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PROJECT MEMORANDUM

To:	**Faro Mine Closure Planning Office**	**Fax No.:**	
Attention:	**John Brodie**	**CC:**	**Rock Drain Working Group**
From:	**Gerry Ferris**	**Date:**	**January 27, 2006**
Subject:	**NFRD, Measured flow through, Rev A for review**		
No. of Pages (including this page): 10 + attachments		**Project No:**	**0257-031-01**

This memorandum is part of a series that will be sent to the Rock Drain Working Group to describe the analysis being undertaken for the North Fork Rock Drain (NFRD). This second memorandum describes the results of the 2005 monitoring program.

The purpose of this series of memoranda is to provide a description of the work being performed and to allow comments from members of the working group to be incorporated. The memoranda planned for this series are:

- Memorandum 1 – Flow through rockfill, Theoretical Basis – Issued for review, January 16, 2005
- Memorandum 2 – NFRD, Measured flow through
- Memorandum 3 – Estimated current flow through capacity
- Memorandum 4 – Predictions of future flow through capacity

1.0 INTRODUCTION

During 2005 a monitoring program was employed to gain an understanding of the flow through performance of the NFRD. The program consisted of monitoring the water elevation at four different locations (R7, NFRC20/21, Pond and NFRC22/23/X2) to either directly determine the water elevation or to use the water elevation to estimate the discharge. The position of these stations relative to the NFRD is shown on Figure 1. The water elevations were determined by the use of an electronic sensor/datalogger (installed by BGC staff), readings of staff gauges or direct survey (by site staff).

Rating curves were developed for stations NFRC 20/21 and NFRC22/23/X2 based on:

1. Elevation survey of the channel base at each station (performed by YES),
2. Concurrent in stream discharge measurements and water elevation readings (performed by Laberge), and
3. Hydraulic modelling, using the data from 1 and 2 above and extending the measured conditions to bankfull (performed by nhc).

This memorandum provides a summary of the original design and construction of the NFRD and the results of the 2005 monitoring program.

2.0 NORTH FORK ROCK DRAIN

The haul road between the Vangorda mining area and the Faro mill area was constructed as a dumped rock fill structure. This road crossed several creeks between the Faro and the Vangorda/Grum mine areas. The method selected for crossing the North Fork Rose Creek (NFRC) was to construct the haul road as a “rock drain”. The rock drain was constructed such that coarse fragments of clean waste rock were at the base of the road structure. These rocks would have the appropriate capacity to pass water through the void space (Golder 1986a). A copy of the original design drawing for the NFRD is shown in Figure 2. The following summarizes key design conditions:

1. The drain is to be constructed from calc-silicate rock. The remainder of the haul road could be constructed of schistose rock.
2. The design flood for this structure was the 100 year return period flood, 70 m^3/s.
3. The width of the drain was to be 70 m, centered on the pre-existing creek channel. That is, the portion constructed from calc-silicate rock.
4. The construction of the NFRD was to be accomplished by end-dumping the rock from the final road elevation, the final height was noted to be approximately 55 m. This method would result in natural sorting of the rock, with the largest rocks being at the base of the road and the fine material near the top.
5. The assumed slope of the upstream and downstream faces of the drain was 37°, the angle of repose for the calc-silicate rock.
6. For prediction purposes, the design considered that the drain would consist of the lower 3.6 m of the causeway. The ‘representative’ grain size was assumed to be 0.3 m, given the likely maximum particle size and an allowance for particle breakage due to the overlying weight of the rock fill.
7. In determination of the capacity of the drain, no flow was considered to occur within the upper portions of the rock drain (above 3.6 m). The routing analysis indicated that the 100 year flood would produce a 40 m deep pool on the upstream side of the drain and that the mean annual flow would result in an 11 m deep pool.

8. The downstream face of the drain (if left at the assumed angle of repose, 37º) was considered to be unstable under high flow rates, due to seepage forces. The design included the construction of a “fillet” of large diameter rock to be installed at the downstream toe. The “fillet”, which was intended to stabilize the toe with respect to seepage forces was to have a minimum slope of 3H:1V and extend at least to 15m above the toe of the drain. *Note that this fillet at the toe was not constructed*.
9. The original design intent was that the NFRD would be abandoned by construction of an emergency overflow spillway.

During the design phase, considerable discussion was provided concerning potential failure modes for rock drains, given the relative newness of the concept (Golder 1986a, Golder 1986b). As summarized in BGC 2006 the use of rock drains did not begin in North America until about 1982. The conclusions of the designer were that the drain would perform adequately, and that the flow capacity was conservatively selected.

Foundation Soil

The foundation soil conditions for the NFRD was not considered a key design parameter given the relative flatness of the ground (Golder 1986a) but were later investigated prior to construction (EBA 1987). Prior to the 1987 investigation the estimated foundation conditions for the drain were based on boreholes drilled approximately 400 m downstream of the site. The depth to bedrock at the site 400 m downstream was between 7.9 and 10.5 m (Golder 1986b).

The 1987 investigation (EBA 1987) consisted of excavating 5 test pits to a maximum depth of 6.0 m. The sub-soils were reported as consisting predominately of till as shown on the test pit logs included in Appendix A. A buried peat layer was encountered in 3 of the 5 test pits and alluvial silt, sand and gravel was encountered in test pit 1. Numerous boulders were encountered at all locations. At the time of the investigation (April), the ground encountered in the test pits was frozen. However, only at test pit 3 was the ground considered frozen below 2.5 m (the estimated depth of seasonal frost penetration). The seasonal frost contained up to 20% ice by volume. The permafrost at test pit 3 consisted of a “pliable soil” matrix with stratified and randomly oriented clear ice formations (up to 15% by volume).

Notes From Construction

During construction, one site visit was conducted by the design engineer (Golder 1987). During the inspection, placement of rock for the drain was temporarily halted. The face of the dump was about 20 m from the edge of the creek, within the proposed footprint of the NFRD. The rock encountered by the inspector was calc-silicate.

A review of the grain size of the material making up the NFRD was undertaken. A summary of the results is provided in Table 1 and a copy of the photos collected during this inspection is included in Appendix B “1987 construction photographs”. The rock within the lower 55 m of the advancing face of the NFRD was noted to be “remarkably clean”. Fines were noted only in the upper 10 m of the advancing face.

Table 1 Summary of Observed Particle Sizes during Construction

Location	D_{max}	D_{65}	D_{50}
Toe of dump	2 m[1]		1 m[1]
7 m above toe		0.5 m	0.3 m
10 m above toe	0.8 m[1]		0.4 m[1]
17 m above toe		0.5 m	0.15 m
55 m above toe		0.4 m[1]	0.2 m[1]

Note 1: Rock sizes estimated from 1987 photos by BGC for this study. Other estimates from the 1987 Golder report.
D_{max} is the maximum particle size.
D_{65} – 65% of the observed particles are smaller than this.
D_{50} is the mediam particle size.

The grain size of the material making up the rock drain was evaluated by BGC in 2004 and 2005. The grain size of the material at the toe of the drain was determined from photos taken of the rock fill material. Photos of the rockfill at the toe of the rock drain are shown in Figure C1 (Appendix C) and the resultant grain size curves are shown on Figure C2. The D_{50} of the rockfill was found to be in the range of 300 to 700 mm. The grain size from this assessment is similar to the range estimated from the 1987 construction photos from the toe area of the advancing dump face.

Two test pits were excavated into the crest of the NFRD in 2005, a copy of the test pit logs are included in Appendix D. Test pit TP05-04 was excavated directly above the center of the creek channel and TP05-03 was located near the low point in the crest of the haul road. Sieve analysis was performed on the samples collected from these test pits, the results are shown in Figure D3 (Appendix D). The D_{50} of the material was 35 to 45 mm and there were 10 to 16% fines (smaller than the No. 200 sieve) within the samples. The samples contained 40 to 44% finer than the U.S. No. 4 sieve and therefore do not meet the definition of ‘rockfill’ (BGC 2006). This is consistent with the observations made in 1987 that the upper 10 m of the waste embankment contained ‘fines’ (Golder 1987).

Construction of the NFRD created a barrier across the NFRC which (Figure 1) could be thought of as a dam, although flow through the structure keeps the resultant reservoir small under normal flow conditions. The actual and potential storage created behind this structure is presented as a storage capacity curve in Figure 3. This storage capacity curve was created based on a topographical contour plan based on air photographs. The pond elevation was estimated to be 1091 m amsl when the photograph was taken, the relationship below this must therefore be considered as a rough estimate. A longitudinal section view of the NFRD is shown in Figure 4 (note that the original ground surface was estimated based on 1979? Air photographs). The relationship (from the longitudinal section shown in Figure 4) between the elevation of the pond water and the vertical area available for water flow (the entire structure, not just the calc-silicate portion) is shown in Figure 5.

2005 Visual Inspection

No signs of overall instability problems were encountered during the 2005 inspections, similar to the observations in the annual geotechnical inspections performed since the NFRD was constructed. An overview of the upstream side of the NFRD is shown in Figure 6 and the downstream side in Figure 7. Surficial sloughing of the fine grained material stockpiled at the edge of the haul road has occurred (Figure 8). In some cases this material has flowed down the complete face of the rock dump, from the crest to the base. Some movement of the rock has occurred at the downstream toe (Figure 9) with the most obvious movement occurring immediately above the center of the old channel (where the majority of flow is concentrated). A small “hollow” has been created in the face of the drain (lower right hand photo in Figure 9) and it is thought that this was due to removal of material by water forces. The particle size that would have been removed from this location is estimated to be between 10 and 20 mm (based on the small particles remaining at the edge of the “hollow”).

Considerable organic debris, mainly consisting of conifer trees and branches, is located on the upstream face of the drain (Figure 10). In addition to the organic debris, sediment which consists mostly of silt sized particles has been deposited on the upstream face amongst the woody debris. Grass is growing in the sediment (Figure 11). The thickness of the sediment is approximately 100 mm at its greatest extent. Three samples of the sediment were collected and the grain size determined by hydrometer analysis (testing by Almor Laboratory). The results of the analysis (Figure 12) indicated that the sediment was silt with trace sand, trace clay. Prior to performing the hydrometer analysis the fibrous/vegetal material was removed in amounts ranging between 0.6 to 11.2% by weight.

3.0 MONITORING PROGRAM RESULTS

Monitoring information was collected at four sites as shown on Figure 1: R7, NFRC 20/21, Pond and NFRC22/23/X2.

Initially it was thought that the information collected upstream of the pond could be used in combination with the pond levels and the downstream flow to provide evidence of the peak flow attenuation of storm flow events though the NFRD. The magnitude of the spring freshet in 2005 was such that the data from these upstream stations was unusable. At station R7, flows above about 4 m^3/s become over bank but the rating curve developed for this site does not take this into account. Therefore the flow is under estimated. At the peak flood levels the pond formed behind the NFRD extended upstream to the Stations NFRC 20 and NFRC 21, overtopping the gauges. For lower flow levels the variations did not appear significant, with local losses to/gains from groundwater flow and errors in the flow measurements being more significant than any routing effects.

The discharge in NFRC was measured using in stream velocity meter on August 10, 2005 (Laberge), both upstream and downstream of the NFRD. The results from this day of discharge measurement are summarized in Table 2. It should be noted that stations NFRC SC-1 through NFRC SC-4 were monitored by Laberge as part of a separate study being performed by SRK Consulting. The locations of these stations are near the “S-cluster wells”, downstream of the NFRD and upstream of NFRC 22/23/X2.

Table 2 – Measured Flow in North Fork Rose Creek, August 10, 2005

Site Name	Time	Discharge, m^3/s
R7	11:15 am	1.206
NFRC 20/21	1:10 pm	1.114
NFRC SC-1	1:50 pm	1.656
NFRC SC-2	2:30 pm	1.346
NFRC SC-3	3:10 pm	1.496
NFRC SC-4	3:50 pm	1.510
NFRC 22/23/X2	5:00 pm	1.512
NFRC 22/23/X2	5:15 pm	1.563

All flows measured by Laberge Environmental Services

The water elevation of the pond was measured in 15 minute intervals using a datalogger. The water elevation of the pond was confirmed via the use of regular direct surveys of the water elevation from a benchmark. The regular surveys of the water elevation allowed corrections to be made to the datalogger elevations, as needed. The results of the pond elevation survey are shown in Figure 13. Included on Figure 13 are the average elevation of the driftwood and the top of the silt (average of four individual elevation measurements by YES in 2005). The overall base of pond elevation about 150 m upstream of the face of the NFRD is 1088.5 m amsl (2005 survey from one section of the pond). The elevation of the pond sensor in 2005 was 1087.9 m (2005 survey) and the base of the pond prior to the construction of the NFRD was 1086.5 m amsl (based on topography developed on 1974 airphotos).

The outflow from the NFRD was measured near the main access road (Figure 1), which allowed easy access to the stations for regular confirmatory readings to be collected. This location consisted of three staff gauges:

- NFRC 22, the upstream station located upstream of the culvert under the main access road,
- NFRC 23, the middle station located upstream of the culvert under the main access road,
- X2, the downstream station located on the outlet end of the culvert under the main access road (installed in 1993).

In addition to these three staff gauges a sensor with datalogger was located midway between stations NFRC 22 and 23. The sensor recorded the water elevation on 15 minute intervals. The elevation of the staff gauges were surveyed on a regular interval. The regular survey was used to correct the data for relative movements between the sensor and the staff gauges due to settlement or other disturbances (nhc 2006). At this station all the flow, even at the peak of the spring melt period, was confined within the channel making the developed rating curve valid throughout all river stages. The results of the flow measurement are shown in Figure 14.

The maximum discharge of 22.5 m^3/s at station X2 (downstream of the NFRD) in Figure 14 was noted as being calculated based on the upstream pond elevation. A comparison of the measured flow at station X2 (based on daily or twice daily staff gauge readings) and the computed flow at station X2 from the pond elevation is shown in Figure 15. The computed discharge was developed based on the elevation versus discharge relationship shown in Figure 16.

A comparison of the measured pond elevation (Figure 13) and measured downstream flow (Figure 14) on a month by month basis are shown in Appendix D. Based on an inspection of these figures a correlation between the pond level and the resultant flow is clear. A plot of all of the pond elevation data versus the corresponding discharge (at the same time interval) is shown in Figure 16. The majority of the data is concentrated between elevations 1089.5 and 1093.3 m amsl or flows between 1 and 6 m^3/s, this has resulted in variation in the correlation between the pond elevation and resultant flow in the range. The same type of fluctuation would be expected for the higher discharge values if more data were available. The data is plotted in Figure 17 with most of the data points below elevation 1093 m amsl removed to show the general trend of the flow through relationship for the structure.

The water exit elevation on the downstream toe of the drain was measured at various times throughout 2005. For each individual survey event either four or five individual points were collected at varying locations across the seepage face. Generally the survey at the toe was performed immediately following a survey of the upstream pond elevation. The results of this surveying are shown in Figure 18. The three data points in early May 2005 show a marked difference from the rest of the data collected. In early May 2005 ice was noted within the void spaces of the rock on the downstream toe and it is thought that the high water elevations measured at this time (both in the pond and at the toe) was due to ice blockage of a portion of the drain. The estimated flow in early May 2005 was similar to that measured in July and August.

The results presented in Figure 18 have been re-plotted in terms of the measured gradient through the NFRD versus the pond elevation in Figure 19. To create this plot the elevation difference between the pond and the exit point was divided by the flow length (210 m) and plotted versus pond elevation. In this plot the three data points collected in May under ice conditions are obviously different than the summer and fall flow. In this figure one other ‘outlier’ is noted, which is data from late June which is most likely due to survey error since minus the ice effects and this single outlier a linear relationship exists between the pond elevation and the resulting gross gradient through the structure.

4.0 DISCUSSION

The purpose of the measurement program undertaken in 2005 was to obtain an assessment of the flow through characteristics of the NFRD. The flow through relationship for the NFRD is well established below about 1093 m amsl where most of the data is available. The flow through above pond elevation 1093 m amsl up to 1096.5 m amsl has been measured during 2005, but not repeatedly as below 1093 m amsl. Memorandum number 3 of this series will attempt to define the current relationship for pond elevations above those experienced to date. The extension of the flow through relationship is complex given the amounts of unknown parameters.

It is expected that the comparison of the theoretical background presented previously (BGC 2006) with the measured flow through relationship will be difficult due to:

- The elevation discharge is defined in the elevation range of 1089.3 to 1096.5 m amsl with the best definition below 1093 m amsl.
- The elevation of the base of the pond is estimated based on topographic information resolved to 25 foot intervals which were developed from air photographs. The elevation defined as the base of the pond is subject to uncertainty.
- The storage capacity curve above 1091 m amsl was developed from topographic information (2 m contours) from air photographs. This curve should be reliable above elevation 1091 m amsl with the error resulting from the methodology having little influence on the estimate volume. The pond elevation was estimated to be 1091 m amsl when the air photograph was taken, therefore below this elevation the storage curve will not be accurate.
- The area available for flow through is based on air photo topographic information which was resolved into 2 m contours (the current topographic information) and 25 foot contours for the pre-mine. It is thought that this resolution should not result in significant errors in the calculated area for flow though for elevations greater than about 1097 m amsl (estimated flow through area of 1000 m^2). Below elevation 1093 m amsl the potential errors become more significant, and at very low elevations maybe as much as 100% of the estimated area.
- The velocity of the water flowing through the drain is unknown, therefore comparisons to velocities predicted by theory will not be possible.

In summary the elevation versus discharge information is known for pond water elevations below 1096.5 m amsl. Reasonably accurate storage capacity is available for pond elevation above 1091 m asml. Also reasonably accurate on the wetted flow area is available only above about 1093 m amsl. Based on this combination of know flow information and unknows related to volumes and areas, detailed back analysis using the theory's previously presented (BGC 2006) may not be successful.

5.0 CONCLUSIONS

This memorandum has presented the results of the 2005 monitoring program. This data will be used in later memoranda along with the theoretical background presented previously (BGC 2006) to gain an understanding of the performance of the NFRD as compared with other similar structures. The use of this data and the theoretical framework will be discussed further in Memorandum 3 and 4.

