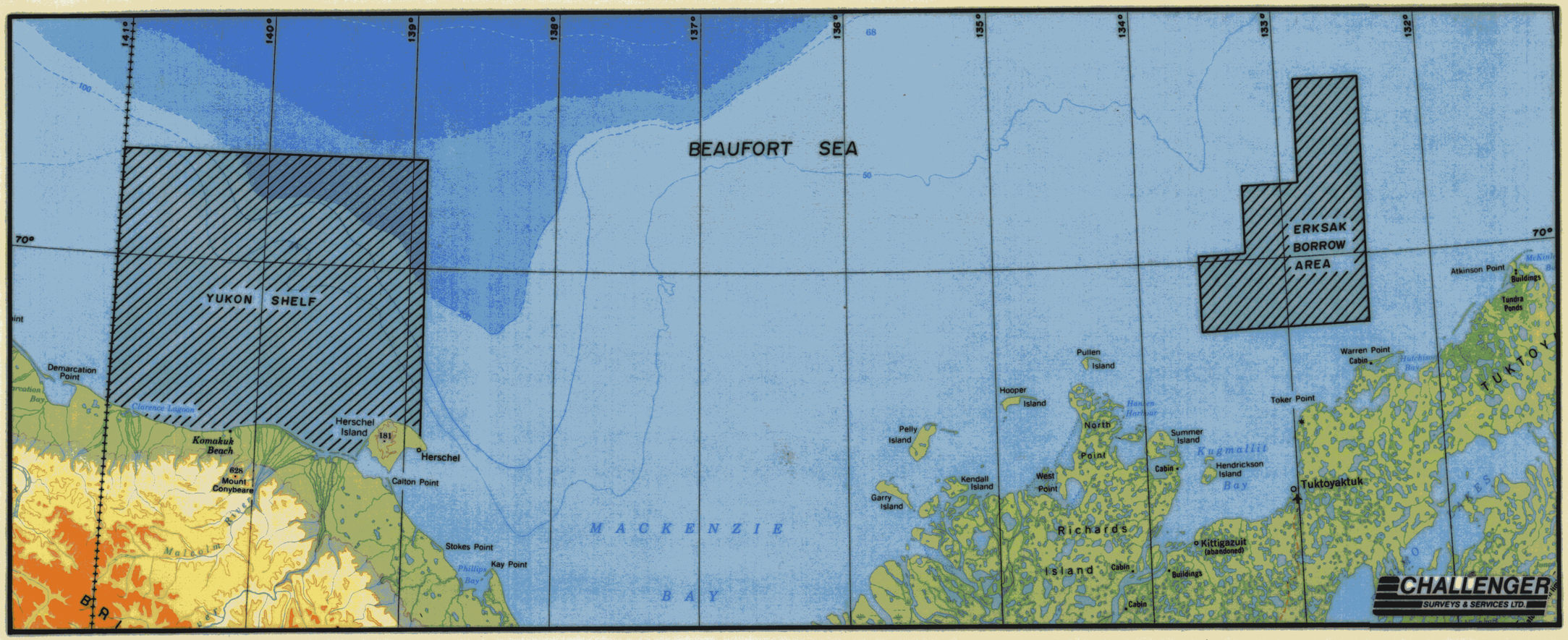
REPORT
ON THE
" COMPUTER-BASED ANALYSIS OF DIGITAL BATHYMETRIC DATA "
BEAUFORT SEA
FOR
DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT



REPORT

on the

"COMPUTER-BASED ANALYSIS OF DIGITAL BATHYMETRIC DATA"

BEAUFORT SEA

for

DEPARTMENT OF INDIAN AFFAIRS

AND NORTHERN DEVELOPMENT

by

CHALLENGER SURVEYS & SERVICES LTD.

1988

Edmonton, Alberta

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1.0 INTRODUCTION

On behalf of the Department of Indian Affairs and Northern Development (DIAND), Challenger Surveys & Services Ltd. was contracted to undertake a computer based analysis of bathymetric data collected in the Canadian Beaufort Sea. The purpose of the analysis was to locate and characterize subtle bathymetric highs.

Granular resource data for the Beaufort Sea indicates that almost all of the gravel deposits identified are located on subtle bathymetric highs, and within a relatively narrow range of water depths. Analysis of seabed morphology and detailed bathymetry is, therefore, useful in establishing any bathymetric control of the geological framework as related to granular resources. The results of an initial bathymetric data analysis of the Western Beaufort (YUKON) Continental Shelf demonstrated that subtle bathymetric anomalies which may contain granular resources can be identified efficiently from the raw digital data of hydrographic surveys. (Challenger, 1986) The above study, which utilized a digital terrain model to represent the seabed surface in the form of an axonometric projection of meshed grids, revealed seabed features which were not readily apparent on field sheets or detailed contour maps.

The study indicated that mesh grid plots provided a visual image of the seabed which is useful for general geological interpretation and identification of the presents of subtle bathymetric anomalies, but their usefulness in quantifying the location and magnitude of the feature is limited.

The purpose of this investigation was to first perform a detailed analysis of selected bathymetric features

identified on the Yukon Shelf from the above mentioned project. Next an analysis of a second area was undertaken to locate and characterize bathymetric features in the Erksak block in the Beaufort Sea.

This report outlines the work performed under Department of Supply and Services (DSS) contract file number A7134-6-0038/01ST. The Scientific Authority for this project was Mr. Robert J. Gowan, P. Geol., Geotechnical Advisor, Land Management Division, DIAND.

1.1 Acknowledgements

The authors would like to acknowledge the following, who helped in one way or another during the project.

The CHS in Sidney B.C. for providing the digital data and undertaking an initial review of the data to ensure that it was in machine readable format.

Mr. R.J. Gowan, the scientific authority for the project, for assistance in the selection of the areas for the detailed study and in the analysis and interpretation of the identified features.

2.0 DIGITAL TERRAIN MODELLING

A three dimensional continuous surface may be represented on a two dimensional medium in many ways. Contour lines, spot heights, shading or coloring are examples. On a hydrographic chart, the sea bottom is generally represented by spot depths supplemented by contour lines and colour shading. This serves as a useful tool for the mariner who must navigate vessels of different size and draft safely through channels but is not adequate for an engineer/geologist who is attempting to analyze the seabed topography. Through the use of digital terrain modelling techniques, more suitable methods of representing seabed topography are possible.

2.1 Digital Terrain Models

A digital terrain model is a numeric representation of continuous surface. A Cartesian coordinate system (X,Y,Z) can be used to define such a model. Data to complete such a model can be collected in a variety of ways, for example;

1) In conventional land surveying X,Y,Z data is collected using a theodolite and distance measurement device.

2) In photogrammetry, stereographic photographs are used in an analytical recovery of the X,Y,Z ground coordinates.

3) In hydrographic surveying the planar components of system are derived by simultaneous multiple distance measurements to known shore targets. The Z component is observed as a depth measurement through water to the seafloor.

In both the land surveying and photogrammetric models it is possible to visually inspect the continuous surface used for the collection of the digital data base. In the survey application the surface can be seen while the data is being collected. In the photogrammetric application the surface can be analyzed stereographically by use of overlapping photographs. Only in the case of the hydrographic survey is the visual interpretation of the surface topography based solely on a surface interpolated from single points.

2.2 DTM Products

Hydrographic digital terrain models can be portrayed in various ways including:
1) spot elevations
2) contours
3) colour coding
4) mesh perspectives

Spot Elevations

The simplest, and from a visual perspective, the least useful way to portray a surface is through the use of spot depths. Hydrographic charts are created in this manner and are very useful for the mariner since a general water depth for an area is provided quite adequately. To physically use this product and visualize a 3 dimensional surface from this product is difficult.

Contours

Contours provide a better representation of the trend of a surface and can be even more useful to the mariner especially when coupled with spot depths. It is possible

to visualize regional topography through contour plans with a relatively large contour interval, but the visual representation becomes more confusing with increasingly detailed contouring of smaller topography features, and the product is still a 2-dimensional (2D) representation of a 3D surface.

Colour Coding

A somewhat less analytical tool but more pleasing to the eye and somewhat easier to interpret is the shading of spot elevations, contours, or depth interval areas using different colours to represent various depth intervals. Colour coding is most useful when used to supplement other methods of presentation. Still we have a 2D representation.

Mesh Perspective

With the advent of the computer and more importantly the desktop micro-computer the computing power has become available for the manipulation of large amounts of hydrographic data and portrayal of this data in non-traditional methods which are easier to visualize and interpret. Using a digital terrain model where the Z values are mapped to the nodes of a regular spaced grid, mesh perspective plots that give the interpretation of 3 dimensions can be produced.

2.3 Mesh Perspective Selection

In our 3-dimensional world, we see and interpret our environment in 3 dimensions. Because of this we find it difficult to interpret 3D results that are presented in a

2D fashion. Mesh perspectives allow for integration and use of large amounts of data in their presentation. Whereas 1000 depths will fit on a 2 by 3 foot map 10000 depths may be used in the mathematical generation of a 3D surface that will also be portrayed on a 2 foot by 3 foot map. Exaggeration of the vertical component of the model allows for the detection of subtle bathymetric features that otherwise would have gone unnoticed. As can be seen in Figure 1 the final mesh looks as close as one would get to a photograph of seafloor. Once the subtle features have been located more traditional methods can be used to quantify the results.

On the basis of their ability to represent subtle bathymetric anomalies which may contain granular resource deposits, mesh perspectives were chosen as the technique for analyzing seafloor topography for both the Yukon Shelf and Erksak borrow area DTM.

3.0 DETAILED ANALYSIS OF THE YUKON SHELF BATHYMETRY

3.1 Previous Work

Under DSS contract file number 25 ST-A7134-5-0033, Challenger performed an initial analysis of the Yukon Shelf hydrographic data (Challenger, 1986). A large isometric mesh covering the entire area was produced and used to locate bathymetric anomalies. (figure 1) The success of this initial analysis in location of subtle seabed features, which on the basis of their morphology, might be composed of granular materials, prompted Challenger to propose further detailed studies of the area as well as the analysis of an additional area.

3.2 Selection of Further Analysis Areas

Based on the previous bathymetric data analysis and other interpretations 10 smaller areas on the Yukon Shelf were selected for further investigation. Challenger was responsible for reviewing the site selections to ensure that at least six of the selected areas did in fact have the data density required for a detailed analysis. The location of the selected areas are shown in Figure 2 and the coordinates of each area are listed in Table 1.

