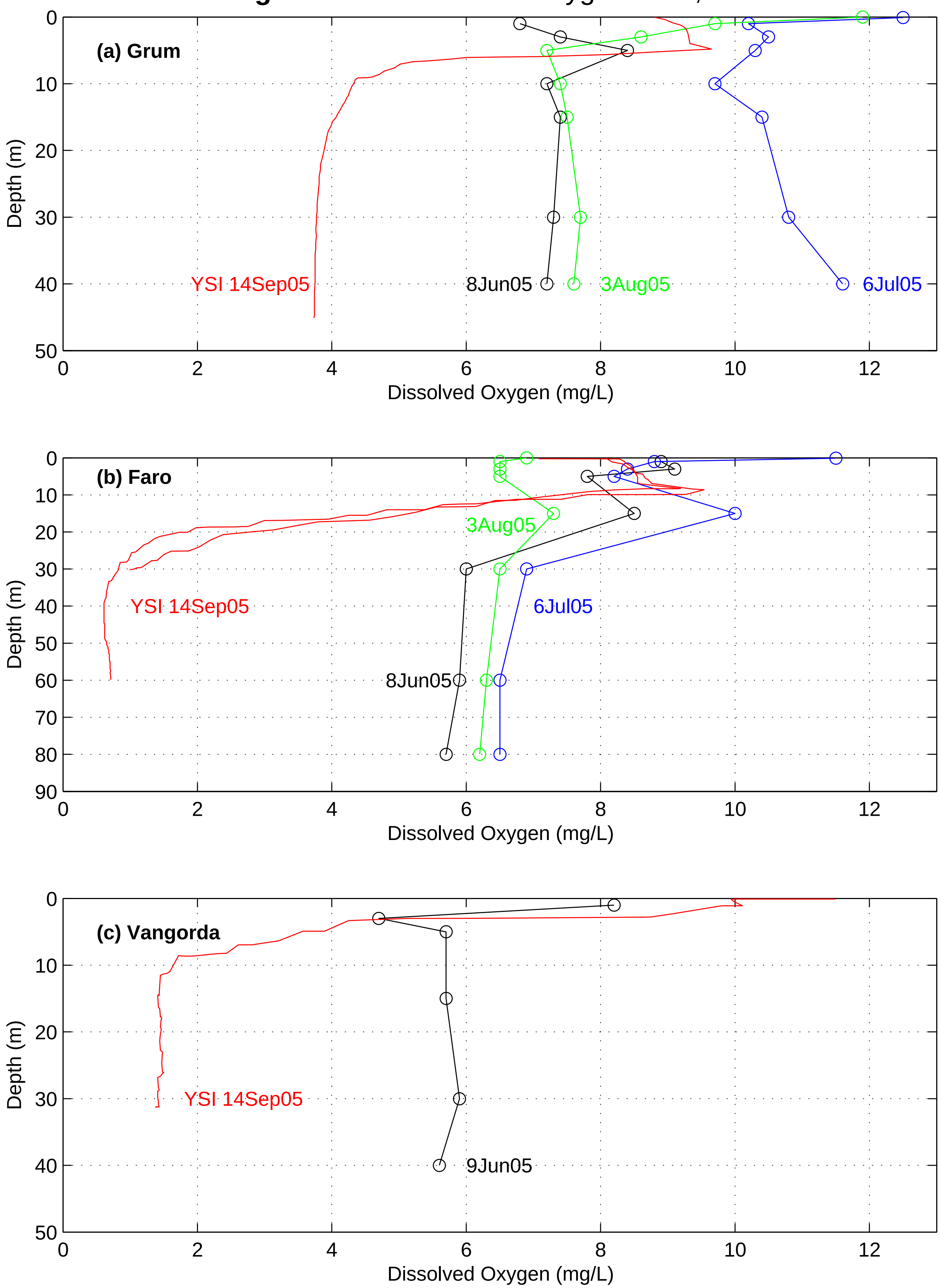
One indicator of the absence of dissolved oxygen is the presence of dissolved iron. In Grum, all dissolved iron concentrations were at or below detection except for the two shallowest under-ice samples in February 2005 and one deep value in September 2005. This suggests oxygen may be present in Grum.

In both Faro and Vangorda, dissolved iron ranged from 2 to 40 mg/L in all the deep samples in both 2004 and 2005. This suggests the absence of dissolved oxygen in these two pit lakes.

Measurement of low-level dissolved oxygen with a hand held probe is unlikely to be successful for a variety of reasons:

- significant oxygen is entrained as the sample is poured into the beaker,
- typically polarographic sensors need to be pumped to provide sufficient flow of water over the membrane, and simple up and down motion of the sensor is not likely adequate for reliable and accurate measurements (Wetzel and Likens, 2000),
- oxygen can dissolve in the sample in the time it takes for the sensor to reach equilibrium, and
- most polarographic sensors are not reliable between 0 and 1 mg/L (Wetzel and Likens, 2000).

Figure A3.1 Dissolved Oxygen Data, 2005



Appendix D

Updated Post-Closure Water Quality in Pit Lakes

(SRK Report 1CD003.046)

Updated Estimates of Post-closure Water Quality in Faro, Grum, and Vangorda Pit Lakes

Prepared for

Deloitte & Touche Inc.

On behalf of

Faro Mine Closure Planning Office

Prepared by

SRK Consulting
Engineers and Scientists

January 2006

Updated Estimates of Post-closure Water Quality in Faro, Grum, and Vangorda Pit Lakes

Deloitte & Touche Inc.

On behalf of

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January 2006

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1 Introduction

1.1 Overview

Biological treatment of the Faro, Grum and/or Vangorda pit lakes has been identified as a potential alternative for removal of metals. An extensive field and laboratory study was initiated in 2004 to further characterize the limnological and chemical characteristics of the pit lakes, characterize sources of metal loading to the pit lakes, determine fertilization requirements, and assess phytoplankton growth and metal removal rates. A more detailed overview of this program is provided in the accompanying report.

Earlier estimates of source concentrations to the pit lakes and therefore long-term water quality in the pits lakes were made as part of the 2003 pit lake assessment (SRK 2004a). Further refinement of these estimates was identified as a priority for the 2004 field program. The source characterization work included the following.

- Collection of additional seepage and runoff samples from the pit walls, particularly for areas that are above the future elevation of flooding. If suitable samples could be collected, the resulting data were intended to replace the current estimates of seepage concentrations based on data from the waste rock seepage sampling programs.
- Ground-truthing existing mapping. Accessible zones within the pits were briefly examined to define the geochemical variations within the zones and to refine the locations of the contacts between the different zones. A limited number of contact tests, sulphur/sulphate analyses, and solids metal analyses were completed to determine how these materials compare to material in the waste rock dumps.
- Improve understanding of current inflows and outflows from each of the pits to allow calibration of load models. Further information on the water management activities in the Faro and Vangorda pits was obtained and used to construct a water and load balance reflecting current conditions in each of the pits.
- Updated water quality estimates, including sensitivity analyses to determine the probable range of loadings to the pits given different closure alternatives in each of the pits.

This report presents results of the additional field studies, a summary of current conditions in each of the pits, and estimates of future water quality. The estimates presented herein supersede those in the 2003 pit lake assessment (SRK 2004a).

1.2 Background Information

There are a number of related studies that were used to improve our understanding of geochemistry and water quality in the pit lakes. A brief description of each of these is as follows.

A number of studies have been completed over the past 20 years to characterize the geochemistry of waste rock at the Anvil Range Mining Complex. A review and compilation of this historical information was completed by SRK in 2002, and supplemental field and laboratory studies were completed in 2002 and 2003 (SRK 2003a and 2004b). These programs included sampling of waste rock and seepage, installation of gas and temperature monitors, and laboratory testing, including static tests, extraction tests, humidity cell tests, and column tests. In 2004, seepage monitoring and gas and temperature monitoring were continued (SRK 2004c). The results of these programs were used to supplement data from the pit lake studies. In particular, data from the seepage surveys were used to supplement the more limited database of pit seep samples, and data from the solids testing programs were used to estimate the long-term weathering behaviour of different types of rock in the pit walls.

Routine monitoring of the pit lake water quality has been completed by site personnel in each of the pits since mining operations ceased and each of the pits were allowed to fill. This has included monthly sampling at Station X22B in Faro Pit Lake since 1996, quarterly sampling at Station V23 in Grum Pit Lake since 1997, and quarterly sampling at Station V22 in Vangorda Pit Lake since 1998.

Detailed studies on Vangorda Pit Lake were completed by SRK in June 2000 (SRK 2000). The study included a pit wall seep survey, sampling of the pit lake at depths of 2 and 12.5 metres, a profile of temperature, pH, conductivity and dissolved oxygen levels, sampling and testing of waste rock and talus, and characterization of secondary minerals found on the pit walls. The study included mass loading estimates, and a preliminary assessment of potential impacts to receiving water quality if untreated water was to be released from the pit.

Estimates of water quality from the waste rock dumps, including the dumps which drain into the Faro pit were made in December 2003 (SRK 2003b). A recent update of those predictions was issued in November 2004 (SRK 2004d). These estimates are the basis for inputs from the waste rock dumps into the pits.

Where relevant, results of the above studies have been incorporated in the summary of current conditions provided in Sections 3 and 4 of the report.

2 Field Investigations

2.1 Methods

2.1.1 Mapping/Ground Truthing

Rough maps of the distribution of lithologies in the current pit walls were produced based on available pit geology maps of existing Faro and Vangorda pits and the design final Grum pit (Brown and McClay 1992; RGI 1996). Limited field mapping and ground truthing of existing maps was undertaken in September of 2003 as part of the initial pit lake assessment (SRK 2004a). Additional field mapping was undertaken in September 2004. Additional mapping consisted of traversing accessible benches and roads within the pits, recording observations of lithology, and photographing pit walls to aid in definition of map units. The mapping included detailed examination of accessible lithologies to assess the degree of uniformity and to define the geochemical variations within each rock type. Additional information on fine scale variations in geology, alteration zones and mineralogy of the units was recorded. For inaccessible sections of pit wall, lithological distribution was verified/ mapped remotely through inspection of visual unit boundaries in pit walls. From the pit rim, the opposite walls were observed, and colour variations in the wall rocks were compared with existing mapped unit boundaries. Where no existing units were defined, colour unit boundaries were mapped and panoramic series of photographs were taken for future reference.

Final map compilation was undertaken by updating existing maps to reflect field observations. Photographs of pit walls were used as a final check on the distribution of lithological units. For Grum Pit, where the available pit geology map was based on the ultimate design pit, photographs were used to define lithological contacts for areas of the pit that were inaccessible. Where lithology of a particular unit could not be verified in the field, unit boundaries were defined based on color variations in pit wall photographs. To apply lithologies to these inaccessible units, the design ultimate pit geology map was consulted and rock units were extrapolated to the current walls. Where these extrapolated units were the same rock type as accessible units, the pit wall photographs were examined to verify visual similarity between these extrapolated units and field-verified units.

A description of rock units and nomenclature at the Anvil Range mines is included in Appendix A.

2.1.2 Waste Rock Seepage

Waste rock seepage within the Faro Pit catchment has been collected in spring and fall since 2002 as part of the waste rock seepage monitoring. Up to 100% of the seepage from each of the Faro Valley North, Faro Valley South, Outer Northeast, Upper Northeast, Lower Northeast, Southwest Pit Wall, Ranch, and Ramp Zone Dumps currently reports to the Faro Pit. Waste rock seepage sampling methods and results are described in a separate report (SRK, 2004c).

2.1.3 Pit Wall Seepage

During spring 2003, six samples were collected of pit wall seepage/ runoff from accessible areas in Grum Pit, in conjunction with the concurrent waste rock seepage sampling.

In spring 2004, a more extensive pit seep sampling effort was undertaken. Pit wall seeps were collected where presented from accessible benches and access roads. At Grum Pit, a total of 13 seeps were sampled. At Faro Pit, samples were collected by accessing the pit walls by boat from the lake; six pit wall seep samples were collected from the pit lake, with one sample subsequently collected from higher up. At Vangorda Pit, seven samples were collected by boat and an additional nine samples were collected from roads and benches.

Where accessible, samples of seepage located within each pit catchment were collected and submitted for analysis of routine parameters (pH, conductivity, acidity, alkalinity, chloride and sulphate), and dissolved metals (dissolved metals by ICP-OES). The samples were filtered and preserved in the field according to standard methods for collection of environmental samples. Field pH, conductivity, redox, temperature measurements were taken at each station using a WTW meter. Flow estimates were made using the bucket and stopwatch method, by estimating the velocity and cross sectional area of the seep, or by visual estimation. Observations of pit wall lithology at sampling stations were recorded to allow correlation of water chemistry and wall rock lithology.

2.1.4 Solids Characterization

Fifteen samples collected during pit traverses were subjected to a distilled water leach extraction to assess the quantity of stored oxidation products in pit wall rock and talus. Samples were collected from talus at the toes of benches and shipped to Canadian Environmental and Metallurgical, Inc. (CEMI) for testing. In the laboratory, as-received samples were screened through a 1 cm mesh sieve. The fines fraction was evaluated for rinse pH and conductivity, using a 1:1 mass ratio of distilled water to solids. Samples were then subjected to a 96-hour distilled water leach at a 3:1 mass ratio of liquid to solids, using 250 g samples. At the end of the extraction, pH and conductivity of the supernatant were measured, and the leachate was filtered and submitted for analysis of acidity, alkalinity, sulphate, and dissolved metals by ICP-OES.

2.2 Results

2.2.1 Mapping/Ground Truthing

Faro Pit

The pre-existing pit geology map for the Faro Pit (RGI, 1996) shows a detailed distribution of rock types, and is based on information from ‘Faro Mine Abandonment Plan’ (Curragh Resources Inc., 1988, referenced in RGI, 1996). Most of the pit walls were inaccessible and prohibited detailed verification of map units; remote visual verification confirmed existing unit boundaries on the basis of color. Where field checking was possible, the existing map was found to be largely representative of existing geological distribution, with a few exceptions described below. The updated Faro Pit map is shown in Figure 2.1.

Field verification led to a change in the lithology assigned to the southwest pit wall, from Unit 2A (ribbon banded graphitic pyritic quartzite) to Unit 3D0 (calc-silicate and related rocks). This change has significant implication for predicted pit water quality, as runoff from Unit 3D0 is expected to be much better quality than runoff from Unit 2A.

Minor changes to two unit boundaries were made on the high northwest pit wall. These included extending Unit 1D4 (quartz muscovite schist) and Unit 10E (hornblende diorite and quartz diorite) to the current pit rim. The pre-existing map had no lithology mapped above Unit 1D4, and thus this change slightly increases estimates of both total pit wall area and area of Unit 1D4. This will increase estimates of loading to the pit lake from the northwest pit wall, as runoff from Unit 1D4 is expected to carry high levels of acidity and metals. The pre-existing map had Unit 1D (biotite schist) mapped from Unit 10E up to the current pit rim; thus, extending Unit 10E to the current pit rim does not change the estimate of total pit wall surface area, but does reduce the exposure of Unit 1D and increases the exposure of Unit 10E. This change will reduce estimates of loading to the pit lake from the northwest pit wall, as runoff from Unit 10E is expected to be better quality than runoff from Unit 1D.

In the southeast pit wall, Unit 1D4 was extended over the pit rim to include a benched area that drains to the pit lake. This will increase estimates of loading to the pit lake due to the poor runoff water quality expected from Unit 1D4.

Active failure of the east wall of Faro Pit results in ongoing changes to the areas of each rock unit exposed at each elevation. Sloughed material covering the pit wall prevents remote updates of pit wall geology, and access to this active failure area for field mapping is dangerous at best. Because this wall largely consists of Unit 1D, the changes in lithological distribution are assumed to be minimal, and for the purposes of pit lake water quality prediction, the pre-existing distribution of rock units (RGI, 1996) is considered to be acceptable.

Grum Pit

The pre-existing Grum Pit geology map was based on the ultimate pit design in the original mine plan, the block model for which was generated from lithological data collected during exploration drilling. Actual mining at Grum followed an updated mine plan that envisioned a modified ultimate pit. This, coupled with the cessation of mining at an intermediate stage of the mine plan, resulted in the current pit shell being substantially different than that depicted in the initial pit geology map. The initial pit geology map provided guidance on the expected distribution of rock types in general, but was not representative of existing geological unit boundaries.

The majority of wall rock exposed in Grum Pit consists of Vangorda Formation phyllites, which make up the entire west wall of the Grum Pit. These phyllites were further divided during operations into a dark grey to black carbonaceous, weakly calcareous member (Unit 5A0) and a silver to dark grey calcareous member (Unit 5B0). Initially, attempts were made to map the distribution of these units separately. However, complex folding has resulted in intimate bench scale mixing of these two units, and it was found to be impractical to differentiate the two units effectively at the pit scale given that large areas of the pit walls are inaccessible. It was decided to map these rocks as a single unit (Unit 5A0/5B0) of undifferentiated Vangorda Formation phyllites, and to define an average runoff water quality for the bulk unit. The new Grum Pit geology map is shown in Figure 2.2.

The second largest component of Grum Pit walls is till, which forms the entire east wall of the pit. A large portion of the east wall is actively failing, which has resulted in a layer of till masking any wall rock that may exist on the east wall above the current pit lake surface. Since the till is expected to dominate runoff quality, this area was mapped as till.

Small areas of undifferentiated sulphides were mapped at the north and south ends of the pit, extending from the current pit lake level (1185 masl) up to approximately 1255 masl. These areas were identified initially through examination of photographs, and subsequently defined following field mapping. Most of the exposed sulphides will be covered when Grum Pit Lake reaches its final spill elevation of 1230 masl, as shown in Figure 2.2. Small areas of Mt. Mye Formation phyllites were defined based on the pre-existing map and the definition of unit boundaries from colour photographs.

Vangorda Pit

The pre-existing pit map was developed during advanced stages of mining at Vangorda as part of a doctoral study of the Vangorda deposit (Brown and McClay, 1992). This simplified map differentiates the Vangorda Pit wall rock into 3 units: Mt. Mye Formation, Vangorda Formation, and massive sulphides.

The boundaries of the geological units observed in the field were found to generally agree with those on the existing map (presented in SRK 2004a). The mapped Mt. Mye Formation was further divided during field mapping to Unit 3G0 (non-calcareous phyllite) and Unit 4L0 (bleached pyritic phyllite).Two small additional sulphide zones were located on the upper part of the north wall internal to the previously mapped Mt. Mye Formation. The mapped Vangorda Formation was inspected where exposed above the Vangorda Creek diversion, and the lithology was identified to be Unit 5A0 (carbonaceous phyllite). Figure 2.3 shows the revised Vangorda Pit geology map.

Southeast of the pit ramp, the previously mapped Mt. Mye Formation wall rock was observed to contain high proportions of sulphides and to have thick coatings of secondary oxidation products. For the purposes of prediction of pit lake water quality, the Mt. Mye Formation here has been lumped with the adjacent undifferentiated sulphides unit. It is expected that runoff water quality of the Mt. Mye wall rock in this area will be dominated by the ongoing oxidation of the contained sulphides, and that loadings from this rock will be more typical of sulphide material.

2.2.2 Waste Rock Seeps

Faro Pit Catchment

Complete results from 2002 through 2004 waste rock seepage monitoring are summarised in the draft report “2004 Waste Rock Seepage Surveys and ARD-related Data Collection” (SRK 2004c).

The largest waste rock seepage input to Faro Pit is water in the former Faro Creek valley that flushes the base of the Faro Valley North and Faro Valley South dumps before flowing over the north pit wall into the lake. This flow can be greater than 1000 L/minute (typically lower), and is sampled at station SRK-FD40. Water quality at SRK-FD40 over the monitoring period has ranged from slightly to strongly acidic (pH 3.0 to 6.2), with zinc concentrations ranging from 47 to 108 mg/L.

Drainage from the Northeast dumps enters the pit at the southern pit ramp. Flow volume can be greater than 1000 L/min (typically lower); this flow is sampled at SRK-FD26, and has neutral pH (6.6 to 7.3) and low zinc concentrations (1.3 to 2.8 mg/L). A number of seeps are collected southeast of the pit (SRK-FD21 through –FD24). These range from neutral to strongly acidic (pH 3.6 to 7.0) and have moderate zinc concentrations (7.2 to 65 mg/L).

The Faro Pit receives occasional waste rock seepage inputs from the low grade ore stockpiles southwest of the pit. These seepage inputs have been present and sampled at SRK-FD38 during two of six sampling events. Flow volumes were low on both occasions (2.5 to 10 L/min), with neutral to acidic pH (pH 3.1 to 7.0) and high zinc concentrations (287 to 595 mg/L). Most loading from the low grade stockpiles to the Faro Pit likely follows a subsurface flowpath, and is rarely available for surface sampling.

There are no waste rock dumps within the catchment of Grum Pit, and therefore all seepage collected within the pit reflects loading from wall rock sources.

Vangorda Pit Catchment

No waste dump toe seepage was collected within the Vangorda Pit catchment. Several seeps were collected that have chemical contributions from both pit walls and in-pit dumps; these are discussed in the following section. In general, all waste rock within the Vangorda Pit catchment is expected to generate acidic seepage with high metal concentrations.

One possible source of seepage to Vangorda Pit could be the Vangorda Dump. The pre-mining topography shows a moderate surface gradient from the location of the dump to the pit. The increase in elevation resulting from placement of the waste rock could theoretically result in the formation of a groundwater mound at this location. This increase in elevation combined with the lowering of the water table adjacent to the pit may have caused a high gradient to develop between the dump and the nearest part of the pit. No seeps have been identified from a waste-dump impacted groundwater source, although the seepage observed on the southwest side of the pit ramp (inside the hairpin) may originate as groundwater.

2.2.3 Pit Wall Seeps

Faro Pit

Faro Pit wall seeps were concentrated along the north and west sides of the pit; seep locations and a summary of water quality results are shown in Figure 2.4. Seep sample locations are also shown on the Faro Pit geology map for reference. Complete pit seep sampling results are provided in Appendix B.1. Faro Pit seeps were collected on June 3, 2004; the area had experienced no precipitation since May 27, and as such the seeps are thought to represent base flow conditions. It should be noted that all seeps wash over wall rock above the point of collection.

Seeps flowing from or over Unit 10E (hornblende diorite and quartz diorite) were neutral to slightly alkaline pH (7.0 to 8.1), with low zinc concentrations (<0.005 to 0.832 mg/L). These flows (seeps 04FP04, -FP05, and -FP07) represent the majority of water entering the pit along the north pit wall. The remainder of the water which enters via the north pit wall flows over Units 1D4 (quartz muscovite schist), 2A (ribbon-banded graphitic pyritic quartzite) and 2E (massive pyritic sulphides). A sample of this water was collected at station 04FP03, and was found to be strongly acidic (pH 3.0) with a high concentration of dissolved zinc (875 mg/L).

Two seeps along the west wall of the Faro Pit (04FP01 and 04FP02) were sampled. This pit wall consists almost entirely of Unit 3D0 (calc-silicate and related rocks) and produces little seepage, as surface and groundwater flow is dominantly driven to the southwest by topography. Sample 04FP02 was collected at the base of the highest section of calc-silicate pit wall. This sample had a slightly alkaline pH (7.5) and a low concentration of dissolved zinc (0.051 mg/L). Sample 04FP01 is adjacent to the west pit ramp, and is likely influenced by upgradient waste rock and low grade ore stockpiles situated near the pit edge. The pH of this sample was slightly acidic (pH 6.5) and the zinc concentration was moderately high (45 mg/L). Due to the likely contamination from low-grade ore and waste rock, this sample was not considered to be representative of Unit 3D0. The water quality measured at 04FP02 was selected to represent runoff from calc-silicate pit walls.

The only pit seep observed originating from the east wall was 04FP06. This water was muddy brown at the time of sampling, with very high total suspended solids derived from the till exposed in the pit wall above. The pH of this water was neutral (pH 7.2) and contained no detectable dissolved zinc. This flow was visually observed to have a similar volume to the seeps on the north pit wall, and likely results from leakage from the Faro Creek diversion.

Grum Pit

Results from 2003 and 2004 Grum Pit seep sampling showed no year-over-year change. Seep locations and water quality results are summarized in Figure 2.5. Seep sample locations are also shown on the Grum Pit geology map for reference. Complete results from pit seep sampling are provided in Appendix B.2. Grum Pit seeps were collected on May 31 and June 1, 2004; the area had experienced no precipitation since May 27, and as such the seeps are thought to represent base flow conditions. It should be noted that all seeps wash over wall rock above the point of collection.

Two seeps were collected from the east wall of the pit, from with the actively failing till unit (04GP04 and 04GP05). A third sample which reflects till runoff water quality was collected from the shallow permanent pond located in the depression in the access ramp that exits the pit to the south (sample 04GP13). All three samples had slightly alkaline pH (pH 7.8 to 8.3) with zinc concentrations ranging from below detection to low levels (<0.005 to 0.031 mg/L).

Four seeps from walls composed of various sulphide materials were sampled. One additional seep (04GP14) within a Vangorda phyllite map unit was sampled, but has water quality that is indicative of a sulphide source. This sample is located midway between two mapped areas of sulphide material, and it is assumed that the seep water contacts similar material upgradient. Abundant iron oxyhydroxide precipitates were observed at 04GP14. This sample also returned the highest zinc concentration (97.5 mg/L) and the lowest pH (6.8) of all Grum Pit seepage samples, and for purposes of pit lake water quality prediction, this sample is assumed to be sourced from sulphide material. Taken together, the five samples had slightly alkaline to slightly acidic pH (pH 6.8 to 8.5) and moderate to high zinc concentrations (6.7 to 98 mg/L).

Fourteen seep samples were collected from benches in mixed Vangorda Formation phyllites along the west wall of Grum Pit (03GP03,-05, -06, 04GP01 through -03, -06 through -08, -11, -12). These samples were characterised by neutral to slightly alkaline pH (pH 7.4 to 8.4) and low zinc concentrations ranging from <0.005 to 0.073 mg/L.

Vangorda Pit

Vangorda Pit seeps were concentrated along the north and east sides of the pit lake, and along the pit access ramp southeast of the pit lake. Seep locations and a summary of water quality results are shown in Figure 2.6. Seep sample locations are also shown on the Vangorda Pit geology map for reference. Complete pit seep sampling results are provided in Appendix B.3. Vangorda Pit seeps were collected on June 1 and 2, 2004; the area had experienced no precipitation since May 27, and as such the seeps are thought to represent base flow conditions. It should be noted that all seeps wash over wall rock above the point of collection.

One seep from Unit 5B0 (Vangorda Formation carbonaceous phyllite) was sampled at the north end of the pit. This seep emerged from the pit wall about 1.5 m above the lake level and had produced a rusty stain on the pit wall below, with local formation of precipitates. Little to no soluble secondary oxidation products were noted in the immediate vicinity; however, abundant salts and secondary copper minerals (green) were observed higher up on the wall within the same unit. This seep had a slightly acidic pH of 6.3 and a high dissolved zinc concentration of 180 mg/L.

Four seeps from Unit 3G0 (Mt. Mye Formation non-calcareous phyllite) were sampled at the north end of the Vangorda Pit. One of these, sample 04VP01, was collected from the wall above the Vangorda Creek Diversion. As this water had contacted at most three metres of pit wall, the water quality is reflective of background conditions with low zinc concentration and neutral pH. The remaining three seeps (04VP11, -12, -13) were collected immediately above the pit lake, and were acidic to neutral pH (pH 3.4 to 7.2) with moderate to high zinc concentrations (2.9 to 42 mg/L). The sources of these seeps had variable amounts of rusty brown staining and bright orange to orangey brown staining. Adjacent rocks and the geological unit as a whole displayed a moderate accumulation of secondary oxidation products. Hard dark grey and occasional tan precipitates were observed on walls that appeared to experience continuous flushing below sources of seepage (04VP12 and -13 only).

One seep was sampled below a till bank along the east wall of the pit south of the pit lake (04VP03). No wall rock was exposed along the flowpath upgradient of this station, and the water quality is assumed to reflect water quality in runoff from exposed till. Where seepage emerged from the till bank, the substrate wais stained a rusty orange; the degree of staining decreased with distance from the seep source. Sample 04VP03 had a neutral pH of 7.6 and no detectable dissolved zinc.

Three seeps from Unit 4L0 (Mt. Mye Formation bleached phyllite) were sampled along the northeast wall of the pit ramp (04VP05 through -07). Unit 4L0 is overlain by siliceous massive sulphides at this location which may be controlling water quality. An undefined amount of sulphide waste was placed on the wide bench above this wall, and seepage may reflect the influence of water acquiring dissolved load as it moves through this waste. However, runoff water quality from Unit 4L0 is expected to be poor, and an average runoff quality defined by these three samples is likely an appropriately conservative approximation.

Seven samples (04VP02, -04, -08, -09, -14, -15, -16) were collected from pit wall runoff and seepage sources draining undifferentiated massive and disseminated sulphides (Figure 2.6). Three of the samples were collected from pit wall runoff immediately above the pit lake surface; these had acidic to neutral pH (pH 3.7 to 7.2) and moderate to high zinc concentrations (19.9 to 238 mg/L). The four samples collected southeast of the pit lake all had acidic pH (2.8 to 5.6) and moderate to very high zinc concentrations (12 to 1550 mg/L). All seepage locations were characterized by orange to rusty brown staining and/ or accumulations of bright reddish orange precipitates. The samples with the highest zinc concentrations (04VP04 and 04VP08) were both downgradient of in-pit sulphide dumps, and seep water quality may reflect dissolved load from these sources. Sample 04VP02 was collected from seepage that had contacted a single bench (~3 m) of blocky siliceous massive sulphide, and the relatively low zinc concentration (12.1 mg/L) is likely reflective of this minimal opportunity for contact.

2.2.4 Solids Characterization

Pit wall talus sample locations are shown on the respective pit geology maps for Faro, Grum, and Vangorda Pits (Figures 2.1 through 2.3). Lithological descriptions of each sample are shown in Table 2.1, along with results from contact testing and leach extraction testing. A brief discussion of the results from each pit follows.

Faro Pit

Seven samples were collected from Faro Pit. Six samples of intrusive, calc-silicate, and biotite schist had neutral to slightly alkaline rinse pH ranging from 7.2 to 8.1, with rinse conductivity ranging from 55 to 1816 µS/cm, as shown in Table 2.1. The lone sample from altered quartz muscovite schist (FP03) had a rinse pH of 2.7 and a rinse conductivity of 2590 µS/cm.

The 96-hour leach extraction testing returned similar pH and conductivity results for all samples, with the altered quartz muscovite schist (FP03) producing acidic leachate (pH 2.6) with higher conductivity (2070 µS/cm) than all other samples. The FP03 leachate had correspondingly high acidity, and elevated concentrations of sulphate and dissolved metals (eg. 19.8 mg/L Zn). The leachate from the remaining Faro Pit talus samples was neutral to slightly alkaline, with low to elevated sulphate and dissolved metal concentrations at or near detection levels.

Grum Pit

Seven samples were collected from Grum Pit, including six samples of mixed Vangorda Formation phyllites and one sample of pyritic quartzite. All phyllite samples had slightly alkaline rinse pH (8.1 to 8.8) and low to elevated rinse conductivity (130 to 1650 µS/cm), as shown in Table 2.1. The pyritic quartzite sample (GP03) returned a slightly acidic rinse pH (6.4) and a somewhat elevated rinse conductivity (620 µS/cm). Extraction leachate from GP03 had high dissolved zinc (55 mg/L) and lead (1.2 mg/L) concentrations, and detectable concentrations of dissolved cadmium, cobalt, copper, and manganese. Extraction leachate from the various phyllite samples contained dissolved metals at or near detection limits; three samples had detectable dissolved zinc with a maximum concentration of 0.0304 mg/L.

Vangorda Pit

Two samples were collected from Vangorda Pit. Sample collection in 2004 was limited as solids testing of Vangorda Pit talus samples had been carried out as part of an earlier study (SRK 2000).

One sample of Vangorda Formation carbonaceous phyllite was collected; rinse pH for this sample was slightly acidic (pH 5.9), with a low rinse conductivity 75 µS/cm. Leach extraction on this sample produced a leachate with slightly alkaline pH and elevated conductivity and sulphate. Dissolved metal concentrations were at or near detection levels, with a dissolved zinc concentration of 0.0089 mg/L.

One sample of Mt. Mye Formation non-calcareous phyllite was collected. This lithology was sampled and tested a number of times during the previous investigation, and was subjected only to contact tests as part of the current program. This sample returned an acidic rinse pH of 3.4, and a moderate rinse conductivity of 570 µS/cm.

A total of nineteen samples were collected in the earlier study (SRK 2000), including talus and waste rock. The results indicated six of the samples had rinse pH below 5, eight samples with rinse pH between 5 and 6, and five samples with rinse pH above 6. Most of the samples contained significant amounts of sulphide, and minimal neutralization potential, and are therefore classified as potentially acid generating. The single exception was a till sample. Concentrations of arsenic, cobalt, copper, lead and zinc were elevated, indicating a strong potential for metal leaching. Leach extraction tests completed at a water to solids ratio of 20:1 indicated soluble zinc loads of 14 to 5580 mg/kg of solids. Several other metals were present at elevated concentrations, particularly in the low pH samples. Secondary minerals were observed at many locations in the pit, and included bianchite (a hydrated zinc sulphate), melanterite (iron sulphate), gypsum and iron hydroxides.

Table 2.1 Sample descriptions, contact test and leach extraction results

		Contact tests		96-hour distilled water extraction															
				Physical Parameters and Anions						Dissolved Metals (mg/L)									
Sample ID	Lithological Unit	Rinse pH	Rinse Conductivity (us/cm)	Final pH	Final Conductivity (uS/cm)	Alkalinity (mg CaCO3/L)	Acidity (pH 4.5) (mg CaCO3/L)	Acidity (pH 8.3) (mg CaCO3/L)	Sulphate (mg/L)	Arsenic	Barium	Cadmium	Cobalt	Copper	Iron	Lead	Manganese	Antimony	Zinc
FP01	10E- Hornblende diorite and quartz diorite	7.72	55	7.46	48	15.75	0	4	8	<0.20	0.06	<0.010	<0.010	<0.010	0.387	<0.050	0.0142	<0.20	<0.0050
FP02	10E- Hornblende diorite and quartz diorite	8.13	1816	7.80	1555	33.5	0	10.5	1818	<0.30	0.037	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	<0.0050
FP03	1D4- Altered quartz muscovite schist	2.69	2590	2.57	2070	0	520	770	1054	0.58	0.013	0.247	0.546	5.95	128	<0.050	6.77	<0.20	19.8
FP04	1D- Biotite schist	7.24	1278	7.82	1062	36	0	7.75	945	<0.20	0.033	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	0.0059
FP05	3D0- Calc-silicate	8.53	140	8.15	166	65.5	0	2	21	<0.20	0.035	<0.010	<0.010	0.01	0.036	<0.050	<0.0050	<0.20	<0.0050
FP06	1D- Biotite schist	7.98	91	7.89	108	40.5	0	4.75	12	<0.20	<0.010	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	<0.0050
FP07	10F- Quartz feldspar porphyry	8.09	128	8.00	191	49.25	0	1.25	36	<0.20	0.061	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	<0.0050
GP01	5A0/5B0- mixed Vangorda Formation phyllite	8.25	429	8.22	316	72	0	0.5	100	<0.20	0.044	<0.010	<0.010	<0.010	0.099	<0.050	<0.0050	<0.20	<0.0050
GP02	5A0/5B0- mixed Vangorda Formation phyllite	8.10	265	8.14	231	62.75	0	2.25	59	<0.20	0.038	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	<0.0050
GP03	4C- Pyritic quartzite (mapped as 4EC)	6.37	616	6.75	448	5.5	0	72.75	242	<0.20	0.061	0.112	0.039	0.019	<0.030	1.2	0.195	<0.20	55.3
GP04	5A0/5B0- mixed Vangorda Formation phyllite	8.25	930	8.04	1001	49.75	0	5	559	<0.20	0.02	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	0.0061
GP05	5A0/5B0- mixed Vangorda Formation phyllite	8.71	193	8.19	197	69	0	1	40	<0.20	0.038	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	<0.0050
GP06	5A0/5B0- mixed Vangorda Formation phyllite	8.75	337	8.02	269	64	0	2.25	78	<0.20	0.024	<0.010	<0.010	<0.010	<0.030	0.051	<0.0050	<0.20	0.0304
GP07	5A0/5B0- mixed Vangorda Formation phyllite	8.28	1656	7.78	1122	41.25	0	8.75	1017	<0.20	0.024	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	0.0148
VP01	3G0- Mt. Mye non-calcareous phyllite	5.93	45	7.78	1137	40.5	0	7.25	1029	<0.20	0.027	<0.010	<0.010	<0.010	<0.030	<0.050	<0.0050	<0.20	0.0089
VP02	5A0- Carbonaceous phyllite	3.36	357	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Note: Sample VP02 was not subjected to to leaching extraction testing

3 Current Conditions

3.1 Faro Pit Lake

3.1.1 Routine Monitoring

Faro Pit Lake water quality is currently sampled as part of the routine monitoring required by the site water license. Samples are collected by site environmental staff from the pit lake surface at station X22B. Sulphate and zinc concentrations at station X22B for the period of 1998 to present are shown in Figure 3.1; dissolved concentrations are plotted where available, and total concentrations were substituted where necessary to complete the record. Complete monitoring results for the 1998-2004 period are provided in Appendix C.1.

The results indicate the pit lake surface water currently has neutral to slightly alkaline pH's (ranging from 6.7 to 7.8), moderate alkalinity levels and sulphate concentrations of approximately 600 mg/L. Calcium and magnesium are the dominant cations. Concentrations of cadmium (0.012 mg/L)[1], cobalt (0.036 mg/L), copper (0.039 mg/L), and zinc (12 mg/L) are elevated. As shown in Figure 3.1, sulphate concentrations indicated some short-term variability, but have typically been in the range of 600 mg/L since the start of monitoring in 1996. Zinc concentrations were typically less than 5 mg/L from 1996 to 2000. From August 2000 to November 2000, there was a brief spike in surface water concentrations. The cause of this temporary increase in surface zinc concentrations is not known, but may be related to high zinc inflows due to site water management. This increase is unlikely to be related to fall turn-over of the lake, as Figure 3.1 shows the bottom water to have a lower zinc concentration. Following the Fall 2002 spike, concentrations then stabilized in the range of 10 to 15 mg/L. However, periodic spikes were observed in March 2002, 2003 and 2004.

3.1.2 Depth Profiles

In April 2003 Gartner Lee Limited (GLL) carried out a program of sampling and analysis to characterize water quality in Faro Pit Lake. A similar program was carried out in June 2004 by Lebarge Environmental Services (Lorax, 2004). Complete results are presented in Appendix D.1.

The results shown in Figure 3.2 indicate that the Faro Pit has two haloclines: one at 3-5 metres depth, and the other at 15 to 20 metres depth, with conductivity increasing in two distinct steps. The uppermost layer is characterized by higher pH (7.9), lower conductivity (1070 uS/cm), and generally higher metal concentrations (eg. 11 mg/L zinc), the middle layer shows a slight decrease in pH (7.5 to 7.8), increase in conductivity (1200 uS/cm) and decrease in metal concentrations (eg. 8.4 to 10 mg/L zinc), while the lower layer has the lowest pH (6.9 to 7.3), highest conductivity (1350 uS/cm) and lowest metal concentrations (eg. 1.4 to 3 mg/L zinc).

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[1] Values represent the average of the 2003 and 2004 data.

Suboxic conditions were also observed at depth, and corresponded to a substantial increase in redox sensitive metals such as iron and manganese. As discussed previously, tailings were deposited in the Faro pit. Sulphide minerals in the tailings may help to facilitate sulphate reduction, which could be acting as a sink for metals in this system.

3.2 Grum Pit Lake

3.2.1 Routine Monitoring Data

Routine monitoring of Grum Pit Lake water quality is currently completed to fulfil the requirements of the site water license. Samples are collected from the surface of the pit lake at station V23, which is located at the bottom of the ramp. Sulphate and zinc concentrations from 1997 to present are shown in Figure 3.3. Complete monitoring results are provided in Appendix C.2.

The pit lake currently has a slightly alkaline pH (approximately 7.8), elevated alkalinity levels and sulphate concentrations of approximately 420 mg/L. Calcium and magnesium are the dominant cations. Concentrations of cadmium (0.012 mg/L)[2], cobalt (0.041 mg/L), copper (0.021 mg/L), and zinc (7.0 mg/L) are somewhat elevated. As shown in Figure 3.3, sulphate concentrations increased over the first two years of filling, and there are no clear trends in zinc concentrations. In general, concentrations of most metals were highly variable, and had the highest concentrations in 2000/2001. For example, zinc concentrations in 2000/2001 ranged from less than detection to 14 mg/L, while more recent concentrations were in the range of 4 to 8 mg/L. It should be noted that the last sample, collected in July 2004 is influenced by the pit lake study.

