**Golder Associates**
CONSULTING GEOTECHNICAL ENGINEERS

403A LPT/RI

# REPORT TO CYPRUS ANVIL MINING CORPORATION LTD. ON STABILITY OF PROPOSED CRUSHER EXCAVATION

GRUM DEPOSIT

016951

DISTRIBUTION:

2 copies - Cyprus Anvil Mining Corporation Ltd.
Vancouver, British Columbia

3 copies - Swan Wooster Engineering Company Ltd.
Vancouver, British Columbia

1 copy - Golder Associates
Calgary, Alberta

2 copies - Golder Associates
Vancouver, British Columbia

November 1980

802-1591

TABLE OF CONTENTS


| | | PAGE |
|---|---|---|
| 1.0 | INTRODUCTION | 1 |
| 2.0 | SITE DESCRIPTION | 1 |
| 3.0 | CONCLUSIONS AND RECOMMENDATIONS | 3 |
| | 3.1 Conclusions | 3 |
| | 3.2 Recommendations | 5 |
| 4.0 | GEOLOGY AND ROCK STRENGTH | 6 |
| | 4.1 Geology | 6 |
| | 4.2 Ground Water | 7 |
| | 4.3 Ice | 7 |
| | 4.4 Rock Strength | 8 |
| 5.0 | STABILITY CONDITIONS | 8 |
| | 5.1 Rock Slopes | 8 |
| | 5.2 Rock Thrust on Crusher Structure | 9 |
| | 5.3 Blast Vibrations | 10 |
| | 5.4 Loads on Conveyor Tunnel Lining | 11 |
| | 5.5 Crane Foundations | 11 |
| 6.0 | EFFECT OF ICE ON SLOPES AND FOUNDATIONS | 12 |
| | 6.1 Rock Slopes | 12 |
| | 6.2 Crusher Foundations | 13 |
| 7.0 | CONSTRUCTION PROCEDURE | 13 |
| 8.0 | VOLUMES AND QUANTITIES | 15 |

## LIST OF FIGURES


| | |
|---|---|
| Figure 1 | Proposed Crusher - Grum Deposit Site Plan |
| Figure 2 | Sections Showing Excavation Limits and Drill Holes |
| Figure 3 | Drill Hole Location Plan |
| Figure 4 | Sketch Showing Geological Structure in Relation to Crusher and Conveyor Trench Excavation |
| Figure 5 | Slope Stability Conditions - Factor of Safety vs. Height of Water Table |
| Figure 6 | Drainage and Reinforcement of Crusher Excavation - North and East Slopes |


## LIST OF APPENDIX


| | |
|---|---|
| Appendix I | Drill Hole Logs |

## 1.0 INTRODUCTION

At the request of Mr. D. Krefting of Swan Wooster Engineering, the writer made a visit to the proposed crusher site at Cyprus Anvil's Grum deposit to assess rock stability conditions. He was accompanied in this site visit by Mr. Dougal Barron and Mr. Surrendar Menrai of Swan Wooster.

We arrived on the site in the afternoon of October 29th, 1980 and left in the afternoon on October 30th. During this time we held discussions with Mr. Hampton and Mr. Lopaschuck of Cyprus Anvil's staff, and the writer inspected the proposed crusher site, examined the core drilled at the site, and mapped the nearest accessible rock outcrop. We also reviewed a report prepared by Montreal Engineering in 1979 on Slope Design for the Grum Pit. This information has been used in the stability investigations for the proposed crusher because much of the geology, rock strength and ground water data is applicable to this design.

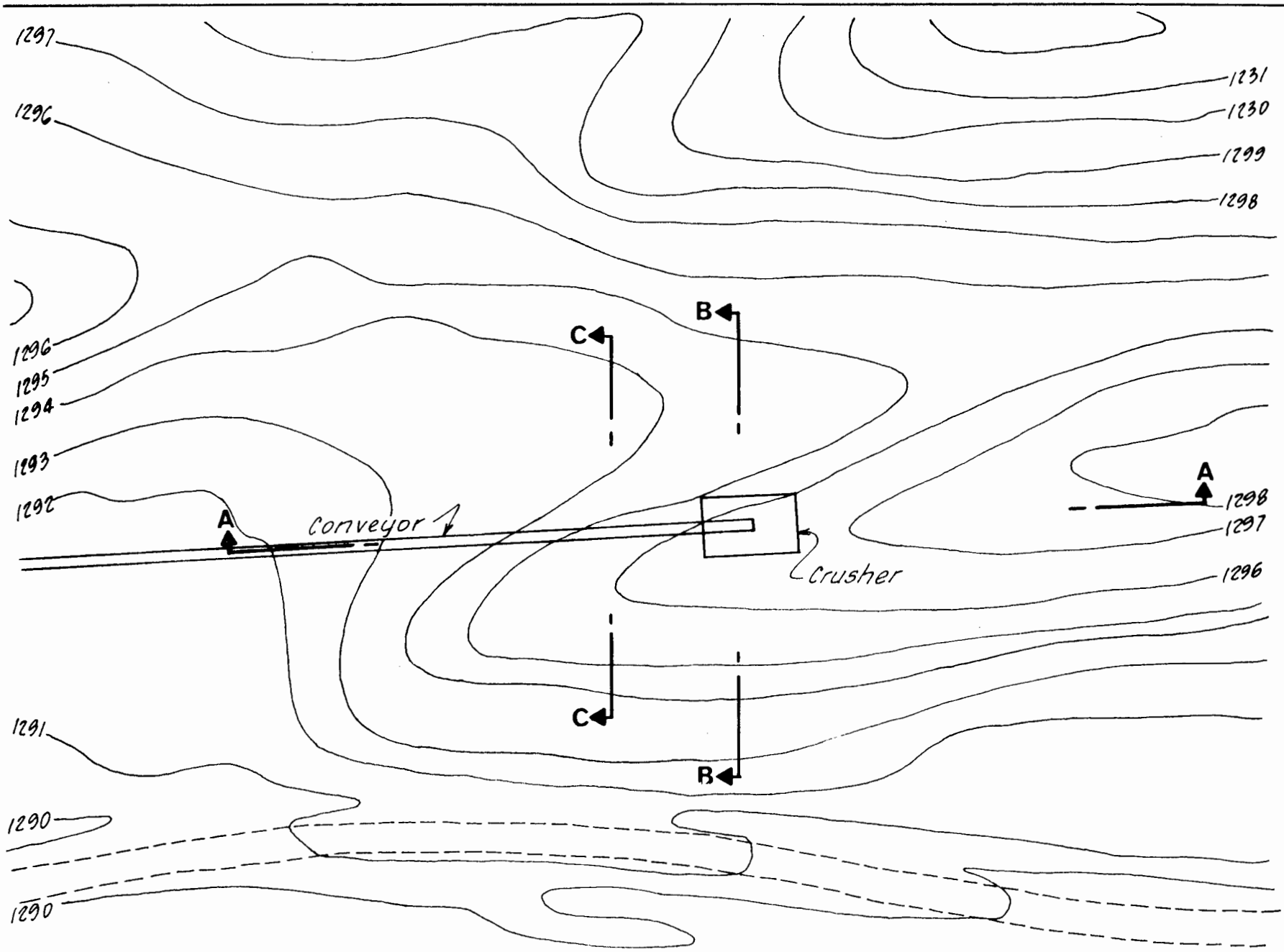
This report describes the stability conditions for the proposed crusher excavation and discuss stabilization measures for the slopes and foundations. Estimated rock and soil excavation volumes and support quantities are listed in the last section of the report.

