DELOITTE & TOUCHE INC.

EVALUATION OF SHORT TERM
MANAGEMENT OPTIONS

VANGORDA DIVERSION FLUME
FARO MINE, YUKON

FINAL

PROJECT NO.: 0257-002-03
DATE: NOVEMBER 20, 2000

DISTRIBUTION LIST:
DELOITTE & TOUCHE, TORONTO – 2 COPIES
DELOITTE & TOUCHE, CALGARY – 1 COPY
DELOITTE & TOUCHE, FARO – 1 COPY
INAC, WHITEHORSE - 2 COPIES
GARTNER LEE, YELLOWKNIFE - 1 COPY
BGC CALGARY – 2 COPIES
BGC VANCOUVER - 1 COPY

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Suite 1170–840 7th Ave. S.W.
Calgary, Alberta
Canada T2P 3G2
Tel: (403) 250-5185
Fax: (403) 250-5330

Project No. 0257-002-03
November 20, 2000

Mr. Doug Sedgwick
Deloitte & Touche Inc.
BCE Place, Suite 1400
181 Bay Street
Toronto, Ontario M5J 2V1

Re: Final Report on Evaluation of Short Term Management Options Vangorda Diversion Flume, Faro Mine, Yukon

Dear Mr. Sedgwick:

Attached is final report on the evaluation of the Vangorda diversion flume and on possible options for the short term of 1 to 3 years. Copies of this final report have been forwarded to Mr. Haggar (Faro), Mr. Stevens (Calgary), Mr. Denholm (Yellowknife) and Mr. Sherstone (Whitehorse), as requested

We trust that the information contained in the report is in keeping with your requirements and we thank you for this opportunity to be of service to Deloitte & Touche. We look forward to working on the construction aspects of this project in the near future.

Yours truly,
BGC Engineering Inc.
per:

James W. Cassie, M.Sc., P.Eng.
Senior Geotechnical Engineer

encl.
JWC/sf

TABLE OF CONTENTS Page

Tables

Figures

1.0 INTRODUCTION

1.1 Background

The Faro Mine, located in the central Yukon Territory as shown in Figure 1, is currently in receivership and is being managed by Deloitte & Touche Inc. (Deloitte). At this mine, ore extraction occurred from three open pits called the Faro, Grum and Vangorda pits, with the latter two being located on the Vangorda Plateau, some 10 km northeast of the Faro townsite.

The development of the Vangorda pit in the early 90's required the realignment of Vangorda Creek around the perimeter of the proposed open pit. Between 1991 and 1992, the diversion project was designed, constructed and realigned, due to the changing footprint of the pit expansion. Robertson (1996) reported that the half-round culvert within the diversion channel had not suffered any major structural damage up until 1996. Since the cessation of mining activities at Faro Mine in January 1998, the diversion channel has been maintained in order to maintain a slow rate of pit filling while a long term management plan for the site is developed. In 1999, a fall of rock from a near-vertical rock slope which overlooks one section of the flume, occurred. This rockfall necessitated emergency replacement of approximately 39 metres of the flume. Anvil Range (1999) provides a summary of the maintenance work undertaken to repair the damaged flume from that event.

It was considered likely that continuing freeze-thaw cycles, in the presence of some seepage on the rock slope and unfavourable foliation planes, would result in additional rock falls similar to that experienced in 1999. As such, a Request for Proposal (RFP) was issued to evaluate possible management options for the Vangorda flume. The study objective was to provide a recommendation for the most appropriate management plan for the flume over the next 1 to 3 year period. This report documents the work scope undertaken by BGC Engineering Inc. (BGC) to evaluate management options for the flume.

SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250 5185

PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
SITE LOCATION MAP

CLIENT:	PROJECT No.	DWG. No.	REV.
DELOITTE & TOUCHE INC.	0257-002-03	FIGURE 1	

1.2 Study Objective and Scope of Services

An RFP was issued by Mr. Eric Denholm (previously the Environmental Engineer on-site for Anvil Range Mining Corporation) of Deloitte in May, 2000 for the following work scope, relative to the Vangorda flume options:

- Describe various alternatives for management of the Vangorda Creek diversion flume which are appropriate for a 1 to 3 year period including but not limited to: maintaining the current emergency preparedness plan, and excavation of a portion of the rock walls.
- Include estimates of capital and operating costs for each alternative accurate in the order of +/-20%.
- Include an assessment of the physical stability of the Vangorda pit wall below the flume.
- Present a comparison of the alternatives which includes consideration of capital costs, operating costs, environmental protection, physical stability and any other appropriate parameters.

As such, BGC prepared a proposal (No. 00-047), dated June 2, 2000, for the required workscope. Mr. Eric Denholm provided verbal authorization on June 19, 2000 to BGC to undertake the work, as outlined in their proposal. As such, travel arrangements were booked to coincide with Mr. Denholm's planned visit to site scheduled for the first week of July.

2.0 BACKGROUND INFORMATION

2.1 Operating History

Robertson (1996), Chapter 5 summarizes the development history of the Vangorda deposit, as outlined below:

- Till dewatering in the area began in 1988 with the excavation of several drainage ditches.
- Mining began at Vangorda in 1990 following issuance of a water licence.
- Between 1990 and 1993, Curragh (one of the previous mine owners) mined 5.7 million tones of ore from Vangorda.
- The site was closed between 1993 and late 1994.
- Anvil Range Mining Corporation (ARMC) took over the site in November, 1994 and undertook some mining at the Vangorda pit as production scheduling allowed.
- ARMC went to receivership in January, 1998 and all mining at the site was stopped.

2.2 Geology

Faro Mine is situated within the Anvil Range lead-zinc-silver district, lying just immediately north of the Cretaceous-Tertiary Tintina Fault, a major, dextural strike-slip fault. Regionally, the Anvil Range district is underlain by Paleozoic meta-sedimentary and lesser meta-volcanic strata. A northwest trending Cretaceous granitic body, the Anvil Batholith, then intruded into the metamorphic sequence. The metamorphic units dip northeast and southwest, away from the batholith. Massive sulphide bodies occur within the Cambrian phyllites and schists.

Jennings and Jilson (1986) summarizes the regional stratigraphic sequence within the area of Faro Mine. Relative to the Vangorda deposit, two units are of significance; the non-calcareous, phyllitic Mt. Mye Formation and the overlying, calcareous, phyllitic Vangorda Formation. Lithologies contained within the two units are as follows:

- Vangorda Formation: calcareous phyllite and calc-silicate metabasite, carbonaceous phyllite, chloritic phyllite and minor marble.
- Mt. Mye Formation: non-calcareous phyllite and schist, marble and calc-silicate lenses. Minor psammitic schist and metabasite.

The lead-zinc-silver ore deposits are located across the boundary between these two units.

Brown (1990) provides a review of the structural geology at the Vangorda open pit, based on 1990 fieldwork undertaken during the early stage of the pit development. His report states the structure of the pit is dominated by east-west plunging folds with a penetrative S_2 axial planar foliation and by roughly northeast striking high angle faults, as shown on Figure 2. The deposit is truncated by the high angle Northwest Fault, situated at the northwest end of the pit. At that time, the exposed pit was divided into three structural domains, which were separated by high angle faults. Figure 2 also illustrates what is interpreted to be the Creek Fault, proximal to the Northwest Fault noted earlier, at the northwest end of the deposit adjacent to the creek diversion alignment.

Robertson (1996) provides an excellent compilation of the geology of the Anvil Range district. Chapter 3 of that report provides the following relevant information, as it pertains to the Vangorda deposit:

- The structural and deformation history of the Anvil Range is complex, but is composed of five phases of fold deformation. The first two phases (D_1 and D_2) of intense fold deformation and contact metamorphism determined the gross structure of the mineral deposits. The remaining three, less intense phases produced only local scale results.
- The first deformation (D_1) produced a regional metamorphic foliation (S_1) axial planar to tight to isoclinal mesoscopic folds (F_1) in bedding (S_0). These early folds are rarely preserved.
- All rocks in the district are metamorphosed, which was polyphase and concurrent with deformation. D_1 metamorphism was largely overprinted by later D_2 metamorphism.
- The second deformation D_2 produced strongly crenulated and ubiquitous close to tight mesoscopic folds (F_2) in S_1. The primary bedding S_0 and S_1 were transposed into near parallelism with the S_2 foliation (crenulation cleavage), which imparts a well developed structure to the rocks, especially those of the Vangorda formation.
- The axial planar foliation, S_2, dips shallowly to the southwest, but is locally quite variable, This foliation is the dominant plane of failure for the host rocks and is a principal factor in the slope stability of the pit walls.

This geological compilation was undertaken mainly from the perspective of geochemistry and assessment of acidic drainage potential. As such, it notes that all phyllites mined from the Vangorda pit are altered and hence, considered to be acid generating. Therefore, any water stored in the Vangorda pit may have to be treated before discharge to the environment.

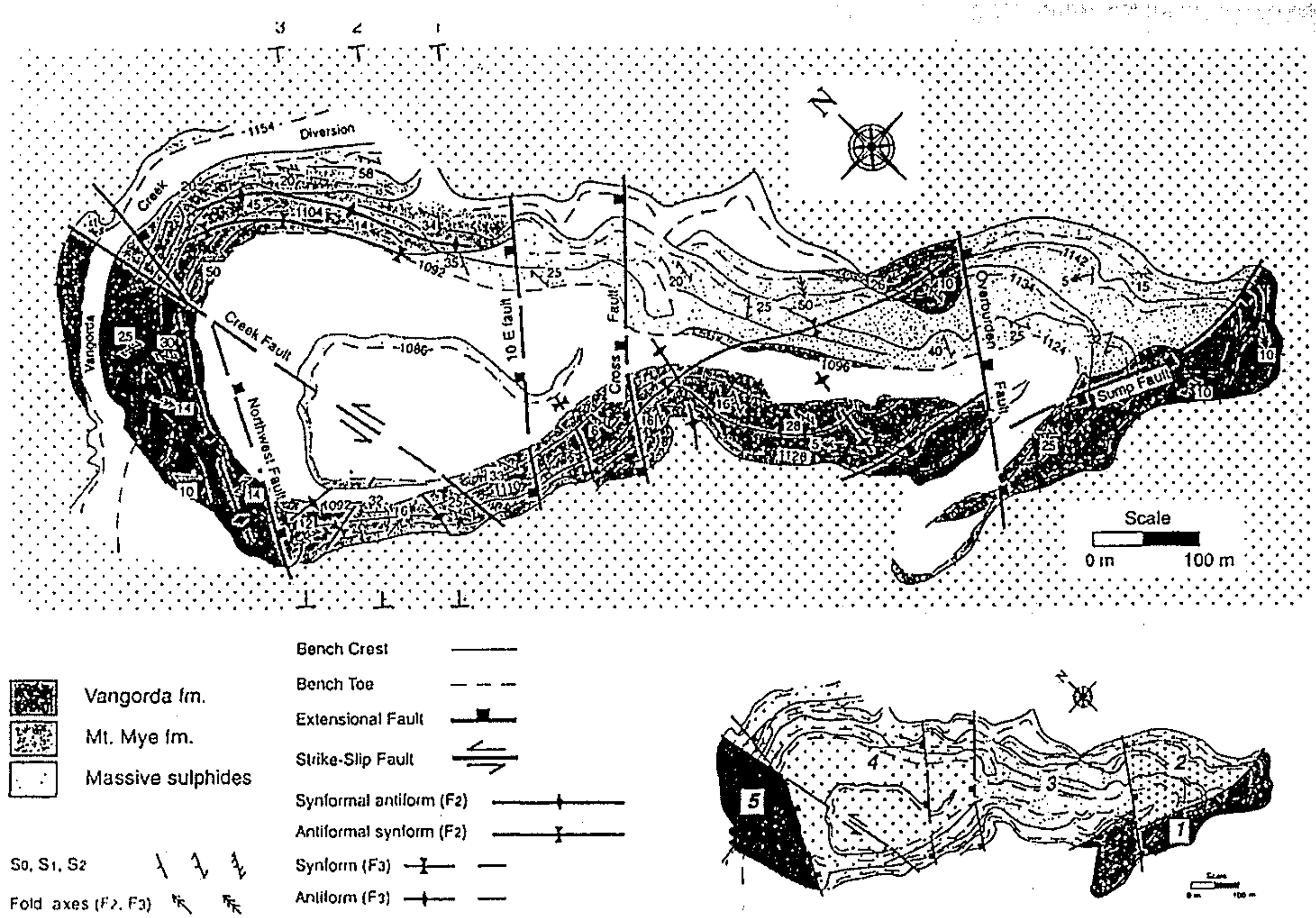


Figure 4.2. Simplified geological map of the Vangorda open pit based on the 1:1000 scale map (Figure 1.2). The inset shows the location of the various fault blocks discussed in the text

(TAKEN FROM D.L. BROWN, "DEFORMATION AND METAMORPHISM OF THE VANGORDA Pb–Zn MASSIVE SULPHIDE DEPOSIT, YUKON TERRITORY, PH.D. THESIS.

SCALE: AS SHOWN	DATE: AUG 2000	DRAWN: MT	DESIGNED: BB	CHECKED: JWC	APPROVED: JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (403) 250-5185
Calgary, AB. Phone: (604) 684 5900

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: STRUCTURAL GEOLOGY MAP OF VANGORDA PIT

PROJECT No. 0257-002-03

DWG. No. FIGURE 2

REV.

2.3 Hydrogeology

In Piteau (1990), an initial hydrogeological assessment was undertaken for the Vangorda pit. At that time, excavation of the pit was down to Elevation 1134 m in the southern portion and the upper benches had just begun in the northern portion. The total quantity of groundwater seepage from sediments in the Vangorda Creek Valley was estimated to vary from 5 l/s initially to a steady state flow of about 1 l/s. Piezometers installed in the bedrock indicated higher piezometric levels in the east wall than in the central portion of the pit. This information was believed to result from impeded groundwater flow resulting from the anisotropic nature of the phyllites. The hydraulic gradients within the central portion of the pit were low, indicating that the hydraulic conductivity of the rock mass in the ore zone was greater than that of the surrounding rock mass. Limited falling head test data from piezometers installed in the Vangorda pit in 1987 indicated a hydraulic conductivity of the rock mass on the order of 10^{-7} m/s. Permeability associated with fracture zones and faults could be much higher.