3.2.2 2003/2004 Depth Profiles

Depth profiling was completed in August 2003 by Gartner Lee Limited (GLL 2003) and from July through September 2004 by Lebarge and Lorax (Lorax 2004). Results from both programs indicated the pit lake was thermally stratified during the summer season, with a warm surface layer extending to depths of 2 to 5 metres; the complete set of data is included in Appendix D.2 and summarised in Figure 3.4. The warmer surface layer had consistently lower conductivity, sulphate and metal concentrations compared to samples collected at depth (for example, zinc concentrations were 3 to 4 mg/L at surface and approximately 9 to 12 mg/L at depth). Possible reasons for this include dilution by melting ice, incident precipitation, clean runoff from the pit walls, and partial removal of zinc due to inherent biological activity present in the lake. The stratification is maintained during the summer months due to the strong thermal gradient; further monitoring is being completed to determine fall and winter conditions when the thermal gradient is reversed.

[2] Values represent the average of the 2003 and 2004 data, excluding the July 2004 data which was influenced by the treatment studies in the pit.

3.3 Vangorda Pit Lake

3.3.1 Routine Monitoring Data

Routine monitoring of Vangorda Pit Lake water quality is currently completed to fulfil the requirements of the site water license. Samples are collected by site environmental staff from the surface of the pit lake at station V22, which is currently located on the barge. Sulphate and zinc concentrations at station V22 from 1998 to present are shown in Figure 3.5. Complete monitoring results are provided in Appendix C.3.

The results indicate the pit lake currently has a neutral pH, moderate alkalinity levels and sulphate concentrations of approximately 1000 mg/L. Calcium, magnesium and zinc are the dominant cations. Concentrations of cadmium (0.069 mg/L), cobalt (0.44 mg/L), copper (0.045 mg/L), iron (0.81 mg/L), manganese (22 mg/L), nickel (0.38 mg/L) and zinc (66 mg/L) are elevated. As shown in Figure 3.5, sulphate and zinc concentrations increased significantly between 2001 and 2003. This was coupled with a slight decrease in pH (from 7.5 prior to 2001 to less than 7 in the more recent data), and increases in cobalt, manganese and nickel concentrations.

3.3.2 2003/2004 Depth Profiles

Depth profiling was completed in September 2003 by SRK (SRK 2004a) and in July 2004 by Lebarge and Lorax (Lorax 2004). A partial profile was also completed in June 2000 by SRK (SRK 2000). Results are provided in Figure 3.6, and Appendix D.3. The results indicated that there was a strong thermocline at a depth of 2 to 3 metres. Results from all three sampling periods indicated that conductivity, sulphate and metal concentrations increased with depth. The differences were more strongly pronounced in the June 2000 and September 2004 results, indicating there is more variability in concentrations in this system. For example, zinc concentrations were 6.3 mg/L in the surface layer and 70 mg/L at depth in June 2000, 92 mg/L at surface and 110 mg/L at depth in August 2003, and 56 mg/L at surface and 131 mg/L at depth in September 2004. The latter results may have been influenced by a short but severe period of fresh water inflow from Vangorda Creek during the large storm event of June 8, 2004.

4 Water Quality Estimates

4.1 Overview

Water quality estimates for each of the pits were estimated using simple mass balance calculations which considered geometry, water balance, limnology, and specific sources of contaminant loading to each pit lake.

Input assumptions and resulting water quality estimates for each of the pits are presented and discussed in the following sections.

4.2 Faro Pit

4.2.1 Modelled Scenarios

Three scenarios were considered in the water quality estimates for Faro Pit Lake. In the base case, it was assumed that the Faro Creek diversion would be breached and allowed to spill into the pit. Two additional scenarios were also evaluated to show the effects of: 1) maintaining the diversion, and 2) removing the Faro Valley Dump.

All three scenarios took the ‘Current Average’ waste rock drainage quality (SRK 2004d) as the estimate for waste rock loading to the pit. To examine the sensitivity of each scenario to waste rock loadings, each scenario was also evaluated with the ‘Future Worst Case’ dump drainage prediction (SRK 2004d) providing the waste rock loading estimate.

Any closure alternative which includes in-pit treatment will also include some form of remediation of waste dumps that contribute load to the pit. In the waste rock seepage prediction (SRK 2004d), it was assumed that 45% of incident precipitation leaves uncovered waste rock dumps as either runoff or seepage. For the estimates herein, it was assumed that simple soil covers would be in place on all contributing dumps, and that infiltration (and seepage) would be limited to 25% of incident precipitation.

Assumptions common to all scenarios were that the ore stockpiles would be removed from the pit catchment and that the Zone II pit discharges would be directed to the water treatment plant. In addition, a plug dam would be constructed across the southeast pit ramp, to increase the flood elevation and thus the residence time in the pit. This would result in an ultimate pit lake elevation of 1173.5 masl. The water and load balances assumed that pit filling began on January 1, 2004.

4.2.2 Geometry, Flow Conditions and Stratification

The volume-capacity curve for the Faro pit was re-assessed using the topography generated from the 2003 aerial photography. To include the volume of water below the current pit lake level, the new curve was 'meshed' with the new pit bathymetry acquired in 2004. The complete volume-capacity curve is provided in Figure 4.1.

The overall water balance for Faro Pit Lake is summarised in Tables 4.1 and 4.2. Estimates of discharge would apply only after the lake reached the spill elevation. Table 4.1 shows conditions for the scenario where Faro Creek is routed through the pit lake, making the total catchment about 17.1 km^2. The mean annual runoff is estimated to be 341 mm and mean annual precipitation 400 mm. The evaporative losses are estimated for a fixed pit lake surface area of about 0.78 km^2 using lake evaporation rates provided in the ICAP (RGI, 1996). The pit lake area adopted in the calculations represents the pit lake at fully flooded conditions. It should however be noted that during the flooding period the pit lake will be smaller and the actual evaporative losses will be lower. The net implication is that the time to flooding will be marginally overestimated and, as a result of the longer time to flooding, the contaminant concentrations at the time of spilling will also be slightly overestimated. Table 4.2 shows the Faro Pit annual water balance for the scenario where Faro Creek is diverted around the pit using the proposed East Interceptor and East Interceptor Extension (Golder, 2004). The catchment reporting to the pit in this case would have an area of 1.7 km^2.

The pit lake stability assessment (Lawrence, 2004) indicated that if Faro Creek is allowed to flow into the pit lake, the kinetic energy introduced will likely result in a completely mixed system having uniform contaminant concentrations.

Table 4.1 Summary of Pit Lake Water balance with Faro Creek Flow-through

Month	Days in month	INFLOWS		OUTFLOWS				
		Runoff	Direct Precipitation on Lake Surface	Groundwater Recharge	Lake Evap	Lake Evaporation	Discharge at Pit Outlet	
		(1000 m^3)	(1000 m^3)	(1000 m^3)	(mm)	(1000 m^3)	(1000 m^3)	(m^3/s)
Jan	31	123	7	1	0	0	128	0.05
Feb	28.25	91	5	1	0	0	95	0.04
Mar	31	88	5	1	8	6	78	0.03
Apr	30	116	6	1	53	41	27	0.01
May	31	1085	58	1	90	70	982	0.37
Jun	30	1873	100	1	112	87	1772	0.68
Jul	31	858	46	1	108	84	710	0.27
Aug	31	427	23	1	81	63	304	0.11
Sep	30	414	22	1	31	24	380	0.15
Oct	31	392	21	1	10	8	393	0.15
Nov	30	207	11	1	0	0	217	0.08
Dec	31	164	9	1	0	0	171	0.06
Annual	365.25	5838	312	16	493	385	5257	0.17

Table 4.2 Summary of Faro Pit water balance with Faro Creek diverted

Month	Days in month	INFLOWS		OUTFLOWS				
		Runoff	Direct Precipitation on Lake Surface	Groundwater Recharge	Lake Evap	Lake Evaporation	Discharge at Pit Outlet	
		(1000 m^3)	(1000 m^3)	(1000 m^3)	(mm)	(1000 m^3)	(1000 m^3)	(m^3/s)
Jan	31	12	7	1	0	0	18	0.01
Feb	28.25	9	5	1	0	0	13	0.01
Mar	31	9	5	1	8	6	6	0.00
Apr	30	12	6	1	53	41	-25	-0.01
May	31	109	58	1	90	70	96	0.04
Jun	30	188	100	1	112	87	200	0.08
Jul	31	86	46	1	108	84	46	0.02
Aug	31	43	23	1	81	63	1	0.00
Sep	30	42	22	1	31	24	38	0.01
Oct	31	39	21	1	10	8	51	0.02
Nov	30	21	11	1	0	0	31	0.01
Dec	31	16	9	1	0	0	24	0.01
Annual	365.25	587	312	16	493	385	498	0.02

4.2.3 Contaminant Inventory and Sources

Pit water quality will be determined by the inventory of contaminants currently present in the pit lake and by the future influx of contaminants. Potential contaminant sources to Faro Pit Lake include seepage and runoff from the wall rock, talus, and in-pit dumps, dissolution of secondary minerals from sheltered areas of the pit walls during flooding, and releases from material at the bottom of the lake, such as tailings and tailings porewater, and any secondary minerals that have precipitated.

Current Pit Inventory

The contaminant mass currently resident in Faro Pit Lake determines the current pit water quality and provides the starting point for calculating future pit water quality. Resident contaminant mass was calculated from results of depth profiling conducted in June 2004, as discussed in Section 3.1.2. Table 4.3 summarizes the mass of contaminants currently resident in the pit lake.

Table 4.3 Current contaminant inventory in Faro Pit

Parameter	Current mass in pit lake (kg)
Cl	37000
SO4	18000000
Ca	4600000
Mg	1700000
K	370000
Na	850000
Al	1400
Cd	110
Co	970
Cu	240
Fe	350000
Pb	27
Mn	99000
Ni	2100
Zn	150000

Wall Rock

Maps and descriptions of the pit wall rock are provided in Section 2.2.1. The relative areas of each rock for current and future flooding levels are presented in Figure 4.2. As indicated in Figure 2.1, the dominant rock type is biotite schist (Unit 1D), with somewhat smaller exposures of calc-silicate (Unit 3D0), hornblende diorite and quartz diorite (Unit 10E), and altered quartz muscovite schist (Unit 1D4). Minor exposures of quartz feldspar porphyry (Unit 10F), graphitic pyritic quartzite (Unit 2A), and massive sulphides (Unit 2E) are also present.

The geochemical characteristics of each of the above rock types are described in *"Geochemical Studies of Waste Rock at the Anvil Range Mining Complex"* (SRK 2004b). This report included an overall classification of the long-term geochemical behaviour based on acid base accounting tests and kinetic tests. In brief:

- Unaltered biotite schist (Unit 1D) unit has been classified as non-acid generating unless it is mixed with sulphides from other rock types
- Calc-silicates (Unit 3DO) are classified as acid consuming
- Intrusives (Unit 10E and 10F), are theoretically acid generating, but are expected to take several decades before acid generation occurs
- Altered quartz muscovite schists (Unit 1D4) and sulphides (Unit 2) are acid generating, and likely already producing acidic seepage.

Given the advanced state of weathering observed in the Faro pit, and the limited amount of material which is expected to change in the longer term, loading from the wall rock is not expected to change significantly over time.

As discussed in Section 2.2.4, the results of the limited wall rock and talus testing indicated that these samples contained relatively little soluble oxidation products. However, a single sample from Unit 1D4 (altered quartz muscovite schist) generated acidic rinse water and contained a high soluble zinc load. Once the pit reaches its ultimate lake elevation (Figure 4.2), this unit will occupy approximately 80,000 m^2 of the high northwest wall of the Faro Pit, and will therefore remain a major source of loading to the pit lake in the long term.

Seepage data from the 2004 pit seep surveys (Section 2.2.3) provides the most representative means of estimating source concentrations associated with each of the above rock types. Wall rock runoff quality was assumed to be the average of that in seep/runoff samples collected from within each rock unit. Where seeps were not available for a given rock unit, a water type was selected from the available database of waste rock seepage types. In some cases, results of the leach extraction tests (Section 2.2.4) were helpful in selecting these seepage types. Table 4.4 summarizes the water types used to characterize runoff each of the above rock units. A complete set of parameters for each water type is attached in Appendix E.1.

The total contaminant load from the wall rocks was estimated by multiplying the relative areas of each of the rock types (m^2) by the source concentrations in Table 4.4 (mg/L). This was then multiplied by the site runoff ($L/(m^2.year)$) to yield mg/year, and corrected to kg per year. The estimates of total wall rock load are provided in Table 4.5.

Secondary mineral salts such as zinc and iron sulphates observed on the pit walls could also be a source of contaminant loading to the pit lake during the flooding period. Scoping level calculations indicate that this source is insignificant in relation to other sources of load.

Table 4.4 Water types for used to estimate wall rock loadings to Faro Pit Lake

Water type	Unit	Lithology	pH (s.u.)	Alk (mg/L)	SO4 (mg/L)	Cu (mg/L)	Zn (mg/L)	Exposed rock above final spill elev. (m^2)
FT1	1D	Biotite schist	7.3	185	720	0.010	2.5	257,000
FT4	1D4	Altered quartz muscovite schist	3.9	16	1600	2.1	109	76,000
FT5	2E	Barren massive sulphides	3.4	6	17000	92	4260	8,000
FT11	2A	Ribbon-banded graphitic pyritic quartzite	4.3	10	390	0.37	35	18,000
FT12	3DO	Calc-silicate	7.5	139	430	0.010	0.051	81,000
FT13	10E	Hornblende diorite and quartz diorite	7.5	242	140	0.010	0.28	102,000
FT13	10F	Quartz feldspar porphyry	7.5	242	140	0.010	0.28	32,000

Table 4.5 Summary of wall rock contaminant loadings to Faro Pit

	Initial Loading	After spill elevation reached
Parameter	Loading (kg/year)	Loading (kg/year)
Cl	970	610
SO4	259,000	173,000
Ca	32,000	23,000
Mg	25,000	18,000
K	1,500	1,100
Na	14,000	7,800
Al	1,500	1,000
Cd	39	24
Co	36	24
Cu	510	310
Fe	16,000	9,600
Pb	32	23
Mn	2,200	1,300
Ni	49	34
Zn	24,000	15,000

Waste Rock

Several waste dumps are within or partially within the Faro Pit Catchment. They will be an ongoing source of loading to Faro Pit Lake. Loadings from low grade ore stockpiles within the dump catchment were not considered, as these stockpiles will likely be removed or covered by a very low infiltration cover in the near future.

A list of waste dumps partially or fully inside the Faro Pit catchment is shown in Table 4.6, along with an estimate of the proportion of seepage from each dump that will report to the pit. Table 4.6 also includes the water quality estimates presented in the waste dump water quality estimates report (SRK 2004d). The estimated contaminant concentrations were multiplied by the net annual infiltration to each waste rock dump to obtain the total annual loading for that dump. Each waste rock dump load was then multiplied by the proportion of seepage reporting to the pit catchment to estimate the corresponding contaminant loads to the pit lake.

The resulting annual load estimates to Faro Pit from waste rock are summarised in Table 4.7. Loadings to Faro Pit are shown for both the base case, with Faro Valley Dump in place, and for the case where the Faro Valley Dump is removed. Zinc loadings and copper loadings are estimated to be reduced by over 1500 kg/year, and 29 kg/year, respectively, through dump relocation.

Table 4.6 Faro Pit catchment: Waste Rock Dumps and Applied Seepage Quality

Waste Rock Dump	Proportion in Pit Lake Catchment	Acidity	Alk	Cl	SO4	Ca	Mg	K	Na	Al	Cd	Co	Cu	Fe	Pb	Mn	Ni	Zn
Faro Valley North	100%	11215	182	35.6	18697	2006	1870	74	87	171	1.8	3.5	24	884	4.2	116	6.5	1268
Faro Valley South	100%	2691	44	8.6	4487	481	449	18	21	41	0.4	0.8	5.7	212	1.0	28	1.6	304
Southwest Pit Wall Dump	70%	6463	105	20.5	10774	1156	1077	43	50	99	1.1	2.0	14	509	2.4	67	3.7	731
Ranch Dump	20%	117	581	5.9	4371	796	624	26	81	0.8	0.1	0.1	0.1	3.5	0.2	9.1	0.4	51
Ramp Zone Dump	20%	80	572	3.9	10532	1082	1452	92	622	1.0	0.1	0.1	0.1	1.6	0.3	0.7	0.4	31
Outer Northeast Dump	100%	35	176	1.8	1321	241	188	8	24	0.3	0.0	0.0	0.0	1.0	0.1	2.8	0.1	15
Lower Northeast Dump	30%	289	4749	43.9	10758	3083	2212	90	160	4.7	0.2	0.2	0.2	0.7	1.2	1.0	1.2	50
Upper Northeast Dump	40%	269	4426	40.9	10025	2873	2061	84	149	4.3	0.2	0.2	0.2	0.7	1.1	0.9	1.1	47

All units are loadings in kg / year

Table 4.7 Summary of Estimated Annual Contaminant Loadings to Faro Pit from Waste Rock

Parameter	Faro Valley Dump in place	Faro Valley Dump removed
	Loading (kg/year)	Loading (kg/year)
Cl	92	48
SO4	42000	19000
Ca	6000	3500
Mg	5200	2800
K	210	120
Na	420	310
Al	290	73
Cd	3.2	0.95
Co	5.9	1.6
Cu	39	9.8
Fe	1500	340
Pb	7.9	2.6
Mn	200	52
Ni	12	3.7
Zn	2100	580

4.2.4 Water Quality Estimates

A calculation spreadsheet was used to estimate changes in concentrations that could occur once the plug dam is constructed, the pit is allowed to fill to its final level of 1173.5 masl, and the resident load is flushed from the system. No in-pit removal of contaminants through sorption, particulate settling, biological removal, or sulphate reduction was considered. The calculations also assume that no contaminants will enter the pit water from in-pit tailings or from wall rock below the present lake surface, and that no further contaminant removal will occur through water treatment. Steady-state concentrations are assumed to be reached once the amount of load entering the pit is equal to the amount of load leaving the pit.

In the base case estimates, it was assumed that the Faro creek diversion would be breached and allowed to spill into the pit. In this case, the water level is expected to reach the 1173.5 masl spill elevation in August 2007 (Figure 4.3). Results of the pit lake water quality calculations are presented in Figure 4.4.

The most notable feature of the estimates is the decrease in acidity and zinc concentrations due to the influx of clean water. The modelling suggests that, at the time when the pit would first spill, the acidity would be about 34 mg $CaCO_3$ eq/L, the zinc about 5 mg/L, and the copper about 0.04 mg/L. Zinc would then continue to decrease to a long-term steady-state concentration of about 3 mg/L, and acidity would decrease to about 12 mg/L. However, copper would continue to increase to a long-term average of about 0.06 mg/L. Copper estimates are likely very conservative, as detection limit values were substituted for samples where concentrations were less than detection. This apparent accumulation of copper may be a function of the analytical limitations, and may not be representative of actual copper loadings to the pit.

Two additional scenarios were evaluated to show 1) the effects of continuing to divert Faro Creek flows and 2) the effects of removing the Faro Valley Dump. In the case of diversion, pit filling would occur much slower, with the first predicted discharge occurring in 2047 (Figure 4.5). At this time, modelling suggests that the pit lake water would have an acidity of 101 mg $CaCO_3$ eq/L, a zinc concentration of 22 mg/L, and a copper concentration of 0.39 mg/L. The model predicts that acidity and metal concentrations will continue to increase for at least 200 years under these conditions, and that after 200 years, the pit lake would have an acidity of 127 mg $CaCO_3$ eq/L, a zinc concentration of 32 mg/L, and a copper concentration of 0.64 mg/L (Figure 4.6).

Removing the Faro Valley Dump and allowing Faro Creek to flow into the pit results in little change from the base case predictions. When the pit first discharges (August 2007- Figure 4.3), the pit lake water is predicted to have an acidity concentration of 33 mg $CaCO_3$ eq/L, a zinc concentration of 4.6 mg/L, and a copper concentration of 0.04 mg/L. In the long term, the pit lake water is predicted to have acidity of 11 mg $CaCO_3$ eq/L, zinc concentrations of 2.7 mg/L, and a copper concentration of 0.06 mg/L (Figure 4.7).

A summary of results for the three scenarios modelled is presented in Table 4.8.

Table 4.8 Estimated Faro Pit water quality with 'Current Average' waste rock inputs

Parameter	Base Case		Faro Creek Diverted		Faro Valley Dump Removed	
	At spill (Aug. 2007)	Long term (~ yr. 2040)	At spill (yr. 2047)	Long term (yr. 2204)	At spill (Aug. 2007)	Long term (~ yr. 2040)
Acidity (mg CaCO3eq /L)	34	12	101	127	33	11
Zinc (mg/L)	4.7	3.0	22	32	4.6	2.7
Copper (mg/L)	0.04	0.06	0.39	0.64	0.04	0.06

Sensitivity to increased waste rock load

It is conceivable that waste dump seepage quality within the Faro Pit catchment could degrade in the future such that waste rock loads to the pit would increase over the loads assumed in the 'Current Average' predictions. As a check on the sensitivity of the water quality predictions to waste rock load inputs, the 'Future Worst' seepage quality estimated in the dump water quality prediction (SRK 2004d) was used as an input. Table 4.9 summarizes the key results of this sensitivity analysis for the three scenarios modelled. Long term concentrations of acidity, zinc, and copper are higher by a factor of 15 to 20 for the Base Case scenario under conditions of 'Future Worst' waste rock loading. The other two scenarios have similar increases in acidity, zinc, and copper concentrations. Clearly, Faro Pit Lake water quality predictions are sensitive to increased loadings from waste rock currently located within the pit catchment.

Table 4.9 Estimated Faro Pit water quality with 'Future Worst' waste rock inputs

Parameter	Base Case		Faro Creek Diverted		Faro Valley Dump Removed	
	At spill (Aug. 2007)	Long term (~ yr. 2040)	At spill (yr. 2047)	Long term (yr. 2204)	At spill (Aug. 2007)	Long term (~ yr. 2040)
Acidity (mg CaCO3eq /L)	126	218	1153	2256	63	76
Zinc (mg/L)	24	46	243	478	11	17
Copper (mg/L)	0.54	1.2	6.1	12	0.19	0.40

4.3 Grum Pit

4.3.1 Modelled Scenario

Since there is no substantial diversion of water away from Grum Pit, and since there is no waste rock within the pit catchment, a single scenario was considered in the water quality estimate for Grum Pit Lake. The water and load balance assumed that pit filling began on January 1, 2004.

4.3.2 Geometry, Flow Conditions and Stratification

The volume-capacity curve for the Grum pit was re-assessed using the topography generated from the 2003 aerial photography. To include the volume of water below the current pit lake level, the new curve was 'meshed' with that presented in the ICAP (RGI 1996). The complete volume capacity curve is provided in Figure 4.8.

The overall water balance for Grum Pit Lake is summarised in Table 4.10. The table shows conditions whereby the Grum interceptor ditch is breached and surface runoff within the pit lake catchment is routed through the pit lake, making the total catchment about 1.22 km^2. The mean annual runoff is estimated to be 270 mm and mean annual precipitation 450 mm. The evaporation rate is based on a fixed pit lake surface area of about 0.28 km^2. As noted for Faro Pit Lake calculations, the calculations represent the pit lake at fully flooded conditions. The net implication is that the time to flooding will be marginally overestimated and, as a result of the longer time to flooding, the contaminant concentrations at the time of spilling will also be slightly overestimated.

Table 4.10 Summary of Grum Pit water balance with Grum interceptor breached

Month	Days in month	INFLOWS		OUTFLOWS				
		Runoff	Direct Precipitation on Lake Surface	Groundwater Recharge	Lake Evaporation	Lake Evaporation	Discharge at Pit Outlet	
		(1000 m^3)	(1000 m^3)	(1000 m^3)	(mm)	(1000 m^3)	(1000 m^3)	(m^3/s)
Jan	31	5	2	0	0	0	8	0.003
Feb	28.25	4	2	0	0	0	6	0.002
Mar	31	4	2	0	6	2	2	0.001
Apr	30	8	3	0	38	11	-10	-0.004
May	31	68	26	0	64	18	58	0.021
Jun	30	70	27	0	80	22	51	0.020
Jul	31	49	19	0	77	22	24	0.009
Aug	31	34	13	0	58	16	15	0.005
Sep	30	46	17	0	22	6	51	0.020
Oct	31	24	9	0	7	2	29	0.011
Nov	30	11	4	0	0	0	15	0.006
Dec	31	8	3	0	0	0	11	0.004
Annual	365.25	329	126	0	352	99	258	0.008

4.3.3 Contaminant Inventory and Sources

Pit water quality will be determined by the inventory of contaminants currently present in the pit lake and by the future influx of contaminants. Potential contaminant sources to Grum Pit Lake include seepage and runoff from the wall rock and talus, dissolution of secondary minerals from sheltered areas of the pit walls during flooding, and releases from any secondary minerals that have precipitated at the bottom of the lake.

Current Pit Inventory

The contaminant mass currently resident in Grum Pit Lake determines the current pit water quality and provides the starting point for calculating future pit water quality. The resident contaminant mass was calculated from results of depth profiling conducted in June 2004, as discussed in Section 3.2.2. Table 4.11 summarizes the mass of contaminants currently resident in the pit lake.

Table 4.11 Current contaminant inventory in Grum Pit

Parameter	Current mass in pit lake (kg)
Cl	1100
SO4	990000
Ca	270000
Mg	160000
K	7900
Na	25000
Al	99
Cd	21
Co	65
Cu	2.1
Fe	170
Pb	1.9
Mn	1100
Ni	490
Zn	20000

Wall Rock

Maps and descriptions of the pit wall rock are provided in Section 2.2.1. The relative areas of each rock for current and future flooding levels are presented in Figure 4.9. As indicated in Figure 2.2, the dominant rock types are mixed calcareous and carbonaceous Vangorda Formation phyllite (Unit 5A0/5B0), non-calcareous Mt. Mye Formation phyllite (Unit 3G0), and undifferentiated massive and disseminated sulphides (Unit 4EC). In addition, a large portion of the pit wall surface consists of glacial till (Unit T).

The expected long-term geochemical behaviour of each of the above rock types (SRK 2004b) are summarized as follows:

- Carbonaceous phyllites (Unit 5A) are potentially acid generating, but are expected to react slowly, and may not develop acidic conditions for several decades. Calcareous phyllites (Unit 5B) are net acid consuming. Contaminant loads from the carbonaceous phyllites may therefore increase over time. However, calcareous phyllites are likely to neutralize any acidity and limit loading from this mixed unit.
- Non-calcareous phyllites from the Mt. Mye formation (Unit 3GO) have been classified as acid consuming unless they are mixed with sulphides.

- Sulphides (Unit 4EC) are potentially acid generating, and contaminant loading from this unit may increase slightly with time.

In general, any changes in loading due to further weathering and oxidation of the wall rocks are not expected to significantly effect water quality in the pit lake due to the relatively large amount of alkalinity contributed by the till and the calcareous phyllites.

The results of the limited wall rock and talus testing indicated that the majority of the wall rock contains very little soluble oxidation products, as discussed in Section 2.2.4. Moderate zinc concentrations in the leachate from the sulphide rich samples (Unit 4EC) indicate that that these wall rocks are currently a source of metal loading. This unit largely occurs below the expected 1230 masl flood elevation (Figure 2.2), and as such will not be a major source of loading to the pit lake in the long term.

Seepage data from the 2004 pit seep surveys (Section 2.2.3) provides the most representative means of estimating source concentrations associated with each of the above rock types. Wall rock runoff quality was assumed to be the average of that in seep/runoff samples collected from within each rock unit. Table 4.12 summarizes the water types used to characterize runoff each of the above rock units. A complete set of parameters for each water type is attached in Appendix E.2.

The total contaminant load from the wall rocks was estimated by multiplying the relative areas of each of the rock types by the source concentrations in Table 4.12. The estimates of total wall rock load are provided in Table 4.13.

Secondary mineral salts were rarely observed in the Grum Pit walls. However, solids testing described in section 2.2.4 showed that release of soluble products, primarily from sulphide wall rock (Unit 4EC), could contribute loading to the pit during flooding. Scoping level calculations suggest that dissolution of stored products will contribute a minor incremental load compared to the current contaminant inventory in the pit lake.

Table 4.12 Water types for used to estimate wall rock loadings to Grum Pit Lake

Water type	Unit	Lithology	pH (s.u.)	Alk (mg/L)	SO4 (mg/L)	Cu (mg/L)	Zn (mg/L)	Exposed rock above final spill elev. (m^2)
VG7	5A0/5B0, 3G0	calcareous, carbonaceous, and non-calcareous phyllite	8.0	240	630	0.0040	0.020	228,000
VG8	4EC	Massive and disseminated sulphides	7.6	220	830	0.010	28	11,000
VG9	T	Till	8.0	110	330	0.010	0.014	197,000

Table 4.13 Summary of wall rock contaminant loadings to Grum Pit

	Initial Loading	After spill elevation reached
Parameter	**Loading (kg/year)**	**Loading (kg/year)**
Cl	83	58
SO4	65 000	41 000
Ca	14 000	8 800
Mg	12 000	7 800
K	350	230
Na	420	260
Al	7	5
Cd	0.6	0.3
Co	3	1
Cu	0.5	0.3
Fe	180	42
Pb	2	1
Mn	45	11
Ni	16	7
Zn	350	80

4.3.4 Water Quality Estimates

The calculation spreadsheet was used to estimate changes in contaminant concentrations that occur while Grum Pit Lake fills to its final level of 1230 masl, and as the resident load is flushed from the system. No in-pit removal of contaminants through sorption, particulate settling, biological removal, or sulphate reduction was considered. The calculations also assume that no contaminants will enter the pit water from wall rock below the present lake surface, and that no contaminant removal will occur through water treatment. Steady-state concentrations are assumed to be reached once the amount of load entering the pit is equal to the amount of load leaving the pit. The biological treatment assessment will evaluate whether it is possible to achieve sufficient contaminant removal rates during filling such that pit lake surface water is acceptable for discharge to the environment at the time the spill elevation is reached.

With the Grum interceptor ditch breached, Grum Pit Lake is expected to reach the 1230 masl spill elevation in year 2030 (Figure 4.10). Results of the pit lake water quality calculations are presented in Figure 4.11 and summarized in Table 4.14. The modelling suggests that, at the time when the pit would first spill, the acidity would be about 6.1 mg $CaCO_3$ eq/L, the zinc about 2.9 mg/L, and the copper about 0.0014 mg/L. In the long term, zinc and copper would continue to decrease to concentrations of about 0.33 mg/L and 0.0011 mg/L, respectively. Acidity is estimated to decrease to about 1.4 mg/L. As in the case for Faro Pit Lake, copper estimates are likely very conservative, as detection limit values were substituted into water types where sample concentrations were less than detection. This apparent accumulation of copper may be a function of analytical limitations, and may not be representative of actual copper loadings to the pit.

The most notable feature of Grum Pit Lake water quality estimate is that equilibrium conditions require the entire period modelled (200 years) to develop (Figure 4.11). The relatively rapid decline in acidity and zinc concentration over the period of filling (to year 2030) indicates that inflows have lower concentrations than the current pit water. The majority of zinc and acidity expected in the lake when it reaches the 1230 masl level are contained within the current lake inventory.

Over the period of filling, the exposed surface area of sulphide rocks (Unit 4EC) will be greatly reduced (Figure 4.9), thus limiting loading from this unit. This is illustrated in the behaviour of copper as shown in Figure 4.11. In this figure, copper concentrations in Grum Pit Lake peak prior to the estimated spill date, indicating that the decrease in copper loadings due to reduction in exposed Unit 4EC surface area is sufficient to reverse the trend of increasing copper concentration.

Table 4.14 Estimated Grum Pit water quality

Parameter	Base Case	
	At spill (yr. 2030)	Long term (yr. 2204)
Acidity (mg CaCO3eq /L)	6.1	1.4
Zinc (mg/L)	2.9	0.33
Copper (mg/L)	0.0014	0.0011

4.4 Vangorda Pit

4.4.1 Scenarios

Three scenarios were considered in the water quality estimates for Faro Pit Lake. In the base case, it was assumed that the Vangorda Creek diversion would be breached and allowed to spill into the pit. Sensitivity runs were also completed to show 1) the effects of maintaining the diversion and 2) the effects of removing the Southeast (SE) Ramp Dump and the Hairpin Dump.

As discussed in section 4.2.1, any closure alternative which includes in-pit treatment will also include some form of remediation of waste dumps that contribute load to the pit. For the purposes of this exercise, it was assumed that simple soil covers are in place on all contributing dumps, and that infiltration (and seepage) is limited to 25% of incident precipitation.

All three cases assumed that the pit will ultimately overflow the northwest side of the pit at the approximate plan location of the original Vangorda Creek channel. This would result in an ultimate pit lake elevation of 1130 masl. The water and load balances assumed that pit filling began on January 1, 2004.

4.4.2 Geometry, Flow Conditions and Stratification

The volume-capacity curve for the Vangorda pit estimated using the topography generated from the 2003 aerial photography. To include the volume of water below the current pit lake level, the new curve was ‘meshed’ with that presented in the ICAP (1996). The complete volume capacity curve is provided in Figure 4.12.

The overall water balance for Vangorda Pit Lake is summarised in Table 4.15. The table shows conditions whereby the Vangorda Creek diversion is breached and routed through the pit lake. The total pit lake catchment becomes about 21.7 km2. Losses to groundwater are assumed to be negligible. The mean annual runoff is estimated to be 362 mm and mean annual precipitation 380 mm. The evaporation rate is based on a fixed pit lake surface area of about 0.17 km^2. As noted before, the calculations adopted a lake surface area corresponding to fully flooded conditions. Because of the short time to flooding, this assumption has little effect on the calculation results.

Table 4.16 shows the Vangorda Pit water balance for the scenario where Vangorda Creek is permanently diverted. In this case, the total pit lake catchment has an approximate area of 0.67 km^2. This catchment assumes that a surface water interception ditch is constructed above the east edge of the pit south of Vangorda Creek, and that only the catchment below this proposed ditch (SRK 2003c) reports to the Vangorda Pit.

Table 4.15 Summary of Vangorda Pit water balance with Vangorda Creek diversion breached

		INFLOWS		OUTFLOWS				
Month	Days in month	Runoff	Direct Precipitation on Lake Surface	Groundwater Recharge	Lake Evaporation	Lake Evaporation	Discharge at Pit Outlet	
		(1000 m^3)	(1000 m^3)	(1000 m^3)	(mm)	(1000 m^3)	(1000 m^3)	(m^3/s)
Jan	31	123	1	0	0	0	124	0.05
Feb	28.25	123	1	0	0	0	124	0.05
Mar	31	119	1	0	8	1	119	0.04
Apr	30	157	1	0	53	9	149	0.06
May	31	1462	12	0	90	15	1459	0.54
Jun	30	2523	21	0	112	19	2524	0.97
Jul	31	1155	10	0	108	18	1146	0.43
Aug	31	575	5	0	81	14	566	0.21
Sep	30	558	5	0	31	5	558	0.22
Oct	31	528	4	0	10	2	530	0.20
Nov	30	279	2	0	0	0	281	0.11
Dec	31	221	2	0	0	0	222	0.08
Annual	365.25	7823	65	0	493	84	7804	0.25

Table 4.16 Summary of Vangorda Pit water balance with Vangorda Creek diverted

Month	Days in month	INFLOWS Runoff	INFLOWS Direct Precipitation on Lake Surface	OUTFLOWS Groundwater Recharge	OUTFLOWS Lake Evaporation	OUTFLOWS Lake Evaporation	OUTFLOWS Discharge at Pit Outlet	OUTFLOWS Discharge at Pit Outlet
		(1000 m^3)	(1000 m^3)	(1000 m^3)	(mm)	(1000 m^3)	(1000 m^3)	(m^3/s)
Jan	31	4	1	0	0	0	5	0.00
Feb	28.25	4	1	0	0	0	5	0.00
Mar	31	4	1	0	8	1	3	0.00
Apr	30	5	1	0	53	9	-3	0.00
May	31	45	12	0	90	15	42	0.02
Jun	30	78	21	0	112	19	80	0.03
Jul	31	36	10	0	108	18	27	0.01
Aug	31	18	5	0	81	14	9	0.00
Sep	30	17	5	0	31	5	17	0.01
Oct	31	16	4	0	10	2	19	0.01
Nov	30	9	2	0	0	0	11	0.00
Dec	31	7	2	0	0	0	9	0.00
Annual	365.25	243	65	0	493	84	223	0.01

4.4.3 Contaminant Inventory and Sources

Pit water quality will be determined by the inventory of contaminants currently present in the pit lake and by the future influx of contaminants. Potential contaminant sources to Vangorda Pit Lake include seepage and runoff from the wall rock, talus, and in-pit dumps, dissolution of secondary minerals from sheltered areas of the pit walls during flooding, and releases from treatment plant sludges deposited in the lake and/or any secondary minerals that have precipitated in the bottom of the pit lake.

Current Pit Inventory

The contaminant mass currently resident in Vangorda Pit Lake determines the current pit water quality and provides the starting point for calculating future pit water quality. Resident contaminant mass was calculated from results of depth profiling conducted in June 2004, as discussed in Section 3.3.2. Table 4.17 summarizes the mass of contaminants currently resident in the pit lake.

Table 4.17 Current contaminant inventory in Vangorda Pit

Parameter	Current mass in pit lake (kg)
Cl	750
SO4	1800000
Ca	360000
Mg	140000
K	5500
Na	8300
Al	74
Cd	150
Co	1100
Cu	350
Fe	25000
Pb	13
Mn	60000
Ni	990
Zn	180000

Wall Rock

Maps and descriptions of the pit wall rock are provided in Section 2.2.1. The relative areas of each rock for current and future flooding levels are presented in Figure 4.13. As indicated in Figure 2.3, the dominant rock types are massive and disseminated sulphides (Unit 4EC) and till, with moderate exposures of non-calcareous phyllite (Unit 3G0), and minor amounts of carbonaceous phyllite (Unit 5A0), and bleached phyllite (Unit 4L0).

As discussed in Section 2.2.4, wall rock and talus from the Vangorda pit was characterized in an earlier study (SRK 2000). The results indicated that several of the samples had acidic pH's or were potentially acid generating, indicating that seepage quality is likely to worsen over time, potentially to the point where neutral conditions could not be maintained in the pit. However, for the scenario where the Vangorda Creek diversion would be breached and allowed to flow through the pit, there should be sufficient alkalinity to offset any acidic seepage from the pit walls.

Seepage data from the 2004 pit seep surveys (Section 2.2.3) provides the most representative means of estimating source concentrations associated with each of the above rock types. Where insufficient data is available, data from the waste rock seep surveys was used to supplement this data. Table 4.18 summarizes the seepage data used to represent each of the above rock units. A complete set of parameters for each water type is attached in Appendix E.3.

The total contaminant load from the wall rocks was estimated by multiplying the relative areas of each of the rock types by the source concentrations in Table 4.18. The estimates of total wall rock load are provided in Table 4.19.

The results of the wall rock and talus testing also indicated that several samples contained high soluble zinc loads. These and secondary mineral salts such as zinc and iron sulphates observed on the pit walls could also be a major source of contaminant loading to the pit lake during the flooding period (SRK 2000). These sources have not been included in the wall rock load calculations.

Table 4.18 Water types used to estimate wall rock loadings to Vangorda Pit Lake

Water type	Unit	Lithology	pH (s.u.)	Alk (mg/L)	SO4 (mg/L)	Cu (mg/L)	Zn (mg/L)	Exposed rock above final spill elev. (m^2)
VG10	3G0, 5A0	Carbonaceous phyllite and non-calcareous phyllite	6.2	88	620	0.32	46	29,000
VG11	4EC	Undifferentiated massive and disseminated sulphides	5.0	17	2500	6.5	450	71,000
VG12	4L0	Bleached pyritic phyllite	3.8	4	6100	6.9	780	2,000
VG13	Till	Till	7.6	200	25	0.010	0.0050	48,000

Table 4.19 Summary of wall rock contaminant loadings to Vangorda Pit

	Initial Loading	After spill elevation reached
Parameter	Loading (kg/year)	Loading (kg/year)
Cl	47	36
SO4	111 000	77 000
Ca	10 000	7 500
Mg	7 500	5 100
K	340	240
Na	430	330
Al	580	420
Cd	24	18
Co	63	42
Cu	240	180
Fe	11 000	8 200
Pb	30	23
Mn	5 100	3 200
Ni	51	37
Zn	18 000	13 000

Waste Rock

Waste rock has been placed within the Vangorda pit ramp area that leads down to the pit lake. Two waste rock piles are located in this area on either side of the access road. The smaller dump is located within the hairpin of the access road (hairpin dump) and the second comprises waste rock that has been placed along the road to the south of the bend and to the east of the road as it descends to the pit lake (SE ramp dump). The hairpin dump represents an area of about 15,000 m^2 and the SE ramp dump an area of about 20,000 m^2. To be consistent with the assumptions for the wall rock runoff, it was assumed that all of the runoff (i.e. surface overflow and infiltration) would be contaminated. Table 4.20 shows the waste rock seepage quality used in the model to characterize dump loadings to Vangorda Pit Lake.

Previous characterization of the waste rock in these dumps (SRK 2000) indicated that this material was consistently net acid generating, with high concentrations of soluble metals.

