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VANGORDA GEOTECHNICAL STUDY

FEASIBILITY STAGE

OCTOBER, 1980 019551

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VANGORDA GEOTECHNICAL STUDY

FEASIBILITY STAGE

OCTOBER, 1980 019551

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October 1, 1980

SUMMARY

This report describes the geotechnical investigation and analysis carried out for the proposed open pit mine at the Vangorda Deposit. The analyses were based on the structural geology characteristics of the deposit with consideration given to a range of mechanical properties and groundwater conditions. The study consisted of:

1) Preparation of representative design sections using a cumulative sums technique and structural information from Vangorda diamond drill hole logs.

2) Establishment of structural domains and design sectors.

3) Compilation of mechanical properties and groundwater data.

4) Slope stability analyses using the design sections and subsequent creation of design charts for overall slope design and bench design.

Foliation is considered to be the most prominent discontinuity affecting slope stability. Joints and faults may also affect stability but insufficient information on these discontinuities has limited their significance in this analysis.

Different pit wall orientations require basically different design considerations, therefore, the proposed pit was divided into two design sectors - Design Sector A encompassing the N.E. wall, and Design Sector B encompassing the S.W. wall.

The recommended slope design angles are summarized in the following table:

Design Sector	Recommended Overall* Slope Angle	Bench Design	
		Batter Face Angle	Bench Height
A	40°	70°	12 m
		60°	17 m
B	45°	65°-70°	12-24 m

* Overall Slope Angle is from top pit crest in rock to pit bottom toe with benches but not including haul roads in Design Sector A. Assumes Phase 3 Pit, Slope Height - 100 m, Cohesion - 20 p.s.i. The slope angles do not assume a fully dewatered slope.

The overburden slopes should be designed with a 32°-36° slope angle. Detailed analysis of varying overburden conditions and related slope angles is included in this report.

The above recommendations represent the results of analysis done at the feasibility stage of the Vangorda Pit development. Continued re-analysis will be necessary, as more information becomes available, up to and including the mine operating stage.

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SECTION 1 - INTRODUCTION

The main purpose of this report is to describe the geotechnical studies carried out on the Vangorda deposit and to provide geotechnical recommendations for the initial pit design.

This geotechnical study has been prepared by the Faro Engineering staff using the extensive information collected by the Cyprus Anvil Exploration and Feasibility & Development Groups. Additional information has come from previous geotechnical reports on the Faro and Grum deposits prepared by Piteau, Gadsby, Macleod Ltd. and Montreal Engineering, respectively.

The objectives of this report are:

- To identify the important geotechnical features of the Vangorda deposit.
- To establish rock properties and hydrogeology conditions pertaining to slope design.
- To present stability analyses in the form of design charts for use in pit planning considerations.

The stability analyses presented in this report were limited by several important factors:

- Un-orientated drill core.
- No drillholes in area of proposed ultimate pit walls.
- No joint and fault orientation data.
- Lack of groundwater information.

SECTION 2 - GEOLOGY

2.1 REGIONAL GEOLOGY AND SURFICIAL GEOLOGY:

The Vangorda deposit lies within the Anvil Range, which is located along the south western margin of the Selwyn Fold Basin, northeast of the Tintina Trench. The deposit is regionally stratabound between the lower Paleozoic units of the Vangorda formation and the Mt. Mye formation. Meta volcanic rocks, though rare in the immediate vicinity of the deposit, are regionally common throughout the Vangorda formation.

The stratigraphy in the Vangorda pit area generally consists of a glacial till of varying thickness (2-30 m) overlying phyllite bedrock. The glacial till is relatively consistent across the site and it is primarily composed of sandy silt with some clay and gravel.

Permafrost has not been encountered in any test pits or drill holes, and is not considered a factor in the Vangorda pit design.

2.2 BEDROCK GEOLOGY:

Regionally stratabound between lower Paleozoic units, the deposit is spatially associated with a graphitic phyllite that occurs at a broad vertical facies change between calcareous pelitic phyllites of the Vangorda formation above and non-calcareous pelitic phyllites of the Mt. Mye formation below.

The sulfide horizon consists of the following principal strataform lithologies from stratigraphic top to bottom:

a) Sulfide bearing graphitic meta-chert, generally pyrite bearing, locally base metal bearing.

b) Barite bearing massive pyritic sulfides, base metal bearing.

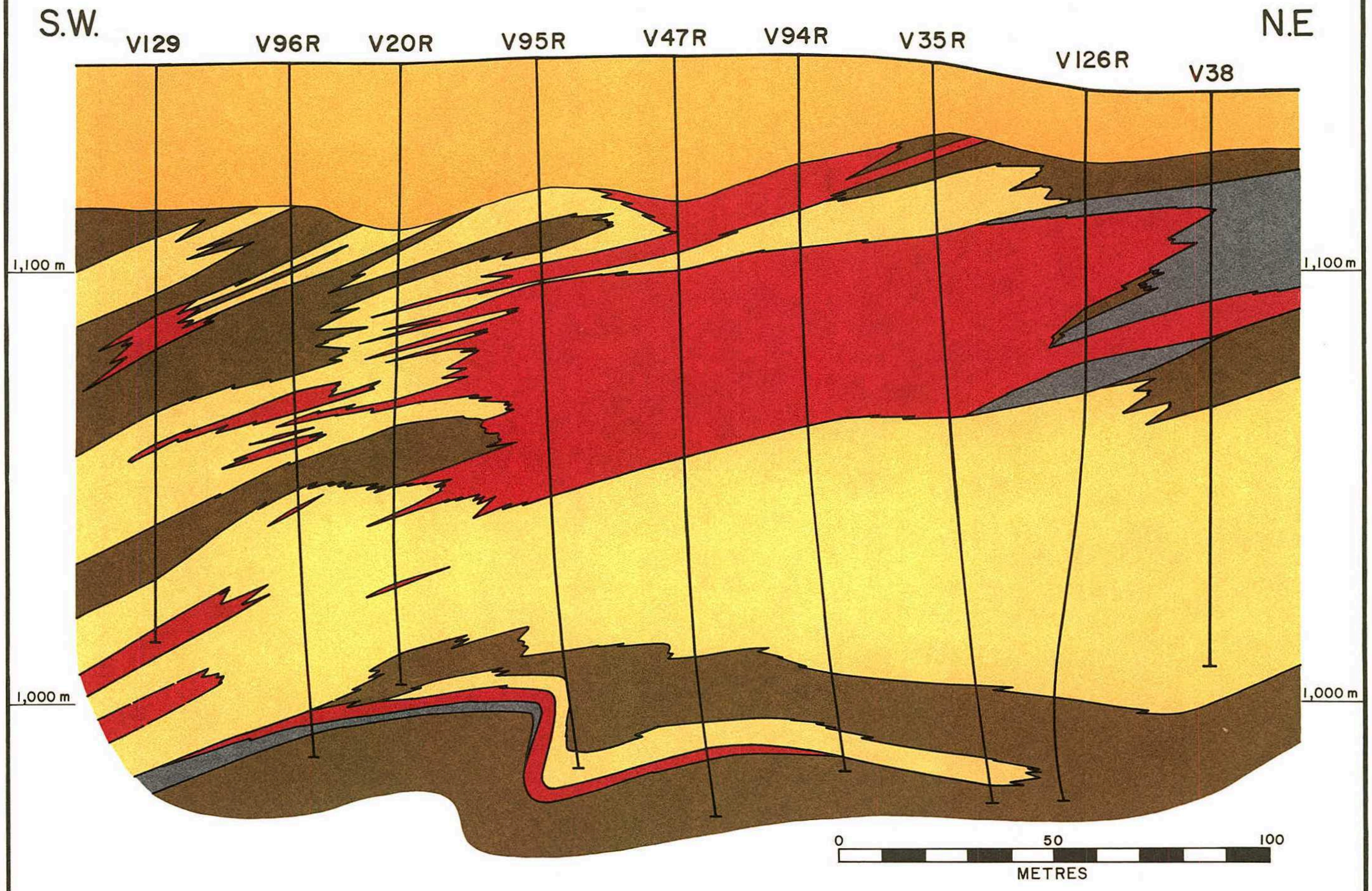
c) Massive pyritic sulfides, variably base metal bearing, variably calcareous.

d) Pyritic meta-chert, generally base metal deficient.

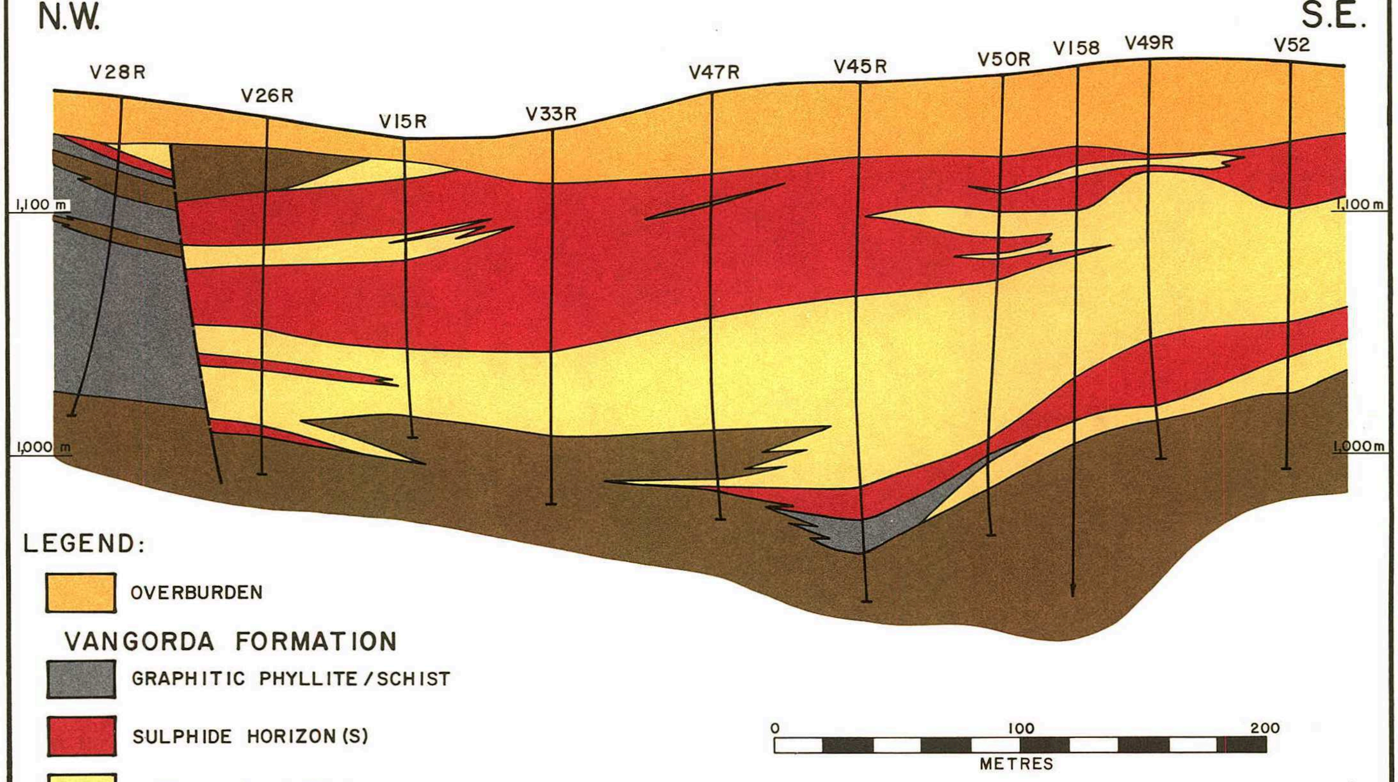
The deposit is generally underlain by a sulfide bearing, sericite alteration assemblage of variable thickness.

The Vangorda sulfide horizons and host rocks have been deformed by four phases of folding and segmented by one phase of faulting. An axial plane cleavage, produced during the second phase (D2) of folding, is the dominant fabric in the host rocks. The average orientation for this S2 foliation is 130°/28° SW but locally it is broadly warped and/or kinked by post-D2 events.

VANGORDA GEOLOGICAL CROSS SECTION 6+00 E



VANGORDA LONGITUDINAL SECTION 0+00



LEGEND:

🟧 OVERBURDEN

VANGORDA FORMATION

◼ GRAPHITIC PHYLLITE / SCHIST

🟥 SULPHIDE HORIZON (S)

🟨 ALTERATION OVERPRINT

MT. MYE FORMATION

🟫 NON-CALCAREOUS PHYLLITE / SCHIST

March 1980 P.T. / r.w.r.

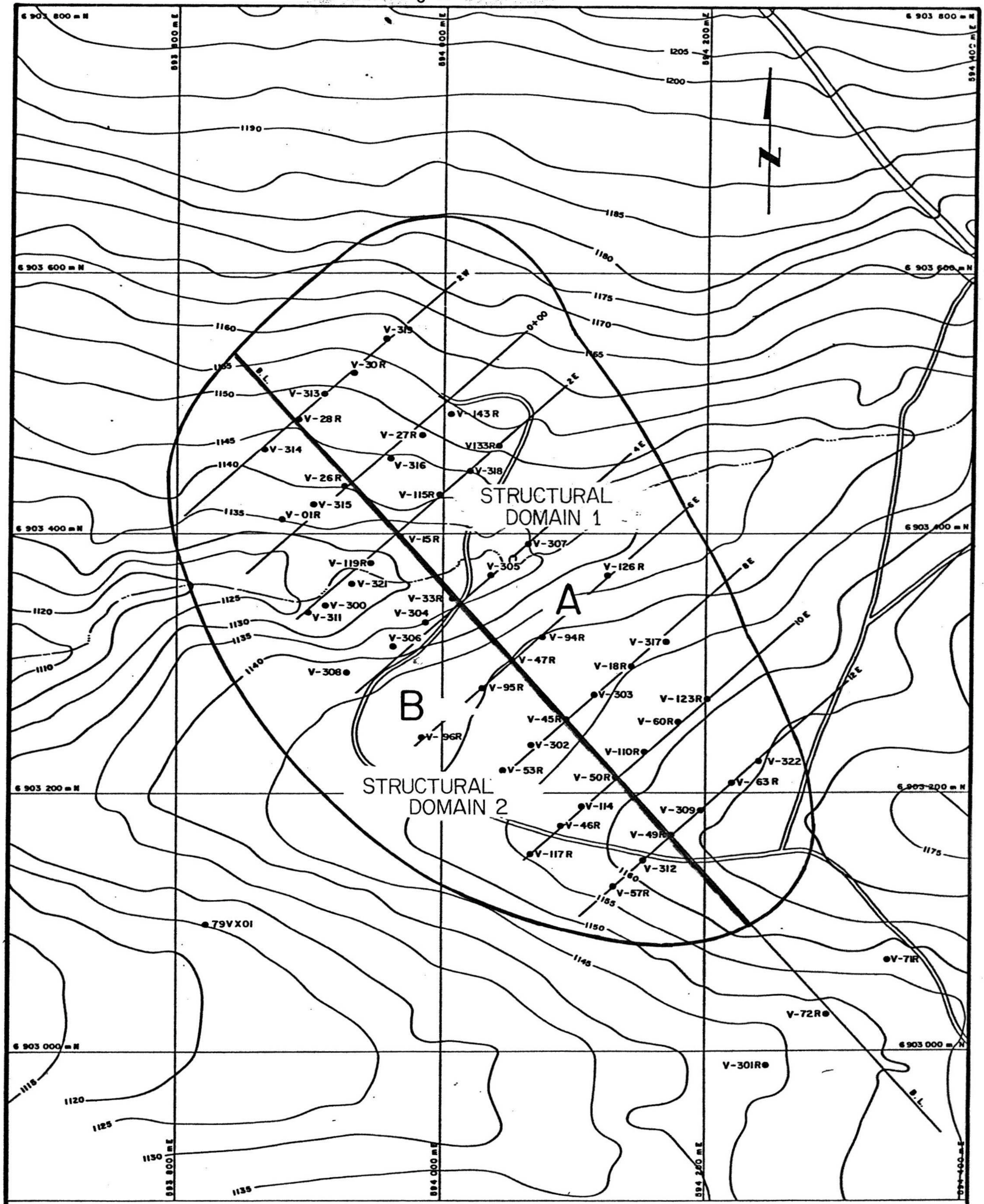
Figure 5

SECTION 3 - STRUCTURAL GEOLOGY

3.1 GENERAL:

Ensuring stability of the pit walls is a necessary part of the Vangorda mine design. The rock slope stability will be predominantly governed by the occurrence and properties of critically oriented discontinuities such as foliation, joints and faults. The objective of a structural geology investigation is to identify structural domains followed by the delineation of design sectors for which orientations of slope faces, rock types and discontinuities are similar. Areas of similar geologic structure are called structural domains.

In previous slope stability studies done on the Faro and Grum deposits, the orientation of foliation was considered to be the most significant single factor affecting pit stability. From structural information obtained to date, the S2 foliation is the most important feature affecting the Vangorda pit stability as well. The orientation of foliation has been used to delineate the structural domain boundaries - two structural domains were considered for evaluation of overall pit slopes. One domain encompasses the N.E. half of the proposed Vangorda pit and the other covers the S.W. half of the pit as shown in Figure 6.



DESIGN SECTORS

VANGORDA DEPOSIT

D.D.H. PLAN

50 25 0 50 100
METRES

March 1980 P.T. / c.l.c.

Figure 6

3.2 FOLIATION:

All foliation data used in this study was obtained from S2 measurements taken from the Vangorda diamond drill core. The diamond drill data used came from holes drilled in the 1979 re-drilling program. The drill hole deflections were measured but no core orientations relative to the drill hole were obtained. This is significant because only the average S2 strike of 130° azimuth is then used in the structural model; with no knowledge of the variability of the strike available at this time. The assumption of one average foliation strike for all the Vangorda deposit is a limiting factor in the accuracy of the stability analysis.

Structural data obtained from the Faro Open Pit and the adit at the Grum indicates that the foliation strike appears to be quite variable. A re-evaluation of the stability analysis will have to be done when more detailed foliation strike data is obtained from oriented core measurements and pit mapping.

The stereographic projections of the foliation data in Figure 7 and 8 indicate an average foliation orientation of 220°/27° SW (dip direction/dip) on the NE side of the pit and 220°/23° SW on the SW side of the pit. These two average foliation trends were used to establish the two structural domains mentioned previously. The foliation dips into the pit on the NE wall and it dips into the wall on the SW wall. Whenever the foliation dips toward the pit, it constitutes a major discontinuity set along which instability may develop. Therefore, a detailed analysis of foliation was done on the NE side of the pit using the Cumulative Sums technique.[1]

FIGURE 7

STEREOGRAPHIC PROJECTION OF FOLIATION IN DESIGN SECTOR A - NE WALL

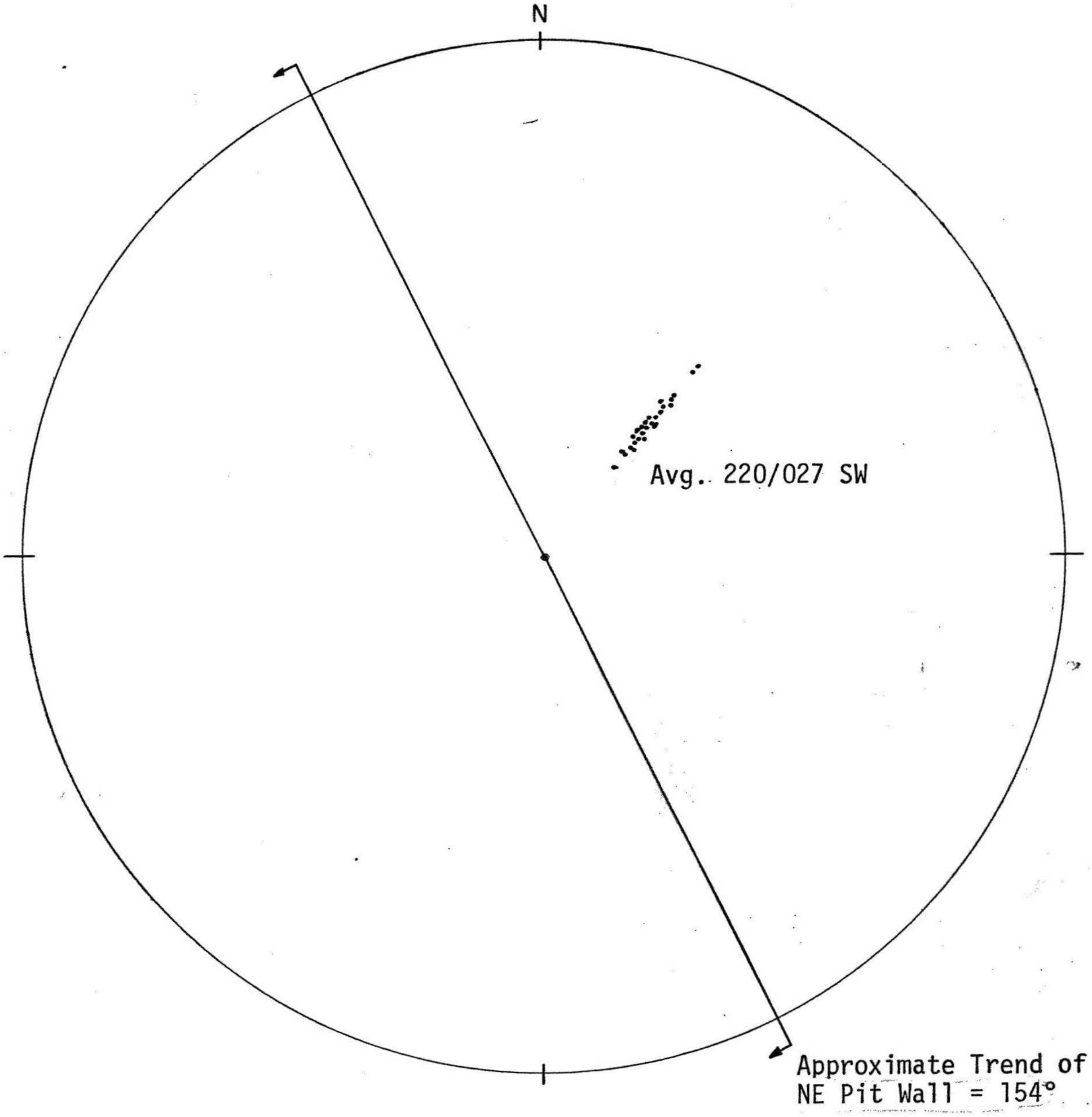
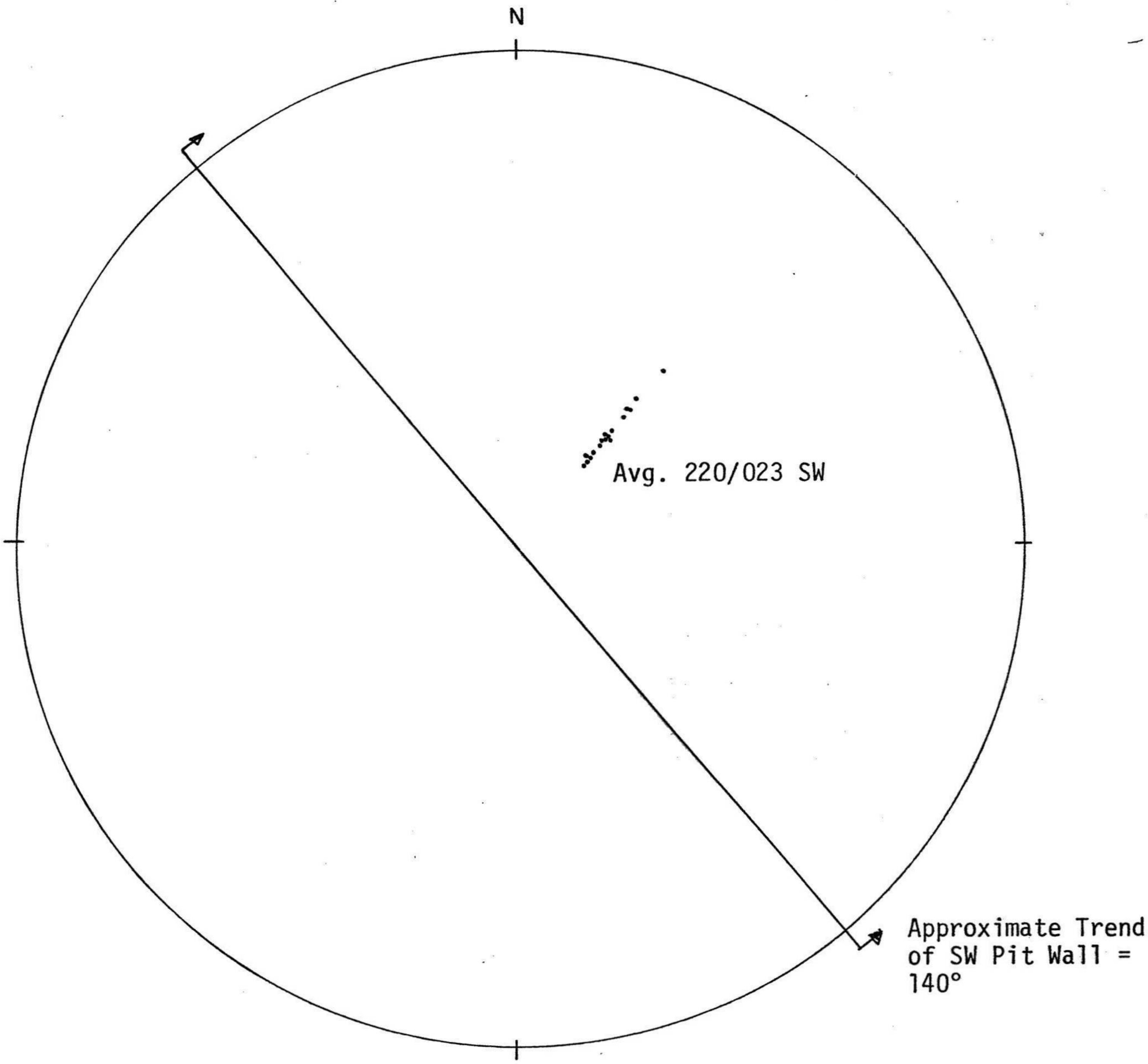