## 2.0 SITE DESCRIPTION

The primary crusher will be about 600 m from the proposed Grum open pit. Ore from the pit will be trucked to the primary crusher, and the crushed ore will be loaded into a train by a series of conveyor belts for transportation to the existing mill at the Faro pit. The crusher requires of a 26 m deep, by 25 m long by 10 m wide, excavation with vertical sides in the rock. There will also be an inclined slot in which a conveyor will be installed to carry the crushed ore from the bottom of the crusher to a stockpile.

Figure 1 shows the site plan and Figure 2 shows three cross-sections through the excavation. The conveyor will be enclosed in a reinforced concrete lining and the trench will be backfilled. The crusher structure will be built so that the outer side of the concrete wall is in direct contact with the rock so that the minimum outside form work will be required. The rock will also provide rigid support for the crusher structure and will be an essential part of the resistance to the dynamic loads generated by the crusher.

Project No. 802-1591 Drawn HJ Reviewed [illegible] Date NOV. '80




Reference : Swan Wooster Engineering.

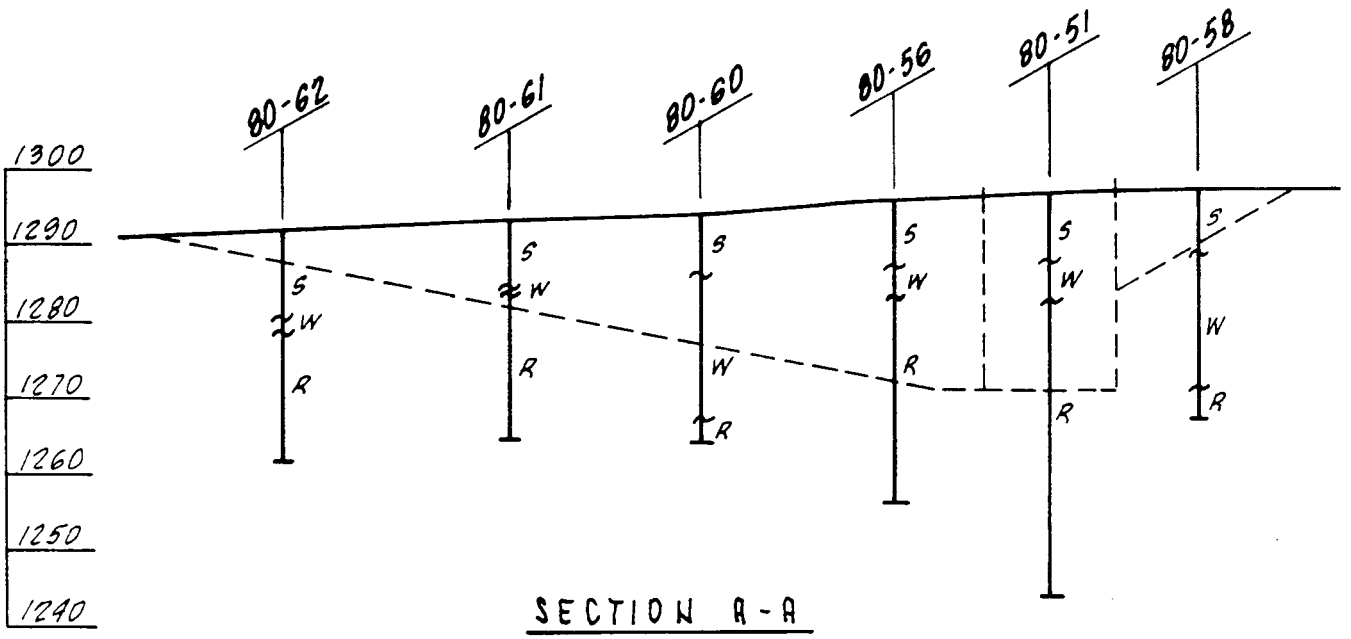
Scale 1 : 1000

PROPOSED CRUSHER - GRUM DEPOT
SITE PLAN

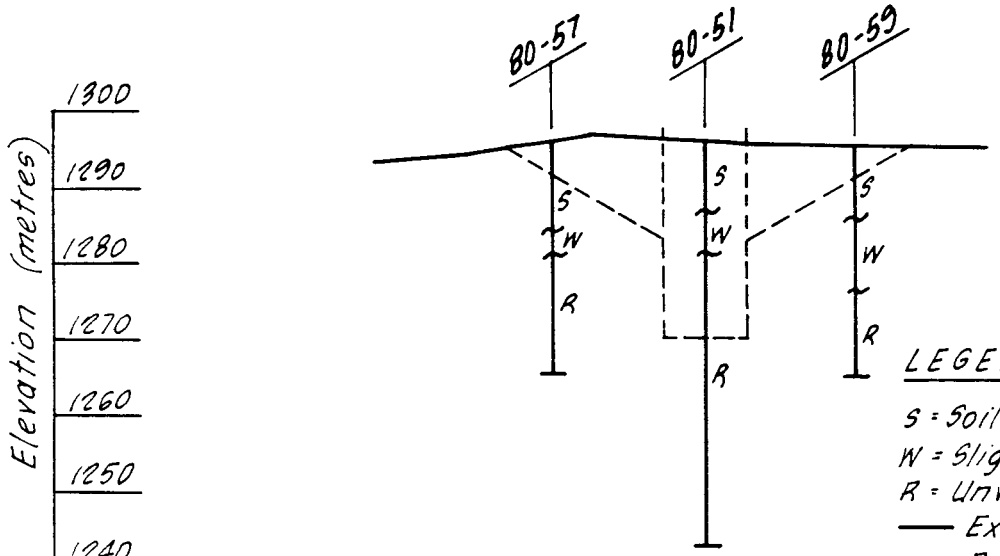
Figure 1

# SECTION SHOWING EXCAVATION LIMITS AND DRILL HOLES

**Figure 2**



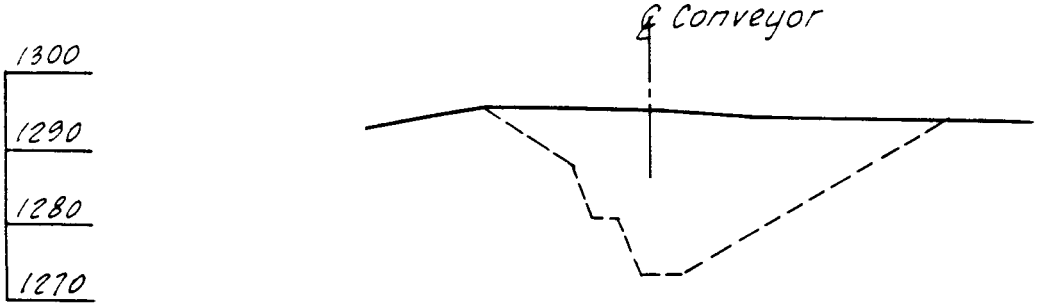

SECTION A-A




SECTION B-B

LEGEND :

S = Soil / highly weathered rock
W = Slightly weathered rock
R = Unweathered rock
—— Existing ground surface
– – Proposed excavation




SECTION C-C

Scale 1 : 1000

## 3.0 CONCLUSIONS AND RECOMMENDATIONS

### 3.1 Conclusions

(a) We believe that the proposed method of construction for the crusher is feasible as regards to the geotechnical aspects of the design. However, special precautions, as described below, will be required to ensure that the vertical slopes in rock are stable, and that the formation or thawing of ice in the rock is not detrimental to foundation stability.