Area	UTM Zone	North	East	South	West
1	7	7 764 000	563 000	7 755 000	552 000
2	7	7 780 000	550 000	7 765 000	524 000
2A	7	7 786 000	524 000	7 779 000	515 000
3	7	7 765 000	579 000	7 731 000	561 000
4	7	7 730 000	552 000	7 721 000	531 000
4A	7	7 724 000	568 000	7 718 000	552 000
5	7	7 781 000	564 000	7 768 000	550 000
6	7	7 732 000	511 000	7 723 000	504 000
7	7	7 732 000	568 000	7 727 000	559 000
8	7	7 745 000	514 000	7 741 000	506 000

This table lists the four boundaries that define each of the 10 study areas of the Yukon Shelf data base. All coordinates are listed in Universal transverse Mercator (UTM) zone 7 coordinates.

" Coordinates of Detailed Study Areas, Yukon Shelf"

Table 1

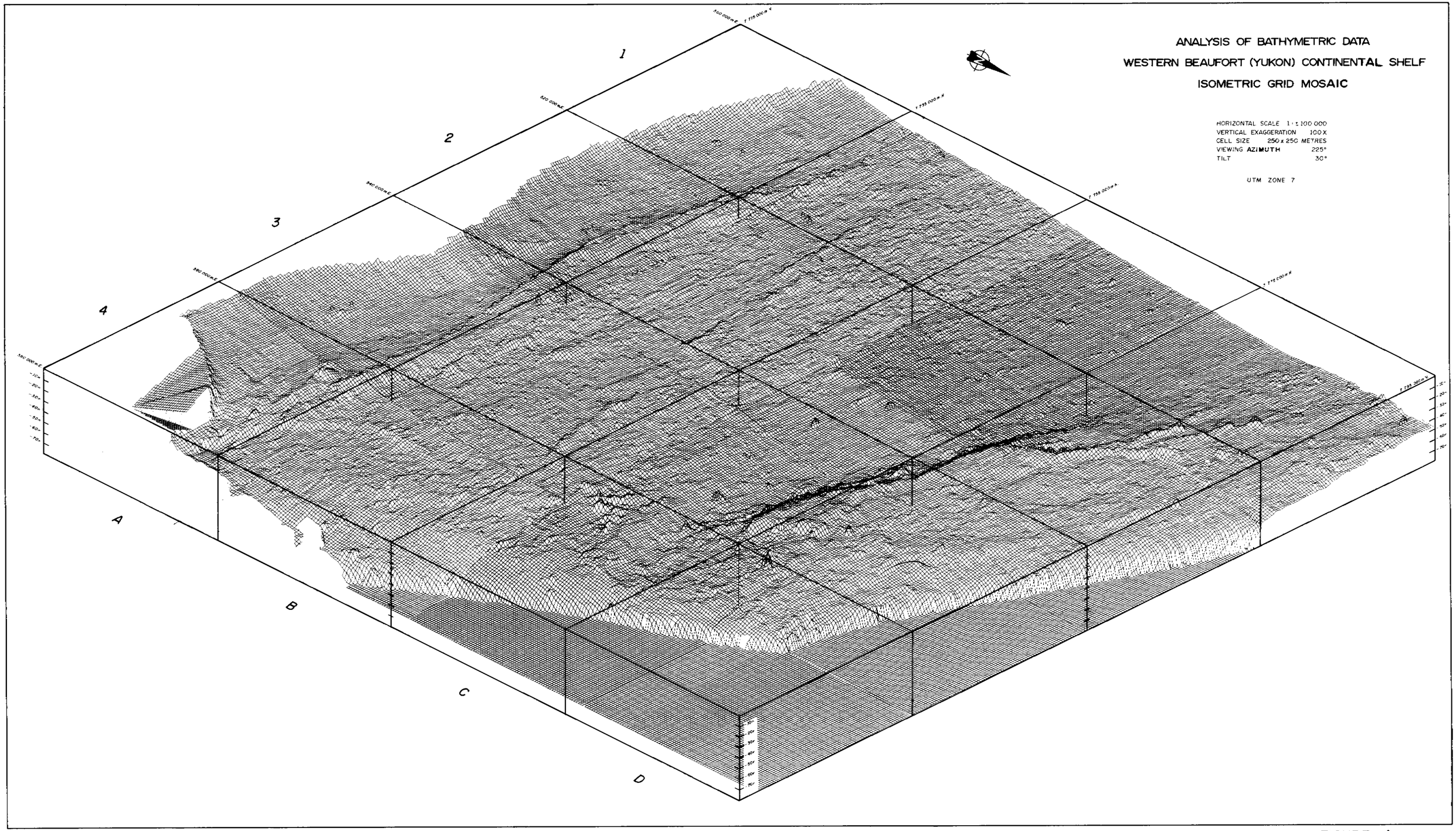

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON) CONTINENTAL SHELF
ISOMETRIC GRID MOSAIC
HORIZONTAL SCALE 1 : 100 000
VERTICAL EXAGGERATION 100 X
CELL SIZE 250 x 250 METRES
VIEWING AZIMUTH 225°
TILT 30°
UTM ZONE 7
1
2
3
4
A
B
C
D

FIGURE : 1

N

7 760 000

7 740 000

7 720 000

7 700 000

2A

2

5

1

3

8

6

7

4

4A

LEGEND & NOTES

INDIAN & NORTHERN AFFAIRS CANADA

PLAN SHOWING
DETAILED STUDY AREAS
ON THE YUKON SHELF

CHALLENGER

SCALE :	JOB NO :
1 : 500000	S-617
DATE : 2 MAY 1988	DWG # :

FIG. 2

3.3 Data Sorting & Thinning

The data from the Yukon Shelf had been acquired during the previous work. All 140,000 X,Y,Z data points composing the DTM for this area were already in the HP LIF and HP CS80 format required for detailed analysis.

The outlines of 10 areas selected for further investigation were plotted on the large mosaic map. The northing and easting for these areas was scaled off and the data was sorted into 10 separate files containing the data of each section. The newly created files contained varying amounts of data from 3000 up to about 15000 data points.

The original data used to prepare the DTM for the previous analysis was collected on survey lines of 500 meter spacing with data being recorded down line at 100 meter intervals. Using all the data gives a down line biasing which results in a plot that has rough surface in one direction(downline) and an apparent smooth surface in the other (across line). During the production of mesh plans this biasing was evident as can be seen in figure 6, Dwg # S617-1D in which all the data was used to produce the mesh. This gives the viewer a less than realistic impression of the surface. To alleviate this problem, the data was thinned by distance so that no two neighbors were closer than 250 meters to each other. This gave a 2 to 1 ratio of across line and down line data density and made the plots appear more representative of the seabed. This thinned the file sizes to an average of 2500 data points. To put this in perspective, only about 1000 spot soundings could be comfortably displayed on a map of the same area as the mesh.

During the examination of the down-line biasing effect, a

series of mesh perspectives were prepared using every third point, in the following sequences: 1-4-7-etc., 2-5-8-etc., and 3-6-9-etc. These plots are shown in figures 3 through 5, drawing #'s S617_1A, S617_1B and S617_1C. The comparison of these plots showed that each perspective clearly displays the large scale features in a similar size and shape, but the micro-relief on these features varies considerably depending on the sequence of grid points used. A by-product of this analysis is the ability to recognize individual erroneous soundings which would appear as a single spike on only one of the series of perspectives.

3.4 Plan Production

In the initial analysis of the Yukon Shelf (Challenger,1986), the meshes produced were not in true perspective. What this means is that the mesh did not converge to a vanishing point as the apparent depth into the plot increased. With a new software package utilized in the present study, a true perspective plot was produced. This allows for a more realistic representation of the seabed topography. An attempt was made to find, for comparative interpretation, a single combination of viewing azimuth, tilt angle and multiplicative factor that could be used for all the mesh perspectives in the Yukon Shelf area. After producing plots using various values for the above parameters the following combination was selected as that giving the best results on the majority of the data sets.

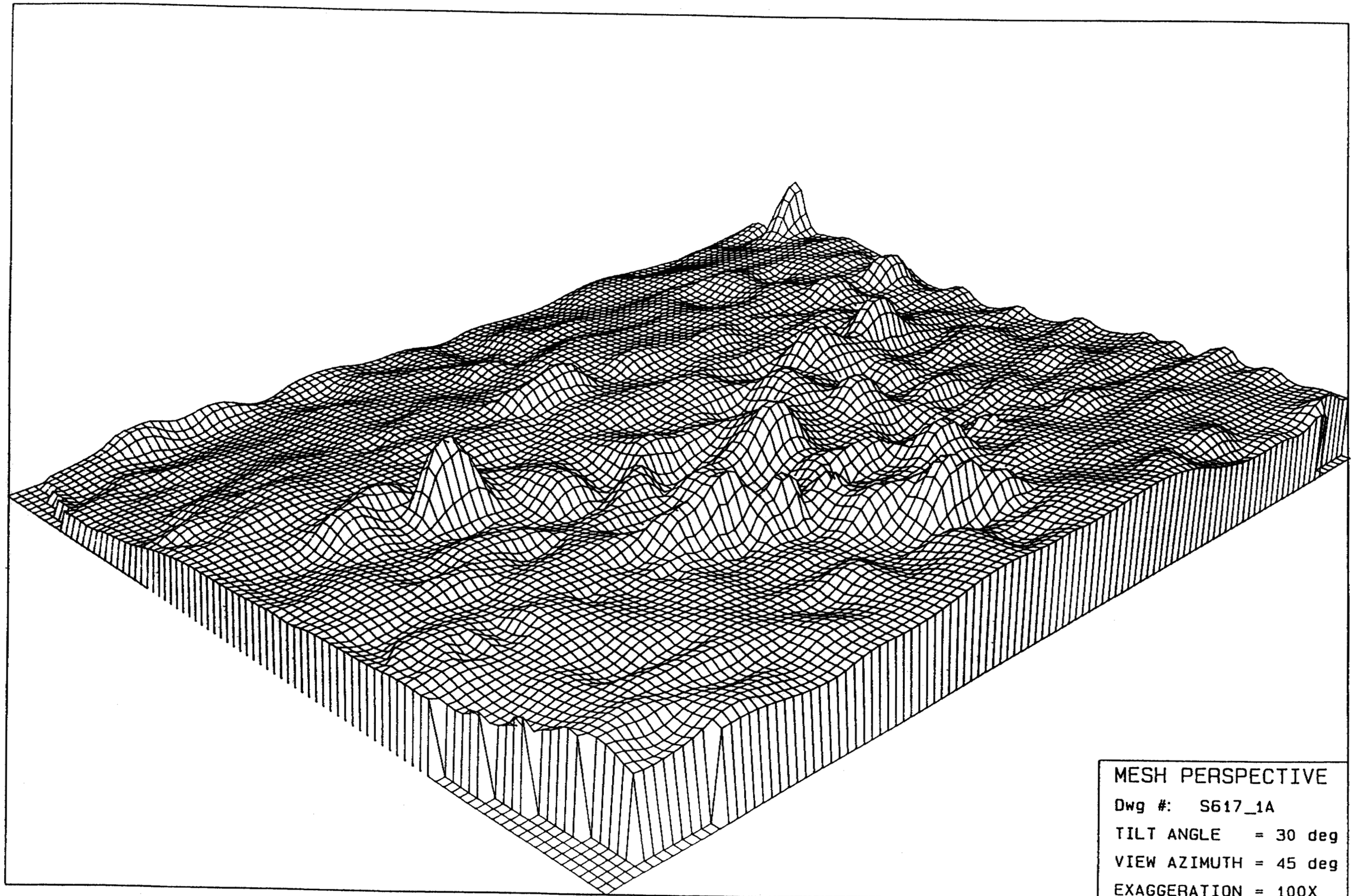
viewing azimuth - 45 degrees
tilt angle - 30 degrees
exaggeration - 100X

Table 2 lists the detailed plans produced and the plot parameters for the Yukon Shelf data set.