Chapter 5 of Robertson (1996) indicated that the development of the Vangorda pit resulted in a partial dewatering ("depressurization") of the surrounding soils and bedrock. This observation was based on a decreasing amount of seepage water per year over time.

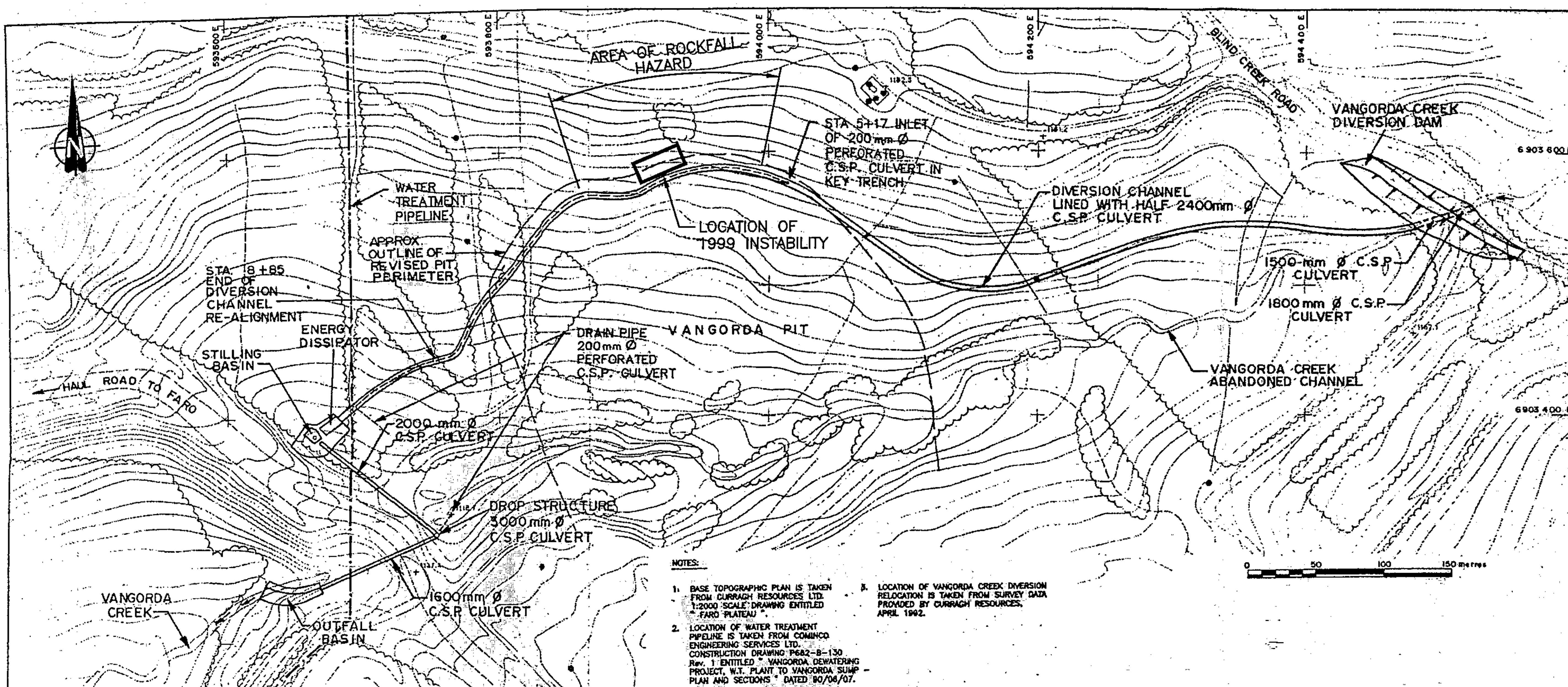
Further comments regarding pit seepage are summarized in Section 2.4.

2.4 Geotechnical and Seismic

Flume Geotechnical Data

SRK (1990) provides the preliminary geotechnical and hydraulic design basis for the creek diversion project. It should be noted that the project consisted of the following three major components, which are shown on Figure 3:

- An 8 m high diversion dam and culvert for the passage of Vangorda Creek discharge.
- An 800 m long diversion channel, lined with a half-section culvert.
- A final stilling basin, drop structure and outfall basin to convey the discharge water back into Vangorda Creek.



(FIGURE IS TAKEN FROM STEFFEN ROBERTSON & KIRSTEN, 1992, REPORT TO CURRAGH RESOURCES, PRIOR TO PIT DEVELOPMENT)

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: GENERAL ARRANGEMENT OF DIVERSION CHANNEL

PROJECT No. 0257-002-03

DWG. No. FIGURE 3

REV.

Eight test pits were excavated underneath the proposed dam (and existing road embankment) located at the top of the diversion channel. These test pits varied from 1.2 to 6.1 m deep and encountered glacial till (fine sand with some gravel becoming more cobbly with depth) underlain by thinly foliated phyllite bedrock. The report does not indicate that any test pits and/or boreholes were excavated/drilled under the diversion channel alignment.

Pit Slope Data

Piteau (1991) states some information relevant to the discussion of Vangorda pit wall stability. The letter indicates that the Northwest Fault dips at 55° to 60° toward 103° (inferring a strike direction of 013°). Following a blast on the "east wall" adjacent to the flume on the 1152 m level, a 15 to 30 m long crack was observed in the flume excavation. Mapping of the crack indicated it occurred along a pre-existing surface subparallel to foliation; the dip direction/dip of the fracture was estimated at 184°/10°, approximately the same as the regional foliation orientation. As such, remedial measures including the installation of reinforcing dowels, was suggested. It should be noted that these observations were made on the original flume location, which was later realigned in 1992.

Piteau (1992a) provides some pit wall stability comments following observations made on June 15 and 16, 1992. The creek diversion flume was flowing nearly full and some seepage was observed under the flume, particularly in the vicinity of the Northwest Fault. The fault was characterized as a highly broken fault zone that was estimated to be 50 m wide. Instability of the north wall underneath the flume, relative to its intersection with the Northwest Fault, was not considered to be a significant problem at that time. The bench on which the Vangorda Creek diversion flume was located appeared to be in generally good condition. The only indicator of movement, near where the Northwest Fault intersects the bench was in the area where the sideboards have been welded to the flume culvert.

Piteau (1992b) provides comments from a visit undertaken on July 30 and 31, 1992. Some leakage from the flume was observed. In addition to the previously noted Northwest Fault, a second fault appeared in the area, having an estimated dip direction/dip of 125°/60° (interpreted to be the Creek Fault on Figure 2 of this report). Foliation orientation within the fault zone area was erratic but two dominant orientations of 30° to 40° dip into the pit and 15° to 40° northeast dip were identified. This area in the pit was very wet. The letter report notes that the second fault did not appear to significantly alter the stability condition of the pit wall. In addition, the potential for the two Northwest Faults and the Cross Fault to intersect and form a large wedge failure appeared low. The bench on which the flume diversion was located was in good condition.

Piteau (1992c) summarizes the observations seen on September 22 to 24, 1992. Some leakage was observed from the flume and considerable seepage and artesian conditions were noted within the pit. Seepage was observed from the flume down to the pit bottom along the eastern portion of the north wall (where the Northwest Fault intersects the slope). The bench on which the diversion flume was located appeared to be in good condition.

Seismicity Data

Robertson (1996), Chapter 3 reviews the seismic parameters for the Faro area. Based on work undertaken by the Geological Survey of Canada (GSC), the following seismic parameters were provided:

Table 2.1 Seismic Values for Faro Mine (Robertson 1996)

Return Period (years)	475	10,000
Peak Ground Acceleration (g)	0.05	0.13

2.5 Hydrology

SRK (1990) outlined the hydrology and hydraulic design for the diversion project Appendix B of that report provides a review of the Vangorda Plateau hydrology and methods used for estimating peak flows in Vangorda Creek. The first method used was a "focused" regional analysis, which uses regional streamflow data for calibration. The second method used, the SCS Unit Hydrograph, follows from HEC-1 modeling, which is a standard computer model for simulating precipitation / surface run-off processes. Table 2.2 provides a summary of the recommended discharge values for Vangorda Creek:

Table 2.2 – Peak Discharge Values for Vangorda Creek (SRK 1990)

Return Period (years)	Peak Discharge (m^3/s)
2	4.1
MAF	4.2
10	6.6
20	7.6
50	9.0
100	10.0
500	18.0

As such, the diversion channel was designed to handle the 1:100 year event, which amounts to 10.0 m^3/s.

2.6 Flume Design and Construction

SRK (1990) outlines the design parameters for the diversion project. The following list provides a summary of some of the main points:

- The diversion channel was designed to be reasonably watertight. Hence, the half-round corrugated steel pipe (CSP) was specified.
- The upstream collection dam was designed to retain water to the 1:100 year level of 1168 m. Allowing for one metre of freeboard, the physical crest of this dam was designed for Elevation 1169.0 m.
- A 1.5 m diameter CSP was designed to convey the water through the upstream collection dam.

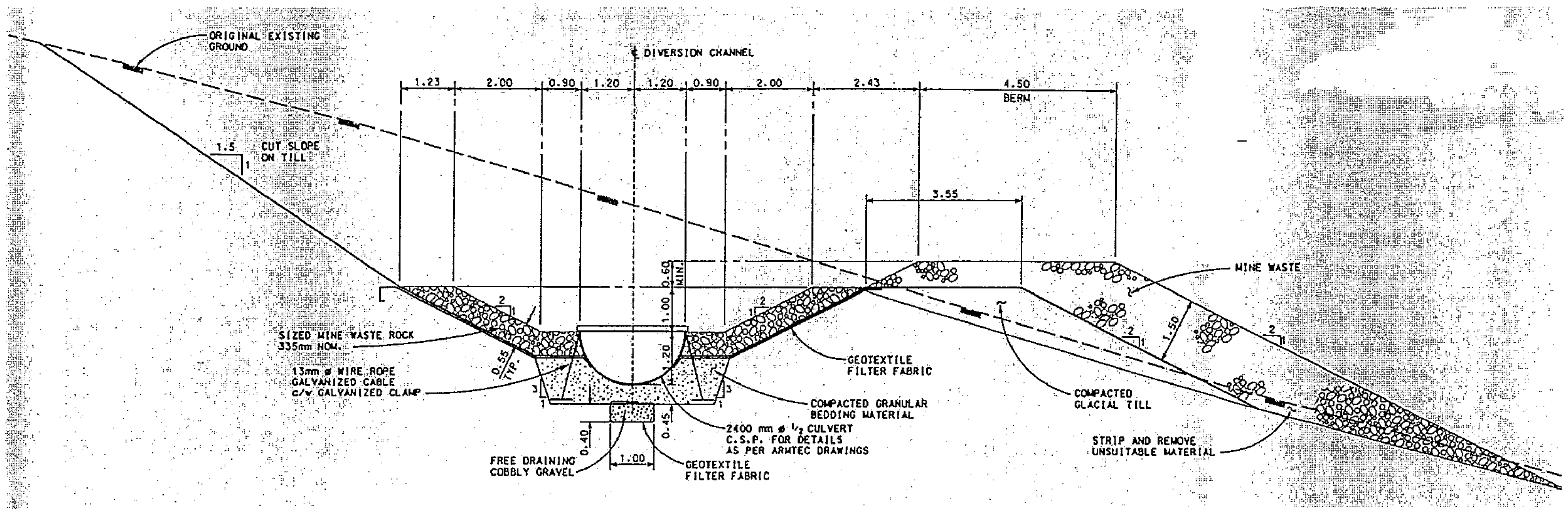
- The main diversion channel, approximately 800 m in length, was designed with a 2400 mm half-round CSP set within a rip rap lined trapezoidal section. A longitudinal slope of 0.5% was selected to ensure subcritical flow within the section, which was considered preferable for this application.
- During the design event, the depth of water flow in the channel was to be 0.73 m above the crest of the CSP liner.

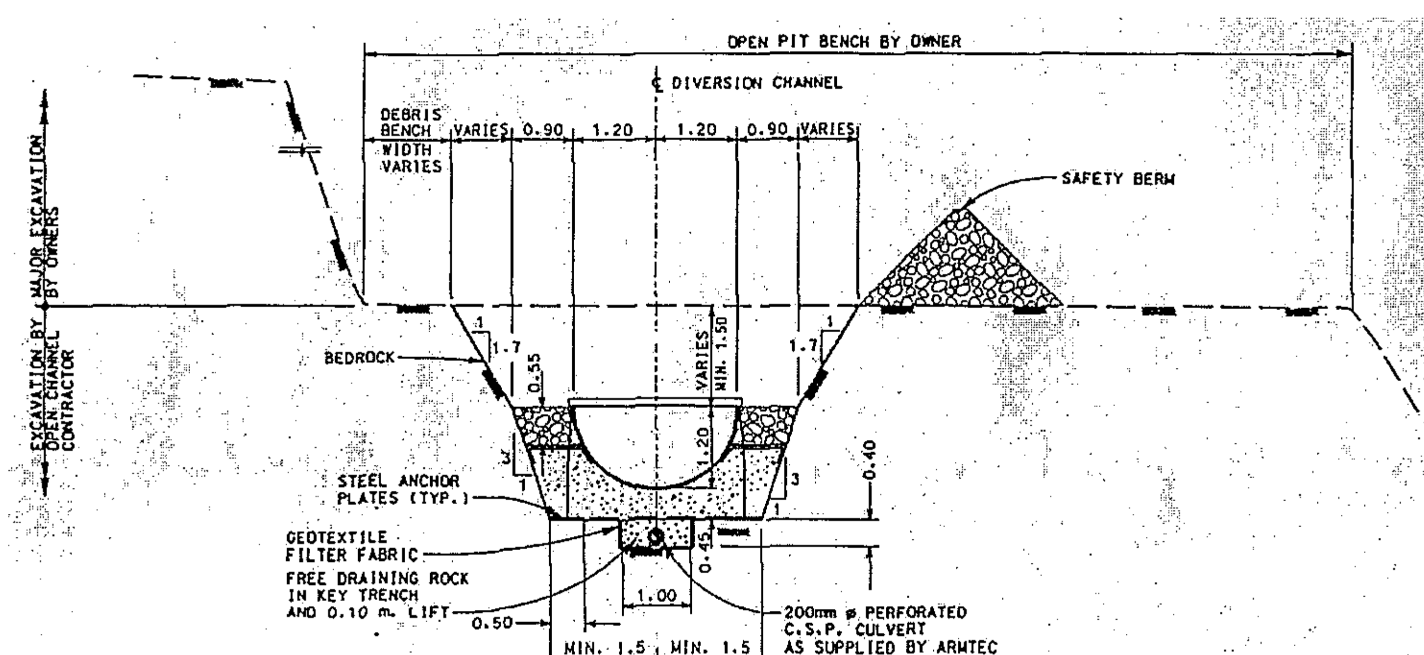
Figure 4 provides two as-built cross-sections for the flume. Further details on site preparation, excavation and fill placement were also provided in that report.