FIGURE 8

STEREOGRAPHIC PROJECTION OF FOLIATION IN DESIGN SECTOR B - SW WALL



3.2.1 Analysis of Data from Drill Core by the Cumulative Sums Technique:[2]

The cumulative sums technique provides a rapid and precise method of determining major trends above or below a particular reference value which is selected. It also ascertains both the magnitude and location of these variations. A "cusums" analysis has been done on the Vangorda foliation data for the following reasons:

a) To determine a reliable estimate of the mean dip of the foliation in each drill hole.

b) To detect general changes in current mean foliation dip above and below the mean level of the foliation data.

c) To predict the average dip of foliation between drill holes on section and also in parts of the rock mass where drill hole structural data is not available.

d) To construct graphical geological sections from which the overall mean foliation dip can be determined as well as the degree of waviness of the foliation, both of which are values that are required in the slope stability analysis.

The cusums method consists of subtracting a constant quantity, K, which is the mean foliation dip in the drill hole, from each value of S2 dip measured in the drill hole. The random spacing of the S2 measurements recorded presents no problem, so long as the position, not the distance, in the sequence is used. It does not matter if the interval between observations changes. Successive accumulated differences are designated the cumulative sums of the original sequence of foliation data. The cumulative sums are then plotted on a graph (see Appendix A for example) called the cusums plot. The structural interpretation is based on the average slope of the cusums plot. The current foliation dip ($\overline{X}$) over an interval of the cumulative sum plot is given by:

$$\overline{X} = K + \frac{\text{change in the cumulative sum}}{\text{change in n}}$$

n = position in sequence of S2 value

A template was constructed so that the slope of the cusums curve, which gives the actual deviation of foliation from the mean, could be read directly from the template.

Jim Marlon-Lambert of ICAS Software Services Inc. wrote a computer program to calculate the cumulative sums in each drill hole using the Vangorda S2 data contained in Cyprus Anvil's computer drill-hole data handling system.

The computer converted the recorded S2 dip from an apparent dip to a true dip based on the deflection of the drill hole. The strike of foliation was assumed to be a constant in each drill hole.

The original and converted S2 dips, as well as the cumulative sums for each drill hole used in the design sections, are compiled in Appendix A.

The results of the cusums analysis are summarized in Table 1. The current mean dips of foliation in selected drill holes were used to construct design sections (Appendix B) which are approximately normal to the strike of the foliation. By interpolating foliation dip between drill holes on the design sections, a good approximation of the foliation dip can be determined. This foliation can then be incorporated into slope stability analyses for the purposes of slope design.

TABLE 1

MEAN DIP AND CURRENT MEAN DIP OF FOLIATION IN SELECTED DRILLHOLES BASED ON CUMULATIVE SUMS ANALYSIS

Drillhole Number	Mean Dip	Depth Interval (m)	Current Mean Dip
V-15R	25.24	10.1- 17.4	18.34
		17.4- 28.9	47.24
		28.9- 38.3	17.44
		38.3- 52.4	45.24
		52.4- 78.3	20.44
		78.3-124.1	14.84
V-28R	28.63	22.6- 78.9	26.77
		78.9-132.3	31.68
V-30R	39.29	17.4- 49.7	22.29
		49.7- 72.5	33.29
		72.5-133.2	52.79
V-35R	20.40	19.2- 52.1	18.00
		52.1- 96.6	14.70
		96.6-138.4	27.10
		138.4-171.3	13.60
V-47R	24.39	34.1- 54.3	20.99
		54.3-106.1	12.89
		106.1-139.6	22.59
		139.6-176.8	32.69
V-49R	27.31	41.5- 75.1	20.86
		75.1- 96.3	49.31
		96.3-114.6	30.16
		114.6-126.9	18.91
		126.9-166.7	21.51
V-63R	27.65	32.6- 78.3	24.85
		78.3-123.1	31.15
		123.1-133.2	22.65
V-94R	23.13	25.5- 57.0	17.63
		57.0- 84.7	28.13
		84.7-115.2	18.93
		115.2-132.9	28.13
		132.9-157.9	21.13
Drillhole Number	**Mean Dip**	**Interval (m)**	**Current Mean Dip**
V-115R	30.66	3.8- 20.7	32.06
		20.7- 52.7	47.66
		52.7- 95.4	27.66
		95.4-121.0	15.16
		121.0-143.6	31.96
V-126R	17.78	19.8- 49.7	25.58
		49.7- 78.6	18.48
		78.6-165.8	12.13
V-133R	22.59	9.8- 48.2	17.79
		48.2- 71.6	11.84
		71.6- 99.8	16.39
		99.8-135.9	36.89
V-309	30.53	38.1- 72.8	39.53
		72.8- 96.3	22.68
		96.3-120.7	37.33
		120.7-143.9	25.33
V-313	38.25	21.0- 51.2	20.25
		51.2-108.2	46.45
V-318	26.22	6.6- 25.0	32.22
		25.0- 67.1	20.92
		67.1- 93.6	23.02
		93.6-121.0	37.22
		121.0-142.0	20.82
V-319	25.64	17.4- 63.1	22.59
		63.1-103.9	33.64
		103.9-121.0	18.94
		121.0-147.2	23.14
V-322	32.90	35.1- 60.0	35.90
		60.0- 76.8	27.60
		76.8-114.9	36.70

3.3 JOINTS:

No information on the joints in the Vangorda deposit has been collected as yet. In discussion with Exploration personnel, they indicated that joints were tough to measure in the drill core as most of the breakage was along S2. Joint orientation would be difficult to determine in the drill core because the core is not oriented and the joint measurements would then have to be related to the average foliation strike of 130°. In the Faro pit slope study by Piteau, core orientation joint data was inconclusive and, therefore, joint data from core was not used in the structural analysis. Joint data was also not used in the stability analysis done by Montreal Engineering on the Grum deposit. All this does not mean that joint data is not important in slope stability analyses. Past slope failures in the Faro Pit indicate that unfavourable joint orientations have provided the planes along which sliding occurred.

In the Faro Pit, joints have been the primary discontinuities along which bench failures have occurred, rather than foliation planes.

If joint sets are found in the Vangorda pit parallel or sub-parallel to foliation, then compound translational failure planes can develop. Cross joints in combination with foliation can provide the suitable geometry for wedge failures.

Joint data should be collected from pit mapping as the Vangorda pit develops and be used in further slope stability analyses to determine its effect on wall stability. In this study joint data will not be available but foliation is still the main discontinuity affecting overall wall stability and should be adequate for initial wall design.

3.4 FAULTS:

As was the case with joints, fault orientations have not been measured in the drill core but indications of fault and shear zones have been recorded. Several inferred faults have been indicated on the sections of the Vangorda geological model and these faults can be analysed to see if they could possibly have geotechnical importance.

SECTION 4 - HYDROGEOLOGY

4.1 SURFACE WATER:

The most significant surface water in the proposed Vangorda pit area is Vangorda Creek. This creek will be diverted around the open pit. An engineering study has already been done on the proposed diversion of Vangorda Creek by Golder Associates. The diversion should be planned so that no major seepage of creek water enters the open pit or recharges the local groundwater regime around the pit. The proposed diversion ditch alignment has been located 100 feet back from the North end of the pit. This alignment may be too close and will certainly have to be re-investigated if the pit limits are extended.

Experience at the Faro Pit has shown that unlined diversion ditches can cause problems, especially if the overburden-bedrock contact is near the base of the ditch. The possibility of lining the Vangorda Creek diversion ditch should be given serious consideration as in all likelyhood the ditch will be relatively close to the pit limits.

Intermittent streams and local runoff should be contained by small drainage trenches located around the perimeter of the pit.

4.2 GROUNDWATER:

Local groundwater conditions have been investigated by using P100 piezometers installed in two drillholes; V-307 and V-33R. Readings from the piezometers are shown in Table 2. Not enough readings have been obtained to establish seasonal groundwater trends but the groundwater table is indicated as being close to the ground surface in both holes. Both piezometer holes are located in the Vangorda Creek valley, and as this is a local discharge area, it follows that the groundwater table should be high. Drill hole V-322, on Section 12E on the east slope above Vangorda Creek, has been making water ever since it was drilled. The artesian conditions exhibited here could be the results of an impermeable boundary (i.e., fault) between the hole and the creek or a confined perched water table.

The limited groundwater information available to date suggests the possibility of high groundwater in the area of the proposed Vangorda pit. For this reason, the stability analyses have been done using high groundwater, "WET" conditions, as well as low groundwater, "DRY" conditions. The wet conditions assume a phreatic surface within the rock mass that will intersect the slope face at a point at least half way up the slope above the pit bottom. The dry conditions assume that no groundwater pressures are generated in the slope or along the failure plane.

More groundwater information on the Vangorda is needed, especially if any dewatering methods are attempted.

TABLE 2

VANGORDA PIEZOMETER READINGS

Date	Hole Number	Elevation of[1] Piezometer (ft.)	Reading P.S.I.	Piezometric Head[2] Elevation (ft.)
September 5, 1979	V-33R	86.0	34.0	78.5
	V-307	243.0	106.0	244.9
October 25, 1979	V-33R	86.0	33.0	76.2
	V-307	243.0	102.0	235.6
May 20, 1979	V-33R	86.0	31.0	71.6
	V-307	243.0	102.0	235.6
June 24, 1980	V-33R	86.0	35.0	80.8
	V-307	243.0	104.0	240.2
September 9, 1980	V-33R	86.0	33.5	77.4
	V-307	243.0	101.0	233.3

[1] Relative to ground surface

[2] Relates to an approximate groundwater elevation of 3,712 ft.

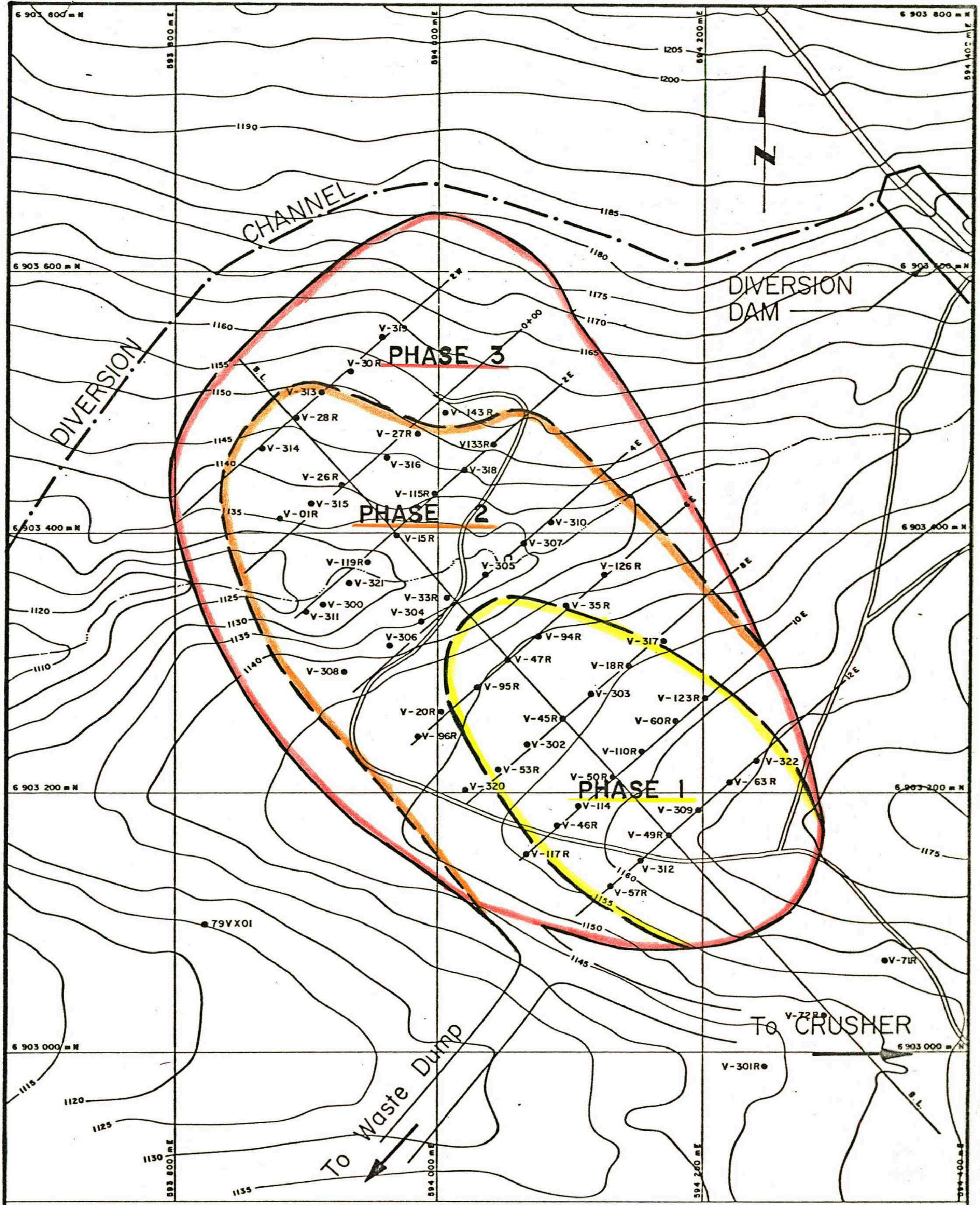
SECTION 5 - SLOPE STABILITY ANALYSES AND SLOPE DESIGN

5.1 PIT PLAN:

The phases and ultimate pit limits used in this study are those derived from the initial Vangorda feasibility study done in December, 1979 (Figure 9).

To generate those limits, the Mintec Medsystem cone mining, or "Dipper" technique, was applied to the Vangorda preliminary model.

This initial feasibility design was based on data available at the time and is subject to modifications that will arise as further engineering studies are carried out.



March 1980 P.T. / c.l.c.

VANGORDA DEPOSIT

D.D.H. PLAN

OPEN PIT OUTLINE

Figure 9

5.2 DESIGN SECTORS:

After dividing the Vangorda pit into structural domains, design sectors had to be designated. The main consideration in determining individual design sectors is the overall orientation of the final pit wall. Different pit wall orientations require basically different design considerations. Therefore, design sectors are zones of the proposed pit which contain one structural domain and one general pit slope orientation.

The Vangorda pit has been divided into only two design sectors at this stage. Design Sector A encompasses the NE wall and Design Sector B the SW wall (see Figure 6). When more structural information is obtained, a further sub-division of the design sectors may be necessary.

5.3 ROCK STRENGTH PARAMETERS:

The rock strength parameters used in this study were adopted from values obtained from the Faro and Grum deposits, as limited mechanical testing has been performed on Vangorda rock. When Montreal Engineering collected samples for laboratory testing for the Grum geotechnical study, they obtained some core from Hole V-27-R of the Vangorda deposit. A sufficient amount of fresh Grum core was not available at the time and, therefore, core was selected from the Vangorda hole because it was similar to the predominant rock types at the Grum deposit.

Rock strength parameters used in the Faro and Grum studies were established by means of direct shear and triaxial laboratory tests. The two basic shear strength parameters used in the analysis are angle of friction, or shearing resistance - ϕ - and cohesion - C. The residual angle of friction - ϕr, is generally used in stability analysis and in many cases a geometric component, i, is added to the value of ϕr. The component, i, represents the surface roughness and geometric irregularities found along the failure surface. This roughness inhibits sliding and, therefore, must be added to the friction angle in the analysis.

The rock shear strength characteristics are summarized in Table 3.

TABLE 3

ROCK SHEAR STRENGTH CHARACTERISTICS

	Faro	Grum	Vangorda*
Discontinuity	Faults sub-parallel to foliation	Joints parallel to foliation	Foliation
Angle of Friction	$\phi r = 21°$ and $24°$	$\phi = 19.5°$ $i = 6°$ $\phi + i = 25.5°$	$\phi r = 25°$ and $21°$
Apparent Cohesion C	Low - 720 psf High - 2,880 psf	850 psf	Low - 864 psf = 6 psi High - 2,880 psf, 20 psi

* Assumed Vangorda characteristics would be more similar to Grum than Faro.

5.4 SLOPE STABILITY ANALYSES:

The calculation of the stability of slopes is progressively more difficult and less accurate when one goes from existing slopes that are failing (eg., Faro Pit) to planned pit slopes that do not exist yet, as is the case with the Vangorda deposit. An allowable factor of safety of 1.2 was considered to be acceptable for design of the Faro pit slopes but due to a larger degree of uncertainty of the complexity of Vangorda pit geology at this point, a factor of safety of 1.3 will be regarded as the minimum acceptable value.

Stability analysis should be no more complex than the knowledge of the slope permits. Because there are many variables and many assumptions involved in these analyses, they were kept as simple as possible at this stage. Emphasis was placed on the design of the overall slope and the individual benches with respect to failure on foliation. A detailed look at the NE pit wall, using four constructed design sections, was the main focus of the analysis. More limited analyses were carried out for the design of the SW pit wall and overburden slopes.

In rock slopes, instability is not likely to occur through intact rock but rather along discontinuities such as foliation, joints and faults. Therefore, slope stability analyses were done by assuming the shape of the potential failure planes using geological discontinuities, mainly foliation. Different types of slope failures were considered for each design sector of the pit based on the failure modes that were judged to be kinematically possible.

Plane failure along foliation daylighting on the pit face was the main failure mode considered for the NE pit wall. Wedge failures bounded by faults and foliation were also considered on the NE wall. On the SW pit wall, foliation dips into the wall which is favourable in terms of wall stability. Faults dip toward the pit on the SW wall but are too steeply dipping to allow for plane failure. The possibility of toppling failure was also evaluated.

5.4.1 Plane Failure:

Plane failure along foliation is the most significant failure mode in Design Sector A. Plane failure analyses were carried out using a limit equilibrium method of analysis detailed in Figure 10. A plane failure is basically analysed as a two-dimensional slope problem. This simple failure mode is particularly useful for demonstrating the sensitivity of the slope to change in shear strength and groundwater conditions. These changes are less obvious when analysing the more complex mechanics of a three-dimensional slope failure.

The following assumptions were used in the plane failure analysis:

1. Both the failure plane and associated tension crack strike parallel to the slope face.

2. There are no moments which would tend to cause rotation of the failure block and, therefore, failure is by sliding only.

3. Except in the case of a dry slope, hydrostatic water pressure conditions will be assumed to exist in the tension crack and along the base of the failure plane.