(b) Stope Stability: to a depth of about 12 m, i.e. the top half of the excavation, the rock is highly to moderately weathered and the slopes in this material should be cut at an angle of about 30 - 40 degrees. Excavation can be carried out by ripping and dozing. Below a depth of about 12 m the rock is slightly weathered to fresh and vertical slopes can be cut in this material for the crusher. In order to form stable slopes at this angle it will be necessary that carefully controlled blasting be carried out to prevent minor rock falls. On the north and east faces there is a possibility of overall slope failure on the foliation planes and these slopes should be stabilized with 34 mm diameter rock anchors (see Figure 6). Rock thrust and water pressure on the crusher walls could be as much as 100 kPa.

The excavation for the conveyor does not require vertical slopes. The south slope can be cut at an angle of about 75 degrees in the rock and the north slope can be cut on the foliation planes.

(c) Crusher structure stability; the rock below a depth of about 12 m is sufficiently strong to support the crusher provided there is minimal blasting damage to the base of the excavation. However, the presence of ice may produce the following stability problems. If there is no permafrost at the present time in the rock, the circulation of cold air during the winter through the crusher could freeze the water around the crusher which would produce heaving. If the drainage system in the slopes is effective and the void ratio of the rock is low we do not believe that there will be significant heaving. However, if the void ratio is high, clear ice lenses could form on the foliation planes and heaving of the foundation could be significant.

Alternatively, there may be permafrost in the rock, in which case, circulation of warm air through the crusher during the summer could melt clear ice lenses and cause settlement.

These problems due to ice could be overcome by insulating the floor and lower portion of the walls with styrofoam, or putting in heating/cooling coils. That is, heating coils to prevent formation of permafrost, or cooling coils to prevent thawing of permafrost. Personnel at the mine believe that there is no permafrost in the rock, but we believe that this should be firmly established because of its influence on the performance of the crusher.

Footing Stability: The footings for the crane will be on backfill. To ensure that there is no frost-heave, this backfill should be free-draining so that the water table is

below the level of the footings. The footings should be located at a depth of 3 m below ground surface and the fill under the footings should be placed to maximum standard Proctor dry density. Total and differential settlements will be less than 25 mm and 20 mm respectively.

3.2 Recommendations

(a) The crusher could be moved about 10 m to the northeast (towards drill hole CH80-57). The depth of weathering here appears to be 3 to 4 m less than at the present location.

(b) If the height of the vertical rock slopes does not provide sufficient contact between the rock and the concrete structure, tensioned rock anchors could be used to tie the concrete securely to the rock.

(c) If it is decided to proceed with the proposed construction method, we recommend that the following additional data be collected in order to proceed to final design:

(i) The actual orientation of the foliation in the rock be established by cutting a 4 m deep trench with a dozer along the long axis of the crusher. This geological data will determine how much support is required for the vertical slopes, which also depends on the actual vertical slope height.

(ii) Two holes be drilled to a depth of about 5 m below the bottom of the crusher to determine the dimensions of voids in the rock, and if ice lenses are present. This will require drilling during the winter and use of drilling fluid that will not thaw ice lenses.

## 4.0 GEOLOGY AND ROCK STRENGTH

### 4.1 Geology

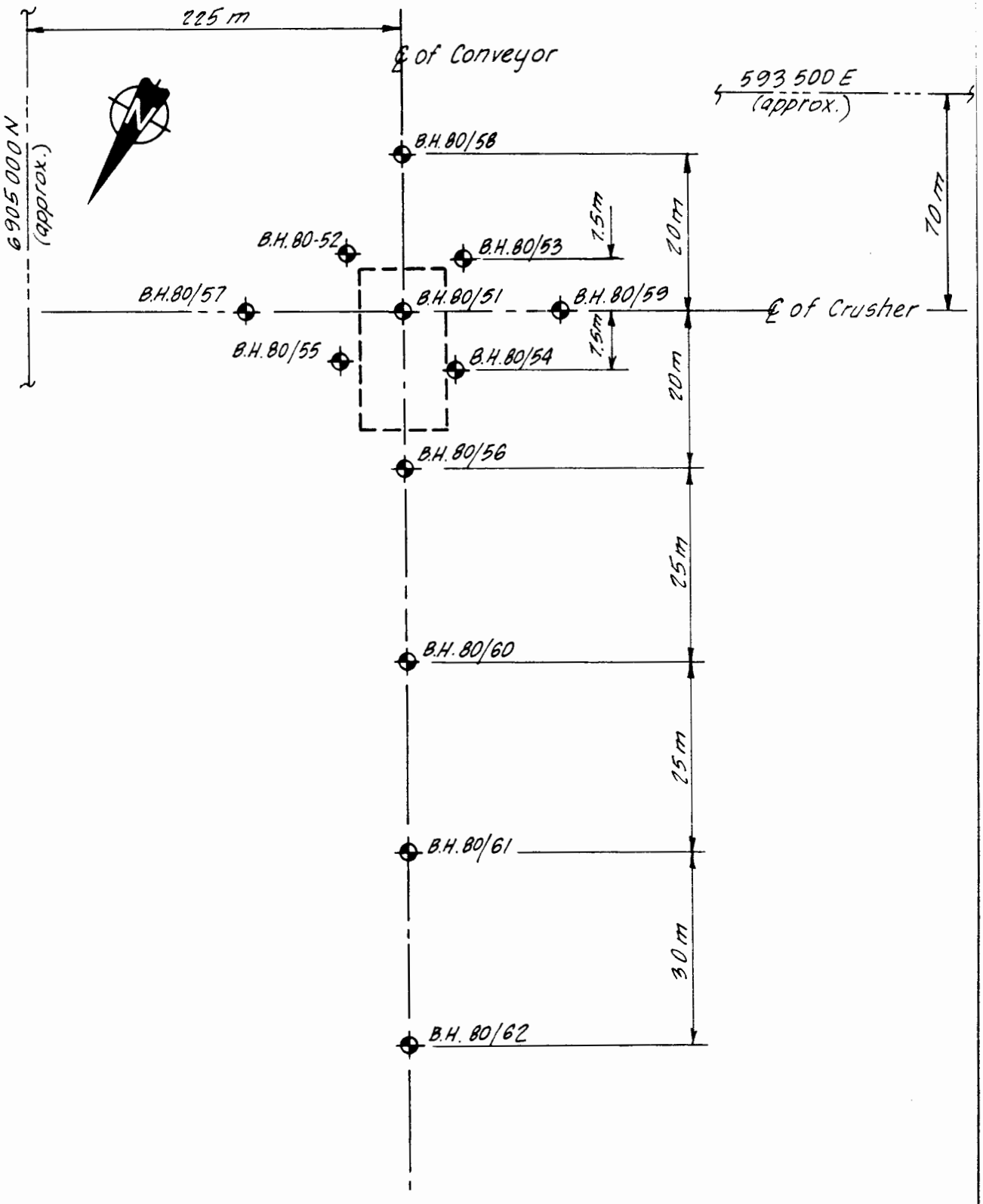
Twelve diamond drill holes were drilled by Cyprus Anvil at the site; Figure 3 shows the location of these holes and the logs are shown in Appendix I. They are also plotted on the sections (Figure 2). The rock type at the site is a phyllite with a foliation spacing of a few millimeters. The vertical weathering profile ranges from highly weathered, to slightly weathered, to fresh. It is likely that the top 1 to 2 m of the strata is soil, and that between 2 m and 12 m below surface the rock is highly weathered such that it can be dug with geological hammer and most of the foliation planes are broken. This material was drilled with a tricone because no recovery would have been obtained within a diamond bit. Between about 12 and 20 m the rock itself is fresh and moderately strong, but some joints are stained indicating fluctuation of the water table. Below about 12 to 20 m the rock shows no sign of weathering and it is somewhat less fractured. The intact pieces of rock are moderately strong but drilling forces are sufficient to break the core along some foliation planes. This is shown by the very much greater amount of breakage that occurred in the NQ core (76 mm diamter) compared to the HQ core (96 mm diameter). A double tube barrel was used for the drilling and the core was removed from this barrel by hammering the tube.