SRK (1991) provides a summary of the construction activities undertaken for the diversion project. Construction was undertaken between early January, 1991 and early April, 1991, with an SRK engineer on-site from February 6 until March 22, 1991. During construction, several design changes were made, some relevant to the flume as detailed below:

- Rather than an expected culvert diameter of 1500 mm in the embankment, the existing culvert was actually 1800 mm. As such, an 1800 to 1500 mm reducer section had to be fabricated on-site and installed in the dam section.
- The concrete deadmen and rock bolts were replaced with steel anchor plates and cables.
- Several areas of significant groundwater inflow were encountered downstream of Station 5+10 (approximately the top of the rock slope area currently under consideration), so that the key trench was added during construction to the backfilled channel to intercept and direct away surface flow.

SRK (1992) provides a summary of the additional construction work carried out for the realignment of the Vangorda Creek diversion, undertaken in approximately February, 1992. The realignment of the diversion channel, starting at approximately Sta. 6+30 and ending at 8+85, was required due to expansion of the open pit which was previously not forecast. During this realignment work, two design changes were also incorporated. Firstly, the channel freeboard was reduced from 1.6 to 0.9 m above the lip of the half-round culvert, because of the steepened grade. Secondly, because a source of clean drain rock was not readily available, the 200 mm perforated corrugated steel pipe (CSP) underdrain was wrapped in geotextile filter fabric and backfilled with granular bedding material.





(TAKEN FROM CONSTRUCTION DRAWINGS PREPARED BY KILBORN FOR CURRAGH RESOURCES INC., 1991)

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: FLUME DESIGN SECTIONS

PROJECT No.	DWG. No.	REV.
0257-002-03	FIGURE 4	

SRK (1997) outlines some observations and recommendations made regarding the creek diversion, which are summarized below:

- The loss of fine bedding material has resulted in settlement of the rip rap.
- Rip rap loss at the outlet end of the flume where it enters the stilling basin.
- Poor condition of the lower section of the flume where cross bars are badly bent and the flume is buckled.

Anvil Range (1999) reviewed the June 1999 rock fall event that damaged the flume and resultant repair work. Seven sections of the flume were replaced at the location shown on Figure 3. The cost of the remedial work was estimated to be $36,000. Seven recommendations regarding flume components and further assessment work were provided. In addition, a smaller rock fall occurred at the same location in September, 1999.

3.0 SITE VISIT AND FIELDWORK

3.1 General

Two BGC staff members, Mr. Jim Cassie, P.Eng., and Mr. Bill Burton, E.I.T., traveled to Faro Mine for two days on July 9 and 10, 2000. During that time, the following tasks were undertaken:

- Visual inspection of the flume section from the diversion dam to the drop box structure.
- Visual inspection of the Vangorda pit slope directly proximal to the flume alignment.
- Collection and review of various drawings and reports regarding the Vangorda pit, located at the mine site offices.
- Inspection and collection of structural data regarding the rock slope overlooking the flume sections.
- Meeting and discussion with Mr. Dana Haggar, Site Manager, regarding equipment and materials on-site, construction capabilities and inspection and monitoring plans for the future.

Mr. Eric Denholm was also on-site during the majority of the site visit. During the site inspection period, climatic conditions were clear and sunny, except for some light rain on the afternoon of July 9th.

During the site visit, observations were recorded on a Dictaphone, complemented by a series of photographs documenting the conditions observed. All other data such as culvert section condition and structural data were recorded in a field book. Several reports were copied from those available at site.

After the completion of the site visit at Faro Mine, Messrs. Cassie and Burton met with Mr. Darren Klippenstein of Golden Hill Ventures Ltd. The purpose of the meeting was to review possible construction options for the flume so that Golden Hill could prepare estimates of construction costs. This information is summarized in Section 5.0.

In addition, Messrs. Cassie and Burton met in Whitehorse with Mr. Dave Sherstone of Indian and Northern Affairs Canada and a briefing was held on the observations made on-site.

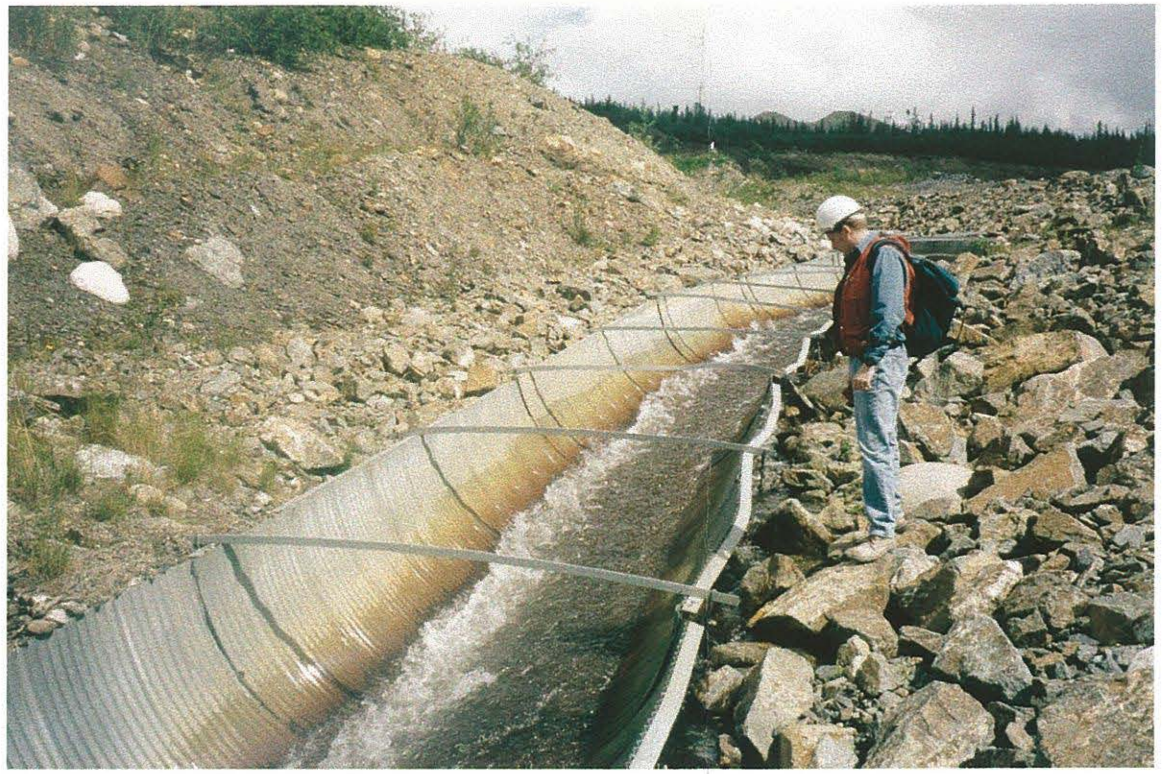
3.2 Flume Condition Assessment

During the visual inspection, each culvert section was numbered, starting with Section #1 at the downstream end at the plunge pool and ending at Section #152 at the toe of the diversion dam. The condition of the flume on a section-by-section basis is summarized in Appendix 1.

At the time of the site visit, the depth of water in the flume was typically 0.3 to 0.5 m at a gradient of approximately 4°. This flow configuration was compared to published relationships for flow properties in corrugated steel culverts (AISI, 1984) and corresponds to a discharge of approximately 3 m^3/s. As previously noted, the design flow (1:100 year return period) was estimated to be approximately 10 m^3/s. Photographs of the lower downstream portion of the diversion flume are shown in Figure 5, while Figure 6 provides four views of the upper portion of the flume.

In general, the flume was successfully passing the Vangorda Creek flow and no water was observed outside of the excavated channel. However, the flume's overall condition, especially in the lower portion from Section #1 to approximately Section #20, is deteriorating with time. Several of the cross-braces were damaged by rockfall and de-icing activities. A few small holes were seen in the culvert bottom and gaps have opened at some of the joints. Near the downstream end of the flume, water was seen flowing in the base of the channel outside the corrugated steel half-culvert.

DISCHARGE END OF THE FLUME (SECTION #1).



VIEW OF SOME FLOW ON THE OUTSIDE OF SECTION #8.

VIEW OF THE METAL SIDE WALLS BEGINNING AT SECTION #48.

VIEW OF THE TALUS SLOPE CREATED BY WEATHERED PHYLLITE.

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

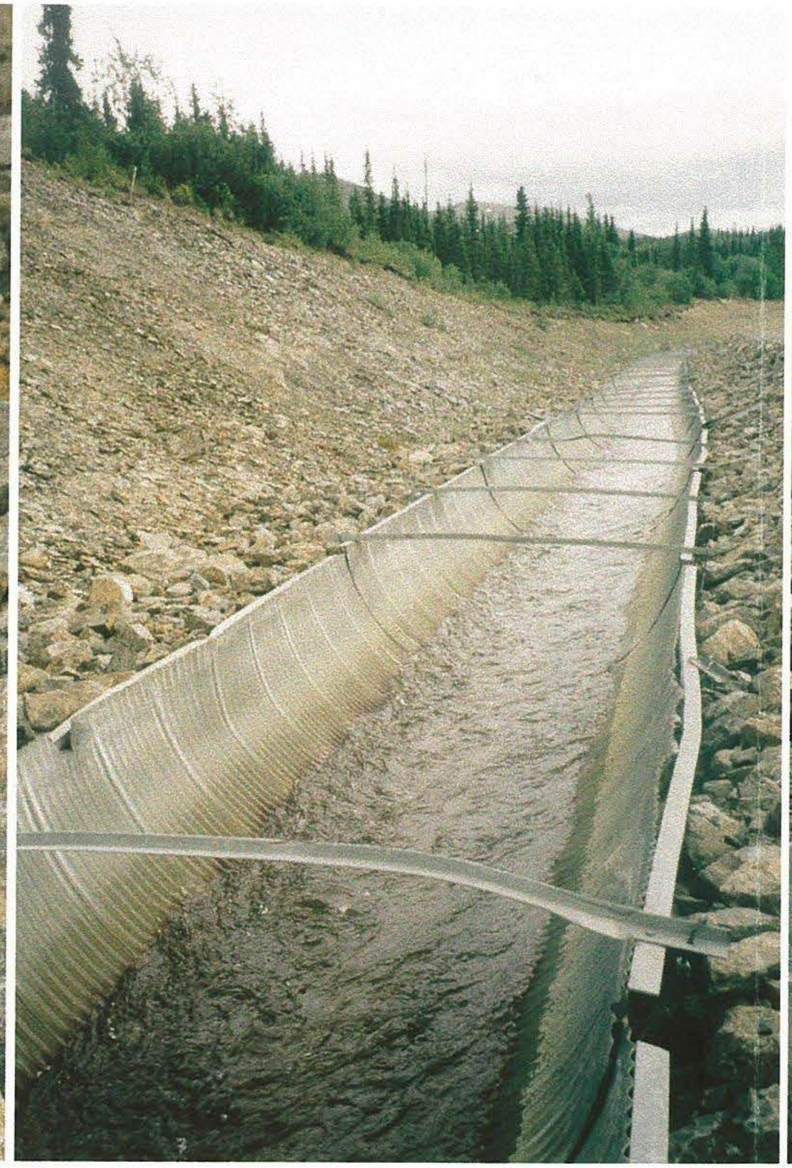
TITLE: PHOTOGRAPHS OF DIVERSION FLUME (LOWER PORTION)

PROJECT No. 0257-002-03

DWG. No. FIGURE 5

REV.

VIEW OF THE TIE-DOWN DETAIL AT SECTION #112.



VIEW OF THE FLUME FROM SECTION #107.

VIEW FROM SECTION #148 UP TOWARDS THE DIVERSION DAM.

VIEW LOOKING DOWNSTREAM ALONG THE FLUME FROM THE DIVERSION DAM.

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: PHOTOGRAPHS OF DIVERSION FLUME (UPPER PORTION)

PROJECT No. 0257-002-03

DWG. No. FIGURE 6

REV.

The freeboard height of the road above the half culvert lip was measured at various points along the length of the flume. These measurements are included in the table in Appendix 1. The freeboard varied from a minimum of 1 m to a maximum of 4.3 m, with an average of approximately 1.5 m. The channel width available varied throughout the flume length; the road embankment crest setback from the culvert varies from 1 m to 6 m.

Several sections of the flume are currently unsupported by backfill due to settling or washing out of underlying material. The sections that are deficient in rip rap backfill are itemized in Appendix 1. In addition, Appendix 1 lists the sections where the tie-down cables, that attach to the cross braces and anchor the culvert against uplift forces, have been damaged.