4. The shear strength properties of the sliding surface are defined by:

$$\tau = C + (\sigma - \upsilon)\ \mathrm{TAN}\ (\phi + i)$$

where τ = shear stress
C = cohesion
σ = normal stress
υ = water pressure
ϕ = angle of friction along discontinuity
i = geometrical component of friction related to surface asperities

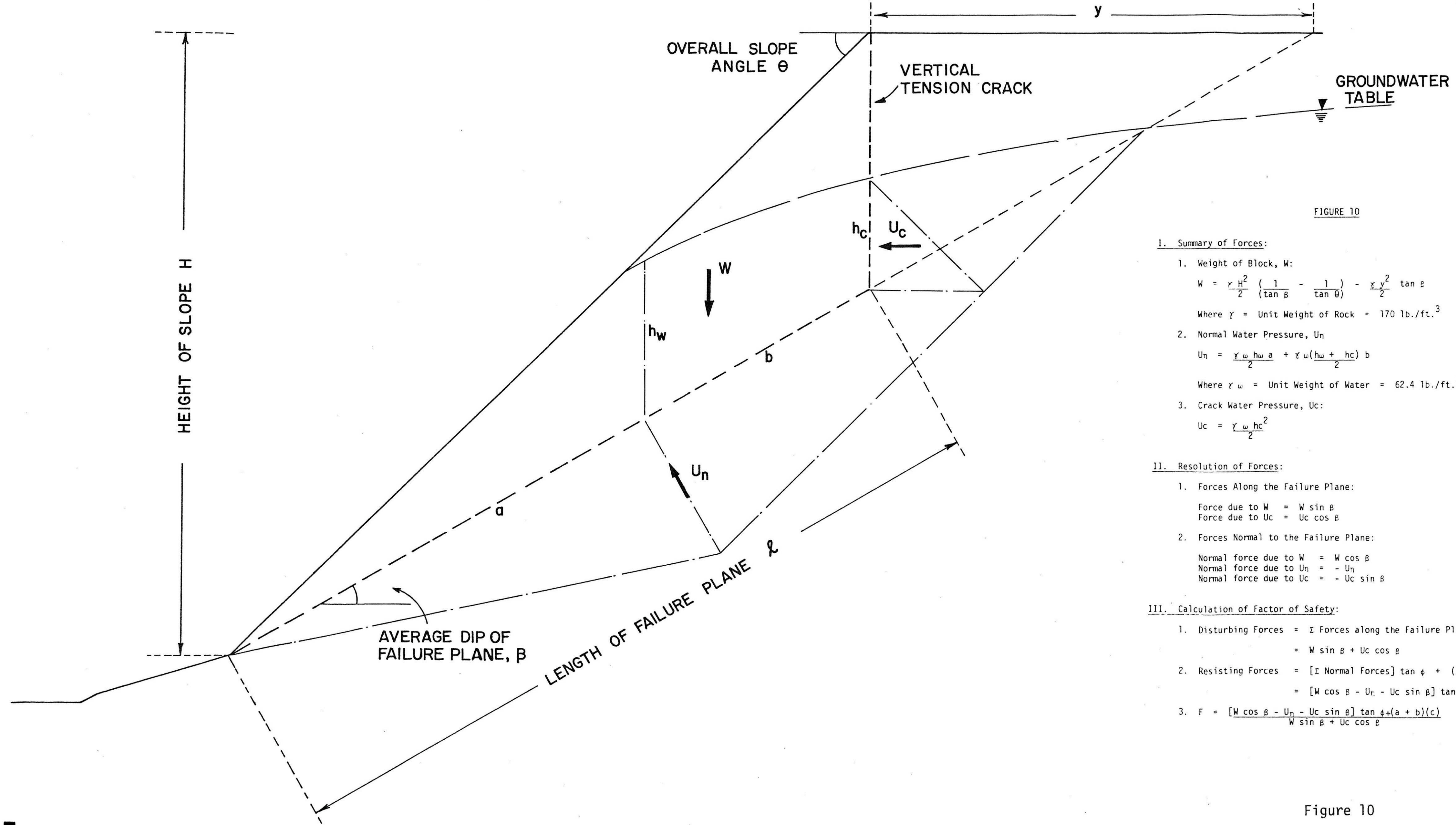


FIGURE 10

I. Summary of Forces:

1. Weight of Block, W:

$$W = \frac{\gamma H^2}{2}\left(\frac{1}{\tan\beta} - \frac{1}{\tan\theta}\right) - \frac{\gamma y^2}{2}\tan\beta$$

Where γ = Unit Weight of Rock = 170 lb./ft.^{3}

2. Normal Water Pressure, U_n

$$U_n = \frac{\gamma_\omega h_\omega a}{2} + \gamma_\omega\left(\frac{h_\omega + h_c}{2}\right) b$$

Where γ_ω = Unit Weight of Water = 62.4 lb./ft.^{3}

3. Crack Water Pressure, U_c:

$$U_c = \frac{\gamma_\omega h_c^2}{2}$$

II. Resolution of Forces:

1. Forces Along the Failure Plane:

Force due to W = $W \sin\beta$
Force due to Uc = $U_c \cos\beta$

2. Forces Normal to the Failure Plane:

Normal force due to W = $W \cos\beta$
Normal force due to U_n = $-U_n$
Normal force due to Uc = $-U_c \sin\beta$

III. Calculation of Factor of Safety:

1. Disturbing Forces = Σ Forces along the Failure Plane

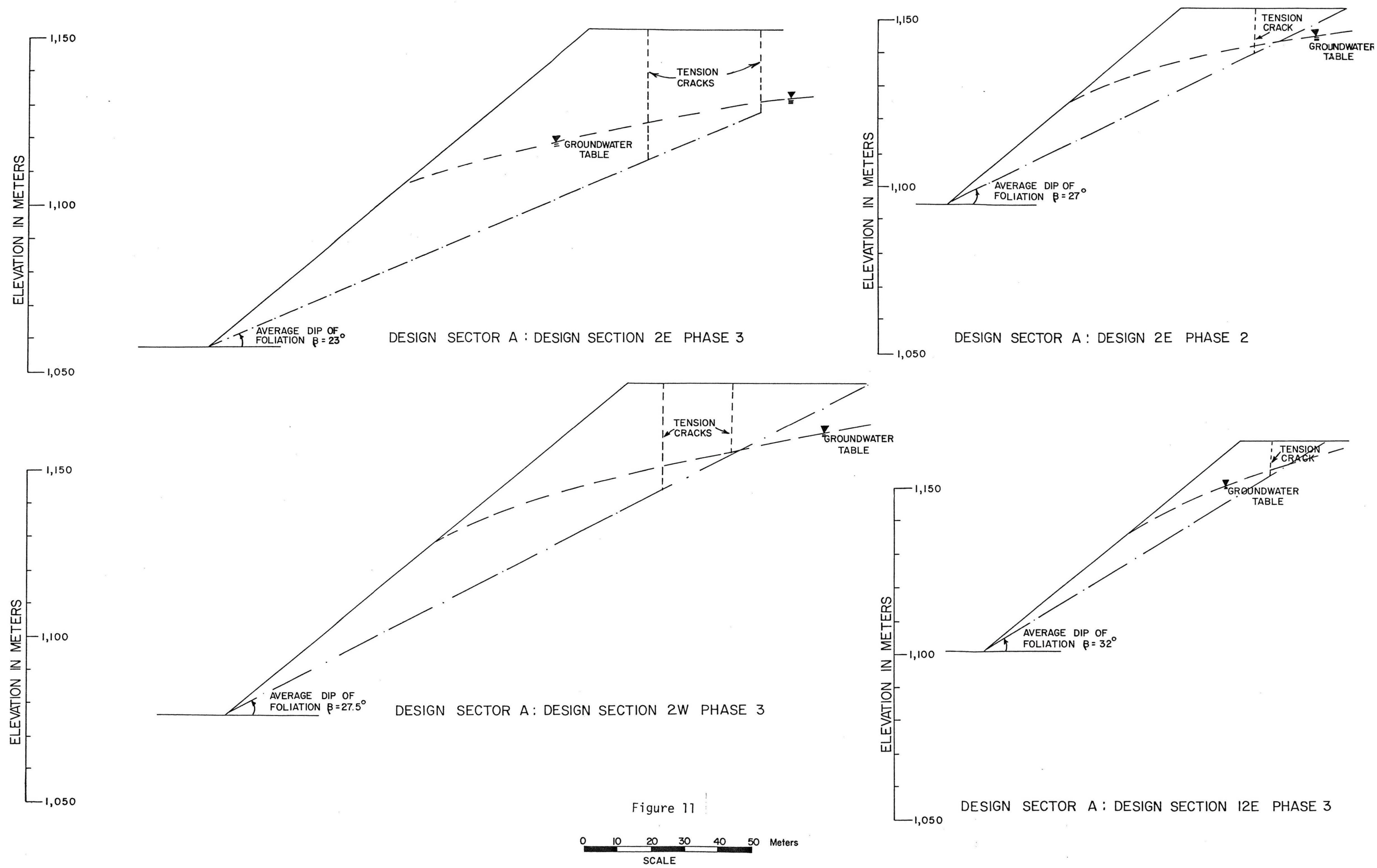
$= W \sin\beta + U_c \cos\beta$

2. Resisting Forces = [Σ Normal Forces] $\tan\phi$ + $(\ell)(c)$

$= [W\cos\beta - U_n - U_c\sin\beta]\tan\phi + (a + b)(c)$

3. $$F = \frac{[W\cos\beta - U_n - U_c\sin\beta]\tan\phi + (a+b)(c)}{W\sin\beta + U_c\cos\beta}$$

Figure 10



DESIGN SECTOR A : DESIGN SECTION 2E PHASE 3

DESIGN SECTOR A : DESIGN 2E PHASE 2

DESIGN SECTOR A: DESIGN SECTION 2W PHASE 3

DESIGN SECTOR A : DESIGN SECTION 12E PHASE 3

Figure 11

5. A slice of unit thickness is considered and it is assumed that release surfaces are present so that there is no resistance to sliding at the lateral boundaries of the failure.

The analyses were carried out for varying groundwater conditions, i.e., dry slopes and high groundwater. The average dip of the failure plane was assumed to be the approximate average foliation dip as determined from the design sections in Appendix B. The location and average dip of the foliation was used to calculate the weight of the failure block and the length of the failure plane. The geometric relationship of the failure planes for each design section are shown in Figure 11.

Factor of safety for different overall slope angles for the various slope conditions are given in Section 5.5 - Design Charts.

5.4.2 Wedge Failure:

Wedge failure could be a possible failure mode in Design Sector A, NE wall, with sliding along the intersection of faults and foliation or joints and foliation. With virtually no structural orientations available for faults and joints, a comprehensive wedge failure analysis could not be done.

Experience from the Faro Pit indicates that wedge failures are common on a bench scale, especially involving joint sets.

Wedge failure analysis involving an inferred fault orientation of 245/80° N and foliation on the NE wall was performed on a 20 m bench height to determine stability. Bray's short solution (Hoek and Bray, 1977, Appendix 2)[3] was used to determine the possibility of wedge sliding. The analysis indicated that the wedge formed by the fault and foliation was stable.

When more structural information is obtained on the Vangorda deposit, wedge failure analysis is important because plane failure analysis usually provides a lower bound and is conservative. When structural features, which are likely to control stability, are not parallel to the slope face, the stability analysis should be carried out using three-dimensional methods, i.e., wedge failure analysis.

5.4.3 Toppling Failure:

In Design Sector B, the foliation dips into the pit wall, rendering plane failure on these discontinuities kinematically impossible. Toppling is a possible failure mode in this design sector if a set of sub-parallel discontinuities exist that dip into the wall. Generally, a steeply dipping discontinuity set is involved in toppling failure. The average foliation dip of 23° in Design Sector B is too shallow to represent a likely possibility for toppling.

The conditions for toppling failure are:

1. A discontinuity set dipping into the wall with its strike parallel or sub-parallel to the trend of the wall (no more than ± 20° variance).

2. Space must exist for toppling to occur into.

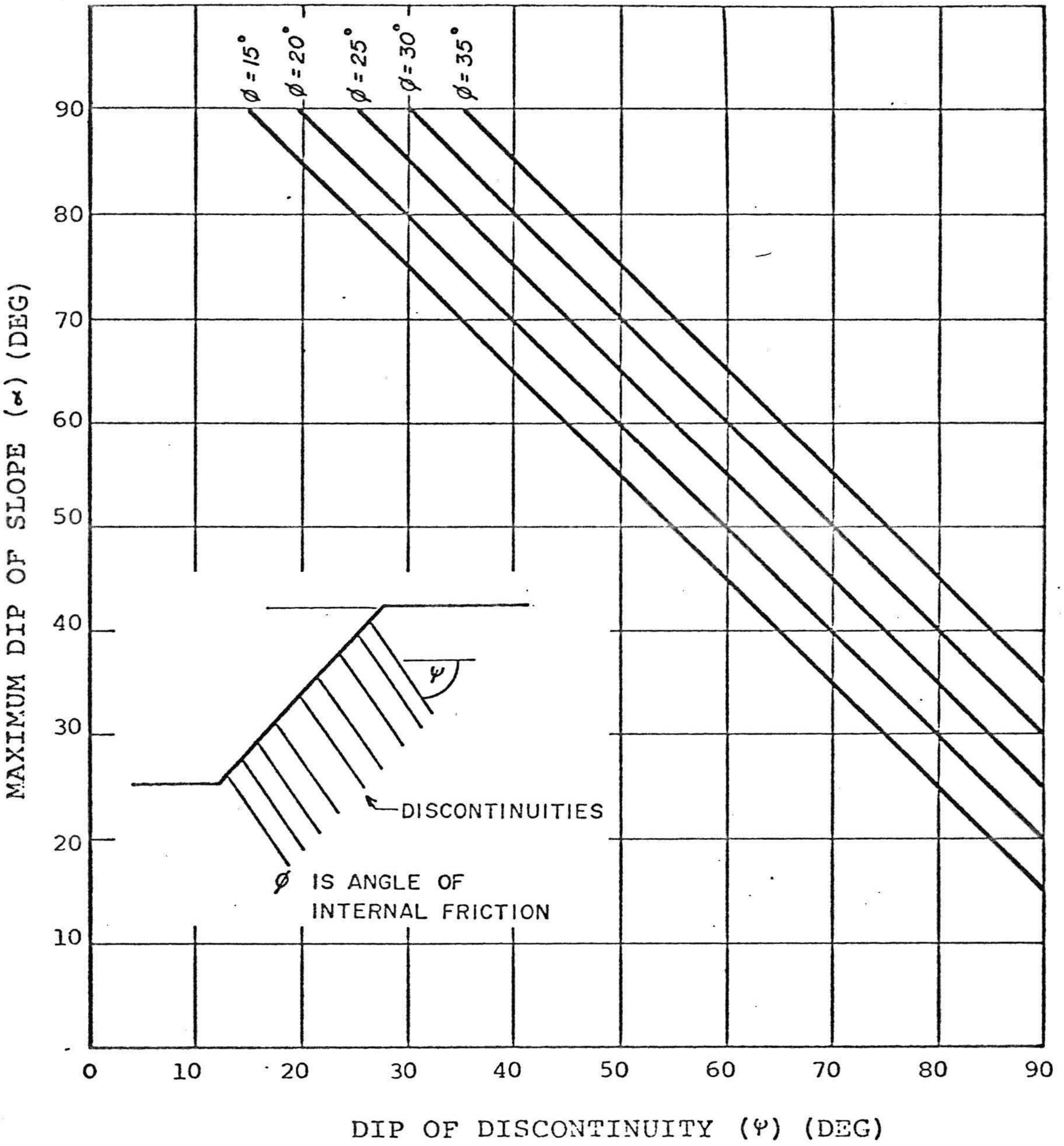
Figure 12 illustrates the kinematic conditions for toppling that were used in the Grum geotechnical study by Montreal Engineering. The same criteria can be applied to the Vangorda study. The graph indicates that at a friction angle, ϕ, of 25°, a 45° slope would not have a risk of toppling failure for any discontinuity set dipping shallower than 70°. Some steeply dipping faults of orientation 245/80 N have been inferred in the Vangorda structural interpretation. These faults would only sub-parallel the trend of the pit wall at the narrow N.W. and S.E. ends of the pit and they would not dip in the proper direction to cause toppling at these locations.

None of the structural information collected to date suggests the possibility of toppling failure. As more information on discontinuity sets is obtained, the possibility of toppling can be further assessed.

5.4.4 Circular Failure in Overburden:

Stability analysis of the overburden portion of the pit slopes must be approached differently than the stability of the rock slopes. In overburden, failure usually occurs along a surface which approaches a circular shape and thus a circular failure analysis has been used to determine overburden slope angles.

Extensive knowledge of the overburden depth is only known in the area of influence of the diamond drill holes. Unfortunately, the depth of the overburden along the proposed pit limits is not well defined and this is where the stability of any overburden slope is of the most concern. Using the drill logs and sections, it appears that the overburden is shallow in the N.E. corner of the pit ($\sim$ 10 m) and that it increases in depth to the S.W. (30 m+).



NOTES

1) ASSUMES C = O

2) ASSUMES DISCONTINUITYES DIP INTO WALL AND THAT OVERALL OR LOCAL WALL STRIKE AND DISCONTINUITY STRIKE DO NOT DIFFER BY MORE THAN ± 20°

FIGURE 12. KINEMATIC CONDITIONS FOR TOPPLING

The approach to overburden analysis adopted in this study was to use the slope stability charts for circular failure developed by Hoek and Bray.[3] These charts enable a check to be made on the factor of safety of a slope or upon the sensitivity of the factor of safety to change in groundwater conditions or slope profile.

The following assumptions were used in the analysis:

1. The overburden is assumed to be homogeneous, i.e., its mechanical properties do not vary with direction of loading.
2. Shear strength properties are defined by the equation $\tau = C + \sigma \tan \phi$.
3. Failure occurs on a circular failure plane which passes through the toe of the overburden slope.
4. A tension crack is assumed to occur in the upper surface of the slope.

The parameters used in the circular failure analysis are:

Case 1:

H = 30 m = 98 ft.
γ = 120 lb./ft.^{3}
C = 720 lb./ft.^{2}
ϕ = 30°

Surface water source 200 ft. behind the toe of the slope.

Use Chart No. 4 - Figure 14.

$$\frac{C}{\gamma H \cdot \tan\phi} = 0.106$$

∴ from chart for a 32° slope

$$\frac{C}{\gamma HF} = 0.048$$

$$F = 1.28$$

If completely saturated, the slope can stand at 28°. If fully drained, the slope can stand at 36°.

Case 2:

$H = 50$ ft.
$\gamma = 120$ lb./ft.^{3}
$C = 720$ lb./ft.^{3}
$\phi = 30°$

Surface water source 200 ft. behind the toe of the slope.

Use Chart No. 3 - Figure 13

$$\frac{C}{\gamma H \cdot \tan\phi} = 0.208$$

∴ from chart for a 36° slope

$$\frac{C}{\gamma HF} = 0.076$$

$$F = 1.6$$

If completely staurated, the slope can stand at 34°. If fully drained, the slope can stand at 40°.

The circular analysis indicates that for a partially saturated overburden slope 100 ft. high, the slope should be designed at 32°. For an overburden slope partially saturated but only 50 ft. high, a 36° slope would be stable. The slope angles will increase or decrease, as indicated in Table 4, if the slope is fully drained or completely saturated.

TABLE 4

OVERBURDEN SLOPE ANGLES

Height (Feet)	Groundwater Conditions	Slope Angle
100	Completely Saturated	28°
100	Partially Saturated	32°
100	Fully Drained	36°
50	Completely Saturated	34°
50	Partially Saturated	36°
50	Fully Drained	40°

FIGURE 13

CIRCULAR FAILURE CHART NUMBER 3

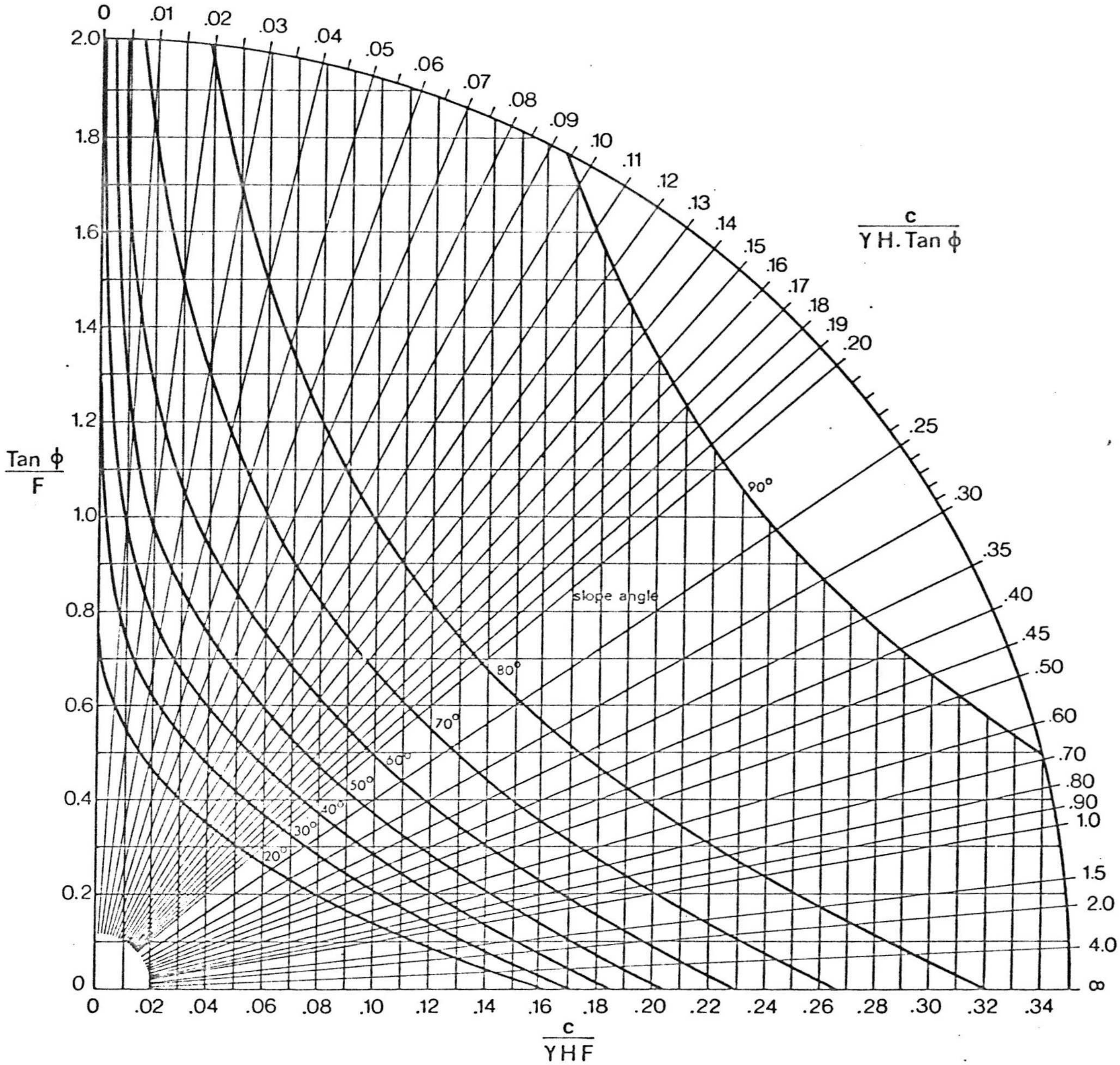


FIGURE 14

CIRCULAR FAILURE CHART NUMBER 4

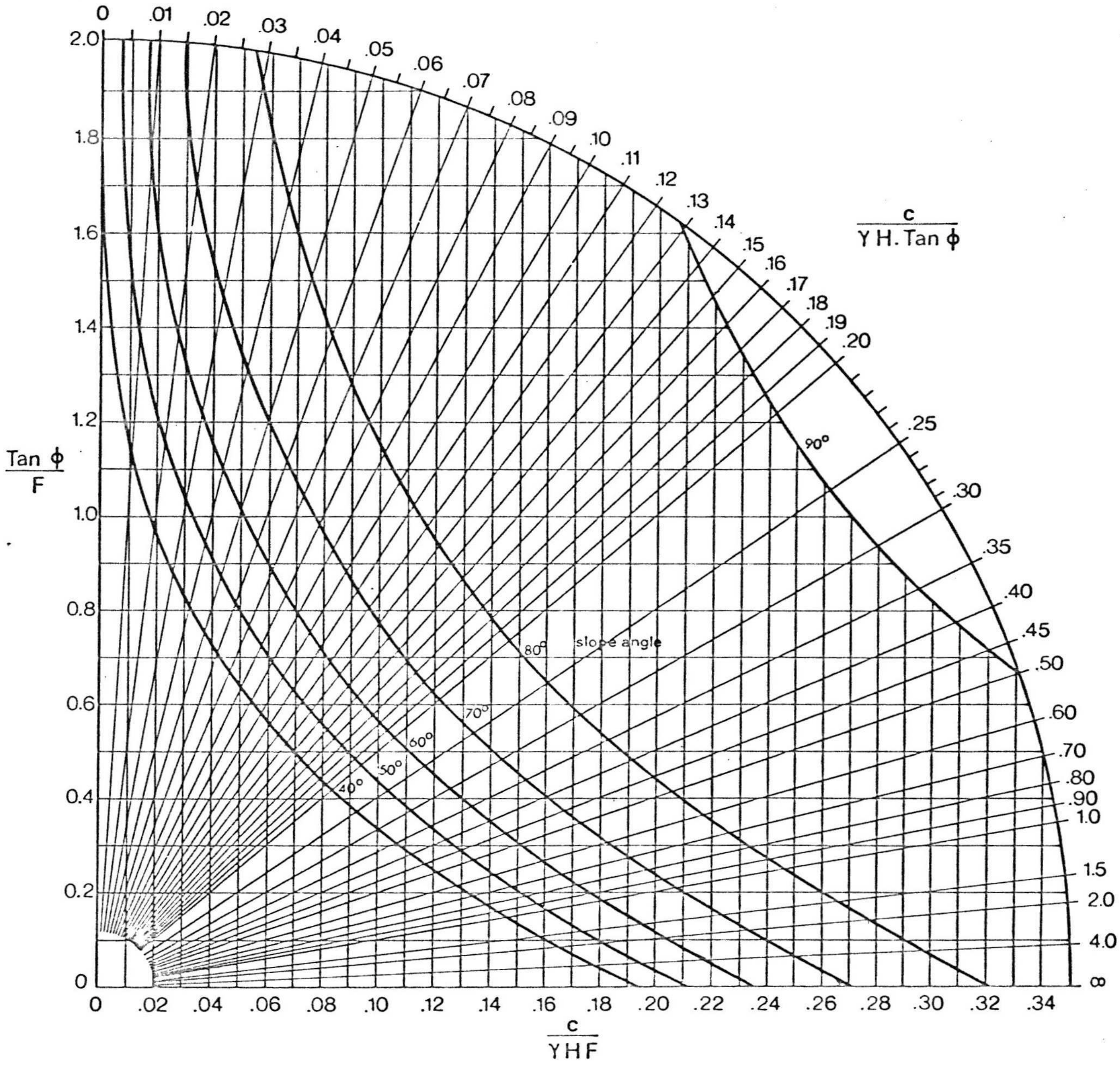


Figure 14

5.5 DESIGN CHARTS:

Design charts have been produced for both overall slope stability and bench stability. The effect of varying the input parameters in the stability analysis is reflected in the design charts. Cohesion is the parameter whose dispersion is the most influential in the analysis with water pressure and slope height affecting the critical slope angle to a lesser degree.