The water quality estimates derived in the waste dump and load balances (SRK 2003b) were used directly to estimate the corresponding contaminant loads to the pit lake. The hairpin dump is expected to remain above the water level; however, a layer of about 10 m of waste rock in the second pile would remain below the ultimate lake level. Some reduction in the loadings may result from this which was not accounted for in the calculations.

The in-pit dumps at Vangorda represent a significant source of loading to the pit (Table 4.21). However, if a flow-through pit system is implemented, these dumps would be removed or isolated from the main section of the pit to minimize contaminant loading. The prediction for the case where these dumps are removed provides the best available estimate of the long term water quality facing biological treatment.

Sludges and Precipitates

The Vangorda pit was reportedly used for a short period to store sludges from the water treatment plant. The quantity of sludges is not known. Under reducing and/or acidic pH conditions, it is possible that these sludges could become remobilized, resulting in increased loading to the pit lake.

Equilibrium modelling of the pit water quality completed in the 2000 pit lake study (SRK 2000) indicated that water in the lower portions of the pit were close to equilibrium with the minerals smithsonite ($ZnCO_3.H_2O$) and rhodochrosite (manganese carbonate). This suggests that these minerals could be present in the bottom sediments. Decreasing zinc concentrations in the water column resulting from changes to the water balance (such as breaching the Vangorda Creek diversion), or changes in the pH could lead to short-term remobilization of these precipitates into the water column.

Table 4.20 Vangorda Pit catchment: Waste rock dumps and applied seepage quality

Waste Rock Dump	Proportion in Pit Lake Catchment	Acidity	Alk	Cl	SO4	Ca	Mg	K	Na	Al	Cd	Co	Cu	Fe	Pb	Mn	Ni	Zn
SE Ramp Dump	100%	4088	638	3.7	10950	607	1233	14	15	26	2.3	6.2	19	457	0.74	645	5.5	1911
Hairpin Dump	100%	84	228	2.7	2819	477	383	13	26	0.45	0.050	0.086	0.074	3.1	0.11	8.2	0.27	43

All units are loadings in kg / year

Table 4.21 Summary of Estimated Annual Contaminant Loadings to Vangorda Pit From Waste Rock

Parameter	In-pit dumps in place	In-pit dumps removed
	Loading (kg/year)	Loading (kg/year)
Cl	6	0
SO4	14 000	0
Ca	1 100	0
Mg	1 600	0
K	27	0
Na	41	0
Al	27	0
Cd	2	0
Co	6	0
Cu	19	0
Fe	460	0
Pb	1	0
Mn	650	0
Ni	6	0
Zn	2000	0

4.4.4 Water Quality Estimates

The calculation spreadsheet was used to estimate changes in contaminant concentrations that occur while Vangorda Pit Lake fills to its final level of 1130 masl, and as the resident load is flushed from the system. No in-pit removal of contaminants through sorption, particulate settling, biological removal, or sulphate reduction was considered. The calculations also assume that:

- no contaminants will enter the pit water from treatment sludges stored within the pit;
- no contaminants will enter the pit water from the wall rock below the present lake surface;
- no contaminants will enter the pit water from the stored oxidation products present on the pit walls and within the pit talus;
- no further contaminant additions will occur via pumping of contaminated water to the pit;
- no further contaminant removal will occur through treatment of pit water.

Steady-state concentrations are assumed to be reached once the amount of load entering the pit is equal to the amount of load leaving the pit.

With the Vangorda Creek diversion breached, Vangorda Pit Lake is expected to reach the 1130 masl spill elevation within a single year (Figure 4.14). Results of the base case pit lake water quality calculations are presented in Figure 4.15 and summarized in Table 4.22. The modelling suggests that, at the time when the pit would first spill, the acidity would be about 86 mg$CaCO_3$ eq/L, the zinc about 33 mg/L, and the copper about 0.091 mg/L. In the long term, zinc and copper would continue to decrease to concentrations of about 1.5 mg/L and 0.020 mg/L, respectively. Acidity is estimated to decrease to about 5.8 mg/L. Copper concentrations in Vangorda Pit seeps were at measurable levels, and copper estimates are likely more reflective of field conditions than at the estimates for both Faro and Grum.

Two additional scenarios were evaluated to show 1) the effects of continuing to divert Vangorda Creek flows and 2) the effects of removing the in-pit dumps. In the case of diversion, pit filling would occur much slower, with the first predicted discharge occurring in 2023 (Figure 4.16). At this time, modelling suggests that the pit lake water would have an acidity of 349 mg $CaCO_3$ eq/L, a zinc concentration of 102 mg/L, and a copper concentration of 0.97 mg/L. The model predicts that acidity and metal concentrations will continue to increase for at least 200 years under these conditions, and that after 200 years, the pit lake would have an acidity of 251 mg $CaCO_3$ eq/L, a zinc concentration of 67 mg/L, and a copper concentration of 0.87 mg/L (Figure 4.17).

Removing the Vangorda in-pit dumps and allowing Vangorda Creek to flow into the pit results in little change from base case predictions. When the pit first discharges (July 2004- Figure 4.14), pit lake water is predicted to have an acidity level of 85 mg $CaCO_3$ eq/L, a zinc concentration of 33 mg/L, and a copper concentration of 0.89 mg/L. In the long term, pit lake water is predicted to have acidity of 5.1 mg $CaCO_3$ eq/L, zinc concentrations of 1.3 mg/L, and a copper concentration of 0.018 mg/L (Figure 4.18).

A summary of results for the three scenarios modelled is presented in Table 4.22. A sensitivity analysis for conditions of increased waste rock loading to the Vangorda Pit was not warranted due to the high concentrations of contaminants in pit lake water under ‘Current Average’ loading conditions.

Table 4.22 Estimated Vangorda Pit water quality

Parameter	Base Case		Vangorda Creek diverted		In-Pit Dumps removed	
	At spill (Jul. 2004)	Long term (~ yr. 2014)	At spill (yr. 2023)	Long term (~ yr. 2104)	At spill (Jul. 2004)	Long term (~ yr. 2014)
Acidity (mg $CaCO_3$eq /L)	86	5.8	350	250	85	5.1
Zinc (mg/L)	33	1.5	100	67	33	1.3
Copper (mg/L)	0.091	0.020	0.97	0.87	0.89	0.018

5 Conclusions

This project has developed revised estimates of contaminant concentrations in the Faro, Grum, and Vangorda Pit lakes. These estimates are based on the following assumptions.

- January 1, 2004 is the beginning of the modelled water balance.
- All diversions will be breached.
- Summer 2004 contaminant concentrations in each lake provide the starting point for estimates of future concentrations.
- Pit walls and waste rock provide the only significant sources of contaminant loading to each pit lake.
- In-pit removal of contaminants through biological and geochemical processes will be insignificant.
- Influx and outflow of contaminants due to site water management and water treatment will not occur going forward.

Under conditions where Faro Creek is routed through the pit, Faro Pit Lake is estimated to have a zinc concentration of approximately 5 mg/L at the time of first discharge in 2007. Long term water quality in Faro Pit Lake is estimated to be characterized by zinc concentrations of 3 mg/L.

Discharge from Grum Pit Lake is estimated to have zinc a concentration of about 3 mg/L when it first overflows. Zinc concentration is projected to decline slowly over the long term, reaching a concentration of 0.33 mg/L after 200 years.

Under conditions where Vangorda Creek is routed through the pit, Vangorda Pit Lake is estimated to have a zinc concentration of 33 mg/L at the time of first discharge, and to have a long term zinc concentration of 1.5 mg/L.

Additional calculations were completed to examine two remediation options, which consist of permanent diversion of creeks and relocation of contributing waste rock. These estimates indicate that permanent diversion of Vangorda and Faro Creeks will result in higher zinc concentrations and longer periods before the respective pits discharge to surface water. Removal of waste rock from the Vangorda and Faro Pit catchments was estimated to have little impact on pit lake zinc concentrations in both the short and the long term.

This report, "**1CD003.046 - Updated Estimates of Post-closure Water Quality in Faro, Grum, and Vangorda Pit Lakes",** was prepared by SRK Consulting (Canada) Inc.

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Reviewed by

Daryl Hockley, P.Eng

6 References

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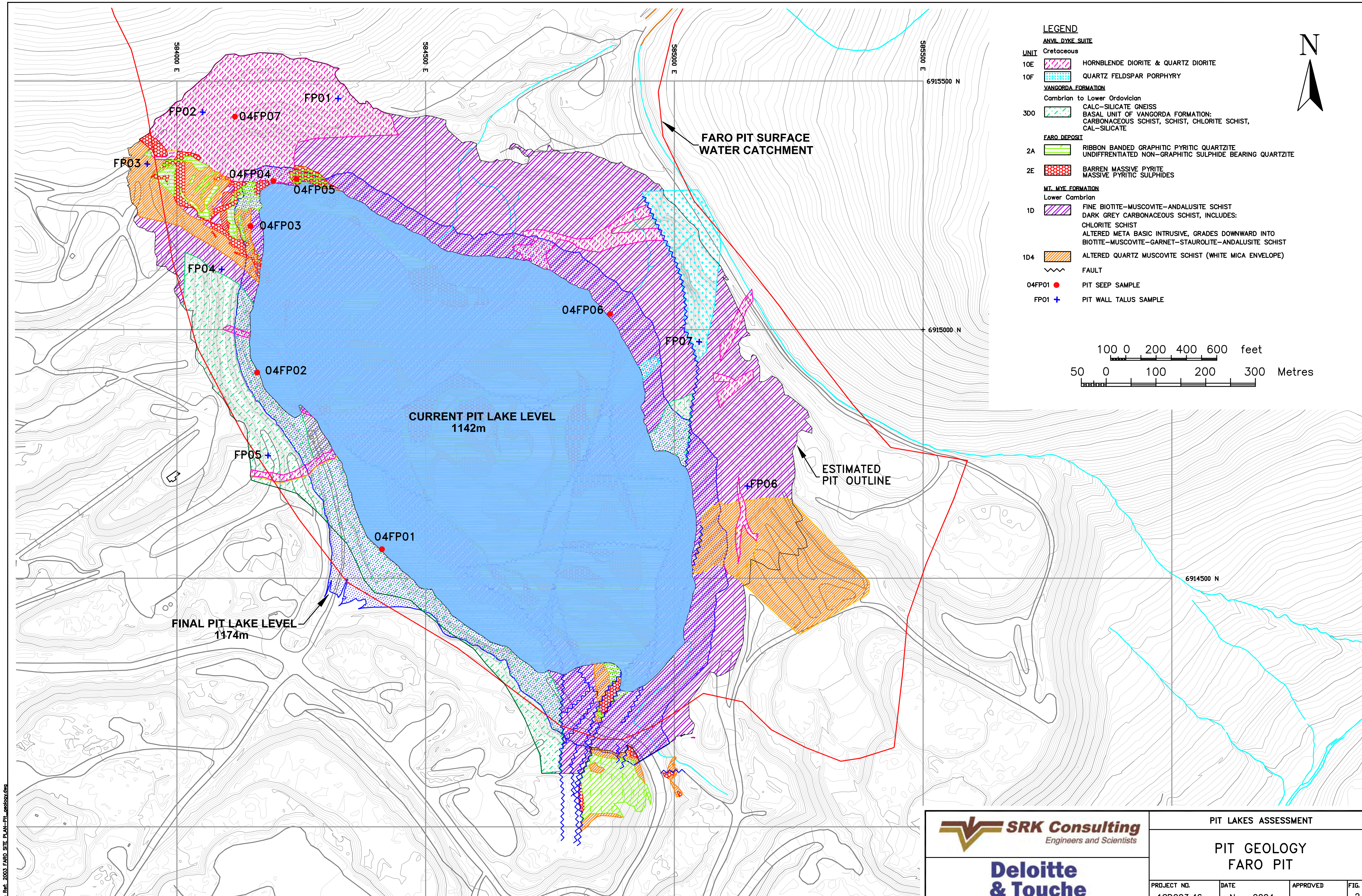
Figures


LEGEND
ANVIL DYKE SUITE
UNIT Cretaceous
10E HORNBLENDE DIORITE & QUARTZ DIORITE
10F QUARTZ FELDSPAR PORPHYRY
VANGORDA FORMATION
Cambrian to Lower Ordovician
3DO CALC-SILICATE GNEISS
BASAL UNIT OF VANGORDA FORMATION: CARBONACEOUS SCHIST, SCHIST, CHLORITE SCHIST, CAL-SILICATE
FARO DEPOSIT
2A RIBBON BANDED GRAPHITIC PYRITIC QUARTZITE
UNDIFFRENTIATED NON-GRAPHITIC SULPHIDE BEARING QUARTZITE
2E BARREN MASSIVE PYRITE
MASSIVE PYRITIC SULPHIDES
MT. MYE FORMATION
Lower Cambrian
1D FINE BIOTITE-MUSCOVITE-ANDALUSITE SCHIST
DARK GREY CARBONACEOUS SCHIST, INCLUDES:
CHLORITE SCHIST
ALTERED META BASIC INTRUSIVE, GRADES DOWNWARD INTO BIOTITE-MUSCOVITE-GARNET-STAUROLITE-ANDALUSITE SCHIST
1D4 ALTERED QUARTZ MUSCOVITE SCHIST (WHITE MICA ENVELOPE)
FAULT
04FP01 PIT SEEP SAMPLE
FP01 PIT WALL TALUS SAMPLE
N
100 0 200 400 600 feet
50 0 100 200 300 Metres
584000 E
584500 E
585000 E
585500 E
6915500 N
6915000 N
6914500 N
FP01
FP02
FP03
FP04
FP05
FP06
FP07
04FP01
04FP02
04FP03
04FP04
04FP05
04FP06
04FP07
FARO PIT SURFACE WATER CATCHMENT
CURRENT PIT LAKE LEVEL 1142m
ESTIMATED PIT OUTLINE
FINAL PIT LAKE LEVEL 1174m
SRK Consulting
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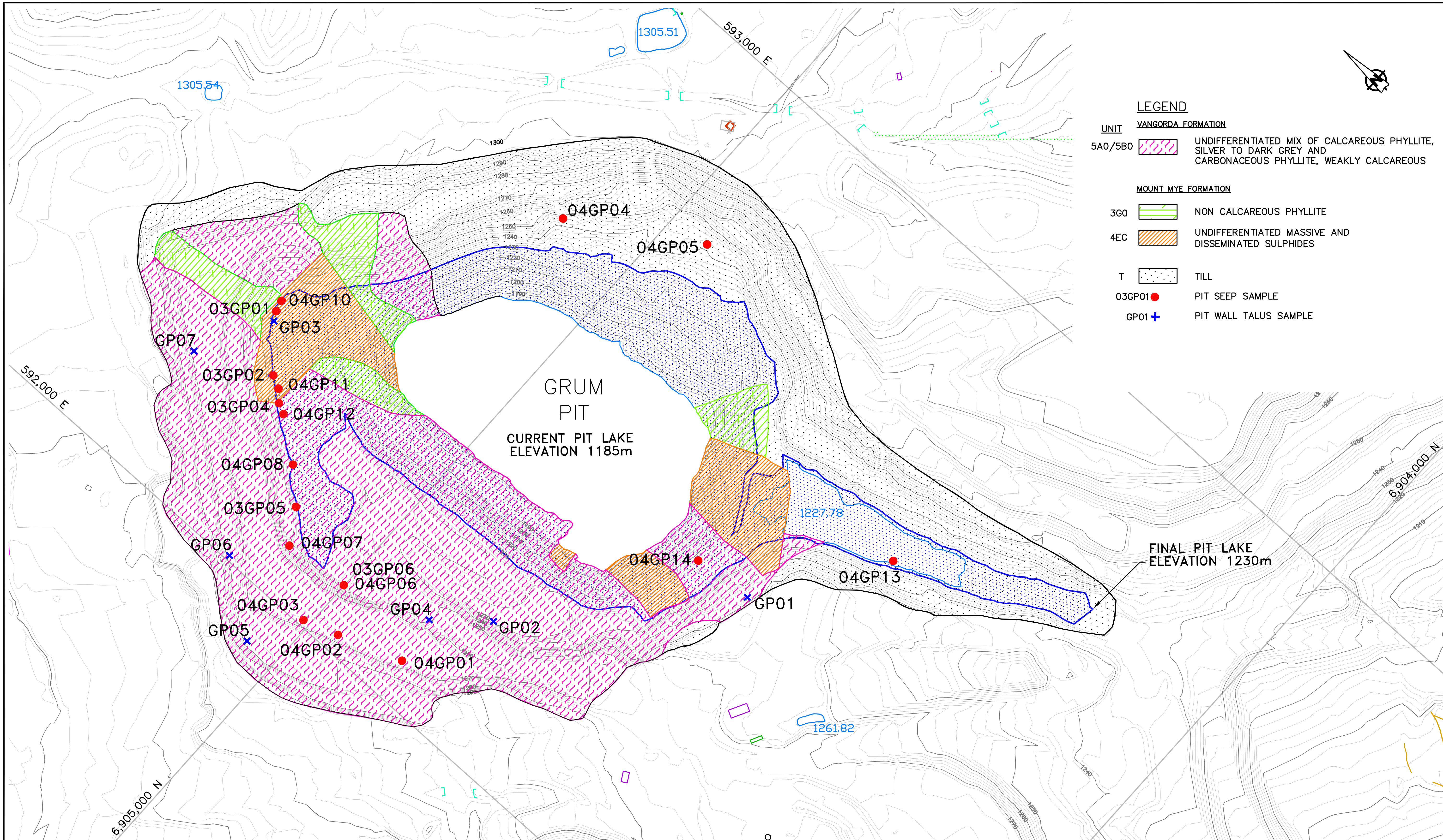
Deloitte & Touche
PIT LAKES ASSESSMENT
PIT GEOLOGY
FARO PIT
PROJECT NO. 1CD003.46
DATE Nov. 2004
APPROVED
FIG. 2.1
File Ref: 2003 FARO SITE PLAN-Pit_geology.dwg



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

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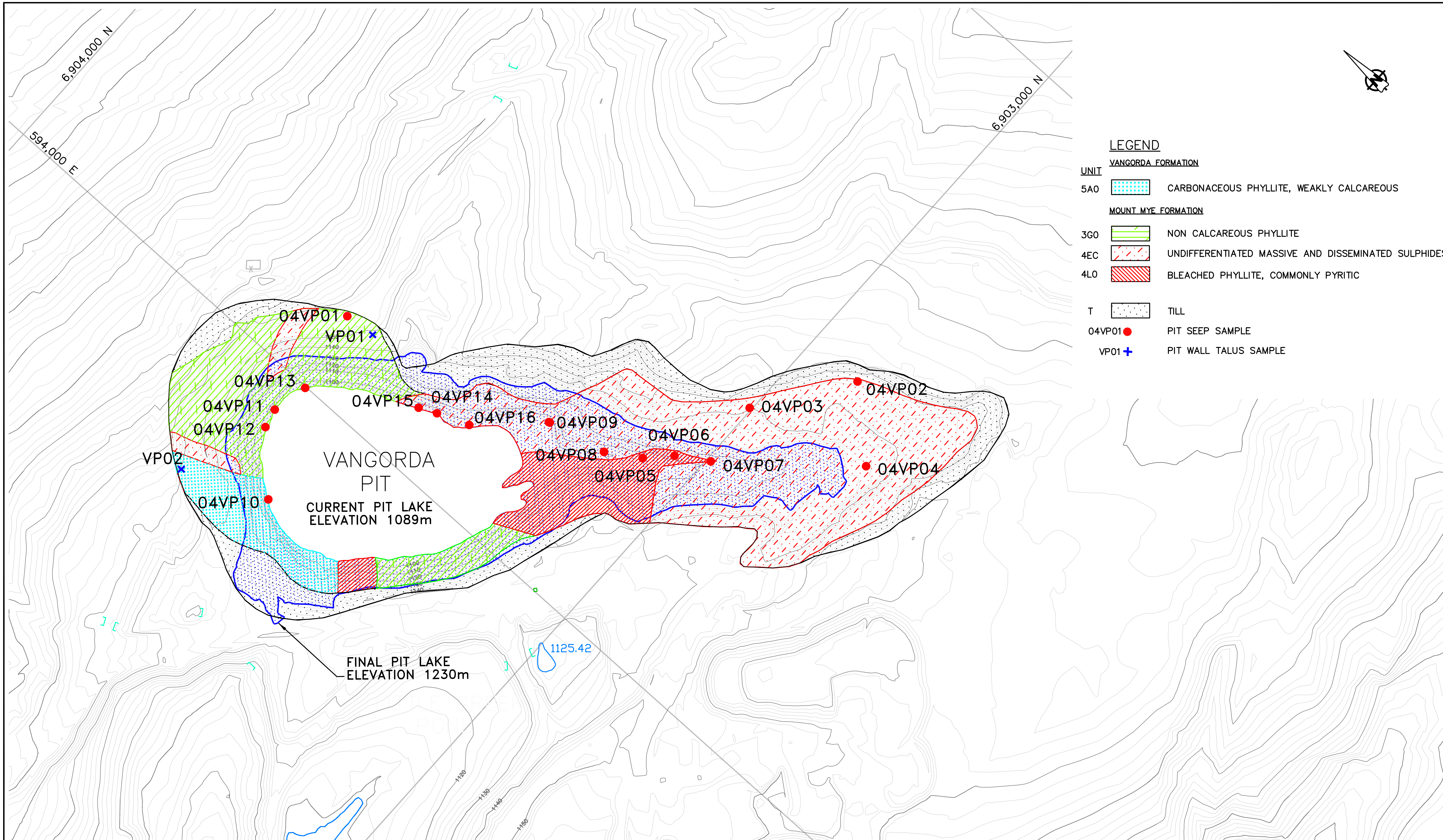
PIT LAKES ASSESSMENT

PIT GEOLOGY
GRUM PIT

PROJECT NO.	DATE	APPROVED	FIG.
1CD003.46	Nov. 2004		2.2



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WO 8856

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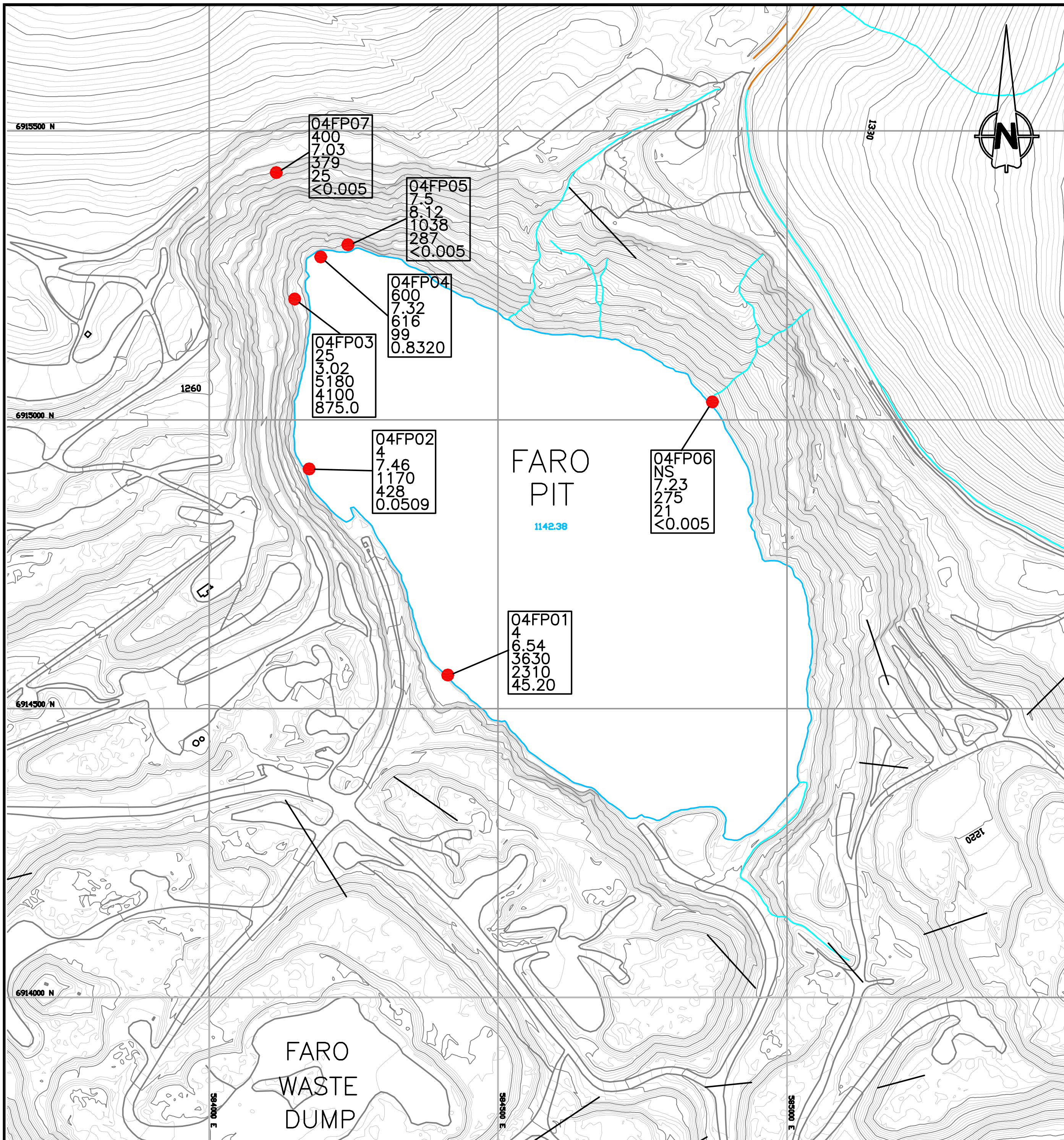
PIT LAKES ASSESSMENT

PIT GEOLOGY
VANGORDA PIT

PROJECT NO.	DATE	APPROVED	FIG.
1CD003.46	Nov. 2004		2.3



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

● Seep sample location

SAMPLE ID	
Flow	(L/min)
pH	S.U.
Conductivity	(uS/cm)
Sulphate	(mg/L)
Zinc	(mg/L)

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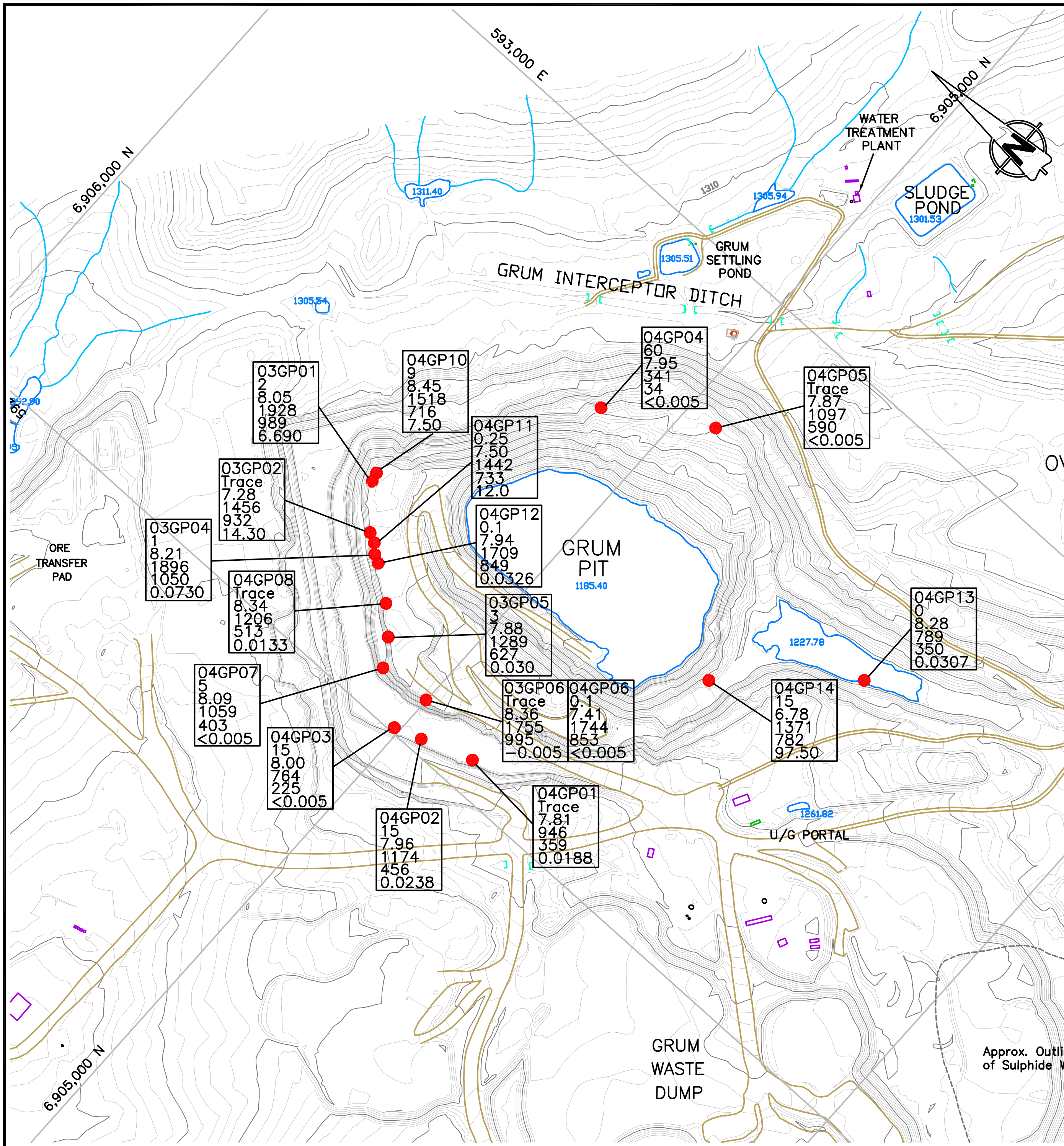
FARO MINE SITE

FARO PIT
SEEP SURVEY RESULTS

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.046	Nov. 2004		2.4

Dwg Ref: 2004 faro site plan-Seep.dwg



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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 8858

LEGEND

● Seep sample location

SAMPLE ID	
Flow	(L/min)
pH	S.U.
Conductivity	(uS/cm)
Sulphate	(mg/L)
Zinc	(mg/L)

File Ref: Site_plan_2004-Seep.dwg

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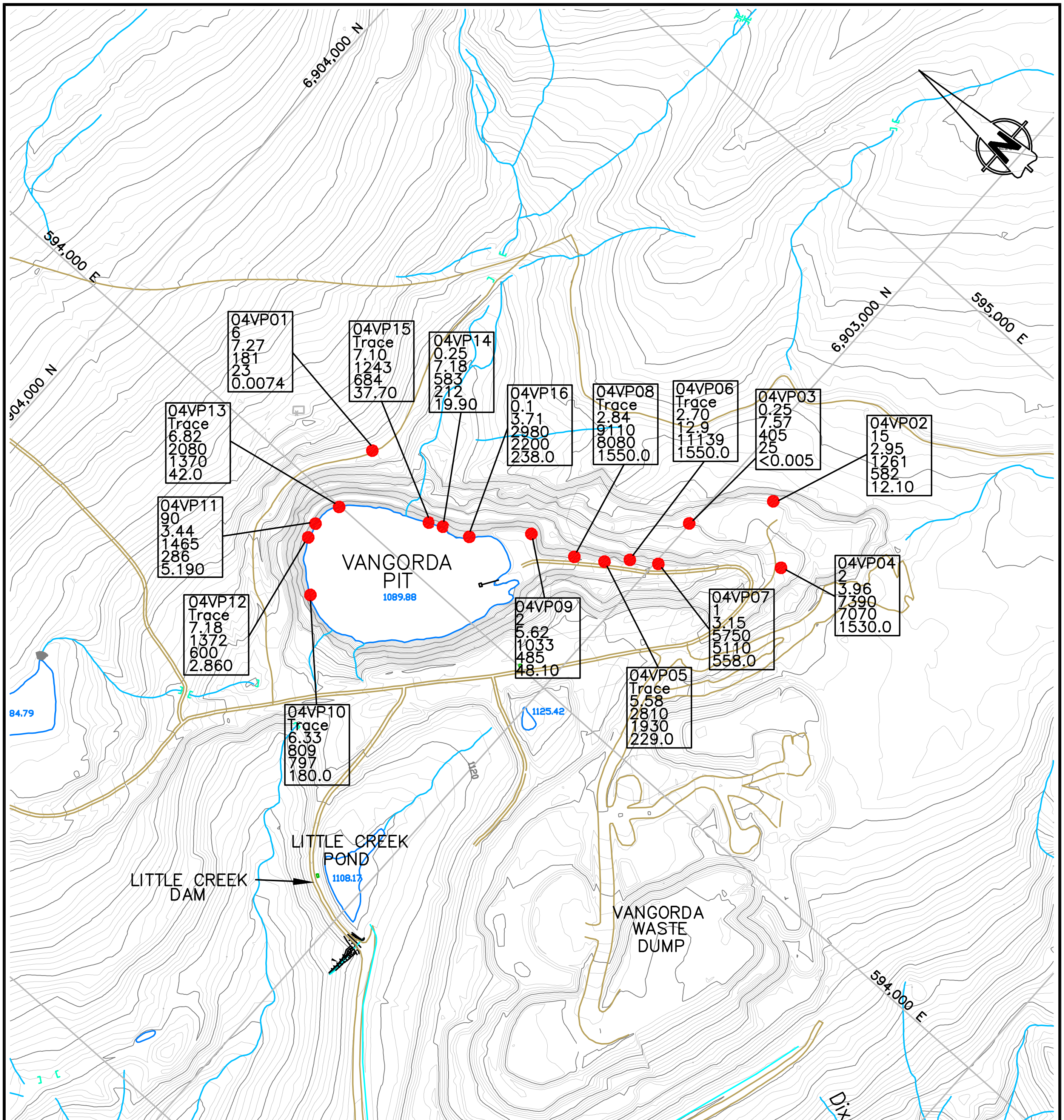
VANGORDA PLATEAU MINE

GRUM PIT
SEEP SURVEY RESULTS

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.046	Nov. 2004		2.5



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Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8858

LEGEND

● Seep sample location

SAMPLE ID	
Flow	(L/min)
pH	S.U.
Conductivity	(uS/cm)
Sulphate	(mg/L)
Zinc	(mg/L)

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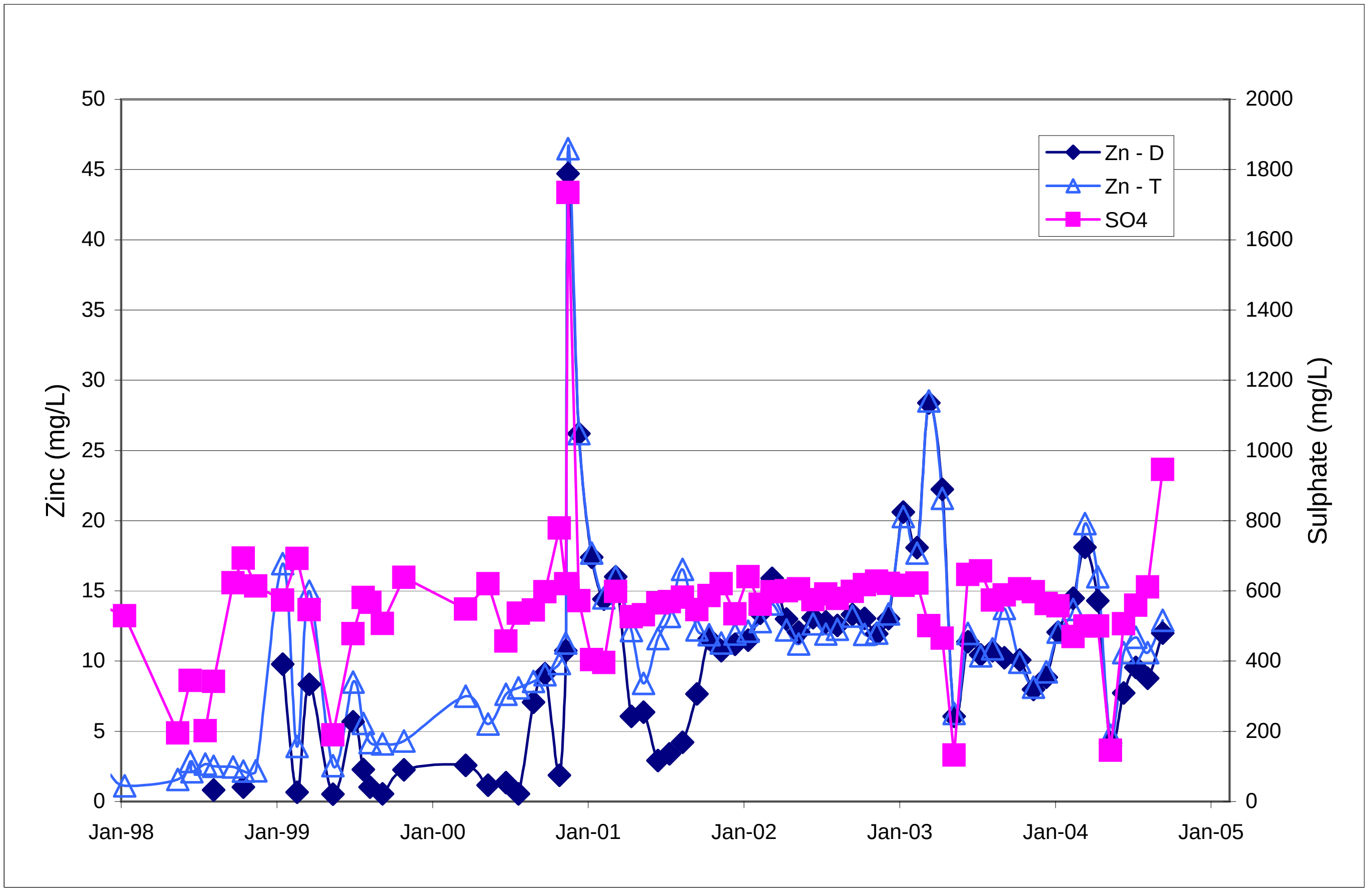
VANGORDA PLATEAU MINE

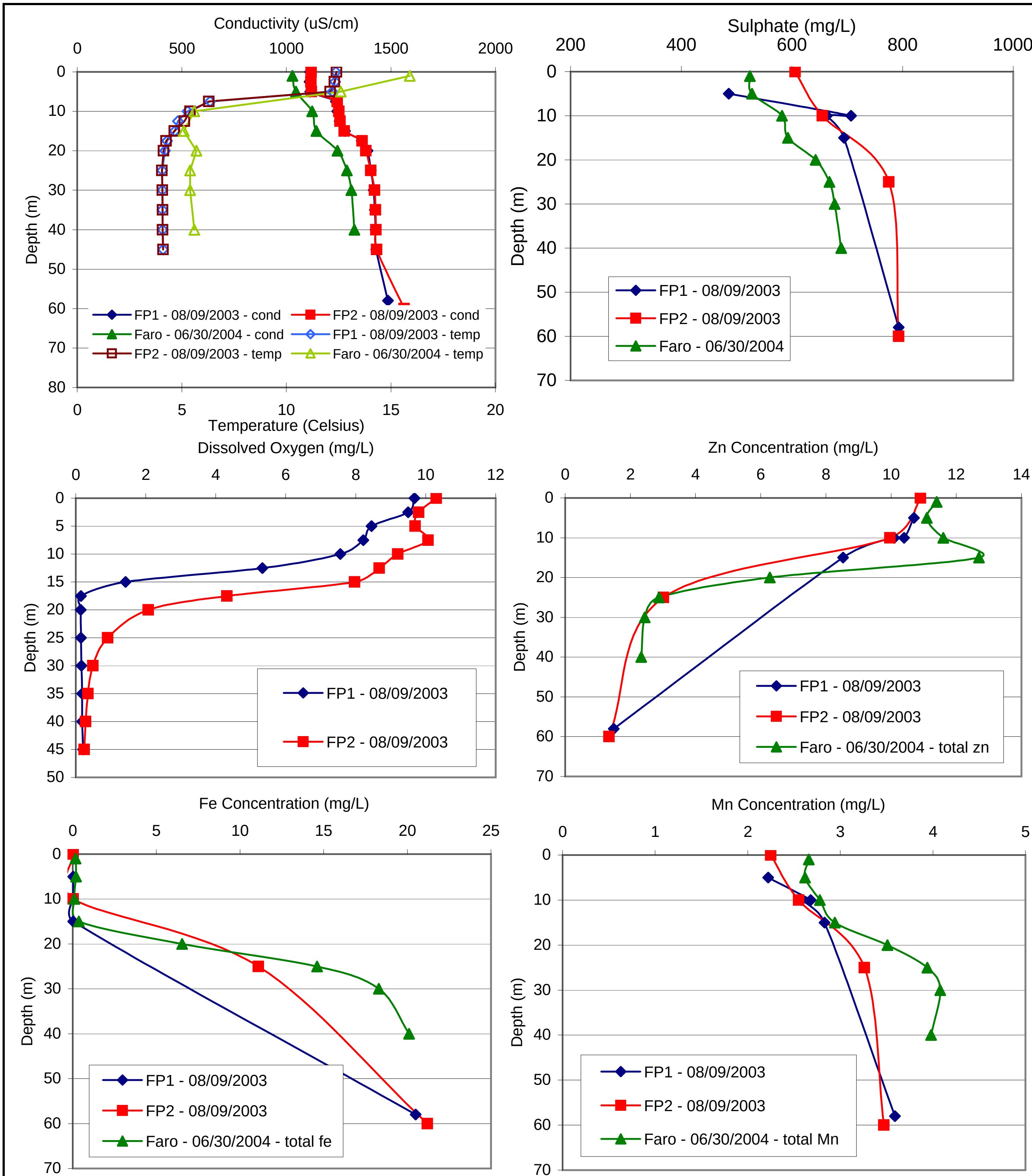
VANGORDA PIT
SEEP SURVEY RESULTS

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.046	Nov. 2004		2.6

File Ref: Site_plan_2004-Seep.dwg



SRK Consulting Engineers and Scientists	Updated Post-Closure Estimates of Water Quality in the Faro, Grum and Vangorda Pits		
DELOITTE & TOUCHE INC.	Trends in Sulphate and Zinc Concentrations - Faro Pit Surface Water		
Project: 1CD003.46	Date: Dec-04	Approved:	Figure: **3.1**