3.3 Rock Slope Characterization

The slopes above the diversion flume are predominantly composed of a silty sand and gravel till with some boulders. In some areas the rock slopes are adjacent to the flume as shown in Figure 3. The rock slopes were grouped into four zones, based on slope morphology and potential rockfall release mechanisms.

The first rock slope encountered, moving upstream from the plunge pool has been designated Zone 1, this zone includes the area which generated a large rockfall in 1999. Photographs of Zone 1 are shown in Figure 7. Zone 1 is approximately 95 m in length and extends from flume Section #46 to Section #62. The slope is approximately 10 to 12 m high and is composed of a graphitic phyllite with well developed foliation planes and joint sets. Some seepage was noted in the area of the detachment zone of the 1999 rockfall and also to the east of that area.

The orientations of the discontinuities in the rock mass in Zone 1 were measured from access along the crest and the base of the slope. The discontinuities are planes of weakness in the rock and include both foliations and joint sets. A foliation is a planar structure that results from the realignment or flattening of mineral grains during metamorphism. Foliation often forms repeating, parallel planes. However, in areas of multiple stages of metamorphism and deformation, such as the Vangorda pit area, more than one foliation orientation may be present. Joint sets are often described as the 'fabric' of the rock mass, and represent discontinuous but repeating breaks in the mass. A stereonet projection of the intersection of the planes of the discontinuities with a lower hemisphere is shown in Figure 11. The poles (perpendicular axes) to the measured planes are plotted and contoured in order to show the dominant trends in the naturally varying discontinuities. The poles of the projections of the slope face, two foliation planes forming the base of the 1999 rockfall, and the joint surface forming the backscarp are highlighted in Figure 11. The interpreted mechanics of the 1999 failure are discussed in more detail in Section 5.4.2.

The next rock slope area encountered moving upstream, Zone 2, is characterized by closely spaced near-horizontal structure. Zone 2 is approximately 25 m in length and extends from Section #63 to #67. The slope profile in this zone is raveling in small fragments from the steep slopes. The slope profile is concave and a very large catchment area for potential rockfall has developed at the base of the slope. The slope morphology in Zone 2 is shown in a photograph in Figure 8. A minor amount of seepage appears to be covering most of the rock face.

Zone 3 is a composite slope with rock outcropping near the base of the slope, and till near the top of the slope. Zone 3 is approximately 20 m in length and extends from Section #68 to Section #72. Several rounded boulders are visible at the top of the slope in the till. A panorama of the slope in Zone 3 is shown in Figure 9. The till slope, situated on the west side of Zone 3 appeared to be wet and saturated along the bottom portion of the slope.

Zone 4 is composed of a dark gray to black carbonaceous phyllite with a talus fan at the base. The talus fan development is encroaching on the flume. Zone 4 is approximately 25 m in length and extends from Section #73 to Section #77. A band of more competent rock, approximately 2 m in thickness, is visible at the top of the slope. The raveling process, forming the talus slope, is undercutting the more competent rock and several tension cracks are visible 1 to 2 m from the crest edge. A panorama of the slope and a view of the tension cracks are shown in Figure 10. Some seepage was observed at the toe of the slope.

AREA OF 1999 ROCKFALL

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: PANORAMA OF POTENTIAL ROCKFALL SOURCE AREA (ZONE 1)

PROJECT No. 0257-002-03

DWG. No. FIGURE 7

REV.

NOTE: NATURAL CATCHMENT AREA FORMED AT THE BASE OF THE SLOPE

SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250 5185

PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
PHOTO OF ROCK SLOPE ABOVE DIVERSION FLUME (ZONE 2)

CLIENT:
DELOITTE & TOUCHE INC.

PROJECT No.
0257-002-03

DWG. No.
FIGURE 8

REV.

NOTE: ROUNDED BOULDERS AT TOP OF THE SLOPE.

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: PANORAMA OF POTENTIAL ROCKFALL SOURCE AREA (ZONE 3)

PROJECT No. 0257-002-03

DWG. No. FIGURE 9

REV.

NOTE: TENSION CRACK FORMED IN UPPER MORE COMPETENT MATERIAL

ZONE 4 – POTENTIAL ROCKFALL SOURCE AREA.
– BAND OF COMPETENT ROCK BEING UNDERCUT BY DEBRIS.
– DEBRIS CONE ENCROACHING ON DIVERSION FLUME.

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

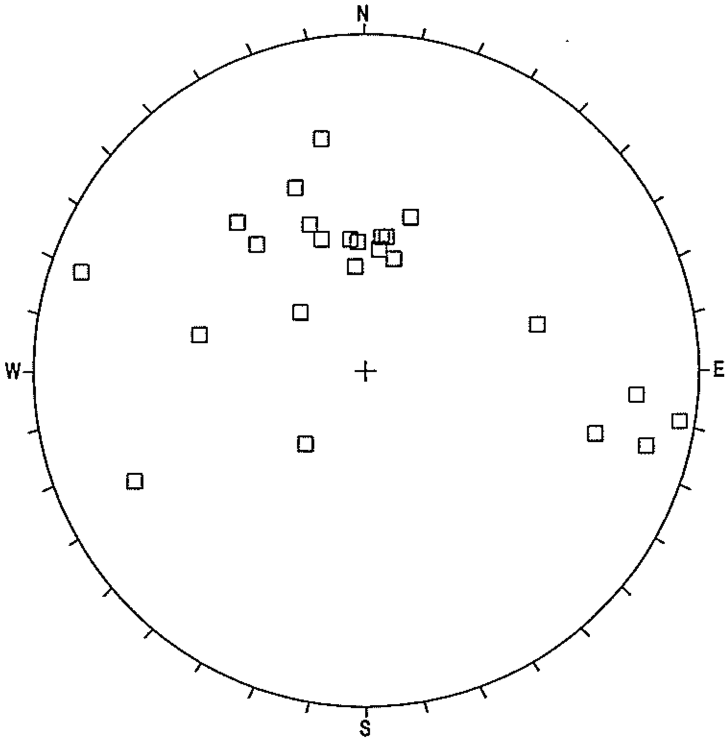
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

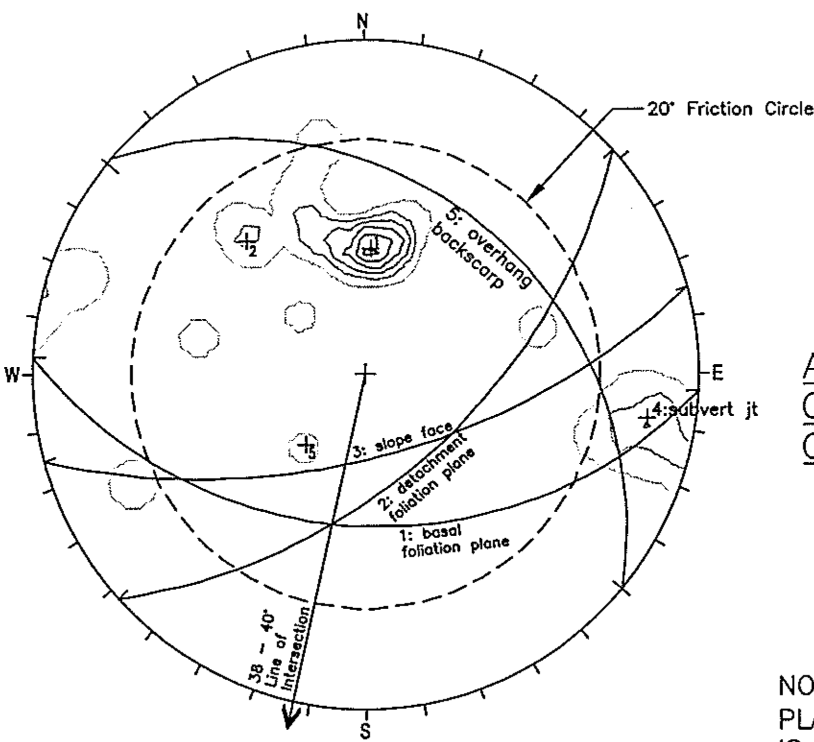
PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: PANORAMA OF POTENTIAL ROCKFALL SOURCE AREA (ZONE 4)

PROJECT No.	DWG. No.	REV.
0257 – 002	FIGURE 10	



MEASURED POLES TO DISCONTINUITY PLANES



AVERAGE DISCONTINUITY ORIENTATIONS BASED ON CONTOURING MEASUREMENTS

NOTE:
PLANE FOR POLE SET "4: SUBVERT JT" IS NOT SHOWN FOR CLARITY.

SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (250) 374-8600

PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
STRUCTURAL DATA STEREONET PLOT
ZONE 1

CLIENT:	PROJECT No.	DWG. No.	REV.
DELOITTE & TOUCHE INC.	0257-002-03	FIGURE 11	

3.4 Vangorda Pit Slope

The stability of the Vangorda pit slope along the flume was assessed by visual inspection during the site visit and review of geotechnical reports issued while the pit was being excavated. The reports discussing pit wall stability during mining are described in Section 2.4. These reports do not make note of any evidence of large-scale pit wall instability that could potentially impact the current alignment of the flume.

At present, the pit slope is experiencing widespread raveling and many of the catch benches have been filled with debris. A panorama of the slope is shown in Figure 12. Other than the bench scale failures, no evidence of large-scale distress such as cracking at the crest, or bulging of the slope was noted. On-site personnel have not noted any signs of large-scale slope deformation or reported any unusual maintenance requirements for the access road located between the flume and the pit.

At the time of the site visit, the pit slope bordering the flume was observed to be generally dry with only a few seeps in isolated locations, generally located on the lower benches.

3.5 Site Equipment, Inspection Schedule and Response Time

Based on the discussions held with Mr. Haggar, the following major surface equipment is currently located at the Faro mine site:

- 40 t mobile crane,
- 120 t mobile crane,
- 986 wheeled loader,
- 235 tracked excavator,
- 16G road grader plus
- miscellaneous trucks and haul trailers.

All of this equipment is currently working and operators for same are generally available in Faro, Ross River or Whitehorse. This equipment is expected to be available to undertake any construction work required on site, unless this equipment is sold in the future to satisfy creditor demands.

REV.	DATE	REVISION	DRAWN	CHECKED	APPROVED

SCALE:	N.A.
DATE:	AUG 2000
DRAWN:	MT
DESIGNED:	BB
CHECKED:	JWC
APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250-5185

CLIENT: DELOITTE & TOUCHE INC.

PROJECT: VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE: PANORAMA OF VANGORDA PIT SLOPE BELOW DIVERSION FLUME

PROJECT No. 0257-002-03

DWG. No. FIGURE 12

REV.

At the current time, daily visual inspections of all mine facilities are undertaken. As such, no more than 24 hours may elapse before potential events, such as rockfalls or pit slope movements, would be noted. Beginning sometime in September of this year, in order to save costs, the inspection schedule may be reduced to three times per week, which would increase the hourly period between the identification of any potential events. In addition, it is unlikely that snow clearing will be undertaken on mine site access roads and the inspection trips will be done on snowmobile. As such, the time delay between potential event occurrence and the arrival of appropriate construction equipment may be 72 hours or more.

4.0 CONSEQUENCES OF FAILURE

In order to evaluate potential remedial options regarding the flume, it is necessary to consider the potential consequences if a rockfall were to occur and the channel were to be blocked for a certain period of time. Alternatively, another scenario to be reviewed is if the Vangorda pit wall were to fail, and the diversion flume collapsed, then all of the creek drainage would be directed into the pit.

The current configuration of the rockslope adjacent to the flume has the potential for rockfall ranging from individual boulders, to approximately 5 m^3 for a small wedge failure up, to an estimated maximum size of approximately 80 m^3. For smaller events, such as individual boulders and rockfall up to approximately 2 to 5 m^3, damage to individual flume sections may occur, along with some constriction of the flume flow. For events larger than that size, the following consequences are likely:

1. The flume section and/or the entire channel section may be partially or totally blocked preventing the flow of creek water in the flume.
2. If only the flume section is blocked, and depending upon the creek quantity, water flow may be transferred out of the flume and onto the channel section. Depending on the actual flow velocities, erosion of bedding materials under the rip rap materials may occur. SRK (1997) notes that this resultant event has already occurred.

3. If the channel section is partially or totally blocked, creek water will rise up and either flow downhill along the access road berm and/or down into the Vangorda pit. As such, "clean" creek water would be mixed with the "dirty" pit water. Depending upon the time period for drainage into the pit, this event could potentially result in future water treatment costs, if the pit water was ever discharged to the environment.
4. Erosion of the access road berm may occur. Hence, the access road may have to be reconstructed before any flume rehabilitation work could be undertaken.
5. Limited to severe damage and/or destruction of the actual flume sections will result. Additional culvert sections and associated materials (geotextile, bedding materials, pipe, etc.) would be required, possible in excess of the supplies currently maintained at site.

While on-site, Mr. Haggar indicated that the rockfall event of June, 1999 included approximately 25m^3 of material. The diversion channel was partially blocked and seven flume sections had to be replaced. The clearing of the flume section and completion of the repair work finished approximately two weeks after the blockage was noted. Using equipment and materials on-site at the mine, the total estimated cost for the repair work was $36,000.

If either blockage to the channel, or instability of the pit wall occurred, creek drainage would be directed into the pit. Table 5.1 of Robertson (1996) provides height-capacity data for the Vangorda Pit. At the time of the inspection, the Vangorda pit water elevation was at approximately 1077 m (amsl). It is estimated the current water level in the pit is at approximately 1080 m (amsl) and the pit capacity between 1080 and 1092 m amounts to some 700,000 m^3. If the creek were to be diverted into the pit, and assuming a typical flow of 4 m^3/s, then some 50 hours would be required to fill the 12 m high interval. For the design event of 10 m^3/s, only 19 hours would be required to fill this pit interval. For a winter flow quantity of around 2 m^3/sec, then 100 hours would be required to fill this interval.