The core recovery is generally in the range of 70 to 90 per cent despite there being little evidence of crushed rock that might have been washed out by the drilling fluids. This low recovery may indicate the presence of water-filled voids or ice lenses.

Natural fractures in the rock consist of the foliation planes and two sets of vertical joints. Foliation dips at angles between 15 and 20

# DRILL HOLE LOCATION PLAN

**Figure 3**




Scale 1 : 75

Reference : Swan Wooster Engineering.

Project No. 802-159/ Drawn Reviewed Date Nov. 180

degrees to the west and strike is assumed, from regional measurements, to be 140 degrees from true north. One of the sets of vertical joints has the same strike as the foliation and the other set of joints is at right-angles to the foliation. Figure 4 shows a 3-dimensional respresentation of the relative orientation of these fractures. The spacing between the foliation planes varies from a few millimeters at the surface to possibly 1 m at a depth of 25 m; frequency of fracturing is dependent not only on the weathering but also on the disturbance to the rock such as would be caused by blasting. The spacing between the joints probably varies between .25 m to 1 m.

## 4.2 Ground Water

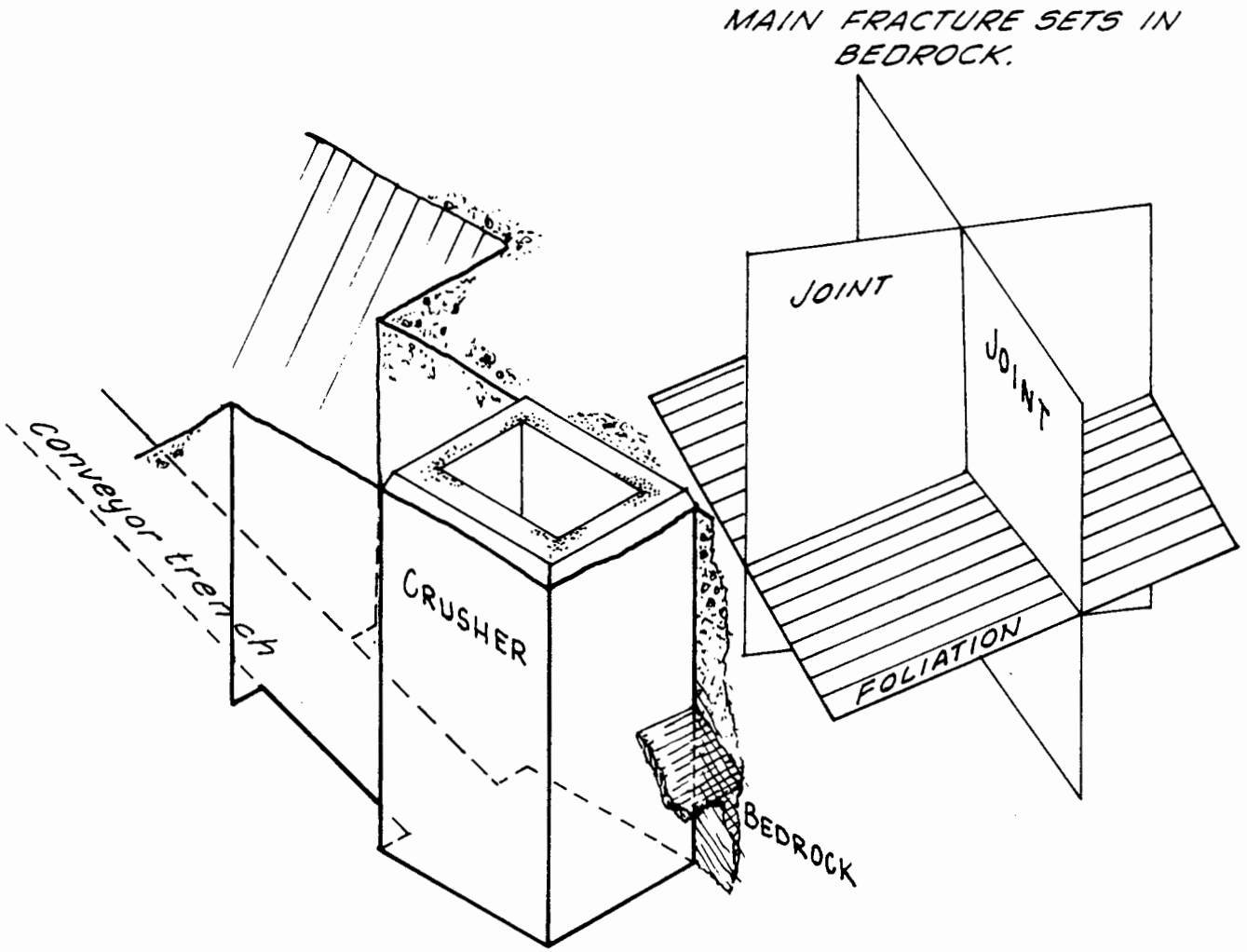
The present position of the ground water table in the drill holes is about 2 m below ground surface. It is not known what seasonal fluctuation occurs, but this level has been used for design. It may be a perched water table above frozen rock.

## 4.3 Ice

Intermittent permafrost in the rock can occur in Faro area, but it is generally believed by mine personnel that, at the crusher site, the permafrost only extends to a depth of about 3 to 4 m. A 25 m deep well at the Grum deposit flows all year round. The drilling done in October 1980 would not show the presence of ice because it would be melted by the drilling water. Verification of the presence or absence of ice, and the thickness of the lenses would require diamond drilling during the winter using a cold drilling fluid such as diesel that will not melt ice.

SKETCH SHOWING GEOLOGICAL STRUCTURE IN RELATION TO CRUSHER AND CONVEYOR TRENCH EXCAVATION.

**Figure 4**




Schematic Only - Not to Scale.

## 4.4 Rock Strength

The intact rock is sufficiently strong for it to resist failure under the loads in the slopes and in the foundation. Therefore, slope stability will be dependent upon the orientation of the natural fractures in relation to the sides of the excavation, and by the shear strength of these frac- tures.

The shear strength in defined by the friction angle and cohesion of the surface; this information has been obtained from Montreal Engineering's report on Slope Design for the Grum Pit. Our interpretation of these tests is that the friction angle is 26 degrees (20 degrees material friction and 6 degrees due to roughness) and that the cohesion is zero. No cohesion was measured in the tests on broken fractures and we do not believe that this factor should be relied upon in the design.