REFERENCES

BGC Engineering Inc. 2006 Flow through Rockfill – Theoretical Basis: Rev A for review. Technical memorandum submitted to Faro Mining Closure Planning Office, January 2006. 8 pages plus figures

EBA Engineering Consultants Ltd. 1987 Foundation Evaluation proposed rockfill causeway, North Fork Rose Creek, Curragh Mine, Faro, Y.T. Report submitted to Curragh Resources, April 1987. 4 pages plus figures and appendices

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Golder Associates Ltd., 1986b. Letter to Curragh Resources Inc. Re: Proposed Rock Drain, North Fork Rose Creek. Letter submitted to Curragh Resources, December 31, 1986. 10 pages plus figures.

Golder Associates Ltd., 1987a. Foundation Evaluation, Proposed Rockfill Causeway, North Fork – Rose Creek, Curragh Mine, Faro, Y.T. Report submitted to Curragh Resources Ltd., April, 1987. 4 pages plus figures and appendices.

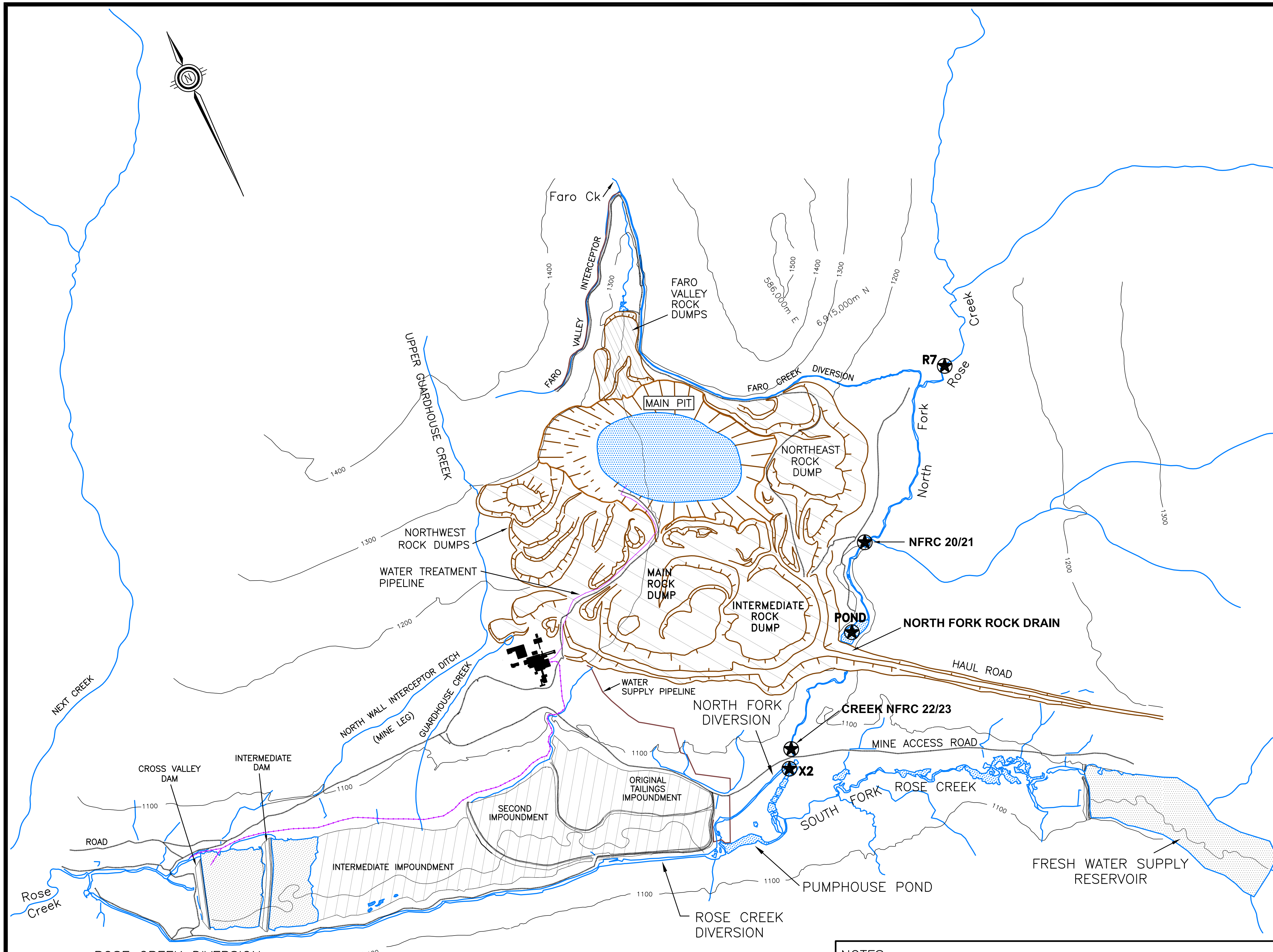
Golder Associates Ltd., 1987b. Letter Report to Curragh Resources Ltd.. Re: Inspection of North Fork Rock Drain. Report submitted to Curragh Resources, May 7, 1987. 3 pages plus figures and appendices.

Hansen, D., Garga, V.K. and Townsend, D.R. 1995 Selection and application of a one-dimensional non-Darcy flow equation for two-dimensional flow through rockfill embankments. Canadian Geotechnical Journal; 32: 223 – 232.

Northwest Hydraulic Consultants 2006 Memorandum concerning the measured flow

Wilkins, J.K. 1956 Flow of water through rockfill and its application to the design of dams. Proceedings of the 2nd Australian New Zealand Conference on Soil Mechanics and Foundation Engineering, 141 – 149.

FIGURES



600m 0 600m 1.2km 1.8km

Scale

NOTES:

1. BASE MAP SUPPLIED BY THE ORTHOSHOP, JANUARY 1991
2. NORTH AMERICAN DATUM 1927
3. CONTOUR INTERVAL 100m
4. UNIVERSAL TRANSVERSE MERCATOR PROJECTION
5. MAP IS A COMPOSITE OF 9 BASEMAPS

0257-031-03 001 Fig 2.dwg

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LEGEND:

- ROADS
- EXISTING DRAINAGE
- ORIGINAL DRAINAGE
- EFFLUENT PIPELINE
- PIPELINE
- WATER MONITORING SITE

REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED

SCALE:	AS SHOWN
DATE:	JANUARY 2006
DRAWN:	REM
DESIGNED:	GWF
CHECKED:	GWF
APPROVED:	JWC

PROJECT: TASK 22F–2005 ROCK DRAIN ANALYSIS

TITLE: SITE PLAN

PROJECT No.	FIGURE No.	REV.
0257–031–01	1	A

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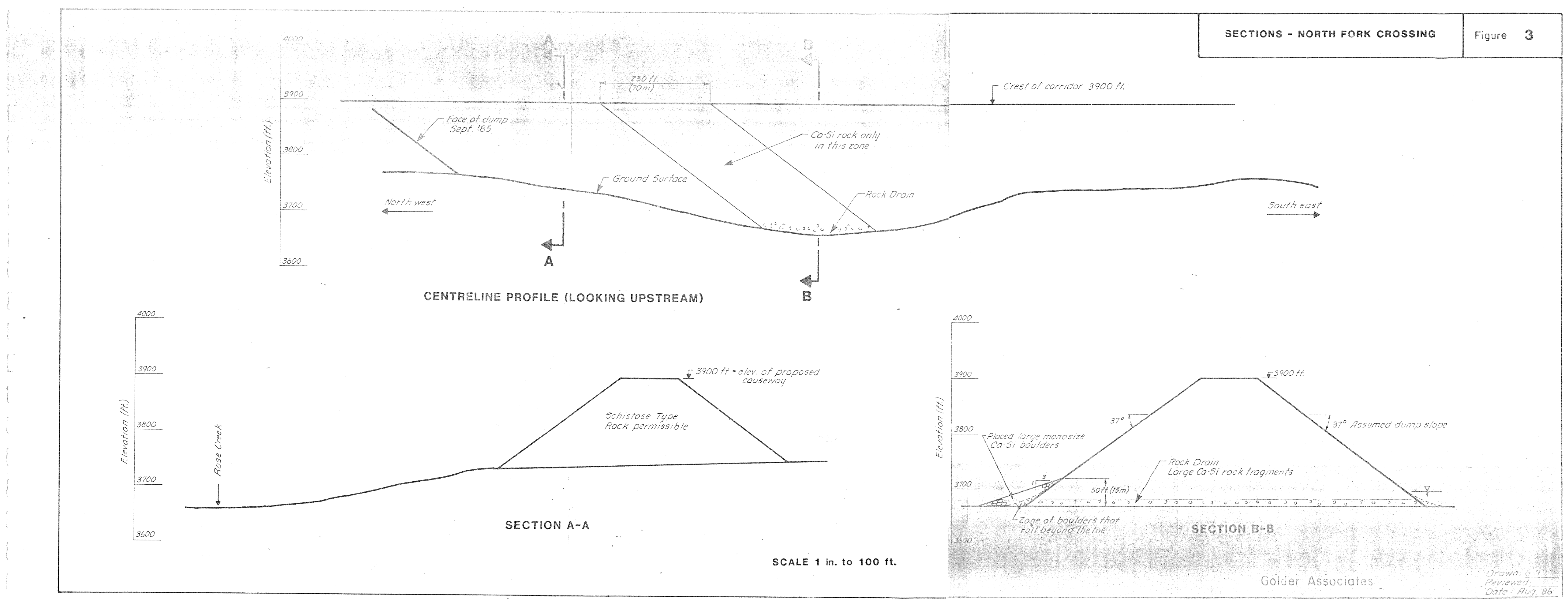

Source: Report No. 2 to Curragh Resources Corporation Re: Proposed rock drain, north fork, Rose Creek Faro, Yukon Golder Associates, September 1986.

CLIENT:

Deloitte & Touche

REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED

SCALE:	AS SHOWN
DATE:	JAN 2006
DRAWN:	REM
DESIGNED:	GWF
CHECKED:	HHH
APPROVED:	

PROJECT
TASK 22F–2005 ROCK DRAIN ANALYSIS

TITLE
1986 DESIGN PLAN AND SECTION

PROJECT No.	FIGURE No.	REV.
0257–031–01	2	A

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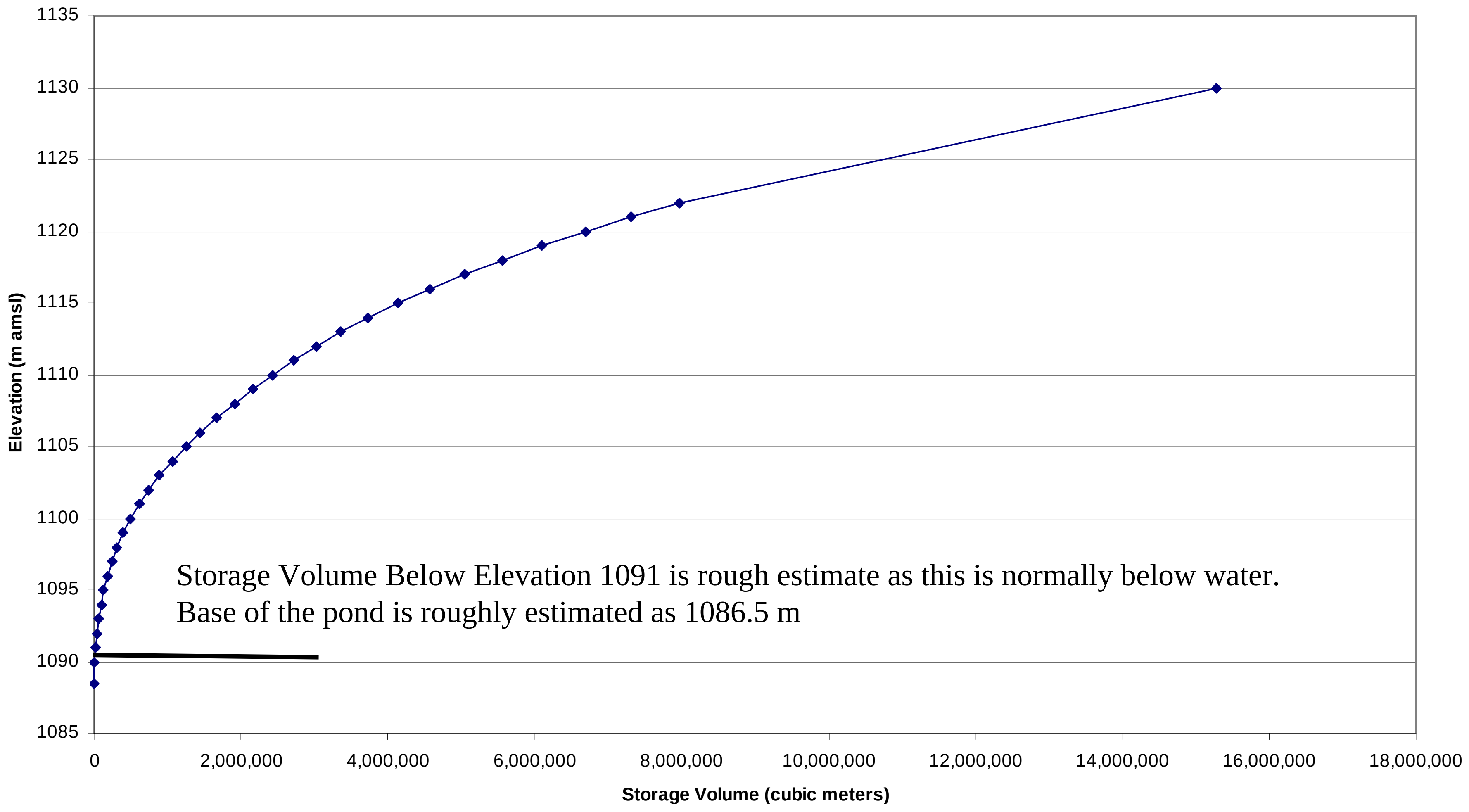
0257–031–01 001 Rock.dwg



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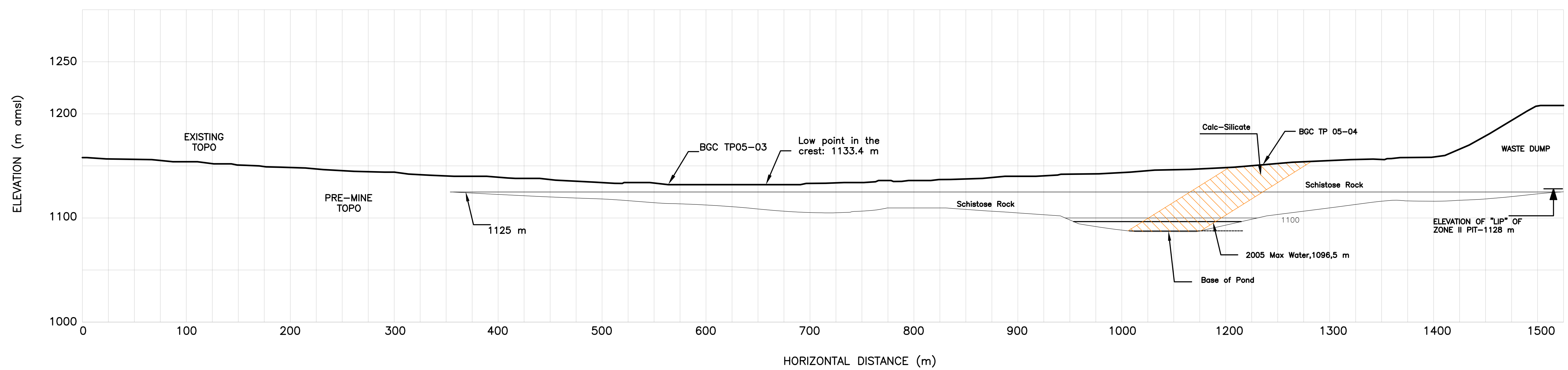
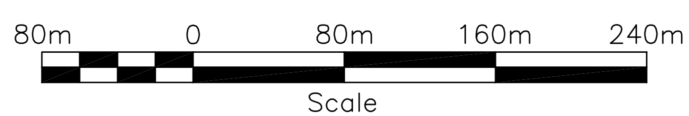
Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS					
Title: STORAGE CAPACITY CURVE – NFRD POND					
Project #: 0257-031-01	Date: JAN 2006	Scale: NA	Drawn: GWF	Approved:	Figure: 3





NOTE:

1. EXISTING AND CURRENT TOPOGRAPHIC INFORMATION FROM SRK 2003.
2. LOCATION OF CALC-SILICATE PART OF EMBANKMENT FROM GOLDER 1986 a.
3. ELEVATION OF "LIP" OF ZONE II PIT TAKEN FROM RBC 1996.
4. THE HORIZONTAL LINE DRAWN AT ELEVATION 1125 m amsl IS THE PRESUMED MAXIMUM ALLOWABLE WATER ELEVATION TO PREVENT WATER FLOW INTO THE ZONE II PIT.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE	AS SHOWN
DATE	JAN 2006
DRAWN	REM
DESIGNED	GWF
CHECKED	HHH
APPROVED	