The 1092 m level is significant because it is the proposed level where a pumping station may be installed at a latter time. At this level, some waste rock has been dumped at the east end of the pit and hence, a large, flat area is available for the placement of a pumping station. If the pit water level were to rise above this elevation, then some pumping and treatment from higher up would have to be initiated before an in-pit pumping station could be established.

It should be noted that the Vangorda Pit contains an estimated capacity of 6.36 million m^3 from the 1080 m level up to the crest at 1140 m.

5.0 ASSESSMENT OF DIVERSION FLUME CONDITIONS

5.1 Flume Condition

As previously discussed, the flume is essentially functioning in its role of passing Vangorda Creek around the open pit. However, the overall condition of the flume and margin of safety in the ability of the flume to pass a large storm event are continuing to erode. Thus, regardless of the remediation option chosen for the rock slopes overlooking the flume, some maintenance of the flume culvert will be required in order to ensure the flume continues to perform as designed for the upcoming years. The flume components that are sufficiently damaged that they are no longer functional are listed in Appendix 1 and summarized in Table 5.1.

Table 5.1 - Summary of Damaged Flume Components

Flume component	Amount Requiring Repair
Cross-braces	42
Side-rails	9
Culvert Wall	1 hole, 3 buckled sections
Joint	10
Rip Rap	7 flume sections

The extent to which these repairs are required must be evaluated in context with the long-term plan for the flume and consequence of failure. Given the 3 to 5 year design life and limited consequence for small amounts of seepage, as a minimum, it is recommended that at least one cross-brace be functioning in each section; never should two non-functioning braces exist in a row.

5.2 Vangorda Pit Slope Condition

As noted in Section 3.4, the pit slope adjacent to the flume is experiencing ongoing raveling of catchment benches but no signs of large-scale pit slope movement were observed, either during operation or since the mine has been closed.

As previously noted, a relatively high phreatic surface is anticipated for the pit wall and the valley wall in general. Any minor seepage quantity from the flume sections is estimated to have little impact on the groundwater level in the slope. However, if the flume conditions were to degrade to the extent that the slope became saturated, then instability of the pit wall may become a concern.

Ongoing raveling of the pit slope can be expected. In its current routing, the Vangorda Creek diversion channel will require regular inspection to ensure it remains functional. However, enhancing the stability of the overall pit slopes is a significant undertaking and is not considered warranted for the short term. Steep slopes and lack of rockfall protection restrict access to the pit wall. The stability of the slope can be increased by flattening the overall slope. However, flattening the slope by excavation would require the relocation of the flume. Further, flattening the slope by placement of a buttress would preclude any further mining and would require transporting an extensive amount of material, which may be more costly than relocating the diversion away from the pit.

As well as ongoing inspection for evidence of slope movement, such as bulging of the slope face or the appearance of tension cracks at the crest, monitoring stakes can be placed along the pit crest and upslope of the flume to aid the visual monitoring program. If the stakes are well marked and installed in a straight line, then sighting down the line will help to indicate if any deformation of the slope is occurring. More sophisticated monitoring methods can be implemented if signs of slope distress are observed during regular flume inspections.

5.3 Rockfall Mitigation Options – Zones 2, 3, and 4

5.3.1 Zone 2

A large catchment bench is present at the base of the slope in Zone 2 that retains the dominant rockfall fragment sizes. Hence, no further rockfall mitigation measures are proposed at this time.

5.3.2 Zone 3

The boulders that are imbedded within the sandy till at the top of the slope will continue to be undermined by erosion and could reach the flume in individual rockfall events. The boulders could damage the flume walls or cross-braces, but are not likely to block the passage of water. Therefore, the owner could accept the risk of this potential damage (and resultant repair work and cost), or the following remedial work could be undertaken.

As stabilizing the soil slope would be difficult, the construction of a catchment bench near the base of the soil slope should be considered. In order to construct a catchment bench, the following would be required:

- Mobilize a bulldozer to site;
- Construct access to the top of the slope. A road along the top of the slope is already in existence, but pushing through the small brush at the top of the slope will be required;
- Bulldoze a level area along the crest of the rock slope, approximately the width of the bulldozer blade (approximately 6 m wide).

Construction of a catchment bench with the on-site excavator can also be considered. This would be less efficient than construction with a bulldozer but may be less costly if mobilization costs for a bulldozer are high. Additionally, the use of the bulldozer may initiate the movement and release of individual boulders while the use of an excavator may not have the same effect.

5.3.3 Zone 4

The talus slope that is encroaching on the flume in Zone 4 is not expected to damage or block the flume. The undercut band of competent rock at the top of the slope may release rock of sufficient size to damage the flume, although blockage of the channel is not expected. Impact from rockfall is expected to be relatively low energy, as the talus slope will ensure the rocks are rolling and not bouncing as they move down the slope. Again, the owner could accept the potential risk or the following remedial work could be undertaken.

Scaling the rock blocks at the top of the slope can reduce the potential for rockfall. Scaling can be done by pushing with an excavator from the crest, or by "bulldozing" with small explosive charges. The flume should be protected from rockfall during scaling by covering with timber or other suitable locally available materials.

Reinforcing the slope in Zone 4 would be difficult due to the poor overall rock quality. Long term protection from individual rockfall events can be achieved by covering the flume with steel covers, as discussed below in Section 5.5.6. A wood cover may also provide protection if it is fashioned to allow rock to pass overtop, and is covered in talus to cushion the impact.

5.4 Rockfall Mitigation Options – Zone 1 (Area of 1999 Rockfall)

5.4.1 Rock Slope Downstream of 1999 Rockfall

Downstream of the area of the 1999 rockfall, in a separate rock knob, several structures, including foliation planes and joint planes, were observed. Several potential wedges were interpreted, but these tended on the order of 5 m^3 as opposed to the larger, 25 m^3 sized, 1999 instability. Intersecting foliation planes forms the gully between this rock knob and the location of the 1999 rockfall.

5.4.2 Interpreted Failure Mechanism of 1999 Rockfall

It is interpreted that the 1999 rockfall occurred as a wedge failure along the basal foliation plane, joint set 1, and the detachment foliation plane, joint set 2. The orientation of the foliation planes and slope face are shown in Figure 11. The wedge formed by joint sets 1 and 2 did not fail as an intact block, but rather was truncated along a joint dipping back into the slope, joint set 5. It appears that sliding took place predominantly along the basal foliation plane, and this plane appears to be continuous up to the top of the slope. The upstream side of the 1999 wedge failure released along steeply dipping joints that trend into the slope, joint set 4. Photographs of the 1999 rockfall source area are shown in Figure 13. In the lower photograph in Figure 13 the person is standing on the basal foliation plane and pointing to the intersection with the detachment foliation plane. The repeating joints forming the backscarp of the failure can be seen at the top of this photo, and the joints forming the side release can be seen to the far right of the photo.

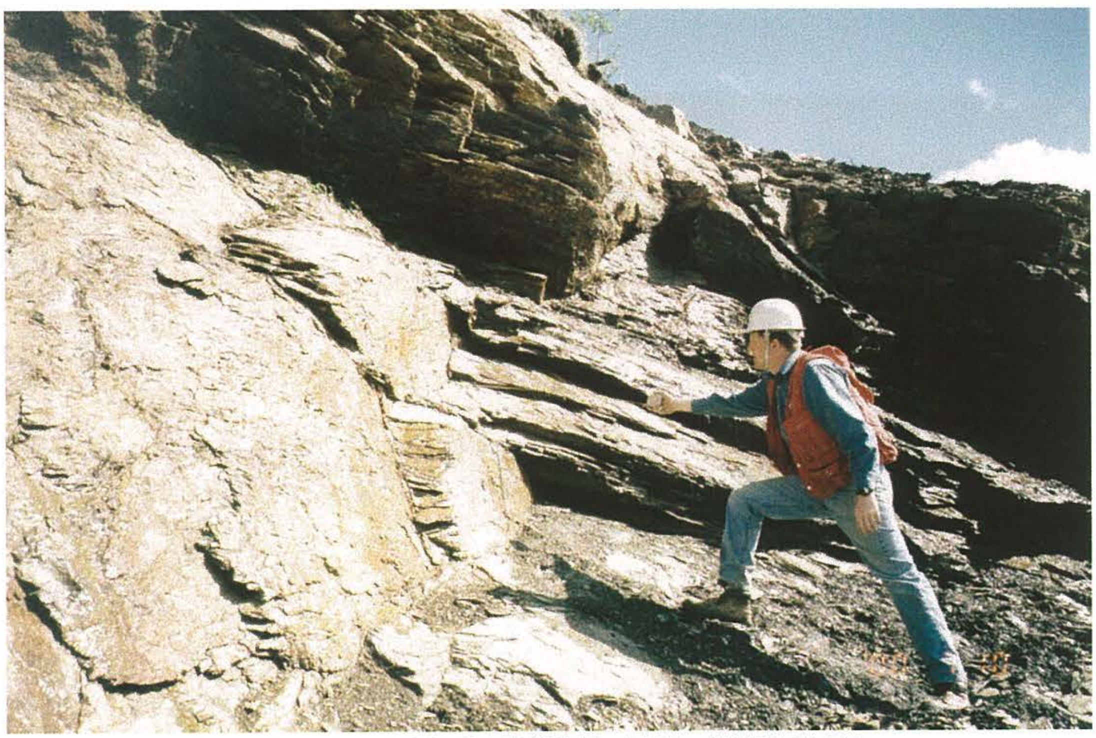
The discontinuity measurements from Zone 1 were plotted and contoured and are shown in Figure 11. The average orientation of the poles to joint sets and their corresponding planes that were interpreted to have caused the 1999 failure are labelled in Figure 11. As can be seen in this figure, the basal foliation plane and the release foliation plane, form a kinematically admissible potential failure mechanism. As the two foliation planes are similar in orientation they form a very open wedge, and thus sliding occurs predominantly along one plane as opposed to along the line of intersection. In this case the sliding is along the basal foliation plane, which is in agreement with the failure mechanism interpreted in the field. A simplified stability assessment compares the line of intersection of a potential wedge failure to the slope configuration and frictional resistance. The friction angle along the foliation planes was estimated to be 20° to 25° based on their smooth form and graphitic nature. As the line of intersection is shallower than the slope face, and thus able to daylight on the slope, and steeper than the angle of friction, the wedge will be unstable unless cohesion is acting along the joint.

A more sophisticated analysis was undertaken to calibrate the field interpretation and to allow an assessment of reinforcement requirements for the remaining rock mass. The commercially available software program SWedge was utilized to analyze the failure using methods described by Hoek and Bray (1981). A simplified wedge modeling the average orientation of joint sets 1 and 2 was analyzed and is shown in Figure 14. In the analysis the Mohr-Coulomb friction angle parameter along joint sets 1 and 2 was set at 22° and the cohesion parameter was varied until a condition of marginal stability simulating the 1999 failure was achieved. A cohesion of 20 kPa along each joint set resulted in a Factor of Safety of 1.3 for a dry slope and 0.9 for a fully saturated slope. A Factor of Safety of below 1.0 indicates a condition where equilibrium is not satisfied and the analyzed configuration is unstable. As the water table is high in the slope, evidenced by groundwater discharging along the base of the overhang, these parameters were considered a reasonable approximation of the strength operative in the slope shortly before the 1999 failure.

These analysis results indicate that an increase in water pressure or a loss of cohesion along the foliation planes is sufficient to initiate a failure in the slope. The size of the failure will be affected by other structural weaknesses in the slope, which cannot be accounted for in this simplified analysis.

The options for mitigating the hazard from the potentially unstable rock mass remaining after the 1999 failure are discussed in the sections below.

LOCATION OF 1999 INSTABILITY



CLOSE UP OF DISCONTINUITIES BOUNDING 1999 INSTABILITY

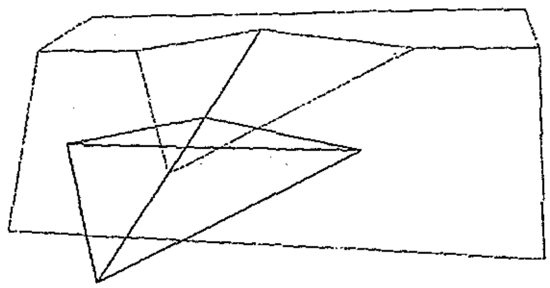
SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250 5185

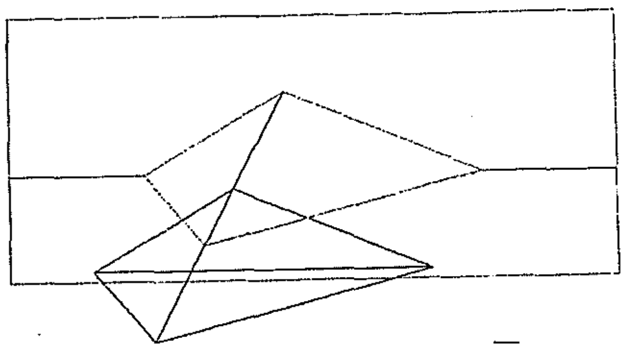
PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
PHOTOGRAPHS OF 1999
ROCKFALL SOURCE AREA

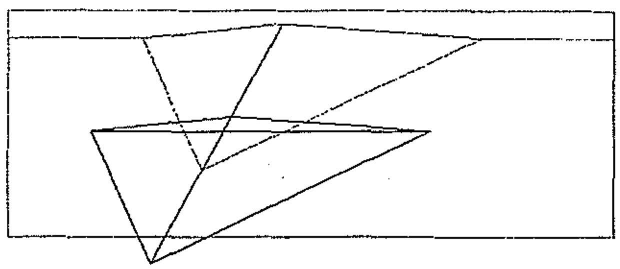
CLIENT:	PROJECT No.	DWG. No.	REV.
DELOITTE & TOUCHE INC.	0257-002-03	FIGURE 13	



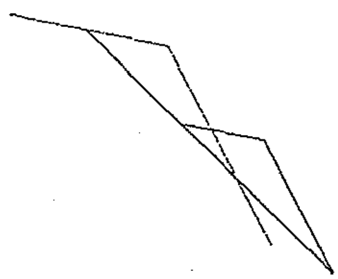
PERSPECTIVE VIEW



TOP VIEW



FRONT VIEW



SIDE VIEW

SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250 5185

PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
DIAGRAM OF WEDGE ANALYZED FOR STABILITY

CLIENT:	PROJECT No.	DWG. No.	REV.
DELOITTE & TOUCHE INC.	0257-002-03	FIGURE 14	

5.4.3 Monitor and Repair Option

The rock mass discontinuities that acted as detachment plans for the 1999 rockfall can be seen to extend into the slope. As well, the discontinuities are repeated on regular intervals. As the discontinuity planes dip at angles greater than the frictional resistance available, some form of cohesion must be acting along the discontinuities in order for the remaining overhanging rock, to stay in place. This cohesion is most likely in the form of intact rock bridges across the joint sets. Given the seepage observed at the base of the overhanging rock it can be expected that freeze-thaw cycling will reduce the cohesion in the slope and initiate rockfall. It is difficult to predict with certainty when further instability can be expected, but the recurrence interval is more likely to be on the order of years as opposed to tens of years.