5.5.1 Overall Slope Design:

The design charts for the overall slope angles are only intended for use for designing rock slopes. The overburden portion of any pit wall must be designed separately. Figures 15 thru 20 are design charts for Design Sector A. No design charts were produced for Design Sector B. The parameters used in each design chart are as follows:

Figure 15:

Phase 2
Slope Height H = 200 ft.
Cohesion C = 6 p.s.i. (low cohesion)
Friction Angle ϕ = 25° for Failure Planes β = 27° and 32°

Assuming the low cohesion, flattening the slope has only a gradual effect on the factor of safety. A dry slope at 37° - 38° would be stable under these conditions.

Figure 16:

Phase 3
Slope Height H = 315 ft.
Cohesion C = 6 p.s.i.
Friction Angle ϕ = 21° for β = 23° and ϕ = 25° for β = 27.5°

The slope is not judged stable under these conditions. In this analysis only the weight component, W, was altered by the reduction in slope angle and because the uplift force of groundwater pressure was greater than the cohesive force, the factor of safety did not change significantly.

Figure 17:

Phase 2
H = 200 ft.
C = 10 p.s.i.
ϕ = 25°
β = 27° and 32°

The slope is stable at 38° under wet conditions and at 42° under dry conditions. This chart well illustrates the stability advantage gained by slope dewatering.

Figure 18:

Phase 3
H = 315 ft.
C = 10 p.s.i.
ϕ = 21° and 25°
β = 23° and 27.5°

Only a dry slope at 39° slope angle would have an adequate factor of safety at this slope height and low-moderate cohesion.

Figure 19:

Phase 2
H = 200 ft.
C = 20 p.s.i. (high cohesion)
ϕ = 25°
β = 27° and 32°

This chart best illustrates the large increase in factor of safety when a relatively high cohesion value is used in the analysis. Slopes under these conditions should stand at +45°.

Figure 20:

Phase 3
H = 315 ft.
C = 20 p.s.i.
ϕ = 21° and 25°
β = 23° and 27.5°

With good cohesion, this slope will be safe at 38° - 40° slope angle even under wet conditions. Dewatering can increase the safe slope angle to 43°+.

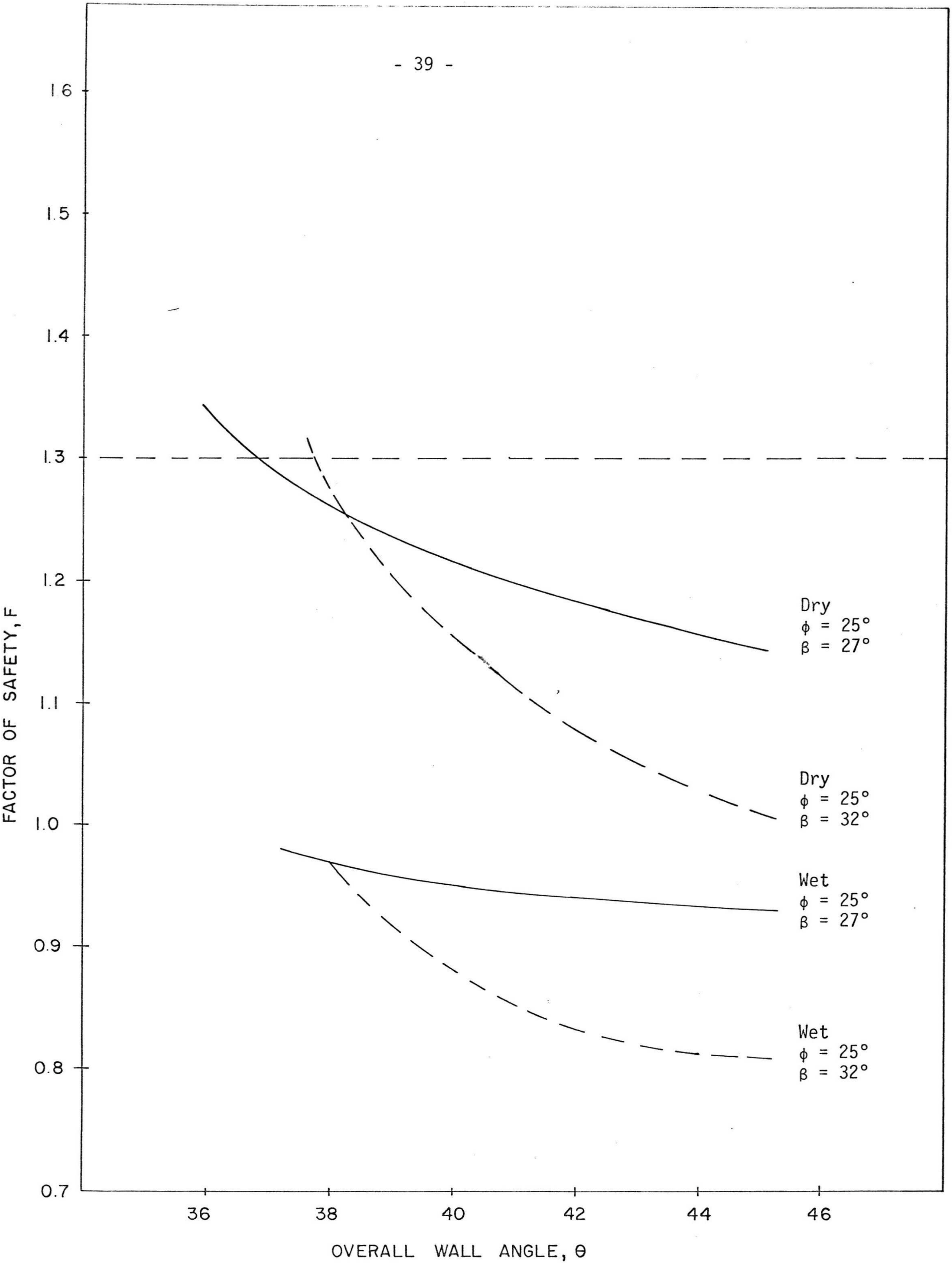


Fig. 15 Stability Analysis for Design Sector A
Phase 2 H = 200 ft. Cohesion = 6 p.s.i.

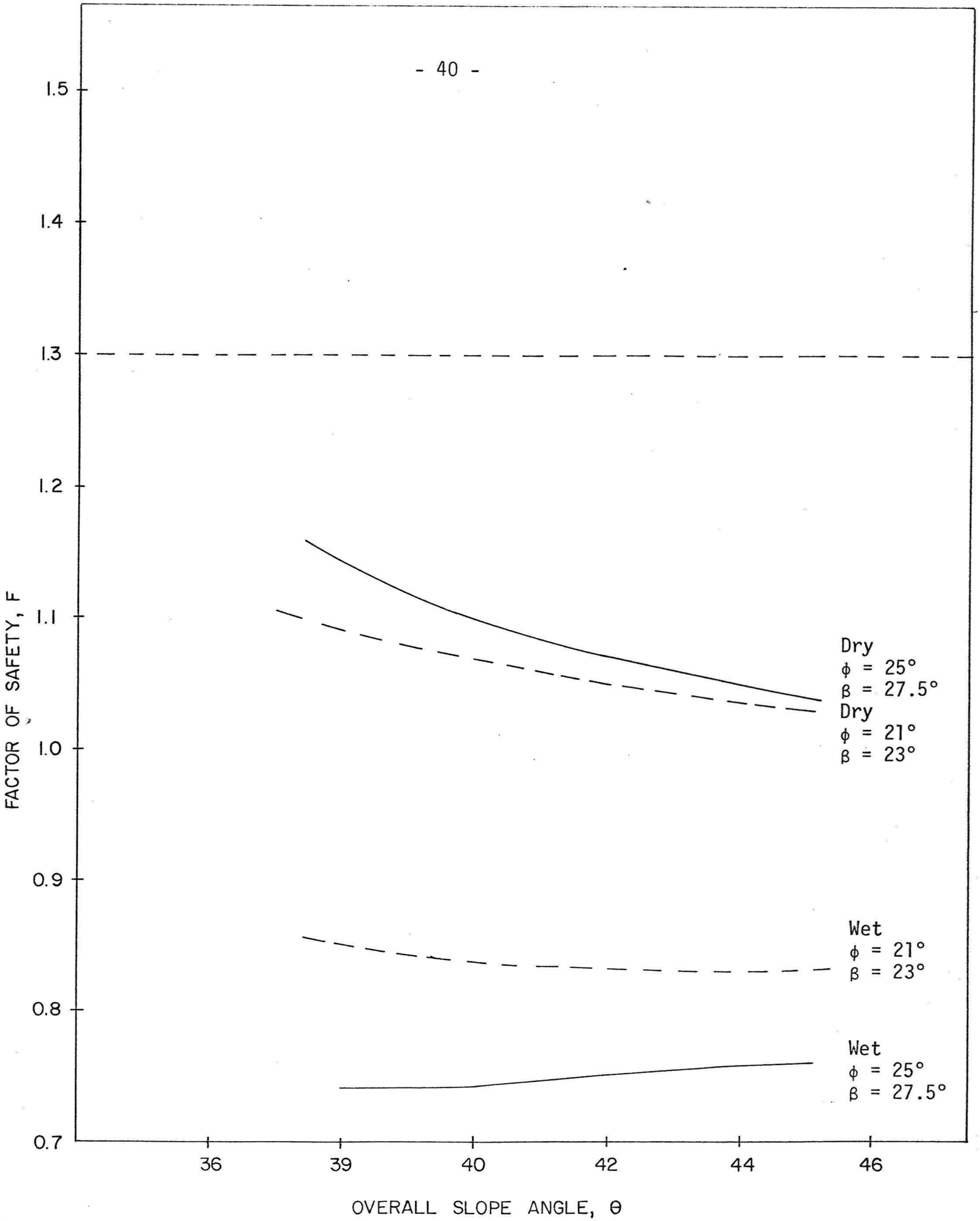


Fig. 16 Stability Analysis for Design Sector A
Phase 3 Pit H = 315 ft. Cohesion = 6 p.s.i.

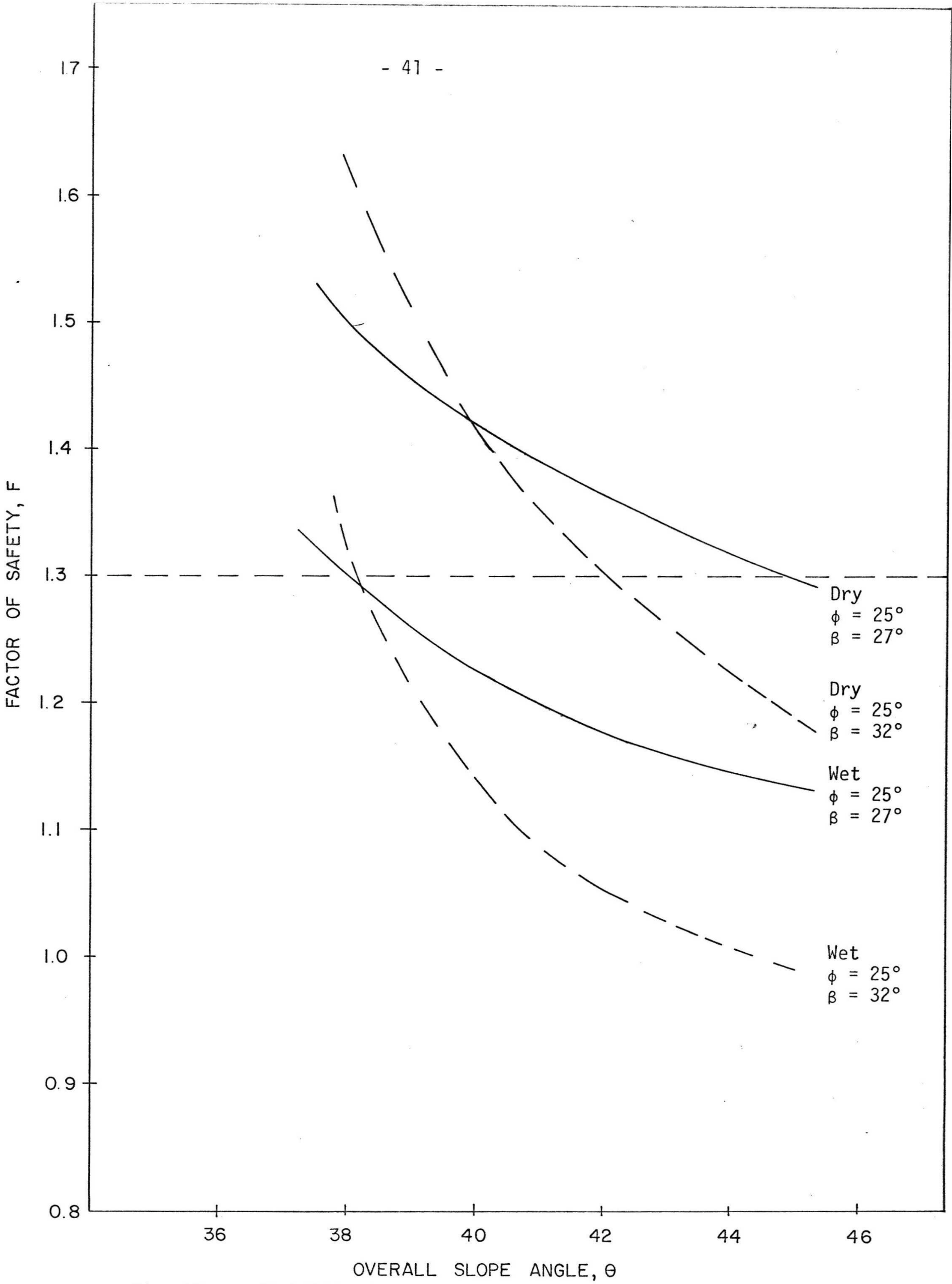


Fig. 17 Stability Analysis for Design Sector A
Phase 2 H = 200 ft. Cohesion = 10 p.s.i.

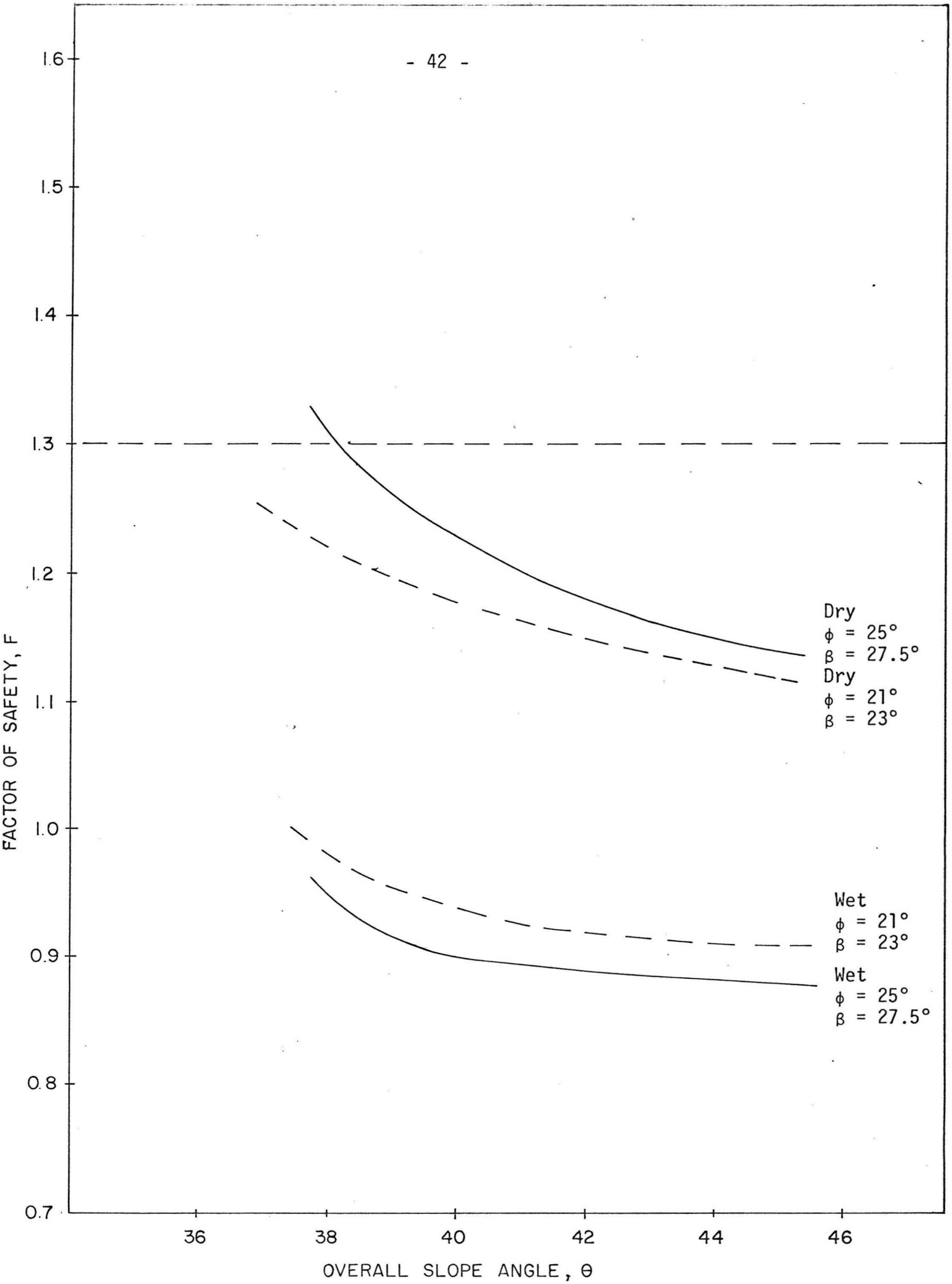


Fig. 18 Stability Analysis for Design Sector A
Phase 3 Pit H = 315 ft. Cohesion = 10 p.s.i.

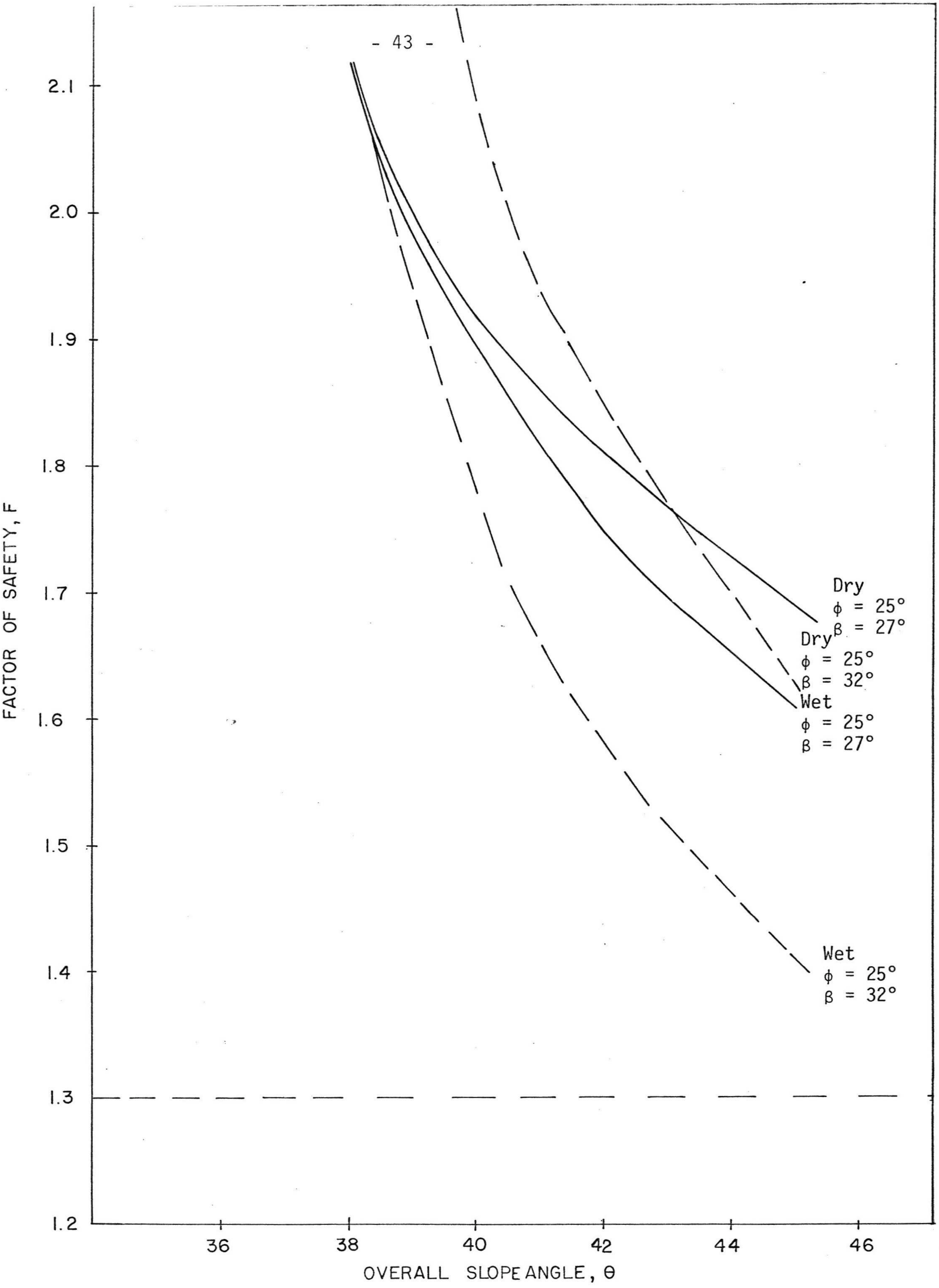


Fig. 19 Stability Analysis for Design Sector A
Phase 2 H = 200 ft. Cohesion = 20 p.s.i.