# 5.0 STABILITY CONDITIONS

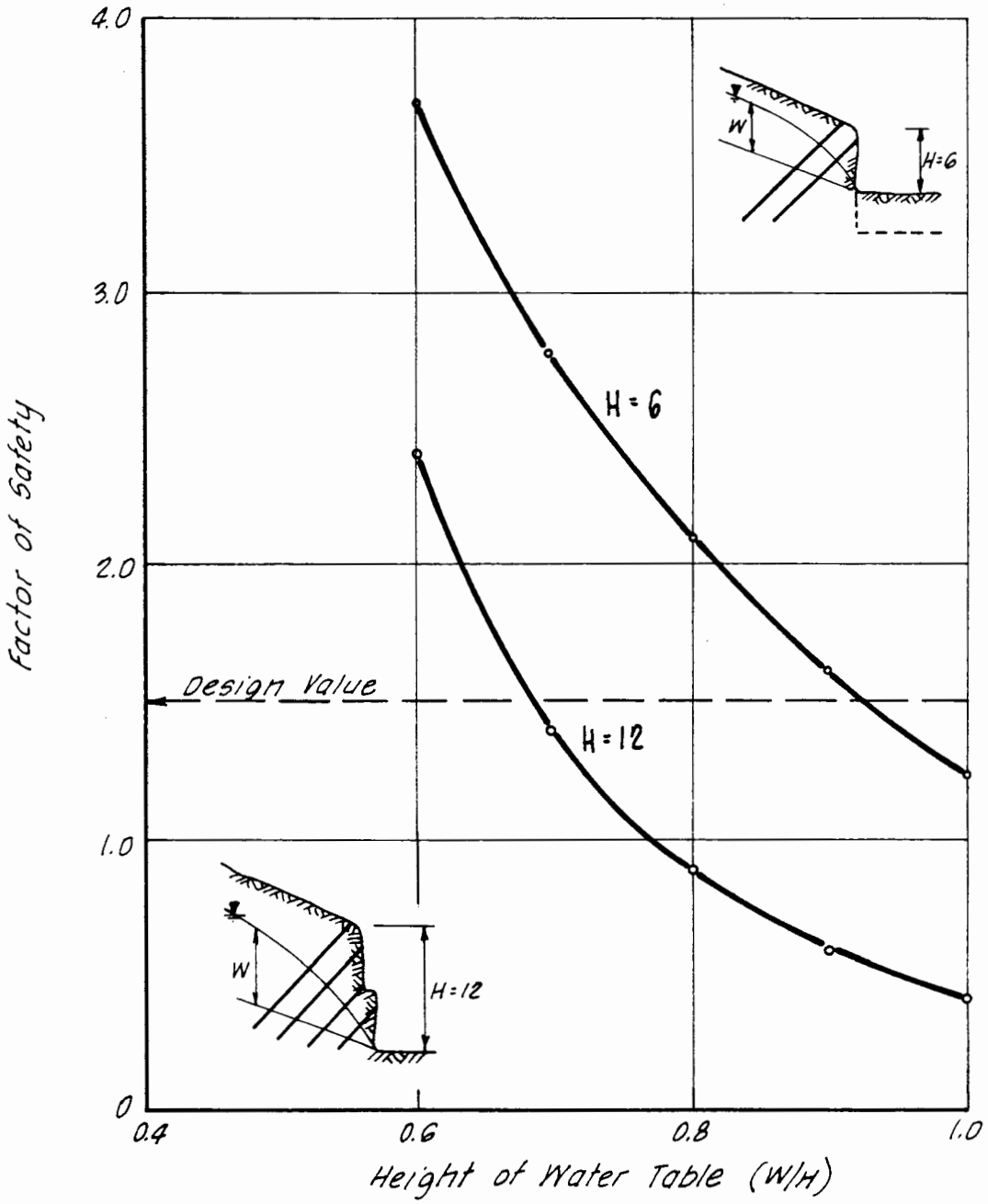
## 5.1 Rock Slopes

Stability of the cut slopes will be dependent upon the fractures in the rock, the ground water pressures that will act within the slope if there is no permafrost, and upon the amount of damage to the rock produced by blasting. The vertical jointing will help to form vertical faces parallel to these faces, while sliding is likely to occur on faces which undercut the foliation. The stability of the excavation will be improved, and the amount of overbreak reduced if the excavation could be aligned parallel and perpendicular to the foliation strike direction. The trenching will show whether this can be readily achieved.

With the existing orientation of the crusher, it is likely that failure of the north and east cut slopes for both the trench and the cru-