The presence of pervasive structures within the overhanging rock suggests that the rock mass is not likely to fail as one massive block, but rather in a series of events. As well, any rock mass that becomes unstable is likely to break-up during the block run-out.

The option of monitoring the slope and repairing damage to the flume in the event of rockfall can be considered given the following:

- Ongoing rockfall can be expected in this area, but the time frame may be on the order of years.
- That the size of each event is likely to be of a size that can be excavated by on-site equipment.
- The flume, in its present configuration, is considered a viable solution for a 3 to 5 year time frame.

Only limited materials currently are available on-site for the repair of the flume. Additional materials will need to be purchased and brought to the site, if this option is to be viable.

5.4.4 Drill, Blast and Bolt Option

Overhanging rock could be removed by trim blasting. Success will depend on continuity of the basal foliation plane for controlled transmittal of the blast energy. As discussed previously, there are likely some intact rock bridges providing a cohesive component to the strength. However, due to the observed pervasiveness of the foliation plane, it is considered that controlled trim blasting, followed by scaling, will have high likelihood of success in detaching the remaining overhanging rock. As well, some rock bolts may be required to stabilize areas of the remaining rock slope damaged by blasting. Engineering supervision will be required during construction, particularly after blasting.

A conceptual plan for construction with the drill, blast and bolt option would include the following:

- Mobilize to site (drill, compressor, personnel and equipment);
- Prepare site (provide access to rock face, ensure safe work site by removing loose rock);
- Drill blast holes;
- Protect the flume from blast rock;
- Trim blast overhanging rock;
- Inspect the rock slope, then scale, and/or bolt as required, undertake further blasting if required;
- Remove blast debris and flume protection;
- Demobilize from site.

5.5.5 Shotcrete Buttress and Bolt Option

As an alternative to blasting and excavating, the remaining wedge of undercut rock can be left in place and reinforced with rockbolts. Rockbolts alone may not be effective due to the persistent discontinuities in the rock mass; the rock mass may simply break away around the reinforcing bolts. A buttress (or "whaler") of shotcrete can be constructed and bolted to the rock mass to provide reinforcement all along the base of the overhanging rock.

The potential 120 m^3 wedge failure depicted in Figure 14 was analyzed using SWedge to determine the extent of rockbolting required to achieve an adequate factor of safety against sliding. The analysis permits the input of force vectors (direction and magnitude) and then re-assesses the equilibrium of the wedge. The force vectors are assumed to act on the centroid of the analyzed wedge.

This analysis is simplified in that the wedge is assumed to behave as an intact, rigid block such that progressive, block-by-block, failure cannot be accounted for. The simplified analysis undertaken is conservative in that the rock mass was assumed to lose all cohesion at once.

The stabilizing force vectors were varied until a Factor of Safety of 1.4 against sliding was achieved; the resulting force vectors are shown in Figure 15. The magnitude of the force required to stabilize the wedge 600 kN. A standard resin grouted and pre-tensioned rockbolt, 25 mm in diameter, constructed of 500 MPa steel, 5 m in length and installed into competent rock typically has a capacity of 130 kN. Thus the required stabilizing force corresponds to a total of 5 rockbolts. The two force vectors shown in Figure 15 are plunging at 10° and trending towards a bearing of 20° and 320°. The installed rockbolts should be directed generally similar to the force vectors shown in Figure 15, but should be field-fit to the local rock mass shape, and to intersect the local discontinuities at the most favourable orientation. At least two additional rockbolts will be required beyond the minimum of 5 calculated to provide support along the entire buttress, as the wedge may not behave as a rigid body because of the discontinuities. Wide anchor plates should be installed for the bolts to ensure the pre-tensioning load is transferred to the reinforcing steel and thus distributed along the entire buttress.

A conceptual plan for construction of a shotcrete buttress would include:

- Mobilize to site (drill, compressor, shotcrete and equipment, personnel and equipment);
- Prepare site (provide access to rock face, ensure safe work site by removing loose rock);
- Drill holes along base of overhang, grout in dowels, connect dowels with reinforcing steel (rebar), place some steel mesh;
- Apply shotcrete (include drainage pipe within buttress);
- Drill through the shotcrete buttress and install tensioned bolts, install bolts in rock mass above buttress if required;
- Demobilize from site.

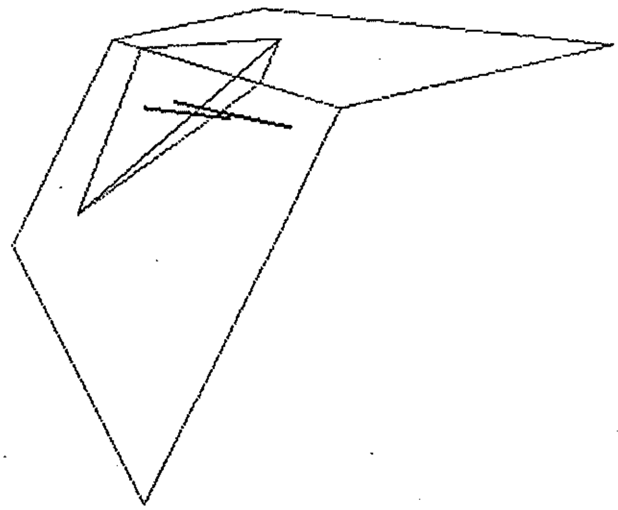
This option is considered to be equivalent as the drill and blast option in terms of likelihood for success. Although the potentially unstable rock mass is not removed, the uncertainties associated with blasting are not present. A decision between drilling and blasting or buttressing can be made on the basis of economics alone. In addition, shortcrete could not be applied practically during cold weather.

5.5.6 Cover Option

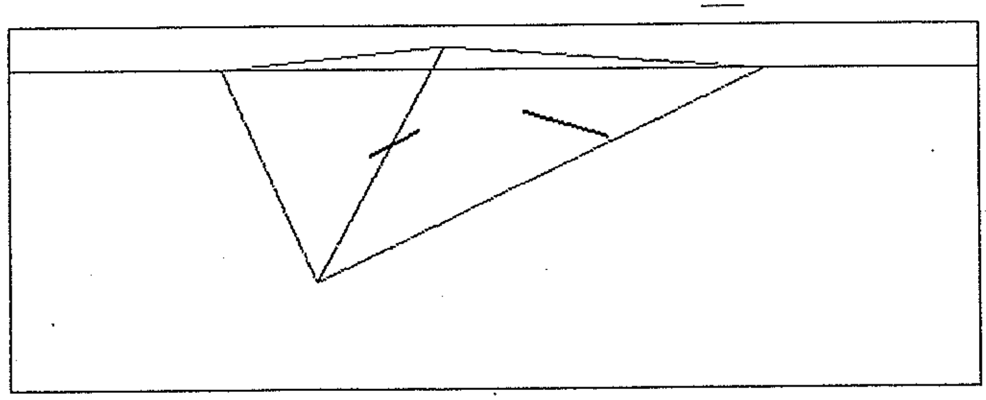
An alternative to reinforcing the rock slopes along the flume is to cover the parts of the flume at risk from rockfall. The cover should allow rock fall to pass over the flume, should be sufficiently strong to support the rock debris until its removal, and should be removable in case of excess ice build-up.

It is understood that reinforced steel plates are already present on site as canopies of abandoned mining trucks. The canopies are scheduled to be cut into manageable pieces and shipped to Edmonton for recycling as part of ongoing clean-up of the site. The steel plates from the canopies would make ideal covers for the flume. The canopies of haul trucks are heavily reinforced as they are designed to protect the operator during loading and when operating in an active pit. According to on-site personnel involved in the recycling operation, the roof of the canopy consists of 2 cm thick steel, in approximately 3.7 m by 6 m pieces that are reinforced on 1.2 m intervals. The canopy roof is estimated to have a mass of approximately 8 to 10 tonnes.

A conceptual design for a cover system is shown in Figure 16. Rip rap could be potentially placed over the cover in the “highly recommended” areas, as described in Table 5.2 to dissipate the energy of falling rock and ensure that the cover will not be dislodged by rockfall. The covers should not bear directly on the flume. The cover can include an angled side, as shown in Figure 16, or small rip rap berms to support the cover can be built up, whichever is deemed to be easier during construction.



PERSPECTIVE VIEW



FRONT VIEW

NOTE:
BOLTS SHOWN INDICATE ANALYZED FORCE VECTORS ONLY, ACTUAL BOLT SPACING PATTERN TO BE DETERMINED.

SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250 5185

PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
CONCEPTUAL ROCKBOLT REINFORCEMENT

CLIENT:
DELOITTE & TOUCHE INC.

PROJECT No.	DWG. No.	REV.
0257-002-03	FIGURE 15	

A conceptual construction sequence for the cover option is as follows:

- Fabricate covers;
- Prepare the flume channel banks (level, place rip rap);
- Load covers onto a truck with a crane;
- Transport cover to the flume;
- Place the covers using a crane;
- Place rip rap over the covers, if required, using an excavator.

All of the heavy equipment required for this construction sequence can currently be found on site. If the equipment on site is not available, then additional mobilization will be required.

The areas exposed to potential rockfall were prioritized and are listed in Table 5.2.

Table 5.2 Summary of Areas for Covering

Priority	Sections	Slope Area	Approximate Length	Comments
Very highly recommended	57 to 62	Zone 1	37 m	- no preparation of channel banks expected to be required
Highly recommended	52 to 56	Zone 1	27 m	-rip rap required on banks for cover support
Highly recommended	75 to 77	Zone 4	18 m	-some leveling of banks required
		Total	*82 m*	
Recommended	46 to 51	Zone 1	30 m	
Recommended	73 to 74	Zone 4	12 m	-some leveling of banks required
		Total	*42 m*	

According to site personnel, there are enough truck canopies on-site to cover approximately 70 m of flume, or enough for most of the high priority sites. The lower priority areas could be left uncovered, or could be covered with other, less-reinforced, materials.

It is understood that problems with icing in the channel have occurred upstream of this area. However, the gradient through the area where a cover is proposed has sufficiently limited ice accumulation. Should icing occur, then the covers could be lifted and the ice broken up as has been done in the past. Steel rings or hooks can be fastened to the cover as attachment points to facilitate lifting of the covers.

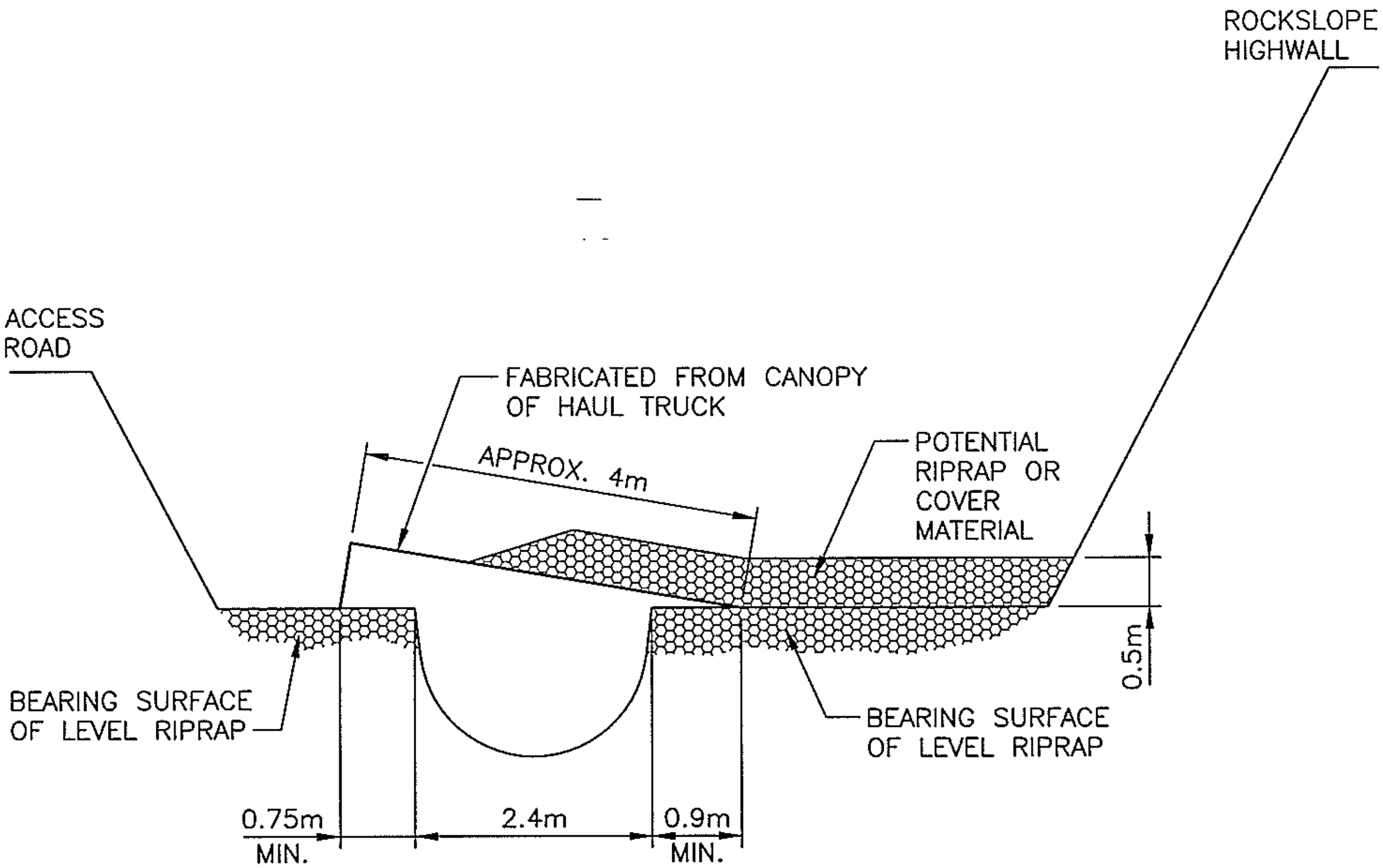
5.5.7 Relocate Flume Option

Another option for reducing rockfall hazard is to move the flume further away from the rock slopes, closer to the pit wall. This option would involve the following steps:

- Expand the excavation for the channel towards the pit (blast and transport the waste rock);
- Install the deadman anchors for the tiedowns and place bedding material;
- Divert the creek, possibly into the open pit;
- Relocate the flume sections, add extra sections as necessary;
- Seal the joints and place rip rap against the culvert.