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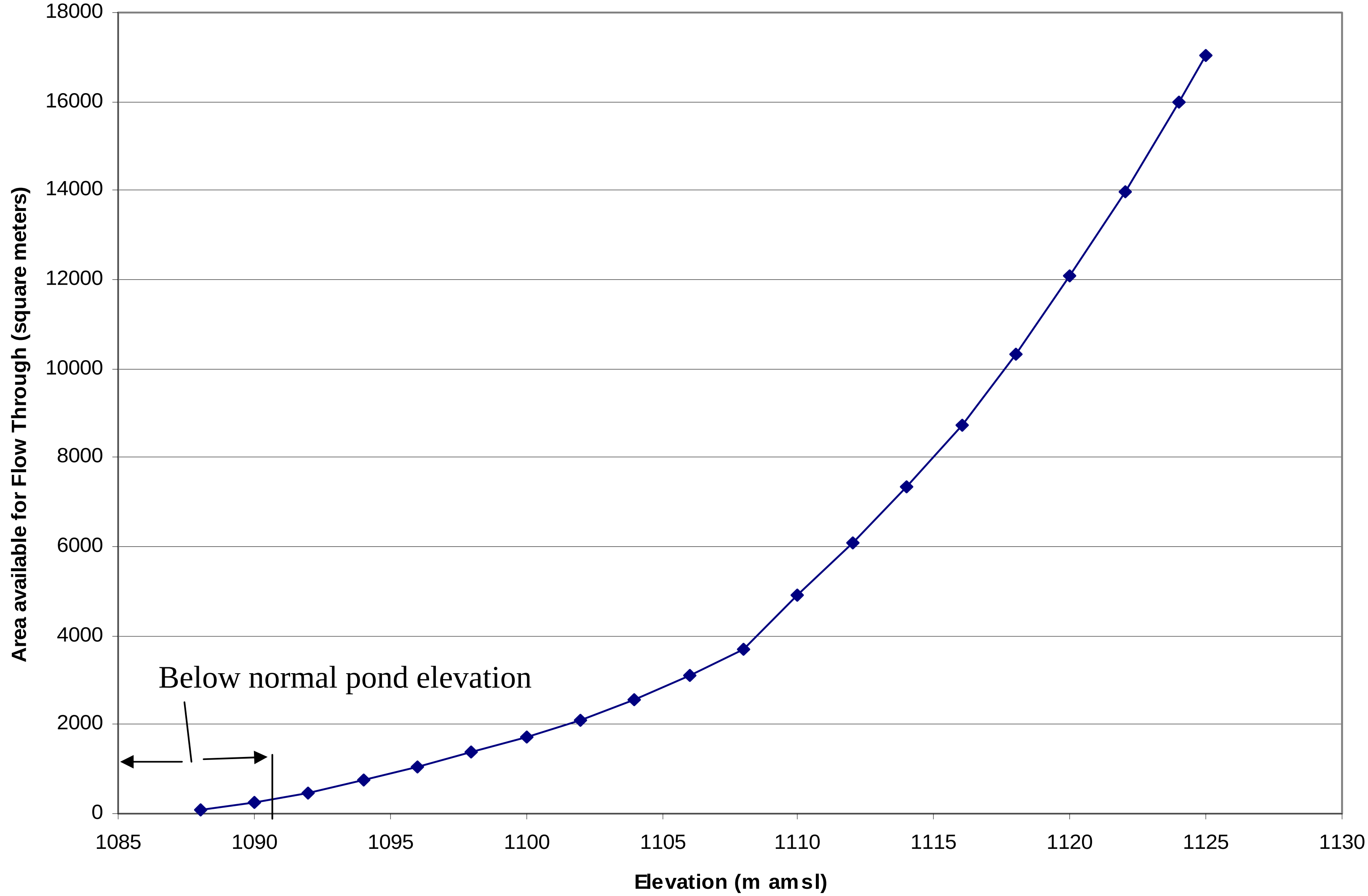
PROJECT
TASK 22F-2005 ROCK DRAIN ANALYSIS

TITLE
SECTION THROUGH HAUL ROAD

PROJECT No.	FIGURE No.	REV.
0257-031-01	4	A

0257-031-03 001 FIG 9.dwg



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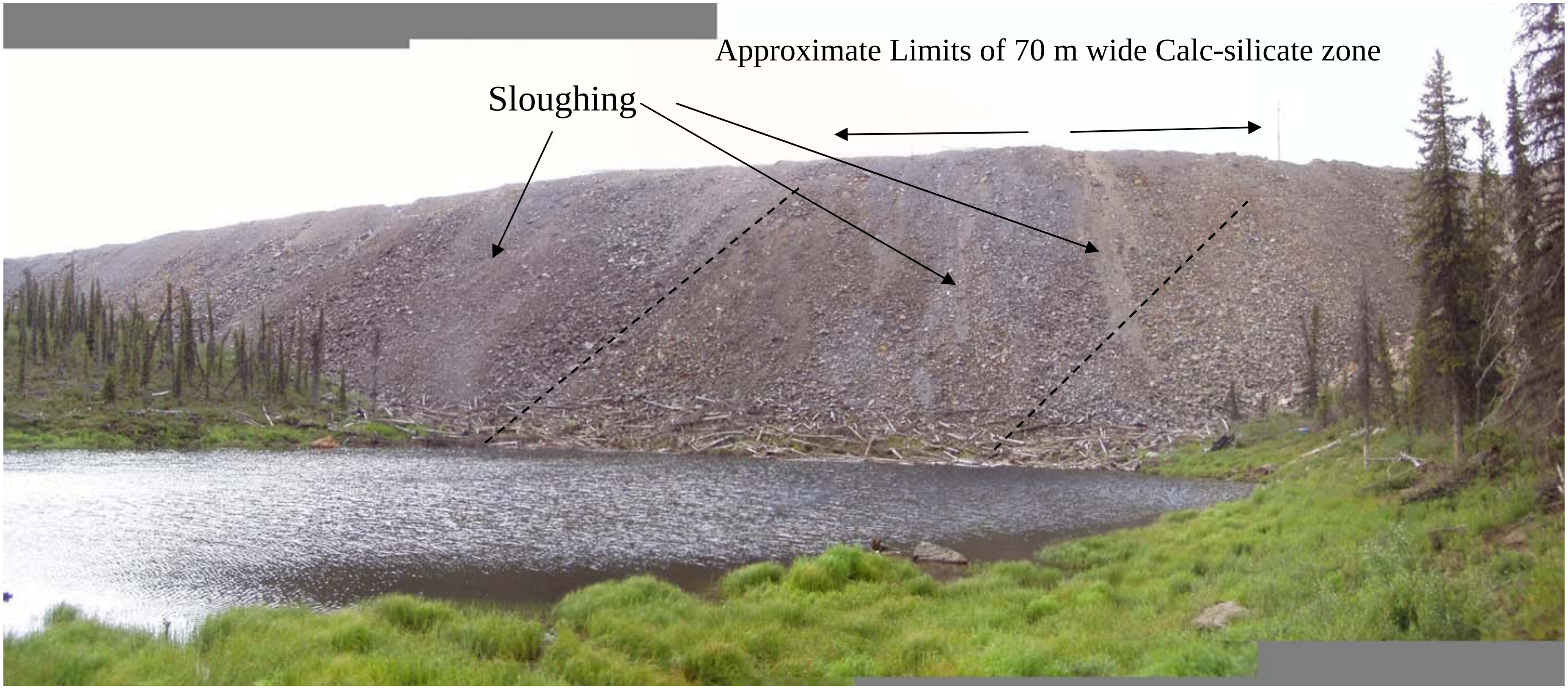
Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: FLOW THROUGH AREA OF EMBANKMENT

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	5



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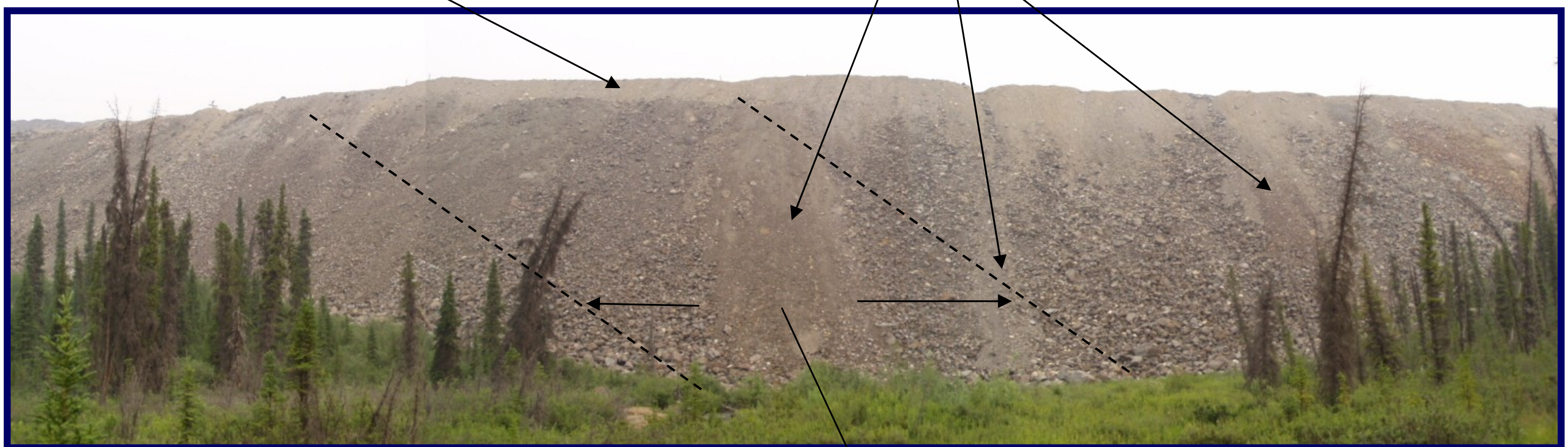
Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: UPSTREAM SIDE OF NFRD

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	6



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Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: DOWNSTREAM SIDE OF NFRD

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	7

Crest of Haul Road

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Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: SLOUGHING ON FACE OF EMBANKMENT

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	8

Downstream face of drain in the Calc-silicate zone, much finer material in this local area likely due to sloughing down the face. The finer material has been moved by water flow.

Discharge between 1.5 and 2 m^3/s

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Project:	TASK 22F – 2005 ROCK DRAIN ANALYSIS				
Title:	DOWNSTREAM TOE AREA				
Project #: 0257-031-01	Date: JAN 2006	Scale: NA	Drawn: GWF	Approved: -	Figure: 9

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AN APPLIED EARTH SCIENCES COMPANY
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Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS					
Title: WOODY DEBRIS ON THE UPSTREAM FACE OF NFRD					
Project #: 0257-031-01	Date: JAN 2006	Scale: NA	Drawn: GWF	Approved: -	Figure: 10

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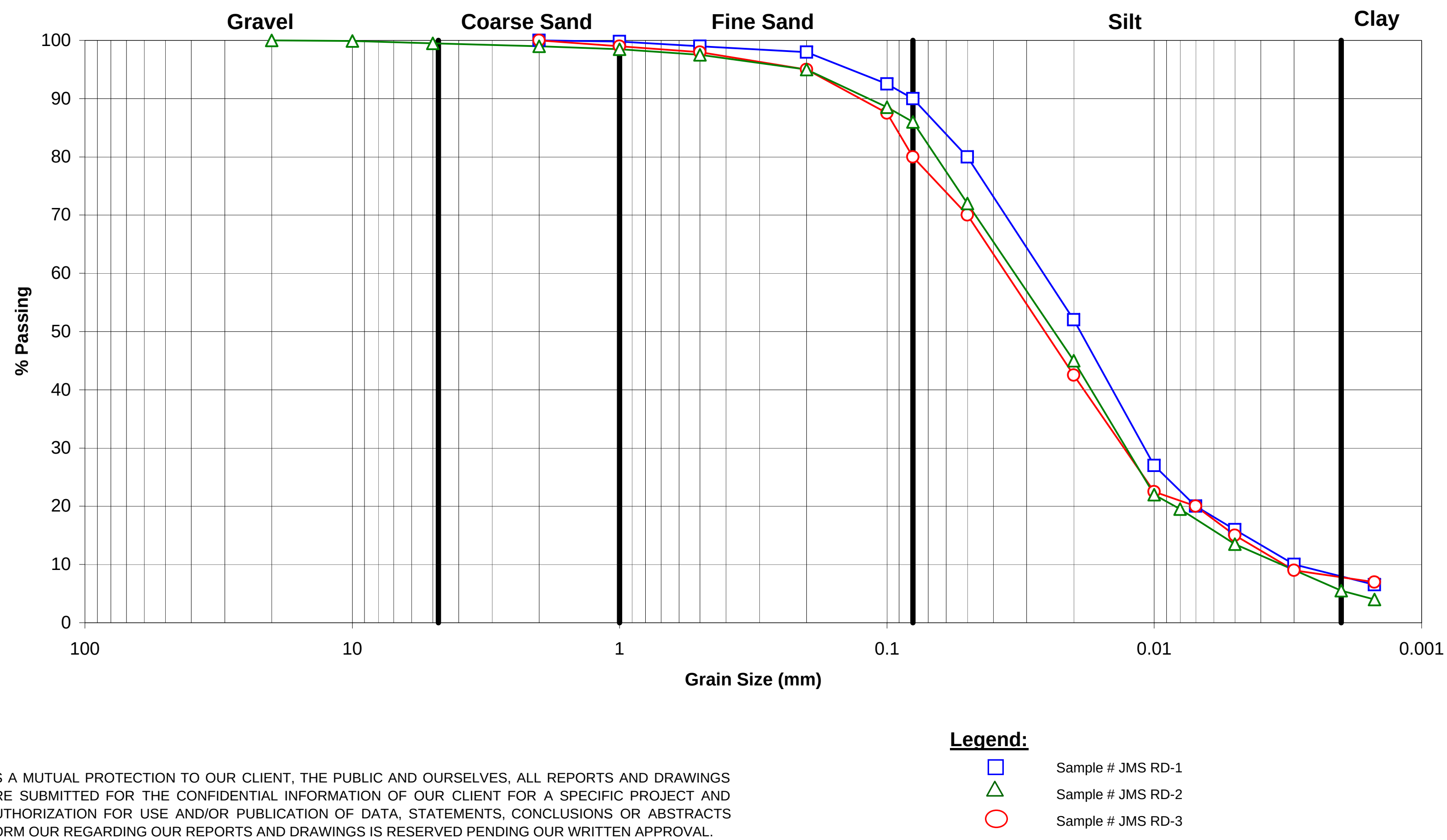
Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: SEDIMENT AND VEGETATION ON THE UPSTREAM FACE OF NFRD

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	11



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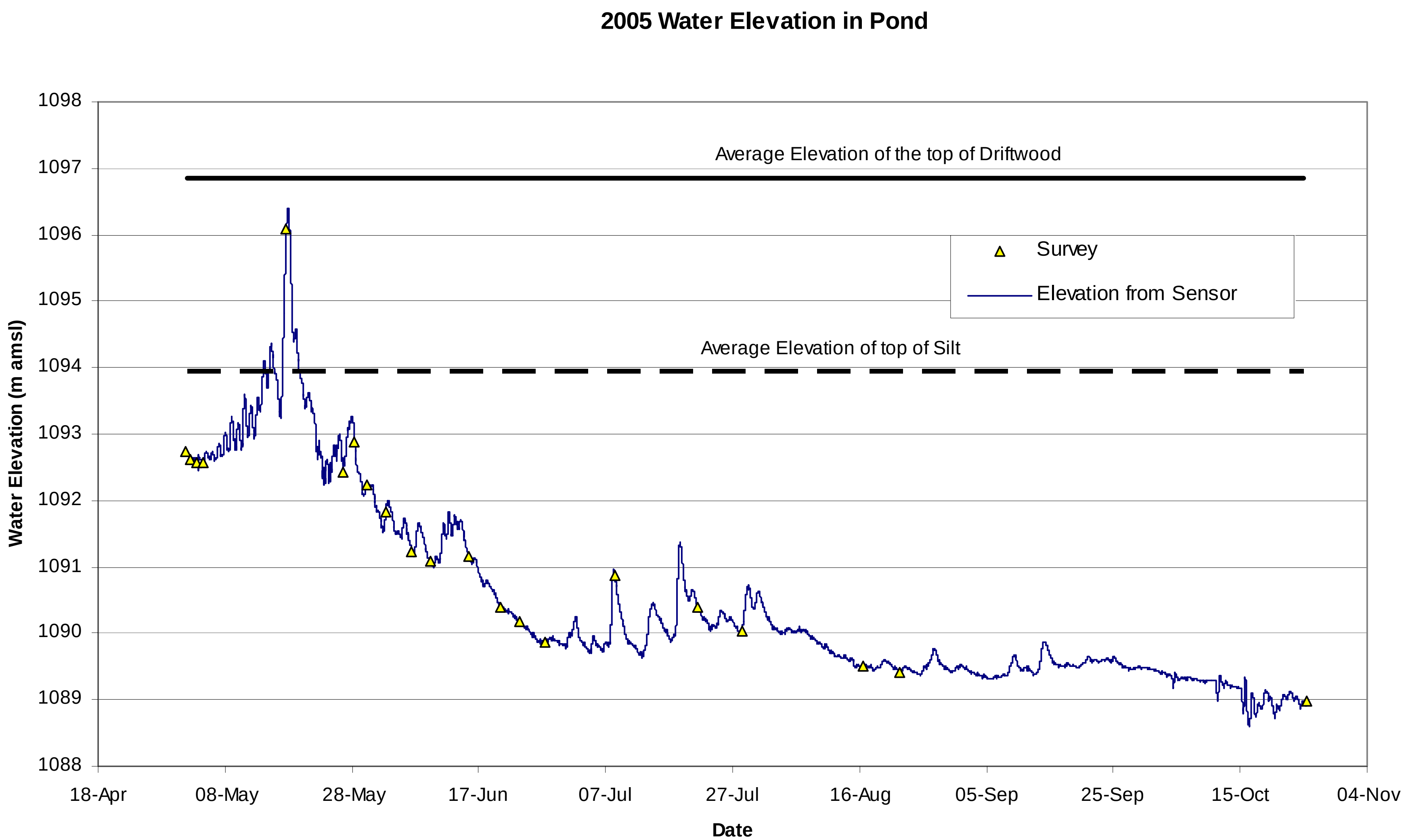
CLIENT: **Deloitte & Touche**