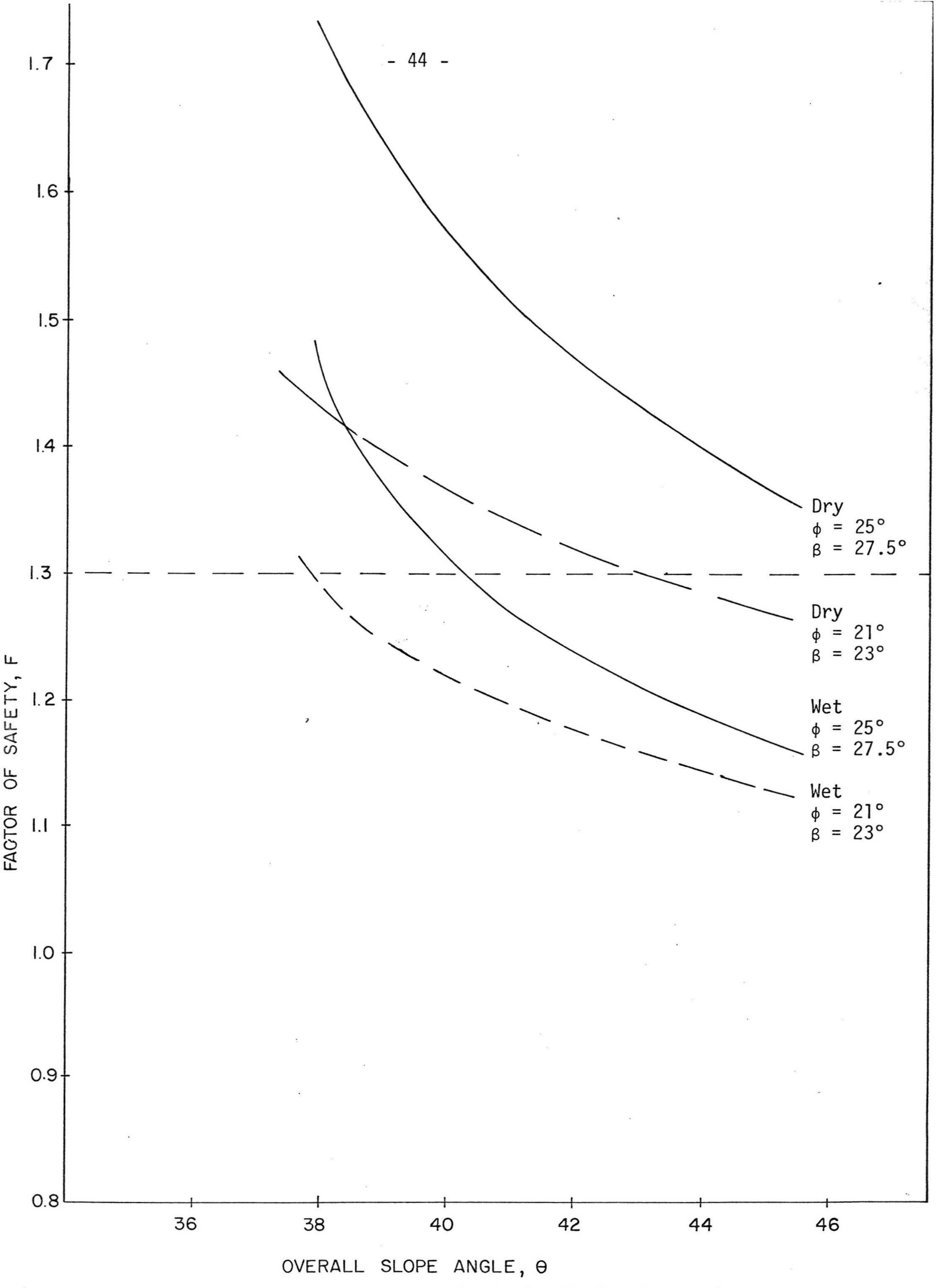


Fig. 20 Stability Analysis for Design Sector A
Phase 3 H = 315 ft. Cohesion = 20 p.s.i.

5.5.2 Bench Design:

Stability analyses for bench design were carried out using the same approach as for overall slope design. The main possible modes of bench failure are plane failure on foliation or joints, wedge failure involving a combination of joints, faults and foliation, and toppling failure on steeply dipping joints or faults.

At the Faro open pit the main type of bench failure is plane or wedge failure involving joints. No joint data is yet available for the Vangorda deposit so the bench failure analysis was done by analyzing plane failure on foliation.

For purposes of bench design, the following parameters were used:

1. Using the design sections, Figures 1-4, three relatively steep foliation dips were chosen for bench stability analysis, i.e., 47°, 40° and 36°.

2. A low effective cohesion of 6 p.s.i. was used because of effects of blasting damage.

3. High groundwater conditions were not assumed in the analysis because benches are generally well drained due to an increased amount of open fractures as a result of blasting and unloading. Normal groundwater (water break-out point is at toe of bench) and dry conditions were used.

4. A factor of safety of 1.2 should be the minimum for bench design.

5. Batter face angles of 60°, 65° and 70° were used in the analysis.

Figures 21-23 are the charts for bench design. In most cases the bench height can exceed 40 ft. and stability is retained up to a bench height of 55 ft.

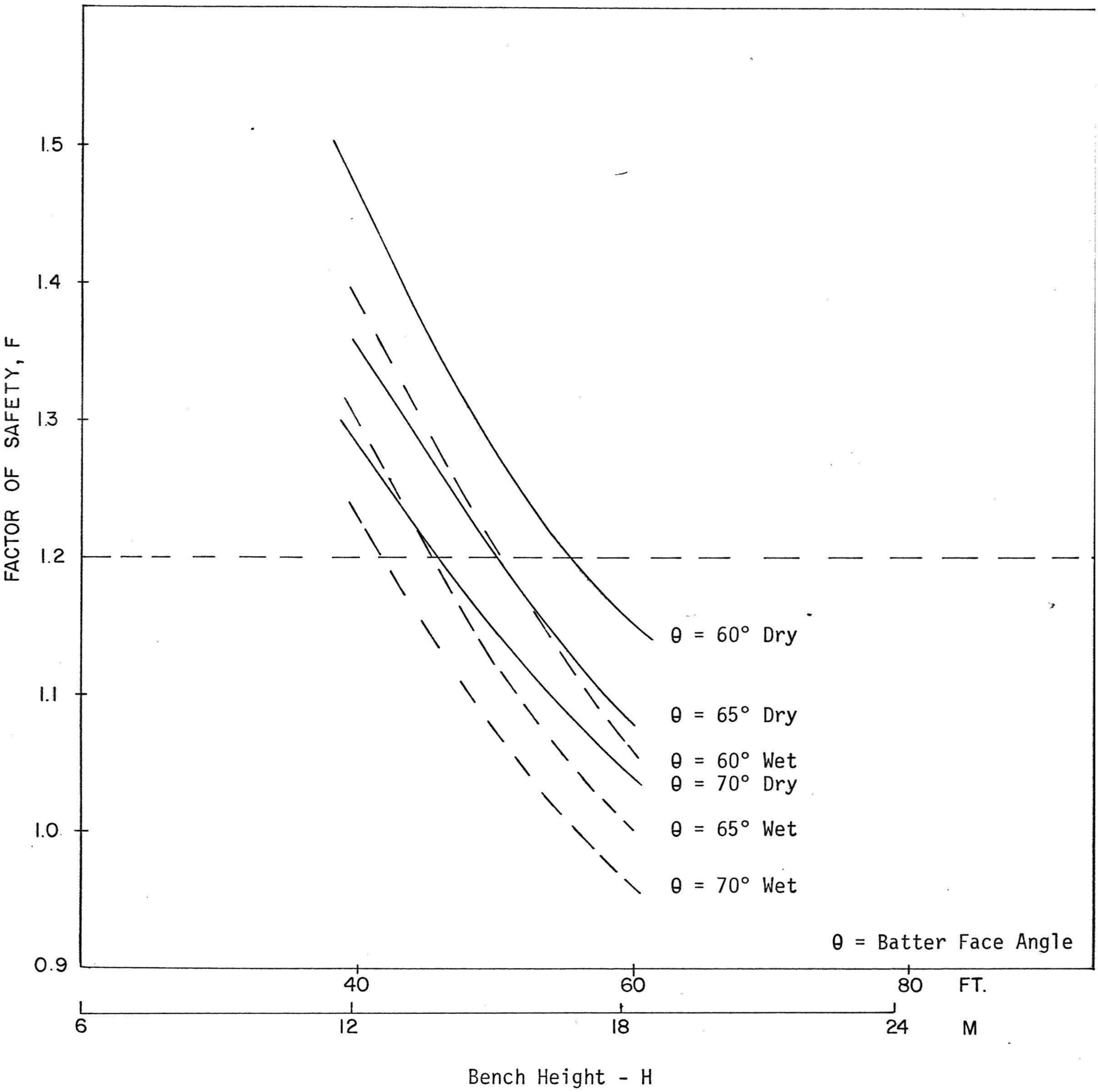


Fig. 21 Plane Failure on Foliation - Foliation Dip 36°

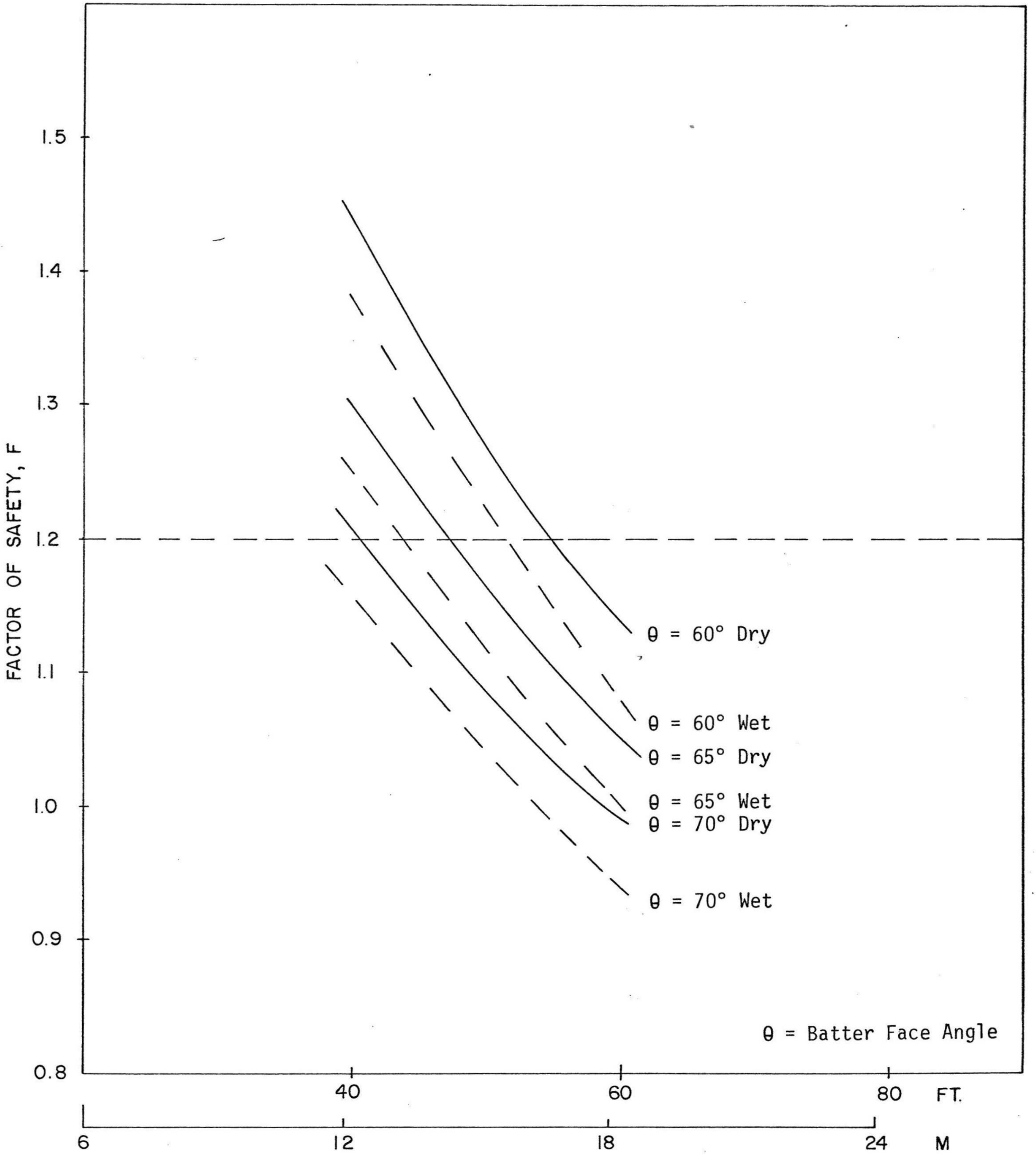
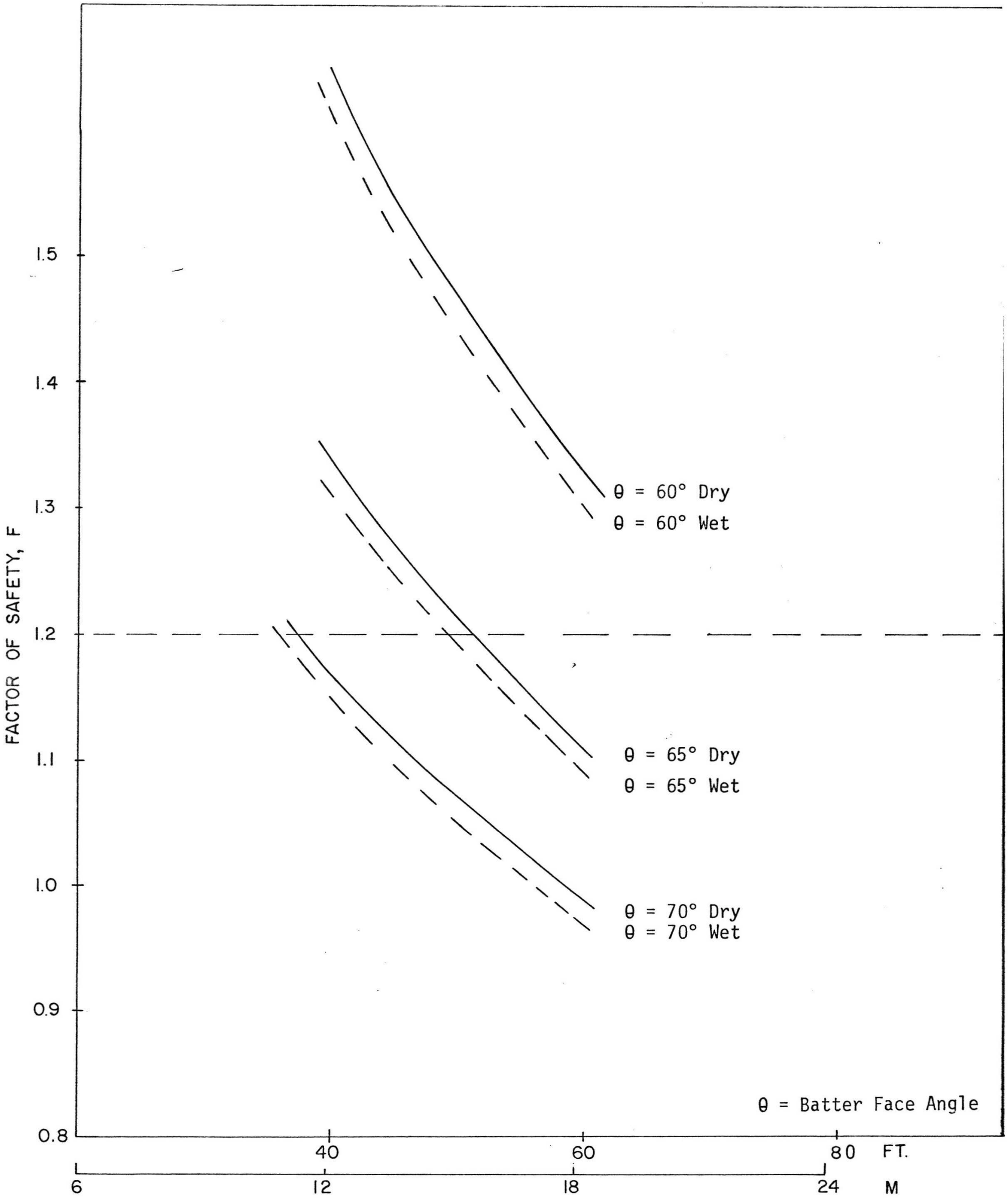


Fig. 22 Plane Failure on Foliation - Foliation Dip 40°



Bench Height - H

Fig. 23 Plane Failure on Foliation - Foliation Dip 47°

SECTION 6 - RECOMMENDATIONS

This study was carried out for the purpose of providing recommendations on geotechnical factors affecting the design of the proposed Vangorda open pit.

6.1 SLOPE DESIGN:

Foliation is considered to be the most prominent discontinuity affecting slope stability. Whenever foliation dips toward the pit it constitutes a major discontinuity set along which instability may develop. On the N.E. wall of the proposed pit the foliation dips into the pit, establishing this as the most critical area. Emphasis was placed on the analysis of plane failure on foliation as the potential failure mode on the N.E. wall.

Unless major discontinuities (faults and joints) are found dipping into the S.W. side of the pit, stability of the S.W. wall is expected to be good.

The recommended slope design angles are summarized in the following table:

TABLE 5

RECOMMENDED SLOPE DESIGN PARAMETERS

Design Sector	Recommended Overall* Slope Angle	Bench Design	
		Batter Face Angle	Bench Height
A	40°	70°	12 m
		60°	17 m
B	45°	65°-70°	12-24 m

* Overall Slope Angle is from top pit crest in rock to pit bottom toe with benches but not including haul roads in Design Sector A. Assumes Phase 3 Pit, Slope Height - 100 m, Cohesion - 20 p.s.i. The slope angles do not assume a fully dewatered slope.

The overburden slopes should be designed at 32°-36° depending on slope height. See Table 4 for details, Section 5.4.4.

6.2 STRUCTURAL GEOLOGY:

The structural geology investigation for this study basically concentrated on S2 foliation measurements. The S2 measurements were obtained from unoriented drill core and only an average strike direction was assumed for all foliation in the Vangorda Deposit. The lack of knowledge of the amount of deviation from this average orientation is a limiting factor in the accuracy of the stability analysis. If the drill core could be oriented when future drilling is done, important knowledge would be gained on discontinuity orientations.

Fault and joint orientations have not been measured on the Vangorda drill core. Several major faults have been inferred but the nature, extent and relative significance of these faults on the stability of the pit slopes are not well known.

Geologic structural mapping should be carried out as mining procedes. Line mapping techniques on the bench faces should be used to obtain information for a continually updated geologic structural map. Definition of joint sets and confirmation of foliation strike and dip on the N.E. wall are particularly important.

New structural information will be used in a re-evaluation of the initial slope stability analysis.

6.3 DEWATERING:

The stability analysis clearly illustrates that a reduction in groundwater pressures can increase slope stability significantly. The recommended slope angles in Table 5 did not assume a fully dewatered pit wall but analysis should be done, when more groundwater data is available, to determine if there is a significant cost benefit to dewatering the Vangorda pit.

More piezometers are needed in the vicinity of the pit limits to monitor groundwater pressures during mining and to assess the performance of any dewatering systems that may be introduced.

Limited groundwater data collected to date indicates the possibility of high groundwater pressures in the pit area. This possibility must be investigated, especially in the N.E. wall.

Pump tests may prove valuable to define the viability of dewatering ore and/or waste. This option will become easier to assess after pump testing has been performed on the Faro deposit.

All surface drainage should be diverted away from the pit so that water does not seep in behind the pit walls or drain into the pit. Room should be left on benches at the overburden-bedrock contact to allow for collector ditches.

6.4 CONTROL BLASTING:

Control blasting techniques should be tested when mine production begins. If successful, control blasting will increase the stability of the slope, especially the bench stability. Control blasting can reduce the loss of cohesion on joint and foliation surfaces and this is very important because cohesion is the most significant variable in the slope stability analysis. The recommended overall slope angle assumes a relatively high cohesion of 20 p.s.i. and control blasting will be necessary to maintain this cohesion. Experience gained at the Faro Deposit will, hopefully, define a successful control blasting system.

6.5 SLOPE MONITORING:

All slopes should be monitored as mining progresses to detect slope displacements before they become critical. An initial monitoring phase using surveying techniques will be adequate unless serious instabilities start to develop.

Monitoring will take place during the mine operating stage but advanced planning is necessary during the mine design stage to decide the nature and location of monitors.

6.6 FUTURE CONSIDERATIONS:

All the above recommendations have been brief, but extensive studies, not intended in the scope of this report, should be conducted on groundwater, blasting and monitoring control.

During the feasibility stage the following geotechnical work should be considered:

1. Diamond drilling located in the area of the proposed pit limits. The drillholes could be used for core orientation, groundwater investigation, structural interpretation and overburden depth.