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Updated Post-Closure Estimates of Water Quality in the Faro, Grum and Vangorda Pits

Trends in Temperature, Conductivity, Sulphate, Diss. Oxygen, Zinc, Iron and Manganese - Faro Pit

Project	Date	Approved	Figure
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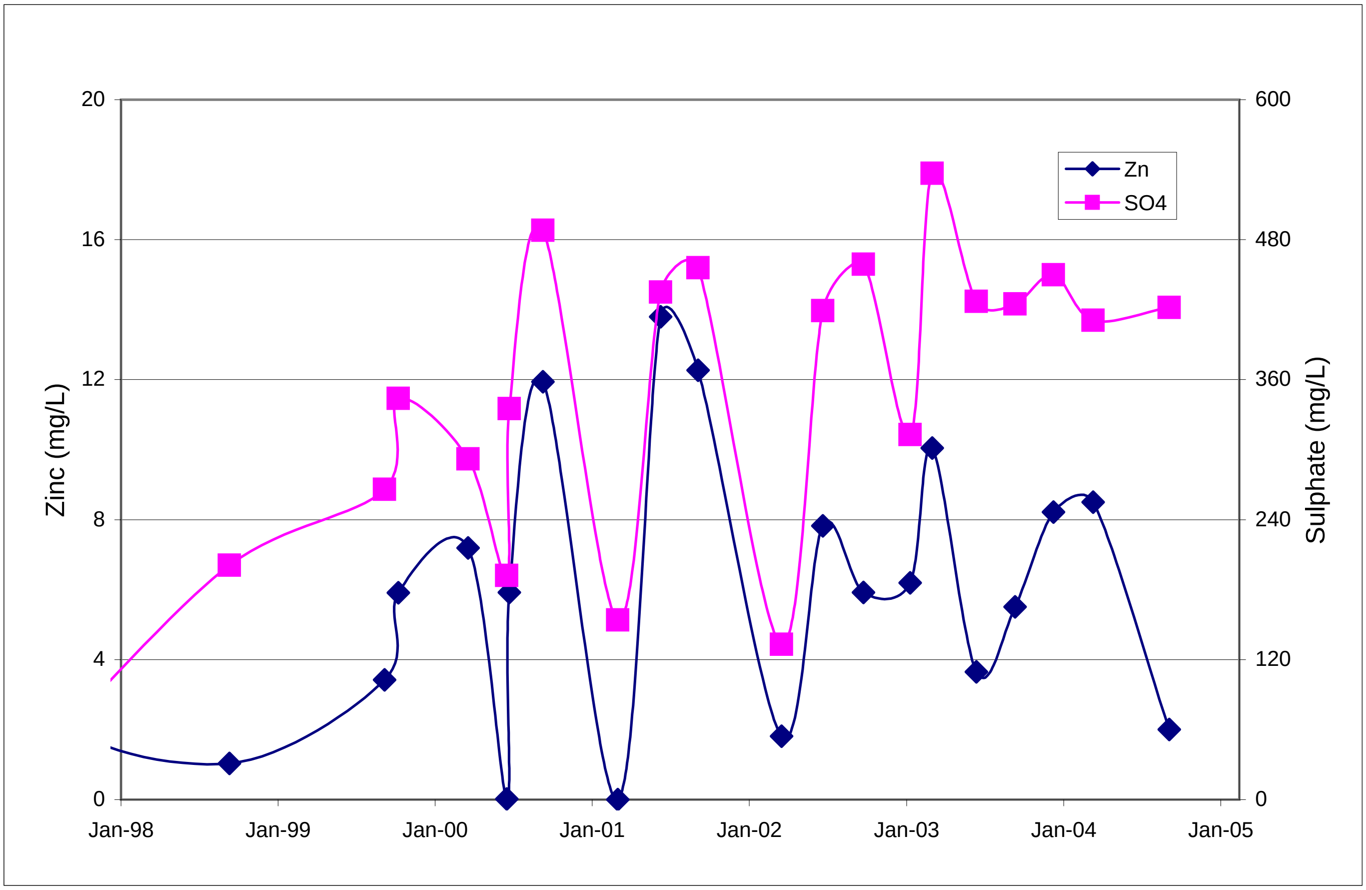

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Updated Post-Closure Estimates of Water Quality in the Faro, Grum and Vangorda Pits

Trends in Sulphate and Zinc Concentrations - Grum Pit Surface Water

Project	Date	Approved	Figure
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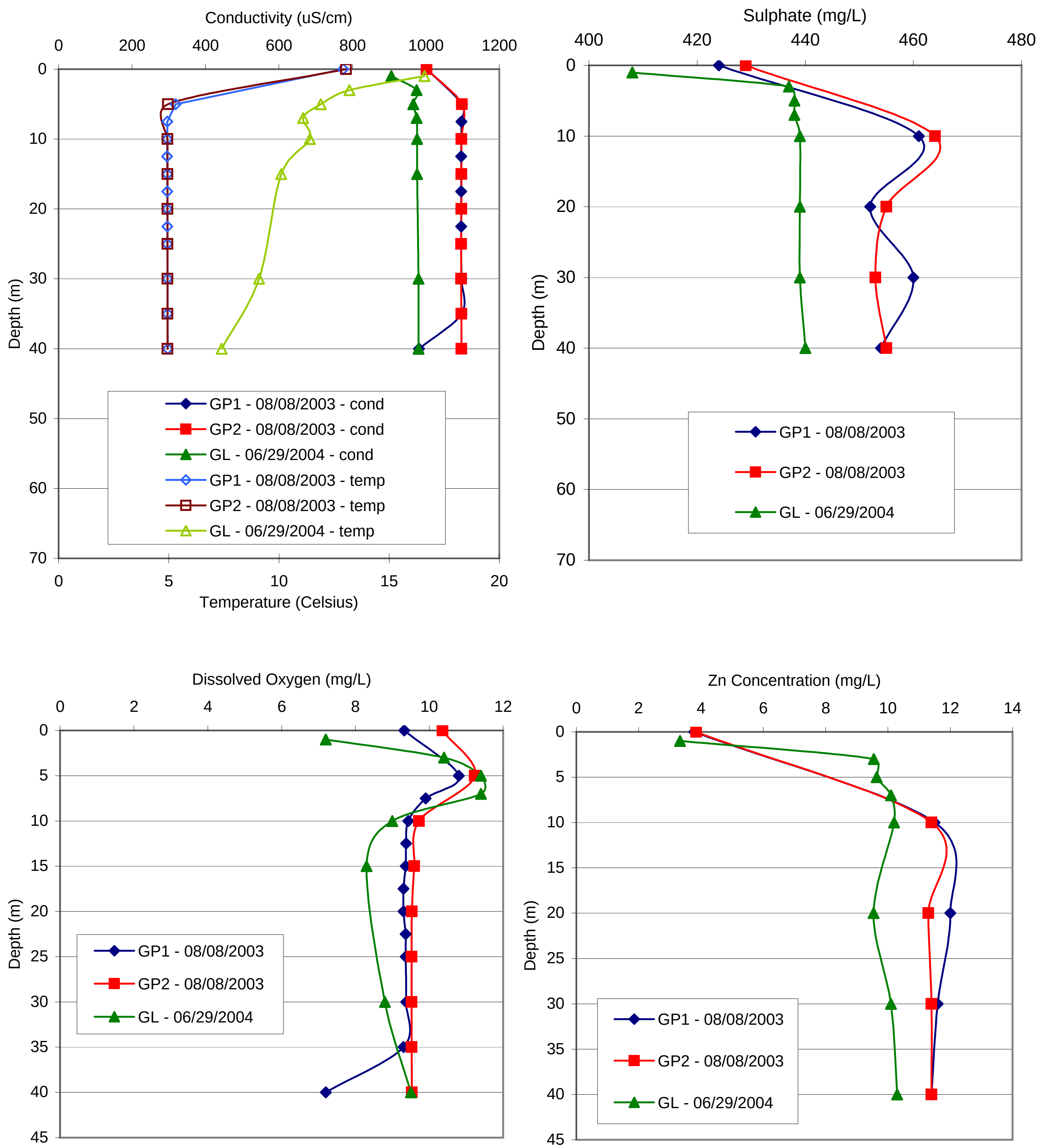

SRK Consulting Engineers and Scientists	Updated Post-Closure Estimates of Water Quality in the Faro, Grum and Vangorda Pits			
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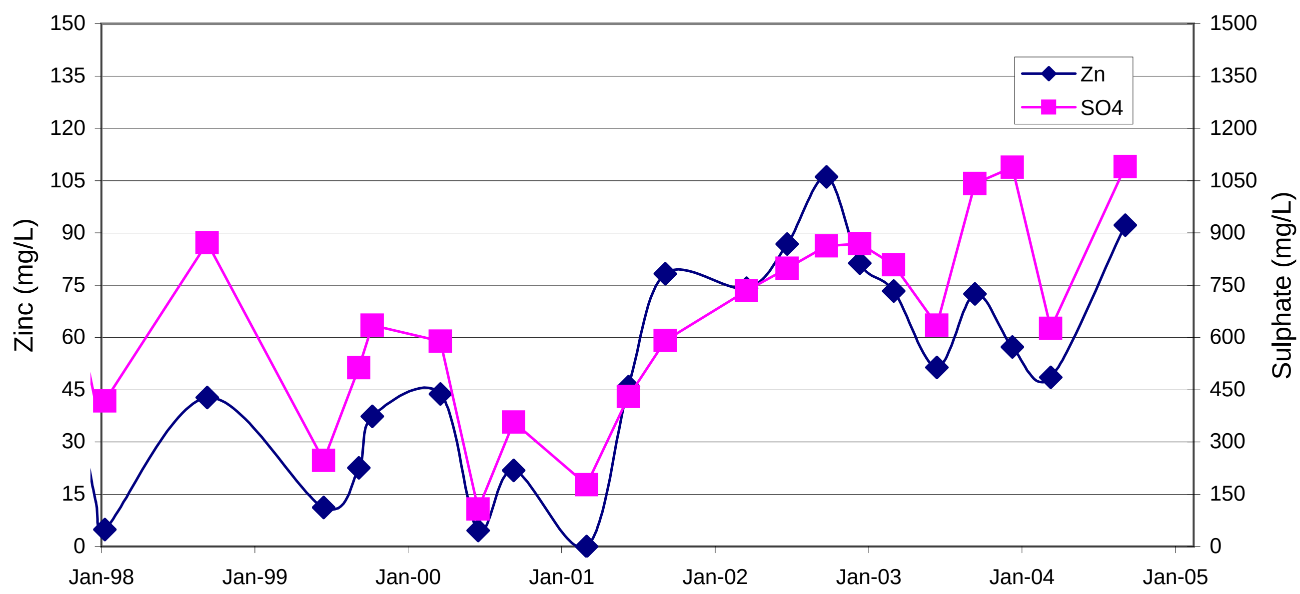
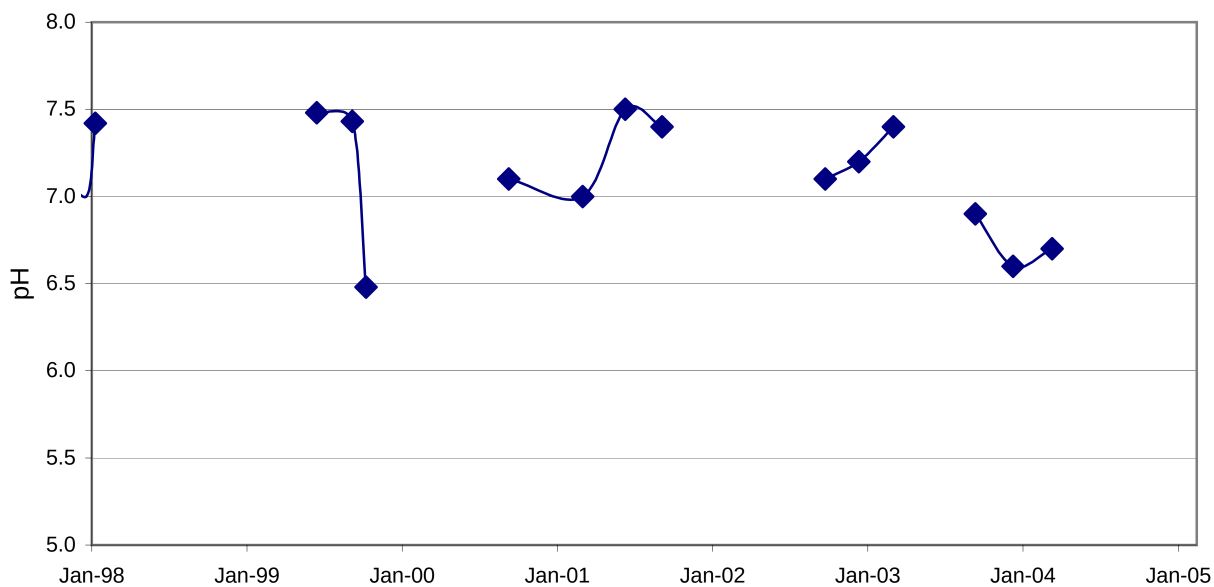
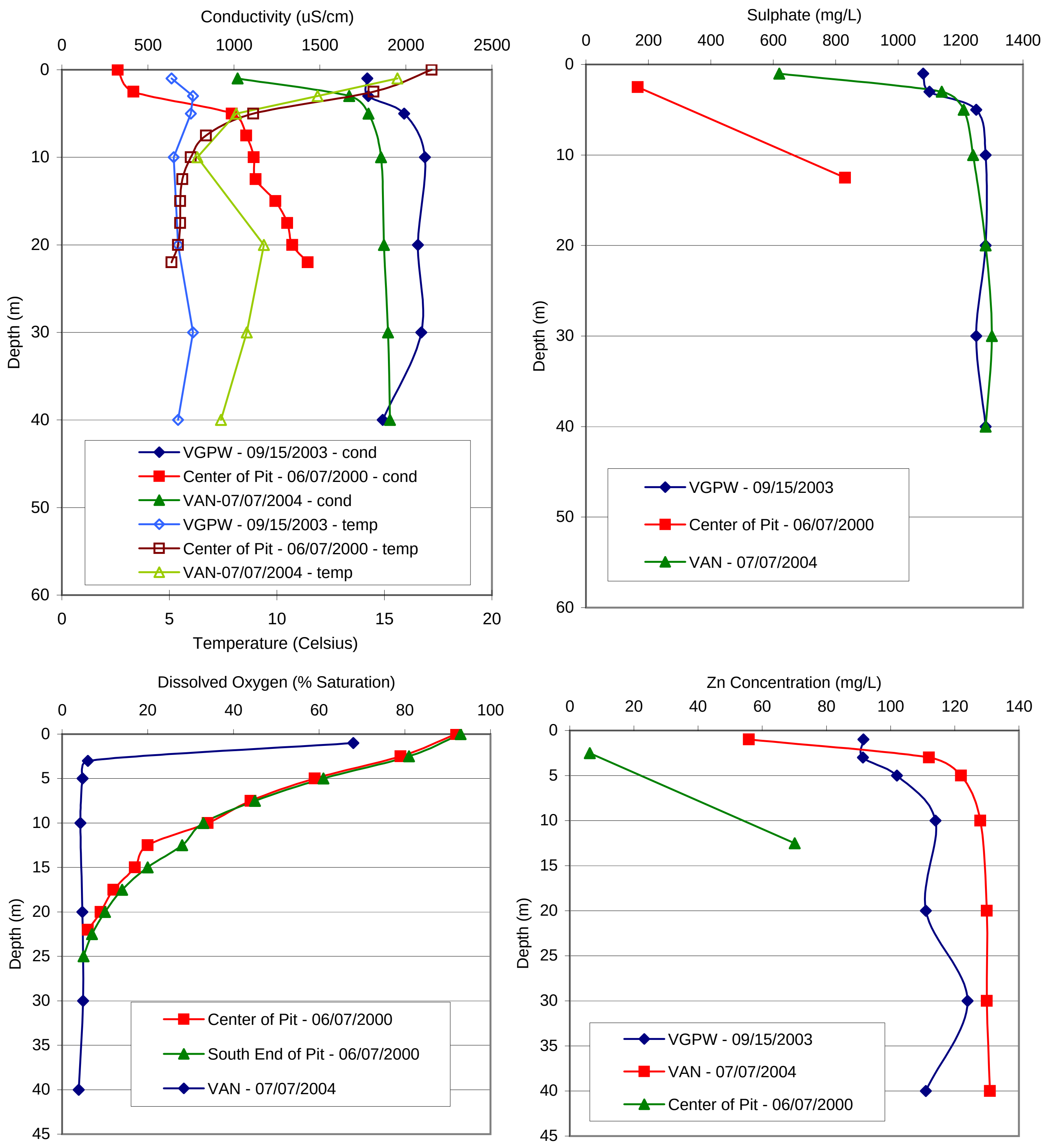
DELOITTE & TOUCHE INC.	Project 1CD003.046	Date Dec-04	Approved	Figure **3.4**





SRK Consulting — Engineers and Scientists	Updated Post-Closure Estimates of Water Quality in the Faro, Grum and Vangorda Pits			
	Trends in SO4 and Zn Concentrations and pH - Vangorda Pit Surface Water			
DELOITTE & TOUCHE INC.	Project 1CD003.46	Date Dec-04	Approved	Figure **3.5**



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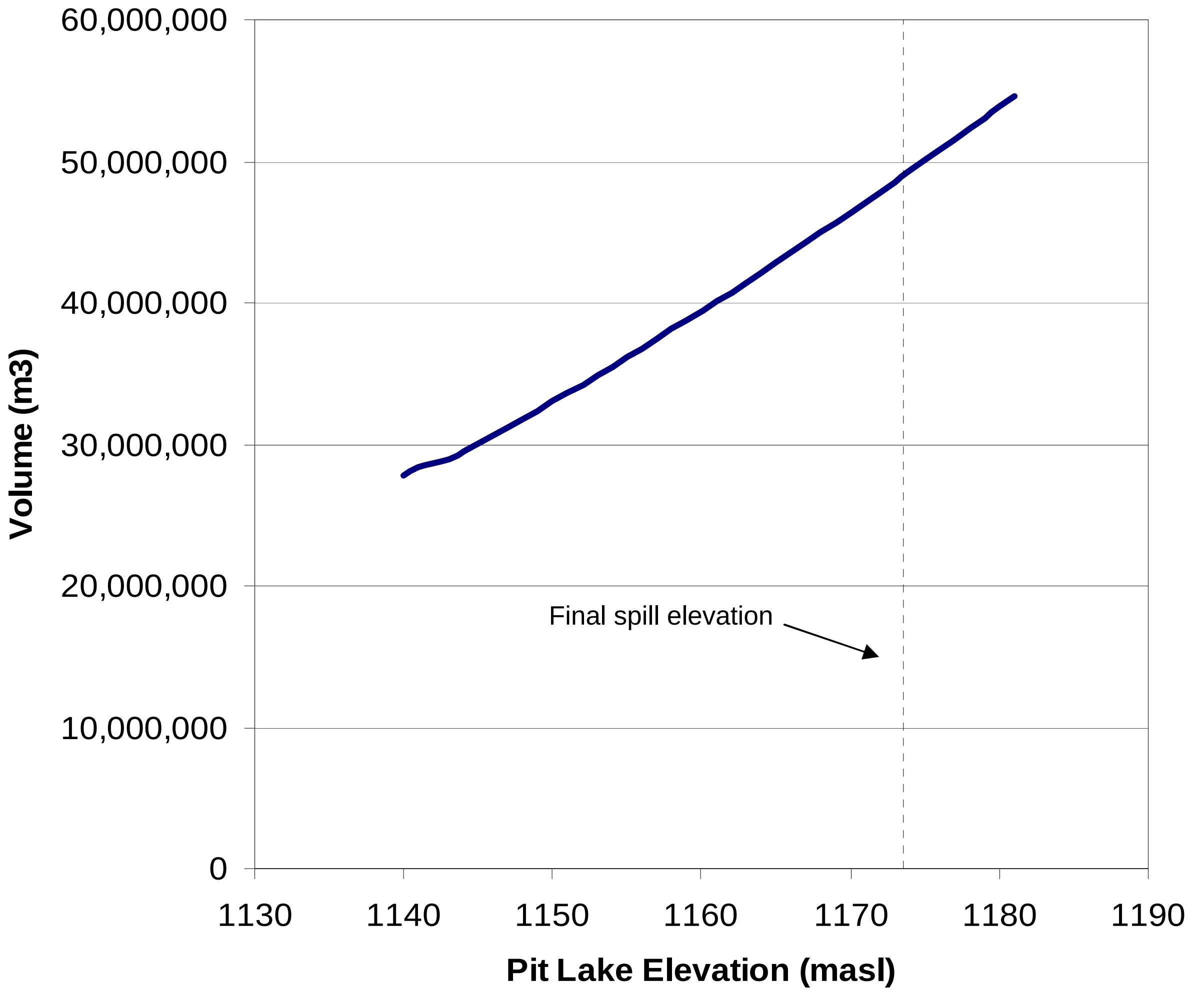
Updated Post-Closure Estimates of Water Quality in the Faro, Grum and Vangorda Pits

Trends in Temperature, Conductivity, Sulphate, Diss. Oxygen and Zinc - Vangorda Pit

Project	Date	Approved	Figure
1CD003.046	Dec-04		**3.6**



FILE REF: Figures 3-1_3-14.xls

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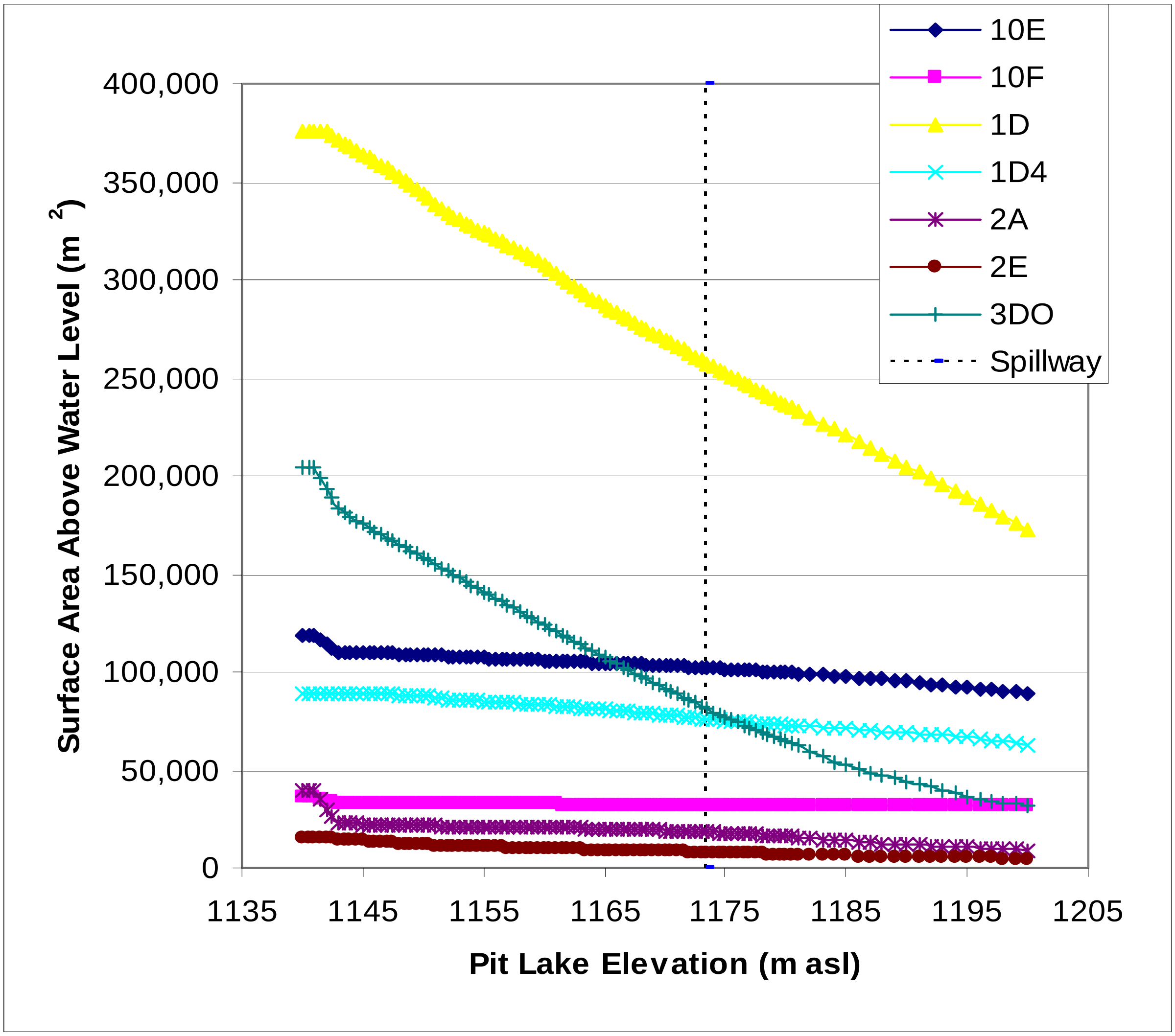
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Faro Pit Height-Capacity Curve

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.1**



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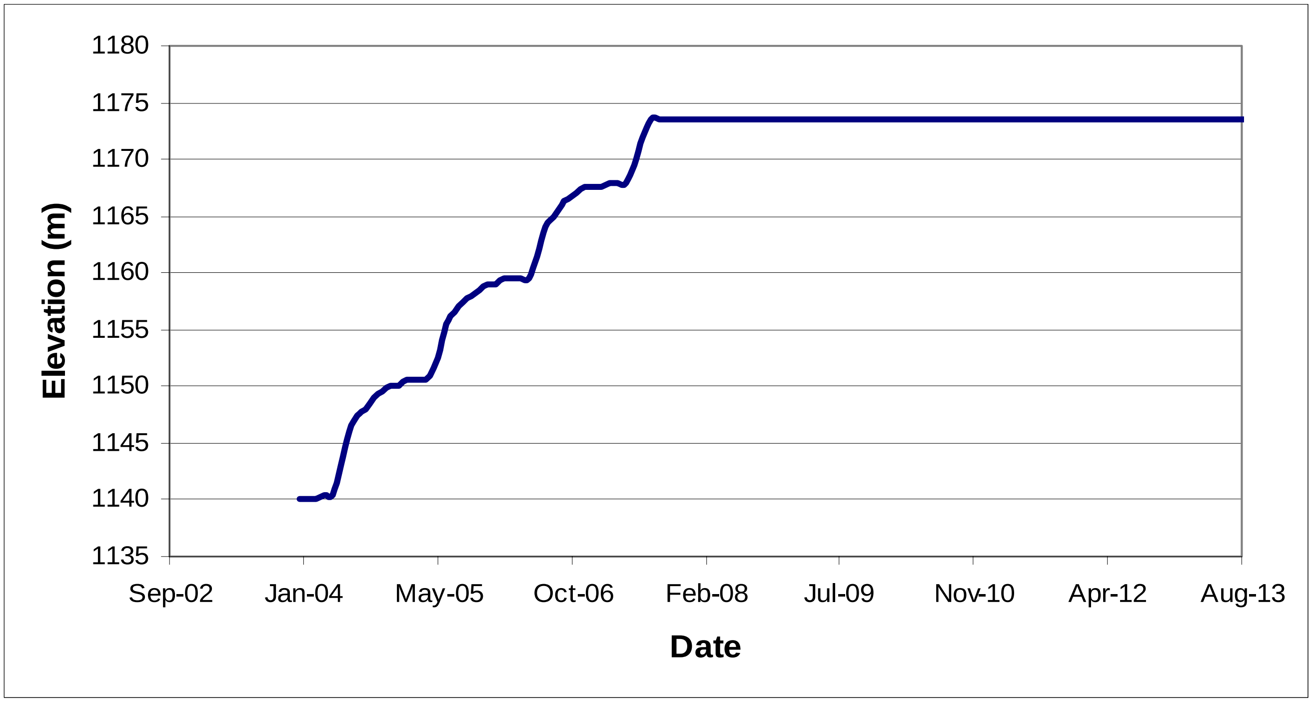
SRK Consulting *Engineers and Scientists*	Anvil Range Pit Lakes Assessment of Post Closure Conditions
	Faro Pit: Estimated Wall Rock Surface Exposure, 1140 - 1200 masl
Deloitte & Touche Inc.	PROJECT 1CD003.46 | DATE Nov. 2004 | APPROVED | FIGURE **4.2**



FILE REF: Figures 3-1_3-14.xls

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Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Faro Pit Filling Curve: Base Case

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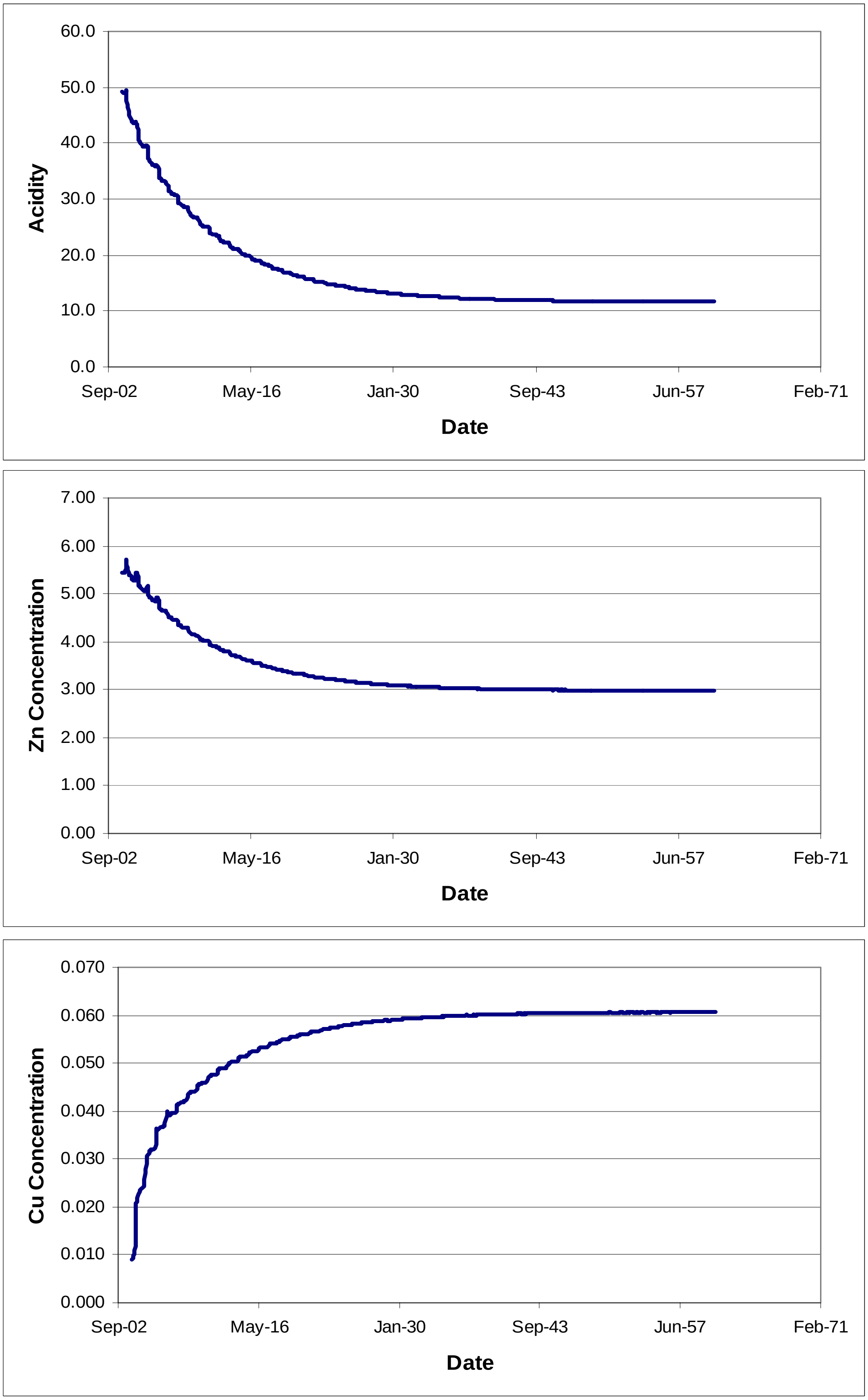
PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.3**



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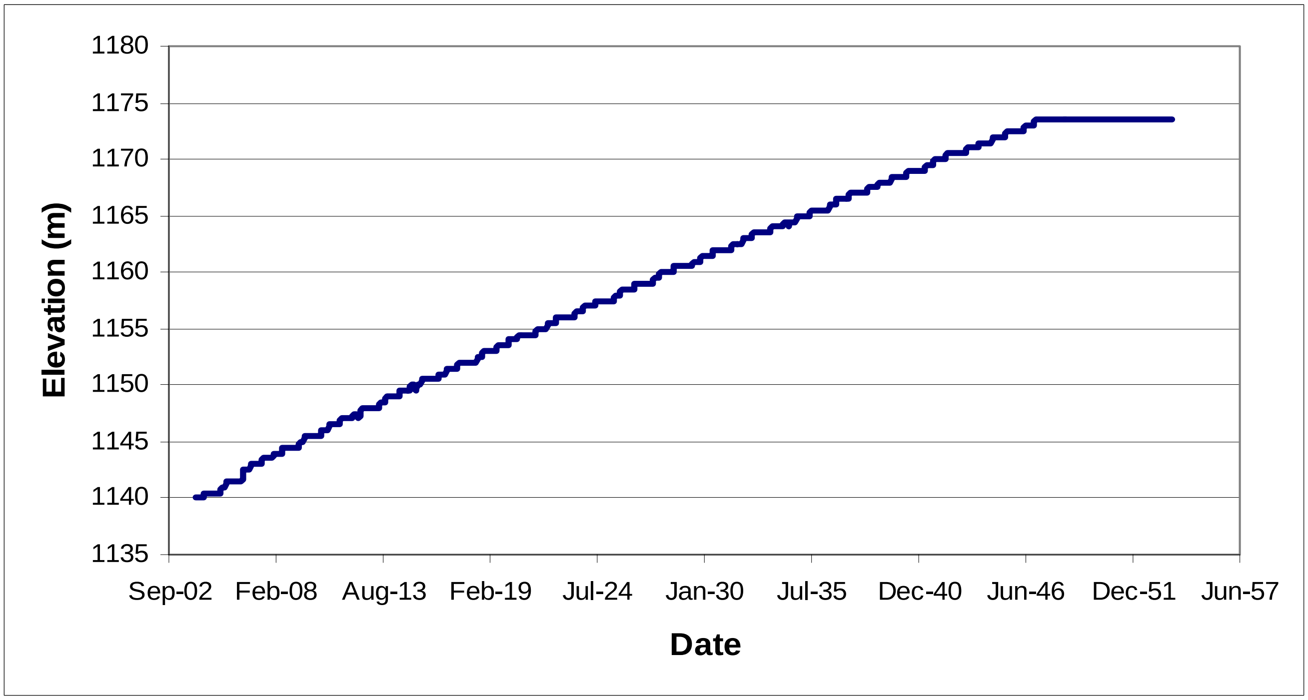
Deloitte & Touche Inc.

Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Faro Pit Lake Water Quality
Base Case

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		4.4

FILE REF: Figures 3-1_3-14.xls



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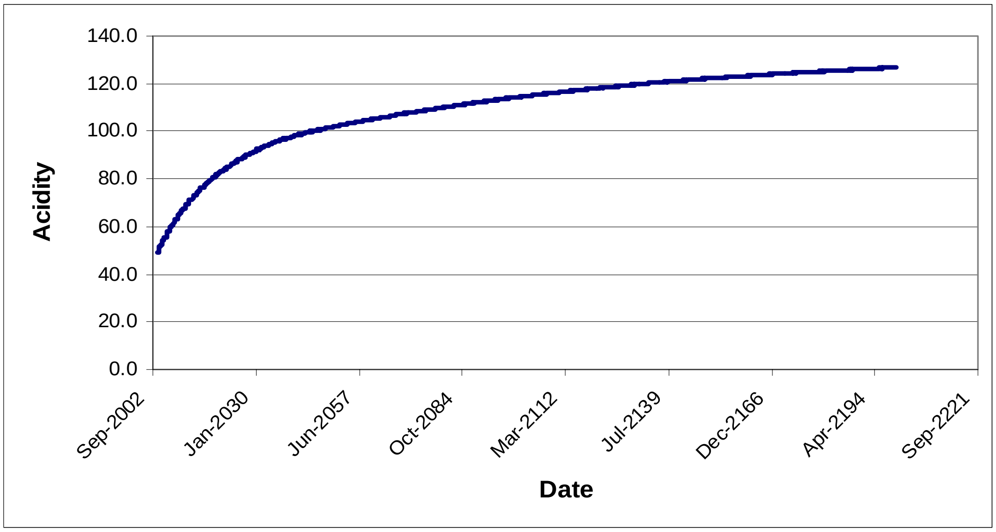
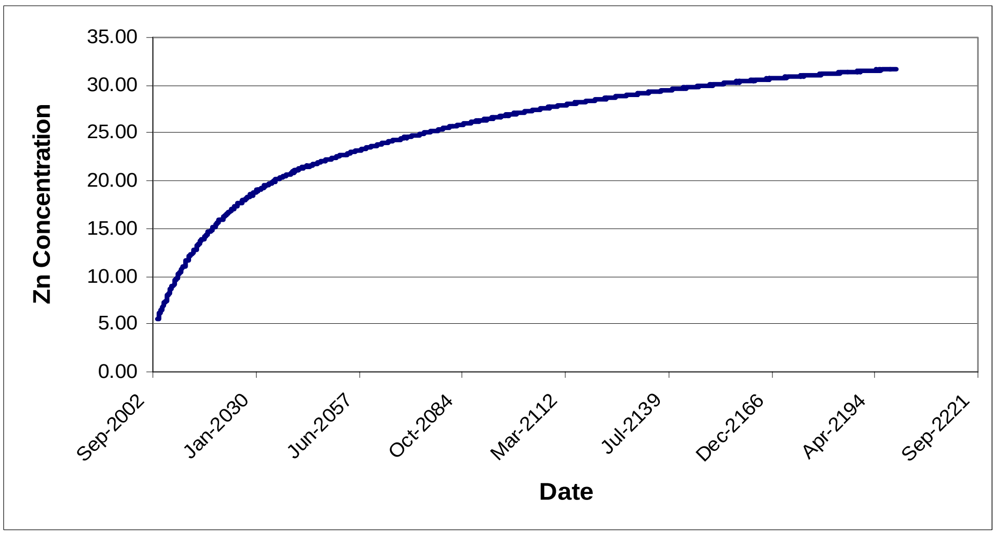
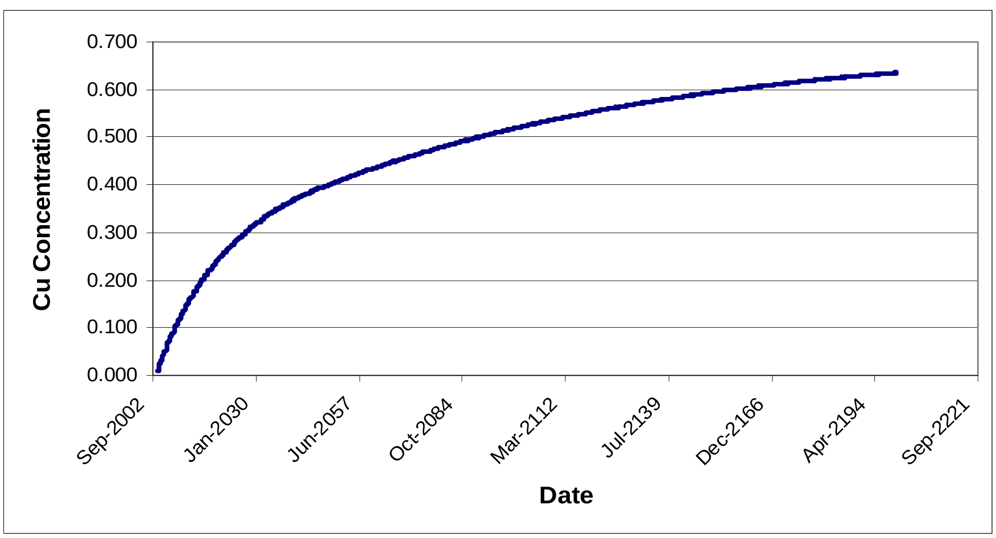
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Faro Pit Filling Curve: Faro Creek Diversion in place

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.5**







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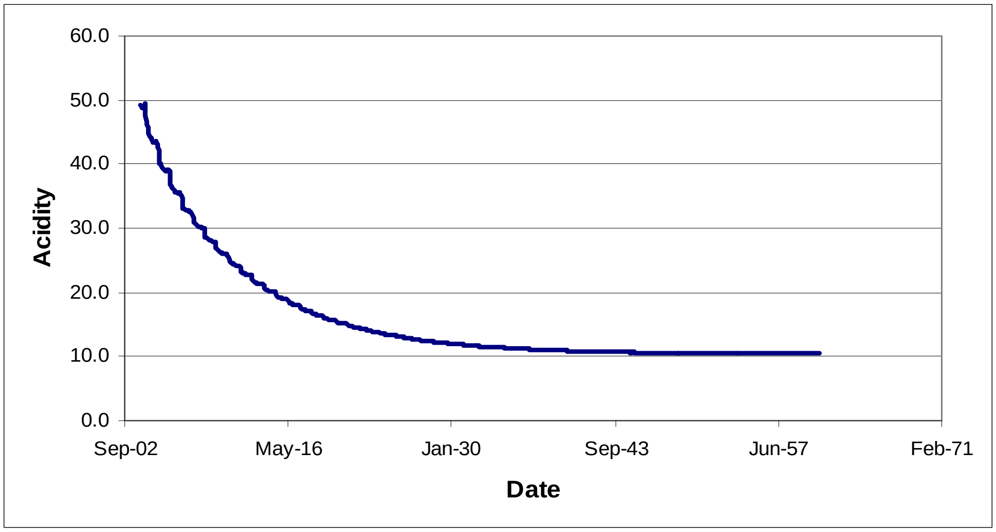
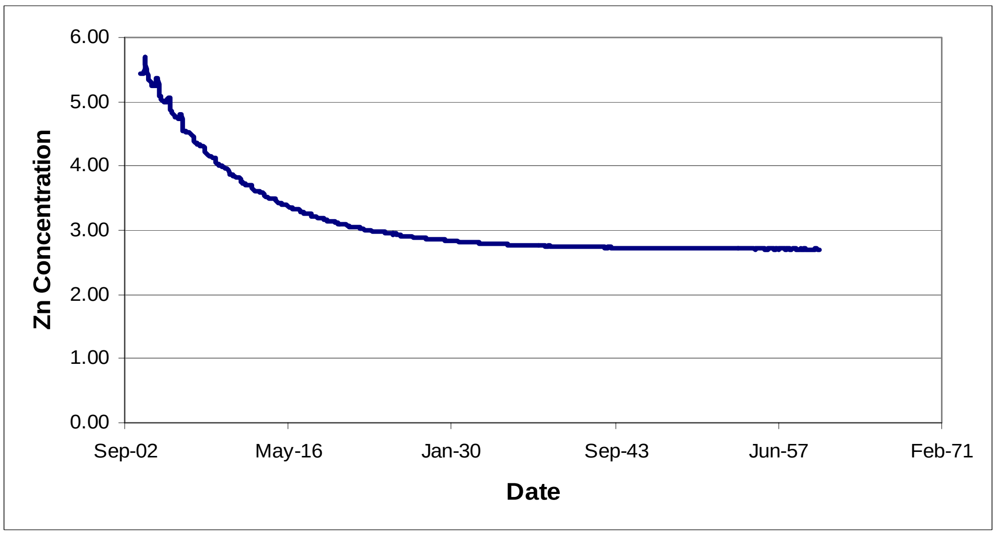
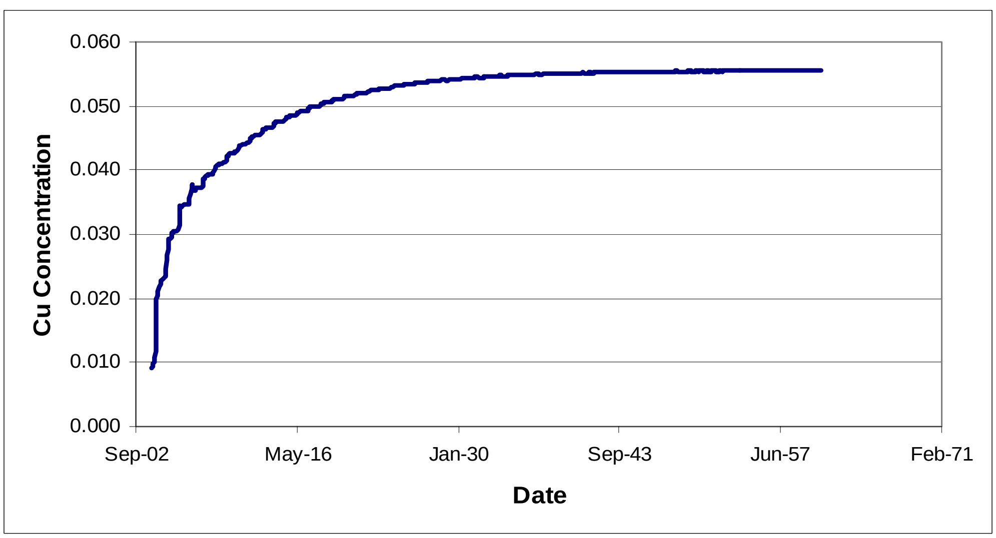
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Faro Pit Lake Water Quality
Faro Creek diversion upgraded

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.6**







FILE REF: Figures 3-1_3-14.xls

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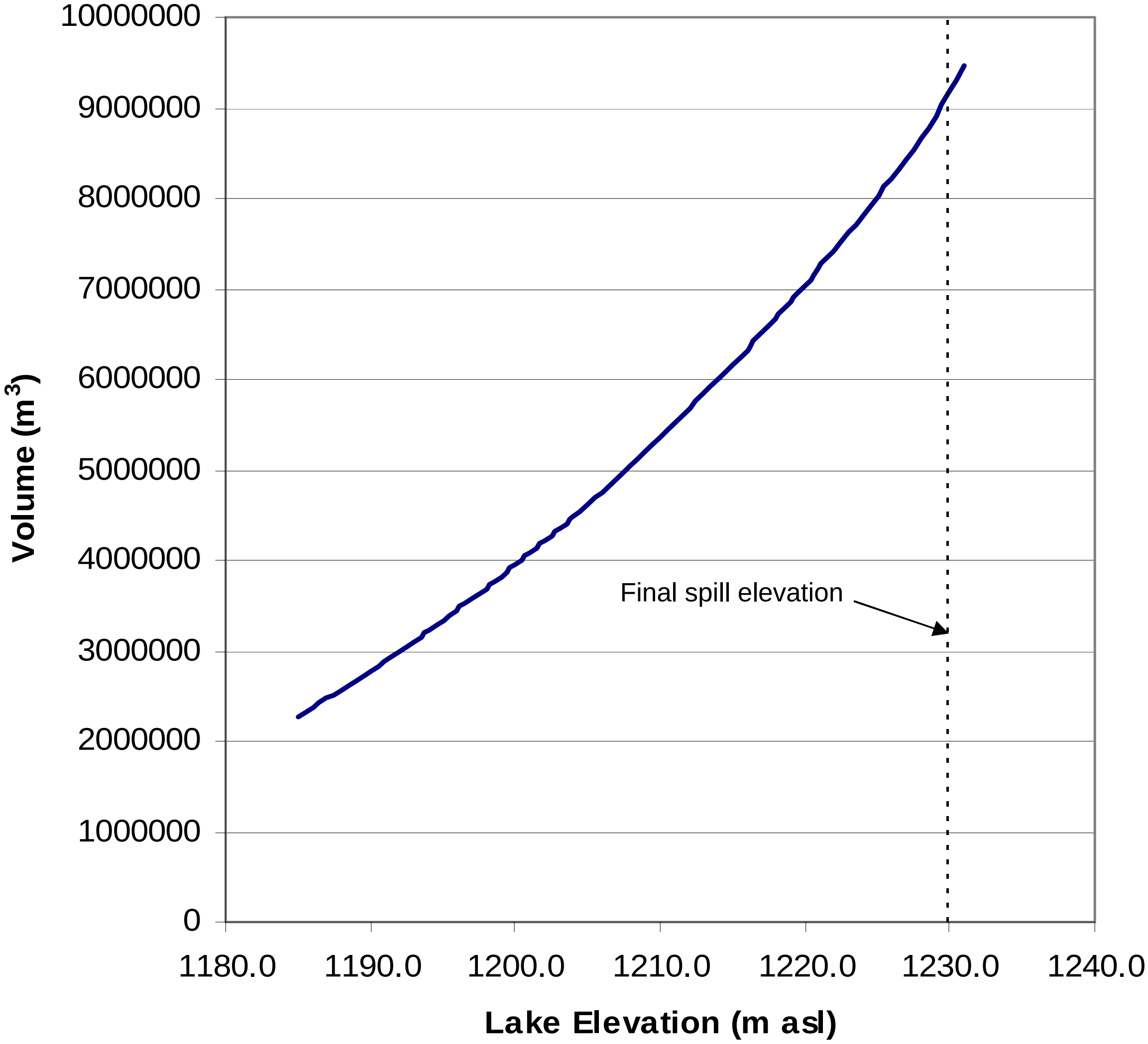
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Faro Pit Lake Water Quality
Faro Valley Dumps removed

Deloitte & Touche Inc.

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		4.7



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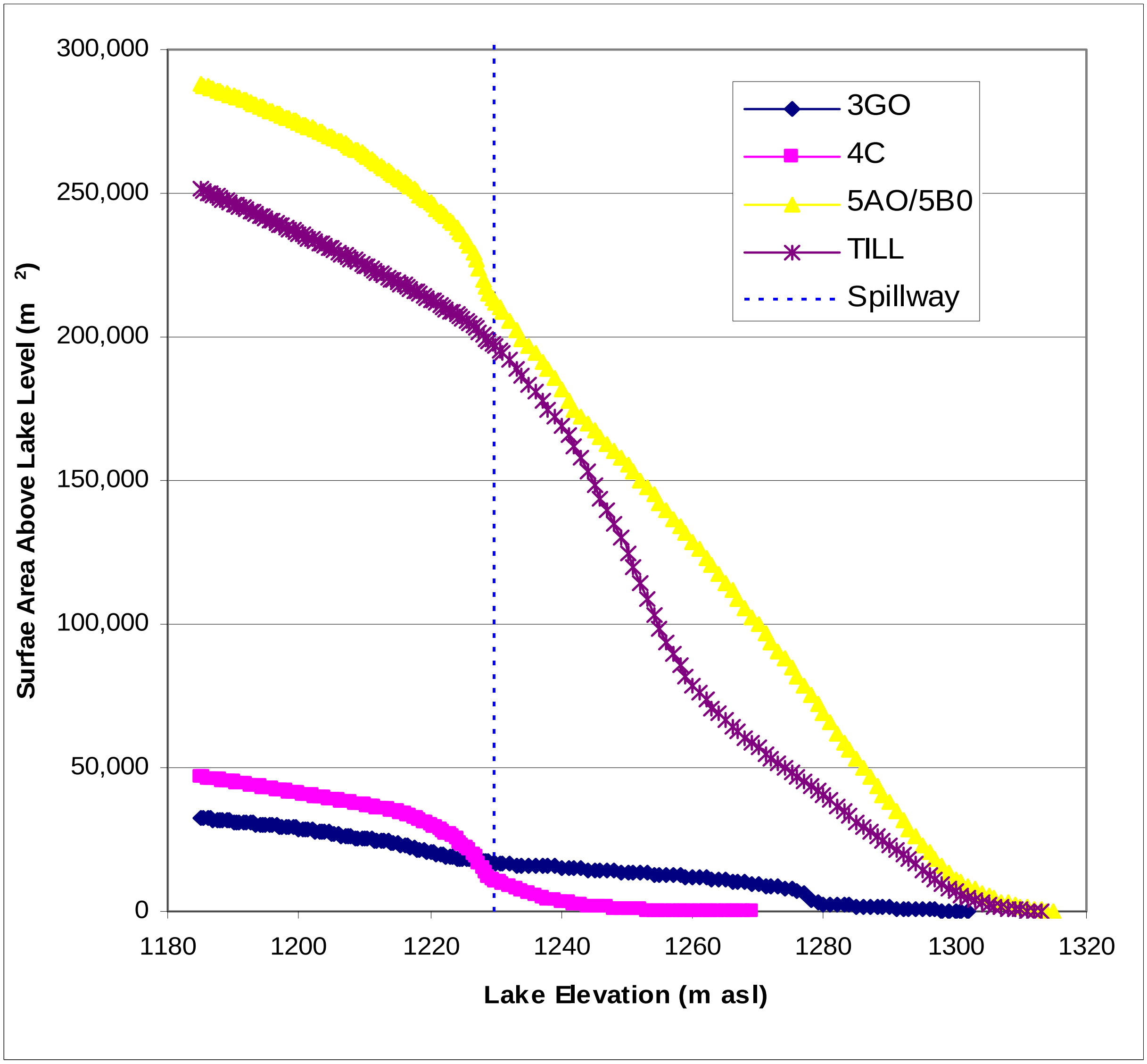
Deloitte & Touche Inc.

Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Grum Pit Volume Capacity Curve

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.8**

FILE REF: Figures 3-1_3-14.xls



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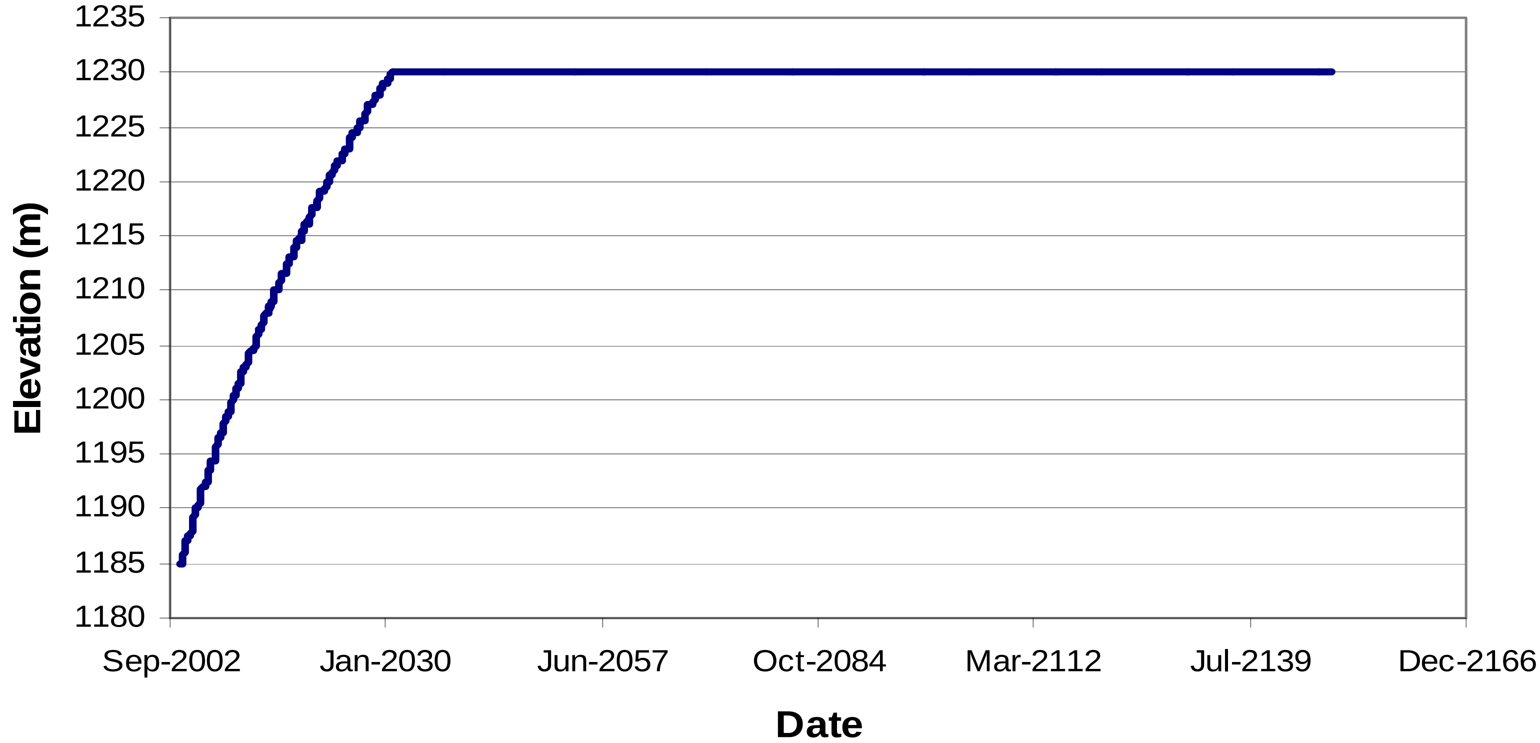
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Grum Pit Wall Rock Exposure

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.9**

FILE REF: Figures 3-1_3-14.xls



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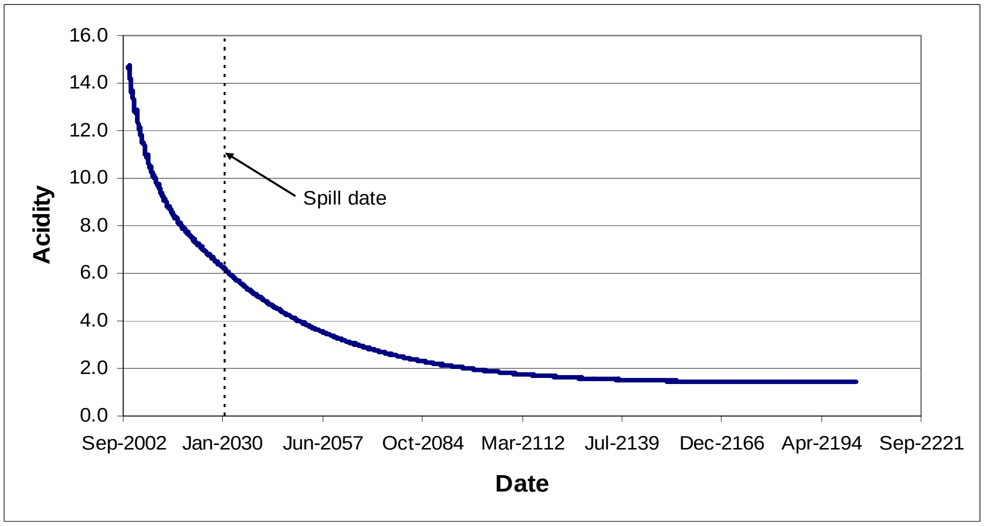
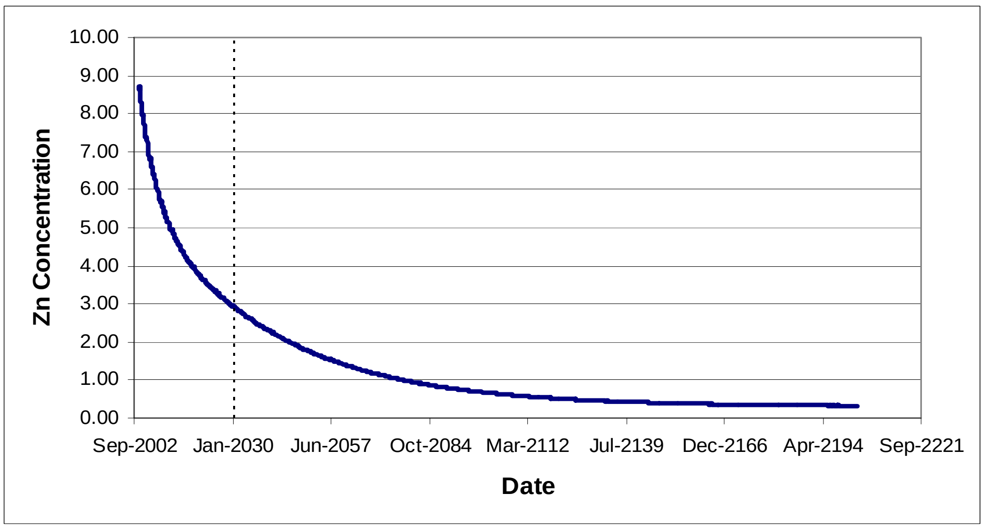
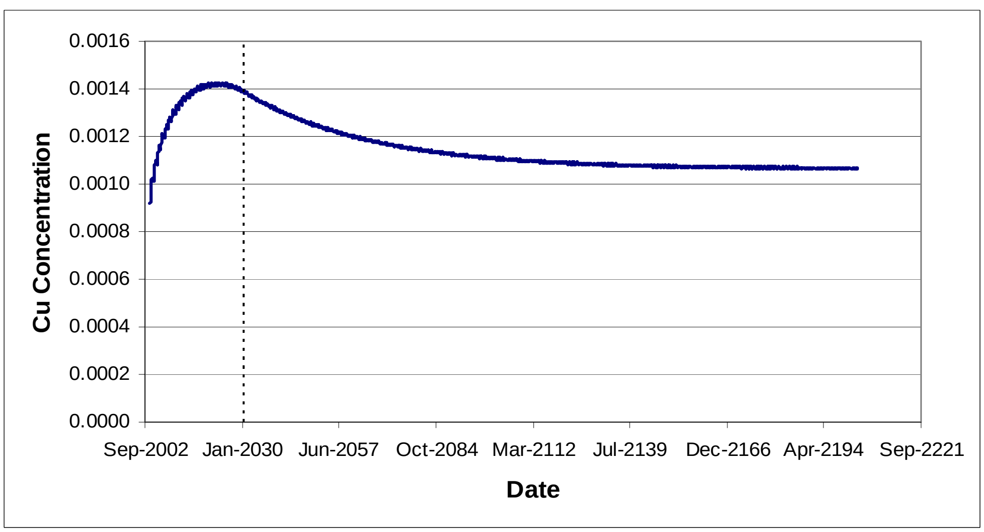
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Flooding Rate of the Grum Pit

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.10**







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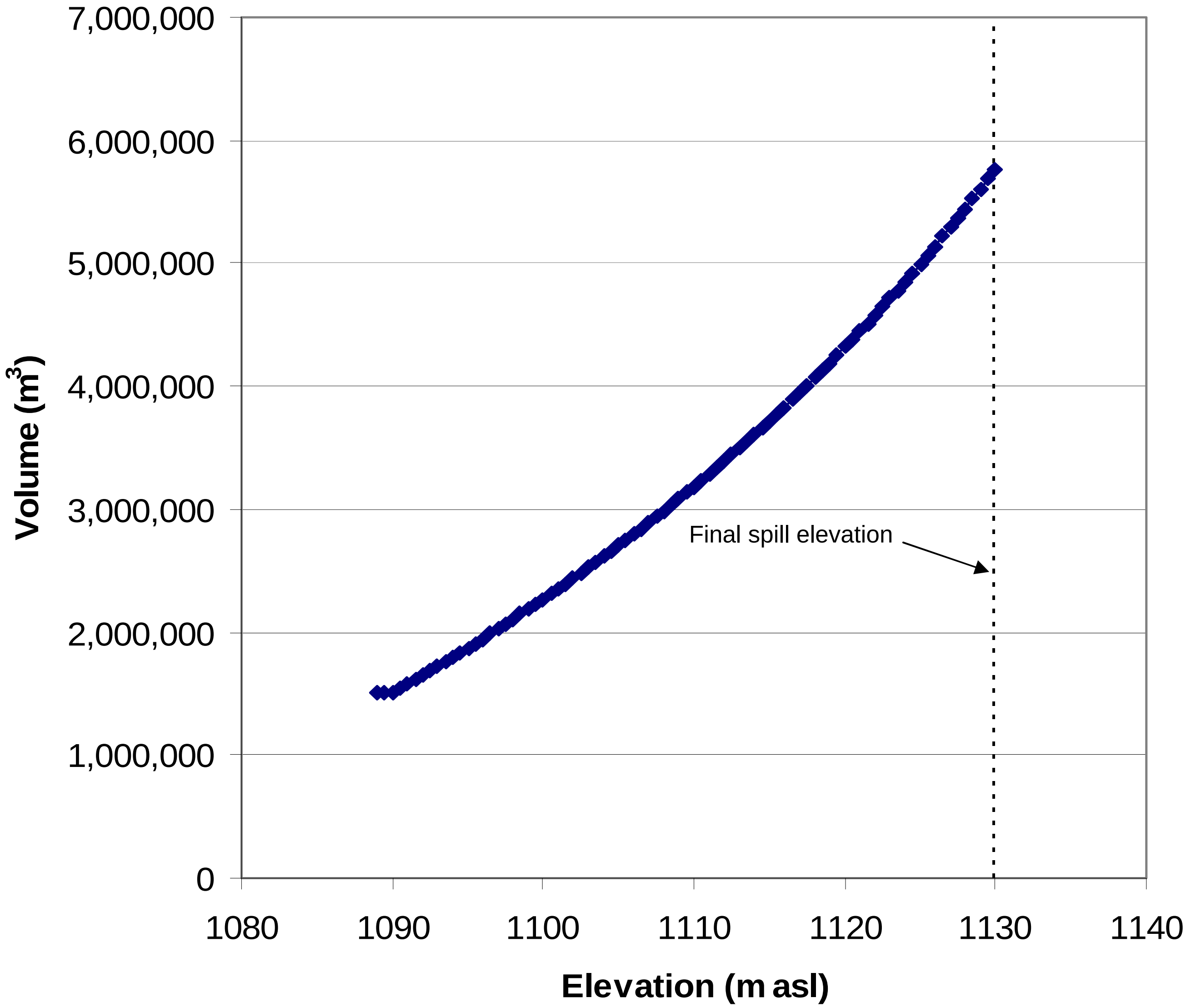
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Future Grum Pit Lake Water Quality

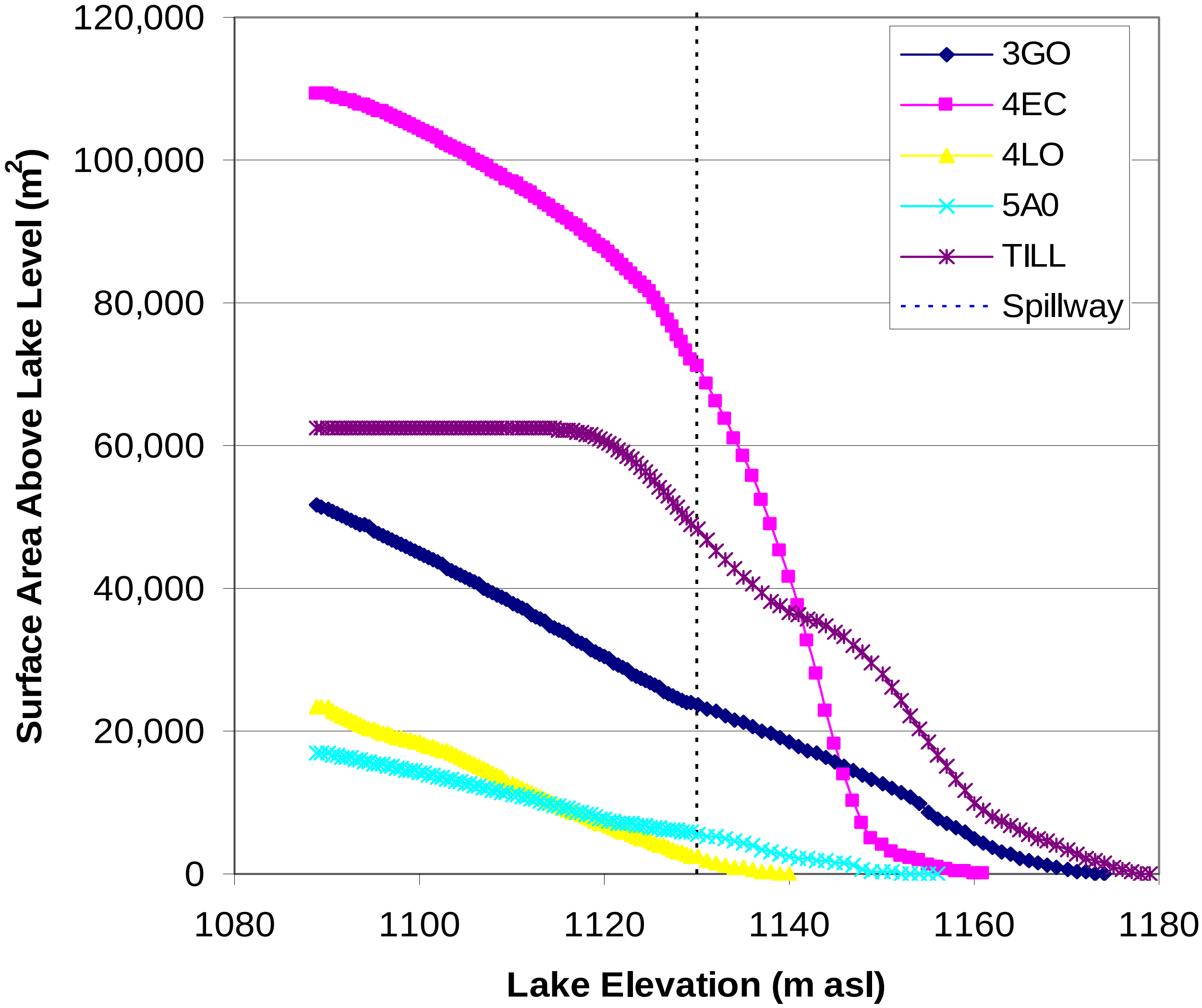
Deloitte & Touche Inc.

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.11**

FILE REF: Figures 3-1_3-14.xls



SRK Consulting Engineers and Scientists	Anvil Range Pit Lakes Assessment of Post Closure Conditions
	Vangorda Pit Volume Capacity Curve
Deloitte & Touche Inc.	PROJECT 1CD003.46 · DATE Nov. 2004 · APPROVED · FIGURE **4.12**



FILE REF: Figures 3-1_3-14.xls

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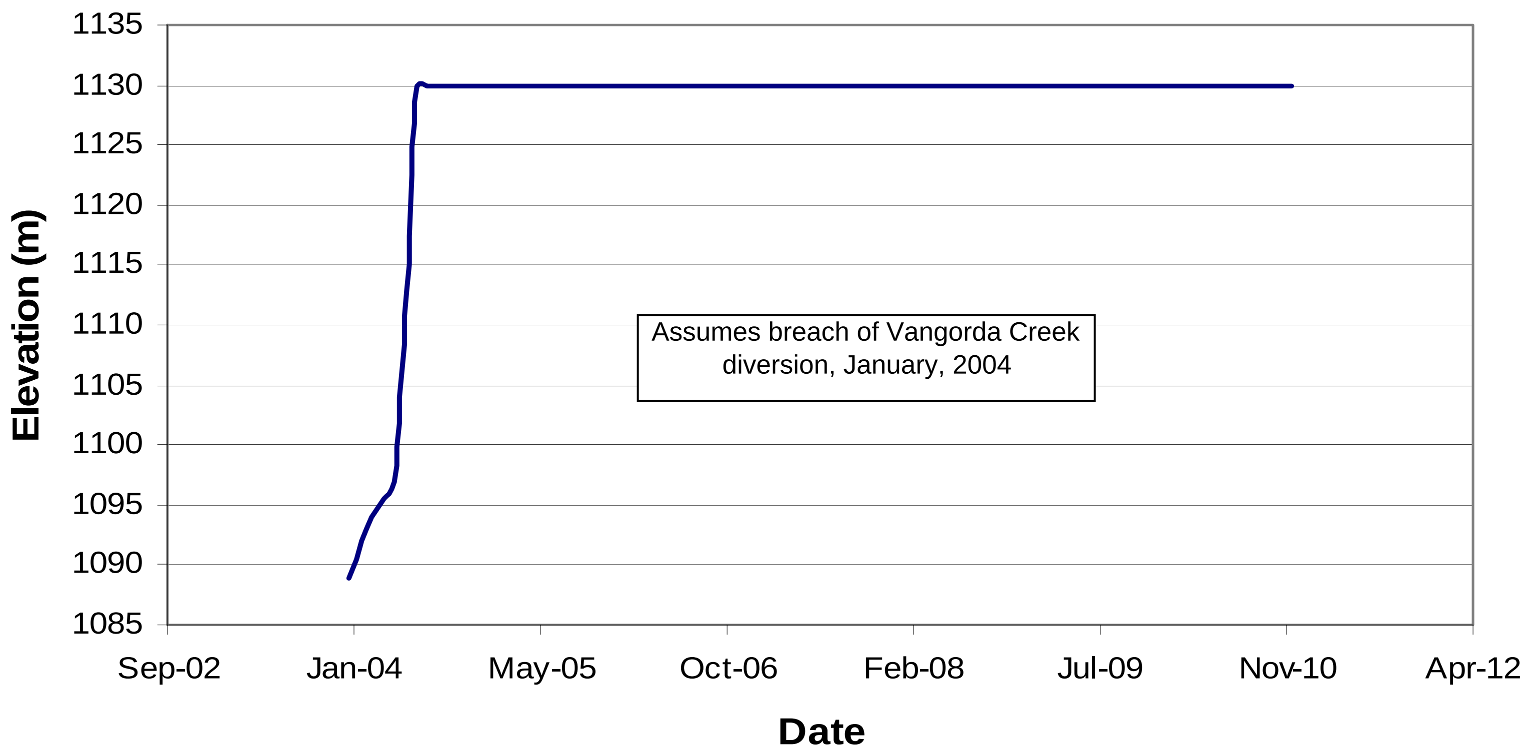
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Vangorda Pit Wall Rock Exposure

Deloitte & Touche Inc.

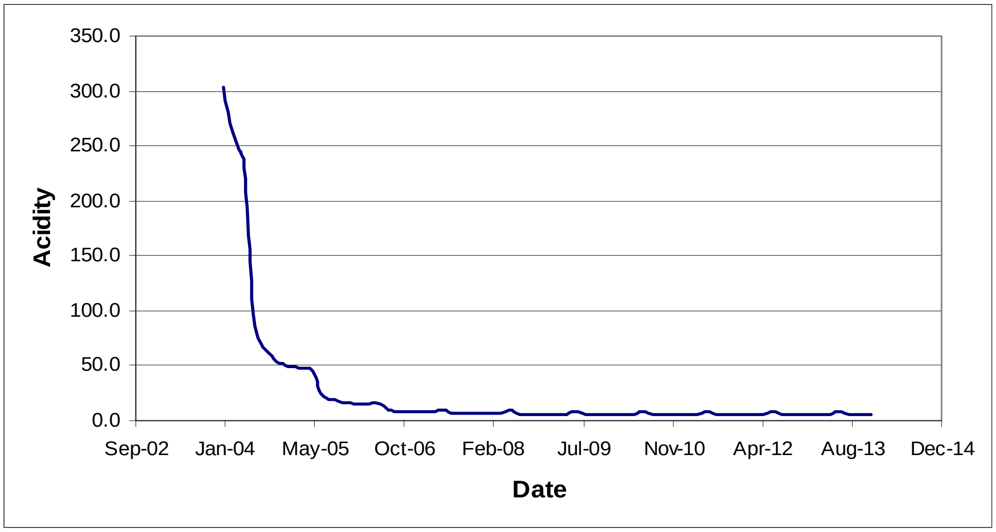
PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.13**

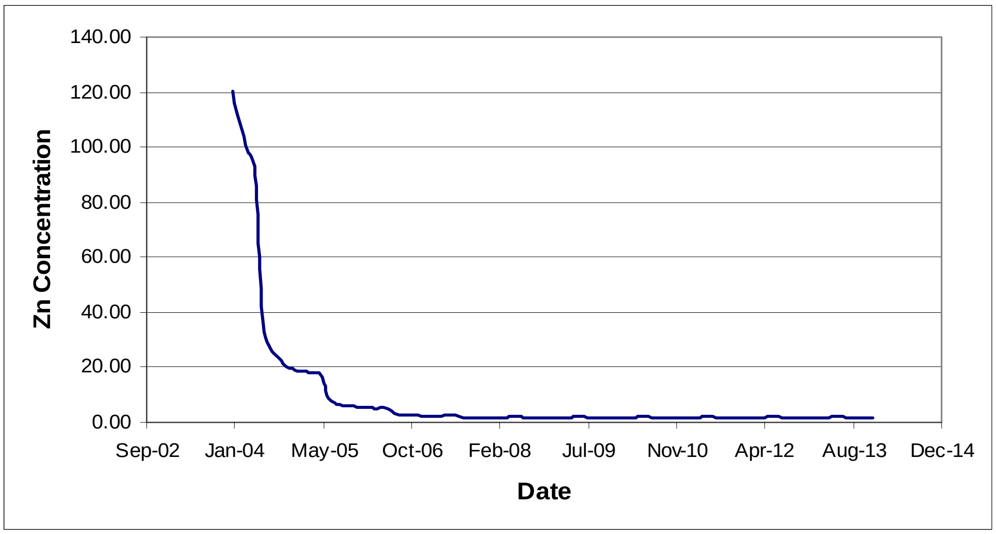
FILE REF: Figures 3-1_3-14.xls

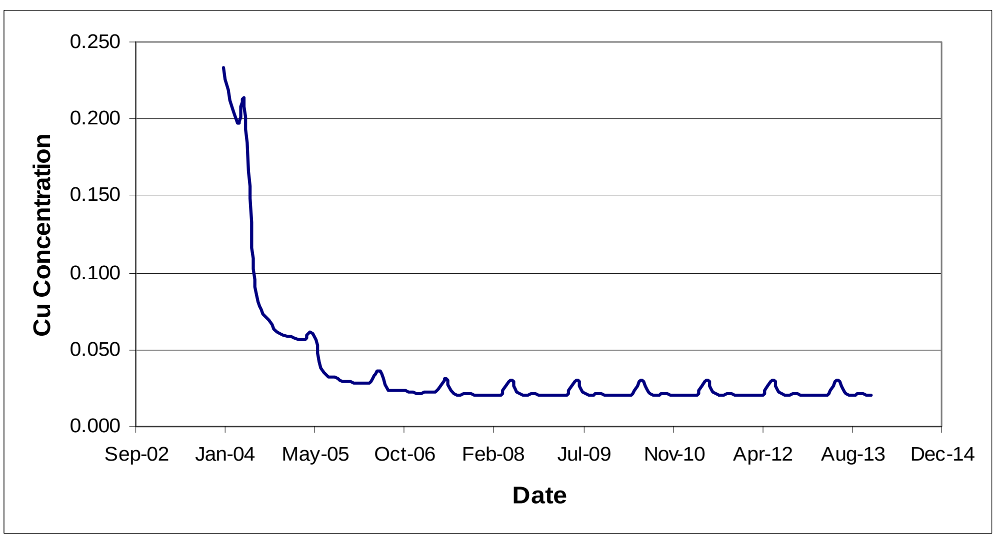


SRK Consulting Engineers and Scientists	Anvil Range Pit Lakes Assessment of Post Closure Conditions
Deloitte & Touche Inc.	**Estimated Filling Period for Vangorda Pit**

PROJECT	DATE	APPROVED	FIGURE
1CD003.046	Nov 2004		**4.14**







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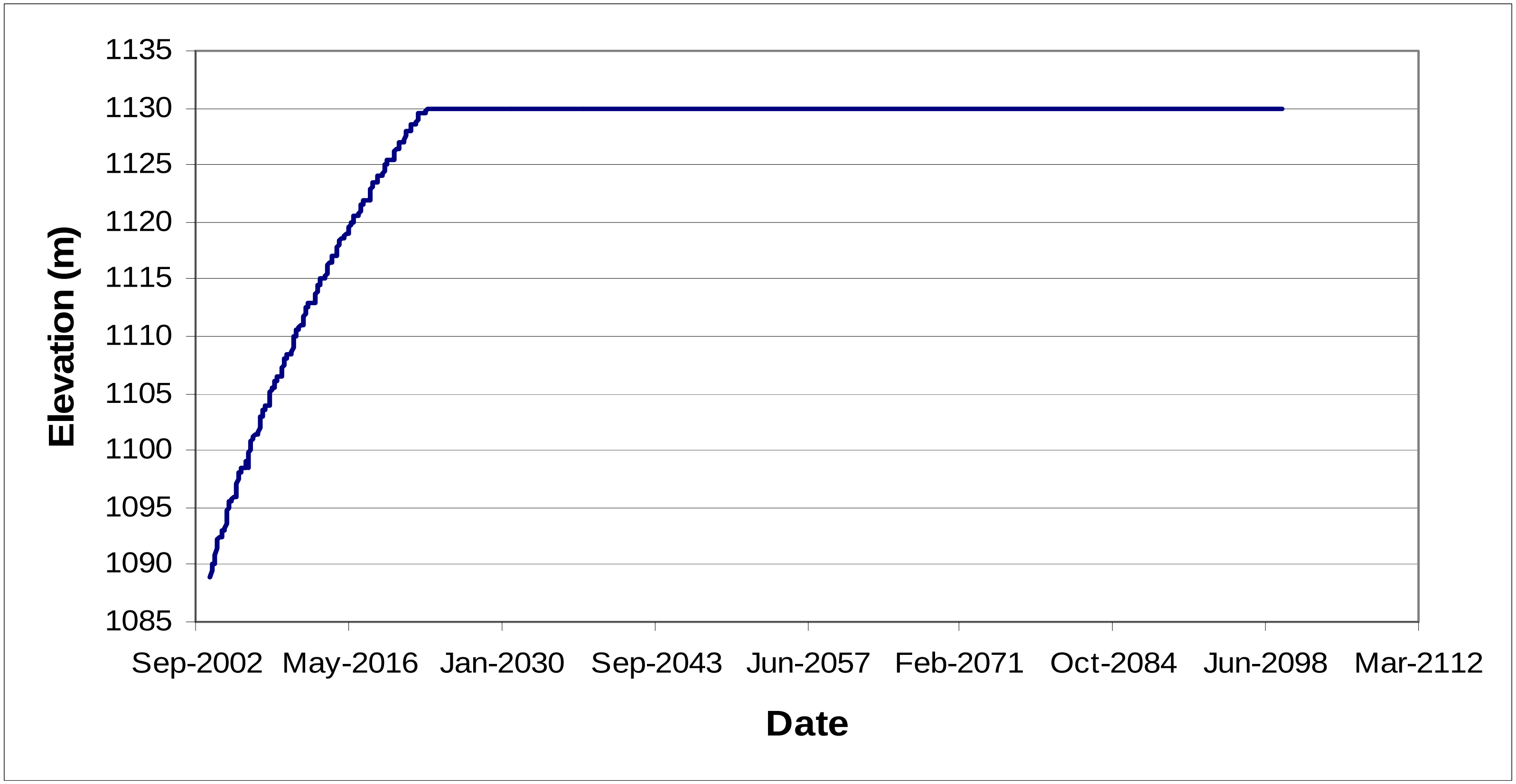
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Vangorda Pit Lake Water Quality
Base Case

Deloitte & Touche Inc.