The flume would not need to be relocated along its entire length, only for Zones 1 and 4 and enough to either side to ensure a smooth flume alignment.

Drawbacks with this option include the high cost of reconstructing the flume, greater exposure to undermining from instability in the pit wall, and reduced accessibility for inspection and maintenance.



NOTE:
CANOPY IS FABRICATED OF 2cm THICK STEEL.

SCALE:	N.A.	DESIGNED:	BB
DATE:	AUG 2000	CHECKED:	JWC
DRAWN:	MT	APPROVED:	JWC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, B.C. Phone: (604) 684 5900
Calgary, AB. Phone: (403) 250 5185

PROJECT
VANGORDA CREEK DIVERSION FLUME EVALUATION

TITLE
CONCEPTUAL FLUME COVER DESIGN

CLIENT:	PROJECT No.	DWG. No.	REV.
DELOITTE & TOUCHE INC.	0257-002-03	FIGURE 16	

6.0 COST ESTIMATES

6.1 Background

As noted in Section 3.1, Messrs. Burton and Cassie of BGC met with Golden Hill Ventures, a Whitehorse-based civil contractor, to discuss possible construction methods, equipment and costs for the various options proposed for the management of the Vangorda flume. This meeting was held so that cost estimates proposed for the various options reflected the remote location of the mine site. At that meeting, the various options, along with proposed methods and estimated quantities, were reviewed.

Subsequent to the meeting, Golden Hill provided budgetary estimates for three of the options and their cost estimate is attached in Appendix 2. The shotcrete buttress option was selected later after the meeting as a potential option, and BGC undertook its cost estimate, based on some of the Golden Hill unit rates provided (also attached in Appendix 2).

These cost estimates are based on limited engineering design work and on preliminary quantity estimates. As a result, the estimated direct construction costs may not be absolute in their actual value, but given the consistency of the estimating source, should be accurate relative to one another.

Given the relatively low value (tens to hundreds of thousands of dollars) of the proposed works, the potential impact of additional engineering design work and engineering construction supervision will be significant for the various options. Hence, in all cases, BGC has estimated the additional site survey, geotechnical engineering design and construction supervision costs that will be required for each of the options.

It should also be noted that the cost estimates assume that the work scope would be done under frost and snow-free conditions. If any construction were to be done under winter conditions, the costs would certainly be higher. In addition, the technical and practical feasibility would have to be reviewed in detail.

6.2 Zones 2, 3 and 4 Work

As noted in Section 5, the suggested work for these three rockfall zones consists of the following three major items;

- Construction of a catchment berm near the top of the Zone 3 and 4 rockfall areas to prevent individual cobbles and boulders from falling from the top of the slope.
- Scaling (and possibly some light blasting) of the undercut crest of the rock cut within the Zone 4 rockfall area.
- Installation and removal of flume protection measures required during the preceding two items.

Given the site equipment as outlined in Section 3.5, it may be possible to construct the catchment berm using the 235 excavator. Alternatively, it may be practical and more efficient to bring a medium sized dozer (such as a D8) to site (likely from Ross River) to undertake the work. If so, the following cost estimate is provided:

- Haul truck and low-boy for the dozer - $2,000.
- Two days work for dozer on access berm - $3,000.
- Scaling and clean-up of overhanging rock face - $5,000.
- Flume protection (assumed to done under the Zone 1 covering option) - $0.

As such, direct construction costs for this work is estimated to be $10,000. In addition, a small allowance for engineering input and review of $2,000 should be included, bringing the estimated total to $12,000.

6.3 Zone 1 Options

As reviewed in Section 5, five potential options exist for the management of the rockslope in Zone 1, consisting of the following:

1. Monitor for rockfalls and repair as required.
2. Drill and blast the undercut rock, bolt any loose or potentially loose rock and remove blasted material.
3. Construct a shotcrete buttress (or "whaler") at the bottom of the undercut rock and bolt through the buttress. Bolt any loose or potentially loose rock.
4. Cover and protect the flume structure and let rockfalls occur, supplemented by occasional cleaning of rockfall debris from the channel section.
5. Remove flume from its current location and reconstruct closer to the pit slope side.

Table 6.1 provides a summary of the estimated total costs (direct construction plus detailed engineering and construction supervision) for each of the five proposed options. Background on the cost estimates are provided in Appendix 2.

It must be noted that some significant assumptions were made in order to estimate the potential cost for Option 1. As noted earlier, the undercut rock in Zone 1 amounts to approximately 80 m^3 in size. It is unlikely that the entire block will come down in one event. Hence, it was assumed that three significant rockfall events, similar to that which occurred in 1999, will occur over the next three years. If this option were selected, then it would be necessary to order additional flume sections and other materials since only six sections currently are located at site. Therefore, the $162,000 cost for Option 1 is determined from the purchase and shipment of materials to site, along with the internal labour and equipment fees which totaled $36,000 for the 1999 event. As also noted in Table 5.1, the total cost may be significantly less than $162,000 if less than three rockfall events were to occur, but this likelihood is very low. In addition, some costs should be incurred immediately to obtain additional materials for the site so that any emergency repair may be made in a timely manner.

Based on the total estimated costs provided in Table 6.1, the cheapest to most expensive options for reducing rockfall hazard to the flume in Zone 1 are as follows:

1. Option 4 – cover and protect.
2. Option 3 – shotcrete buttress and bolt.
3. Option 2 – drill, blast and bolt.
4. Option 1 – monitor and repair.
5. Option 5 – relocate the flume.

Therefore, the option of covering and protecting the flume is the cheapest option, if the steel plates are currently available on-site for use at the flume. It must be noted that removal of rockfall debris from the covering plates will be required in the future, such that the diversion channel section does not become significantly impeded. Costs for removal of any rockfall debris and for crane time required to lift the covering plates, if icing becomes a problem, have not been included in the $41,600 value.

6.4 Cost Summary

For the recommended rock slope and flume protection work in zones 1 to 4, a total cost is estimated of approximately $53,000. Allowing for a contingency of 25%, approximately $66,000 should be allotted as a budgetary value for this work.

This value does not include any costs for the recommended flume maintenance work, as provided in Section 7.0.

Table 6.1
Summary of Zone 1 Rehabilitation Options and Estimated Costs

Option Number Description	1 Monitor and repair	2 Drill, blast and bolt	3 Shotcrete buttress and bolt	4 Cover and protect flume	5 Move flume from current location
Significant Assumptions	5 extra flume sections ordered to site. 3 significant rock fall events occur over a 3 year period. mine site equipment used.	drill and blast approx. 80 m^3 from the rock face. install additional rockbolts (16) in loose / blocky areas. external contractor costs used.	construct ~25 m long shotcrete buttress "whaler" reinforce with rebar and rockbolts plus other for blocky areas. external contractor used.	cut truck canopies provided at no cost to this project assumed that 60 lin. m. of flume are covered external contractor used.	dismantle and move approx. 245 lin. m. of the flume reuse a significant amount of the current flume materials external contractor used.
Estimated Direct Costs	$160,000	$72,500	$45,700	$39,600	$261,000
Need for further engineering design work	minor input on contigency planning and materials on-site	site survey, detailed design and construction dwgs. and specifications required	site survey, detailed design and construction dwgs. and specifications required	minor engineering input	site survey, possible site investigation, detailed design, quantities and specifications
Estimated cost for same	$3,000	$15,000	$15,000	$3,000	$25,000
Need for engineering construction supervision	none	definitely required	definitely required	likely not required	definitely required
Estimated cost for same	$0	$20,000	$20,000	$0	$35,000
Estimated Engineering Costs	$3,000	$35,000	$35,000	$3,000	$60,000
Estimated Total Costs	$163,000	$107,500	$80,700	$42,600	$321,000
Potential for Variation in This Estimated Cost	Significant upside and/or downside possible.	Small variation expected. Large upside expected if done in the winter.	Potential for some small downside. Large upside if done in the winter.	Significant downside expected. Slight possible upside.	Significant upside possible.
Explanation	Less than 3 rockfall events would significantly reduce the costs. More than 3 events would significantly increase the costs; more flume sections would need to be ordered. If current mine site equipment fleet changed, then external contractor and equipment must be brought on site, increasing the costs.		If cast-in-place concrete used rather than shotcrete, some potential cost savings on the material component.	If mine site equipment and manpower from Faro & Ross River used, then significant cost savings should be realized. In addition, use of local trademens and operators for the project assists local communities. Upside possible if additional rip rap required.	Final design of such a relocation may require significant geotechnical investigation and design may be required. Potential difficult ground conditions could increase costs significantly.

7.0 RECOMMENDATIONS

Based on the information and analyses presented herein, and the requirement to manage the Vangorda Creek flows for the next three years or so, the following recommendations are provided:

1. The various deteriorating components (cross braces, culvert sections, etc.) of the flume, as summarized in Section 5.1, should be repaired to ensure that future larger-scale events can be passed without detriment to the structure.
2. The 1800 to 1500 mm reducer section "within" the upstream diversion dam should be inspected to determine its condition. Practically, this may be done when the low-level pipe in the fresh water supply dam is inspected.
3. Regular visual inspection of the diversion channel must be maintained.
4. Some form of simple, visual monitoring should be initiated along the downhill side flume access road, adjacent to the Vangorda pit, as an early indicator of potential wall movements.
5. The cover and protect option should be implemented for the protection of the flume within the Zone 1 rockfall area.
6. The remedial measures specified in Section 5.3 and 6.2. should be implemented for the rockfall hazards in Zones 2, 3 and 4.
7. Some further engineering design and input should be initiated immediately such that these remedial measures can be implemented before frost penetration into the ground becomes excessive and before extensive amounts of snow accumulate on the ground. It will likely not be practical or cost effective to undertake any construction work during wintertime conditions.
8. An assessment of the future Vangorda pit water quality should be initiated such that planning for a long-term solution during mine closure can be started.

It should be stated that expenditures required to reduce potential risks should balance with the expected probabilities and consequences of failure.

8.0 CLOSURE

This report outlines the current condition of the diversion channel situated adjacent to the Vangorda flume. Its condition is deteriorating over time but should remain serviceable for the next three years, if the recommended maintenance work is undertaken. Five potential options are available for the rehabilitation of the Zone 1 rockfall. Covering and protection of the flume section appears to be the cheapest option, yet still technically feasible.

We trust that this report contains the information needed to address your requirements. Should you have any questions or comments or wish to proceed with the next phase of the work, please contact the undersigned at your convenience.

Respectfully submitted:
BGC ENGINEERING INC.
Per:

PROFESSIONAL
YUKON
J. W. CASSIE
TERRITORY
00-NOV-20
ENGINEER

for Jerry Ferris

Bill Burton, M.Eng., E.I.T. (BC)
Geotechnical Engineer

James W. Cassie, M.Sc., P.Eng.
Senior Geotechnical Engineer

REFERENCES

Anvil Range Mining Corporation, 1999. Report on the 1999 Maintenance Work at the Vangorda Creek Diversion Flume. Internal report prepared by Mr. Eric Denholm, October, 1999, 7 pages plus photos.

American Iron and Steel Institute, 1984. Handbook of Steel Drainage & Highway Construction Products. American Iron and Steel Institute, 413 pages.

Brown, Dennis, 1990. Structural Analysis of the Vangorda Open Pit Mine, Anvil Pb-Zn-Ag District, Faro Yukon. Report prepared by Mr. Dennis Brown, Department of Earth Sciences, Memorial University of Newfoundland, 16 pages plus figures.

Hoek, E. and Bray, J.W., 1981. Rock Slope Engineering, Revised Third Edition, E & FN Spon, 358 pages.

Jennings, D.S. and Jilson, G.A., 1986. Geology and Sulphide Deposits of the Anvil Range, Yukon. In J.A. Morin (ed.), Mineral Deposits of the Northern Cordillera, CIM Special Paper 37, pages 319-361.

Piteau Associates Engineering Ltd., 1990. Hydrogeological Assessment and Development of Groundwater Control Strategy, Vangorda Pit. Report submitted to Curragh Resources Inc., Project No. 90-193A, December, 1990, 12 pages plus table and figures.