AREA	PLAN TYPE	SCALE	PARAMETERS View	Tilt	Exag.
1	Mesh	N/A	45	30	100X
1	Bathymetry	1/40 000			
1	Profile Plan	horz. 1:50 000 vert. 1:500			
2	Mesh	N/A	45	30	100X
2	Bathymetry	1:60 000			
2	Profile Plan	horz. 1:100 000 vert. 1:500			
2A	Mesh	N/A	45	30	100X
2A	Bathymetry	1:30 000			
2A	Profile Plan	horz. 1:50 000 vert. 1:500			
3	Bathymetry	1:150 000			
	Mesh	N/A	45	45	80X
4	Bathymetry	1:60 000			
4	Profile Plan	horz. 1:50 000 vert. 1:500			
4A	Mesh	N/A	50	30	100X
4A	Bathymetry	1:40 000			
4A	Profile Plan	horz. 1:50 000 vert. 1:500			
5	Mesh	N/A	45	30	80X
5	Bathymetry	1:50 000			
5	Profile Plan	horz. 1:100 000 vert. 1:1000			
6	Mesh	N/A	45	30	60X
6	Bathymetry	1:40 000			
6	Profile Plan	horz. 1:50 000			
7	Mesh	N/A	45	30	100X
7	Bathymetry	1 : 25 000			
7	Profile Plan	horz. 1:50 000 vert. 1:500			
8	Mesh	N/A	45	30	100X
8	Bathymetry	1 : 25 000			
8	Profile Plan	horz. 1:20 000 vert. 1:500			

" Plan Plot Parameters Yukon Shelf "

Table 2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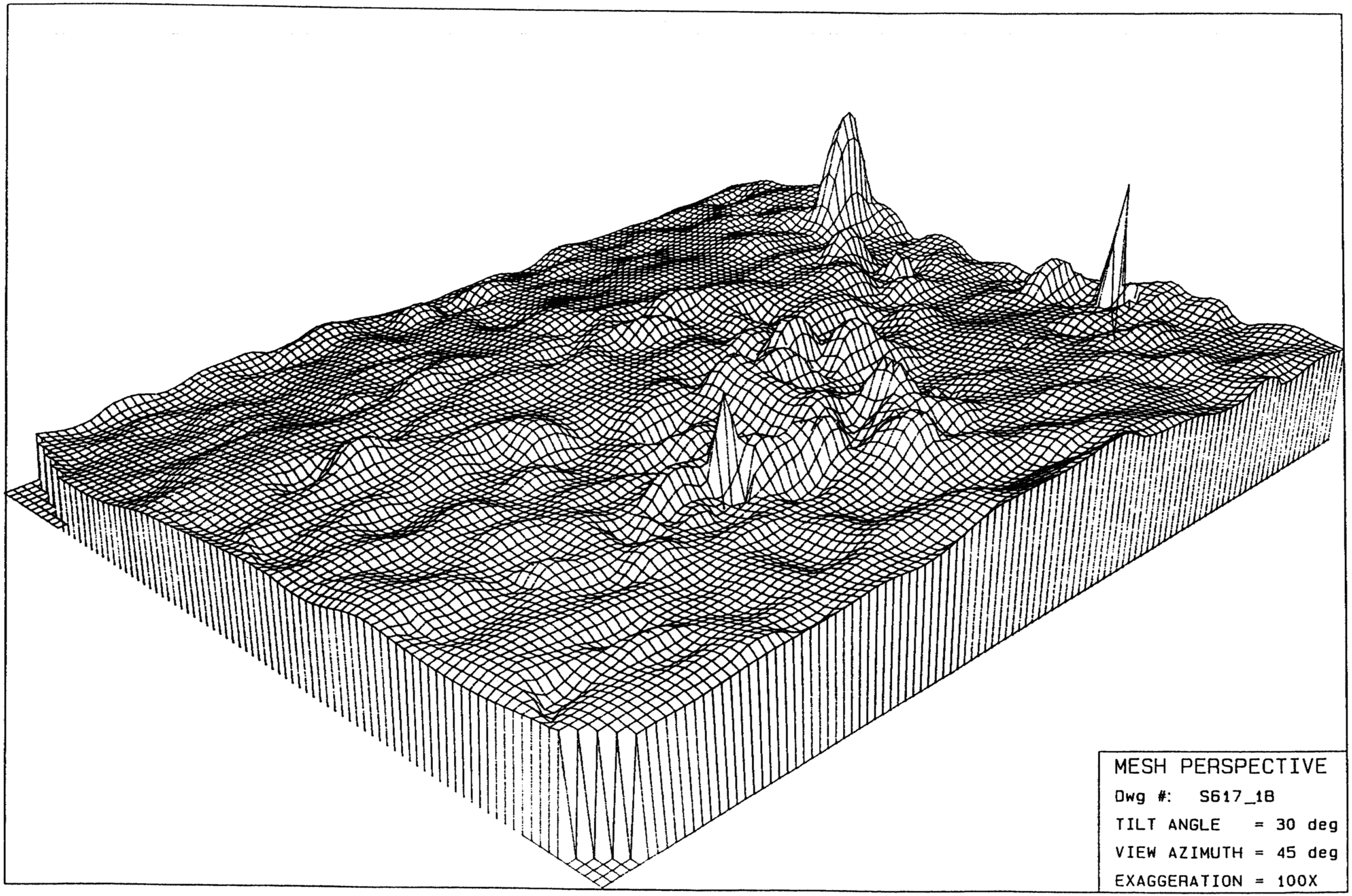
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 3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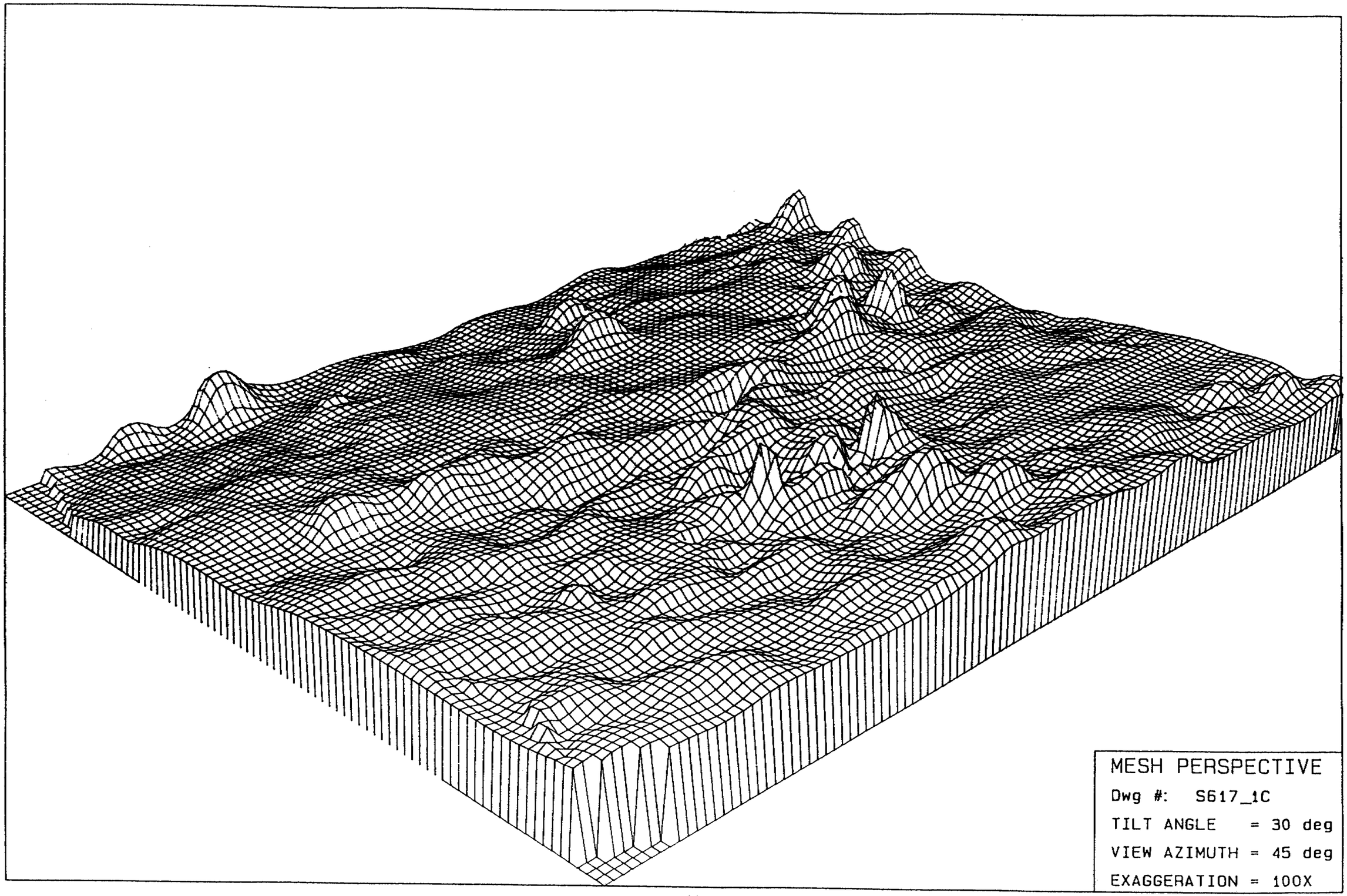
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 4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Dwg #: S617_1C
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 5