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.15**

FILE REF: Figures 3-1_3-14.xls



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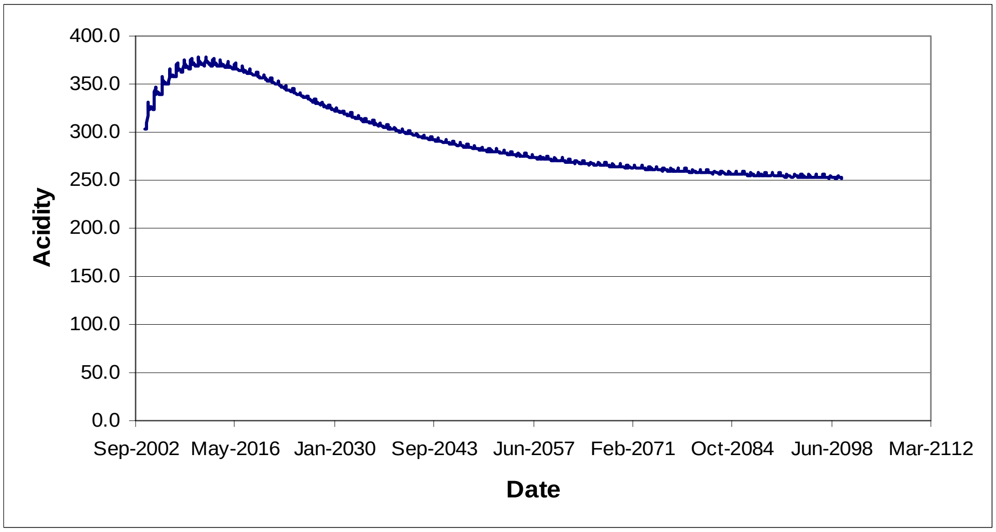
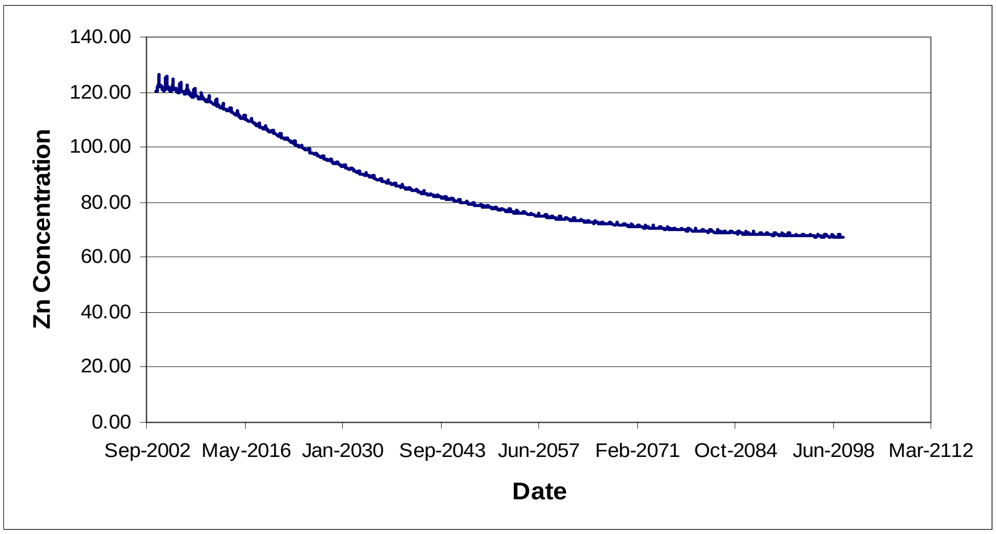
Deloitte & Touche Inc.

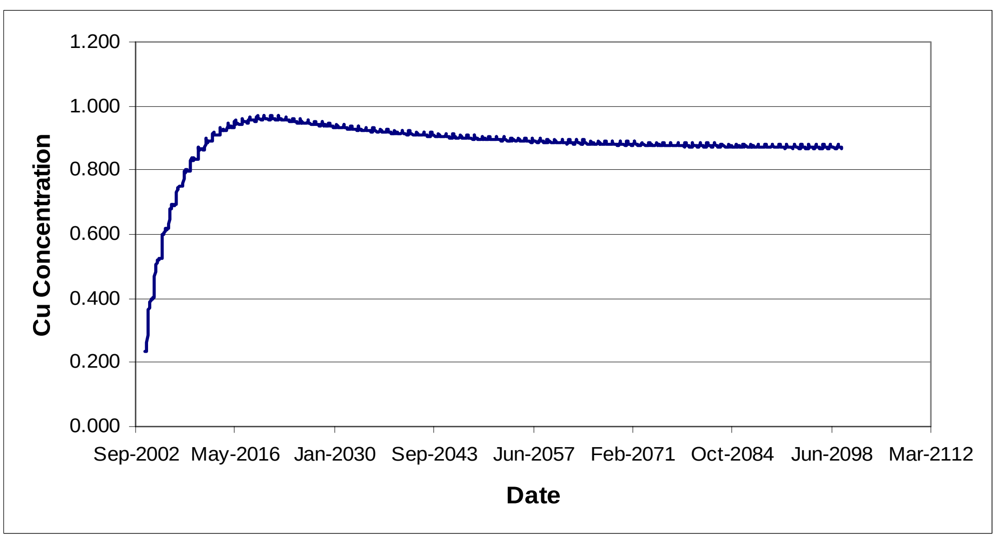
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Filling Period for Vangorda Pit with Vangorda Creek diversion maintained

PROJECT	DATE	APPROVED	FIGURE
1CD003.046	Nov 2004		**4.16**







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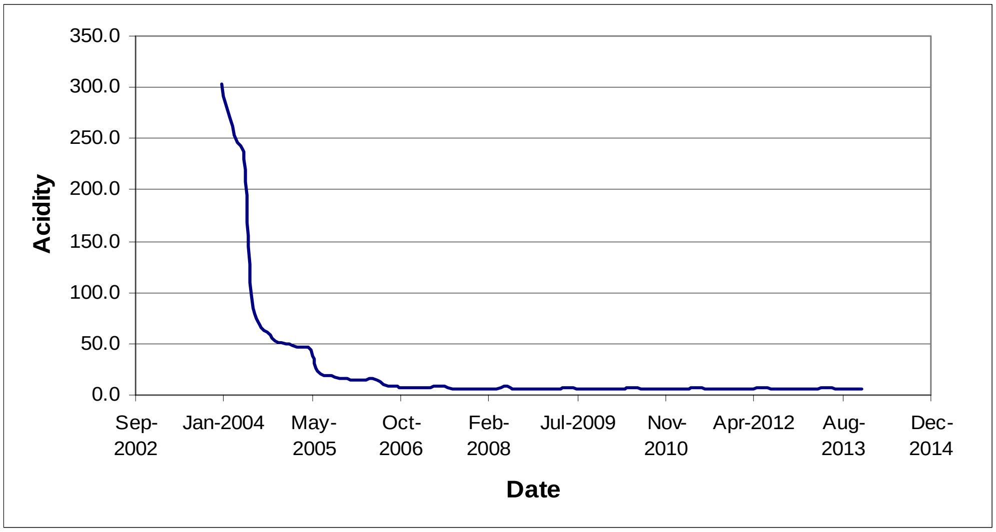
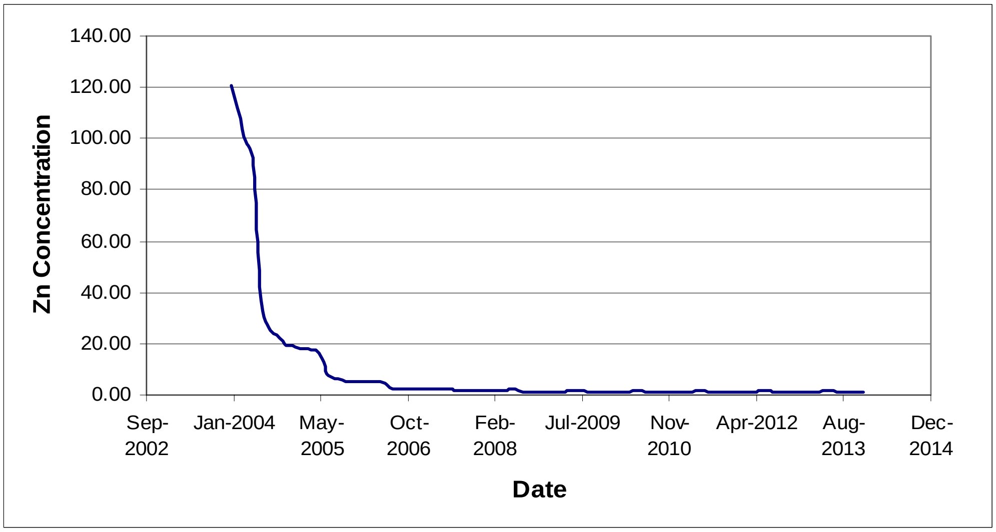
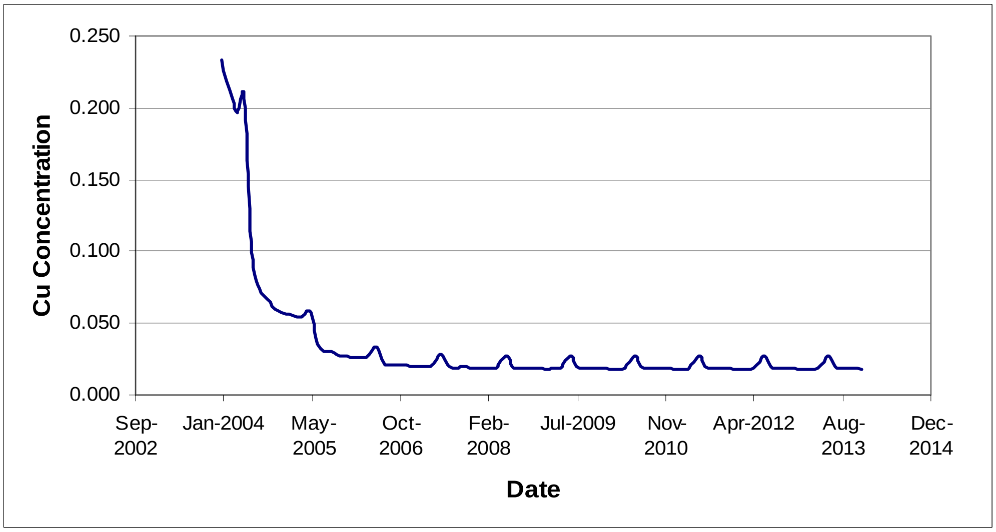
Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Vangorda Pit Lake Water Quality
Vangorda Creek diversion maintained

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		4.17







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Deloitte & Touche Inc.

Anvil Range Pit Lakes
Assessment of Post Closure Conditions

Estimated Vangorda Pit Lake Water Quality
In-pit dumps removed

PROJECT	DATE	APPROVED	FIGURE
1CD003.46	Nov. 2004		**4.18**

Appendix A

Description and Nomenclature of Anvil Range Rock Types

Geochemical Studies Logging Guide

Faro Area Rock Types

1D Non-carbonaceous fine-grained schist containing muscovite, biotite and andalusite. Typically contains finely disseminated pyrite or pyrrhotite along foliations. May contain quartz veins with coarse grained pyrite and/or chalcopyrite. Occassionally contains calcite in fractures and along foliations. Often loose but sometimes cemented by white salts. May be blocky or fine-grained.

A variety of 1D is maroon-stained and typically contains more visible pyrite and calcite. Sometimes appears to be a transitional form between 1D and 1D4.

1C6 Same as above but with biotite and andalusite porphyroblasts along foliation

1D2 Carbonaceous fine-grained schist. Typically friable with abundant fines.

1D4 Quartz muscovite schist. In palest form, is extremely friable and decomposed. Fine-grained pyrite may be visible. Oxidized fines are pale yellow to orange brown. Quartz veins typically contain pyrite. Rinse pH is strongly acidic (pH<3). See comment about maroon stained variety of 1D.

2 Sulphide rock types. These include massive to semi-massive siliceous pyrite occurring as blocks (brown stained), massive crumbly pyrite occurring as blocks and fines (no stain), and massive sphalerite. Barite is common.

3D0 Amphibolite and calc-silicate schist. Distinctive centimetre-scale light and dark banding. Calcite is common both as a matrix component and as a fracture filling. Rare sulphides. Typically blocky.

6 Milky quartz. Informal name.

10E Hornblende biotite quartz diorite. Dark porphyritic rock type. Typically blocky and stable but also rapidly decomposing and fines forming.

10F Quartz feldspar porphyry. Distinctive white rock and 1 mm biotite and hornblende phenocrysts. Typically blocky and stable but also rapidly decomposing and fines forming.

5 or T Overburden. Till.

Grum and Vangorda Area

Units		Symbols Used on Field Maps
Vangorda Formation		
5C	Poorly foliated greenstone	
5D	Chlorite phyllite, calcareous	5D0, 5D4
5B0	Calcareous phyllite, silver to dark grey	5B
5A0	Carbonaceous phyllite, weakly calcareous	5A
Mount Mye Formation		
3G0	Non-calcareous phyllite	3G
4EC	Undifferentiated massive and disseminated sulphides	
4E	Massive pyritic sulphides (60 to 100% pyrite)	
4C	Pyritic quartzite (<30% pyrite)	
4L0	Bleached phyllite, commonly pyritic	4L

Modifiers

ca	Calcareous
py	Pyritic
ox	Oxidized
st	Visible salts (describe type in notes)
gn	Galena
sl	Sphalerite
bl	Blocky (describe in notes)
sk	Slaking (describe in notes)
ms	Massive sulphide

Clast sizes

m>cm:	Coarse
cm/m:	Mixed metre and centimetre scale
mm>cm>>m	Fine Frained

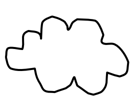
Mapping Conventions

3D0ox/10Fsk About equal quantities.
10% 3D0ox/90% 10Fsk Proportions indicated

Symbols

Distinct contact

Indistinct contact


FD – Free dumped area

* Small cluster of sulphide boulders

- GUS-01 Fine screened sample location for contact test

Appendix B

Pit Wall Seep Sampling Results

Appendix B.1

Faro Pit Seeps

Yr-Sample ID	04FP01	04FP02	04FP03	04FP04	04FP05	04FP06	04FP07
Sample ID	FP01	FP02	FP03	FP04	FP05	FP06	FP07
Source rock type	Calc-silicate with WR/ LG ore influence	Calc-silicate	4E (barren sulphides)/ 4C (white mica envelope) mix	HBL diorite w/ some sulphide influence	HBL Diorite	Till/ 1D4 (not a good 1D4 source)	Hbl Qtz Diorite
Date	6/3/2004	6/3/2004	6/3/2004	6/3/2004	6/3/2004	6/3/2004	6/3/2004
Field Parameters							
pH	6.54	7.46	3.02	7.32	8.12	7.23	7.03
Conductivity	3630	1170	5180	616	1038	275	379
Temp	11.5	11.1	12.4	12.5	14.8	11.2	4.2
Redox	411	376	654	346	328	433	421
Flow	4	4	25	600	7.5	not recorded	400
Notes							
Easting (NAD 27)	584413	584173	584148	584193	584240	584871	584116
Northing (NAD 27)	6914558	6914915	6915209	6915282	6915303	6915031	6915428
Laboratory Parameters							
pH	7.29	8.01	2.94	8.05	8.11	7.84	7.99
Conductivity	3540	1150	5120	600	983	277	393
Dissolved Anions							
Acidity pH 8.3	80.6	2.4	1960	4.2	3.9	1	4.1
Alkalinity Total as CaCO3	280	139	<1.0	239	293	119	193
Chloride	44.2	0.64	0.94	<0.50	<0.50	<0.50	<0.50
Sulphate	2310	428	4100	99.4	287	21.7	25.5
Dissolved Metals							
Aluminum	<0.20	<0.20	2.5	<0.20	<0.20	<0.20	<0.20
Antimony	<0.20	<0.20	<1.0	<0.20	<0.20	<0.20	<0.20
Arsenic	<0.20	<0.20	<1.0	<0.20	<0.20	<0.20	<0.20
Barium	<0.010	0.014	<0.050	0.036	0.031	0.016	0.062
Beryllium	<0.0050	<0.0050	<0.025	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth	<0.20	<0.20	<1.0	<0.20	<0.20	<0.20	<0.20
Boron	<0.10	<0.10	<0.70	<0.10	<0.10	<0.10	<0.10
Cadmium	0.022	<0.010	0.904	<0.010	<0.010	<0.010	<0.010
Calcium	631	44.4	302	58.6	94.2	32.8	50.4
Chromium	<0.010	<0.010	<0.050	<0.010	<0.010	<0.010	<0.010
Cobalt	0.047	<0.010	1.55	<0.010	<0.010	<0.010	<0.010
Copper	0.014	<0.010	2.55	<0.010	<0.010	<0.010	<0.010
Iron	<0.030	<0.030	192	<0.030	<0.030	<0.030	<0.030
Lead	<0.050	<0.050	0.95	<0.050	<0.050	<0.050	<0.050
Lithium	0.097	0.032	0.131	0.043	0.055	0.021	<0.010
Magnesium	171	10.1	413	28.4	59.2	10.4	13.2
Manganese	6.01	<0.0050	82	0.0928	<0.0050	<0.0050	<0.0050
Molybdenum	<0.030	<0.030	<0.15	<0.030	<0.030	<0.030	<0.030
Nickel	0.194	<0.050	1.41	<0.050	<0.050	<0.050	<0.050
Phosphorus	<0.30	<0.30	<1.5	<0.30	<0.30	<0.30	<0.30
Potassium	8.2	<2.0	<10	3.1	6.1	2.2	<2.0
Selenium	<0.20	<0.20	<1.0	<0.20	<0.20	<0.20	<0.20
Silicon	7	2.61	3.86	0.989	0.808	4.66	1.75
Silver	<0.010	<0.010	<0.050	<0.010	<0.010	<0.010	<0.010
Sodium	58.3	150	<10	14.9	35.6	3	2.6
Strontium	2.24	1.2	0.796	1.66	3.24	0.234	0.536
Thallium	<0.20	<0.20	<1.0	<0.20	<0.20	<0.20	<0.20
Tin	<0.030	<0.030	<0.15	<0.030	<0.030	<0.030	<0.030
Titanium	0.012	<0.010	<0.050	<0.010	<0.010	<0.010	<0.010
Vanadium	<0.030	<0.030	<0.15	<0.030	<0.030	<0.030	<0.030
Zinc	45.2	0.0509	875	0.832	<0.0050	<0.0050	<0.0050

Appendix B.2

Grum Pit Seeps

Yr-Sample ID	03GP01	03GP02	03GP04	03GP05	03GP06	04GP01	04GP02	04GP03	04GP04
Sample ID	SRK-GP01	SRK-GP02	SRK-GP04	SRK-GP05	SRK-GP06	GP01	GP02	GP03	GP04
Source rock type	ore/ undiff. sulphides	ore/ undiff. sulphides	Mixed phyllite	Mixed phyllite	Mixed phyllite	Mixed phyllite	Mixed phyllite	Mixed phyllite	Till/ deep groundwater
Date	6/9/2003	6/9/2003	6/9/2003	6/9/2003	6/9/2003	5/31/2004	5/31/2004	5/31/2004	5/31/2004
Field Parameters									
pH	8.05	7.28	8.21	7.88	8.36	7.81	7.96	8	7.95
Conductivity	1928	1456	1896	1289	1755	946	1174	764	341
Temp	12.7	13.7	15.4	3.7	11.2	12	8.6	5.5	4.3
Redox	635	622	617	586	462	346	1357	334	351
Flow	2	Trace	1	3	Trace	Trace	15	15	60
Notes									
Easting (NAD 27)	592306	592241	592220	592123	592081	592057	592025	592009	592659
Northing (NAD 27)	6905309	6905243	6905228	6905120	6905001	6904872	6904962	6905010	6905112
Laboratory Parameters									
pH	7.8	7.51	8.08	7.65	8.13	8.29	8.29	8.31	8.28
Conductivity	1850	1550	1780	1240	1660	935	1190	757	346
Dissolved Anions									
Acidity pH 8.3	37	51	20	36	11	<1.0	<1.0	<1.0	<1.0
Alkalinity Total as CaCO3	373	189	266	223	264	139	210	187	145
Chloride	-0.5	-0.5	-0.5	-0.5	2.7	0.78	2.3	0.86	<0.50
Sulphate	989	932	1050	627	995	359	456	225	34.7
Dissolved Metals									
Aluminum	-0.2	-0.2	-0.2	-0.2	-0.2	<0.20	<0.20	<0.20	<0.20
Antimony	-0.2	-0.2	-0.2	-0.2	-0.2	<0.20	<0.20	<0.20	<0.20
Arsenic	-0.2	-0.2	-0.2	-0.2	-0.2	<0.20	<0.20	<0.20	<0.20
Barium	0.01	0.01	0.01	0.01	0.01	0.014	0.011	0.017	0.109
Beryllium	-0.005	-0.005	-0.005	-0.005	-0.005	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth	-0.2	-0.2	-0.2	-0.2	-0.2	<0.20	<0.20	<0.20	<0.20
Boron	-0.1	-0.1	-0.1	-0.1	-0.1	<0.10	<0.10	<0.10	<0.10
Cadmium	-0.01	-0.01	-0.01	-0.01	-0.01	<0.010	<0.010	<0.010	<0.010
Calcium	239	197	268	158	90	94.9	117	64.8	46
Chromium	-0.01	-0.01	-0.01	-0.01	-0.01	<0.010	<0.010	<0.010	<0.010
Cobalt	0.01	0.1	0.02	0.02	-0.01	<0.010	<0.010	<0.010	<0.010
Copper	-0.01	-0.01	-0.01	-0.01	-0.01	<0.010	<0.010	<0.010	<0.010
Iron	-0.03	-0.03	-0.03	-0.03	-0.03	<0.030	<0.030	<0.030	<0.030
Lead	-0.05	-0.05	-0.05	-0.05	-0.05	<0.050	<0.050	<0.050	<0.050
Lithium	0.02	0.02	0.03	0.03	0.05	0.023	0.017	0.02	<0.010
Magnesium	167	112	144	96.9	235	70.9	97.1	59.6	9.78
Manganese	0.015	0.224	0.013	-0.005	-0.005	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum	-0.03	-0.03	0.06	-0.03	-0.03	<0.030	<0.030	<0.030	<0.030
Nickel	0.51	1.03	0.17	0.07	-0.05	0.092	0.108	0.08	<0.050
Phosphorus	-0.3	-0.3	-0.3	-0.3	-0.3	<0.30	<0.30	<0.30	<0.30
Potassium	3	3	5	3	4	2.9	3.9	3.6	<2.0
Selenium	-0.2	-0.2	-0.2	-0.2	-0.2	<0.20	<0.20	<0.20	<0.20
Silicon	2.37	3.46	1.94	1.78	1.21	0.949	0.879	1.11	5.72
Silver	-0.01	-0.01	-0.01	-0.01	-0.01	<0.010	<0.010	<0.010	<0.010
Sodium	6	8	6	5	5	<2.0	3	<2.0	6.9
Strontium	1.14	1.41	1.78	1.47	0.403	0.465	0.498	0.289	0.314
Thallium	-0.2	-0.2	-0.2	-0.2	-0.2	<0.20	<0.20	<0.20	<0.20
Tin	-0.03	-0.03	-0.03	-0.03	-0.03	<0.030	<0.030	<0.030	<0.030
Titanium	-0.01	-0.01	-0.01	-0.01	-0.01	<0.010	<0.010	<0.010	<0.010
Vanadium	-0.03	-0.03	-0.03	-0.03	-0.03	<0.030	<0.030	<0.030	<0.030
Zinc	6.69	14.3	0.073	0.03	-0.005	0.0188	0.0238	<0.0050	<0.0050

Yr-Sample ID	04GP05	04GP06	04GP07	04GP08	04GP10	04GP11	04GP12	04GP13	04GP14
Sample ID	GP05	GP06	GP07	GP08	GP10	GP11	GP12	GP13	GP14
Source rock type	Till	Mixed phyllite	Mixed phyllite	Mixed phyllite	ore/ undiff. sulphides	ore/ undiff. sulphides	Mixed phyllite	Till (lake in sot)	Pyritic quartzite
Date	5/31/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004
Field Parameters									
pH	7.87	7.41	8.09	8.34	8.45	7.5	7.94	8.28	6.78
Conductivity	1097	1744	1059	1206	1518	1442	1709	789	1371
Temp	17.4	12.4	8	7.9	7.3	10.8	14.6	12.8	3.9
Redox	not recorded	293	307	291	not recorded	321	303	303	256
Flow	Trace	0.1	5	Trace	9	0.25	0.1	0	15
Notes									
Easting (NAD 27)	592765	592123	592146	592169	592301	592236	592222	592611	592480
Northing (NAD 27)	6904941	6905120	6905136	6905153	6905303	6905238	6905215	6904459	6904642
Laboratory Parameters									
pH	7.87	7.96	8.14	8.04	7.92	7.61	8.05	8.29	6.67
Conductivity	1190	1770	1090	1280	1520	1480	1680	775	1340
Dissolved Anions									
Acidity pH 8.3	3.3	2.3	<1.0	3.7	5.8	13.4	4	<1.0	173
Alkalinity Total as CaCO3	99.2	297	245	268	273	217	280	91.8	28.5
Chloride	0.76	1.5	0.84	0.61	<0.50	<0.50	0.63	0.74	1.18
Sulphate	590	853	403	513	716	733	849	350	782
Dissolved Metals									
Aluminum	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Antimony	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.34
Barium	0.342	0.011	0.024	0.015	0.011	0.014	0.018	0.043	0.03
Beryllium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.098
Calcium	185	103	83.9	144	173	176	216	103	113
Chromium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt	<0.010	<0.010	<0.010	0.011	0.022	0.101	0.018	<0.010	0.529
Copper	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	1.73
Iron	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	72
Lead	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.074
Lithium	<0.010	0.036	0.03	0.022	<0.010	0.022	0.019	0.011	0.025
Magnesium	34.8	206	98.2	89.3	109	99.6	121	34.3	66.9
Manganese	0.0252	0.0149	0.0083	0.0168	0.0216	0.158	0.0102	0.558	17.4
Molybdenum	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	0.046	<0.030	<0.030
Nickel	<0.050	0.056	<0.050	0.052	0.418	1.03	0.13	<0.050	0.65
Phosphorus	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium	5.2	3.8	2.5	2.9	2.7	3	4.8	2.9	<2.0
Selenium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon	1.4	1.33	0.887	1.58	1.44	3.06	1.74	0.726	5.57
Silver	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium	14.7	4.1	<2.0	4	2.7	5.8	4.8	8.3	16
Strontium	0.745	0.516	0.418	1.37	0.805	1.25	1.45	0.35	0.552
Thallium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Vanadium	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc	<0.0050	<0.0050	<0.0050	0.0133	7.5	12	0.0326	0.0307	97.5

Appendix B.3

Vangorda Pit Seeps

Yr-Sample ID	04VP01	04VP02	04VP03	04VP04	04VP05	04VP06	04VP07	04VP08	04VP09
Sample ID	VP01	VP02	VP03	VP04	VP05	VP06	VP07	VP08	VP09
Source rock type	Mt Mye Fm non-calc phyllite	Massive pyritic sulphides	Till	Massive pyritic sulphides	Massive pyritic sulphides	Bleached phyllite/ massive sulphides	Bleached phyllite/ massive sulphides	Massive pyritic sulphides	Massive pyritic sulphides
Date	5/31/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/1/2004	6/2/2004	6/2/2004
Field Parameters									
pH	7.27	2.95	7.57	3.96	5.58	2.7	3.15	2.84	5.62
Conductivity	181	1261	405	7390	2810	12.9	5750	9110	1033
Temp	8.4	14.5	20.5	17.8	8.3	10210	11.3	6.9	4.4
Redox	382	672	not recorded	480	254	712	616	607	326
Flow	6	15	0.25	2	Trace	Trace	1	Trace	2
Notes									
Easting (NAD 27)	594111	594513	594386	594419	594237	594269	594297	594208	594186
Northing (NAD 27)	6903499	6902916	6903000	6902875	6903066	6903035	6902993	6903111	6903176
Laboratory Parameters									
pH	8.04	2.83	8.17	3.61	5.14	2.74	2.89	3.08	6.55
Conductivity	174	1240	405	7410	2750	10100	5830	8350	940
Dissolved Anions									
Acidity pH 8.3	1.3	408	<1.0	4370	643	3270	2070	3570	115
Alkalinity Total as CaCO3	59.5	<1.0	201	<1.0	10.6	<1.0	<1.0	<1.0	24.1
Chloride	<0.50	0.57	0.62	<0.50	0.75	<0.50	1.02	1.19	<0.50
Sulphate	23.3	582	25.1	7070	1930	11139	5110	8080	485
Dissolved Metals									
Aluminum	<0.20	7.38	<0.20	45.6	<0.40	19.1	54.6	12.1	<0.20
Antimony	<0.20	<0.20	<0.20	<2.0	<0.40	<2.0	<0.60	<2.0	<0.20
Arsenic	<0.20	<0.20	<0.20	<2.0	<0.40	<2.0	<0.60	<2.0	<0.20
Barium	0.025	0.014	0.034	<0.10	0.021	<0.10	<0.030	<0.10	0.018
Beryllium	<0.0050	<0.0050	<0.0050	<0.050	<0.010	<0.050	<0.015	<0.050	<0.0050
Bismuth	<0.20	<0.20	<0.20	<2.0	<0.40	<2.0	<0.60	<2.0	<0.20
Boron	<0.10	<0.10	<0.10	<1.0	<0.20	<1.0	<0.30	<1.0	<0.10
Cadmium	<0.010	0.025	<0.010	3.21	0.059	1.08	0.823	1.13	0.045
Calcium	27	28.1	52.8	221	232	404	363	455	98.6
Chromium	<0.010	<0.010	<0.010	<0.10	<0.020	<0.10	<0.030	<0.10	<0.010
Cobalt	<0.010	0.345	<0.010	4.65	0.844	9.14	3.34	4.25	0.187
Copper	<0.010	4.75	<0.010	41.3	0.025	11.9	8.64	1.77	<0.010
Iron	<0.030	129	<0.030	1410	166	421	492	860	50
Lead	<0.050	0.436	<0.050	2.49	<0.10	<0.50	0.91	<0.50	<0.050
Lithium	<0.010	0.011	<0.010	<0.10	0.103	0.33	0.2	0.35	0.03
Magnesium	2.33	13.3	14.7	226	131	918	326	675	32.7
Manganese	<0.0050	7.34	0.0084	168	90	924	312	559	21.4
Molybdenum	<0.030	<0.030	<0.030	<0.30	<0.060	<0.30	<0.090	<0.30	<0.030
Nickel	<0.050	0.075	<0.050	2.11	0.65	3.77	1.69	3.34	0.076
Phosphorus	<0.30	<0.30	<0.30	<3.0	<0.60	<3.0	<0.90	<3.0	<0.30
Potassium	<2.0	<2.0	<2.0	<20	7.9	<20	9.5	<20	2.2
Selenium	<0.20	<0.20	<0.20	<2.0	<0.40	<2.0	<0.60	<2.0	<0.20
Silicon	3.92	8.53	5.89	15.7	5.88	13.5	19.7	24	5.08
Silver	<0.010	<0.010	<0.010	<0.10	<0.020	<0.10	<0.030	<0.10	<0.010
Sodium	<2.0	2.1	6	<20	5.1	<20	<6.0	<20	4.9
Strontium	0.087	0.145	0.304	0.258	0.807	1.11	0.946	1.52	0.488
Thallium	<0.20	<0.20	<0.20	<2.0	<0.40	<2.0	<0.60	<2.0	<0.20
Tin	<0.030	<0.030	<0.030	<0.30	<0.060	<0.30	<0.090	<0.30	<0.030
Titanium	<0.010	<0.010	<0.010	<0.10	<0.020	<0.10	<0.030	<0.10	<0.010
Vanadium	<0.030	<0.030	<0.030	<0.30	<0.060	<1.0	<0.30	<1.0	<0.030
Zinc	0.0074	12.1	<0.0050	1530	229	1550	558	1550	48.1

Yr-Sample ID	04VP10	04VP11	04VP12	04VP13	04VP14	04VP15	04VP16
Sample ID	VP10	VP11	VP12	VP13	VP14	VP15	VP16
Source rock type							
	Vangorda Fm Non-calc phyllite	Mt Mye Fm Non-calc phyllite + sx	Mt Mye Fm Non-calc phyllite	Mt Mye Fm Non-calc phyllite	Pyritic quartzite	Pyritic quartzite	Pyritic Quartzite
Date	6/2/2004	6/2/2004	6/2/2004	6/2/2004	6/2/2004	6/2/2004	6/2/2004
Field Parameters							
pH	6.33	3.44	7.18	6.82	7.18	7.1	3.71
Conductivity	809	1465	1372	2080	583	1243	2980
Temp	13.3	11.9	12.6	12	12.6	12.8	15.1
Redox	354	666	431	455	443	458	634
Flow	Trace	90	Trace	Trace	0.25	Trace	0.1
Notes							
Easting (NAD 27)	593847	593924	593906	593975	594094	594083	594100
Northing (NAD 27)	6903325	6903483	6903462	6903479	6903329	6903341	6903312
Laboratory Parameters							
pH	3.67	7.32	8	7.24	7.46	7.4	4.08
Conductivity	1400	773	1330	2020	568	1230	2920
Dissolved Anions							
Acidity pH 8.3	356	17.4	8.4	87.5	35	75	766
Alkalinity Total as CaCO3	<1.0	150	216	14	90	15.5	<1.0
Chloride	<0.50	<0.50	<0.50	1.37	<0.50	<0.50	1.08
Sulphate	797	286	600	1370	212	684	2200
Dissolved Metals							
Aluminum	4	<0.20	<0.20	<0.20	<0.20	<0.20	49.3
Antimony	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Arsenic	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.2
Barium	0.017	0.018	0.015	0.011	0.041	0.011	<0.010
Beryllium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0132
Bismuth	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium	0.322	<0.010	<0.010	<0.010	0.036	0.036	0.284
Calcium	105	129	199	324	70.2	166	298
Chromium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt	0.355	0.05	<0.010	0.113	0.072	0.144	1.41
Copper	1.54	<0.010	<0.010	<0.010	<0.010	<0.010	2.37
Iron	6.14	1.4	<0.030	<0.030	<0.030	<0.030	4.17
Lead	0.685	<0.050	<0.050	<0.050	<0.050	0.101	1.85
Lithium	0.048	<0.010	0.045	0.157	0.01	0.072	0.309
Magnesium	55.6	29	77.2	91.8	21.6	44.5	147
Manganese	16.1	0.698	0.245	31.7	4.13	15	51.9
Molybdenum	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Nickel	0.603	0.125	0.087	0.646	0.183	0.745	2.51
Phosphorus	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium	<2.0	<2.0	2.4	3.1	<2.0	<2.0	4.2
Selenium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silicon	8.99	5.76	2.02	3.14	4.39	3.52	20.9
Silver	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sodium	<2.0	3	2.3	2.4	2.1	2.3	5.2
Strontium	0.447	1.38	1.05	1.18	0.334	0.794	1.23
Thallium	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.2
Tin	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Titanium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Vanadium	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc	180	5.19	2.86	42	19.9	37.7	238

Appendix C

Pit Lake Routine Monitoring Results

Appendix C.1

Faro Pit

X22B, Faro Pit water

Date	pH Field s.u.	pH Lab s.u.	ALK-T mg/L	SO4-D mg/L	SO4-T mg/L	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Al mg/L	Cd mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Ni mg/L	Zn - D mg/L	Zn - T mg/L
21-Jun-96	7.72		123		731	135.2	50.3		27	-0.05	0.012	0.041	0.009	0.18	0.11	4.19	0.155		7.80
17-Jul-96	7.3				686													8.56	
15-Aug-96	7.78		122		678	130.2	46.0		27	0.05	0.012	0.040	0.045	0.15	0.22	3.77	0.111		4.08
12-Sep-96					741	163.8	56.5		43	0.13	0.013	0.049	0.045	0.96	0.03	5.05	0.059		4.01
21-Oct-96	6.50		126		531	128.9	45.1		37	0.05	0.010	0.043	0.047	0.24	-0.02	3.28	0.077		3.33
21-Nov-96	7.51				636	130.3	45.3		40	-0.05	0.006	0.032	0.023	0.16	0.02	3.23	0.094		3.70
19-Dec-96	7.51				679	153.0	52.9		37	0.40	0.006	0.029	0.032	2.33	0.27	3.78	0.108		4.26
20-Jan-97			102		709	144.4	49.0		36	0.40	0.008	0.028	0.019	0.37	-0.02	4.05	0.087		4.20
11-Mar-97					493	138.8	44.6		28	0.93	0.006	0.037	0.161	0.51	0.05	3.33	0.074		1.57
15-Apr-97	7.12				232	58.8	21.8	1.2	4	0.07	0.003	0.009	0.028	0.80	0.10	0.86	0.054		5.82
4-May-97		6.5			72	20.3	5.5	3	3	-0.05	0.002	0.006	0.006	0.03	-0.02	0.40	-0.005	0.81	1.57
12-May-97	7.39				190	53.1	17.9	-1	11	-0.05	0.003	-0.005	0.055	0.04	-0.02	1.23	0.025		1.28
23-Jun-97	7.93				549	140.8	44.1	5	25	-0.05	0.003	0.017	0.081	0.22	-0.02	2.81	0.063		1.85
15-Jul-97	7.7				105	166.5	53.9	13	33	0.24	0.006	0.033	0.107	0.27	0.05	3.58	0.073		2.51
12-Aug-97	7.74				208	135.3	46.5	13	29	0.10	0.007	0.034	0.059	-0.01	-0.02	3.16	0.061		2.85
22-Sep-97	7.53				206	152.6	49.7	12	29	0.10	0.005	0.038	0.113	0.21	-0.02	3.14	0.073		2.70
20-Oct-97	7.68				541	144.0	47.2	11	27	-0.05	0.003	0.024	0.053	0.13	0.04	2.76	0.057		2.25
18-Nov-97	7.5				591	157.9	47.3	15	28	-0.05	0.010	-0.005	0.165	0.50	0.09	3.46	0.065		2.04
8-Dec-97	7.65				548	154.6	47.1	15	28	-0.05	-0.002	-0.005	0.158	0.11	0.09	3.11	0.065		1.95
13-Jan-98	8.33				529	144.6	42.3	9	27	-0.05	-0.002	0.014	0.152	0.13	0.07	2.73	0.055		1.11
18-May-98	7.68				195	25.8	8.2	2	7	0.11	-0.002	-0.005	0.038	-0.01	0.03	0.38	0.015		1.58
16-Jun-98	7.49		111		345	153.1	45.6	12	27	0.42	0.008	0.021	0.137	1.18	0.04	2.58	0.052		2.85
20-Jun-98						139.7	44.4	13	28	0.12	0.003	0.020	0.107	0.12	-0.02	2.37	0.050		2.11
21-Jul-98	7.31				202	164.9	54.0	14	31	0.12	0.007	0.037	0.108	0.09	-0.02	2.72	0.071		2.67
10-Aug-98	7.23				342	168.9	52.7	14	31	0.25	0.007	0.022	0.111	0.12	0.05	2.88	0.062	0.83	2.51
25-Sep-98		8.03			623	172.4	55.1	14	33	0.17	0.003	0.029	0.082	0.06	-0.02	2.87	0.064		2.46
19-Oct-98	7.15			494	693	163.1	53.6	15	34	0.29	-0.002	0.032	0.075	0.27	0.04	2.74	0.067	1.02	2.16
17-Nov-98	7.25				614	194.9	60.1	19	35	0.19	0.008	0.025	0.099	0.20	0.02	2.78	0.061		2.20
19-Jan-99	6.87				574	119.7	58.4	7	16	0.13	0.030	0.013	0.050	0.08	0.08	1.42	0.090	9.79	16.95
22-Feb-99	7.42				692	188.0	60.7	15	34	0.41	0.010	0.035	0.066	0.02	-0.01	2.95	0.062	0.65	3.92
22-Mar-99		7.11			546	130.7	50.8	9	20	0.30	0.025	0.037	0.062	0.17	0.04	2.80	0.056	8.35	14.98
17-May-99	6.91				190	19.3	7.4	2	3	-0.05	-0.001	-0.005	0.020	0.03	-0.01	0.31	0.020	0.52	2.56
3-Jul-99	7.26				478	125.2	46.1	11	20	0.37	0.009	0.042	0.040	0.95	-0.01	2.55	0.073	5.67	8.50
27-Jul-99	7.74			571	581	120.5	46.6	10	19	0.25	0.005	0.051	0.033	0.24	0.05	2.52	0.069	2.28	5.56
12-Aug-99	7.72				567	155.2	50.1	12	27	-0.05	-0.001	0.048	0.018	0.11	-0.01	2.26	0.041	1.03	4.19
10-Sep-99	7.58		98		507	123.3	42.6	10	19	0.20	0.008	0.019	0.027	0.13	-0.01	2.25	0.060	0.54	4.11
30-Oct-99	6.85				638	131.0	43.8	6	25	0.12	-0.001	-0.005	0.013	0.29	-0.01	2.56	0.039	2.26	4.31