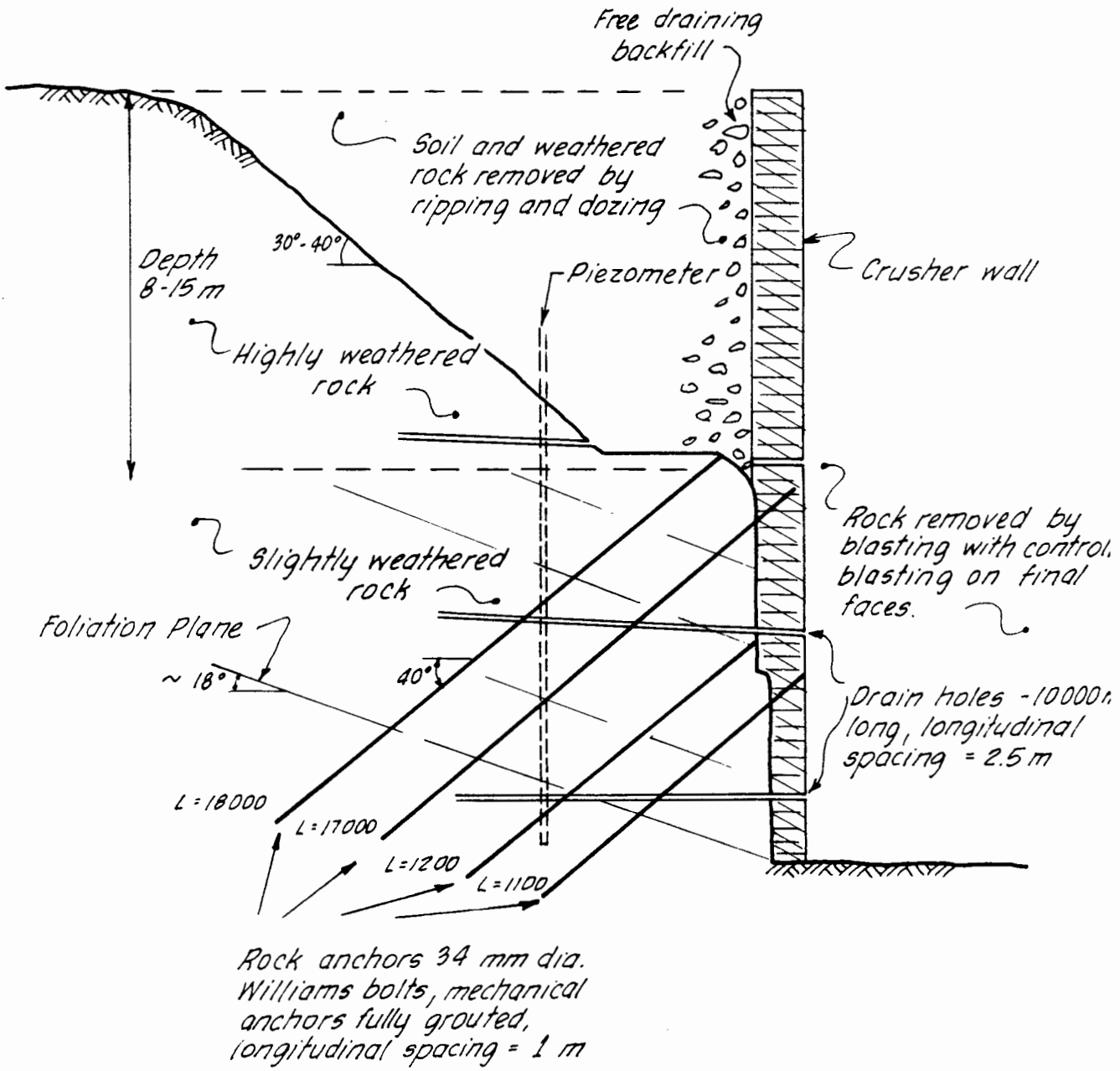
SLOPE STABILITY CONDITIONS
FACTOR OF SAFETY vs HEIGHT OF WATER TABLE

**Figure 5**



DRAINAGE AND REINFORCEMENT OF CRUSHER EXCAVATION
NORTH AND EAST SLOPES

**Figure 6**




Scale 1 : 200

sher will occur on the foliation planes if no remedial action is taken. The slopes would probably be stable if they were completely drained, but the water pressures are sufficient to induce failure in steep slopes. Since it is important, the bottom half of the crusher excavation have vertical slopes, it is proposed that this be achieved in the north and east slopes by lowering the water pressures and installing rock anchors. Figure 5 shows the relationship between the factor of safety and the height for the excavation of the first 6 m high bench, and then for the full 12 m excavation. The diagrams related to each curve show the reinforcement that is installed before excavation of each bench. The curves illustrate the sensitivity of stability to water pressures and the importance of drilling drain holes into the face. Piezometers should be installed to ensure that water pressures have been lowered sufficiently before making each cut.

Actual reinforcement will depend upon the final height of the vertical slope. Drainage will be induced by cutting back the top portion of the slope and backfilling this with free-draining gravel and by drilling horizontal drains into the slope. Rock anchors will be installed from each bench before the excavation is made so that the rock is pre-supported (see Figure 6). This support would only be done in the crusher excavation; the northeast slope in the conveyor trench would be cut at the foliation angle.

The overall stability of the south slopes of the crusher excavation and conveyor trench will not be affected by the geological structure, and vertical slopes should be stable as long as very careful blasting is practiced. However, minor rock falls may still occur.

## 5.2 Rock Thrust on Crusher Structure

It is possible that water pressures will rise in the future due to blockage of drain holes and/or contamination of the backfill. Because sta-

bility is highly dependent on water pressure, an increase in pressure could result in failure of a wedge of rock on the foliation planes. The thrust produced by this wedge will be the difference between the component of the weight down the plane, and the frictional resistence of that plane. The maximum value of this thrust, which includes the water pressure, is likely to be about 80 kPa.

There could be an additional thrust due to gradual creep of the rock as a result of locked in stresses in the rock which usually have a significant horizontal component. Calculation of this thrust cannot be done precisely, but we believe that a value of 20 kPa could be used for design.

The total thrust from the rock on the concrete will, therefore, be 100 kPa. Any imbalance between the thrust from opposite walls will be resisted, in the direction of the shorter dimension, by the rock slope. In the long dimension, the rock thrust will be resisted by the pressure of the backfill and the shear resistence of the crusher foundation.

## 5.3 Blast Vibrations

Blasting in the open pit will produce ground vibrations in the crusher. We estimate that the magnitude of these vibrations will not exceed about 2-3 inch/sec. at a frequency of about 50-100 cycles/sec. This vibration level is below the damage threshold for massive concrete structures but may disturb sensitive electrial equipment. Blasting restrictions may have to be imposed when blasting at the closest point to the crusher.

## 5.4 Loads on Conveyor Tunnel Lining

The loads on the concrete lining for the conveyor tunnel will be made up of both water and soil pressures. The water pressure should be taken as the hydrostatic head, i.e. 9.8 kPa/m depth. The pressure due to the back fill will be as follows:

Vertical Stress = 10 kPa/m depth

Horizontal Stress = 6 kPa/m depth

## 5.5 Crane Foundations

The foundations for the proposed travelling crane, located above the crusher, will be founded within the excavation backfill. As discussed previously, all backfill behind the crusher walls should be clean, free draining granular material. This should be specified so that good drainage and a low frost susceptibility is obtained. At this time, material sources have not been established but we recommend that the fill have not greater than 5 and 10 per cent passing the 200 mesh sieve. The fill should be placed in maximum standard Proctor dry density. Adjacent to the walls only light tamping equipment should be used to prevent structural damage by heavy compaction equipment impact loads.

The overhead crane gantry may be supported on spread footings located within the compacted backfill placed as discussed above. It is recommended that the footings be located at a minimum depth of 3 m below final grade for frost protection purposes. It is understood that the crane column loads are of the order of 670 kN per column and that only small differential settlements between columns are acceptable.

As a result, care should be taken in the backfill placement operations to achieve good compaction and to ensure that no contaminated or

frozen materials be placed in the excavation. We recommend that a design bearing value of 200 kPa be used for the design of the spread footings located within the fill. Under the above conditions, total and differential settlements will be less than 25 mm and 20 mm respectively.

It is pointed out that the footings will be located below the existing ground water level, but, the permanent drainage system recommended around the crusher walls will be effective in maintaining the water level at a low elevation.

An alternative construction to deep foundations would be to locate the spread footings at a higher elevation within the backfill and insulate for frost protection because it is unlikely that the drainage will be 100 per cent effective. However, based on a freezing index of the order of 5,000 degree days, it would be expected that 150 mm to 250 mm of styrofoam insulation may be required depending on the actual depth below ground surface of the foundation.

## 6.0 EFFECT OF ICE ON SLOPES AND FOUNDATIONS

The presence of ice in the slopes, and under the crusher, and conveyor tunnel lining, will effect both the stability of the slopes and heaving/settlement of the crusher structure. It is not known whether ice exists at present; the core recovery figures of 70 to 100 per cent are indicative that voids may exist in the rock.

The significance of ice is as follows.

### 6.1 Rock Slopes

If the rock is frozen, there will be some cohesion on the failure planes which will enhance stability. But grouted anchors on the rock bolts will not be effective in ice so mechanical anchors will be used.

## 6.2 Crusher Foundations

The effect of the crusher construction will be to allow air at ambient temperatures to circulate within the structure and through the conveyor tunnel. Therefore, if the rock is presently frozen, warm air in the summer could thaw the ice and cause settlement. If the ice is contained in lenses which are thicker than a few millimeters, then this settlement could be significant. This problem could be overcome by preventing thawing by insulating the floor and lower walls, or putting in cooling coils operated by a therostat when the temperature rises above freezing.

Alternatively, there may be no ice present. In this case, the water in the rock may freeze in the winter and heaving may occur if the void ratio in the rock is significant. If the void ratio is low, the heave is not likely to be significant because only thin ice lenses will be formed and water can flow into the surrounding rock as the freezing front advances.

We believe that is is important to know the ice and void conditions in the rock which will require drilling two diamond holes during the winter.