PROJECT: **Task 22F - 2005 Rock Drain Analysis**

TITLE: **Grain Size Analysis of Pond Sediment from Upstream Face of NFRD**

PROJECT NO. **0257-031-01**

FIGURE. NO. **12**



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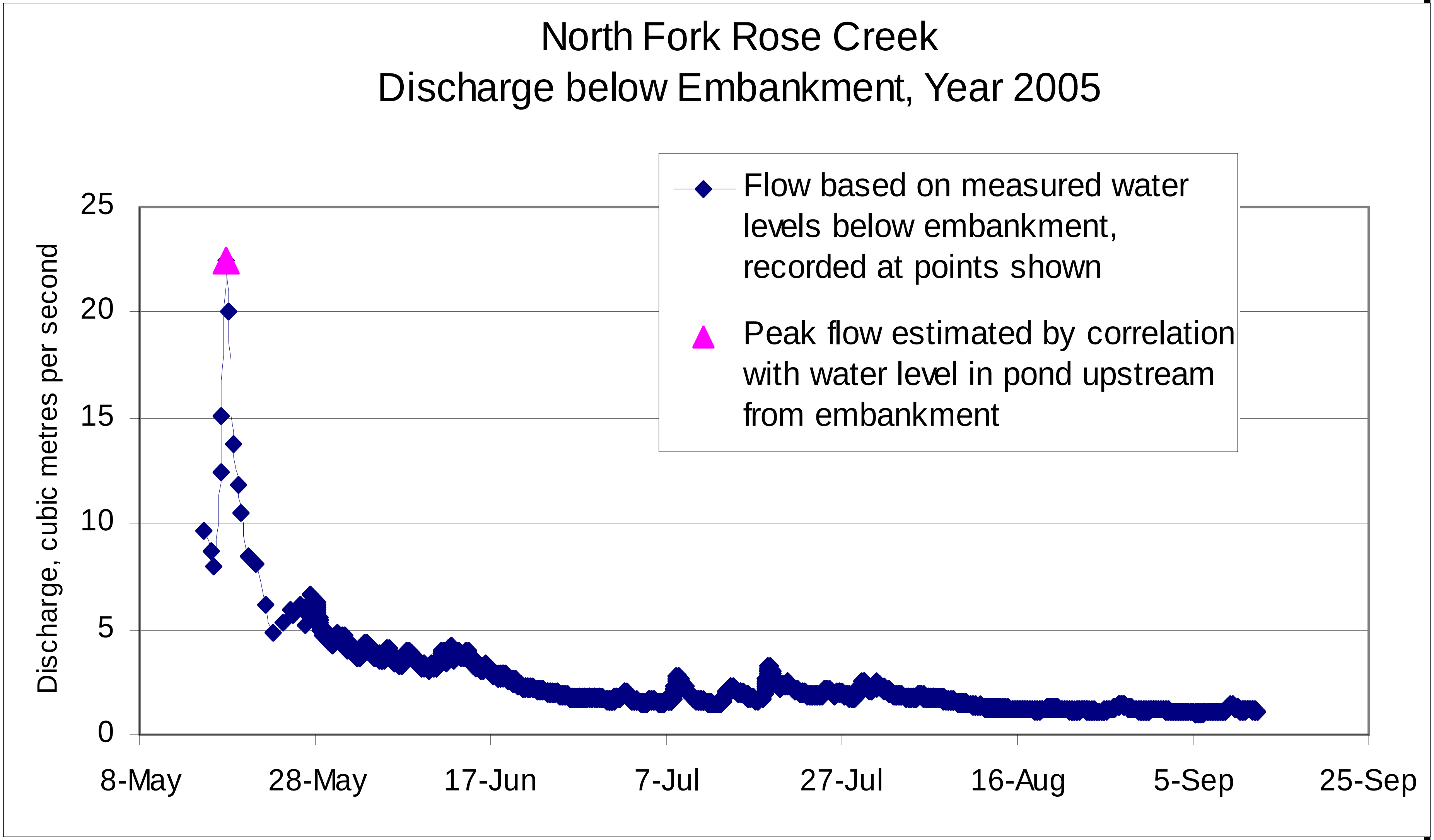
Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: POND WATER ELEVATIONS

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	13



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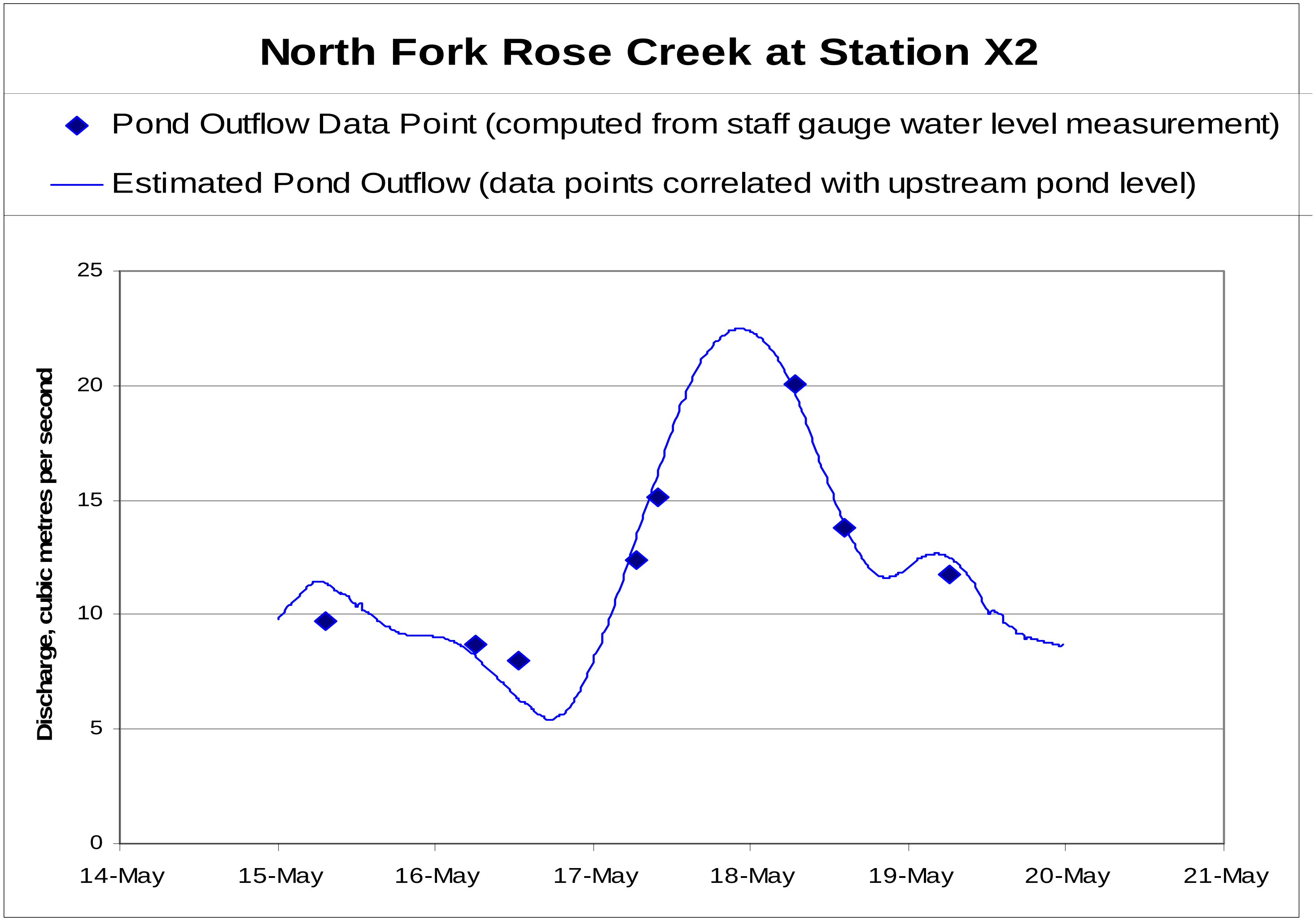
Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS					
Title: DISCHARGE DOWNSTREAM OF ROCK DRAIN					
Project #: 0257-031-01	Date: JAN 2006	Scale: NA	Drawn: GWF	Approved: -	Figure: 14



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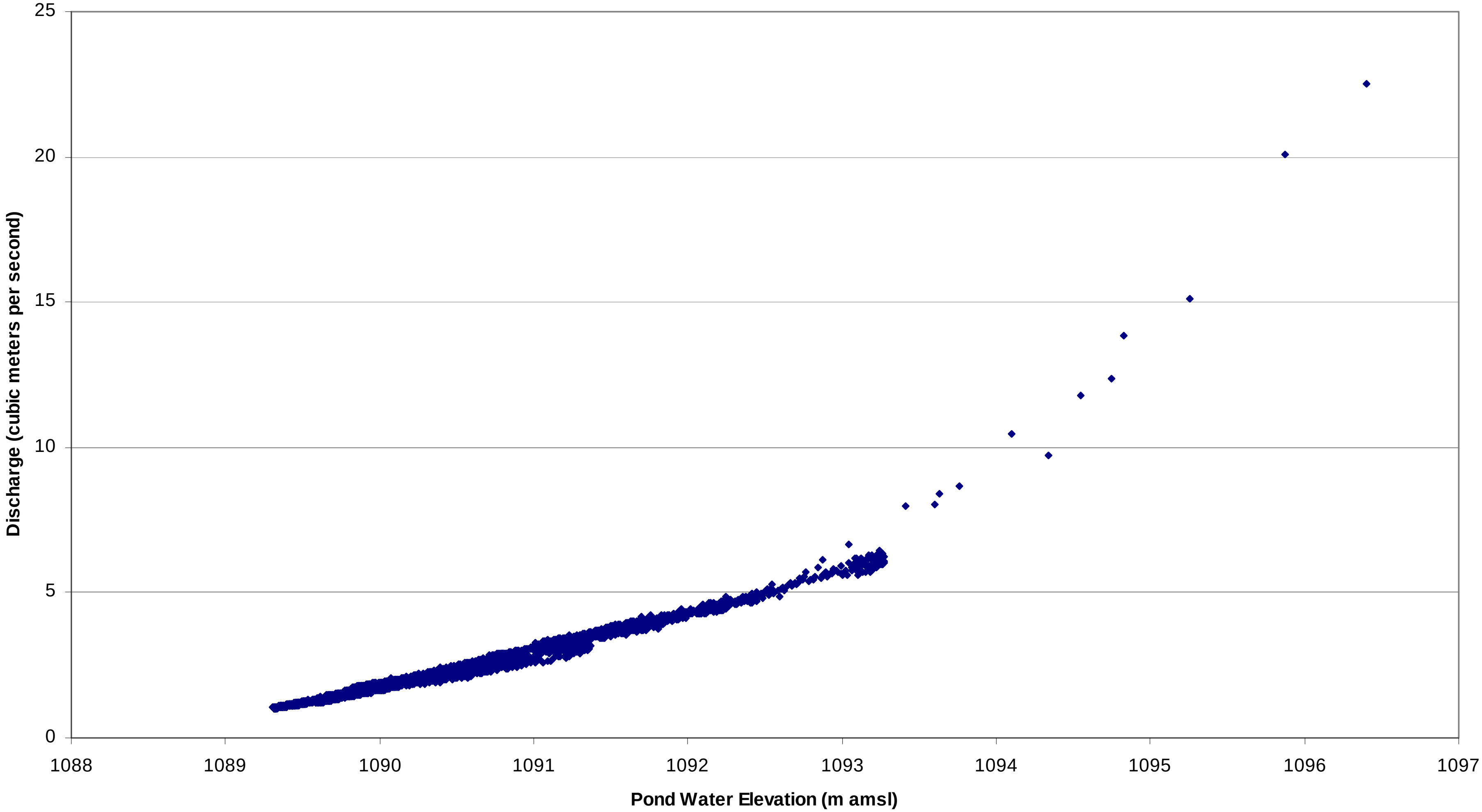
Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: COMPARISON OF PREDICTED DISCHAGE BELOW NFRD BASED ON POND ELEVATION AND MEASURED DISCHARGE

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	15



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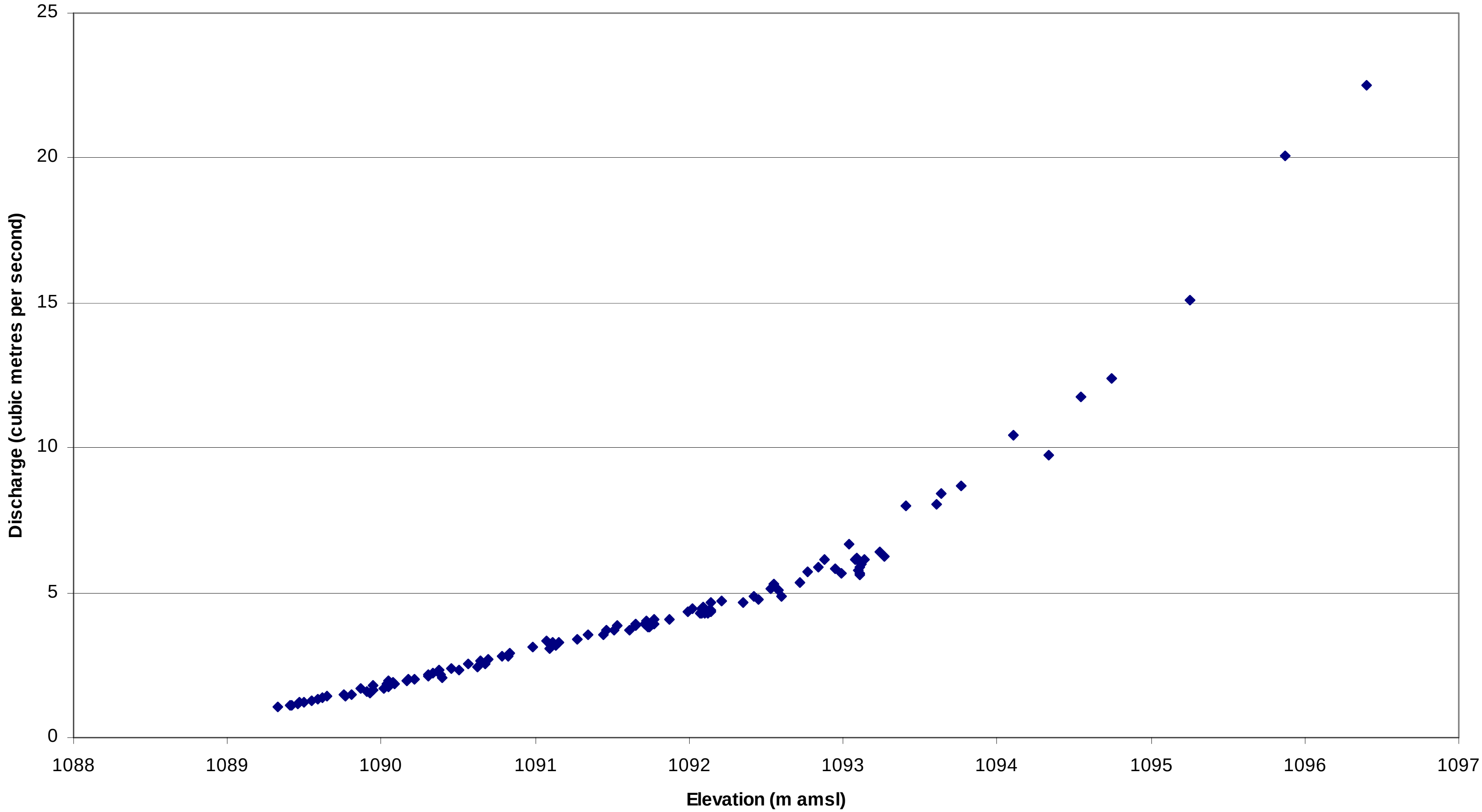
Client: Deloitte & Touche

Project:	TASK 22F – 2005 ROCK DRAIN ANALYSIS
Title:	DISCHARGE VERSUS POND ELEVATION – ALL DATA

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	16



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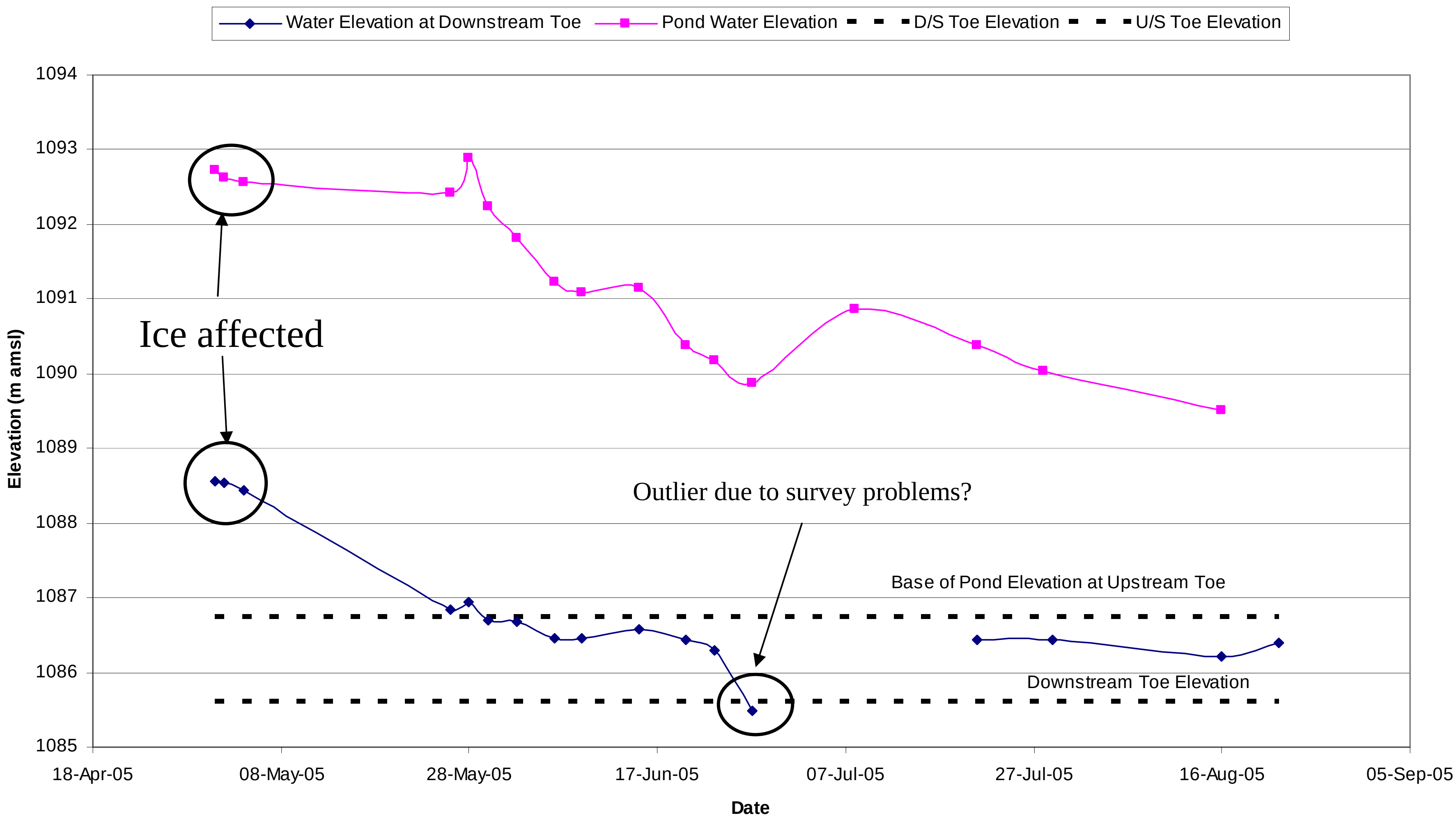
Phone: (403) 250-5185

Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS

Title: DISCHARGE VERSUS ELEVATION – REDUCED DATASET

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	17



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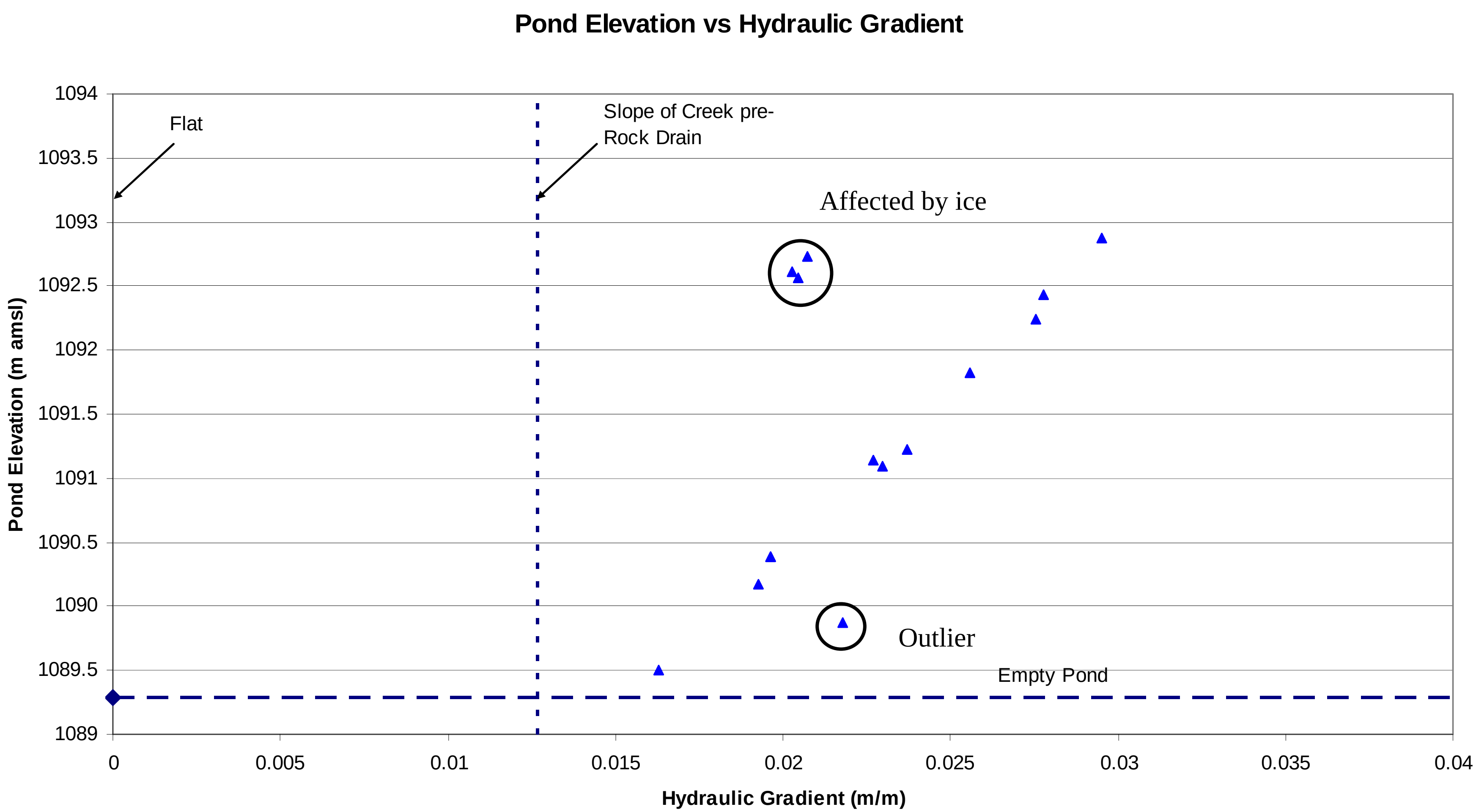
Phone: (403) 250-5185

Client: Deloitte & Touche

Project: TASK 22F – 2005 ROCK DRAIN ANALYSIS					
Title: MEASURED WATER ELEVATION AT NFRD					
Project #: 0257-031-01	Date: JAN 2006	Scale: NA	Drawn: GWF	Approved: -	Figure: 18



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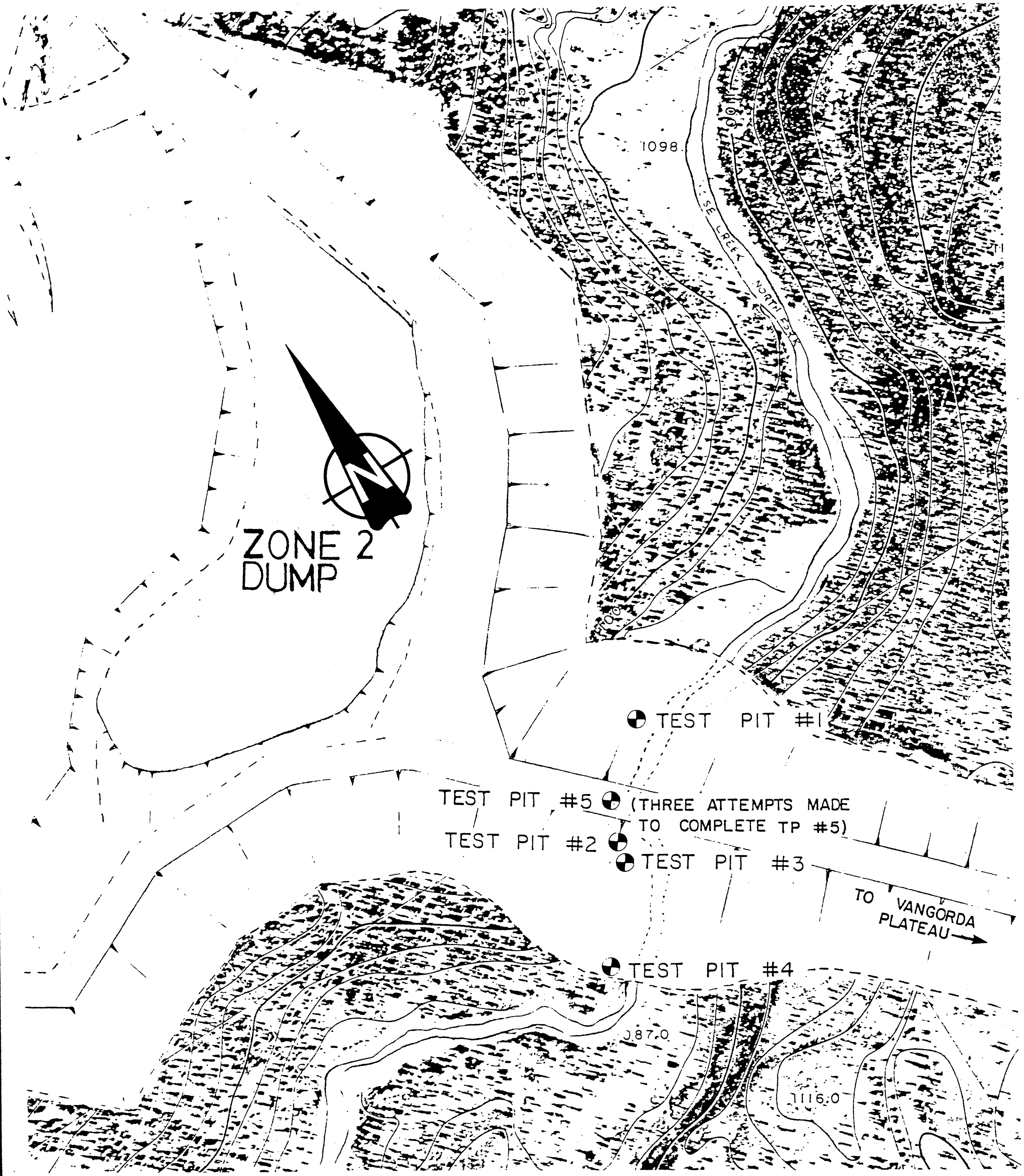
Phone: (403) 250-5185

Client: Deloitte & Touche

Project:	TASK 22F – 2005 ROCK DRAIN ANALYSIS
Title:	MEASURED GRADIENT THROUGH NFRD

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF	-	19

APPENDIX A
1987 TEST PIT LOGS
(EBA 1987)

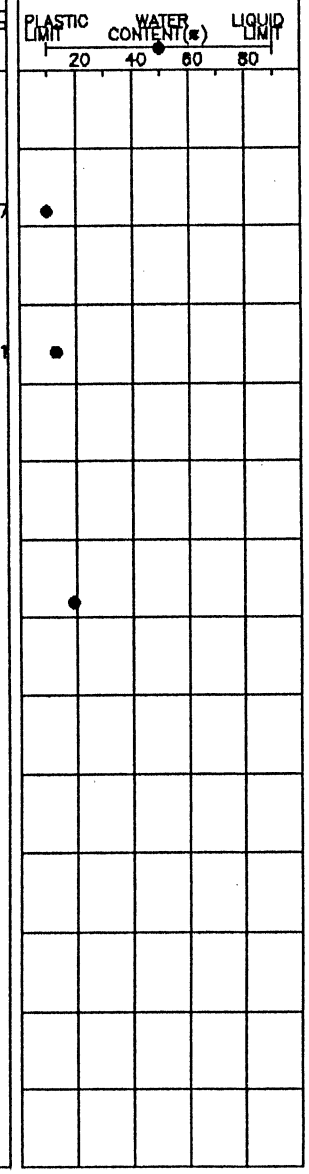


EBA Engineering Consultants Ltd.	PROJECT ROCKFILL CAUSEWAY - PERMAFROST EVALUATION
CLIENT CURRAGH RESOURCES LTD.	TITLE SITE PLAN & APPROXIMATE TEST PIT LOCATIONS
DATE 1987-04-22 DWN WAS CHKD	DWG NO. 4661-A-1 0201-4661

PROJECT NUMBER: 0201-4661 | CLIENT: CURRAGH RESOURCES LTD.

COMPLETION DEPTH: 5.5 m | LOGGED BY: MAV | EQUIPMENT USED: CAT 245 BACKHOE

SAMPLE TYP	SAMPLE NO.	SAMPLE Q	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMP C
			PEAT(Pt)—moss,rootlets and organic silt; frozen due to seasonal frost; very dark brown to black	Frozen	
GRAB	1		SAND TILL(SM)—gravelly,some silt,trace clay;with occasional cobbles and boulders throughout;quartz and schist fragments;iron oxide staining;subrounded to subangular gravel —silt content increasing with depth		−0.7
GRAB	2		—with randomly orientated ice formations (Vr Vc 5–10%) —seasonal frost to 2.0 m —ground water infiltrating sidewall of test pit	Vr Vc 5–10%	−0.1
			PEAT(Pt) AND ORGANIC SILT—with decayed organic matter;strong organic odour;black		
			SAND(SM)—silty;coarse to fine-grained sand;wet;nonplastic;orange		
GRAB	3		SILT(ML)—trace of fine-grained sand; with mica platlets disseminated throughout;uniform;homogeneous; wet;nonplastic;dark grey		
			GRAVEL(GM)—sandy,some silt;with occasional cobbles/boulders throughout; rounded to subrounded,smooth gravel;wet;orange		
			END OF TEST PIT 5.5 m TEST PIT TERMINATED DUE TO SLOUGHING SOILS		



SPECIAL TESTS | UNIT

DEPTH (m): 0 1 2 3 4 5 6 7

DEPTH (ft): 0 2 4 6 8 10 12 14 16 18 20 22

ROCKFILL DRAIN—PERMAFROST EVALUATION
NORTH FORK ROSE CREEK
FARO, YUKON
DATE EXCAVATED: 1987-04-10

SAMPLE TYPE: SHELBY | NO RECOVERY | SPT | GRAB | CRREL | CORE

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE YUKON

DRAWING NUMBER 4661-A-2

BOREHOLE NUMBER 4661-1

BOREHOLE LOG AND LABORATORY TEST RESULTS

PROJECT NUMBER: 0201-4661
CLIENT: CURRAGH RESOURCES LTD.
COMPLETION DEPTH: 1.4 LOGGED BY: MAV
EQUIPMENT USED: CAT 245 BACKHOE

SAMPLE TYP	SAMPLE NO.	SAMPLE Q	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMP	PLASTIC LIMIT / WATER CONTENT (%) / LIQUID LIMIT (20, 40, 60, 80)		SPECIAL TESTS	UNIT
			PEAT(Pt)—moss,rootlets,and organic silt; with occasional cobbles through-out;with stratified and randomly orientated ice formations (Vr Vs 30%), ice lenses to 20 mm thick;dark brown	Frozen					
			VOLCANIC ASH—with stratified and randomly orientated clear ice formations, ice lenses to 3 mm thick;white —boulders encountered						
			PEAT(Pt)—and fibrous organics;dark brown —boulders encountered,unable to penetrate past 1.4 m						
			END OF TEST PIT 1.4 m TEST PIT TERMINATED DUE TO COBBLES AND BOULDERS.						

DEPTH (m): 0 1 2 3 4 5 6 7

DEPTH (ft): 0 2 4 6 8 10 12 14 16 18 20 22

ROCKFILL DRAIN—PERMAFROST EVALUATION
NORTH FORK ROSE CREEK
FARO, YUKON
DATE EXCAVATED: 1987-04-10

SAMPLE TYPE
SHELBY
NO RECOVERY
SPT
GRAB
CRREL
CORE

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE YUKON
DRAWING NUMBER
4661-A-3

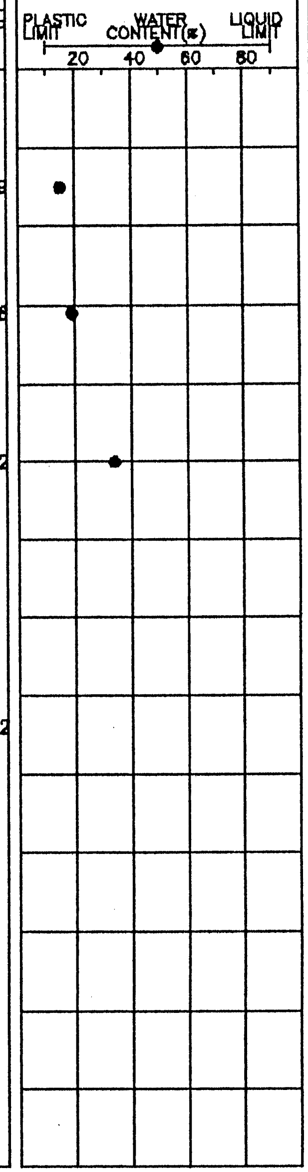
BOREHOLE NUMBER
4661-2

BOREHOLE LOG AND LABORATORY TEST RESULTS

PROJECT NUMBER: 0201-4661 COMPLETION DEPTH: 6.0 m LOGGED BY: MAV

CLIENT: CURRAGH RESOURCES LTD. EQUIPMENT USED: CAT 245 BACKHOE

SAMPLE TYP	SAMPLE NO.	Q	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMP C
			PEAT(Pt)—moss and rootlets at surface; with fibrous organics and organic silt;brown —with occasional cobbles —with occasional lenses of volcanic ash	Frozen	
GRAB	1			Vr 5–10%	−0.8
			SAND TILL(SM) AND SILT—trace gravel,trace clay;with occasional cobbles throughout;subrounded to angular gravel;with randomly orientated ice formations (Vr 5–10%) to 2 mm thick;iron oxide staining;low plastic;olive grey		
GRAB	2		—with stratified ice formations (Vs 40%) to 10 mm thick	Vc Vs 5%	−0.6
GRAB	3		—gravelly,trace organics;with stratified ice formations (Vs Vc 5%) —cobbles —with stratified and randomly orientated clear ice formations (Vr Vs 15–20%);olive —easy digging with backhoe;soil is pliable with clear ice lenses	Vr Vs 15–20%	−0.2
GRAB	4		—ice lenses to 5 mm thick (Vr Vs 15%)	Vr Vs 15%	−0.2
			END OF TEST PIT 6.0 m TEST PIT TERMINATED DUE TO SLOUGHING SOIL AT 2.9 m. GROUND WATER INFILTRATING TEST PIT.		