Date	pH Field s.u.	pH Lab s.u.	ALK-T mg/L	SO4-D mg/L	SO4-T mg/L	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Al mg/L	Cd mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Ni mg/L	Zn - D mg/L	Zn - T mg/L
23-Mar-00		7.96	105		548	151.0	53.6	15	20	0.36	0.008	0.069	0.018	0.07	-0.01	2.72	0.059	2.58	7.49
15-May-00	7.29				620	153.8	54.6	12	23	0.52	0.010	0.041	0.026	0.79	0.04	2.53	0.058	1.17	5.51
26-Jun-00	7.58				457	136.3	48.4	12	22	0.26	0.008	0.042	0.037	0.16	-0.01	2.36	0.081	1.34	7.64
25-Jul-00	6.93				536	130.8	47.2	11	25	0.13	0.017	0.062	0.033	0.55	-0.01	2.40	0.101	0.54	8.09
29-Aug-00	7.37				545	153.3	53.7	13	25	0.31	0.016	0.039	0.030	0.28	-0.01	2.47	0.102	7.06	8.56
25-Sep-00	7.47				597	142	53.9	10	24	0.09	0.009	0.04	-0.01	0.2	-0.05	2.51	0.07	9.09	9.02
29-Oct-00					779	135.6	50.6	12	28	0.42	0.016	0.031	0.051	0.43	-0.01	2.69	0.071	1.87	9.83
13-Nov-00	7.4				620	152.3	56.9	13	29	0.06	0.012	0.051	0.008	0.12	0.01	3.63	0.089	10.75	11.29
18-Nov-00					1735	540	229	42	98	0.1	0.055	0.16	0.09	0.15	-0.05	9.84	0.3	44.7	46.5
14-Dec-00	7.02				572	134	61.9	7	15	-0.05	0.027	0.04	0.04	0.05	-0.05	2.21	0.10	26.2	26.2
13-Jan-01		7.03			404	127.0	52.8	10	21	0.14	0.025	-0.005	0.057	0.30	0.10	2.32	0.088	17.40	17.70
10-Feb-01		7.03			396	124.9	48.8	9	21	0.16	0.006	-0.005	0.030	0.07	0.05	2.32	0.138	14.40	14.50
10-Mar-01	7.3				598	130	53.25	1.15	22.76	0.47	0.014	-0.005	0.03	0.06	-0.01	2.71	0.072	16	16
16-Apr-01	7.9				526	146.4	55.3	-1	23	-0.05	0.009	-0.005	0.023	0.09	-0.01	3.36	0.079	6.07	12.17
14-May-01	7.9				532	146.2	50.4	9	22	0.30	0.011	0.015	0.022	0.56	-0.01	2.31	0.074	6.35	8.42
17-Jun-01	7.8				565	152.6	56.0	11	26	0.12	0.014	0.046	0.022	0.18	-0.01	1.92	0.096	2.91	11.60
14-Jul-01	7.6				569	150.7	56.1	11	24	0.12	0.011	0.048	0.014	0.38	-0.01	3.25	0.102	3.39	13.18
14-Aug-01	7.6				582	160.8	67.3	10	25	0.10	0.013	0.053	0.014	0.10	-0.01	3.19	0.119	4.22	16.53
17-Sep-01	7.6				546	125.6	52.5	9	25	0.06	0.012	0.045	0.009	0.04	0.01	3.14	0.091	7.67	12.21
15-Oct-01	7.6				586	141.2	55.1	12	23	-0.05	0.010	0.043	0.010	-0.01	-0.01	3.31	0.091	11.58	11.89
13-Nov-01	7.4				620	152.3	56.9	13	29	0.06	0.012	0.051	0.008	0.12	0.01	3.63	0.089	10.75	11.29
15-Dec-01	7.5				534	156.1	60.7	10	22	-0.05	0.01	0.057	0.015	0.06	0.01	3.02	0.085	11.2	11.93
15-Jan-02					640	153.0	62.9	15	28	0.06	0.011	0.049	0.012	0.05	-0.01	2.93	0.085	11.50	12.14
12-Feb-02					562	154.7	62.4	13	28	-0.05	0.012	0.045	0.021	0.02	0.03	2.77	0.084	13.40	12.81
12-Mar-02					597	149.2	60.8	13	25	-0.05	0.012	0.044	0.026	0.05	-0.01	2.67	0.086	15.90	14.06
15-Apr-02	7.7				600	145.8	56.7	14	25	-0.05	0.007	0.044	0.012	-0.01	-0.01	2.57	0.080	12.99	12.21
13-May-02					606	149.5	57.6	12	25	0.15	0.012	0.042	0.012	0.45	0.04	2.57	0.078	12.05	11.22
16-Jun-02				575	575	157.5	56.5	11.3	23.8	0.095	9.5	0.045	0.027	0.097	0.011	2.693	0.081	13.084	12.659
16-Jul-02				591	591	147.9	54.9	10.4	20.0	0.079	15.7	0.047	0.029	0.068	0.006	2.442	0.082	12.784	11.924
12-Aug-02				578	578	145.4	53.4	11.0	24.6	0.058	11.2	0.044	0.013	0.055	0.012	2.479	0.087	12.550	12.273
16-Sep-02				598	598	154.5	60.8	13.6	23.4	0.040	12.2	0.049	0.021	0.179	0.003	2.749	0.087	13.312	13.202
15-Oct-02				617	617	148.5	59.4	13.1	24.5	0.067	11.3	0.046	0.024	0.112	-0.002	2.730	0.082	13.043	11.892
12-Nov-02	7.7			627	627	160.0	61.7	14.6	27.2	0.055	11.1	0.049	0.028	0.146	-0.002	2.984	0.085	11.942	11.994
10-Dec-02	7.7			621	621	151.1	61.8	14.2	24.3	0.036	11.9	0.045	0.033	0.075	0.017	2.764	0.090	13.011	13.364

Date	pH Field s.u.	pH Lab s.u.	ALK-T mg/L	SO4-D mg/L	SO4-T mg/L	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Al mg/L	Cd mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Ni mg/L	Zn - D mg/L	Zn - T mg/L
14-Jan-03	7.50			616		144.2	64.7	11.5	22.6	0.069	0.0179	0.041	0.050	0.065	-0.002	2.379	0.098	20.603	20.288
15-Feb-03	7.5			622		144.2	60.1	11.4	21.6	0.047	0.0168	0.043	0.035	0.047	0.008	2.437	0.095	18.082	17.692
15-Mar-03	7.5			501		122.9	62.6	8.2	15.9	0.077	0.0292	0.045	0.056	0.042	0.004	2.161	0.099	28.380	28.520
15-Apr-03	7.5			465		108.9	52.0	6.8	13.9	0.121	0.021	0.035	0.031	0.087	0.008	1.754	0.109	22.220	21.585
13-May-03	7.8			132		34	13.4	1.9	3.5	0.109	0.0062	0.009	0.007	0.058	0.013	0.465	0.023	6.057	6.273
14-Jun-03	7.4			647		160.2	60.2	14.9	24.6	0.007	0.0109	0.047	0.029	0.139	0.019	2.807	0.090	11.372	11.980
14-Jul-03				657		159.6	60.1	14.3	23.1	0.022	0.0115	0.043	0.020	0.103	0.007	2.717	0.086	10.441	10.379
11-Aug-03	7.6			574		144.5	56.6	11.7	19.6	0.024	0.0127	0.046	0.029	0.226	-0.002	2.508	0.085	10.746	10.873
8-Sep-03	7.7			588		147.2	60.5	12.1	20.1	0.06	0.0115	0.046	0.056	0.265	-0.002	2.617	0.084	10.238	13.751
14-Oct-03	7.3			606		156.9	58.6	12.8	20.7	0.042	0.0105	0.044	0.021	0.286	0.004	2.605	0.082	10.07	9.919
15-Nov-03	7.1			597		159.8	62.5	14.5	24	0.006	0.0101	0.045	0.014	0.044	0.004	2.79	0.083	7.985	8.139
15-Dec-03	7.3			564		157.7	58.8	14.0	23.2	0.004	0.0106	0.042	0.014	0.060	0.005	2.690	0.088	8.838	9.228
12-Jan-04				557		157.3	62.6	12.3	21.5	0.021	0.0135	0.047	0.060	0.085	-0.002	2.615	0.080	12.057	12.052
16-Feb-04	6.7			470		111.2	51.7	7.9	13.2	0.025	0.0166	0.039	0.100	0.038	0.003	1.693	0.069	14.473	13.686
15-Mar-04	6.9			500		121	56.3	6	14.5	0.032	0.021	0.039	0.094	0.02	-0.001	2.28	0.085	18.1	19.8
14-Apr-04	6.7			500		121	52.9	6.0	15.3	0.06	0.02	0.03	0.05	0.13	-0.03	1.97	0.08	14.3	16
14-May-04	7.2		60	146		36.7	14.2	2.4	5.06	0.017	0.0042	0.011	0.005	-0.05	0.008	0.62	0.028	4.18	4.71
14-Jun-04	7.0			506		126	55.3	8.6	21.2	0.03	0.0082	0.035	0.014	0.16	0.002	2.19	0.084	7.74	10.6
12-Jul-04	7.7			559		135	50.1	9	17.8	0.008	0.0086	0.039	0.008	0.18	0.001	2.47	0.092	9.55	11.7
9-Aug-04	7.6			611		137	54.4	8.7	19.6	0.006	0.01	0.04	0.007	0.13	-0.001	2.47	0.092	8.78	10.6
13-Sep-04	7.1			946		133	57.2	8.3	20.4	0.006	0.0093	0.045	0.009	0.41	0.004	2.5	0.1	12	12.9
2004 Avg.	7.1		60	533		120	51	7.7	17	0.023	0.012	0.036	0.039	0.12	-0.002	2.1	0.079	11	12

Notes:

metals are total metal values unless indicated otherwise

Appendix C.2

Grum Pit

V23, Grum Pit Water

Date	pH Field s.u.	pH Lab s.u.	ALK-T mg/L	SO4-D mg/L	SO4-T mg/L	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Al mg/L	Cd mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Ni mg/L	Zn mg/L
14-Jan-97			158		87	75.3	38.2		15	0.17	-0.002	0.007	0.008	0.07	-0.02	0.07	0.177	0.01
26-May-97					51	49.4	23.8	-1	8	0.05	0.011	-0.005	-0.002	0.2	0.03	0.31	0.192	7.79
22-Jul-97	8.3		24		49	61.1	31.4	4	13	0.15	-0.002	0.042	0.021	0.11	-0.02	0.05	0.188	2.53
14-Sep-98	7.65				201	78.0	45.8	4	15	0.16	-0.002	0.026	0.024	0.09	0.04	0.10	0.134	1.03
10-Sep-99	7.64		190		266	82.4	46.0	4	12	0.22	0.010	0.057	0.017	0.18	-0.01	0.37	0.177	3.42
12-Oct-99	7.12		190		344	73.8	41.7	4	11	0.16	0.019	0.044	0.029	0.14	0.04	0.46	0.174	5.91
22-Mar-00		7.55	216		292	101.4	56.1	8	7	0.39	0.018	0.114	0.013	0.08	-0.01	0.66	0.176	7.19
20-Jun-00			59		192	63.7	22.5	5	9	0.46	-0.001	-0.005	0.013	0.43	-0.01	0.02	0.013	0.02
26-Jun-00	7.71		161		335	91.2	49.6	5	10	0.23	0.029	0.073	0.021	0.16	-0.01	0.59	0.221	5.92
12-Sep-00	7.63		249		488	112.2	60.1	2	14	0.29	0.049	0.076	0.051	0.18	-0.01	0.86	0.275	11.94
5-Mar-01	8.1				154	93	41	-1	9	0.327	-0.001	-0.005	-0.002	0.050	-0.01	0.07	-0.005	-0.01
13-Jun-01	7.9		141		435	105.0	64.3	3	12	0.24	0.030	0.091	0.014	0.49	-0.01	1.73	0.181	13.80
8-Sep-01	7.9		148		456	119.9	66.4	4	12	0.11	0.025	0.079	0.006	0.14	-0.01	1.01	0.263	12.27
21-Mar-02			236		133	89.0	30.4	4	13	0.06	0.002	0.010	-0.002	0.02	-0.01	0.18	0.042	1.81
25-Jun-02			123	419	419	107.1	60.2	3.5	10.5	0.128	0.0142	0.053	0.030	0.069	0.004	0.630	0.191	7.822
27-Sep-02	7.9		136	459	459	122.7	67.6	4.3	11.9	0.065	0.0155	0.051	0.020	0.077	0.002	0.577	0.179	5.923
14-Jan-03	7.8		270	313		136.5	57.9	5.2	15.9	0.064	0.0087	0.030	0.013	0.033	-0.002	0.373	0.121	6.198
6-Mar-03	7.8		168	537		144.9	85.8	6.1	16.8	0.070	0.0214	0.066	0.015	0.093	0.007	0.786	0.264	10.043
17-Jun-03			130	427		121.7	66.7	4.2	10.2	0.023	0.0104	0.040	0.069	0.229	0.003	0.636	0.186	3.654
15-Sep-03	7.9		147	425		122.7	66	4.3	9.9	0.051	0.0104	0.038	0.012	0.128	0.004	0.509	0.17	5.507
13-Dec-03	7.6		178	450		137.3	65.7	5.1	13.1	0.018	0.0111	0.035	0.010	0.036	0.007	0.560	0.183	8.216
14-Mar-04	7.6		175	411		133.9	69.7	4.5	10.9	0.026	0.0106	0.034	0.009	0.006	-0.002	0.555	0.205	8.495
7-Sep-04				422		106	62	3.17	10.4	0.11	0.0021	0.016	0.0029	0.22	0.0038	0.22	0.127	2
2003/2004 Avg.	7.7		178	427		133	69	4.9	13	0.042	0.012	0.041	0.021	0.088	0.0028	0.57	0.19	7.0

Notes: * excludes the September 2004 data which was likely influenced by the biological treatment studies.
metals are total metal values unless indicated otherwise

Appendix C.3

Vangorda Pit

V22 - Vangorda pit water

Date	pH Field s.u.	pH Lab s.u.	ALK-T mg/L	SO4-D mg/L	SO4-T mg/L	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Al mg/L	Cd mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Ni mg/L	Zn mg/L
13-Jan-98	7.42				417	144.8	43.9	8	14	0.19	-0.002	0.065	0.020	2.78	0.40	2.79	0.048	4.88
14-Sep-98		7.83			872	217.9	79.0	4	10	0.17	0.099	0.467	0.032	0.20	0.24	19.37	0.487	42.75
18-Jun-99	7.48				247	68.7	25.8	3	5	0.54	0.017	0.052	0.095	1.15	0.04	3.13	0.110	11.21
10-Sep-99	7.43		66		513	119.6	45.4	3	5	0.19	0.058	0.216	0.022	0.28	0.13	9.94	0.261	22.59
12-Oct-99	6.48		85		635	135.9	52.1	4	6	0.23	0.061	0.199	0.034	0.39	0.17	10.77	0.278	37.36
22-Mar-00		6.80	118		589	163.4	59.1	4	9	0.53	0.044	0.273	0.017	0.09	0.05	14.53	0.234	43.76
20-Jun-00			62		107	40.8	13.6	2	3	0.82	0.016	0.011	0.069	1.26	0.03	1.02	0.056	4.62
12-Sep-00	7.1		184		357	92.5	30.5	-1	5	0.26	0.047	0.143	0.030	0.42	0.11	6.21	0.175	21.84
5-Mar-01	7.0				177	112	52	-1	10	0.461	-0.001	-0.005	0.003	0.095	-0.01	-0.01	-0.005	-0.01
13-Jun-01	7.5		45		430	90.8	38.5	2	4	0.22	0.056	0.258	0.028	0.70	0.02	13.65	0.172	45.90
8-Sep-01	7.4		17		591	116.6	49.3	3	4	0.07	0.086	0.381	0.018	2.02	0.16	21.80	0.349	78.29
21-Mar-02			31		734	142.0	59.4	4	6	-0.05	0.101	0.446	0.003	0.08	-0.01	19.57	0.348	74.09
25-Jun-02			30	798	798	165.6	59.9	3.0	5.6	0.091	0.1099	0.475	0.018	0.566	0.014	19.965	0.345	86.758
27-Sep-02	7.1		43	862	862	176.4	67.0	3.8	6.1	0.040	0.0988	0.494	0.059	0.107	0.020	22.259	0.397	106.1
15-Dec-02	7.2			869	869	189.4	72.7	4.1	6.6	0.035	0.0997	0.510	0.047	1.006	0.014	23.433	0.426	81.243
6-Mar-03	7.4		71	808		178.7	71.6	4.9	10.1	0.029	0.0922	0.456	0.029	0.116	0.004	20.418	0.406	73.314
17-Jun-03			37	635		145.9	52.3	3.0	3.5	-0.001	0.0720	0.358	0.095	0.334	0.017	16.509	0.325	51.333
15-Sep-03	6.9		46	1041		261.7	82.8	4.7	6.1	0.019	0.0941	0.664	0.049	1.546	0.004	29.179	0.449	72.472
13-Dec-03	6.6		59	1088		234.6	81.8	5.7	8.6	0.015	0.0619	0.461	0.049	1.155	0.011	24.332	0.384	57.246
14-Mar-04	6.7		127	626		192.4	63.3	4.2	7.4	0.021	0.0348	0.182	0.015	0.406	0.002	9.256	0.226	48.557
7-Sep-04				1090		233	82.5	3.36	5.28	0.08	0.0561	0.497	0.033	1.28	0.021	31.1	0.465	92.2
2003/2004 Avg.	6.9		68	881		208	72.4	4.3	6.8	0.027	0.069	0.44	0.045	0.81	0.0098	22	0.38	66

Notes: values shown in red were divided by 1000, due to a likely unit error in the database
metals are total metal values unless indicated otherwise

Appendix D

Pit Lake Vertical Profiling Results

Appendix D.1

Faro Pit

Pit Lake	Date Sampled	Depth	Sample ID	Field Cond.	Field Water Temperature	Field pH	Field Dissolved Oxygen	Field ORP	Field TDS	Lab Cond.	Hardness	pH	TDS	TSS	Alkalinity Total	Acidity (to pH 8.3)	Chloride - Cl	Sulphate - SO4	Ammonia Nitrogen - N	Nitrate Nitrogen N	Nitrite Nitrogen N	Total Phosphate P	Total Cyanide CN	Chlorophyll a (a)
	mm/dd/yyyy	m		µS/cm	ºC		mg/L - Faro & Grum % Saturation - Vangorda	mV	mg/L	µS/cm	CaCO3 mg/l		mg/L	mg/L	CaCO3 mg/l	CaCO3 mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Faro	8/9/2003	0	FP1	1113	12.37	7.42	9.68	52.8	0.35															
	8/9/2003	2.5	FP1	1111	12.33	7.31	9.5	51.8	0.72															
	8/9/2003	5	FP1-5	1114	12.2	7.18	8.45	60.6	0.71	1070	570	7.6			98	39		486	0.93					
	8/9/2003	7.5	FP1	1237	6.35	7.16	8.22	61.5	0.8															
	8/9/2003	10	FP1-10	1244	5.27	7.15	7.56	43	0.8	1200	644	7.84			108	27		707	1.25					
	8/9/2003	10	FP1-10R							1210	625	7.38			103	23		663	1.12					
	8/9/2003	12.5	FP1	1255	4.81	7.13	5.33	16.3	0.81															
	8/9/2003	15	FP1-15	1281	4.67	7.14	1.42	-16	0.82	1240	640	7.52			108	25		694	1.28					
	8/9/2003	17.5	FP1	1360	4.3	7.27	0.15	-55	0.8															
	8/9/2003	20	FP1	1388	4.2	7.32	0.14	-61.3	0.89															
	8/9/2003	25	FP1	1404	4.06	7.36	0.15	-63	0.91															
	8/9/2003	30	FP1	1417	4.07	7.39	0.16	-64	0.92															
	8/9/2003	35	FP1	1423	4.07	7.39	0.18	-63	0.92															
	8/9/2003	40	FP1	1426	4.08	7.42	0.18	-63.7	0.92															
	8/9/2003	45	FP1	1430	4.11	7.48	0.21	-64.5	0.92															
	8/9/2003	58	FP1-58	1486	*5.18	7.86	6.65*	-119	0.97	1370	726	7.17			96	42		793	1.45					
	8/9/2003	0	FP2-S	1119	12.4	7.4	10.3	-45.5	0.72	1070	554	7.89			97	18		606	0.89					
	8/9/2003	2.5	FP2	1118	12.3	7.5	9.8	-26	0.72															
	8/9/2003	5	FP2	1120	12.1	7.5	9.7	-11	0.72															
	8/9/2003	7.5	FP2	1244	6.3	7.6	10.07	15.5	0.82															
	8/9/2003	10	FP2-10	1251	5.4	7.6	9.2	35.6	0.81	1200	636	7.86			97	26		655	1.13					
	8/9/2003	12.5	FP2	1257	5.13	7.6	8.67	50	0.82															
	8/9/2003	15	FP2	1277	4.65	7.6	7.97	55.5	0.84															
	8/9/2003	17.5	FP2	1362	4.25	7.6	4.32	-37.5	0.88															
	8/9/2003	20	FP2	1381	4.13	7.6	2.07	-50	0.9															
	8/9/2003	25	FP2-25	1404	4.05	7.5	0.91	-51.3	0.92	1330	684	7.36			100	35		775	1.6					
	8/9/2003	30	FP2	1422	4.07	7.5	0.49	-58	0.93															
	8/9/2003	35	FP2	1426	4.08	7.4	0.35	-58	0.93															
	8/9/2003	40	FP2	1429	4.09	7.35	0.28	-58.6	0.93															
	8/9/2003	45	FP2	1432	4.11	7.3	0.24	-59	0.93															
	8/9/2003	60	FP2-60	1563	*5.29	7.5	*5.2	-135	1.02	1390	719	6.87			100	65		793	1.4					
	6/30/2004	1	FARO-1										874	3	105		1.07	524	0.934	0.206	0.0055	0.0068		
	6/30/2004	5	FARO-5										892	<3.0	99.9		1.08	528	1.06	0.184	0.0059	0.005	0.0528	
	6/30/2004	10	FARO-10										982	<3.0	103		1.21	582	1.14	0.151	0.0058	0.004	0.0706	
	6/30/2004	15	FARO-15										983	<3.0	100		1.22	593	1.22	0.158	0.0053	0.0062		
	6/30/2004	20	FARO-20										1050	7.5	98.8		1.35	643	1.29	0.0344	0.0037	0.0046		
	6/30/2004	25	FARO-25										1110	6.5	98.2		1.41	668	1.39	<0.0050	0.0019	0.0051		
	6/30/2004	30	FARO-30										1120	11	94.5		1.41	677	1.46	<0.0050	0.0013	0.0047	0.136	
	6/30/2004	40	FARO-40										1120	12.5	95.8		1.42	689	1.46	<0.0050	0.0023	0.0049	0.145	

Pit Lake	Date Sampled	Depth	Sample ID	T-Al	T-Sb	T-As	T-Ba	T-Be	T-Bi	T-B	T-Cd	T-Ca	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Li	T-Mg	T-Mn	T-Hg	T-Mo	T-Ni	T-P	T-K	T-Se	T-Si	T-Ag	T-Na	T-Sr	T-Tl	T-Sn	T-Ti	T-U	T-V	T-Zn
	mm/dd/yyyy	m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Faro	8/9/2003	0	FP1																																	
	8/9/2003	2.5	FP1																																	
	8/9/2003	5	FP1-5	<0.03	0.004	<0.003	0.02	<0.005		<0.1	0.0129	133	<0.005	0.041	0.008	0.04	<0.003	0.05	57.9	2.24	<0.00005	<0.005	0.092		9	<0.005		<0.0001	21		<0.001	<0.003	<0.01	0.003	<0.03	11
	8/9/2003	7.5	FP1																																	
	8/9/2003	10	FP1-10	0.04	0.004	<0.003	<0.02	<0.005		<0.1	0.0111	156	<0.005	0.045	0.008	0.04	<0.003	0.05	63.5	2.62	<0.00005	<0.005	0.095		11	<0.005		<0.0001	26		<0.001	<0.003	<0.01	0.003	<0.03	10.3
	8/9/2003	10	FP1-10R	<0.03	0.004	<0.003	<0.02	<0.005		<0.1	0.0115	152	<0.005	0.045	0.008	0.04	<0.003	0.05	62.4	2.63	<0.00005	0.005	0.096		12	<0.005		<0.0001	26		<0.001	<0.003	<0.01	0.003	<0.03	10.3
	8/9/2003	12.5	FP1																																	
	8/9/2003	15	FP1-15	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	0.0087	163	<0.005	0.043	0.007	0.15	<0.003	0.06	63.9	2.75	<0.00005	<0.005	0.09		13	<0.005		<0.0001	28		<0.001	<0.003	<0.01	0.003	<0.03	8.39
	8/9/2003	17.5	FP1																																	
	8/9/2003	20	FP1																																	
	8/9/2003	25	FP1																																	
	8/9/2003	30	FP1																																	
	8/9/2003	35	FP1																																	
	8/9/2003	40	FP1																																	
	8/9/2003	45	FP1																																	
	8/9/2003	58	FP1-58	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	<0.0003	180	<0.005	0.031	<0.005	20.4	0.003	0.06	63.7	3.38	<0.00005	0.005	0.06		15	<0.005		<0.0001	34		<0.001	<0.003	<0.01	0.003	<0.03	1.42
	8/9/2003	0	FP2-S	<0.03	0.003	<0.003	<0.02	<0.005		<0.1	0.0129	133	<0.005	0.041	0.008	0.05	<0.003	0.05	57.8	2.23	<0.00005	<0.005	0.093		9	<0.005		<0.0001	21		<0.001	<0.003	<0.01	0.003	<0.03	11
	8/9/2003	2.5	FP2																																	
	8/9/2003	5	FP2																																	
	8/9/2003	7.5	FP2																																	
	8/9/2003	10	FP2-10	<0.03	0.004	<0.003	<0.02	<0.005		<0.1	0.0111	157	<0.005	0.044	0.008	0.06	<0.003	0.05	64.2	2.58	<0.00005	<0.005	0.094		12	<0.005		<0.0001	26		<0.001	<0.003	<0.01	0.003	<0.03	10.2
	8/9/2003	12.5	FP2																																	
	8/9/2003	15	FP2																																	
	8/9/2003	17.5	FP2																																	
	8/9/2003	20	FP2																																	
	8/9/2003	25	FP2-25	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	0.0003	178	<0.005	0.034	<0.005	11.8	<0.003	0.06	63.9	3.27	<0.00005	0.005	0.073		15	<0.005		<0.0001	33		<0.001	<0.003	<0.01	0.003	<0.03	3.04
	8/9/2003	30	FP2																																	
	8/9/2003	35	FP2																																	
	8/9/2003	40	FP2																																	
	8/9/2003	45	FP2																																	
	8/9/2003	60	FP2-60	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	<0.0003	185	<0.005	0.032	<0.005	21.8	<0.003	0.06	65.8	3.38	<0.00005	0.005	0.062		15	<0.005		<0.0001	35		<0.001	<0.003	<0.01	0.003	<0.03	1.4
	6/30/2004	1	FARO-1	0.771	0.002	<0.00050	0.0155	<0.0025	<0.0025	<0.050	0.0111	134	<0.0025	0.0412	0.00975	0.174	0.00156	0.057	57.5	2.66		0.00303	0.095	<0.30	8.9	<0.0050	3.21	<0.000050	22.3	0.51	0.00068	<0.00050	<0.010	0.00308	<0.0050	11.4
	6/30/2004	5	FARO-5	0.007	0.00201	<0.00050	0.0157	<0.0025	<0.0025	<0.050	0.0109	141	<0.0025	0.0399	0.00958	0.202	0.00138	0.052	60.7	2.62		0.00301	0.0915	<0.30	9.4	<0.0050	3.4	<0.000050	23.2	0.5	0.00064	<0.00050	<0.010	0.00295	<0.0050	11.1
	6/30/2004	10	FARO-10	0.0132	0.00215	<0.00050	0.0152	<0.0025	<0.0025	<0.050	0.0116	155	<0.0025	0.041	0.0144	0.094	0.001	0.054	64.6	2.78		0.00324	0.0889	<0.30	11.7	<0.0050	3.51	<0.000050	25.9	0.498	0.00072	<0.00050	<0.010	0.00278	<0.0050	11.6
	6/30/2004	15	FARO-15	0.0188	0.00206	<0.00050	0.0152	<0.0025	<0.0025	<0.050	0.0125	150	<0.0025	0.0444	0.0175	0.362	0.00142	0.056	63.6	2.94		0.00328	0.0924	<0.30	12.1	<0.0050	3.4	<0.000050	26.1	0.513	0.00072	<0.00050	<0.010	0.00266	<0.0050	12.7
	6/30/2004	20	FARO-20	0.0131	0.00076	0.00028	0.014	<0.0010	<0.0010	<0.020	0.00482	167	<0.0010	0.0352	0.016	6.54	0.00114	0.064	62.9	3.51		0.0033	0.074	<0.30	13.1	<0.0020	2.88	<0.000020	31.5	0.533	0.00037	<0.00020	<0.010	0.00242	<0.0020	6.28
	6/30/2004	25	FARO-25	0.0125	<0.00050	0.00055	0.013	<0.0025	<0.0025	<0.050	0.00053	164	<0.0025	0.0337	0.0191	14.6	0.0008	0.071	60.1	3.94		0.00476	0.0729	<0.30	13.2	<0.0050	2.63	<0.000050	31.7	0.574	<0.00050	<0.00050	<0.010	0.00272	<0.0050	2.88
	6/30/2004	30	FARO-30	0.0189	<0.00050	0.00108	0.0134	<0.0025	<0.0025	<0.050	0.00027	178	<0.0025	0.0341	0.00783	18.3	0.00086	0.073	64.7	4.08		0.00473	0.0686	<0.30	14.3	<0.0050	2.83	<0.000050	34.5	0.604	<0.00050	<0.00050	<0.010	0.00305	<0.0050	2.44
	6/30/2004	40	FARO-40	0.0171	<0.00050	0.00153	0.0171	<0.0025	<0.0025	<0.050	0.00025	179	<0.0025	0.0321	0.0029	20.1	0.00078	0.072	64.6	3.98		0.00366	0.0662	<0.30	15.1	<0.0050	2.82	<0.000050	34.1	0.597	<0.00050	<0.00050	<0.010	0.00318	<0.0050	2.33

Pit Lake	Date Sampled	Depth	Sample ID	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn
	mm/dd/yyyy	m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Faro	8/9/2003	0	FP1																																	
	8/9/2003	2.5	FP1																																	
	8/9/2003	5	FP1-5	<0.03	0.004	<0.003	<0.02	<0.005		<0.1	0.0125	133	<0.005	0.04	0.007	<0.03	<0.003	0.05	57.7	2.22	<0.00005	<0.005	0.09		10	<0.005		<0.0001	21		<0.001	<0.003	<0.01	0.003	<0.03	10.7
	8/9/2003	7.5	FP1																																	
	8/9/2003	10	FP1-10	<0.03	0.004	<0.003	<0.02	<0.005		<0.1	0.0114	154	<0.005	0.045	0.007	<0.03	<0.003	0.06	62.6	2.68	<0.00005	0.005	0.095		11	<0.005		<0.0001	25		0.001	<0.003	<0.01	0.003	<0.03	10.4
	8/9/2003	10	FP1-10R	<0.03	0.004	<0.003	0.02	<0.005		<0.1	0.011	149	<0.005	0.044	0.006	<0.03	<0.003	0.05	61.7	2.58	<0.00005	0.005	0.092		11	<0.005		<0.0001	26		<0.001	<0.003	<0.01	0.003	<0.03	10.1
	8/9/2003	12.5	FP1																																	
	8/9/2003	15	FP1-15	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	0.0089	155	<0.005	0.044	0.005	<0.03	<0.003	0.06	61.3	2.83	<0.00005	<0.005	0.093		12	<0.005		<0.0001	27		<0.001	<0.003	<0.01	0.003	<0.03	8.53
	8/9/2003	17.5	FP1																																	
	8/9/2003	20	FP1																																	
	8/9/2003	25	FP1																																	
	8/9/2003	30	FP1																																	
	8/9/2003	35	FP1																																	
	8/9/2003	40	FP1																																	
	8/9/2003	45	FP1																																	
	8/9/2003	58	FP1-58	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	<0.0003	183	<0.005	0.033	<0.005	20.5	<0.003	0.07	65.1	3.59	<0.00005	0.006	0.064		15	<0.005		<0.0001	34		<0.001	<0.003	<0.01	0.004	<0.03	1.49
	8/9/2003	0	FP2-S	<0.03	0.003	<0.003	<0.02	<0.005		<0.1	0.0126	130	<0.005	0.041	0.007	<0.03	<0.003	0.05	56	2.25	<0.00005	<0.005	0.091		10	<0.005		<0.0001	21		<0.001	<0.003	<0.01	0.003	<0.03	10.9
	8/9/2003	2.5	FP2																																	
	8/9/2003	5	FP2																																	
	8/9/2003	7.5	FP2																																	
	8/9/2003	10	FP2-10	<0.03	0.004	<0.003	0.02	<0.005		<0.1	0.0109	152	<0.005	0.044	0.006	<0.03	<0.003	0.05	62.3	2.55	<0.00005	<0.005	0.093		10	<0.005		<0.0001	26		<0.001	<0.003	<0.01	0.003	<0.03	9.97
	8/9/2003	12.5	FP2																																	
	8/9/2003	15	FP2																																	
	8/9/2003	17.5	FP2																																	
	8/9/2003	20	FP2																																	
	8/9/2003	25	FP2-25	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	<0.0003	171	<0.005	0.034	<0.005	11.1	<0.003	0.06	62.2	3.26	<0.00005	0.005	0.072		15	<0.005		<0.0001	33		<0.001	<0.003	<0.01	0.003	<0.03	3.02
	8/9/2003	30	FP2																																	
	8/9/2003	35	FP2																																	
	8/9/2003	40	FP2																																	
	8/9/2003	45	FP2																																	
	8/9/2003	60	FP2-60	<0.03	<0.003	<0.003	<0.02	<0.005		<0.1	<0.0003	181	<0.005	0.033	<0.005	21.2	<0.003	0.07	64.5	3.47	<0.00005	0.006	0.063		15	<0.005		<0.0001	34		<0.001	<0.003	<0.01	0.003	<0.03	1.35
	6/30/2004	1	FARO-1																																	
	6/30/2004	5	FARO-5																																	
	6/30/2004	10	FARO-10																																	
	6/30/2004	15	FARO-15																																	
	6/30/2004	20	FARO-20																																	
	6/30/2004	25	FARO-25																																	
	6/30/2004	30	FARO-30																																	
	6/30/2004	40	FARO-40																																	

Appendix D.2

Grum Pit

Pit Lake	Date Sampled	Depth	Sample ID	Field Cond.	Field Water Temperature	Field pH	Field Dissolved Oxygen	Field ORP	Field TDS	Lab Cond.	Hardness	pH	TDS	TSS	Alkalinity Total	Acidity (to pH 8.3)	Chloride - Cl	Sulphate - SO4	Ammonia Nitrogen - N	Nitrate Nitrogen N	Nitrite Nitrogen N	Total Phosphate P	Total Cyanide CN	Chlorophyll a (a)
	mm/dd/yyyy	m		µS/cm	ºC		mg/L - Faro & Grum % Saturation - Vangorda	mV	mg/L	µS/cm	CaCO3 mg/l		mg/L	mg/L	CaCO3 mg/l	CaCO3 mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Grum	8/8/2003	0	GP1-S	1002	12.91	7.9	9.32	139.6	0.65	955	522	8.08			149	2		424	0.03					
	8/8/2003	5	GP1	1099	5.31	7.79	10.8	163.2	0.71															
	8/8/2003	7.5	GP1	1097	4.93	7.8	9.9	164.6	0.71															
	8/8/2003	10	GP1-10	1097	4.93	7.7	9.43	166.5	0.71	1020	563	7.7			164	28		461	0.02					
	8/8/2003	12.5	GP1	1096	4.92	7.7	9.37	168.1	0.71															
	8/8/2003	15	GP1	1096	4.93	7.7	9.36	167.7	0.71															
	8/8/2003	17.5	GP1	1096	4.93	7.6	9.3	168	0.71															
	8/8/2003	20	GP1-20	1096	4.93	7.6	9.3	168.3	0.71	1050	510	7.79			165	27		452	<0.02					
	8/8/2003	22.5	GP1	1096	4.93	7.6	9.36	169	0.71															
	8/8/2003	25	GP1	1096	4.93	7.57	9.36	168.5	0.71															
	8/8/2003	30	GP1-30	1097	4.94	7.55	9.37	164	0.71	1040	505	7.49			166	26		460	<0.02					
	8/8/2003	35	GP1	1097	4.94	7.5	9.3	161	0.71															
	8/8/2003	40	GP1-40	981	4.95	7.52	7.2	161	0.71	1060	460	7.83			166	23		454	0.08					
	8/8/2003	0	GP2-S	1002	13.05	8.26	10.36	219.9	0.65	961	520	8.22			150	<1		429	0.05					
	8/8/2003	5	GP2	1098	4.96	8.1	11.23	233.6	0.71															
	8/8/2003	10	GP2-10	1097	4.94	8.03	9.72	239.2	0.71	1050	558	7.76			166	26		464	<0.02					
	8/8/2003	15	GP2	1097	4.94	7.97	9.59	240.9	0.71															
	8/8/2003	20	GP2-20	1097	4.94	7.93	9.53	241.4	0.71	1050	566	7.76			166	26		455	<0.02					
	8/8/2003	25	GP2	1096	4.94	7.89	9.52	241.3	0.71															
	8/8/2003	30	GP2-30	1096	4.94	7.85	9.52	240.8	0.71	1060	567	7.77			166	26		453	<0.02					
	8/8/2003	35	GP2	1097	4.94	7.83	9.52	235	0.71															
	8/8/2003	40	GP2-40	1097	4.94	7.8	9.53	152	0.71	1040	569	7.77			161	26		455	0.1					
	6/29/2004	1	GL-1										755	<3.0	152		<0.5	408	0.025	0.904	0.0112	<0.0020		<0.060
	6/29/2004	3	GL-3										816	<3.0	168		<0.5	437	0.024	0.848	0.0024	<0.0020		0.477
	6/29/2004	5	GL-5										814	<3.0	166		<0.5	438	0.023	0.811	0.002	<0.0020		0.89
	6/29/2004	7	GL-7										832	<3.0	169		<0.5	438	0.025	0.864	0.0025	<0.0020		1.5
	6/29/2004	10	GL-10										820	<3.0	170		<0.5	439	0.026	0.978	0.0025	<0.0020		0.773
	6/29/2004	15	GL-15										-	-										0.549
	6/29/2004	20	GL-20										802	<3.0	167		<0.5	439	0.03	0.967	0.0023	<0.0020		
	6/29/2004	30	GL-30										820	<3.0	167		<0.5	439	0.03	0.962	0.0028	<0.0020		
	6/29/2004	40	GL-40										826	<3.0	168		<0.5	440	0.026	0.963	0.0029	<0.0020		