2. Confirm the location of Vangorda Creek diversion and investigate the possibilities of lining the ditch.

3. Determine the nature and extent of the overburden in the pit area.

REFERENCES

1 Piteau, D. R. and Russell, L., "Cumulative Sums Technique: A New Approach to Analyzing Joints in Rocks," Stability of Rock Slopes - 13th. Symposium on Rock Mechanics, 1971

2 Piteau, Gadsby, Macleod Ltd., "Slope Stability Analysis and Design of the Open Pit Slopes," consulting report for Cyprus Anvil Mining Corporation, January, 1976

3 Hoek, E. and Bray, J. W., "Rock Slope Engineering," Revised Second Edition, the Inst. of Min. and Met., London, 1977

4 Montreal Engineering Co. Ltd., "Grum Deposit Phase Two Geotechnical Studies," consulting report for Cyprus Anvil Mining Corporation, December, 1979

Appendix A

APPENDIX A

STRUCTURAL DATA AND CUMULATIVE SUMS

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ANALYSED STRUCTURAL DATA FOR DDH: V-15-H
****************************************
DOWN-HOLE     TRUE   -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP   CUMULATIVE
  DEPTH      DEPTH   EASTING NORTHING                CA   DDIR     DIP  DDIR     DIP  DDIR    USED         SUM

   10.1       10.1      0.       0.    C             70.  220.     20.  220.      0.    0.     20.        -5.24
   14.0       14.0      0.      -.1    C             75.  220.     15.  220.      0.    0.     15.       -15.48
   17.4       17.4      0.      -.1    C      Z      69.  220.     22.  220.     20.   40.     22.       -18.72
   21.0       21.0       .1     -.1    C             50.  220.     41.  220.     39.   40.     41.        -2.97
   22.6       22.6       .1     -.2    C             23.  220.     68.  220.     66.   40.     68.        39.79
   24.4       24.4       .1     -.2    C             30.  220.     61.  220.     59.   40.     61.        75.55
   27.1       27.1       .1     -.2    C      S      48.  220.     43.  220.     41.   40.     43.        93.31
   28.9       28.9       .1     -.3    C      M      50.  220.     41.  220.     39.   40.     41.       109.07
   31.7       31.7       .2     -.3    C             70.  220.     21.  220.     19.   40.     21.       104.83
   35.1       35.1       .3     -.4    C             77.  220.     14.  220.     12.   40.     14.        93.59
   38.3       38.3       .3     -.4    C      S      75.  220.     17.  220.     13.   40.     17.        85.34
   41.8       41.8       .4     -.5                  40.  220.     52.  220.     48.   40.     52.       112.10
   47.9       47.9       .6     -.5    P             49.  220.     43.  220.     39.   40.     43.       129.86
   50.9       50.9       .7     -.6                  65.  220.     27.  220.     23.   40.     27.       131.62
   52.4       52.4       .8     -.6           R      60.  220.     32.  220.     28.   40.     32.       138.38
   57.0       57.0       .9     -.6                  70.  220.     21.  220.     18.   40.     21.       134.14
   63.1       63.1      1.2     -.6                  70.  220.     21.  220.     18.   40.     21.       129.90
   69.2       69.2      1.5     -.7                  72.  220.     19.  220.     17.   40.     19.       123.66
   72.2       72.2      1.6     -.7                  85.  220.      0.    0.      0.    0.    *** NO VALUES USED
   78.3       78.3      1.9     -.7                  75.  220.     16.  220.     14.   40.     16.       114.41
   81.4       81.4      2.0     -.8                  80.  220.     10.  220.      0.    0.     10.        99.17
   88.1       88.1      2.3     -.8           R      82.  220.      8.  220.      0.    0.      8.        81.93
   90.5       90.5      2.4     -.9           Z      78.  220.     13.  220.     11.   40.     13.        69.69
   92.7       92.6      2.5     -.9                  73.  220.     18.  220.     16.   40.     18.        62.45
   99.7       99.6      2.8    -1.1                  78.  220.     13.  220.     11.   40.     13.        50.21
  105.8      105.7      3.2    -1.2                  75.  220.     15.  220.     14.   40.     15.        39.97
  108.8      108.7      3.4    -1.3                  75.  220.     15.  220.     13.   40.     15.        29.72
  114.9      114.8      3.8    -1.6                  73.  220.     17.  220.     16.   40.     17.        21.48
  121.0      120.9      4.3    -1.9                  74.  220.     15.  220.      0.    0.     15.        11.24
  124.1      124.0      4.5    -2.0           P      75.  220.     14.  220.      0.    0.     14.          .00
```

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ANALYSED STRUCTURAL DATA FOR DDH: V-28-R
****************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP   CUMULATIVE
  DEPTH      DEPTH   EASTING NORTHING              CA   DDIR     DIP  DDIR     DIP  DDIR     USED       SUM

   22.6       22.6      -.1       .7    C          73.  220.     19.  220.     15.   40.     19.       -9.63
   29.9       29.9      -.3      1.1    C          68.  220.     24.  220.     20.   40.     24.      -14.26
   35.7       35.6      -.5      1.6    C          69.  220.     23.  220.     18.   40.     23.      -19.89
   41.8       41.7      -.8      2.1    P          58.  220.     34.  220.     30.   40.     34.      -14.53
   48.0       47.9     -1.1      2.7    P          66.  220.     25.  220.     21.   40.     25.      -18.16
   54.1       53.9     -1.5      3.3    P          63.  220.     28.  220.     25.   40.     28.      -18.79
   60.0       59.8     -1.9      3.8    P          73.  220.     17.  220.     14.   40.     17.      -30.42
   66.1       65.9     -2.4      4.4    P          65.  220.     25.  220.     23.   40.     25.      -34.05
   72.8       72.5     -3.0      5.1          R    52.  220.     38.  220.     36.   40.     38.      -24.68
   78.9       78.5     -3.7      5.7    C          57.  220.     33.  220.     31.   40.     33.      -20.32
   84.7       84.2     -4.4      6.4    P          56.  220.     33.  220.     32.   40.     33.      -15.95
   89.2       88.7     -5.0      7.0          S    72.  220.     14.  220.      0.    0.     14.      -30.58
   95.1       94.5     -5.8      7.7    P          48.  220.     41.  220.      0.    0.     41.      -18.21
  101.2      100.4     -6.8      8.6    P          58.  220.     30.  220.      0.    0.     30.      -16.84
  107.6      106.6     -7.9      9.6    P          54.  220.     34.  220.     33.   40.     34.      -11.47
  113.7      112.6     -8.9     10.6    C          58.  220.     30.  220.     27.   40.     30.      -10.11
  119.8      118.4    -10.1     11.8    C          64.  220.     23.  220.     19.   40.     23.      -15.74
  126.5      124.9    -11.3     13.2          Z    50.  220.     40.  220.     34.   40.     40.       -4.37
  132.3      130.4    -12.4     14.5          M    56.  220.     33.  220.     27.   40.     33.         .00
```

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ANALYSED STRUCTURAL DATA FOR DDH: V-30-R
****************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP   CUMULATIVE
  DEPTH      DEPTH   EASTING NORTHING                CA  DDIR     DIP  DDIR     DIP  DDIR     USED        SUM
    17.4      17.4        .1      -.3   C             69.  220.     23.  220.     19.   40.      23.      -16.29
    21.6      21.6        .2      -.4        D        82.  220.     10.  220.      6.   40.      10.      -45.57
    27.7      27.7        .5      -.6   C             67.  220.     25.  220.     20.   40.      25.      -59.86
    33.8      33.8        .9      -.7   C             75.  220.     17.  220.     13.   40.      17.      -82.14
    39.0      39.0       1.2      -.8   C             70.  220.     21.  220.     18.   40.      21.     -100.43
    44.8      44.7       1.6      -.9   C             63.  220.     28.  220.     25.   40.      28.     -111.71
    49.7      49.6       1.9     -1.0        E        65.  220.     26.  220.     24.   40.      26.     -125.00
    54.9      54.8       2.2     -1.2   C             30.  220.     61.  220.     59.   40.      61.     -103.29
    62.5      62.4       2.5     -1.4        Z        61.  220.     29.  220.     28.   40.      29.     -113.57
    68.3      68.2       2.8     -1.5   P             54.  220.     36.  220.     35.   40.      36.     -116.86
    72.5      72.4       3.0     -1.6   P             58.  220.     33.  220.     31.   40.      33.     -123.14
    82.6      82.5       3.4     -1.7        P        52.  220.     40.  220.     36.   40.      40.     -122.43
    87.8      87.7       3.7     -1.7        Z        37.  220.     55.  220.     51.   40.      55.     -106.71
    93.6      93.5       4.0     -1.6   P             43.  220.     49.  220.     45.   40.      49.      -97.00
    98.8      98.7       4.2     -1.5   P             37.  220.     56.  220.     50.   40.      56.      -80.29
   105.2     105.1       4.5     -1.4   P             28.  220.     65.  220.     59.   40.      65.      -54.57
   111.3     111.2       4.7     -1.1   P              8.  220.     85.  220.     79.   40.      85.       -8.86
   117.8     117.6       4.9      -.8        R        39.  220.     54.  220.     48.   40.      54.        5.86
   121.9     121.7       4.9      -.6   P             61.  220.     32.  220.     26.   40.      32.       -1.43
   128.0     127.8       5.0      -.2   P             62.  220.     31.  220.     25.   40.      31.       -9.71
   133.2     133.0       5.0       .1   P             44.  220.     49.  220.     43.   40.      49.         .00
```

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ANALYSED STRUCTURAL DATA FOR DDH: V-35-R
****************************************
DOWN-HOLE    TRUE   -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP   CUMULATIVE
  DEPTH      DEPTH   EASTING NORTHING              CA   DDIR     DIP  DDIR     DIP  DDIR     USED        SUM

   19.2       19.2      0.        .4   C    Z       63.  220.     29.  220.     25.   40.     29.        8.60
   23.5       23.5       .1       .5   P            70.  220.     22.  220.     18.   40.     22.       10.20
   27.4       27.4       .1       .7   P    R       80.  220.     13.  220.      7.   40.     13.        2.80
   32.9       32.9       .2      1.0   P    M       83.  220.     10.  220.      4.   40.     10.       -7.60
   35.7       35.7       .2      1.2   C            70.  220.     23.  220.     16.   40.     23.       -5.00
   38.7       38.7       .3      1.4   C    7       75.  220.     19.  220.     11.   40.     19.       -6.40
   42.1       42.1       .3      1.7   C    Z       80.  220.     14.  220.      6.   40.     14.      -12.80
   46.9       46.8       .5      2.1                70.  220.     25.  220.     15.   40.     25.       -8.20
   52.1       52.0       .6      2.5                75.  220.     19.  220.     10.   40.     19.       -9.60
   60.4       60.3       .9      3.1                60.  220.     35.  220.     25.   40.     35.        5.00
   69.2       69.1      1.2      3.7                85.  220.      9.  210.      1.   30.    *** NO VALUES USED
   75.0       74.8      1.4      4.1                80.  220.     14.  220.      6.   40.     14.       -1.40
   80.9       80.7      1.7      4.5        R       78.  220.     16.  220.      8.   40.     16.       -5.80
   82.0       81.8      1.7      4.5   P    D       80.  220.     14.  220.      6.   40.     14.      -12.20
   82.9       82.7      1.8      4.6   P    S       83.  220.     11.  220.      3.   40.     11.      -21.60
   86.3       86.1      1.9      4.8   P    Z       75.  220.     20.  220.     10.   40.     20.      -22.00
   88.9       88.7      2.1      5.0   P    R       85.  220.     10.  217.      0.   37.    *** NO VALUES USED
   92.4       92.2      2.2      5.2   P    H       80.  220.     15.  220.      5.   40.     15.      -27.40
   96.6       96.4      2.5      5.5   P            85.  220.     10.  220.      0.   40.     10.      -37.80
  100.2      100.0      2.7      5.7   P    R       70.  220.     25.  220.     15.   40.     25.      -33.20
  105.8      105.5      3.0      6.1   P            70.  220.     25.  220.     15.   40.     25.      -28.60
  111.9      111.6      3.4      6.5   C    S       70.  220.     26.  220.     14.   40.     26.      -23.00
  118.0      117.7      3.9      6.9   P            65.  220.     31.  220.     19.   40.     31.      -12.40
  120.7      120.4      4.1      7.1   P            65.  220.     31.  220.     19.   40.     31.       -1.80
  127.1      126.7      4.8      7.5   P            70.  220.     26.  220.     13.   40.     26.        3.80
  130.1      129.7      5.1      7.6   P            72.  220.     24.  220.     11.   40.     24.        7.40
  138.4      137.9      6.2      8.1   P            70.  220.     26.  220.     13.   40.     26.       13.00
  145.4      144.8      7.1      8.4   P            82.  220.      1.  220.     14.  220.     14.        6.60
  148.4      147.8      7.6      8.5   P            84.  220.      4.  220.     11.  220.     11.       -2.80
  151.5      150.9      8.0      8.6   P            85.  220.      4.  256.     14.  256.    *** NO VALUES USED
  160.6      159.9      9.5      8.9   P            80.  220.     16.  220.      1.   40.     16.       -7.20
  166.7      165.9     10.5      9.1   P            75.  220.     21.  220.      6.   40.     21.       -6.60
  171.3      170.4     11.3      9.2   P    P       70.  220.     27.  220.     11.   40.     27.         .00
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ANALYSED STRUCTURAL DATA FOR DDH: V-47-R
*****************************************
DOWN-HOLE     TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2    CONVERSION-1  CONVERSION-2    S2-DIP    CUMULATIVE
  DEPTH      DEPTH    EASTING NORTHING               CA   DDIR       DIP  DDIR     DIP  DDIR     USED        SUM

   34.1       34.1        .1       .4    P            20.  220.      71.  220.     69.   40.      71.        46.61
   36.3       36.3        .1       .4    P            35.  220.      56.  220.     54.   40.      56.        78.21
   40.5       40.5        .2       .5    P      Z     60.  220.      32.  220.     28.   40.      32.        85.82
   45.1       45.1        .3       .7                 70.  220.      22.  220.     18.   40.      22.        83.43
   51.2       51.2        .4       .8                 73.  220.      19.  220.     15.   40.      19.        78.04
   54.3       54.3        .5       .9                 70.  220.      22.  220.     18.   40.      22.        75.64
   60.4       60.4        .6      1.1                 75.  220.      17.  220.     13.   40.      17.        68.25
   63.4       63.4        .7      1.1                 83.  220.       9.  220.      5.   40.       9.        52.86
   71.9       71.9        .8      1.4                 70.  220.      22.  220.     18.   40.      22.        50.46
   78.6       78.6       1.0      1.5                 75.  220.      17.  220.     13.   40.      17.        43.07
   84.7       84.7       1.1      1.6                 80.  220.      12.  220.      8.   40.      12.        30.68
   90.8       90.8       1.3      1.7                 80.  220.      12.  220.      8.   40.      12.        18.29
   93.3       93.3       1.4      1.8                 80.  220.      12.  220.      8.   40.      12.         5.89
   96.4       96.4       1.5      1.8    C      S     80.  220.      11.  220.      8.   40.      11.        -7.50
  101.0      101.0       1.6      1.8    C      M     75.  220.      16.  220.     14.   40.      16.       -15.89
  106.1      106.1       1.8      1.8    C            80.  220.      12.  220.      8.   40.      12.       -28.29
  109.1      109.1       2.0      1.8    C            70.  220.      22.  220.     18.   40.      22.       -30.68
  112.2      112.2       2.1      1.9    C            70.  220.      23.  220.     17.   40.      23.       -32.07
  118.9      118.8       2.5      2.0    C            80.  220.      13.  220.      6.   40.      13.       -43.46
  124.4      124.3       3.0      2.1    C      M     80.  220.      14.  220.      5.   40.      14.       -53.86
  130.5      130.4       3.5      2.2    C      S     53.  220.      42.  220.     32.   40.      42.       -36.25
  136.6      136.4       4.2      2.3    P            80.  220.      14.  220.      4.   40.      14.       -46.64
  139.6      139.4       4.6      2.4    P            65.  220.      30.  220.     19.   40.      30.       -41.04
  142.6      142.4       5.0      2.4    P            64.  220.      31.  220.     20.   40.      31.       -34.43
  148.4      148.1       5.8      2.5    P            70.  220.      25.  220.     13.   40.      25.       -33.82
  151.8      151.5       6.3      2.6    P      P     85.  220.       3.  263.     13.  263.     *** NO VALUES USED
  154.5      154.2       6.7      2.6    P      S     70.  220.      25.  220.     13.   40.      25.       -33.21
  160.9      160.5       7.6      2.7    P            50.  220.      46.  220.     33.   40.      46.       -11.61
  176.8      176.2      10.1      3.0                 60.  220.      36.  220.     23.   40.      36.          .00
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ANALYSED STRUCTURAL DATA FOR DDH: V-49-R
****************************************
DOWN-HOLE     TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2    CONVERSION-1   CONVERSION-2    S2-DIP    CUMULATIVE
 DEPTH       DEPTH    EASTING NORTHING                CA   DDIR     DIP  DDIR      DIP  DDIR      USED         SUM

  41.5        41.5         .9      1.4   P            68.  220.     27.  220.      17.   40.      27.          -.31
  46.6        46.5        1.2      1.7   P            55.  220.     40.  220.      30.   40.      40.         12.39
  50.9        50.8        1.5      1.9   P            82.  220.     13.  220.       3.   40.      13.         -1.92
  53.9        53.8        1.7      2.0                82.  220.     13.  220.       3.   40.      13.        -16.22
  57.0        56.9        1.9      2.2                74.  220.     21.  220.      11.   40.      21.        -22.53
  63.1        63.0        2.4      2.5                68.  220.     27.  220.      17.   40.      27.        -22.83
  68.9        68.7        2.9      2.8                75.  220.     20.  220.       9.   40.      20.        -30.14
  71.9        71.7        3.1      3.0                82.  220.     13.  220.       2.   40.      13.        -44.44
  75.1        74.9        3.4      3.1                70.  220.     25.  220.      14.   40.      25.        -46.75
  79.2        79.0        3.8      3.3                55.  220.     40.  220.      29.   40.      40.        -34.06
  80.8        80.6        3.9      3.4                80.  220.     15.  220.       4.   40.      15.        -46.36
  84.1        83.9        4.2      3.6                50.  220.     46.  220.      34.   40.      46.        -27.67
  87.5        87.2        4.6      3.7   P     R      35.  220.     61.  220.      49.   40.      61.          6.03
  89.3        89.0        4.8      3.6   P            43.  220.     53.  220.      41.   40.      53.         31.72
  92.0        91.7        5.0      3.9   P     Z      55.  220.     41.  220.      29.   40.      41.         45.42
  96.3        96.0        5.5      4.1   P            45.  220.     51.  220.      39.   40.      51.         69.11
  99.1        98.8        5.8      4.2   P            75.  220.     20.  220.       9.   40.      20.         61.81
 102.1       101.7        6.2      4.3   P            65.  220.     31.  220.      19.   40.      31.         65.50
 105.2       104.8        6.5      4.4   P            67.  220.     29.  220.      16.   40.      29.         67.19
 106.7       106.3        6.7      4.5   P     R      65.  220.     31.  220.      18.   40.      31.         70.89
 111.3       110.9        7.3      4.7   P     S      65.  220.     31.  220.      18.   40.      31.         74.58
 114.6       114.1        7.8      4.8   P            68.  220.     28.  220.      15.   40.      28.         75.28
 117.7       117.2        8.2      4.9   P            80.  220.     16.  220.       1.   40.      16.         63.97
 119.2       118.7        8.4      5.0   P     R      77.  220.     19.  220.       5.   40.      19.         55.67
 123.9       123.3        9.2      5.2   P     R      74.  220.     23.  220.       7.   40.      23.         51.36
 126.9       126.3        9.7      5.3   P            68.  220.     29.  220.      13.   40.      29.         53.06
 128.8       128.1       10.0      5.3   C     S      70.  220.     27.  220.      11.   40.      27.         52.75
 132.9       132.2       10.7      5.5   P     R      76.  220.     21.  220.       4.   40.      21.         46.44
 134.1       133.4       10.9      5.5   C     S      70.  220.     27.  220.      11.   40.      27.         46.14
 138.7       137.9       11.8      5.7         R      80.  220.      2.  220.      15.  220.      15.         33.83
 139.3       138.5       11.9      5.7         S      77.  220.     19.  220.       2.   40.      19.         25.53
 141.7       140.8       12.4      5.8   P     Z      84.  220.      0.    0.       0.    0.     *** NO VALUES USED
 145.4       144.4       13.1      5.9                75.  220.     22.  220.       4.   40.      22.         20.22
 147.5       146.5       13.6      5.9         R      68.  220.     30.  220.      11.   40.      30.         22.92
 151.5       150.4       14.4      6.0   P            70.  220.     27.  220.       9.   40.      27.         22.61
 157.6       156.3       15.8      6.2                85.  220.      0.    0.       0.    0.     *** NO VALUES USED
 160.6       159.2       16.5      6.2                80.  220.      9.  220.      11.  220.      11.          6.31
 166.7       165.2       18.0      6.3         R      75.  220.     21.  220.       1.   40.      21.           .00
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ANALYSED STRUCTURAL DATA FOR DDH: V-63-R
****************************************
DOWN-HOLE     TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP    CUMULATIVE
 DEPTH       .DEPTH   EASTING NORTHING               CA   DDIR     DIP  DDIR     DIP  DDIR     USED        SUM

   32.6       32.6        -.3       .3               55.  220.     35.  220.     35.   40.      35.         7.35
   41.8       41.8        -.6       .4               82.  220.      8.  220.      0.    0.       8.       -12.30
   66.1       66.1        -.5       .5    P    R     78.  220.     14.  220.     10.   40.      14.       -25.95
   69.2       69.2        -.4       .5    P    S     65.  220.     27.  220.     23.   40.      27.       -26.60
   70.1       70.1        -.4       .5    P    Z     68.  220.     24.  220.     19.   40.      24.       -30.25
   71.9       71.9        -.3       .6    P    S     60.  220.     33.  220.     27.   40.      33.       -24.90
   78.3       78.3        -.1       .7    P          70.  220.     23.  220.     16.   40.      23.       -29.55
   84.4       84.4         .2       .9    P    Z     68.  220.     26.  220.     18.   40.      26.       -31.20
   87.5       87.5         .3      1.0    P    Z     66.  220.     28.  220.     20.   40.      28.       -30.85
   92.0       92.0         .6      1.3    P          55.  220.     40.  220.     30.   40.      40.       -18.50
   98.5       98.4         .9      1.7    P    Z     60.  220.     35.  220.     25.   40.      35.       -11.15
  102.7      102.6        1.2      2.0    P    S     73.  220.     23.  220.     11.   40.      23.       -15.80
  106.1      106.0        1.6      2.2    P    D     60.  220.     36.  220.     24.   40.      36.        -7.45
  107.6      107.5        1.7      2.3    P    S     65.  220.     31.  220.     19.   40.      31.        -4.10
  110.6     .110.5        2.0      2.4    P    Z     67.  220.     29.  220.     16.   40.      29.        -2.75
  115.5      115.3        2.7      2.6    P          65.  220.     31.  220.     18.   40.      31.          .60
  118.6      118.4        3.1      2.7    P    Z     65.  220.     31.  220.     18.   40.      31.         3.95
  123.1      122.8        3.8      2.8    P          62.  220.     33.  220.     21.   40.      33.         9.30
  128.0      127.7        4.6      2.7    P          70.  220.     23.  220.     13.   40.      23.         4.65
  133.2      132.8        5.5      2.6    P    R     70.  220.     23.  220.     13.   40.      23.          .00
```

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ANALYSED STRUCTURAL DATA FOR DDH: V-094-R
*****************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP   CUMULATIVE
  DEPTH     DEPTH    EASTING NORTHING               CA   DDIR     DIP  DDIR     DIP  DDIR     USED       SUM