SPECIAL TESTS | UNIT

DEPTH (m): 0 1 2 3 4 5 6 7

DEPTH (ft): 0 2 4 6 8 10 12 14 16 18 20 22

ROCKFILL DRAIN—PERMAFROST EVALUATION
NORTH FORK ROSE CREEK
FARO, YUKON
DATE EXCAVATED: 1987-04-11

SAMPLE TYPE: SHELBY, NO RECOVERY, SPT, GRAB, CRREL, CORE

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE YUKON
DRAWING NUMBER 4661-A-4

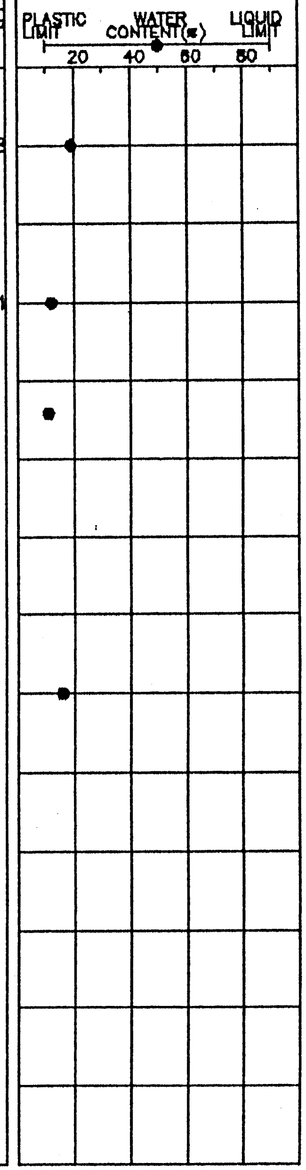
BOREHOLE NUMBER 4661-3

BOREHOLE LOG AND LABORATORY TEST RESULTS

PROJECT NUMBER: 0201-4661 COMPLETION DEPTH: 6.0 m LOGGED BY: MAV

CLIENT: CURRAGH RESOURCES LTD. EQUIPMENT USED: CAT 245 BACKHOE

DEPTH (m)	SAMPLE TYP	SAMPLE NO.	Q	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMP C
0				PEAT(Pt)—root mat,moss and organics	Frozen	
	GRAB	1		SAND TILL(SM) AND SILT—some gravel, some clay,trace coal fragments; with occasional cobbles;sub-rounded to angular gravel;iron oxide staining;low to nonplastic; olive brown —with stratified and randomly orientated ice formations (Vr Vs 10%) —easy digging	Vr Vs 10%	−0.8
	GRAB	2			Vr Vs 5%	−0.1
				PEAT(Pt)—and organics,black		
2	GRAB	3		SAND TILL(SM) AND SILT—some gravel,some clay,trace organics;rounded to subrounded,smooth gravel;with iron oxide staining;wet;soft to firm(estimated);low plastic; olive		0
4	GRAB	4				
6				END OF TEST PIT 6.0 m TEST PIT TERMINATED DUE TO SLOUGHING SOIL AT 2.0 m. GROUND WATER INFILTRATING TEST PIT.		
7						



SPECIAL TESTS	UNIT	DEPTH (ft)
		0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22

ROCKFILL DRAIN—PERMAFROST EVALUATION
NORTH FORK ROSE CREEK
FARO, YUKON
DATE EXCAVATED: 1987-04-11

SAMPLE TYPE: SHELBY, NO RECOVERY, SPT, GRAB, CRREL, CORE

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE YUKON

DRAWING NUMBER 4661-A-5

BOREHOLE NUMBER 4661-4

BOREHOLE LOG AND LABORATORY TEST RESULTS

PROJECT NUMBER: 0201-4661
CLIENT: CURRAGH RESOURCES LTD.

COMPLETION DEPTH: 0.7 m LOGGED BY: MAV
EQUIPMENT USED: CAT 245 BACKHOE

SAMPLE TYP	SAMPLE NO.	SAMPLE Q	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMP
			PEAT(Pt)—moss,rootlets and organic silt; dark brown to black —volcanic ash	Frozen	
			SAND TILL(SM) AND SILT—some gravel,trace clay;with occasional cobbles throughout;subrounded to sub-angular gravel;nonplastic; olive brown —hard digging due to seasonal frost and cobbles —unable to penetrate past 0.7 m due to cobbles/boulders.		
			END OF TEST PIT 0.7 m TEST PIT TERMINATED DUE TO COBBLES AND BOULDERS.		
			NOTE: Three attempts made at different locations to complete Test Pit#5. Backhoe unable to penetrate past cobbles/boulders encountered.		

PLASTIC LIMIT — WATER CONTENT(%) — LIQUID LIMIT: 20, 40, 60, 80

SPECIAL TESTS | UNIT

DEPTH (m): 0, 1, 2, 3, 4, 5, 6, 7

DEPTH (ft): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22

ROCKFILL DRAIN—PERMAFROST EVALUATION
NORTH FORK ROSE CREEK
FARO, YUKON
DATE EXCAVATED: 1987-04-10

SAMPLE TYPE
SHELBY
NO RECOVERY
SPT
GRAB
CRREL
CORE

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE YUKON
DRAWING NUMBER
4661-A-6

BOREHOLE NUMBER
4661-5

BOREHOLE LOG AND LABORATORY TEST RESULTS

EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Rock Causeway - Permafrost Evaluation
North Fork Rose Creek, Faro, Yukon

Project Number: 0201-4661

Date Tested: 1987-04-15

Borehole Number: TEST PIT #1

Depth: 0.8 - 1.0 m

Soil Description: SAND TILL (SM) - gravelly, some silt

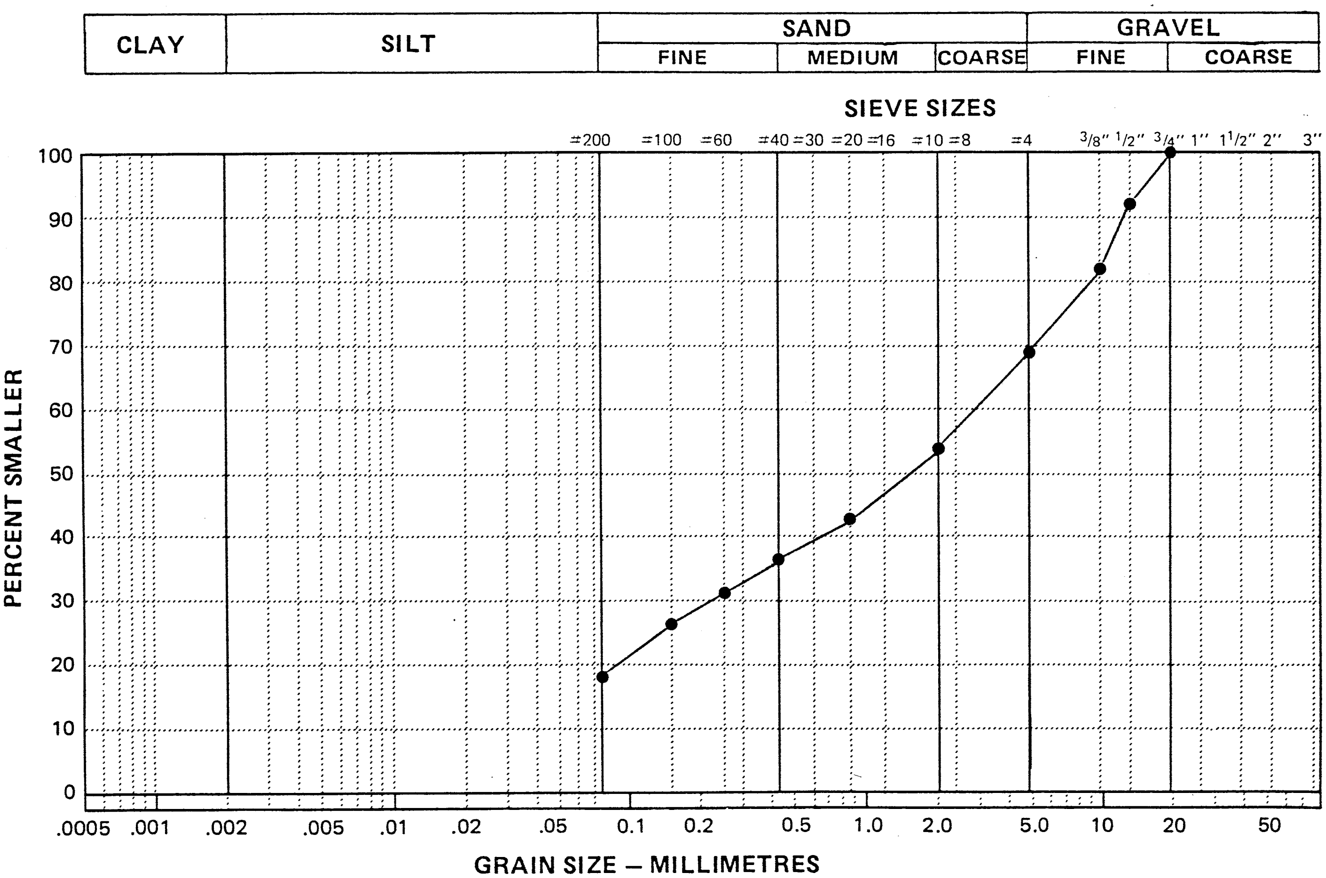
Cu:

Cc:

Natural Moisture Content: 9.7 %

Remarks:

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	100
1/2"	92
3/8"	82
No. 4	69
No. 10	54
No. 20	43
No. 40	36
No. 60	31
No. 100	26
No. 200	18



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Rock Causeway - Permafrost Evaluation
North Fork Rose Creek - Faro, Yukon

Project Number: 0201-4661

Date Tested: 1987-04-15

Borehole Number: TEST PIT #3

Depth: 0.5 - 1.0 m

Soil Description: SAND TILL(SM) AND SILT - trace gravel, trace clay

Cu:

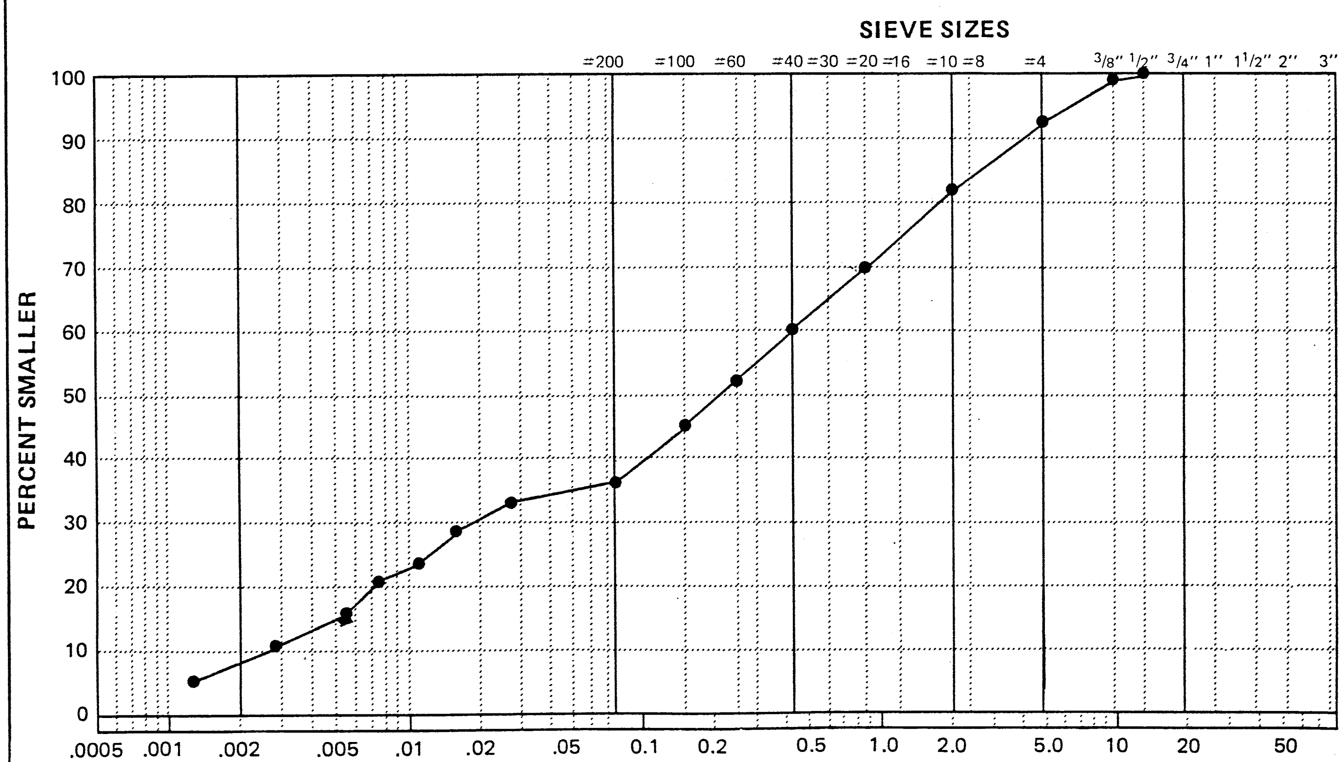
Cc:

Natural Moisture Content: 15.2 %

Remarks:

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	100
3/8"	99
No. 4	93
No. 10	82
No. 20	70
No. 40	60
No. 60	52
No. 100	45
No. 200	36

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

eba

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Rock Causeway, Permafrost Evaluation
North Fork Rose Creek - Faro, Yukon

Project Number: 0201-4661

Date Tested: 1987-04-15

Borehole Number: TEST PIT #4

Depth: 3.9 - 4.1 m

Soil Description: SAND TILL (SM) AND SILT - some gravel, some clay

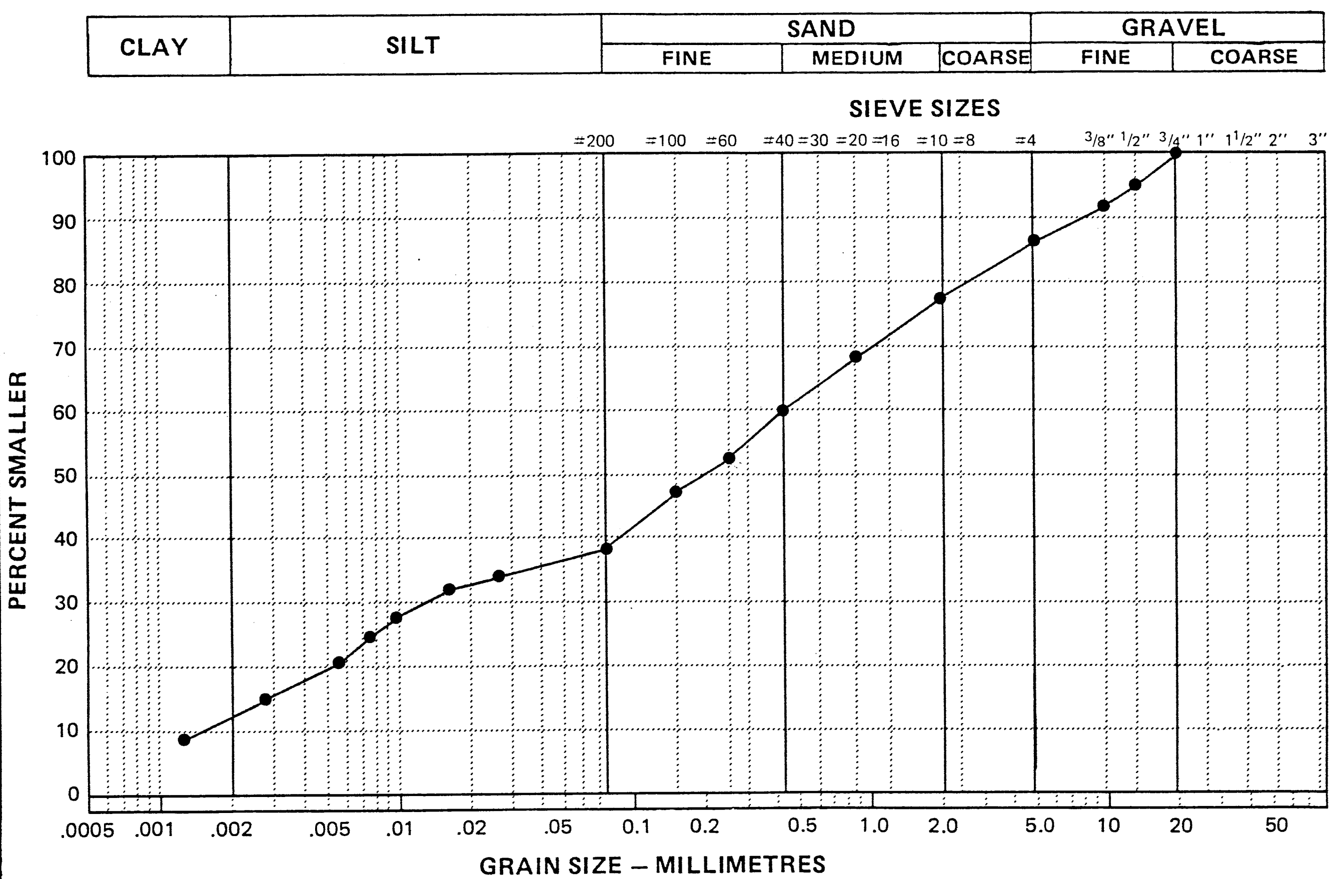
Cu:

Cc:

Natural Moisture Content: 15.9 %

Remarks:

SIEVE	PERCENTAGE PASSING
3″	
1 1/2″	
1″	
3/4″	100
1/2″	95
3/8″	92
No. 4	86
No. 10	77
No. 20	68
No. 40	60
No. 60	53
No. 100	47
No. 200	38



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX B
1987 CONSTRUCTION PHOTOGRAPHS
(GOLDER 1987)

PHOTO 1

VIEW FROM THE CREST OF THE ROCK FILL THAT IS BEING ADVANCED ACROSS THE NORTH FORK OF ROSE CREEK, AS PART OF THE ROAD ACCESS TO THE VAGNORDA ORE DEPOSIT. THE SEGMENT OF THE FILL SHOWN WILL FORM PART OF THE NORTH FORK ROCK DRAIN, AND THE MATERIAL CONSISTS OF CALCIUM SILICATE (CaSi) BRECCIA.
SOME LARGE ROCK FRAGMENTS AT THE TOE OF THE FILL HAVE BEEN SHIFTED BY BULLDOZER INTO INTO THE NORTH FORK DRAINAGE CHANNEL. THE SIZE OF THE ROCK FRAGMENTS THAT SEPARATE ON THE ADVACING FACE OF THE FILL AND ROLL TO THE TOE, ARE OF SUFFICIENT SIZE THAT PLACEMENT OF THE LARGEST OF THESE FRAGMENTS BY BULLDOZER IS NOT NECESSARY. BULLDOZER PLACEMENT OF ROCK IN THE CHANNEL IS TO BE DISCONTINUED.