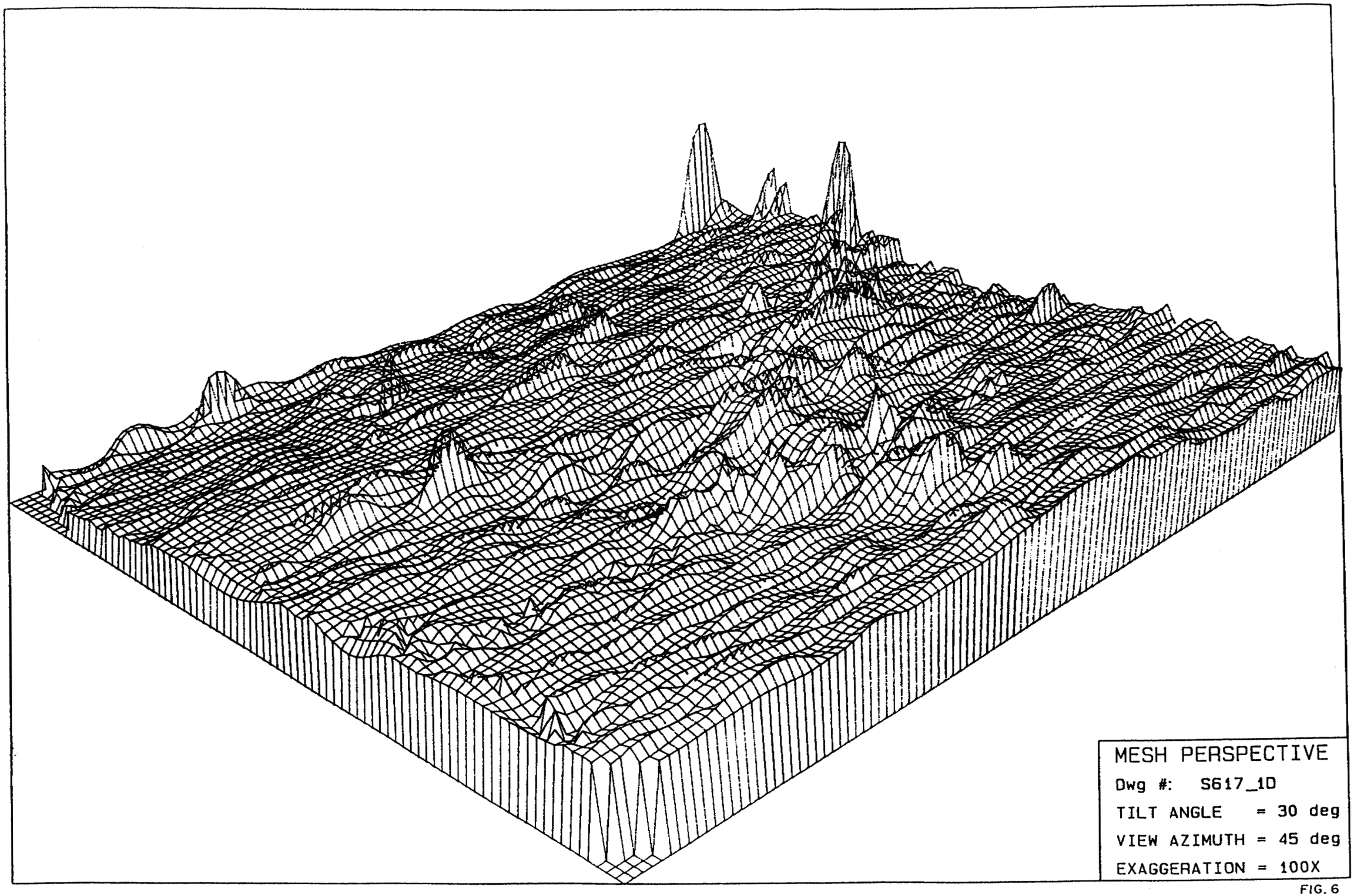

MESH PERSPECTIVE
Dwg #: S617_1D
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 6

A new software module to the package was used to produce color coded thinned spot bathymetry plots. The data was thinned via software such that no two data points would overwrite on each other. The color coding was to give an impression of contour levels. Various depth intervals were plotted in different colours. It was not as useful as hoped but it did highlight any questionable data in the data base as it stood out as a color change in a wrong location. Also, these plots were used to ensure that selected profiles did cross the feature of interest as outlined on the mesh perspective.

The new software also allows a profile line to be interpreted at any direction across the data base. This allows the selection of a profile line that crosses an interesting feature and is not limited to the direction and location of the actual survey line, or the DTM grid.

The end coordinates of the profile lines were scaled off the meshes and profile plots, four to an area, were produced. To fit the profiles on the plans various horizontal and vertical scales were used. Profiles for 9 of the areas were produced. Area 3 could not be processed properly due to a sparse and inadequate distribution of data points.

Mesh perspectives, coloured bathymetrys and profiles of each area are shown beginning at figure 7.

This completed the plan production phase of the Yukon Shelf data.

3.5 Description of Selected Regional Features

The most pronounced features observed on the small scale mosaic of the entire Yukon Shelf study area (Figure 1) trend in roughly east - west to southeast - northwest directions. Therefore, each of the larger scale meshes of the detailed study areas was oriented about 180 degrees from Figure 1, generally to a southwest to northeast direction, to display the onshore portions of the observed bathymetric features.

A noticeable difference in the two series of perspectives, both presented at the same vertical exaggeration, is the apparent roughness of the surface in the smaller scale perspectives. This visual perception is related to the smoothing effect of the algorithms used to create a DTM of smaller cell size for the detailed areas from a set of original soundings of approximately equal density to that used for the small scale plots.

This section provides a brief description of the bathymetric features of each of the detailed study areas, based on the comparison of both scales of mesh perspectives, bathymetry plots, and profiles. The series of detailed plots follows the descriptive text for each area,

3.5.1 Area 1

Area 1 is located about 35 km northwest of Herschel Island, in about 50 m of water depth, near the margin of the Yukon Shelf and Mackenzie Trough physiographical areas. This area was selected for detailed study on the basis of its hummocky bathymetry and relatively high local relief. A mesh perspective, a bathymetry plot and a

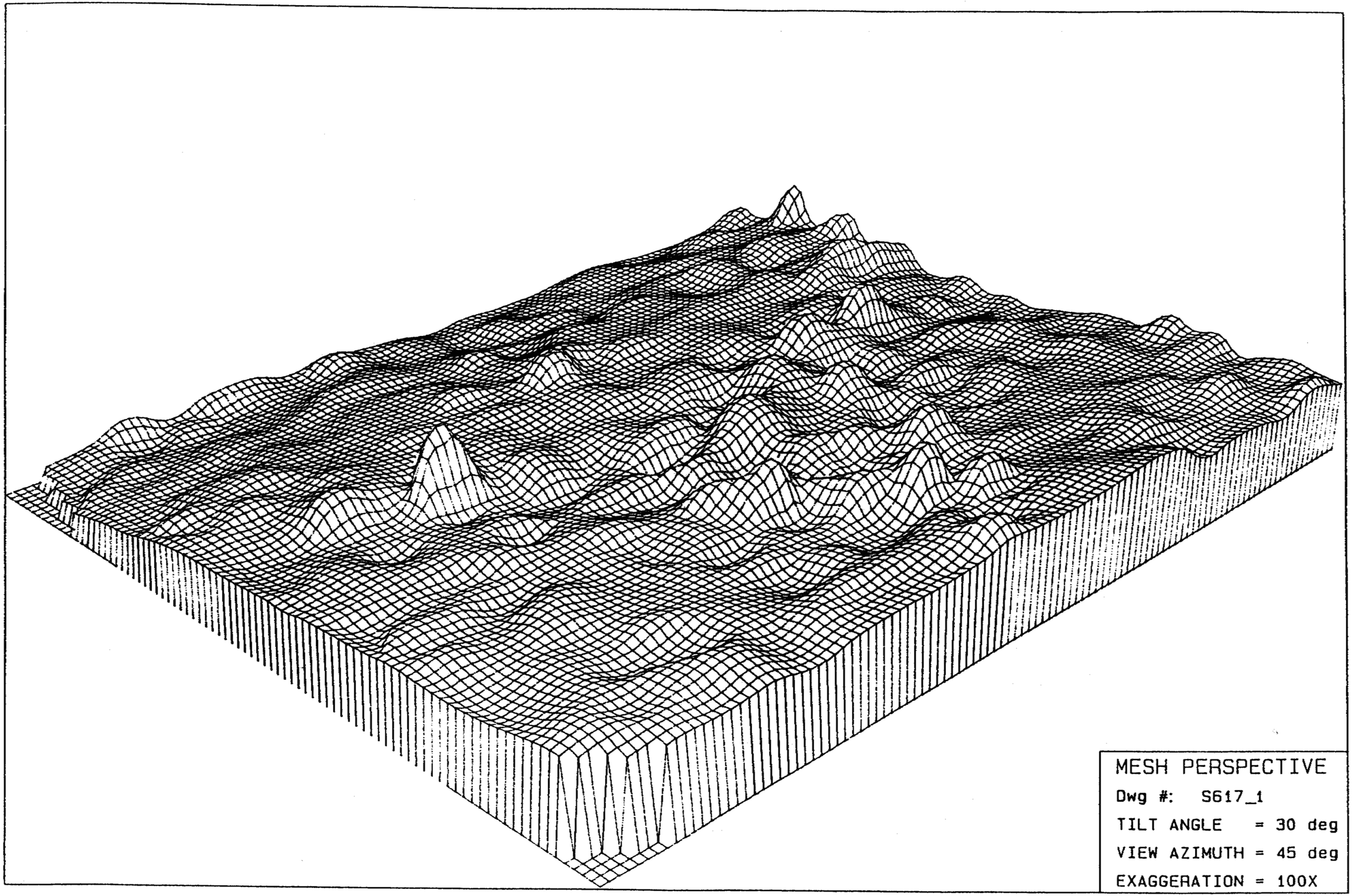
series of profiles for the area are contained in Figures 7 through 9.

The area was identified in two previous studies of the Yukon Shelf undertaken for DIAND. Challenger (1986) described the area as "a series of (parallel, symmetric) interfingering ridges" (Blue-shaded areas, and Detail 7). The origin and composition of these features was not evident from their morphology. Subsequently, Meagher (1986) outlined a similarly irregular-shaped area of "linear shoals and depressions," as Prospect 18, and suggested that this feature may represent lateral or end moraines associated with ice movement along the edge of the Yukon Shelf. A high probability of locating coarse sediment in this prospect was predicted on the basis of geophysical data (hard bottom and unstratified subbottom) and seabed sampling (50 - 80% sand and gravel).

On the small scale mesh (Figure 1), the feature does appear, as outlined in the previous studies, to be a series of southeast - northwest trending ridges. When viewed from the opposite direction, in the detailed mesh (Figure 7), two predominant ridge directions are perceptible. This includes a short, relatively-high relief, northeast - southwest trending ridge located about 12 km inland from the Mackenzie Trough shelf edge. A second, narrower and slightly lower ridge, oriented almost perpendicular to the former, extends from the northern end of the former to the shelf edge to form a roughly "L"-shaped feature. This morphology is also evident in detailed (2m interval) bathymetric contour plans (Meagher, 1986). The latter ridge approximately parallels, and is probably related to, a shallow trough which crosses the outer portion of the Yukon Shelf and enters the Mackenzie Trough just north of Area 1.