Piteau Associates Engineering Ltd., 1991. Geotechnical Review of Faro and Vangorda Pits. Letter report submitted to Curragh Resources Inc., Project No. 85-804B, November 9, 1991.

Piteau Associates Engineering Ltd., 1992a. Geotechnical Review of Faro and Vangorda Pits. Letter report submitted to Curragh Resources Inc., Project No. 85-804B, July 5, 1992.

Piteau Associates Engineering Ltd., 1992b. Geotechnical Review of Faro and Vangorda Pits. Letter report submitted to Curragh Resources Inc., Project No. 85-804B, August 17, 1992.

Piteau Associates Engineering Ltd., 1992c. Geotechnical Review of Faro and Vangorda Pits and Grum Dump Areas. Letter report submitted to Curragh Resources Inc., Project No. 85-804B, October 8, 1992.

Robertson Geoconsultants Inc., 1996. Anvil Range Mining Complex – Integrated Comprehensive Abandonment Plan. Report submitted to Anvil Range Mining Corporation, Report No. 033001/3, November, 1996, three volumes plus appendices.

Steffen, Robertson and Kirsten (Canada) Inc., 1990. Geotechnical/Hydraulic Design, Vangorda Creek Diversion Facility, Vangorda Plateau Development. Report submitted to Curragh Resources Inc., Report 60638, November, 1990, 23 pages plus figures and appendices.

Steffen, Robertson and Kirsten (Canada) Inc., 1991. Construction Report, Vangorda Creek Diversion, Vangorda Plateau Development. Report submitted to Curragh Resources Inc., Report 60639, August, 1991, 18 pages plus figures and appendices.

Steffen, Robertson and Kirsten (Canada) Inc., 1992. Construction Report, Vangorda Creek Diversion Realignment, Vangorda Plateau Development. Report submitted to Curragh Resources Inc., Report 60647, May, 1992, 4 pages plus figures and appendices.

Steffen, Robertson and Kirsten (Canada) Inc., 1997. 1997 Annual Inspection of Waste and Water Management Facilities, Vangorda Mine, Yukon Territory. Report submitted to Anvil Range Mining Corporation, Report 1CA003.00, October, 1997.

Appendix 1
Summary of Flume Conditions
Based on Visual Inspection

Appendix 1
Summary of Flume Conditions Based on Visual Inspection

Section No.	Culvert Condition	No. of cross-braces requiring repair	Condition of Joint with next section	Condition of backfill and rip rap	Freeboard on pit side	Comments
- flume discharges into plunge pool						
1	ok	2	partially open	ok		
2	ok	1	ok	ok		
3	side walls are bent	2	ok (water beside culvert)	ok		
4	side walls are bent	1	ok	ok	road 1m above channel	
5	replace 1 rail	1	ok	ok		
6	ok (minor bending)	1	ok	ok		
7	ok	1	ok	ok		water level flowing alongide culvert is higher than inside
8	ok	0	ok	ok		
9	ok	0	ok	ok		
10	1" hole	0	ok	ok		
11	ok	0	ok	ok		
12	ok	1	open, proper overlap	ok		has settled approx 2"
13	ok	0	ok, partly open	ok		
14	ok	0	ok	ok	road 2m above channel	
15	ok	0	ok	ok		
16	ok	1	ok	ok		
17	ok	0	ok	some voids		anchor point broken
18	ok	1	ok	voids, boulders		
19	ok	0	ok	ok	road 1.1m above channel	
20	ok	0	ok	ok		10 ft section
21	ok	0	open 1"	ok		10 ft section
22	ok	0	open 1"	ok		
23	ok	0	ok	ok		
24	ok	0	ok	ok		
25	ok	0	ok	ok		
26	ok	0	ok	ok		
27	ok	0	ok	ok		10 ft section
28	ok	0	ok	ok		
29	ok	0	small gap	ok		
30	ok	0	ok	ok	road 1m above channel	
31	ok	0	ok	ok, voids		
32	ok	0	open	ok		
33	ok	0	ok	ok		
34	ok	0	ok	more fill req'd		
35	ok	0	ok	ok		
36	ok	0	ok	ok		
37	ok	0	ok	ok		
38	ok	0	ok	ok		
39	ok	0	small gap	ok		
40	ok	0	ok	ok		
41	ok	0	ok	ok		10 ft section
42	ok	0	ok	ok		
43	ok	0	small gap	ok		
44	ok	1	ok	ok	road 1m horz, 2.3m vert from lip	
45	ok	0	ok	culvert unsupported		
46	ok	0	ok	ok		channel depth is 48cm
47	large hole, patch req'd	0	ok	ok		small stream flows into culvert trench
48	ok	0	ok	ok, cobbles and gravel		metal wingwalls added to lip
49	ok	0	ok	ok		

50	ok, buckled	0	ok	ok	road 1m horz, 2.2m vert from lip	
51	ok	0	ok	ok		
52	ok	0	ok	ok		
53	ok	1	ok	ok		
54	ok	0	ok	ok		
55	no tie downs	2	open, proper overlap	ok		settled 6", start of section repaired in 1999
56	ok	0	ok	ok	road 1.3m horz, 4.3m vert from lip	10 ft section
57	ok	0	ok	ok		no tie downs sect. 55 to 63
58	ok	0	ok, partly open	ok		
59	ok	1	ok, tarred	ok		
60	ok	0	ok	ok		rock in channel
61	ok	0	ok	ok		sandbags pit side
62	ok	0	ok	ok		end of repaired section
63	ok	0	ok	ok		
64	ok	0	ok	ok		
65	ok	0	ok	ok		
66	ok	1	ok	ok		
67	ok	1	ok	ok		
68	ok	0	ok	fill req'd		
69	siderail needed	2	ok	fill req'd		
70	ok	2	ok	ok		
71	siderail needed	2	ok	ok		
72	ok	0	ok	ok		6ft section, overlap in wrong direction
73	ok	2	ok	ok		rock in channel until sect. 76
74	ok	0	ok	ok		
75	ok	0	ok	ok		
76	ok	0	ok	ok		large blocks in channel
77	ok	1	ok	ok		
78	ok	1	ok	ok		
79	ok	1	ok	ok		
80	ok	0	ok	ok	road 3.3m horz, 2m vert from lip	
81	ok	0	ok	ok		
82	ok	1	ok	ok		
83	ok	0	ok	ok		small stream under culvert
84	ok	0	ok	ok		approx. 5 gpm seeping from rock obove channel
85	ok	0	ok	ok		
86	ok	0	ok	ok		
87	ok	0	ok	ok		approx. 5 gpm seeping from rock obove channel
88	ok	0	ok	ok		
89	ok	0	ok	ok		
90	ok	0	ok	ok	road 5.9m horiz, 2m vert from lip	
91	ok	0	ok	ok		
92	ok	0	ok	ok		
93	ok	0	ok	ok		
94	ok	0	ok	ok		
95	ok	0	ok	ok		
96	siderail needed	0	ok	ok		
97	ok	1	ok	ok		
98	siderail needed	0	ok	ok		
99	ok	1	ok	ok		
100	ok	0	ok	ok		
101	ok	0	ok	ok		
102	ok	0	ok	ok		
103	ok	0	ok	ok		

104	ok	0	ok	ok		
105	ok	1	ok	ok		
106	ok	2	ok	ok		
107	ok	1	ok	ok		
108	ok	1	ok	ok		
109	ok	0	ok	ok	road 3m horiz, 1.4m vert from lip	
110	ok	1	ok	ok		
111	siderail needed	1	ok	ok		
112	ok	0	ok	ok		
113	ok	1	ok	ok		
114	siderail needed	1	ok	ok		
115	ok	0	ok	ok		
116	ok	0	ok	ok		
117	ok	0	ok	ok		
118	ok	0	ok	ok		
119	ok	0	ok	ok	road 3.1m horz, 1.4m vert from lip	
120	ok	0	ok	ok		
121	ok	0	ok	ok		
122	ok	0	ok	ok		
123	ok	0	ok	ok		
124	ok	0	ok	ok		
125	ok	0	ok	ok		
126	ok	0	ok	ok		
127	ok	0	ok	ok		
128	ok	0	ok	ok		
129	ok	0	ok	ok		
130	ok	0	ok	ok	road 4.6m horz, 1.6m vert from lip	
131	ok	0	ok	ok		
132	ok	0	ok	ok		
133	ok	0	ok	ok		
134	ok	0	ok	ok		
135	ok	0	ok	ok		
136	ok	0	ok	ok		
137	ok	0	ok	ok		
138	ok	0	ok	ok		
139	ok	0	ok	ok		
140	ok	0	ok	ok	road 4.8m horz, 1.6m vert from lip	
141	ok	0	ok	ok		
142	ok	0	ok	ok		
143	ok	0	ok	ok		
144	ok	0	ok	ok		
145	ok	0	ok	ok		
146	ok	0	ok	ok		
147	ok	0	ok	ok		
148	ok	0	ok	ok		
149	ok	0	ok	ok		crosses old creek channel
150	ok	0	ok	ok	road 4.2m horz, 1.5m vert from lip	
151	ok	0	ok	ok		
152	ok	0	ok	ok		10 ft section
discharge of culvert through dam into flume						

Appendix 2

Cost Estimate Background Information

GOLDEN HILL VENTURES LTD

Box 4689 (#30 Laberge Road, Kulan Industrial Area). Whitehorse, Yukon Y1A 3V7
Ph (867) 668-7807 Fax 668-7762

August 10, 2000

BGC ENGINEERING INC.
Suite 1170, 840-7 Avenue S.W.
Calgary, Alberta T2P 3G2

Attention: Jim Cassie, P.Eng.

RE: Vangorda Flume Work

Thank you for allowing us to provide preliminary budgets for various options regarding the above-mentioned project. These estimates are for budgetary purposes only. A more concise estimate can be provided once a final scope of work is outlined.

Option #1 Repair Rock Faces – 3 locations

This option is to repair the failed rock faces at three locations. This would include the following activities:

- Mob and Demob to Vangorda Flume area
- Temporary Flume Protection
- Drill and Blast rock face (2 locations) up to 80 cu.m.
- Scaling, cleanup, excavation, and hauling of blast rock to nearby location
- Rock bolting of remaining areas of concern (approx. 16 bolts)
- removal of Flume Protection

Approximate total Material, Labour, and Equipment.............$72,500.00

Option #2 Move Flume away from Rock Faces (approx. 245 lin.m.)

This option is to physically relocate an existing portion of the flume away from the rock faces. It would include the following activities:

- Mob and Demob to Vangorda Flume area
- Dismantle and remove approx. 245 lin.m. of flume
- reroute existing water flow temporarily
- excavate, and prepare new suitable route c/w geotextile and 200 mm CSP
- add additional flume material
- backfill and stabilize new and existing routes (Rip-Rap)

Approximate Total Material, Labour, and Equipment.............$261,000.00

Cont.

Option #3 Protect Flume with used truck boxes (supplied by owner)

This option is to cover approximately 60 lin.m. of flume at two locations with truck boxes supplied by owner. In addition, one of the rock faces would have to be scaled and stabilized from further erosion. This option would include the following activities:

- Mob and Demob to Vangorda Flume area
- Shape areas for box foundation
- Haul boxes to immediate site
- placement of boxes
- scaling and cleanup of unprotected rock face (phylite area)

Approximate Total Material, Labour, and Equipment..............$44,500.00

If you have further inquiries, please contact myself at the above #.

Regards,
GOLDEN HILL VENTURES LTD.

Darren Klippenstein

Darren Klippenstein, Project Manager

VANGORDA FLUME OPTIONS

Estimated quantities and pricing

Option #1 Repair Rock Faces - 3 locations

Mob and Demob to Vangorda Flume area		$ 8,000.00
Temporary Flume Protection - how?		$ 7,000.00
Drill and Blast rock face (2 locations) up to 80 cu.m.	80 cu.m. @ $325.00	$ 26,000.00
Scaling, cleanup, excavation, and hauling of Blast rock to nearby location	30 hrs @ $350.00	$ 10,500.00
Rock bolting of remaining areas of concern (approx. 16 bolts)	16 @ $1000.00	$ 16,000.00
Removal of Flume Protection		$ 5,000.00
		$ 72,500.00

Option #2 Move Flume away from Rock Faces (approx. 245 lin.m.)

Mob and Demob to Vangorda Flume area		$ 8,000.00
Dismantle and remove approx. 245 lin.m. of flume	245 lin.m. @ $300.00	$ 73,500.00
Reroute existing water flow temporarily	245 lin.m. @ $20.41	$ 5,000.00
Excavate, and prepare new suitable route c/w geotextile and 200 mm CSP	245 lin.m. @ $600.00	$ 147,000.00
Add additional Flume material	50 lin.m. @ $350.00	$ 17,500.00
Backfill and stabilize new and existing routes (Rip-Rap)	245 lin.m. @ $40.82	$ 10,000.00
		$ 261,000.00

Option #3 Protect Flume with used truck boxes (supplied by owned)

Mob and Demob to Vangorda Flume area		$ 10,000.00
Shape areas for box foundation	40 lin.m. @ $380.00	$ 15,200.00
Haul boxes to immediate site	12 boxes @ $600.00	$ 7,200.00
Placement of boxes	12 boxes @ $600.00	$ 7,200.00
Scaling and cleanup of unprotected rock face (phylite area)	20 hrs @ $245.00	$ 4,900.00
		$ 44,500.00

Option #3 Shotcrete Buttress and Bolt

Mob and demob to Vangorda Flume area	$12,000
Spray shotcrete buttress assuming 25 m^3 @ $750/ m^3	$18,750
Bolting for shotcrete buttress and rockmass 10 bolts @ $1,000/bolt	$10,000
Scaling and clean-up of face 10 hours @ $245.00/hour	$2,450
Miscellaneous steel and rebar 1000 kgs @ $2.50/kg	$2,500
Total	**$45,700**