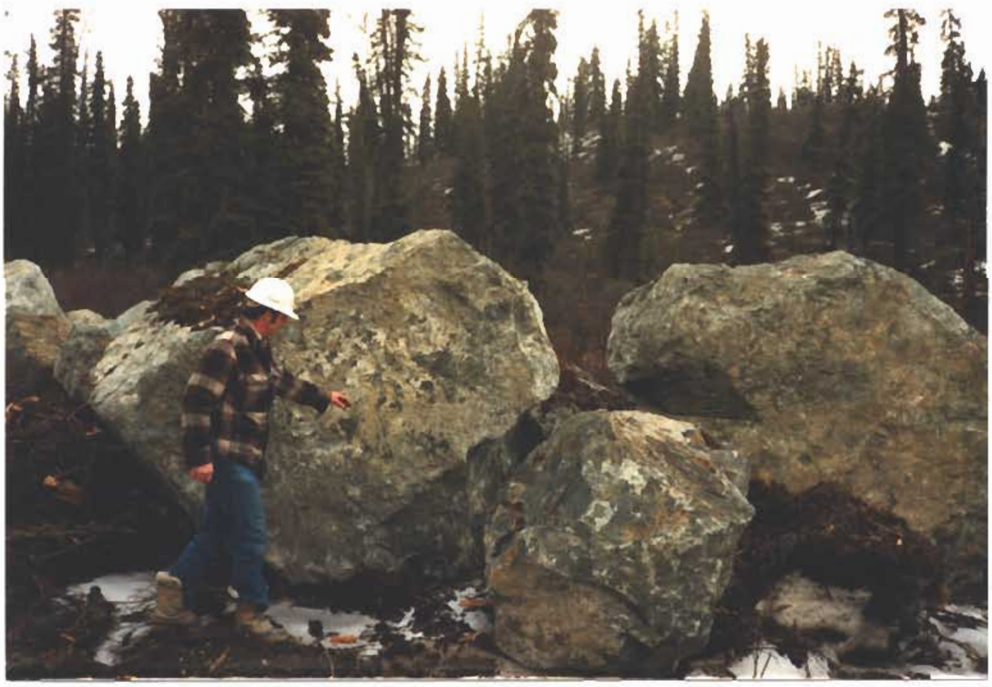


PHOTO 2

AN EXAMPLE OF THE SIZE OF CaSi ROCK FRAGMENTS THAT HAVE BEEN PLACED IN THE NORTH FORK DRAINAGE CHANNEL.

PHOTO 3

ILLUSTRATING THE SIZE OF CaS: ROCK FRAGMENTS THAT HAVE SEPARATED ON THE FACE OF THE ROCK FILL, AND HAVE COME TO REST AT THE TOE.

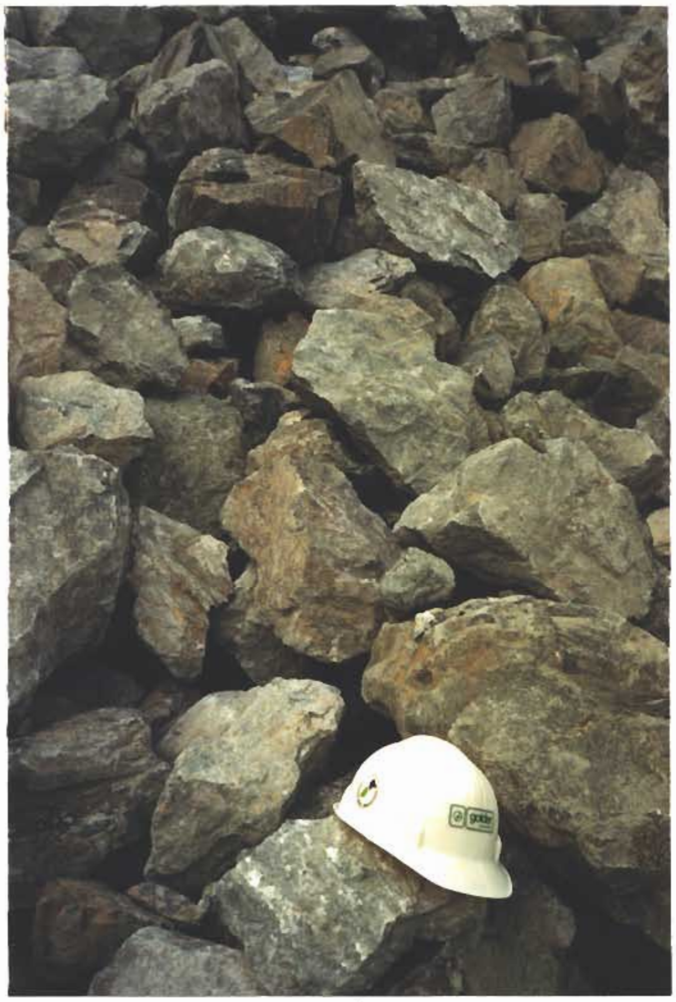


PHOTO 4

ILLUSTRATING THE SIZE OF THE ROCK FRAGMENTS ON THE FACE OF CaS: FILL, AT A HEIGHT OF APPROXIMATELY 7m ABOVE THE TOE OF THE FILL AS AT 7 MAY 87. THE 65% SIZE IS ESTIMATED TO BE 0.5m, AND THE 50% SIZE IS ESTIMATED TO BE APROXIMATELY 0.3m.

PHOTO 5

ILLUSTRATING THE SIZE OF THE CaSi ROCK FRAGMENTS ON THE FACE OF THE FILL AT A HEIGHT APPROXIMATELY 10m ABOVE THE TOE, AS AT 7 MAY 87. AT THIS PARTICULAR SEGMENT ON THE FACE, THE AVERAGE SIZE OF THE ROCK FRAGMENTS IS SLIGHTLY LARGER THAN THE SIZE OF THE FRAGMENTS AT A HEIGHT 7m ABOVE THE TOE.

PHOTO 6

SHOWING THE ROCK FRAGMENTS ON THE FACE OF THE ADVANCING ROADWAY FILL AT AN ESTIMATED HEIGHT OF 17m ABOVE THE TOE, AS AT 7 MAY 87. THE 85% SIZE IS ESTIMATED TO BE 0.5m, THE 50% SIZE IS ESTIMATED TO BE 150mm. NOTE THE 75 TO 150mm SIZE FRAGMENTS ON THE FACE, SIGHTLY ABOVE AND TO THE LEFT OF THE HARD HAT. THE SMALLEST SIZE OF THESE FRAGMENTS IS APPROXIMATELY 40mm.

PHOTO 7

ILLUSTRATING THE CaSi ROCK ON THE FACE OF THE VANGORDA ROADWAY FILL AT A HEIGHT ESTIMATED AT 55m ABOVE THE TOE OF THE FILL AS AT 7 MAY 87. AS IS APPARENT IN THE PHOTO, THE ROCK AT THIS LEVEL IS DEVOID OF FINES. FINES WERE EVIDENT ONLY WITHIN THE UPPER 10 METERS ON THE FACE, ie BETWEEN THE CREST OF THE FILL AT 3900 Ft AND ELEVATION 3770 Ft APPROXIMATELY.

APPENDIX C
GRAIN SIZE OF ROCKFILL

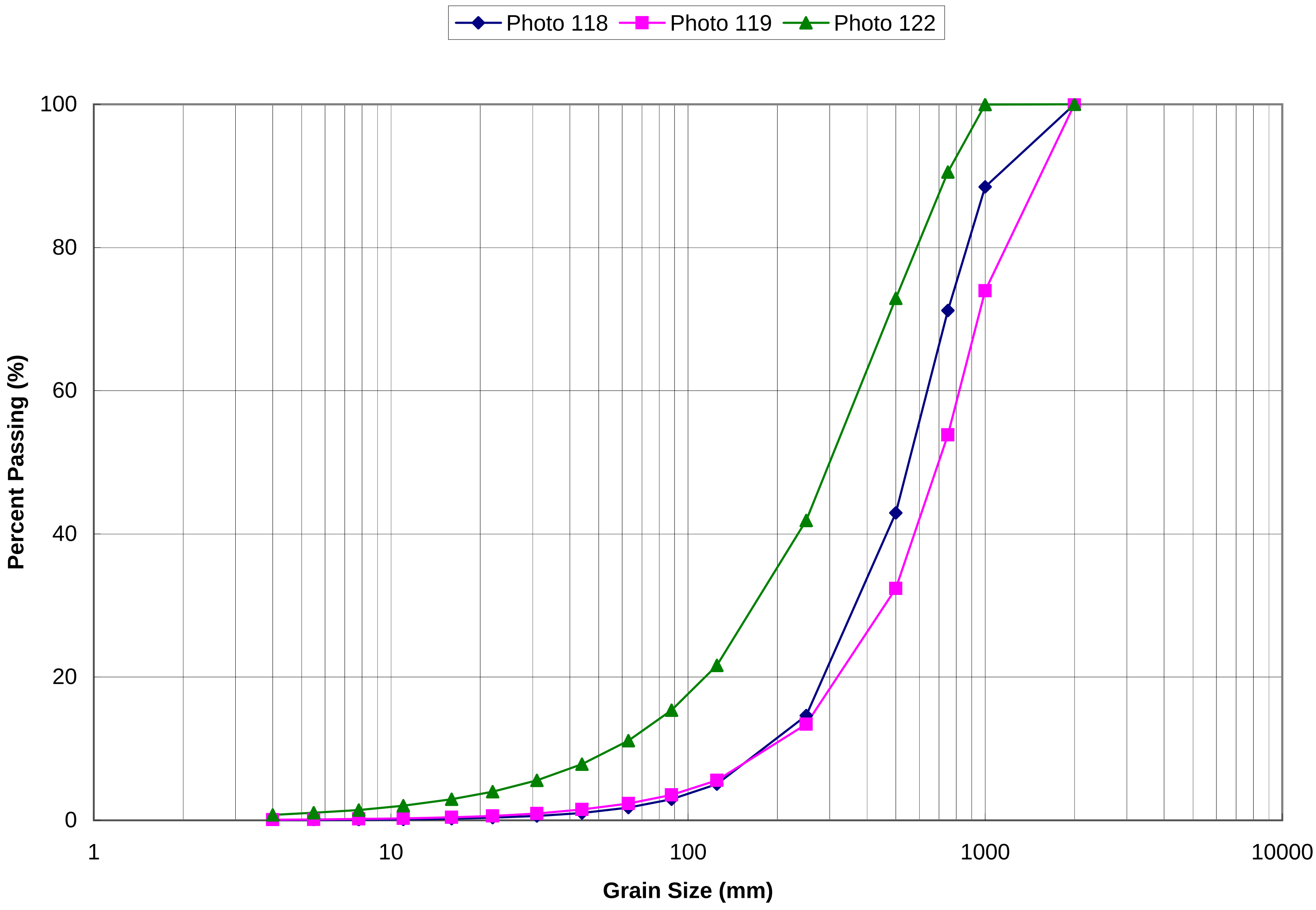
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Calgary, Alberta
Phone: (403) 250-5185

Client: Deloitte & Touche

Project:	TASK 22F – 2005 ROCK DRAIN ANALYSIS
Title:	PHOTOGRAPHS OF THE DOWNSTREAM TOE (THE BALLS ARE 254 mm DIAMETER)

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
0257-031-01	JAN 2006	NA	GWF		C1

Figure C2
Grain Size Analysis (Downstream toe by Split Net method)



Project Number: 0257-031	Project Name: NFRD	Date: Sept. 13, 2005	Page: 1 of: 1
Test Pit Number: TP05-04	Location: NFRD Crest	Elevation: approx. 1148 m	Water level at end of digging: None
Weather: Light Rain	Digging Method: Back Hoe	Depth of Test Pit: 5.1 m	Water Level: ___ min/hr after digging: N/A
Engineer: J.Cassie	Time Started: 9:45 AM	Finished: 10:30 AM	Slouging interval: N/A

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Depth (m)	Soil Description	Sample Type	PP	Constncy/ Density	Grain Size	Colour	USCS
	GRAVEL (Granular Fill) Sandy, some Cobbles, Compact, Damp, Rounded, Brown			Compact		Brown	
1.0	GRAVEL (Mine Waste) Sandy, some Cobbles, trace Silt, trace Boulders Well-graded, Compact, Dry to Damp, Grey, Hole stands vertical. at 4.5 m, Increasing Boulder and Cobble content	Grab Sample (×3)		Compact	G - 60 S - 30 M&C - 10	Grey	GP - GM
5.1	End of Test Pit: 5.1 m Maximum reach of excavator						

View of north wall and base of test pit.

Note:
Test Pit located on north (Upstream) side of crest.
Test Pit backfilled upon completion.
Boulders/Cobbles removed prior to to sieve analysis
GPS Coordinates (NAD 86): 08 V 584885E, 6912946N

Sample Types	Sample Quality	Densities	Consistency
Shelby Sample	Disturbed	Very Loose	Very Soft
Grab Sample	Fair	Loose	Soft
SPT Sample	Good	Compact	Firm
	Lost	Dense	Stiff
		Very Dense	Very stiff
			Hard

Project Number: 0257-031	Project Name: NFRD	Date: Sept. 13, 2005	Page: 1 of: 1
Test Pit Number: TP05-03	Location: North Crest of NFRD	Elevation: approx. 1138 m	Water level at end of digging: None
Weather: Light Rain	Digging Method: Back Hoe	Depth of Test Pit: 5.1 m	Water Level: min/hr after digging: N/A
Engineer: J.Cassie	Time Started: 8:15 AM	Finished: 9:30 AM	Slouging interval: N/A

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Depth (m)	Soil Description	Sample Type	PP	Constncy/ Density	Grain Size	Colour	USCS
0.7	GRAVEL (Granular Fill) Sandy, Cobbly, Compact, Dry to Damp, Brown			Compact		Brown	
5.1	GRAVEL (Mine Waste) Sandy, some Cobbles, trace Silt, trace Boulders Well-graded, Compact, Dry, Max. clast size 1.5 m, Angular, Grey with some brown colour banding, Hole stands vertical.	Grab Sample Grab Sample Grab Sample		Compact	G - 56 S - 29 M&C - 15	Grey	GP - GM
	End of Test Pit: 5.1 m Maximum reach of excavator						

View of east and south walls and base of test pit.

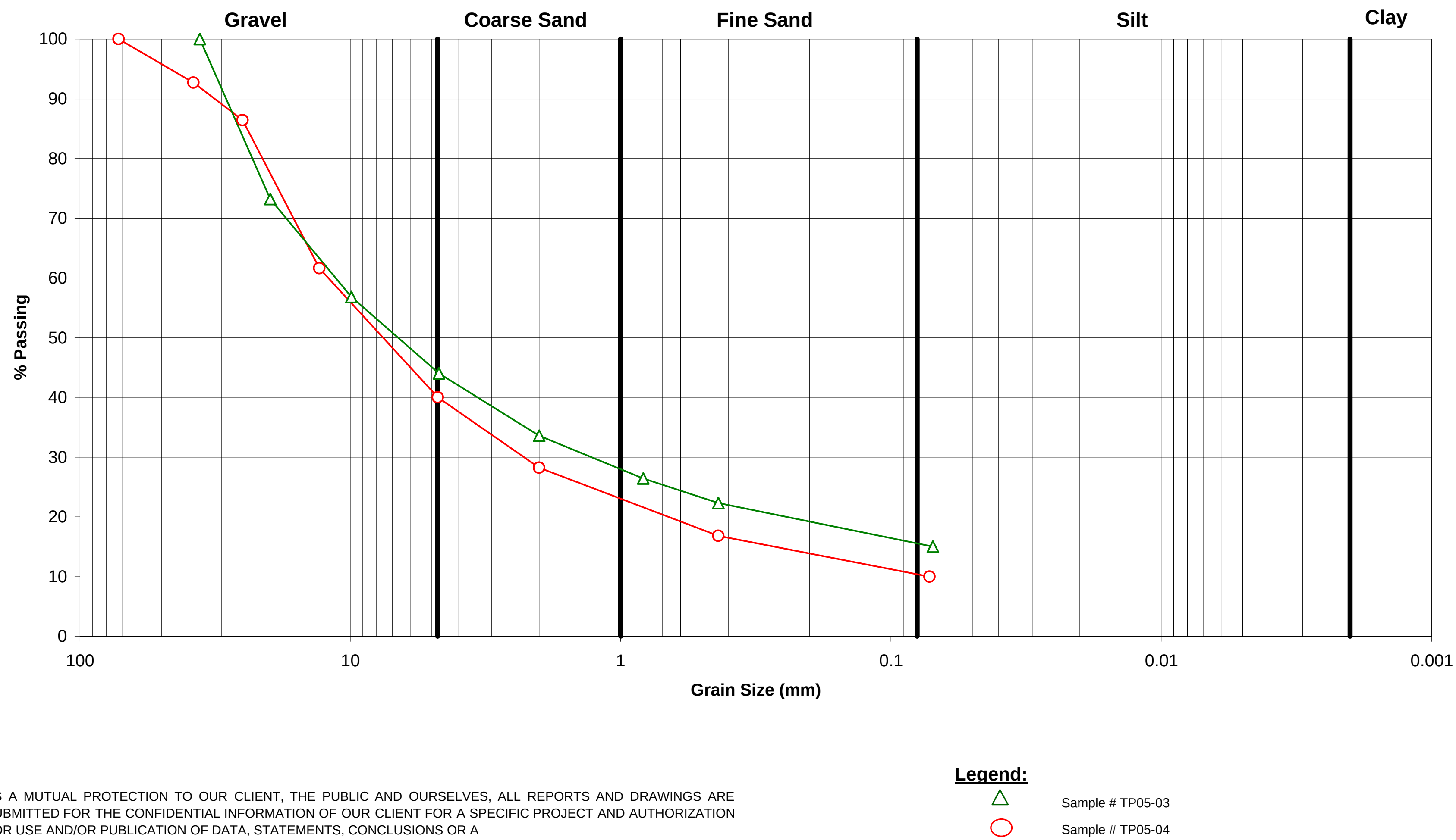
Note:
Test Pit located on north (Upstream) side of crest.
Test Pit backfilled upon completion.
GPS Coordinates (NAD 86): 08 V 585192E, 6912641N