Both of the main ridges contain a series of rounded "knobs", most of which appear to be in the order of 500 m to 1000 m in section and 2 m to 5 m in height (Figure 9 - Profiles). Similar hummocks are scattered around the main feature, and these become clustered around the junction of the two ridges. Some of these are oriented such that they form the sub-parallel "ridges" or "linear shoals" identified in the previous studies.

The hummocky nature of the feature, and the extent and distribution of smaller hummocks and depressions around the main portions of the feature, indicate that it may be related to stagnant ice conditions. The apparent relationship of the long, narrow portion of the feature to the trough along its northern edge suggests that there may have been an opportunity for reworking of the inferred glacial deposits. Both of these conditions would increase the probability of the occurrence of granular material in this area.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TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 7

--7 763 000

--7 757 000

-554 000

-558 000

BATHYMETRY PLOT

Scale: 1/40000

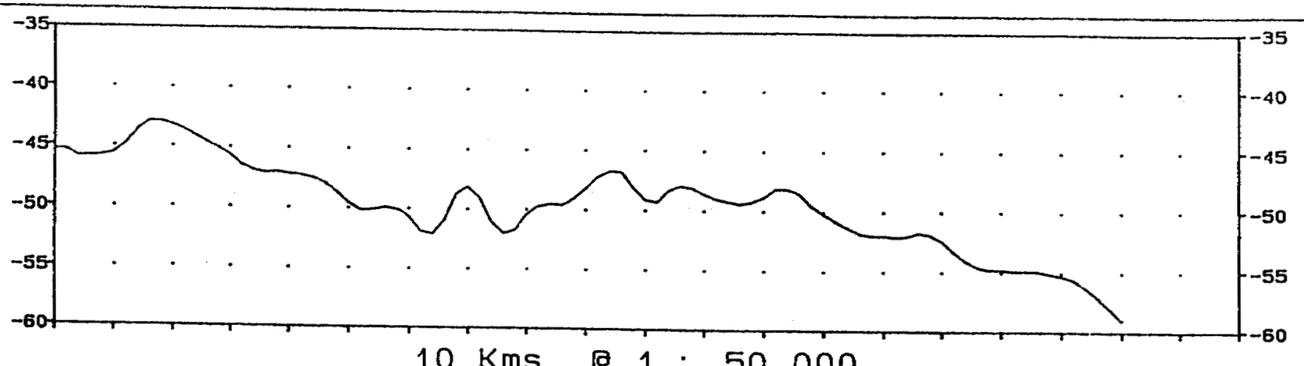
Dwg #: S617_1

- 28 - 40
- 40.1 - 45
- 45.1 - 50
- 50.1 - 55
- 55.1 - 60

FIG. 8

START

LINE # 1
N 7755100
E 559870
AZ 000



END

N 7765100
E 559870

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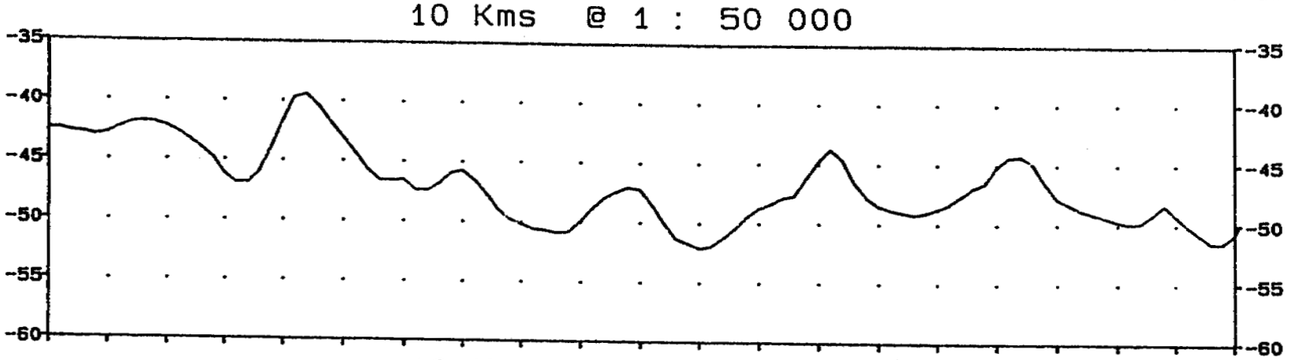
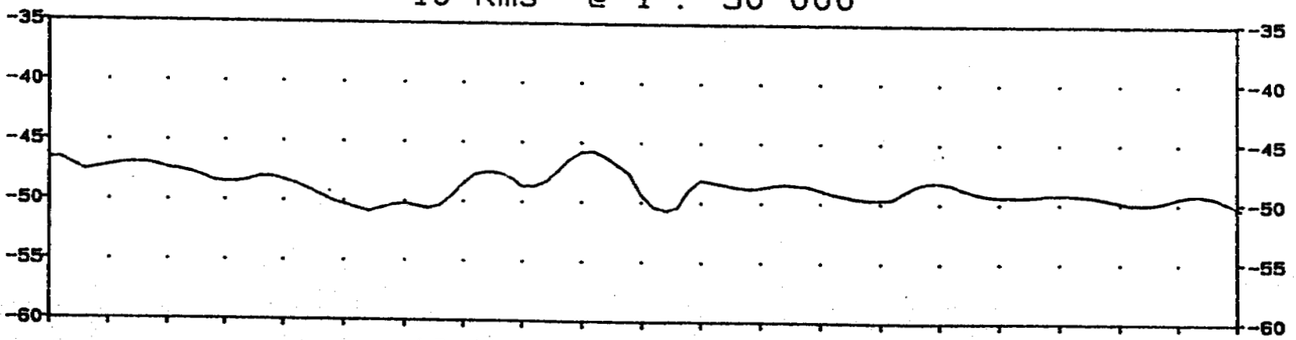
LINE # 2
N 7755074
E 555937
AZ 042



N 7753457
E 546069

10 Kms @ 1 : 50 000

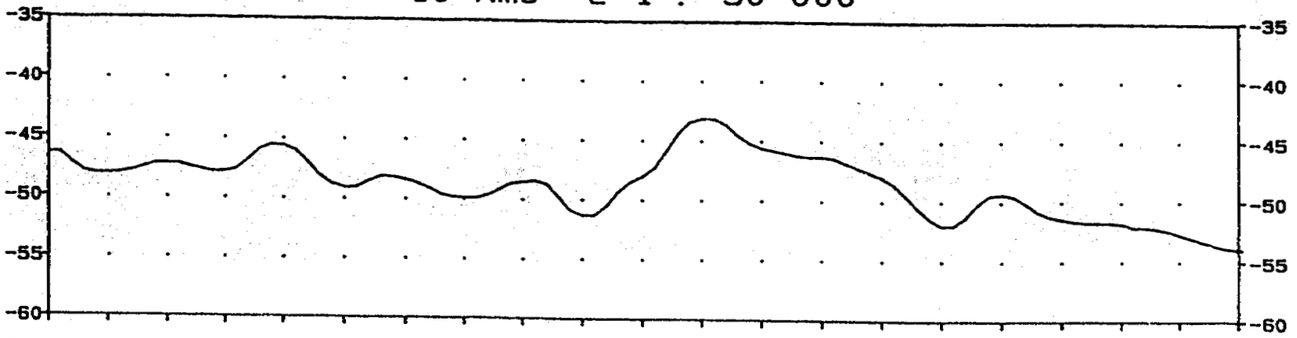
LINE # 3
N 7756808
E 561972
AZ 298



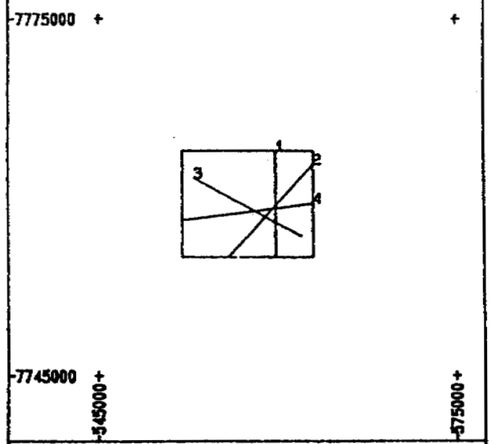
N 7746821
E 562483

10 Kms @ 1 : 50 000

LINE # 4
N 7758143
E 552100
AZ 083



N 7764667
E 559678



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON)
CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 50 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No.	SHEET
A7134-6-0038/01-ST	2 OF 10
CSS JOB NO.	DRAWING NO.
S-617	S617-1