   25.5      25.5        .1        .3   P           75.  220.     15.  220.     14.   40.     16.       -7.13
   30.8      30.8        .1        .4   P           72.  220.     19.  220.     17.   40.     19.      -11.26
   36.6      36.6        .2        .5   C           75.  220.     17.  220.     13.   40.     17.      -17.39
   42.7      42.7        .3        .7   C           75.  220.     17.  220.     13.   40.     17.      -23.52
   47.9      47.9        .4        .9   C           33.  220.     59.  220.     55.   40.     59.       12.35
   53.9      53.9        .5       1.1   P           70.  220.     22.  220.     18.   40.     22.       11.22
   57.0      57.0        .5       1.2   P           73.  220.     19.  220.     15.   40.     19.        7.09
   66.8      66.8        .7       1.6   C           80.  220.     13.  220.      7.   40.     13.       -3.04
   72.5      72.5        .9       1.9   P           65.  220.     28.  220.     22.   40.     28.        1.83
   78.6      78.6       1.0       2.2   P           65.  220.     28.  220.     22.   40.     28.        6.70
   84.7      84.6       1.3       2.5   C           65.  220.     29.  220.     21.   40.     29.       12.57
   90.8      90.7       1.5       2.8   C           82.  220.     12.  220.      4.   40.     12.        1.43
   96.9      96.8       1.9       3.1   C           80.  220.     14.  220.      6.   40.     14.       -7.70
  103.0     102.9       2.2       3.3   C           70.  220.     24.  220.     16.   40.     24.       -6.83
  109.1     109.0       2.7       3.6   C           80.  220.     15.  220.      5.   40.     15.      -14.96
  115.2     115.0       3.2       3.9   C           72.  220.     23.  220.     12.   40.     23.      -15.09
  121.3     121.1       3.7       4.2   C           58.  220.     38.  220.     26.   40.     38.        -.22
  127.4     127.2       4.4       4.5   C           70.  220.     26.  220.     14.   40.     26.        2.65
  132.9     132.6       5.0       4.7   C           67.  220.     29.  220.     16.   40.     29.        8.52
  139.0     138.7       5.8       5.0   C           78.  220.     18.  220.      4.   40.     18.        3.39
  145.5     145.1       6.7       5.3   C           75.  220.     21.  220.      7.   40.     21.        1.26
  150.9     150.4       7.5       5.5   C           75.  220.     21.  220.      7.   40.     21.        -.87
  157.9     157.3       8.6       5.7   C           72.  220.     24.  220.     10.   40.     24.         .00
```

```
ANALYSED STRUCTURAL DATA FOR DDH: V-115-R
*****************************************
DOWN-HOLE      TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP    CUMULATIVE
  DEPTH        DEPTH    EASTING NORTHING               CA   DDIR     DIP  DDIR     DIP  DDIR     USED        SUM
-------------------------------------------------------------------------------------------------------------------
     3.8         3.8        0.       0.   P     Z      75.  220.     16.  220.     14.   40.     16.       -14.66
     7.3         7.3        0.      -.1   P            68.  220.     24.  220.     20.   40.     24.       -21.31
    11.6        11.6         .2     -.2   P            60.  220.     32.  220.     28.   40.     32.       -19.97
    14.6        14.6         .3     -.3   P            62.  220.     30.  220.     26.   40.     30.       -20.62
    17.7        17.7         .5     -.4   P     S      60.  220.     32.  220.     28.   40.     32.       -19.28
    20.7        20.7         .7     -.4   P     M      60.  220.     32.  220.     28.   40.     32.       -17.93
    23.8        23.8         .9     -.4   P            50.  220.     42.  220.     38.   40.     42.        -6.59
    26.5        26.5        1.1     -.5   P            40.  220.     52.  220.     48.   40.     52.        14.76
    29.3        29.3        1.4     -.5   P            48.  220.     44.  220.     39.   40.     44.        28.10
    32.6        32.5        1.6     -.5   P     Z      55.  220.     37.  220.     32.   40.     37.        34.45
    38.1        38.0        2.1     -.6   P            55.  220.     38.  220.     32.   40.     38.        41.79
    41.1        41.0        2.4     -.6   C            25.  220.     68.  220.     62.   40.     68.        79.14
    47.2        47.1        2.9     -.6                55.  220.     38.  220.     31.   40.     38.        86.48
    52.7        52.6        3.5     -.6                58.  220.     35.  220.     28.   40.     35.        90.83
    58.8        58.6        4.1     -.6                70.  220.     23.  220.     16.   40.     23.        83.17
    64.9        64.7        4.7     -.7                62.  220.     31.  220.     24.   40.     31.        83.52
    69.5        69.3        5.1     -.7                68.  220.     25.  220.     18.   40.     25.        77.86
    73.8        73.6        5.5     -.8                60.  220.     33.  220.     27.   40.     33.        80.21
    95.4        95.0        7.6    -1.2   C     Z      70.  220.     22.  220.     17.   40.     22.        71.55
   101.5       101.1        8.2    -1.4   C            75.  220.     16.  220.     12.   40.     16.        56.90
   106.1       105.7        8.6    -1.5   C            80.  220.     10.  220.      7.   40.     10.        36.24
   109.1       108.7        8.9    -1.6   C            75.  220.     16.  220.     12.   40.     16.        21.59
   115.2       114.8        9.5    -1.8   C            72.  220.     19.  220.     15.   40.     19.         9.93
   121.0       120.5       10.1    -2.1   P            74.  220.     17.  220.     12.   40.     17.        -3.72
   127.1       126.5       10.9    -2.4   P            60.  220.     32.  220.     26.   40.     32.        -2.38
   130.5       129.9       11.4    -2.5   P            60.  220.     32.  220.     26.   40.     32.        -1.03
   135.0       134.4       12.1    -2.8   P     3      70.  220.     21.  220.     15.   40.     21.       -10.69
   137.2       136.5       12.4    -2.9   P            50.  220.     43.  220.     36.   40.     43.         1.66
   143.0       142.8       13.5    -3.3   P            63.  220.     29.  220.     22.   40.     29.          .00
-------------------------------------------------------------------------------------------------------------------
```

```
ANALYSED STRUCTURAL DATA FOR DDH: V-126-R
*****************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2  CONVERSION-1  CONVERSION-2  S2-DIP   CUMULATIVE
 DEPTH       DEPTH   EASTING NORTHING               CA   DDIR     DIP  DDIR     DIP  DDIR    USED       SUM

  19.8       19.8        .1      -.2   C            67.  220.     24.  220.     22.   40.     24.        6.22
  25.9       25.9        .2      -.4   C            75.  220.     17.  220.     13.   40.     17.        5.43
  32.0       32.0        .4      -.5   C            64.  220.     27.  220.     25.   40.     27.       14.65
  38.1       38.1        .6      -.7   C            68.  220.     23.  220.     21.   40.     23.       19.87
  44.2       44.2        .9      -.9   C            57.  220.     33.  220.      0.    0.     33.       35.09
  49.7       49.7       1.1     -1.0   C            76.  220.     14.  220.      0.    0.     14.       31.30
  56.4       56.4       1.3     -1.3   C            70.  220.     19.  220.     21.   40.     19.       32.52
  60.4       60.3       1.5     -1.6   P            70.  220.     18.  220.     21.   40.     18.       32.74
  67.1       67.0       1.6     -1.9   C            68.  220.     20.  220.     24.   40.     20.       34.96
  73.3       73.2       1.7     -2.3         3      72.  220.     15.  220.     21.   40.     15.       32.17
  78.6       78.5       1.7     -2.7   C            46.  220.     41.  220.     47.   40.     41.       55.39
  84.7       84.6       1.6     -3.1   C            67.  220.     19.  220.     27.   40.     19.       56.61
  90.8       90.7       1.4     -3.6   C            72.  220.     13.  220.     23.   40.     13.       51.83
  96.9       96.7       1.1     -4.1   C            73.  220.     11.  220.     23.   40.     11.       45.04
 103.0      102.8        .6     -4.6   C            58.  220.     25.  220.     39.   40.     25.       52.26
 109.1      108.9       0.      -5.1   C            77.  220.      5.  220.     20.   40.      5.       39.48
 115.2      114.9       -.8     -5.4   C            70.  220.     12.  220.     27.   40.     12.       33.70
 121.3      120.9      -1.7     -5.6   C            75.  220.      7.  220.     21.   40.      7.       22.91
 127.4      126.9      -2.8     -5.7   C            77.  220.      4.  220.     16.   40.      4.        9.13
 133.5      132.9      -3.9     -5.5   C            64.  220.     20.  220.     28.   40.     20.       11.35
 139.6      138.9      -5.0     -4.9   C            76.  220.      7.   40.      0.    0.   *** NO VALUES USED
 145.7      144.8      -5.9     -4.0   C            75.  220.     11.  220.      6.   40.     11.        4.57
 151.8      150.8      -6.6     -2.8   C            78.  220.      5.  220.      9.  220.      9.       -4.22
 157.9      156.7      -6.9     -1.3   C            81.  220.      0.    0.      0.    0.   *** NO VALUES USED
 165.8      164.4      -7.0       .6   C            75.  220.     22.  220.      1.   40.     22.         .00
```

```
ANALYSED STRUCTURAL DATA FOR DDH: V-133-R
*****************************************
DOWN-HOLE     TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP   CUMULATIVE
  DEPTH       DEPTH    EASTING NORTHING               CA   DDIR    DIP  DDIR     DIP  DDIR    USED       SUM

     9.8        9.8     0.          .1   C            70.  220.    21.  220.     19.   40.     21.       -1.59
    15.2       15.2     0.          .1   C            67.  220.    24.  220.     22.   40.     24.        -.18
    21.6       21.6      .1         .2   C            63.  220.    28.  220.     26.   40.     28.        5.23
    27.7       27.7      .3         .3   C            72.  220.    20.  220.     16.   40.     20.        2.64
    33.8       33.8      .5         .4   C            75.  220.    17.  220.     13.   40.     17.       -2.95
    39.9       39.9      .7         .6   C            75.  220.    18.  220.     12.   40.     18.       -7.55
    48.2       48.2     1.1         .8   C            76.  220.    17.  220.     11.   40.     17.      -13.14
    54.6       54.6     1.5        1.0   C            83.  220.    11.  220.      3.   40.     11.      -24.73
    59.7       59.6     1.9        1.2   C            81.  220.    13.  220.      4.   40.     13.      -34.32
    65.8       65.7     2.4        1.4   C            82.  220.    12.  220.      3.   40.     12.      -44.91
    71.6       71.5     2.8        1.6   C            72.  220.    23.  220.     13.   40.     23.      -44.50
    77.7       77.6     3.3        1.9         3      77.  220.    17.  220.      8.   40.     17.      -50.09
    83.2       83.0     3.7        2.1         E      75.  220.    19.  220.     10.   40.     19.      -53.68
    89.3       89.1     4.2        2.3   C            82.  220.    12.  220.      3.   40.     12.      -64.27
    93.9       93.7     4.6        2.5   C            80.  220.    15.  220.      5.   40.     15.      -71.86
   100.0       99.8     5.1        2.8   C            75.  220.    20.  220.      9.   40.     20.      -74.45
   105.5      105.2     5.7        3.1   C            60.  220.    36.  220.     24.   40.     36.      -61.05
   111.6      111.3     6.3        3.4   C            53.  220.    44.  220.     30.   40.     44.      -39.64
   118.9      118.5     7.3        3.9         S      67.  220.    31.  220.     15.   40.     31.      -31.23
   125.9      125.4     8.3        4.4         S      55.  220.    44.  220.     25.   40.     44.       -9.82
   132.3      131.7     9.4        5.0         E      76.  220.    24.  220.      2.   40.     24.       -8.41
   136.6      135.9    10.2        5.4   C            70.  220.    31.  220.      7.   40.     31.         .00
```

```
ANALYSED STRUCTURAL DATA FOR DDH: V-309
*******************************************
DOWN-HOLE      TRUE     -----OFFSETS----- SYM FEAT.  RECORDED-S2    CONVERSION-1   CONVERSION-2    S2-DIP    CUMULATIVE
  DEPTH        DEPTH    EASTING NORTHING               CA    DDIR     DIP  DDIR      DIP  DDIR      USED         SUM

   38.1         38.1       -.1       1.2   P            59.  220.     33.  220.      28.   40.      33.          2.47
   46.9         46.9      0.         1.7   P            80.  220.     12.  220.       7.   40.      12.        -16.06
   53.0         53.0      0.         1.9   P            52.  220.     40.  220.      36.   40.      40.         -6.59
   59.4         59.3        .1       2.2   P            49.  220.     43.  220.      39.   40.      43.          5.88
   67.4         67.3        .3       2.5   C            53.  220.     39.  220.      35.   40.      39.         14.35
   72.8         72.7        .4       2.7   C            58.  220.     35.  220.      29.   40.      35.         18.82
   78.6         78.5        .6       2.9   C            71.  220.     22.  220.      16.   40.      22.         10.29
   84.1         84.0        .9       3.1   C            75.  220.     19.  220.      11.   40.      19.         -1.24
   90.2         90.1       1.3       3.4   C            69.  220.     26.  220.      16.   40.      26.         -5.76
   96.3         96.2       1.7       3.7   C            62.  220.     33.  220.      23.   40.      33.         -3.29
  102.4        102.2       2.3       4.0   C            66.  220.     29.  220.      18.   40.      29.         -4.82
  107.9        107.7       2.8       4.2   C            63.  220.     33.  220.      21.   40.      33.         -2.35
  114.6        114.4       3.6       4.6         E      59.  220.     38.  220.      24.   40.      38.          5.12
  120.7        120.4       4.4       4.9   C            59.  220.     38.  220.      24.   40.      38.         12.59
  127.7        127.3       5.4       5.3         Z      68.  220.     29.  220.      14.   40.      29.         11.06
  134.7        134.2       6.4       5.6         M      75.  220.     23.  220.       6.   40.      23.          3.53
  140.8        140.2       7.4       6.0   C            71.  220.     27.  220.      10.   40.      27.           .00
  143.9        143.3       7.9       6.2   P            85.  220.      5.  251.      15.  251.     *** NO VALUES USED
```

```
ANALYSED STRUCTURAL DATA FOR DDH: V-313
*******************************************
DOWN-HOLE     TRUE     -----OFFSETS----- SYM FEAT.  RECORDED-S2    CONVERSION-1  CONVERSION-2    S2-DIP    CUMULATIVE
  DEPTH       DEPTH     EASTING NORTHING              CA   DDIR      DIP  DDIR     DIP  DDIR      USED        SUM

   21.0        21.0      0.         .2   C            45.  220.      46.  220.     44.   40.      46.         7.75
   25.9        25.9       .1        .3   C            46.  220.      45.  220.     43.   40.      45.        14.50
   32.6        32.6       .2        .4          E     80.  220.      11.  220.      9.   40.      11.       -12.75
   38.7        38.7       .2        .6   C            65.  220.      27.  220.     23.   40.      27.       -24.00
   45.3        45.3       .4        .7   C            77.  220.      15.  220.     11.   40.      15.       -47.25
   51.2        51.2       .5        .9   C            69.  220.      23.  220.     19.   40.      23.       -62.50
   57.3        57.3       .6       1.2   C            52.  220.      40.  220.     36.   40.      40.       -60.75
   63.7        63.7       .7       1.4   P            47.  220.      45.  220.     41.   40.      45.       -54.00
   69.8        69.8       .7       1.7   C            56.  220.      36.  220.     32.   40.      36.       -56.25
   75.9        75.9       .7       2.0   P            48.  220.      44.  220.     40.   40.      44.       -50.50
   81.4        81.4       .7       2.3   P            42.  220.      50.  220.     46.   40.      50.       -38.75
   87.0        86.9       .6       2.7   P            30.  220.      62.  220.     57.   40.      62.       -15.00
   91.7        91.6       .5       3.1   P            72.  220.      20.  220.     15.   40.      20.       -33.25
   97.5        97.4       .3       3.5   P            33.  220.      59.  220.     55.   40.      59.       -12.50
  103.0       102.9      0.        4.0   P            50.  220.      42.  220.     38.   40.      42.        -8.75
  108.2       108.0      -.3       4.5   P            45.  220.      47.  220.     43.   40.      47.         0.
```

```
ANALYSED STRUCTURAL DATA FOR DDH: V-318
******************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2    CONVERSION-1   CONVERSION-2   S2-DIP    CUMULATIVE
  DEPTH      DEPTH    EASTING NORTHING               CA    DDIR     DIP  DDIR      DIP  DDIR     USED        SUM

     6.6       6.6      0.         .1                54.  220.      37.  220.      35.   40.      37.       10.78
    11.0      11.0      0.         .2   C            55.  220.      37.  220.      33.   40.      37.       21.56
    14.5      14.5       .1        .3   C     S      63.  220.      30.  220.      24.   40.      30.       25.34
    19.0      19.0       .2        .5   C     M      60.  220.      34.  220.      26.   40.      34.       33.13
    21.9      21.9       .3        .7         P      66.  220.      28.  220.      20.   40.      28.       34.91
    25.0      25.0       .5        .9   C     S      65.  220.      30.  220.      20.   40.      30.       38.69
    29.3      29.3       .7       1.2                80.  220.      15.  220.       5.   40.      15.       27.47
    34.1      34.0      1.1       1.5         P      73.  220.      23.  220.      11.   40.      23.       24.25
    38.7      38.6      1.6       1.8   C            70.  220.      26.  220.      13.   40.      26.       24.03
    41.8      41.7      1.9       1.9   C     S      76.  220.      20.  220.       7.   40.      20.       17.81
    47.9      47.7      2.8       2.2   C            75.  220.      21.  220.       7.   40.      21.       12.59
    52.4      52.2      3.4       2.4   C            75.  220.      21.  220.       7.   40.      21.        7.38
    57.6      57.3      4.1       2.6   C     S      75.  220.      21.  220.       8.   40.      21.        2.16
    61.9      61.6      4.6       2.8         P      75.  220.      21.  220.       8.   40.      21.       -3.06
    65.8      65.4      5.1       3.0   C     S      82.  220.      13.  220.       1.   40.      13.      -16.28
    67.1      66.7      5.3       3.0   C     Z      78.  220.      18.  220.       5.   40.      18.      -24.50
    72.2      71.8      5.9       3.2   C            75.  220.      21.  220.       8.   40.      21.      -29.72
    78.3      77.8      6.6       3.5                70.  220.      26.  220.      14.   40.      26.      -29.94
    81.4      80.9      7.0       3.6                72.  220.      24.  220.      12.   40.      24.      -32.16
    87.5      87.0      7.7       3.8                73.  220.      23.  220.      11.   40.      23.      -35.38
    93.6      93.0      8.4       4.1                72.  220.      24.  220.      12.   40.      24.      -37.59
    98.1      97.5      8.9       4.2         R      63.  220.      33.  220.      21.   40.      33.      -30.81
   104.2     103.5      9.6       4.5   P     P      70.  220.      26.  220.      14.   40.      26.      -31.03
   108.8     108.1     10.1       4.6   P            65.  220.      31.  220.      19.   40.      31.      -26.25
   111.9     111.2     10.5       4.7   C            60.  220.      36.  220.      24.   40.      36.      -16.47
   115.2     114.5     10.9       4.9   C     S      53.  220.      43.  220.      31.   40.      43.         .31
   121.0     120.2     11.5       5.2   P            60.  220.      36.  220.      23.   40.      36.       10.09
   124.1     123.3     11.8       5.4   P            72.  220.      24.  220.      11.   40.      24.        7.68
   127.1     126.3     12.2       5.5   P            78.  220.      18.  220.       5.   40.      18.        -.34
   133.2     132.3     12.8       5.9   P            77.  220.      20.  220.       6.   40.      20.       -6.56
   136.2     135.3     13.1       6.2   P            75.  220.      22.  220.       8.   40.      22.      -10.78
   142.0     141.1     13.7       6.6   P     P      60.  220.      37.  220.      23.   40.      37.        0.
```

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ANALYSED STRUCTURAL DATA FOR DDH: V-319
******************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2   CONVERSION-1  CONVERSION-2   S2-DIP    CUMULATIVE
  DEPTH      DEPTH   EASTING NORTHING                CA   DDIR    DIP  DDIR     DIP  DDIR    USED        SUM

    17.4      17.4         .1         .3  P             65.  220.     27.  220.     23.   40.     27.         1.36
    23.2      23.2         .2         .5  P     P       80.  220.     12.  220.      8.   40.     12.       -12.27
    27.4      27.4         .4         .6  P     Z       72.  220.     21.  220.     15.   40.     21.       -16.91
    30.2      30.2         .5         .7  P     S       75.  220.     18.  220.     12.   40.     18.       -24.55
    32.6      32.6         .6         .8  P             70.  220.     23.  220.     16.   40.     23.       -27.16
    35.7      35.7         .7         .9  P             65.  220.     29.  220.     21.   40.     29.       -23.82
    38.7      38.7         .9        1.0  P             68.  220.     26.  220.     18.   40.     26.       -23.45
    44.5      44.4        1.4        1.2  P     P       75.  220.     19.  220.     11.   40.     19.       -30.09
    48.5      48.4        1.7        1.3        Z       73.  220.     21.  220.     13.   40.     21.       -34.73
    51.2      51.1        2.0        1.3                65.  220.     29.  220.     21.   40.     29.       -31.36
    56.1      56.0        2.5        1.4        S       68.  220.     26.  220.     17.   40.     26.       -31.00
    57.6      57.5        2.6        1.4        Z       80.  220.     14.  220.      4.   40.     14.       -42.64
    63.1      62.9        3.3        1.5                70.  220.     25.  220.     14.   40.     25.       -43.27
    66.1      65.9        3.7        1.6                50.  220.     46.  220.     34.   40.     46.       -22.91
    69.2      69.0        4.1        1.7                75.  220.     21.  220.      8.   40.     21.       -27.55
    72.2      72.0        4.5        1.7                85.  220.      4.  258.     14.  258.    *** NO VALUES USED
    75.3      75.0        5.0        1.8                80.  220.     16.  220.      1.   40.     16.       -37.18
    78.6      78.3        5.5        2.0                60.  220.     37.  220.     22.   40.     37.       -25.82
    84.4      84.0        6.5        2.2                50.  220.     48.  220.     32.   40.     48.        -3.45
    87.5      87.0        7.1        2.3        S       65.  220.     32.  220.     16.   40.     32.         2.91
    90.5      90.0        7.6        2.4        M       70.  220.     27.  220.     11.   40.     27.         4.27
    93.3      92.7        8.1        2.4  P             55.  220.     42.  220.     27.   40.     42.        20.64
    98.1      97.4        9.0        2.5  P             60.  220.     36.  220.     21.   40.     36.        31.00
   101.2     100.5        9.7        2.5  P             74.  220.     21.  220.      6.   40.     21.        26.36
   103.9     103.1       10.2        2.5  P     M       60.  220.     36.  220.     22.   40.     36.        36.73
   108.8     107.9       11.2        2.4  P             72.  220.     22.  220.      8.   40.     22.        33.09
   111.9     111.0       11.8        2.4  P             75.  220.     18.  220.      4.   40.     18.        25.45
   116.4     115.4       12.8        2.2  P     S       75.  220.     18.  220.      4.   40.     18.        17.82
   121.0     119.8       13.8        2.1  P             75.  220.     17.  220.      3.   40.     17.         9.18
   124.1     122.8       14.5        2.0  P             68.  220.     26.  220.     11.   40.     26.         9.55
   128.0     126.6       15.5        1.9  P     P       70.  220.     24.  220.      8.   40.     24.         7.91
   133.2     131.6       16.8        1.7  P             65.  220.     30.  220.     13.   40.     30.        12.27
   136.2     134.5       17.6        1.6  P             75.  220.      2.  220.     16.  220.     16.         2.64
   144.5     142.5       20.0        1.3  P             77.  220.      0.    0.      0.    0.    *** NO VALUES USED
   147.2     145.1       20.7        1.2  P     S       70.  220.     23.  220.      5.   40.     23.          .00
```
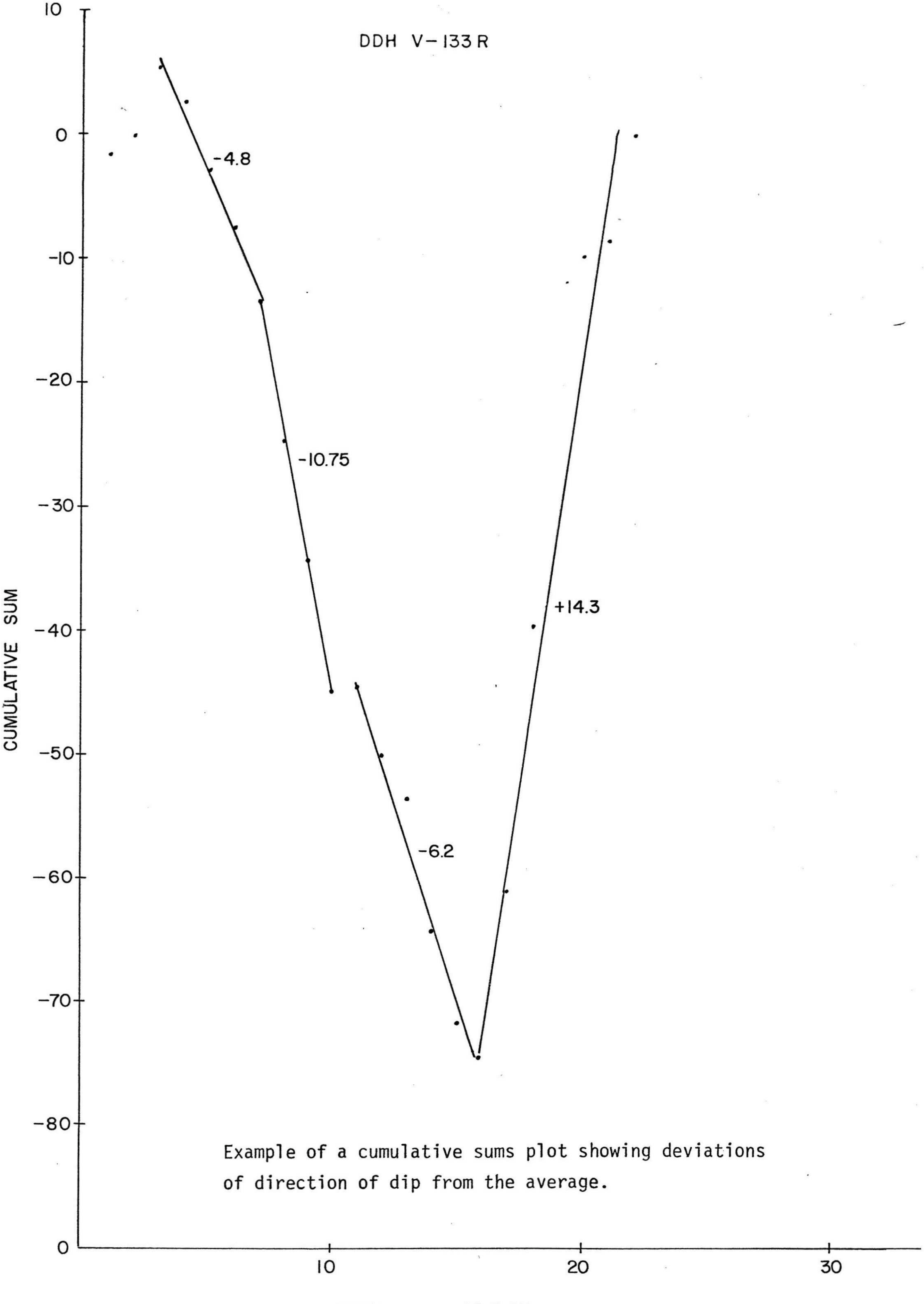

```
ANALYSED STRUCTURAL DATA FOR DDH: V-322
****************************************
DOWN-HOLE    TRUE    -----OFFSETS----- SYM FEAT.  RECORDED-S2    CONVERSION-1   CONVERSION-2    S2-DIP   CUMULATIVE
 DEPTH       DEPTH   EASTING NORTHING               CA   DDIR      DIP  DDIR      DIP  DDIR      USED       SUM

   35.1       35.1        .3       1.4               65.  220.      29.  220.      21.   40.       29.       -3.90
   38.1       38.1        .3       1.6               70.  220.      24.  220.      15.   40.       24.      -12.81
   45.1       45.0        .6       2.2               60.  220.      36.  220.      24.   40.       36.       -9.71
   47.9       47.8        .7       2.5               50.  220.      46.  220.      34.   40.       46.        3.38
   50.9       50.8        .8       2.8        R      70.  220.      26.  220.      14.   40.       26.       -3.52
   53.0       52.9        .9       3.0        S      60.  220.      36.  220.      24.   40.       36.        -.43
   60.0       59.8       1.2       3.8   P    S      64.  220.      33.  220.      19.   40.       33.        -.33
   62.2       62.0       1.3       4.1   P    Z      65.  220.      32.  220.      18.   40.       32.       -1.24
   68.3       68.1       1.6       4.8   P    Z      70.  220.      27.  220.      13.   40.       27.       -7.14
   71.0       70.7       1.7       5.2   P    S      70.  220.      27.  220.      12.   40.       27.      -13.05
   73.8       73.5       1.8       5.5   P           68.  220.      29.  220.      14.   40.       29.      -16.95
   76.8       76.5       2.0       5.9   P           70.  220.      27.  220.      12.   40.       27.      -22.86
   79.9       79.5       2.1       6.4   P           58.  220.      40.  220.      24.   40.       40.      -15.76
   84.4       84.0       2.4       7.0   P    S      66.  220.      33.  220.      15.   40.       33.      -15.67
   86.0       85.6       2.5       7.2   P    S      60.  220.      39.  220.      21.   40.       39.       -9.57
   92.0       91.5       3.0       8.1   P    S      65.  220.      35.  220.      15.   40.       35.       -7.48
   96.6       96.0       3.4       8.7   P           55.  220.      45.  220.      25.   40.       45.        4.62
  102.7      102.0       4.1       9.5   P           72.  220.      28.  220.       8.   40.       28.        -.29
  108.2      107.4       4.9      10.2   P           67.  220.      34.  220.      12.   40.       34.         .81
  111.9      111.1       5.5      10.6   P           74.  220.      27.  220.       5.   40.       27.       -5.10
  114.9      114.0       5.9      11.0   P    P      63.  220.      38.  220.      16.   40.       38.         .00


 STOP ALL CUSUMS FINISHED
SRU'S:94.2
!OFF
USAGE ON 08/13/80 AT 16:39:45
SRU'S:99.4       ELAPSED TIME: 00:03:35
```