# 7.0 CONSTRUCTION PROCEDURE

In excavating the rock slopes, it is important that controlled blasting, such as pre-splitting, be carried out to ensure that the rock forming the slopes is not damaged by blasting. This will require that an experienced contractor be employed, that drill hole alignment and explosive charge be carefully controlled, and that trial blast be conducted before the final face is reached to determine the optimum method. In addition, the center of the cut should be removed first in the direction of the conveyor

trench to ensure that there is a free face to which the blast can break. The cut heights should be restricted to about 6 m to ensure that good drill hole alignment is achieved. Note that because the drill cannot be set up against the face when drilling vertical holes, it will be necessary to step out each bench about 0.5 m so that the overall slope will not be vertical (see Figure 6). Over-excavation of about 1 m will also be necessary because it will not be possible to cut right-angled corners in rock.

It is proposed that partial drainage of the slope be achieved by cutting back the weathered rock at a slope angle of about 30 - 40 degrees, depending on stability conditions. By backfilling this excavation with free-draining granular backfill after completion of the crusher, the water table will not rise above this point. The excavated rock may not be a suitable backfill. This drainage will be supplemented by horizontal drain holes put in from each bench as excavation proceeds. These drain holes must be permitted to drain through the crusher wall when construction is complete. Flow from these holes may amount to about 15 liters per minute.

From the base of each bench, rock anchors will be installed at an angle of about 40 degrees below the horizontal to prevent sliding on the foliation planes. By installing them as excavation proceeds, drilling can be carried out readily with the blast hole drill, and they need not be tensioned because strain in the rock as the next bench is removed will produce tension. Four, 34 mm diameter Williams rock anchors will be installed on each section with a longitudinal spacing between anchors of 1.0 m.

During construction it will probably be necessary to install a number of 2 m long rock anchors on all slopes and attach mesh to the face to protect workers in the bottom of the excavation from minor rock falls. This will be particularly important if the excavation is not aligned parallel to the geological structure.

To ensure that there is adequate bearing capacity on the base of the excavation, the maximum depth of the drill holes should be carefully controlled so that this rock is not broken by blasting and all loose rock should be removed from the base so that the concrete is poured directly on the rock.

We suggest that excavation be carried out in the late winter so that the concrete can be poured in the summer. Rock excavation and support installation are not significantly affected by cold weather.

## 8.0 VOLUMES AND QUANTITIES

The following is an estimate of the volumes of excavation and quantities of support.

Soil and Weathered Rock Excavation:

| | | |
|---|---|---|
| Crusher | = | 16,000 $m^3$ |
| Conveyor Trench | = | 23,000 $m^3$ |

Rock Excavation:

| | | |
|---|---|---|
| Crusher | = | 3,500 $m^3$ |
| Conveyor Trench | = | 4,500 $m^3$ |

Pre-Shear:

| | | |
|---|---|---|
| Crusher | = | 900 $m^3$ |
| Conveyor Trench | = | 500 $m^3$ |
| Anchors | = | 2,200 m |
| Drain Holes | = | 500 m |

Support for face; mesh, bolts - estimated lump sum cost = $50,000.

Yours very truly,

GOLDER ASSOCIATES

D.C. Wyllie, P. Eng.

DCW/bn
802-1591

# APPENDIX I

# DRILL HOLE LOGS

Job No. 802-1591

Type of drilling D/D Double Tube
Rig –
Bit HQ

Coordinates E 593,430
N 6,904,775
Angle from horizontal 90°
Bearing N..... E.....

**DRILLHOLE No: CH 80-51**
Sheet..... of.....
Location Cyprus Anvil
Vangorda Plateau
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | TRICONE | | | | | | | | |
| | | | | 10 | | | | 80 | | | | Iron staining or foliation planes |
| | | | | HQ | | | | 75 | | | | |
| | | | | | | | | 79 | | | | Gouge ? (Ground Core) |
| | | | | 20 | | | | 77 | | | | |
| | | | | | | | | 70 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 78 | | | | |
| | | | | 30 | | | | 67 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 78 | | | | |
| | | | | | | | | 79 | | | | |
| | | | | | | | | 77 | | | | |
| | | | | 40 | | | | 70 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 70 | | | | |
| | | | | 50 | | | | 73 | | | | Breccia Zone |
| | | | | | | | | 70 | | | | |
| | | | | | | | | | | | | Non-calcareous, muscovite-chlorite + biotite phyllite / schist, undifferentiated |
| | | | | 60 | | | | | | | | |

Contractor Arctic
Date started.....
Date finished.....

Logged by CAMC
Checked by.....
Date Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling: O/D Double Tube
Rig: –
Bit: HQ

Coordinates E.....
N.....
Angle from horizontal: 90°
Bearing N..... E.....

**DRILLHOLE No: CH 80-52**
Sheet..... of.....
Location: CYPRUS ANVIL VANGORDA PLATEAU
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 80 | | | | Core broken on foliation, ~1 cm spacing. |
| | | | | | | | | 75 | | | | Limit of iron staining on foliation planes |
| | | | | | | | | 78 | | | | Ground core |
| | | | | HQ | | | | | | | | |
| | | | | | | | | 69 | | | | |
| | | | | 20 | | | | 75 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 72 | | | | |
| | | | | | | | | 80 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | | | | | 80 | | | | |
| | | | | 30 | | | | 75 | | | | |
| | | | | | | | | 78 | | | | |
| | | | | | | | | 50 | | | | |
| | | | | | | | | 80 | | | | |
| | | | | | | | | 80 | | | | |
| | | | | 40 | | | | 78 | | | | |
| | | | | 50 | | | | | | | | |

Contractor: Arctic
Date started.....
Date finished.....

Logged by: CAMC
Checked by.....
Date: Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling: O/D Double Tube
Rig: –
Bit: NQ
Coordinates E..... N.....
Angle from horizontal: 90°
Bearing N..... E.....

**DRILLHOLE No: CH 80-5**
Sheet..... of.....
Location: CYPRUS ANVIL VANGORDA PLATEAU
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tritone | | | | | | | | |
| | | | | 10 | | | | | | | | |
| | | | | NQ | | | | 80 | | | | Broken Core, Iron staining on foliation planes |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 80 | | | | |
| | | | | | | | | 82 | | | | |
| | | | | 20 | | | | 80 | | | | |
| | | | | | | | | 76 | | | | |
| | | | | | | | | 80 | | | | |
| | | | | | | | | 75 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite / schist, undifferentiated. |
| | | | | 30 | | | | 80 | | | | |
| | | | | | | | | 70 | | | | |
| | | | | | | | | 85 | | | | |
| | | | | | | | | 68 | | | | |
| | | | | 40 | | | | 70 | | | | |
| | | | | 50 | | | | | | | | |

Contractor: Arctic
Date started.....
Date finished.....
Logged by: CAMC
Checked by.....
Date: Oct 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-/591

Type of drilling O/D Double Tube
Rig –
Bit NQ
Coordinates E..... N.....
Angle from horizontal 90°
Bearing N..... E.....

DRILLHOLE No: CH 80-5
Sheet..... of.....
Location CYPRUS ANVIL VANGORDA PLATEAU
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | | | | | Broken core, iron staining on foliation planes |
| | | | | NQ | | | | 72 | | | | |
| | | | | 20 | | | | 60<br>75<br>71<br>72<br>69 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | 30 | | | | 81<br>70<br>65<br>76<br>82 | | | | |
| | | | | 40 | | | | 65<br>80 | | | | |
| | | | | 50 | | | | | | | | |

Contractor Arctic
Date started.....
Date finished.....
Logged by CAMC
Checked by.....
Date Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling O/D Double Tube
Rig –
Bit NQ
Coordinates E.....
N.....
Angle from horizontal 90°
Bearing N..... E.....