CHALLENGER SURVEYS & SERVICES LTD.
EDMONTON - ALBERTA

FIG. 9

3.5.2 Area 2

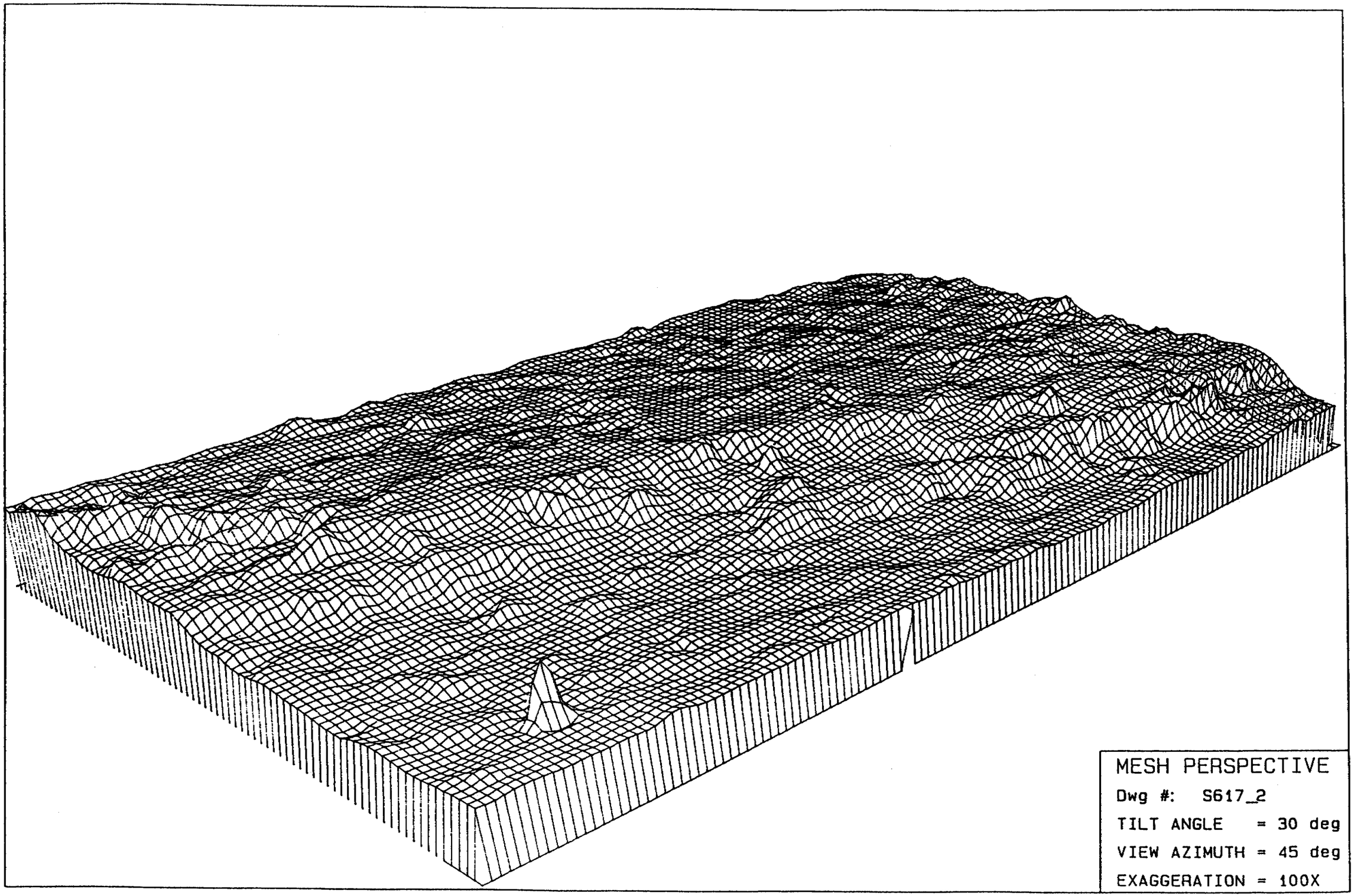
This area, situated about 5 km northwest of Area 1, includes the central to eastern portions of a broad ridge, located about 45 km offshore, near the outer edge of the Yukon Shelf. Superimposed upon the main outer ridge is a narrow, sinuous ridge, up to 15 m in height and 50 km in length, with several tributary branches. This feature was not previously identifed on contour plans but was readily apparent on mesh perspective plots (Challenger, 1986; "yellow area"). Its morphology suggests a glacial origin; possibly an esker or terminal moraine associated with the Illinoian Glaciation. On this basis, this area was thought to have a high potential for the occurrence of granular deposits.

Meagher's (1986) interpretation of the area is less optimistic regarding its granular resource potential. Although the side scan sonar records and grab samples from the main outer ridge suggest the presence of significant amounts of sand and gravel at the seabed, these deposits cross the interpreted seismo-stratigraphic units, and may be so thin that they are not detected by acoustic profiling methods. The available seismic and borehole data also fails to indicate a potential source for the granular material. Meagher (1986) is unable to distinguish a separate stratigraphic unit associated with the superimposed branching feature, designated the "Natsek Ridge," but speculates that it could contain local coarse-grained units.

A detailed mesh perspective of Area 2 is presented as Figure 10, and bathymetric soundings and a series of profiles across the area are shown in Figures 11 and 12, respectively. The detailed mesh shows that the shoreward flank of the main outer ridge is relatively steep,

particularly at its eastern end, and this is supported by the profiles in Figure 12. The superimposed Natsek Ridge, while clearly evident in Figure 10 (viewed from the southwest), appears less branching than it does from the perspective of Figure 1 (oriented 180 degrees from Figure 10).

Features which seemed, on the small scale mesh, to be tributary branches of the main portion of the Natsek Ridge, appear on the detailed mesh to be, perhaps, wave-formed benches or obliquely-attached bars. In profile (Figure 12), the Ridge is about 2.5 km - 3.5 km wide and about 5 m high. At the eastern end of Area 2, it seems to originate from a broader (8 km wide), hummocky upland. Also visually significant on Figure 10, is the distinct contrast between the relatively featureless seabed in the foreground (southwest of the main ridge) and the extremely irregular and hummocky microrelief of the background. It is possible that the areas of relatively smooth seabed are composed of sands which can be mobilized by current action. Meagher (1986) reports that sand ripples are evident on side scan sonographs of this area.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VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 10

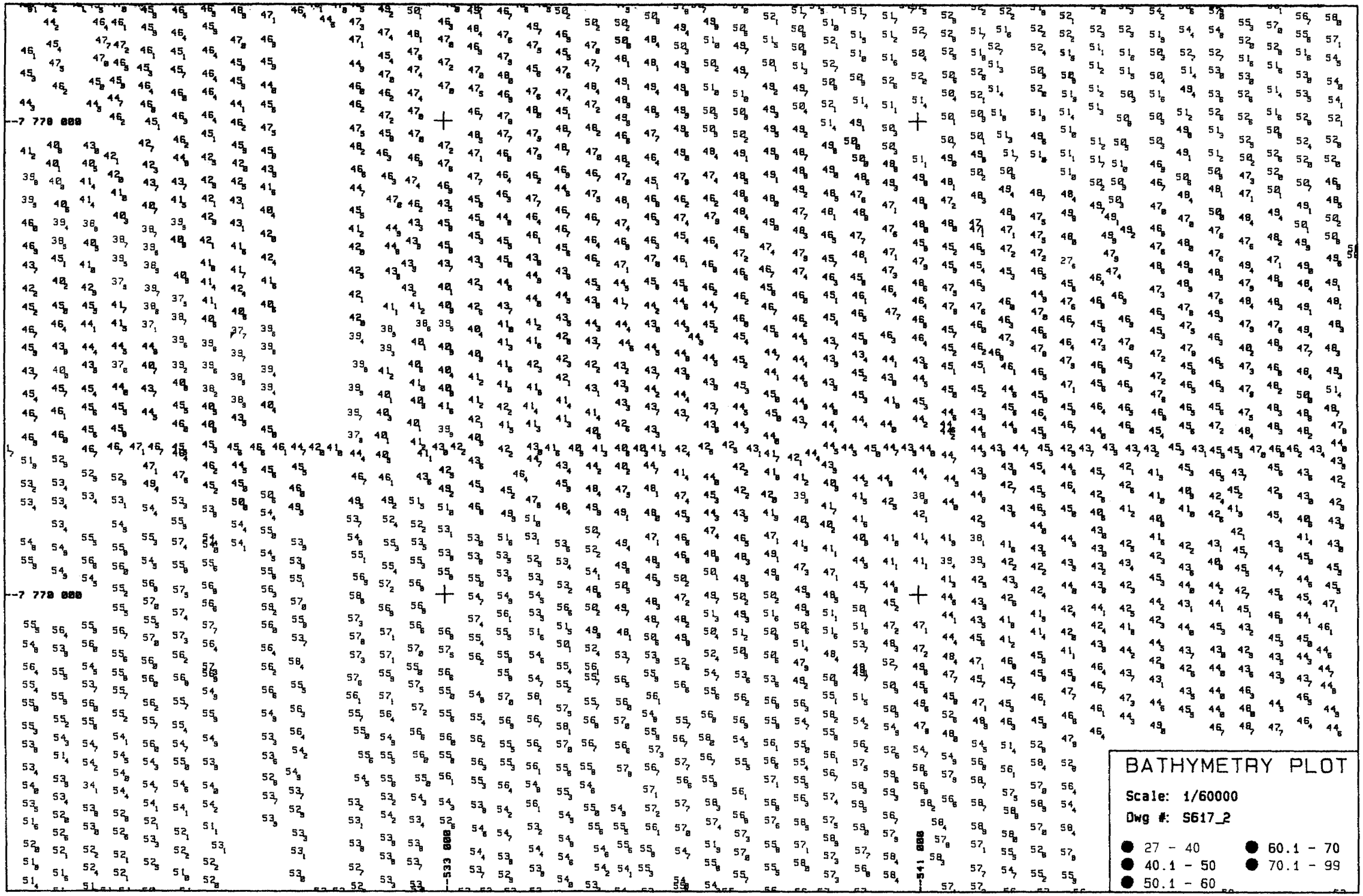
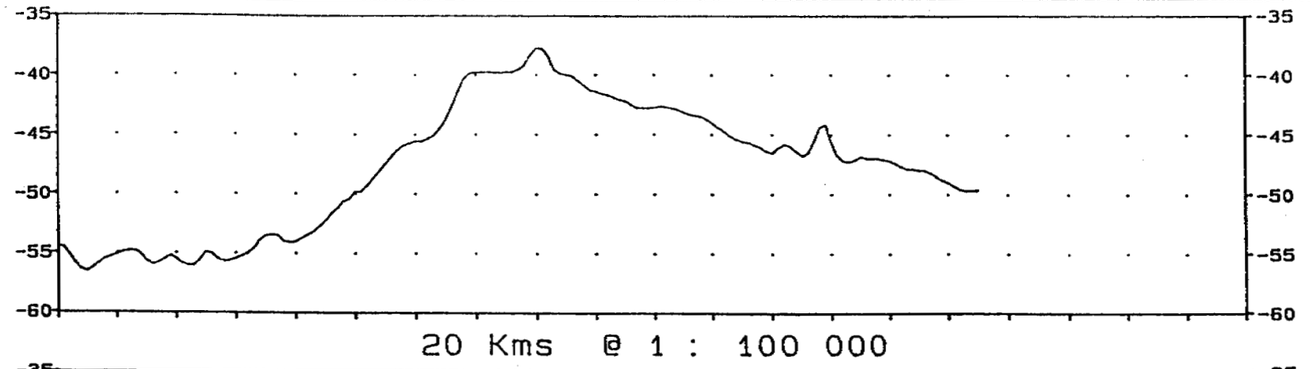

--7 770 000
--7 770 000
--533 000
--541 000
BATHYMETRY PLOT
Scale: 1/60000
Dwg #: S617_2
27 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 99