Pit Lake	Date Sampled	Depth	Sample ID	T-Al	T-Sb	T-As	T-Ba	T-Be	T-Bi	T-B	T-Cd	T-Ca	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Li	T-Mg	T-Mn	T-Hg	T-Mo	T-Ni	T-P	T-K	T-Se	T-Si	T-Ag	T-Na	T-Sr	T-Tl	T-Sn	T-Ti	T-U	T-V	T-Zn
	mm/dd/yyyy	m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Grum	8/8/2003	0	GP1-S	0.07	0.008	<0.001	0.06	<0.002		<0.1	0.0097	107	<0.002	0.0349	<0.002	0.09	0.002	0.03	64.6	0.451	<0.00005	0.004	0.187		4	<0.002		<0.00004	11		0.0012	<0.001	<0.01	0.0029	<0.03	4.4
	8/8/2003	5	GP1																																	
	8/8/2003	7.5	GP1																																	
	8/8/2003	10	GP1-10	0.05	0.01	<0.003	0.06	<0.005		<0.1	0.0159	113	<0.005	0.046	<0.005	0.08	<0.003	<0.03	67	0.658	<0.00005	<0.005	0.263		3	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	12
	8/8/2003	12.5	GP1																																	
	8/8/2003	15	GP1																																	
	8/8/2003	17.5	GP1																																	
	8/8/2003	20	GP1-20	0.04	0.01	<0.003	0.05	<0.005		<0.1	0.0159	109	<0.005	0.046	<0.005	0.06	<0.003	<0.03	65.2	0.66	<0.00005	<0.005	0.269		4	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	12.3
	8/8/2003	22.5	GP1																																	
	8/8/2003	25	GP1																																	
	8/8/2003	30	GP1-30	0.06	0.011	<0.003	0.04	<0.005		<0.1	0.0159	106	<0.005	0.047	<0.005	<0.03	<0.003	<0.03	62.9	0.659	<0.00005	<0.005	0.27		3	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	12.3
	8/8/2003	35	GP1																																	
	8/8/2003	40	GP1-40	0.1	0.01	<0.003	0.05	<0.005		<0.1	0.0159	93.7	<0.005	0.045	<0.005	0.17	<0.003	<0.03	55.6	0.659	<0.00005	<0.005	0.265		3	<0.005		<0.0001	9		0.001	<0.003	<0.01	0.01	<0.03	12
	8/8/2003	0	GP2-S	0.08	0.009	<0.001	0.05	<0.002		<0.1	0.0099	102	<0.002	0.0362	<0.002	0.09	0.002	0.03	61.5	0.468	<0.00005	0.004	0.195		3	<0.002		<0.00004	10		0.0012	<0.001	<0.01	0.003	<0.03	4.43
	8/8/2003	5	GP2																																	
	8/8/2003	10	GP2-10	0.04	0.01	<0.003	0.06	<0.005		<0.1	0.0155	114	<0.005	0.045	<0.005	0.06	<0.003	<0.03	67.6	0.65	<0.00005	<0.005	0.262		4	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	11.8
	8/8/2003	15	GP2																																	
	8/8/2003	20	GP2-20	0.05	0.011	<0.003	0.05	<0.005		<0.1	0.0165	111	<0.005	0.047	<0.005	0.09	<0.003	<0.03	66.3	0.676	<0.00005	<0.005	0.273		4	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	12.4
	8/8/2003	25	GP2																																	
	8/8/2003	30	GP2-30	0.06	0.011	<0.003	0.05	<0.005		<0.1	0.0157	117	<0.005	0.046	<0.005	0.14	<0.003	<0.03	69.3	0.67	<0.00005	<0.005	0.272		4	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.01	<0.03	12
	8/8/2003	35	GP2																																	
	8/8/2003	40	GP2-40	0.06	0.01	<0.003	0.05	<0.005		<0.1	0.0161	115	<0.005	0.046	<0.005	0.13	<0.003	<0.03	68.9	0.659	<0.00005	<0.005	0.271		4	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.01	<0.03	12
	6/29/2004	1	GL-1	0.0205	0.00668	0.00062	0.0497	<0.0010	<0.0010	<0.020	0.00849	109	<0.0010	0.0261	0.00087	<0.03	0.00069	0.025	64.4	0.42		0.00357	0.178	<0.30	3	<0.0020	3.07	<0.000020	10.1	0.821	0.00073	<0.00020	<0.010	0.00275	<0.0020	3.34
	6/29/2004	3	GL-3	0.0281	0.00837	0.00085	0.0498	<0.0010	<0.0010	<0.020	0.011	117	<0.0010	0.0329	0.00115	<0.03	0.00086	0.027	68.5	0.658		0.00366	0.244	<0.30	3.5	0.0021	3.37	<0.000020	10.9	0.926	0.00077	<0.00020	<0.010	0.00314	<0.0020	12.1
	6/29/2004	5	GL-5	0.0224	0.00795	0.00104	0.0491	<0.0010	<0.0010	<0.020	0.00991	126	<0.0010	0.027	0.00088	0.041	0.00072	0.027	73.3	0.521		0.00337	0.205	<0.30	3.6	0.002	3.55	<0.000020	11.5	0.823	0.00068	<0.00020	<0.010	0.00668	<0.0020	9.6
	6/29/2004	7	GL-7	0.0336	0.00801	0.00126	0.0487	<0.0010	<0.0010	<0.020	0.00981	118	<0.0010	0.027	0.00093	0.042	0.00069	0.027	69.3	0.518		0.0033	0.202	<0.30	3.4	0.002	3.33	<0.000020	10.9	0.825	0.00066	<0.00020	<0.010	0.00568	<0.0020	9.85
	6/29/2004	10	GL-10	0.0275	0.00804	0.00148	0.0496	<0.0010	<0.0010	<0.020	0.0101	119	<0.0010	0.0285	0.00098	0.041	0.00088	0.026	69.4	0.562		0.00341	0.214	<0.30	4	<0.0020	3.31	<0.000020	10.9	0.849	0.00067	<0.00020	<0.010	0.00938	<0.0020	10.1
	6/29/2004	15	GL-15																																	
	6/29/2004	20	GL-20	0.0472	0.00777	0.00151	0.0484	<0.0010	<0.0010	<0.020	0.00952	117	<0.0010	0.0277	0.00102	0.082	0.00069	0.025	69	0.533		0.00333	0.209	<0.30	4	0.002	3.34	<0.000020	10.9	0.797	0.00066	<0.00020	<0.010	0.00784	<0.0020	9.53
	6/29/2004	30	GL-30	0.0784	0.00793	0.00158	0.05	<0.0010	<0.0010	<0.020	0.00996	124	<0.0010	0.0285	0.001	0.122	0.00085	0.026	72.2	0.562		0.00345	0.214	<0.30	4.9	<0.0020	3.54	<0.000020	11.6	0.837	0.00068	<0.00020	<0.010	0.00815	<0.0020	9.87
	6/29/2004	40	GL-40	0.0855	0.00799	0.00184	0.05	<0.0010	<0.0010	<0.020	0.01	118	<0.0010	0.0292	0.00112	0.23	0.00104	0.025	70	0.573		0.00337	0.217	<0.30	3	<0.0020	3.5	<0.000020	11.1	0.841	0.0007	<0.00020	<0.010	0.00828	<0.0020	10

Pit Lake	Date Sampled	Depth	Sample ID	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn
	mm/dd/yyyy	m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Grum	8/8/2003	0	GP1-S	<0.01	0.008	<0.001	0.06	<0.002		<0.1	0.0086	105	<0.002	0.0329	<0.002	<0.03	<0.001	0.02	63	0.407	<0.00005	0.004	0.176		3	<0.002		<0.00004	11		0.0011	<0.001	<0.01	0.0028	<0.03	3.79
	8/8/2003	5	GP1																																	
	8/8/2003	7.5	GP1																																	
	8/8/2003	10	GP1-10	<0.03	0.01	<0.003	0.05	<0.005		<0.1	0.0151	113	<0.005	0.044	<0.005	<0.03	<0.003	<0.03	68.2	0.632	<0.00005	<0.005	0.255		3	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.01	<0.03	11.5
	8/8/2003	12.5	GP1																																	
	8/8/2003	15	GP1																																	
	8/8/2003	17.5	GP1																																	
	8/8/2003	20	GP1-20	<0.03	0.011	<0.003	0.04	<0.005		<0.1	0.0156	103	<0.005	0.046	<0.005	<0.03	<0.003	<0.03	61.2	0.666	<0.00005	<0.005	0.266		4	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	12
	8/8/2003	22.5	GP1																																	
	8/8/2003	25	GP1																																	
	8/8/2003	30	GP1-30	<0.03	0.01	<0.003	0.05	<0.005		<0.1	0.0151	103	<0.005	0.044	<0.005	<0.03	<0.003	<0.03	60.4	0.639	<0.00005	<0.005	0.256		3	<0.005		<0.0001	11		0.001	<0.003	<0.01	0.01	<0.03	11.6
	8/8/2003	35	GP1																																	
	8/8/2003	40	GP1-40	<0.03	0.01	<0.003	0.04	<0.005		<0.1	0.0149	92.6	<0.005	0.043	<0.005	<0.03	<0.003	<0.03	55.5	0.633	<0.00005	<0.005	0.254		2	<0.005		<0.0001	10		0.001	<0.003	<0.01	0.01	<0.03	11.4
	8/8/2003	0	GP2-S	<0.01	0.008	<0.001	0.06	<0.002		<0.1	0.0088	105	<0.002	0.034	<0.002	<0.03	<0.001	0.02	62.9	0.422	<0.00005	0.004	0.181		3	<0.002		<0.00004	11		0.0011	<0.001	<0.01	0.0028	<0.03	3.85
	8/8/2003	5	GP2																																	
	8/8/2003	10	GP2-10	<0.03	0.01	<0.003	0.05	<0.005		<0.1	0.0148	113	<0.005	0.045	<0.005	<0.03	<0.003	<0.03	67.1	0.634	<0.00005	<0.005	0.256		4	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.009	<0.03	11.4
	8/8/2003	15	GP2																																	
	8/8/2003	20	GP2-20	<0.03	0.01	<0.003	0.05	<0.005		<0.1	0.0147	114	<0.005	0.043	<0.005	<0.03	<0.003	<0.03	68.1	0.626	<0.00005	<0.005	0.255		3	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.01	<0.03	11.3
	8/8/2003	25	GP2																																	
	8/8/2003	30	GP2-30	<0.03	0.01	<0.003	0.05	<0.005		<0.1	0.0148	115	<0.005	0.044	<0.005	<0.03	<0.003	<0.03	67.9	0.637	<0.00005	<0.005	0.255		3	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.01	<0.03	11.4
	8/8/2003	35	GP2																																	
	8/8/2003	40	GP2-40	<0.03	0.01	<0.003	0.06	<0.005		<0.1	0.015	115	<0.005	0.043	<0.005	<0.03	<0.003	<0.03	68.5	0.635	<0.00005	<0.005	0.257		3	<0.005		<0.0001	12		0.001	<0.003	<0.01	0.01	<0.03	11.4
	6/29/2004	1	GL-1	<0.0020	0.00671	0.00055	0.05	<0.0010	<0.0010	<0.020	0.00838	111	<0.0010	0.0267	0.00081	<0.030	0.00034	0.025	66.1	0.419		0.00367	0.187	<0.30	3.1	<0.0020	3.09	<0.000020	10.6	0.848	0.00076	<0.00020	<0.010	0.00281	<0.0020	3.33
	6/29/2004	3	GL-3	<0.0020	0.00794	0.00064	0.048	<0.0010	<0.0010	<0.020	0.00995	119	<0.0010	0.027	0.00077	<0.030	0.00037	0.028	69.6	0.506		0.00334	0.201	<0.30	2.7	<0.0020	3.32	<0.000020	11.3	0.835	0.00078	<0.00020	<0.010	0.00268	<0.0020	9.55
	6/29/2004	5	GL-5	<0.0020	0.00807	0.00082	0.0491	<0.0010	<0.0010	<0.020	0.0101	129	<0.0010	0.0271	0.00064	<0.030	0.00034	0.028	75	0.522		0.00338	0.205	<0.30	3.6	<0.0020	3.56	<0.000020	11.7	0.848	0.00068	<0.00020	<0.010	0.00666	<0.0020	9.64
	6/29/2004	7	GL-7	<0.0020	0.00819	0.00113	0.0494	<0.0010	<0.0010	<0.020	0.01	116	<0.0010	0.0288	0.00068	<0.030	0.00032	0.028	67.9	0.553		0.00346	0.213	<0.30	3.1	0.0021	3.21	<0.000020	10.8	0.861	0.00068	<0.00020	<0.010	0.00574	<0.0020	10.1
	6/29/2004	10	GL-10	<0.0020	0.00824	0.00108	0.0499	<0.0010	<0.0010	<0.020	0.0101	118	<0.0010	0.0291	0.00078	<0.030	0.00032	0.026	69.8	0.567		0.0035	0.219	<0.30	3.5	0.0022	3.3	<0.000020	10.7	0.875	0.00066	<0.00020	<0.010	0.00855	<0.0020	10.2
	6/29/2004	15	GL-15																																	
	6/29/2004	20	GL-20	<0.0020	0.00799	0.00105	0.0479	<0.0010	<0.0010	<0.020	0.00968	127	<0.0010	0.0275	0.0007	<0.030	0.00019	0.025	73.8	0.534		0.00336	0.209	<0.30	3.5	<0.0020	3.49	<0.000020	11.6	0.801	0.00066	<0.00020	<0.010	0.00788	<0.0020	9.54
	6/29/2004	30	GL-30	<0.0020	0.00802	0.00109	0.0484	<0.0010	<0.0010	<0.020	0.0101	127	<0.0010	0.029	0.00066	<0.030	0.00014	0.027	74.6	0.573		0.00344	0.216	<0.30	4.6	<0.0020	3.57	<0.000020	11.9	0.842	0.00069	<0.00020	<0.010	0.00816	<0.0020	10.1
	6/29/2004	40	GL-40	<0.0020	0.00808	0.00119	0.0483	<0.0010	<0.0010	<0.020	0.0102	119	<0.0010	0.0296	0.00073	<0.030	0.00011	0.026	69.9	0.598		0.00348	0.221	<0.30	4.1	0.0021	3.32	<0.000020	11.1	0.865	0.00068	<0.00020	<0.010	0.00835	<0.0020	10.3

Appendix D.3

Vangorda Pit

Pit Lake	Date Sampled	Depth	Sample ID	Field Cond.	Field Water Temperature	Field pH	Field Dissolved Oxygen	Field ORP	Field TDS	Lab Cond.	Hardness	pH	TDS	TSS	Alkalinity Total	Acidity (to pH 8.3)	Chloride - Cl	Sulphate - SO4	Ammonia Nitrogen - N	Nitrate Nitrogen N	Nitrite Nitrogen N	Total Phosphate P	Total Cyanide CN	Chlorophyll a (a)
	mm/dd/yyyy	m		µS/cm	ºC		mg/L - Faro & Grum % Saturation - Vangorda	mV	mg/L	µS/cm	CaCO3 mg/l		mg/L	mg/L	CaCO3 mg/l	CaCO3 mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Vangorda	6/7/2000	0	Center of Pit	325	17.2	7.8	92																	
	6/7/2000	2.5	Seep 11	416	14.5	7.64	79			444		7.89		15	66	12		166						
	6/7/2000	5	Center of Pit	988	8.9	7.42	59																	
	6/7/2000	7.5	Center of Pit	1072	6.7	7.39	44																	
	6/7/2000	10	Center of Pit	1115	6	7.17	34																	
	6/7/2000	12.5	Seep 12	1127	5.6	7.06	20			1440		7.28		4	82	118		830						
	6/7/2000	15	Center of Pit	1242	5.5	7.04	17																	
	6/7/2000	17.5	Center of Pit	1310	5.5	7.02	12																	
	6/7/2000	20	Center of Pit	1340	5.4	6.99	9																	
	6/7/2000	22	Center of Pit	1430	5.1	6.95	6																	
	6/7/2000	0	South End of Pit	355	15.9	7.8	93																	
	6/7/2000	2.5	South End of Pit	391	13.1	7.87	81																	
	6/7/2000	5	South End of Pit	981	7.8	7.39	61																	
	6/7/2000	7.5	South End of Pit	1079	6	7.19	45																	
	6/7/2000	10	South End of Pit	1108	5.4	7.03	33																	
	6/7/2000	12.5	South End of Pit	1134	5.2	6.91	28																	
	6/7/2000	15	South End of Pit	1218	5	6.88	20																	
	6/7/2000	17.5	South End of Pit	1319	5.1	6.91	14																	
	6/7/2000	20	South End of Pit	1350	5	6.92	10																	
	6/7/2000	22.5	South End of Pit	1430	4.9	6.9	7																	
	6/7/2000	25	South End of Pit	1430	4.8	6.92	5																	
	09/15/2003	1	VGPW	1776	5.1	6.99		139		1710		7.03			57	151	0.7	1080						
	09/15/2003	3	VGPW	1781	6.1	6.86		102		1760		7.35			50	162	1	1100						
	09/15/2003	5	VGPW	1990	6	6.65		48		1930		7.31			48	194	0.9	1250						
	09/15/2003	10	VGPW	2110	5.2	6.58		25		1980		7.3			49	210	1	1280						
	09/15/2003	20	VGPW	2070	5.4	6.57		30		1980		7.28			49	212	0.9	1280						
	09/15/2003	30	VGPW	2090	6.1	6.7		35		1940		6.54			48	217	1	1250						
	09/15/2003	40	VGPW	1865	5.4	6.82		68		1990		7.03			49	221	0.6	1280						
	7/7/2004	1	VAN 1										986	<3.0	26.6		<0.5	619	0.257	0.0866	0.0045	0.0041		<0.060
	7/7/2004	3	VAN 3	1800	5								1770	4.7	31.6		<0.5	1140	0.766	0.0444	0.002	<0.0020		<0.060
	7/7/2004	5	VAN 5										1810	18.7	31.5		<0.5	1210	0.603	0.0358	0.0025	0.002		<0.060
	7/7/2004	10	VAN 10										1910	28	27.7		<0.5	1240	0.576	0.0226	0.0021	0.002		<0.060
	7/7/2004	20	VAN 20										1970	32.7	20.7		<0.5	1280	0.608	0.0178	0.0022	<0.0020		
	7/7/2004	30	VAN 30										1960	36.7	13.6		<0.5	1300	0.599	0.0408	0.0026	0.0027		
	7/7/2004	40	VAN 40										1930	38	14.5		<0.5	1280	0.636	0.013	0.0033	<0.0020		

Pit Lake	Date Sampled	Depth	Sample ID	T-Al	T-Sb	T-As	T-Ba	T-Be	T-Bi	T-B	T-Cd	T-Ca	T-Cr	T-Co	T-Cu	T-Fe	T-Pb	T-Li	T-Mg	T-Mn	T-Hg	T-Mo	T-Ni	T-P	T-K	T-Se	T-Si	T-Ag	T-Na	T-Sr	T-Tl	T-Sn	T-Ti	T-U	T-V	T-Zn
	mm/dd/yyyy	m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Vangorda	6/7/2000	0	Center of Pit																																	
	6/7/2000	2.5	Seep 11																																	
	6/7/2000	5	Center of Pit																																	
	6/7/2000	7.5	Center of Pit																																	
	6/7/2000	10	Center of Pit																																	
	6/7/2000	12.5	Seep 12																																	
	6/7/2000	15	Center of Pit																																	
	6/7/2000	17.5	Center of Pit																																	
	6/7/2000	20	Center of Pit																																	
	6/7/2000	22	Center of Pit																																	
	6/7/2000	0	South End of Pit																																	
	6/7/2000	2.5	South End of Pit																																	
	6/7/2000	5	South End of Pit																																	
	6/7/2000	7.5	South End of Pit																																	
	6/7/2000	10	South End of Pit																																	
	6/7/2000	12.5	South End of Pit																																	
	6/7/2000	15	South End of Pit																																	
	6/7/2000	17.5	South End of Pit																																	
	6/7/2000	20	South End of Pit																																	
	6/7/2000	22.5	South End of Pit																																	
	6/7/2000	25	South End of Pit																																	
	09/15/2003	1	VGPW																																	
	09/15/2003	3	VGPW																																	
	09/15/2003	5	VGPW																																	
	09/15/2003	10	VGPW																																	
	09/15/2003	20	VGPW																																	
	09/15/2003	30	VGPW																																	
	09/15/2003	40	VGPW																																	
	7/7/2004	1	VAN 1	0.043	<0.0020	<0.0020	0.0476	<0.010	<0.010	<0.20	0.0619	129	<0.010	0.307	0.121	0.144	0.0168	<0.10	49.2	16.9		<0.0010	0.325	<0.30	<2	<0.020	2.96	<0.00020	3.2	0.746	<0.0020	<0.0020	<0.010	0.00054	<0.020	56.1
	7/7/2004	3	VAN 3	<0.05	<0.0050	<0.0050	0.0341	<0.025	<0.025	<0.50	0.0913	234	<0.025	0.658	0.321	1.65	0.008	<0.25	92.4	37.2		<0.0025	0.622	<0.30	4.8	<0.050	3.14	<0.00050	5.6	1.34	<0.0050	<0.0050	0.01	<0.00050	<0.050	112
	7/7/2004	5	VAN 5	<0.05	<0.0050	<0.0050	0.0272	<0.025	<0.025	<0.50	0.0862	244	<0.025	0.707	0.243	12.4	0.0027	<0.25	96.6	40.2		<0.0025	0.668	<0.30	3.5	<0.050	3.2	<0.00050	5.6	1.37	<0.0050	<0.0050	0.011	<0.00050	<0.050	119
	7/7/2004	10	VAN 10	<0.05	<0.0050	<0.0050	0.0242	<0.025	<0.025	<0.50	0.0976	244	<0.025	0.737	0.258	16	0.0026	<0.25	97.3	42.3		<0.0025	0.699	<0.30	3.6	<0.050	3.23	<0.00050	5.6	1.41	<0.0050	<0.0050	<0.010	<0.00050	<0.050	126
	7/7/2004	20	VAN 20	<0.05	<0.0050	<0.0050	0.0236	<0.025	<0.025	<0.50	0.111	253	<0.025	0.773	0.226	21.1	0.006	<0.25	100	44.4		<0.0025	0.718	<0.30	4	<0.050	3.36	<0.00050	5.9	1.45	<0.0050	<0.0050	<0.010	<0.00050	<0.050	132
	7/7/2004	30	VAN 30	<0.05	<0.0050	<0.0050	0.022	<0.025	<0.025	<0.50	0.11	247	<0.025	0.747	0.211	23.5	0.016	<0.25	99.1	42.5		<0.0025	0.699	<0.30	3.2	<0.050	3.33	<0.00050	5.6	1.42	<0.0050	<0.0050	0.012	<0.00050	<0.050	129
	7/7/2004	40	VAN 40	<0.05	<0.0050	<0.0050	0.021	<0.025	<0.025	<0.50	0.107	259	<0.025	0.7	0.207	25.6	0.0172	<0.25	104	41.9		<0.0025	0.65	<0.30	3.9	<0.050	3.51	<0.00050	5.9	1.36	<0.0050	<0.0050	<0.010	<0.00050	<0.050	127

Pit Lake	Date Sampled	Depth	Sample ID	D-Al	D-Sb	D-As	D-Ba	D-Be	D-Bi	D-B	D-Cd	D-Ca	D-Cr	D-Co	D-Cu	D-Fe	D-Pb	D-Li	D-Mg	D-Mn	D-Hg	D-Mo	D-Ni	D-P	D-K	D-Se	D-Si	D-Ag	D-Na	D-Sr	D-Tl	D-Sn	D-Ti	D-U	D-V	D-Zn
	mm/dd/yyyy	m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Vangorda	6/7/2000	0	Center of Pit																																	
	6/7/2000	2.5	Seep 11	<0.2	<0.2	<0.2	0.04	<0.005	<0.1	<0.1	0.01	54	<0.01	0.03	0.02	0.06	<0.05	0.02	16.5	1.5		<0.03	0.07	<0.3	<2	<0.2	2.79	<0.01	2	0.51	<0.2	<0.03	<0.01		<0.03	6.27
	6/7/2000	5	Center of Pit																																	
	6/7/2000	7.5	Center of Pit																																	
	6/7/2000	10	Center of Pit																																	
	6/7/2000	12.5	Seep 12	<0.2	<0.2	<0.2	0.02	<0.005	<0.1	<0.1	0.08	181	<0.01	0.41	0.02	0.11	<0.05	0.03	69.7	19.7		<0.03	0.41	<0.3	4	<0.2	2.63	<0.01	6	1.4	<0.2	<0.03	<0.01		<0.03	70.1
	6/7/2000	15	Center of Pit																																	
	6/7/2000	17.5	Center of Pit																																	
	6/7/2000	20	Center of Pit																																	
	6/7/2000	22	Center of Pit																																	
	6/7/2000	0	South End of Pit																																	
	6/7/2000	2.5	South End of Pit																																	
	6/7/2000	5	South End of Pit																																	
	6/7/2000	7.5	South End of Pit																																	
	6/7/2000	10	South End of Pit																																	
	6/7/2000	12.5	South End of Pit																																	
	6/7/2000	15	South End of Pit																																	
	6/7/2000	17.5	South End of Pit																																	
	6/7/2000	20	South End of Pit																																	
	6/7/2000	22.5	South End of Pit																																	
	6/7/2000	25	South End of Pit																																	
	09/15/2003	1	VGPW	<0.2	<0.2	<0.2	0.01	<0.005	<0.2	<0.1	0.08	213	<0.01	0.53	0.1	0.15	<0.05	0.04	85.1	30.4	<0.03	0.5	<0.3		4	<0.2	2.97	<0.01	5	1.22	<0.2	<0.03	<0.01		<0.03	91.5
	09/15/2003	3	VGPW	<0.2	<0.2	<0.2	0.01	<0.005	<0.2	<0.1	0.08	208	<0.01	0.53	<0.01	1.74	<0.05	0.04	84.4	30.3	<0.03	0.51	<0.3		3	<0.2	2.91	<0.01	6	1.19	<0.2	<0.03	<0.01		<0.03	91.4
	09/15/2003	5	VGPW	<0.2	<0.2	<0.2	0.01	<0.005	<0.2	<0.1	0.08	226	<0.01	0.59	0.01	11.3	<0.05	0.04	92.6	34.3	<0.03	0.57	<0.3		3	<0.2	3.04	<0.01	6	1.24	<0.2	<0.03	<0.01		<0.03	102
	09/15/2003	10	VGPW	<0.2	<0.2	<0.2	0.01	<0.005	<0.2	<0.1	0.08	248	<0.01	0.65	<0.01	17.6	<0.05	0.05	103	38.5	<0.03	0.62	<0.3		3	<0.2	3.37	<0.01	6	1.35	<0.2	<0.03	<0.01		<0.03	114
	09/15/2003	20	VGPW	<0.2	<0.2	<0.2	<0.01	<0.005	<0.2	<0.1	0.07	237	<0.01	0.63	<0.01	21.7	<0.05	0.05	98.2	37.2	<0.03	0.59	<0.3		3	<0.2	3.19	<0.01	5	1.26	<0.2	<0.03	<0.01		<0.03	111
	09/15/2003	30	VGPW	<0.2	<0.2	<0.2	0.01	<0.005	<0.2	<0.1	0.08	267	<0.01	0.72	<0.01	27.9	<0.05	0.05	112	43	<0.03	0.66	<0.3		3	<0.2	3.58	<0.01	6	1.43	<0.2	<0.03	<0.01		<0.03	124
	09/15/2003	40	VGPW	<0.2	<0.2	<0.2	0.01	<0.005	<0.2	<0.1	0.08	243	<0.01	0.64	0.01	16.5	<0.05	0.05	100	37.6	<0.03	0.62	<0.3		3	<0.2	3.23	<0.01	6	1.33	0.2	<0.03	<0.01		<0.03	111
	7/7/2004	1	VAN 1	0.034	<0.0020	<0.0020	0.0506	<0.010	<0.010	<0.20	0.0627	125	<0.010	0.307	0.122	0.144	0.0164	<0.10	47.4	16.8		<0.0010	0.318	<0.30	2.7	<0.020	2.85	<0.00020	3	0.745	<0.0020	<0.0020	<0.010	0.00056	<0.020	55.8
	7/7/2004	3	VAN 3	<0.050	<0.0050	<0.0050	0.0346	<0.025	<0.025	<0.50	0.0914	212	<0.025	0.657	0.317	1.13	0.0026	<0.25	84.4	37.1		<0.0025	0.638	<0.30	3.5	<0.050	2.85	<0.00050	5.1	1.31	<0.0050	<0.0050	<0.010	<0.00050	<0.050	112
	7/7/2004	5	VAN 5	<0.050	<0.0050	<0.0050	0.0269	<0.025	<0.025	<0.50	0.0914	240	<0.025	0.716	0.241	11.8	<0.0025	<0.25	94.9	40.8		<0.0025	0.677	<0.30	4.3	<0.050	3.14	<0.00050	5.7	1.42	<0.0050	<0.0050	0.011	<0.00050	<0.050	122
	7/7/2004	10	VAN 10	<0.050	<0.0050	<0.0050	0.0259	<0.025	<0.025	<0.50	0.0997	240	<0.025	0.754	0.257	15.4	<0.0025	<0.25	95.4	43.4		<0.0025	0.722	<0.30	3.6	<0.050	3.15	<0.00050	5.7	1.43	<0.0050	<0.0050	<0.010	<0.00050	<0.050	128
	7/7/2004	20	VAN 20	<0.050	<0.0050	<0.0050	0.0222	<0.025	<0.025	<0.50	0.109	249	<0.025	0.753	0.218	20.6	<0.0025	<0.25	99.7	43.5		<0.0025	0.714	<0.30	3.1	<0.050	3.34	<0.00050	5.7	1.41	<0.0050	<0.0050	<0.010	<0.00050	<0.050	130
	7/7/2004	30	VAN 30	<0.050	<0.0050	<0.0050	0.0217	<0.025	<0.025	<0.50	0.11	249	<0.025	0.744	0.211	23.4	0.0066	<0.25	100	42.5		<0.0025	0.705	<0.30	3.8	<0.050	3.35	<0.00050	5.8	1.4	<0.0050	<0.0050	0.012	<0.00050	<0.050	130
	7/7/2004	40	VAN 40	<0.050	<0.0050	<0.0050	0.0214	<0.025	<0.025	<0.50	0.113	242	<0.025	0.747	0.205	23.5	0.007	<0.25	97.9	42.4		<0.0025	0.684	<0.30	4.2	<0.050	3.31	<0.00050	5.6	1.41	<0.0050	<0.0050	0.011	<0.00050	<0.050	131

Appendix E

Characteristics of Water Types
Used In Predicting Wall Rock Loadings

Appendix E.1

Faro Pit

Type	ID	Statistic	pH	Acidity	Alk	Cl	SO4	Ca	Mg	K	Na	Al	Cd	Co	Cu	Fe	Pb	Mn	Ni	Zn
Faro Type 1	FT1	Average	7.3	14	185	1.6	722	154	114	6.5	29	0.2	0.01	0.01	0.01	0.03	0.06	0.11	0.06	2.5
		Median	7.2	15	190.5	1.6	493	145	86	4.0	7.5	0.2	0.01	0.01	0.01	0.03	0.05	0.05	0.05	2.0
		Min	6.6	3	112	0.5	266	82.2	27	3.0	4.0	0.2	0.01	0.01	0.01	0.03	0.05	0.005	0.05	0.17
		Max	8.1	29	242	2.7	2470	263	378	24	122	0.2	0.01	0.01	0.01	0.03	0.15	0.422	0.09	5.3
		N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Faro Type 2 Waste	FT2	Average	6.7	51	137	1.6	1701	288	231	7.9	16	0.3	0.03	0.052	0.04	1.9	0.06	4.9	0.17	26
		Median	6.8	46	71.5	1.3	1425	227	177	8.0	11	0.2	0.02	0.045	0.01	0.12	0.05	2.8	0.12	26
		Min	5.8	15	4	0.5	334	49.1	37	2.0	3.0	0.2	0.01	0.01	0.01	0.03	0.05	0.037	0.05	3.9
		Max	7.3	115	407	4.6	3860	628	584	15	122	1.6	0.09	0.15	0.5	20.2	0.23	19	0.6	51
		N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Faro Type 2 Ore	FT3	Average	6.5	601	242	12	3783	491	505	13	49	0.4	0.16	0.41	0.08	33	0.10	44	0.61	261
		Median	6.4	477	319.5	15	4285	529	635	14	54	0.4	0.07	0.45	0.05	31.95	0.075	49.5	0.63	221
		Min	6.2	37	13	0.7	962	272	51	7.0	11	0.2	0.01	0.03	0.01	0.09	0.05	3.84	0.05	13.7
		Max	7.0	2160	350	17.5	4600	576	694	17	69	0.6	0.62	0.53	0.3	89.9	0.2	54	0.9	595
		N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Faro Type 3 Waste	FT4	Average	3.9	968	16	3.1	1614	173	161	6.4	7.5	15	0.16	0.30	2	76	0.36	10	0.56	109
		Median	3.4	177	1	0.60	1170	239	104	5.0	4.0	4.1	0.08	0.20	0.58	3.91	0.08	3.79	0.24	46.7
		Min	2.6	27	1	0.50	69	6.45	3.8	2.0	2.0	0.2	0.01	0.01	0.03	0.03	0.05	0.161	0.05	2.2
		Max	5.9	8750	92	23.8	4780	410	504	14	36	73	0.85	1.5	8.06	416	1.6	64.3	3.2	751
		N	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
Faro Type 3 Ore	FT5	Average	3.4	14470	6	126	17107	305	727	39	44	207	6.5	5.0	92	2773	1.5	388	3.9	4260
		Median	2.5	6550	1	2.9	7490	268	235	20	46	71	6.9	1.7	7.8	1040	1.78	125	1.5	2260
		Min	2.2	227	1	0.50	700	107	38.8	2.0	2.0	0.2	0.12	0.080	0.14	1.3	0.3	5.7	0.08	128
		Max	6.0	49500	31	1050	59000	504	3210	100	100	986	15.5	20	559	15100	3.0	2360	15	10900
		N	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Others (average only)	FT6	FD04	2.4	30970	1.00	342	35523	378	1655	73	73	502	10	11	187	6748	2	936	7.7	6930
	FT7	FD05/06	7.2	12	204	1.9	462	133	95	3.9	6.9	0.20	0.010	0.010	0.010	0.030	0.05	0.044	0.05	2.2
	FT8	FD14	7.6	16	111	0.77	2050	211	283	18	121	0.20	0.013	0.013	0.027	0.317	0.05	0.14	0.07	6.0
	FT9	FD19	7.1	85	398	2.1	3680	601	558	10	20	0.25	0.013	0.055	0.038	0.785	0.063	18	0.31	45
	FT10	FD37	2.4	11700	1.0	0.50	14850	242	273	31	31	94	11.3	4.0	127	1410	1.3	149	4.1	6985
	FT11	FD40	4.3	98	10	0.57	386	42	46	2.0	2.7	2.8	0.05	0.09	0.37	2.2	0.08	2.3	0.093	35
	FT12	04FP02	7.5	2	139	0.64	428	44	10	2.0	150.0	0.2	0.01	0.01	0.01	0.0	0.05	0.0	0.050	0
Faro Unit 10E Seeps	FT13	Average	7.49	4.1	242	0.5	137	68	34	3.7	18	0.2	0.01	0.01	0.01	0.03	0.05	0.034	0.05	0.28
		Median	7.32	4.1	239	0.5	99	59	28	3.1	15	0.2	0.01	0.01	0.01	0.03	0.05	0.005	0.05	0.005
		Min	7.03	3.9	193	0.5	26	50	13	2	2.6	0.2	0.01	0.01	0.01	0.03	0.05	0.005	0.05	0.005
		Max	8.12	4.2	293	0.5	287	94	59	6.1	36	0.2	0.01	0.01	0.01	0.03	0.05	0.093	0.05	0.83
		N	3	3	3	3.0	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Appendix E.2

Grum Pit

Type	ID	Statistic	pH	Acidity	Alk	Cl	SO4	Ca	Mg	K	Na	Al	Cd	Co	Cu	Fe	Pb	Mn	Ni	Zn
Grum Phyllite Avg	VG7	Average	8.0	8	238	0.9	633	134	122	3.6	3.8	0	0.00	0.01	0	0	0.02	0	0.08	0
		Median	8.0	3	254.5	0.81	570	110	97.65	3.7	4.1	0.2	0.01	0.01	0.01	0.03	0.05	0.00665	0.075	0.01605
		Min	7.4	1	139	0.50	225	64.8	59.6	2.5	2.0	0.2	0.01	0.01	0.01	0.03	0.05	0.005	0.05	0.005
		Max	8.4	36	297	2.7	1050	268	235	5	6	0.2	0.01	0.0	0.01	0.03	0.05	0.0168	0.17	0.073
		N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Grum Sulphide Avg	VG8	Average	7.6	56	216	0.2	830	180	111	2.7	7.7	0	0.02	0.15	0.35	14	0.01	4	0.73	28
		Median	7.5	37	217	0.50	782	176	109	3.0	6.0	0.2	0.01	0.10	0.01	0.03	0.05	0.158	0.65	12
		Min	6.8	5.8	28.5	0.50	716	113	66.9	2.0	2.7	0.2	0.01	0.01	0.01	0.03	0.05	0.015	0.418	6.69
		Max	8.5	173	373	1.18	989	239	167	3	16	0.2	0.098	0.5	1.73	72	0.074	17.4	1.03	97.5
		N	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Grum Till Avg	VG9	Average	8.0	2	112	0.7	325	111	26	3.4	10.0	0	0.01	0.01	0	0	0.05	0	0.05	0
		Median	8.0	1	99.2	0.74	350	103	34.3	2.9	8.3	0.2	0.01	0.01	0.01	0.03	0.05	0.0252	0.05	0.005
		Min	7.9	1	91.8	0.50	34.7	46	9.78	2.0	6.9	0.2	0.01	0.01	0.01	0.03	0.05	0.005	0.05	0.005
		Max	8.3	3.3	145	0.76	590	185	34.8	5.2	14.7	0.2	0.01	0.0	0.01	0.03	0.05	0.558	0.05	0.0307
		N	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Appendix E.3

Vangorda Pit

Type	ID	Statistic	pH	Acidity	Alk	Cl	SO4	Ca	Mg	K	Na	Al	Cd	Co	Cu	Fe	Pb	Mn	Ni	Zn
Vang Phyllite Avg	VG10	Average	6.2	94	88	0.7	615	157	51	2.3	2.3	1	0.07	0.11	0	2	0.18	10	0.30	46
		Median	6.8	17.4	59.5	0.50	600	129	55.6	2.0	2.3	0.2	0.01	0.05	0.01	0.03	0.05	0.698	0.125	5.19
		Min	3.4	1.3	1	0.50	23.3	27	2.33	2.0	2.0	0.2	0.01	0.01	0.01	0.03	0.05	0.005	0.05	0.0074
		Max	7.3	356	216	1.37	1370	324	91.8	3.1	3	4	0.322	0.4	1.54	6.14	0.685	31.7	0.646	180
		N	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Vang Sulphide Avg	VG11	Average	5.0	1212	17	0.7	2514	180	152	6.8	7.3	15	0.64	1.43	6	307	0.77	105	1.21	452
		Median	4.8	382	1	0.50	740.5	135.5	50.05	2.1	3.6	5.69	0.1645	0.35	1.655	28.07	0.468	18.75	0.674	114.05
		Min	2.8	35	1	0.50	212	28.1	13.3	2.0	2.0	0.2	0.025	0.072	0.01	0.03	0.05	4.13	0.075	12.1
		Max	7.2	4370	90	1.19	8080	455	675	20	20	49.3	3.21	4.7	41.3	1410	2.49	559	3.34	1550
		N	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Vg Bleached Phyll. Avg	VG12	Average	3.8	1994	4	0.8	6060	333	458	12.5	10.4	25	0.65	4.44	7	360	0.50	442	2.04	779
		Median	3.2	2070	1	0.75	5110	363	326	9.5	6.0	19.1	0.823	3.34	8.64	421	0.5	312	1.69	558
		Min	2.7	643	1	0.50	1930	232	131	7.9	5.1	0.4	0.059	0.844	0.025	166	0.1	90	0.65	229
		Max	5.6	3270	10.6	1.02	11139	404	918	20	20	54.6	1.08	9.1	11.9	492	0.91	924	3.77	1550
		N	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Vang Till	VG13	04VP03	7.6	1	201	0.6	25	53	15	2.0	6.0	0.20	0.010	0.010	0.010	0.030	0.050	0.0084	0.050	0.0050