Sample Types
- Shelby Sample
- Grab Sample
- SPT Sample

Sample Quality
Disturbed
Fair
Good
Lost

Densities
Very Loose
Loose
Compact
Dense
Very Dense

Consistency
Very Soft
Soft
Firm
Stiff
Very stiff
Hard



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PROJECT:
Task 22F - 2005 Rock Drain Analysis

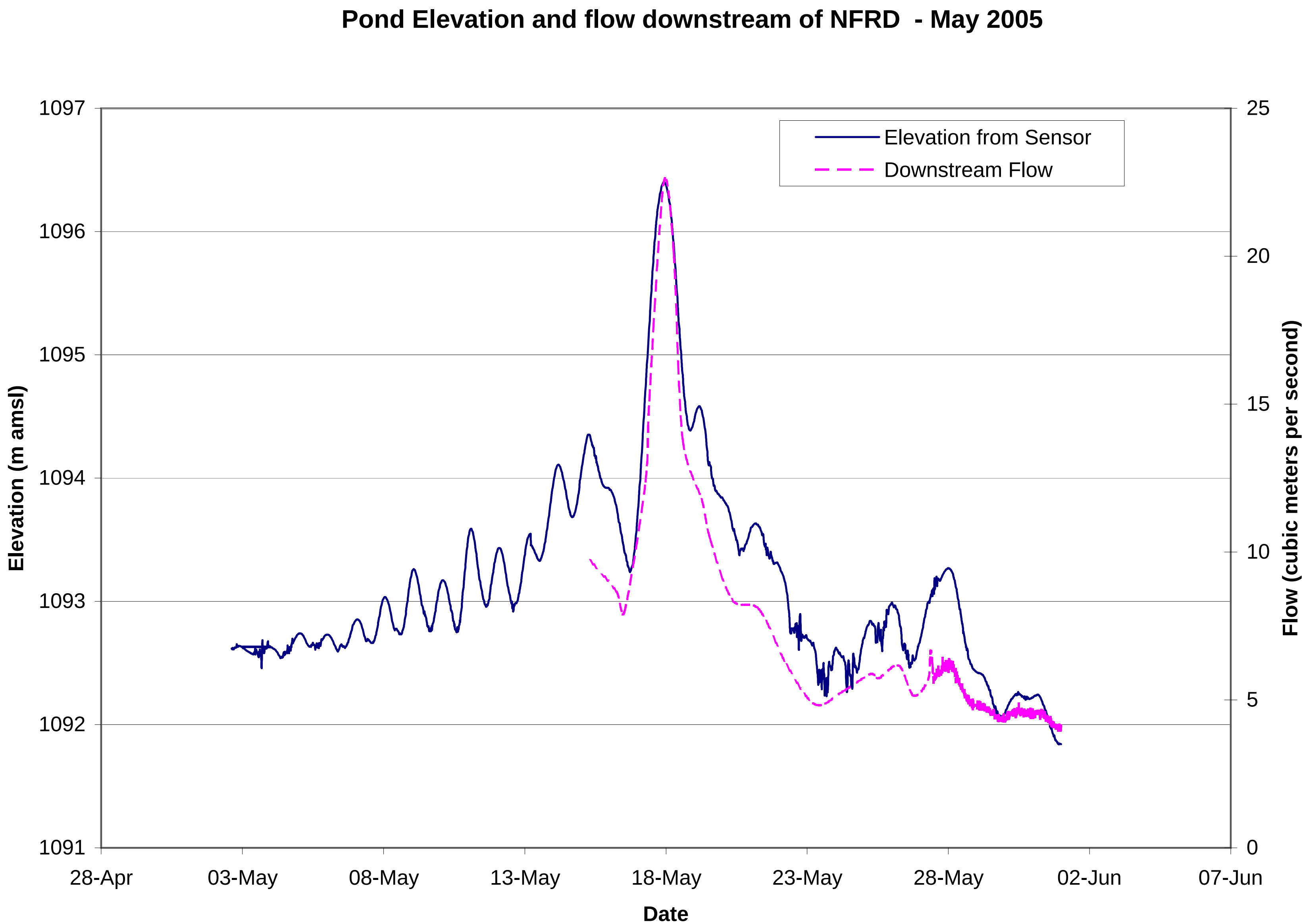
TITLE:
Grain Size Analysis of Sediment Sampled on Rock Drain Crest

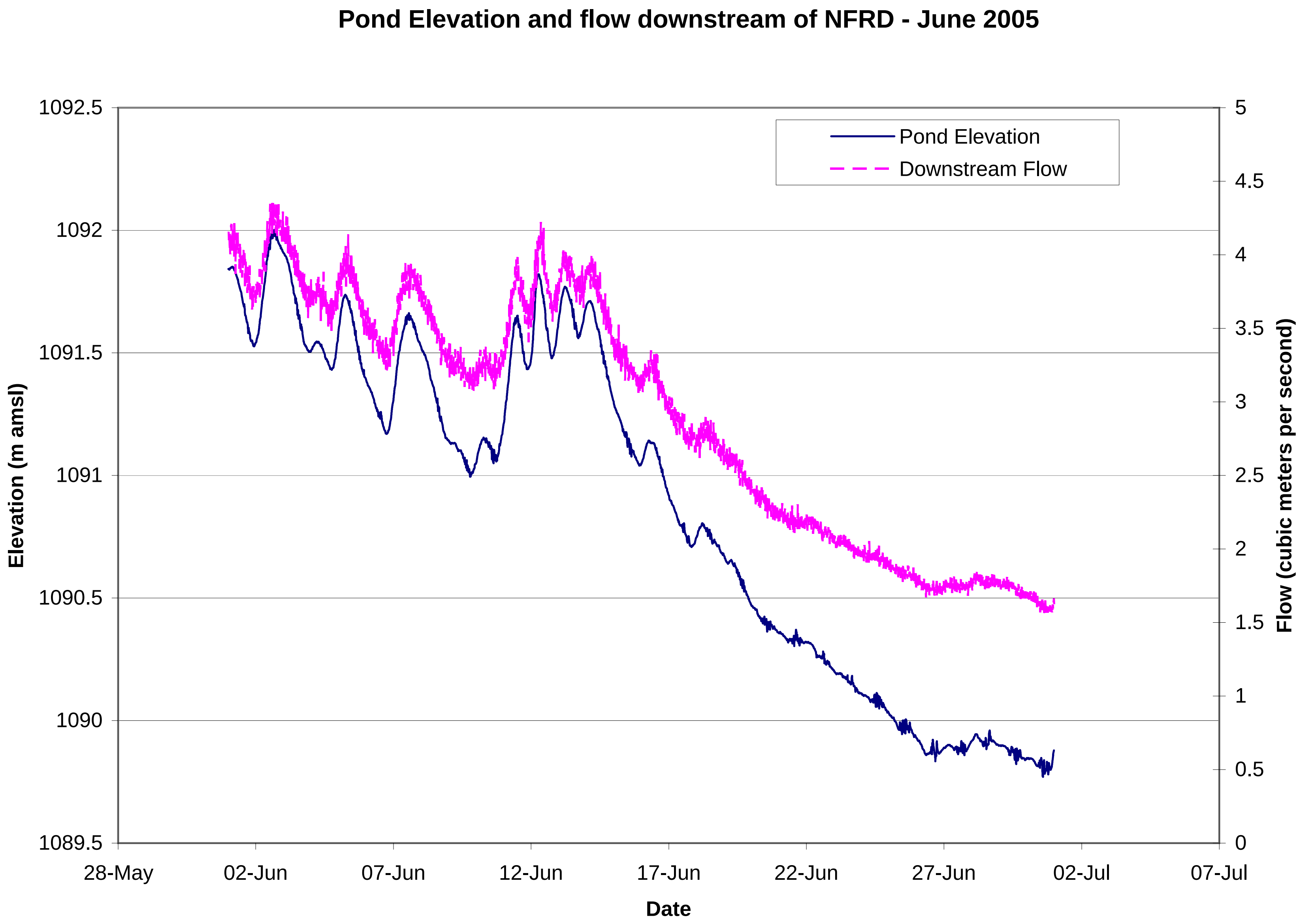
CLIENT:
Deloitte & Touche

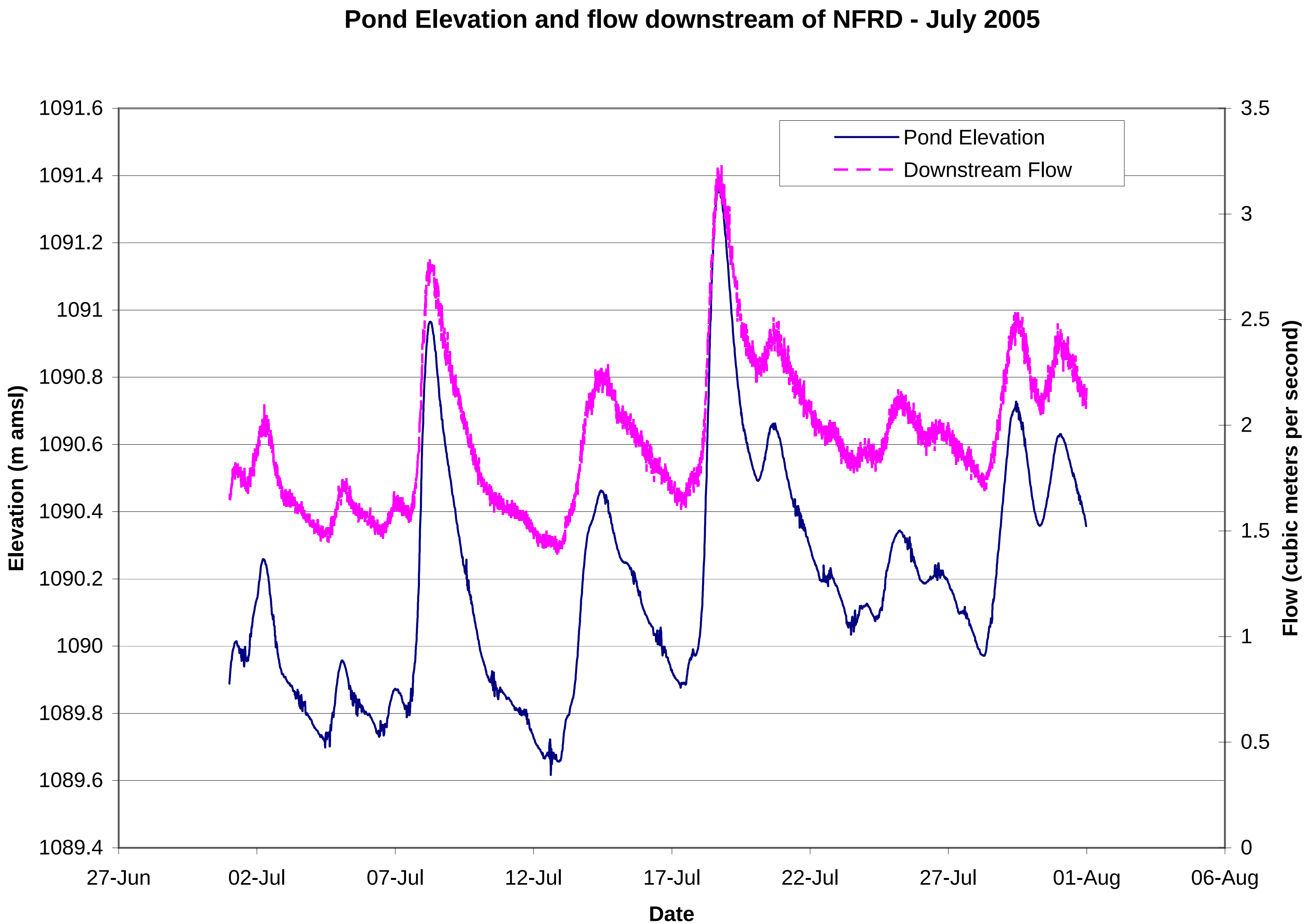
PROJECT NO. **0257-031-01**

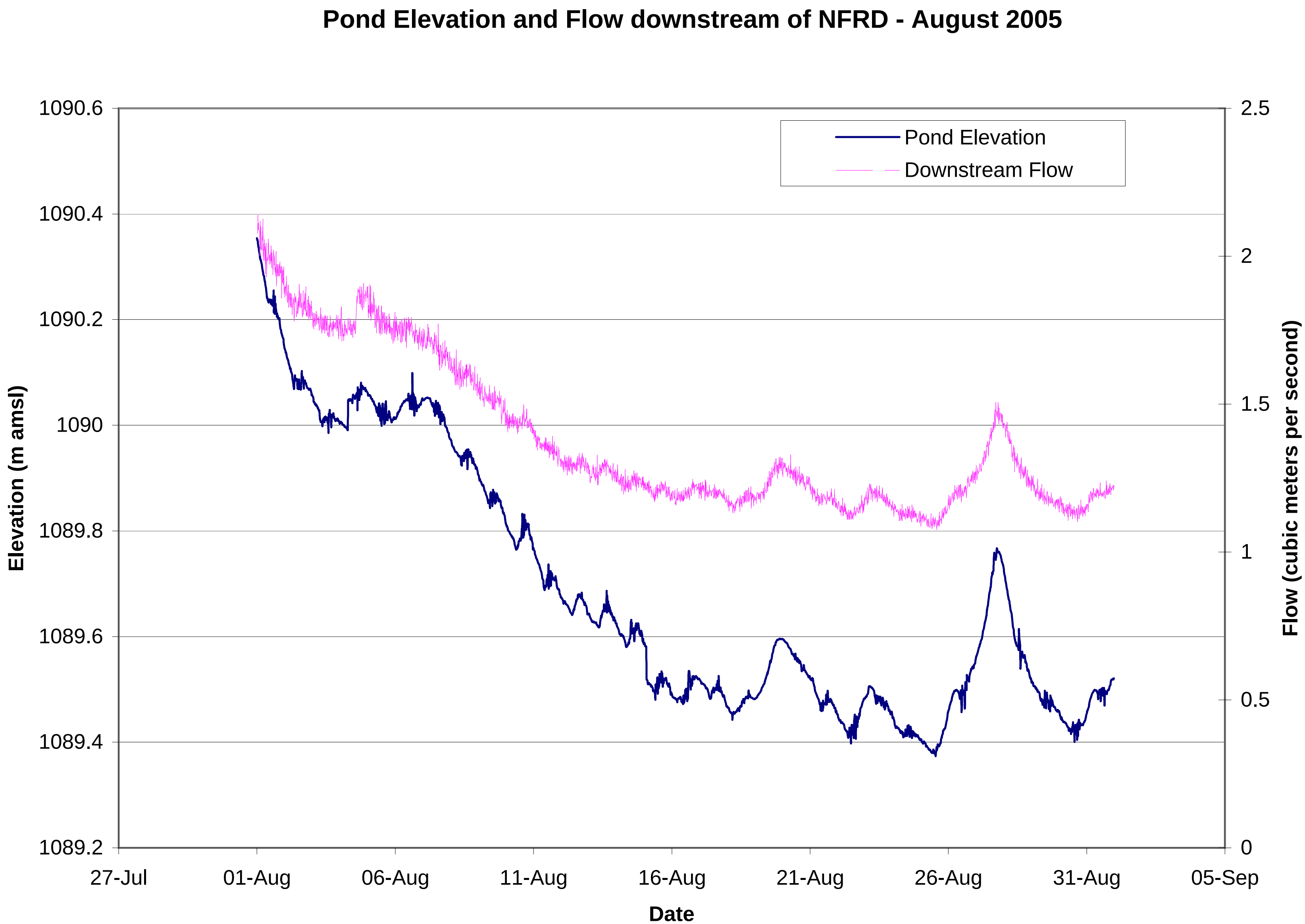
FIGURE. NO. **C3**

APPENDIX D
2005 MONITORING RESULTS
SUMMARIZED BY MONTH


Pond Elevation and flow downstream of NFRD - May 2005
Elevation from Sensor
Downstream Flow
Elevation (m amsl)
Flow (cubic meters per second)
Date
1097
1096
1095
1094
1093
1092
1091
25
20
15
10
5
0
28-Apr
03-May
08-May
13-May
18-May
23-May
28-May
02-Jun
07-Jun


Pond Elevation and flow downstream of NFRD - June 2005
Pond Elevation
Downstream Flow
Elevation (m amsl)
1092.5
1092
1091.5
1091
1090.5
1090
1089.5
Flow (cubic meters per second)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
28-May
02-Jun
07-Jun
12-Jun
17-Jun
22-Jun
27-Jun
02-Jul
07-Jul
Date


Pond Elevation and flow downstream of NFRD - July 2005
Pond Elevation
Downstream Flow
Elevation (m amsl)
1091.6
1091.4
1091.2
1091
1090.8
1090.6
1090.4
1090.2
1090
1089.8
1089.6
1089.4
Flow (cubic meters per second)
3.5
3
2.5
2
1.5
1
0.5
0
27-Jun
02-Jul
07-Jul
12-Jul
17-Jul
22-Jul
27-Jul
01-Aug
06-Aug
Date


Pond Elevation and Flow downstream of NFRD - August 2005
Pond Elevation
Downstream Flow
Elevation (m amsl)
1090.6
1090.4
1090.2
1090
1089.8
1089.6
1089.4
1089.2
Flow (cubic meters per second)
2.5
2
1.5
1
0.5
0
27-Jul
01-Aug
06-Aug
11-Aug
16-Aug
21-Aug
26-Aug
31-Aug
05-Sep
Date

Pond elevation and Flow downstream of NFRD - September 2005