FIG. 11

START

LINE # 1
N 7768663
E 524068
AZ 043

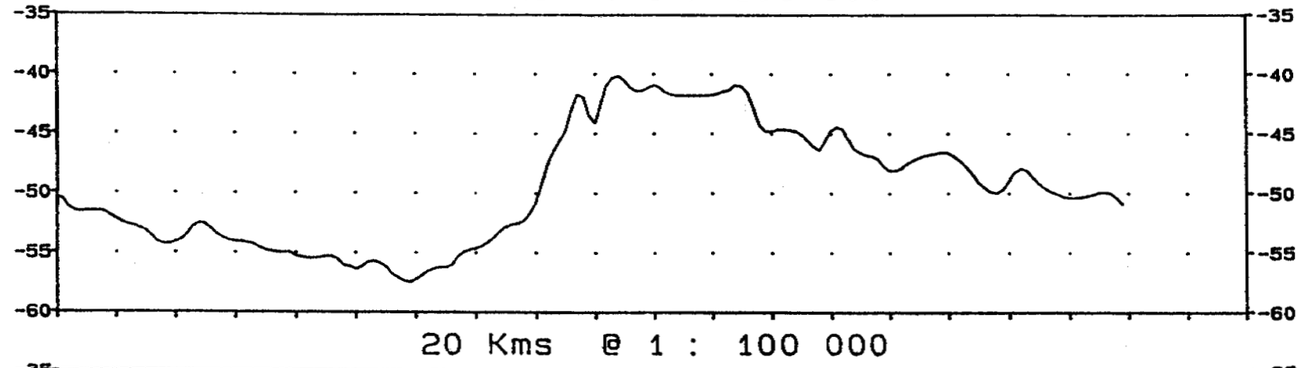


END

N 7781078
E 508388

20 Kms @ 1 : 100 000

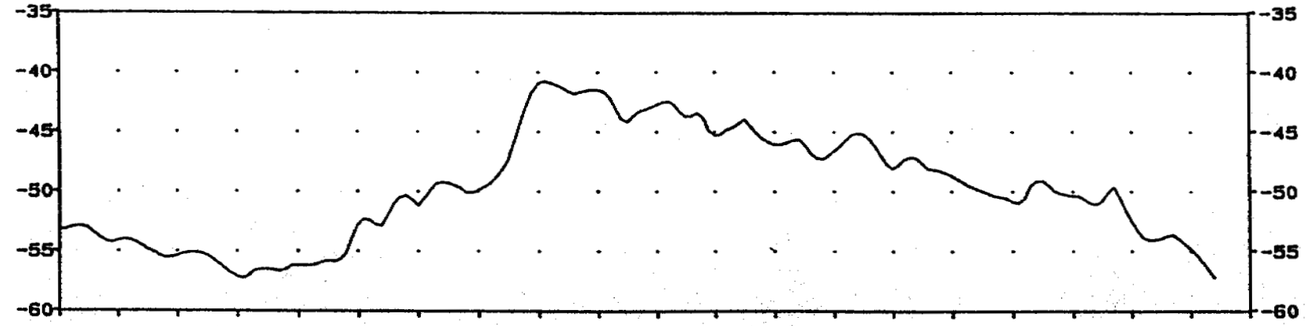
LINE # 2
N 7765083
E 528106
AZ 034



N 7749247
E 540321

20 Kms @ 1 : 100 000

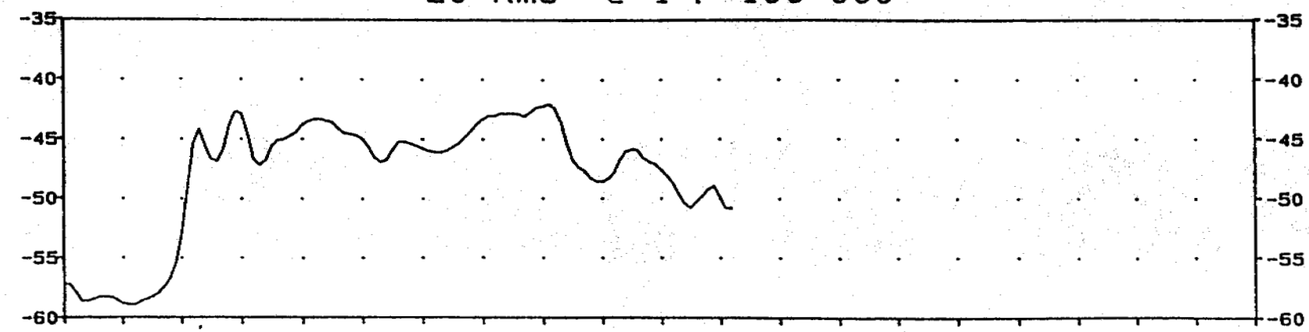
LINE # 3
N 7765077
E 533865
AZ 040



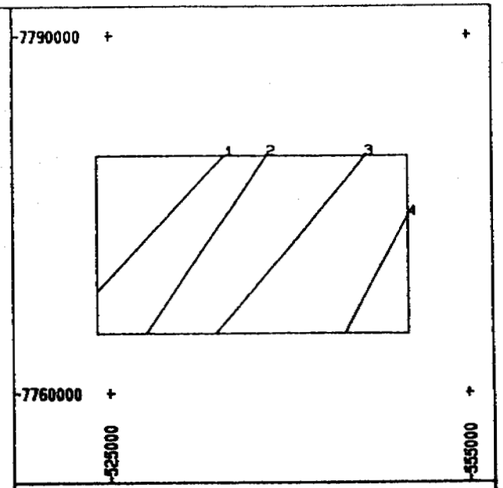
N 7751304
E 548367

20 Kms @ 1 : 100 000

LINE # 4
N 7765088
E 544559
AZ 029



N 7748716
E 533072



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA

WESTERN BEAUFORT (YUKON)

CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 100 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

OSS FILE No. A7134-6-0038/01-ST	SHEET 3
CSS JOB NO. S-617	DRAWING NO. S617-2
CHALLENGER	SURVEYS & SERVICES LTD. EDMONTON - ALBERTA

FIG. 12

3.5.3 Area 2A

The Natsek Ridge divides near its northwesterly end, into three distinct "branches." A mesh perspective, bathymetry plot and series of profiles of this portion of the Yukon Shelf, designated Area 2A and located immediately northwest of Area 2, are presented as Figures 13 to 15. Although the seabed topography of the detailed perspective (Figure 13) is visually smoother than in the small scale drawing (Figure 1), the three ridge crests are clearly evident. Local relief on these 1 km-wide ridges ranges from less than 2 m to about 5 m (Figure 15), and they are more symmetrical than the main body of the Ridge in Area 2. The profile along the main axis of the ridge (Profile 1 in Figure 15) shows that the ridge slopes to the northwest. The main branch fades out just beyond the end of this profile, and although the other two branches continue beyond Area 2, they apparently disappear also east of the international border (Figure 1).

On the basis of their morphology alone, these ridges could represent distributary channels at the mouth of an esker. Meagher (1986) reports that a borehole drilled between two of the branches did not encounter any stratigraphic unit that could be condidered a potential source of coarse-grained seabed sediment. However, grab samples in the vicinity of the borehole are predominantly (50 - 80%) sand and gravel. The surrounding area, although outside of the delineated area of seabed sand ripples (Meagher, 1986), appears relatively featureless from both perspectives (Figure 1 and Figure 13).

3.5.4 Area 3

This area, located along the eastern edge of the Yukon Shelf, was selected for detailed study on the basis of its potential relationhip to the western margin of a postulated offshore ice sheet (Challenger, 1986; orange area and Details 1, 2 and 3). Side scan and (very limited) sample data indicates seabed gravel over much of the area (Meagher, 1986; Prospect 17). Also included in Area 3 is a shoal (Prospect 16), along the postulated ice margin (orange area in Challenger, 1986), from which a grab sample with only 5% fines was recovered.

Due to the combined effects of the orientation of a limited number of survey lines parallel to the long axis of this narrow rectangular block, the occurrence of unreadable lines and missing data points and the relatively large range of water depths, it was not possible to process the data into an appropriate detailed mesh perspective of this area. Area 5, described below, and also along the shelf edge, includes an area that is interpreted from side scan records to contain predominantly gravel materials. The bathymetry plot for Area 3 is presented as Figure 16.

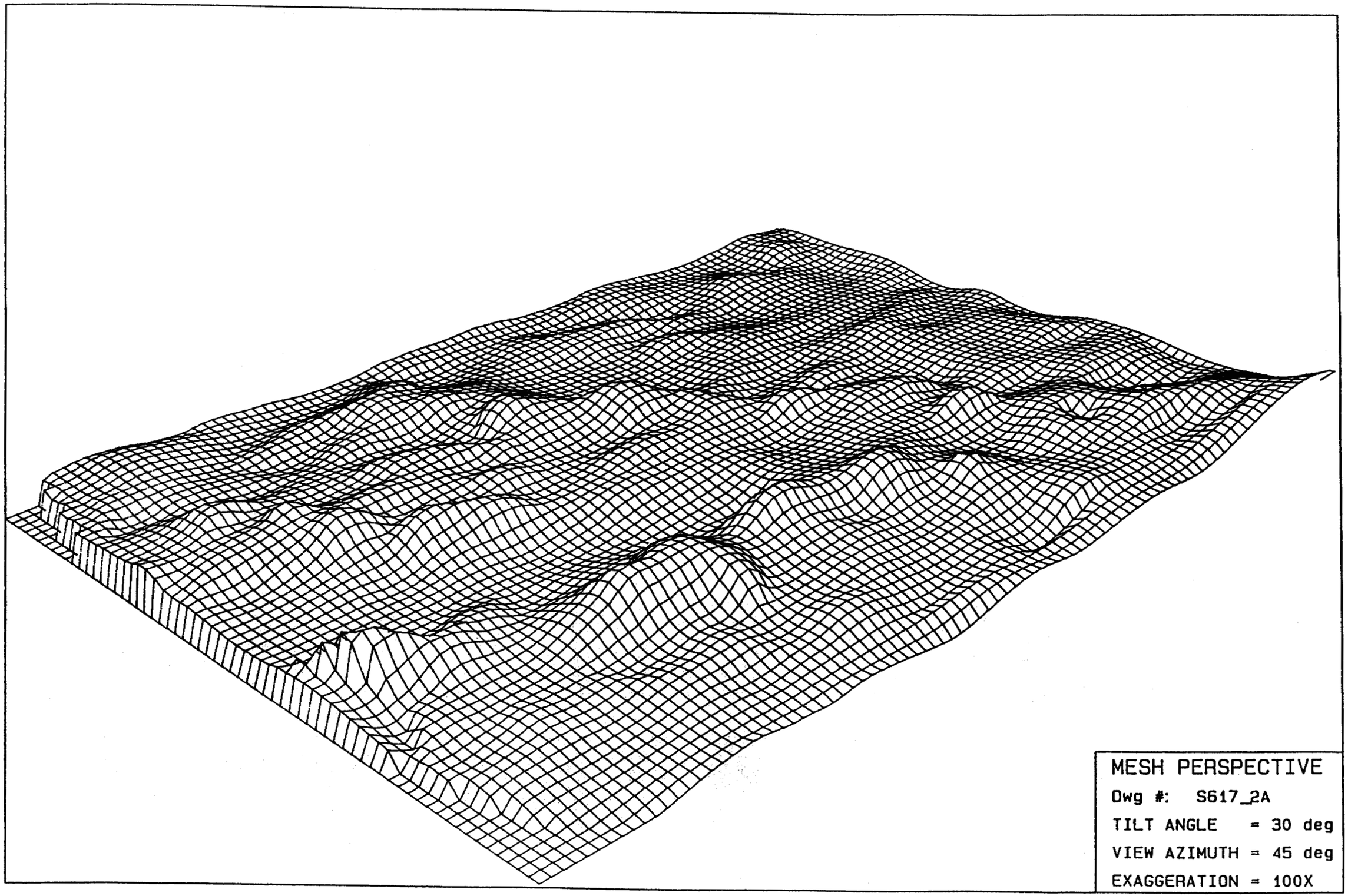

MESH PERSPECTIVE
Dwg #: S617_2A
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 13