Example of a cumulative sums plot showing deviations of direction of dip from the average.

Appendix B

APPENDIX B

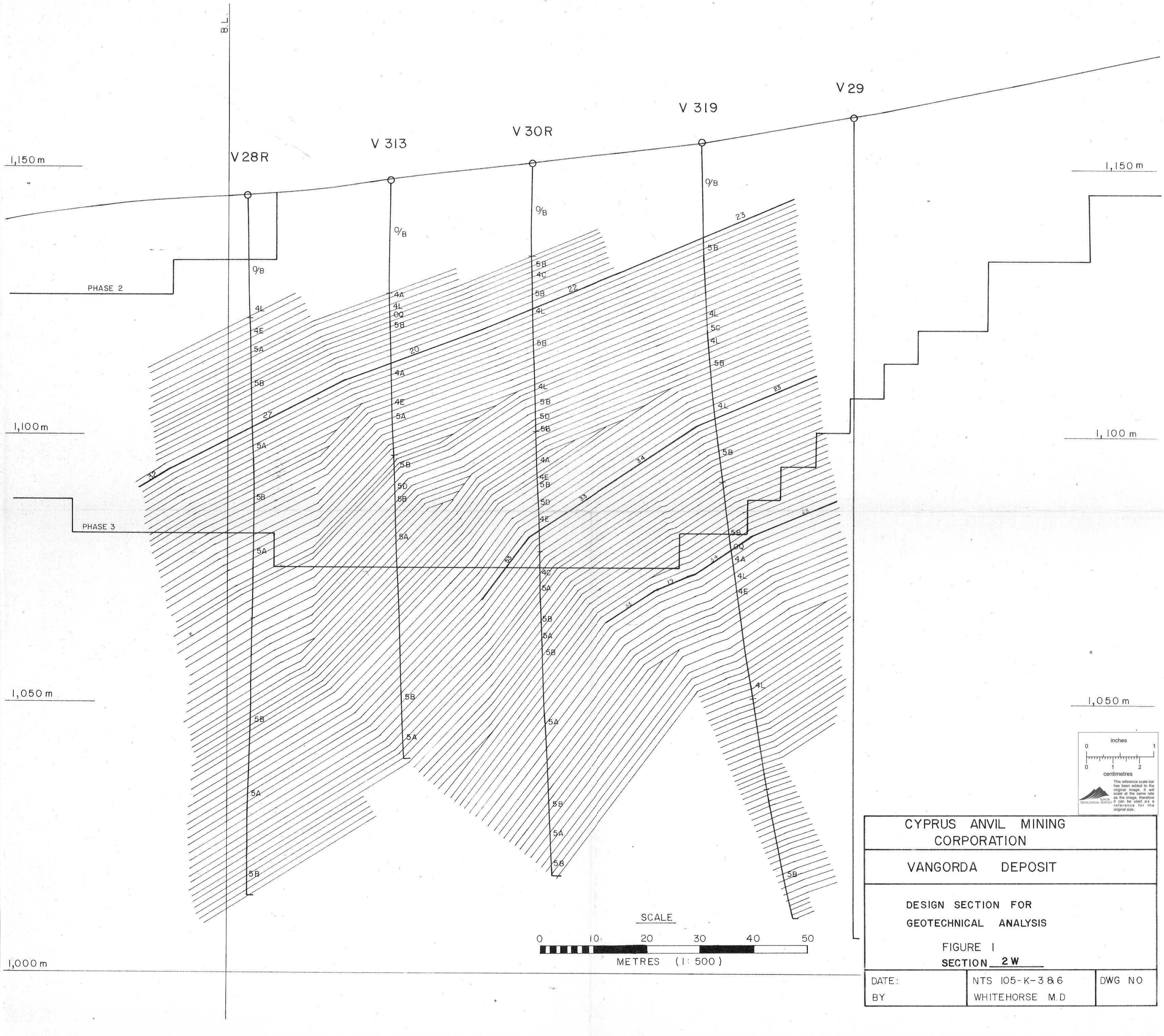
DESIGN SECTIONS

Design Section 2W

Design Section 2E

Design Section 6E

Design Section 12E



CYPRUS ANVIL MINING CORPORATION

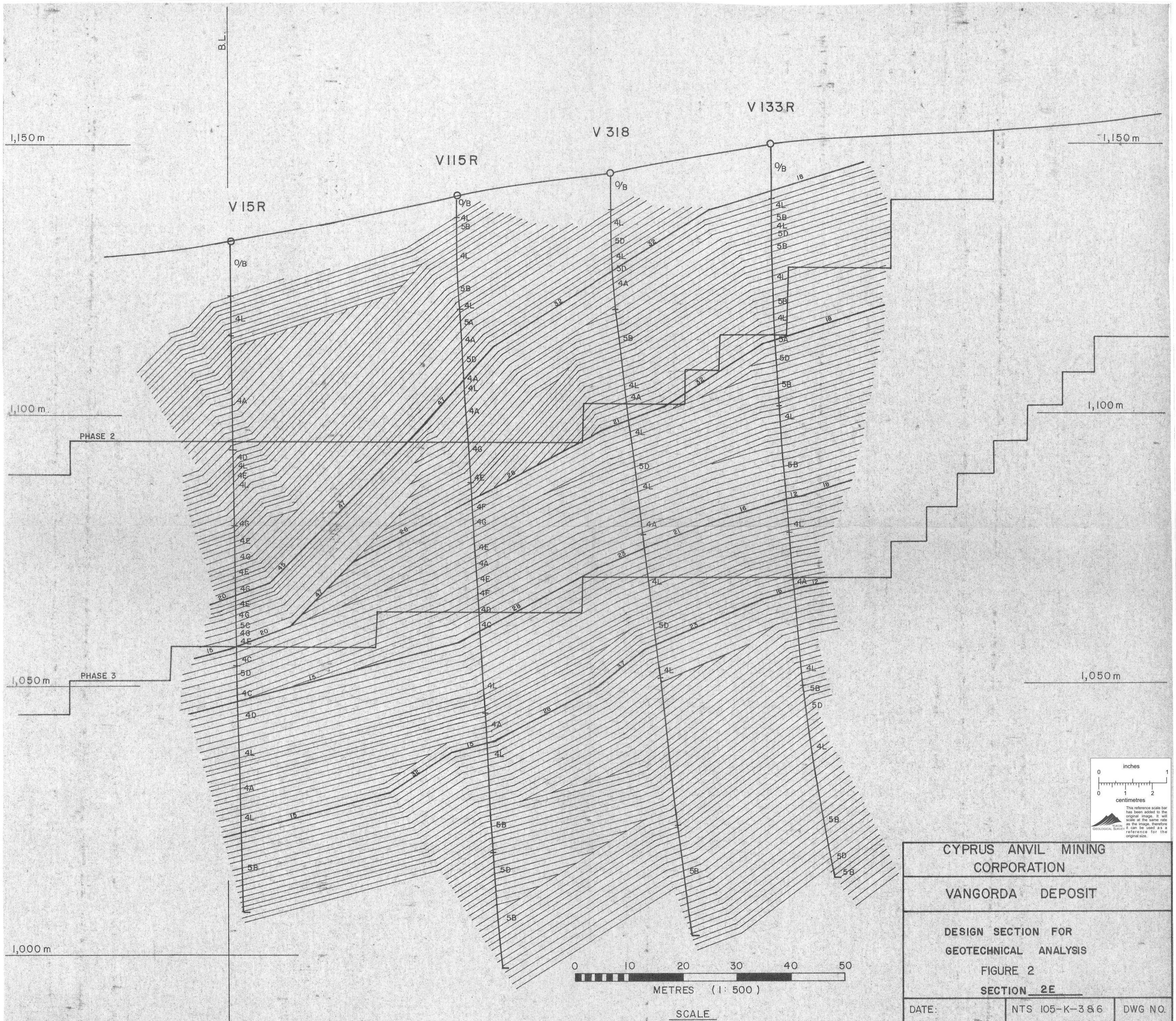
VANGORDA DEPOSIT

DESIGN SECTION FOR GEOTECHNICAL ANALYSIS

FIGURE 1

SECTION 2 W

DATE:	NTS 105-K-3 & 6	DWG NO
BY	WHITEHORSE M.D	

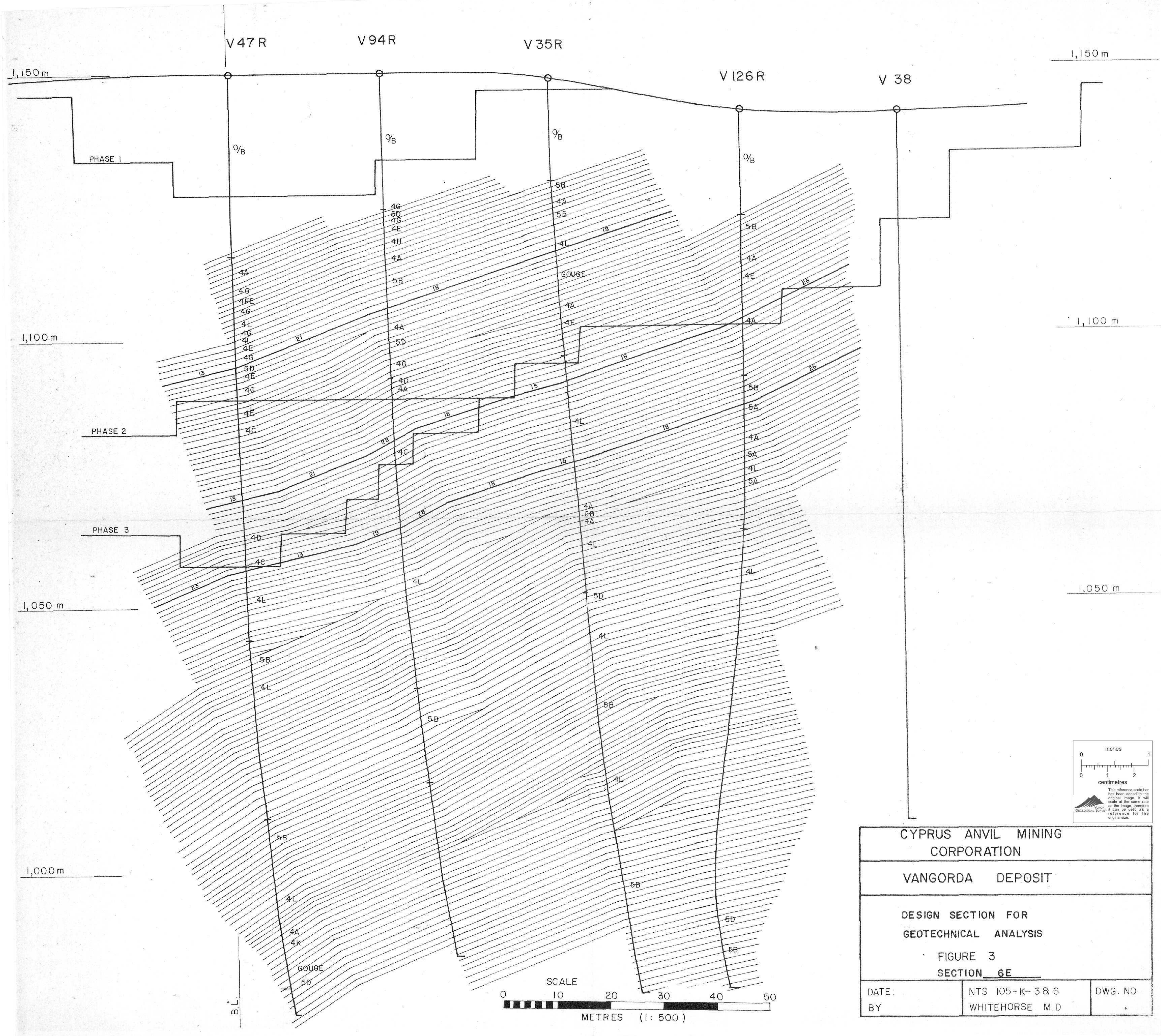


CYPRUS ANVIL MINING
CORPORATION

VANGORDA DEPOSIT

DESIGN SECTION FOR
GEOTECHNICAL ANALYSIS
FIGURE 2
SECTION 2E

DATE:
BY
NTS 105-K-3 & 6
WHITEHORSE M.D
DWG NO.



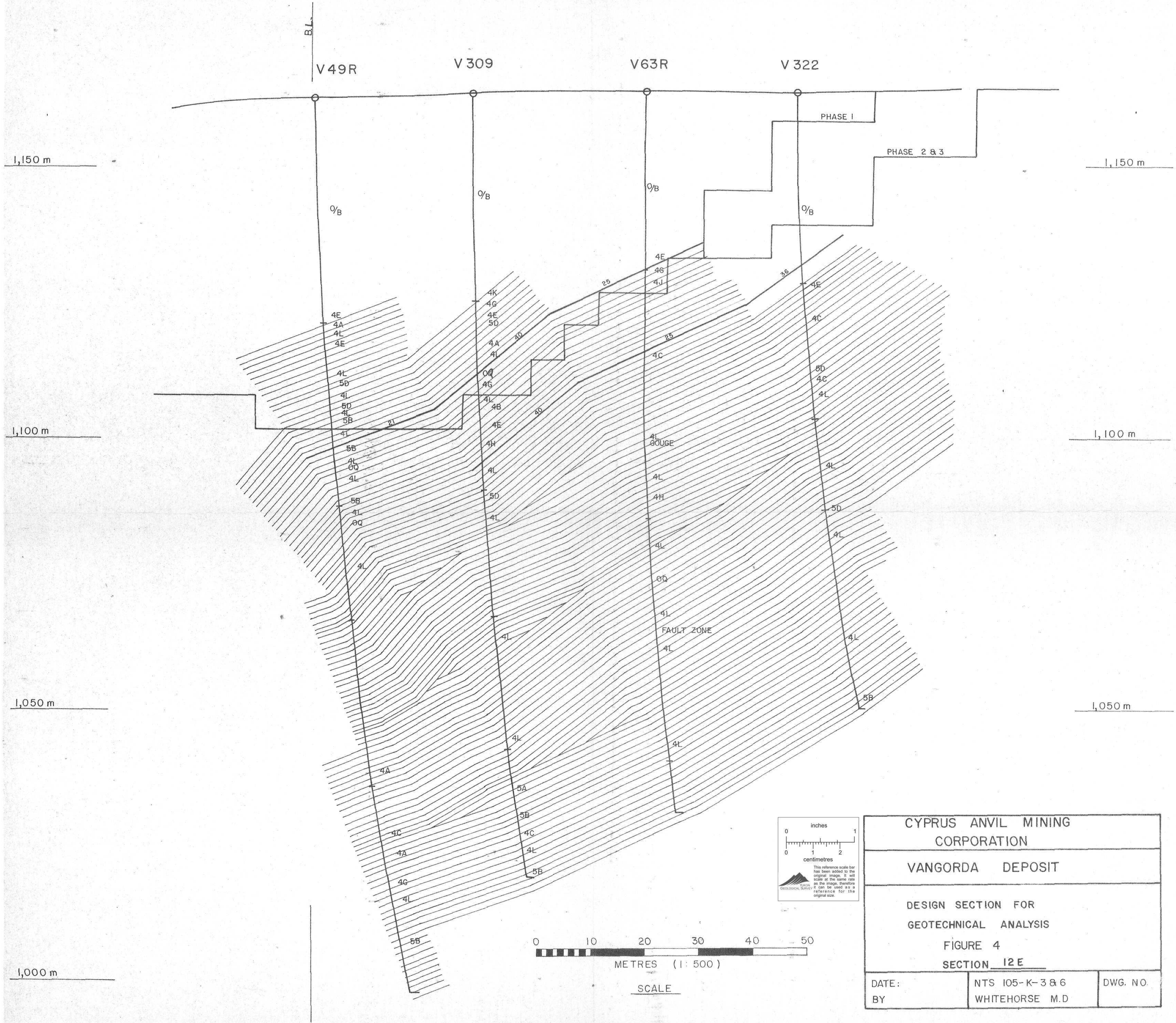
CYPRUS ANVIL MINING CORPORATION

VANGORDA DEPOSIT

DESIGN SECTION FOR
GEOTECHNICAL ANALYSIS

FIGURE 3
SECTION 6E

DATE:
BY
NTS 105-K-3&6
WHITEHORSE M.D
DWG. NO.



CYPRUS ANVIL MINING CORPORATION

VANGORDA DEPOSIT

DESIGN SECTION FOR GEOTECHNICAL ANALYSIS

FIGURE 4

SECTION 12 E

DATE:	NTS 105-K-3 & 6	DWG. NO.
BY	WHITEHORSE M.D	