DRILLHOLE No: CH 80-55
Sheet..... of.....
Location CYPRUS ANVIL VANGORDA PLATEAU
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 Tricone | | | | | | | | |
| | | | | 10 NQ | | | | 70 | | | | Iron staining on foliation planes |
| | | | | | | | | 65 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | 20 | | | | 78 | | | | |
| | | | | | | | | 70 | | | | Broken Core |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 70 | | | | |
| | | | | 30 | | | | 78 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 86 | | | | |
| | | | | | | | | 70 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | 40 | | | | 74 | | | | |
| | | | | 50 | | | | | | | | |

Contractor Arctic
Date started.....
Date finished.....
Logged by CAMC
Checked by.....
Date Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling D/D Double Tube
Rig –
Bit NQ
Coordinates E.....
N.....
Angle from horizontal 90°
Bearing N..... E.....

DRILLHOLE No: CH 80-56
Sheet..... of.....
Location CYPRUS ANVIL
VANGORDA PLATEAU
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 75 | | | | Broken core, iron staining on foliation planes. |
| | | | | NQ | | | | 80 | | | | |
| | | | | | | | | 69 | | | | |
| | | | | | | | | 74 | | | | |
| | | | | 20 | | | | 81 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite / schist, undifferentiated. |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 80 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 79 | | | | |
| | | | | 30 | | | | 74 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 74 | | | | |
| | | | | | | | | 80 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 72 | | | | |
| | | | | 40 | | | | 72 | | | | |
| | | | | 50 | | | | | | | | |

Contractor Arctic
Date started.....
Date finished.....

Logged by CAMC
Checked by.....
Date Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling: O/D Double Tube
Rig: -
Bit: HQ
Coordinates E.....
N.....
Angle from horizontal: 90°
Bearing N..... E.....

**DRILLHOLE No: CH 80-5**
Sheet..... of.....
Feature: CYPRUS ANVIL
VANGORDA PLATEA
Ground level.....
Water table level.....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 72<br>75 | | | | Iron staining on foliation planes |
| | | | | HQ | | | | 75 | | | | |
| | | | | 20 | | | | 75<br>78<br>80<br>80<br>80 | | | | Minor 0.1m wide fault. |
| | | | | 30 | | | | 75 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | 40 | | | | | | | | |

Contractor: Arctic
Date started.....
Date finished
Logged by: C.A.M.C
Checked by.....
Date: Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale:

Job No. 807-1591

Type of drilling: D/D Double Tube
Rig: –
Bit: NB

Coordinates E:
N:
Angle from horizontal: 90°
Bearing N: E:

DRILLHOLE No: CH 80-5
Sheet: of:
Feature: CYPRUS ANVIL / VANGORDA PLATEAU
Ground level:
Water table level:

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 66 | | | | Iron staining on foliation planes. |
| | | | | NQ | | | | 75 | | | | |
| | | | | | | | | 74 | | | | |
| | | | | | | | | 81 | | | | |
| | | | | 20 | | | | 78 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite / schist, undifferentiated. |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 70 | | | | |
| | | | | | | | | 10 | | | | |
| | | | | | | | | 72 | | | | |
| | | | | | | | | 88 | | | | |
| | | | | 30 | | | | 72 | | | | |
| | | | | | | | | 85 | | | | |
| | | | | 40 | | | | | | | | |

Contractor: Arctic
Date started:
Date finished:

Logged by: CAMC
Checked by:
Date: Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 902-1591

Type of drilling: D/D Double Tube
Rig: —
Bit: NQ

Coordinates E:
N:
Angle from horizontal: 90°
Bearing N: E:

DRILLHOLE No: CH 80-59
Sheet: of:
Feature: CYPRUS ANVIL
VANGORDA PLATEAU
Ground level:
Water table level:

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 70 | | | | Broken core, iron staining on foliation planes. |
| | | | | NQ | | | | 70 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | | | | | 75 | | | | |
| | | | | 20 | | | | 74 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | | | | | 72 | | | | |
| | | | | | | | | 68 | | | | |
| | | | | | | | | 70 | | | | |
| | | | | | | | | 68 | | | | |
| | | | | | | | | 69 | | | | |
| | | | | 30 | | | | 71 | | | | |
| | | | | 40 | | | | | | | | |

Contractor: Arctic
Date started:
Date finished:

Logged by: CAMC
Checked by:
Date: Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling: O/O Double Tube
Rig: -
Bit: NQ
Coordinates E: ..... N: .....
Angle from horizontal: 90°
Bearing N: ..... E: .....

DRILLHOLE No: CH 80-6C
Sheet ..... of .....
Feature: CYPRUS ANVIL VANGORDA PLATEAU
Ground level: .....
Water table level: .....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 62<br>80<br>80<br>75<br>72<br>75 | | | | Broken core, iron staining on foliation planes |
| | | | | NQ | | | | | | | | |
| | | | | 20 | | | | | | | | } Highly broken core |
| | | | | 30 | | | | 52<br>70<br>75<br>63 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | 40 | | | | | | | | |

Contractor: Arctic
Date started: .....
Date finished: .....
Logged by: CAMC
Checked by: .....
Date: Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 802-1591

Type of drilling: O/O Double Tube
Rig: -
Bit: NQ

Coordinates E:
N:
Angle from horizontal: 90°
Bearing N: E:

**DRILLHOLE No: CH 80-6**
Sheet: of:
Feature: CYPRUS ANVIL VANGORDA PLATEA
Ground level:
Water table level:

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 0 | | | | | | | | |
| | | | | Tricone | | | | | | | | |
| | | | | 10 | | | | 80<br>72<br>70<br>63 | | | | Broken Core |
| | | | | NQ | | | | 72<br>70 | | | | Iron staining on foliation planes |
| | | | | 20 | | | | 76<br>80<br>65<br>79 | | | | |
| | | | | 30 | | | | 70<br>66 | | | | Non-calcareous, muscovite-chlorite + biotite phyllite/schist, undifferentiated. |
| | | | | 40 | | | | | | | | |

Contractor: Arctic
Date started:
Date finished:

Logged by: CAMC
Checked by:
Date: Oct. 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial

Job No. 1651-208

Type of drilling: O/D Double Tube
Rig: –
Bit: NQ
Coordinates E: ..... N: .....
Angle from horizontal: 90°
Bearing N: ..... E: .....

**DRILLHOLE No: CH 80-62**
Sheet ..... of .....
Feature: CYPRUS ANVIL / VANGORDA PLATEAU
Ground level: .....
Water table level: .....

| Drilling Progress | Rate of Advance | R.Q.D. | Core Recovery % | Depth & Diameter | Reduced Level | Water Level | Permeability | Bedding | Fracture Index | Instrumentation | Legend | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 50 | 0 50 | 1 Tricone | | | | | | | | |
| | | | | 10 NQ | | | | 70<br>66<br>80<br>70<br>70<br>80<br>85<br>80<br>80<br>70<br>80 | | | | Iron staining on foliation planes<br><br>Non-calcareous, muscovite-chlorite + biotite phyllite / schist, undifferentiated |
| | | | | 20 | | | | | | | | |
| | | | | 30 | | | | | | | | |
| | | | | 40 | | | | | | | | |

Contractor: Arctic
Date started: .....
Date finished: .....
Logged by: CAMC
Checked by: .....
Date: Oct. / 1980

Remarks: Complete geologic description on CAMC logs.

Golder Associates

Scale: Imperial