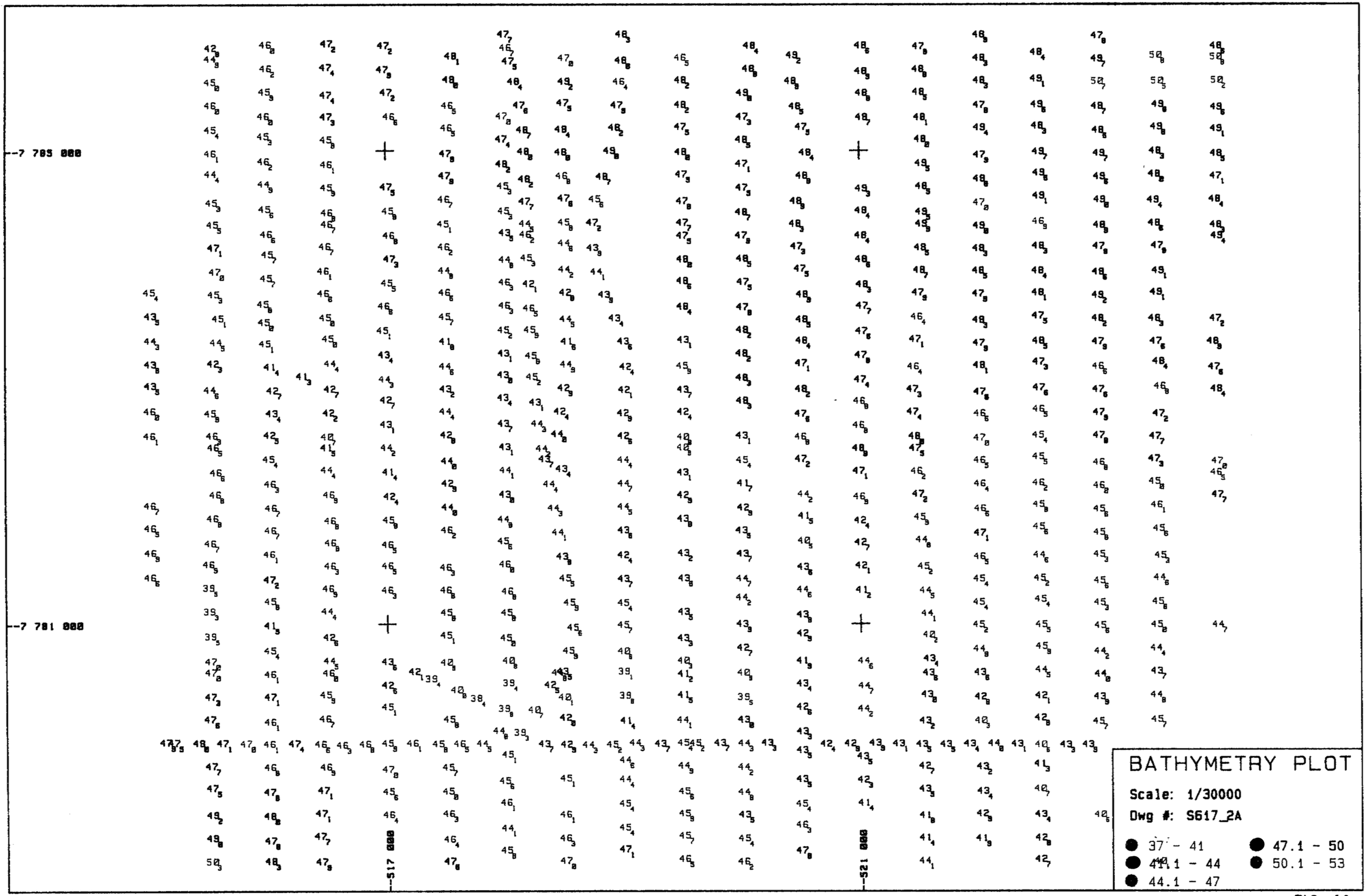
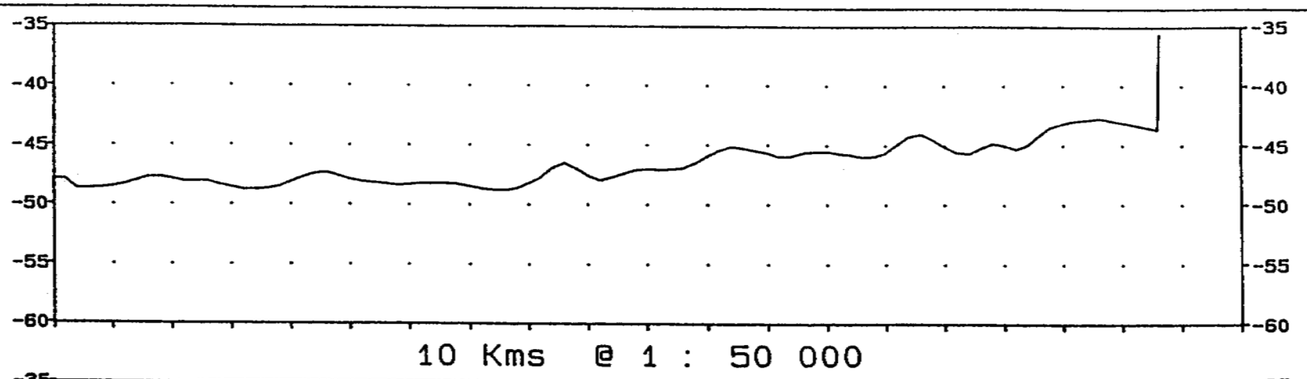

--7 785 000
--7 781 000
--517 000
--521 000
BATHYMETRY PLOT
Scale: 1/30000
Dwg #: S617_2A
37 - 41
41.1 - 44
44.1 - 47
47.1 - 50
50.1 - 53

FIG. 14

START

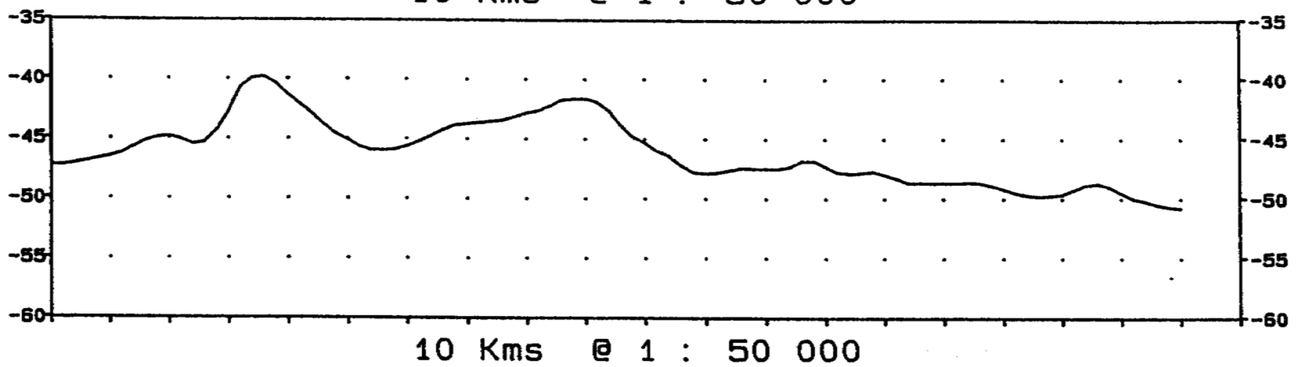
LINE # 1
N 7785925
E 517867
AZ 138



END

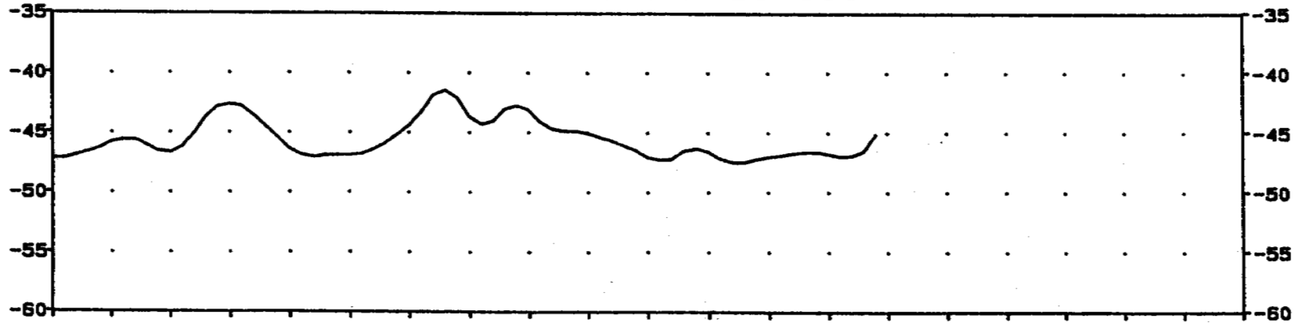
N 7795636
E 520252

LINE # 2
N 7779073
E 516890
AZ 044



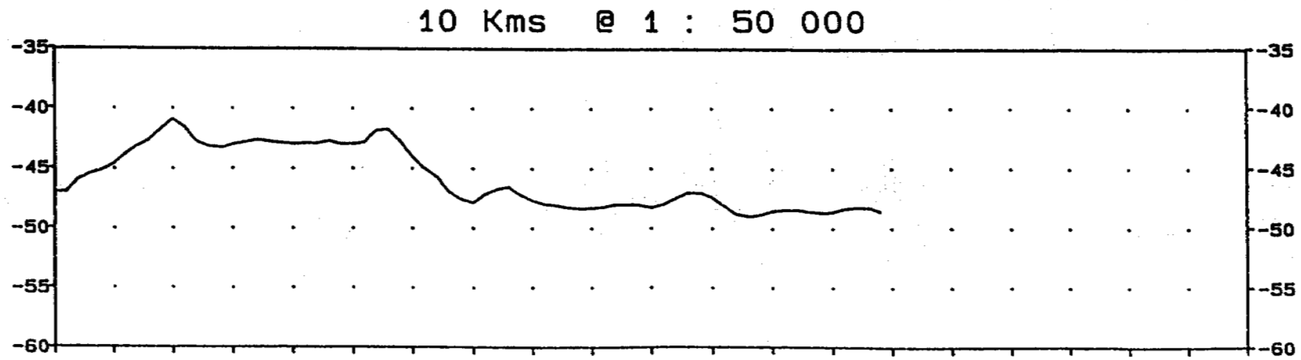
N 7788553
E 513709

LINE # 3
N 7779100
E 517000
AZ 000

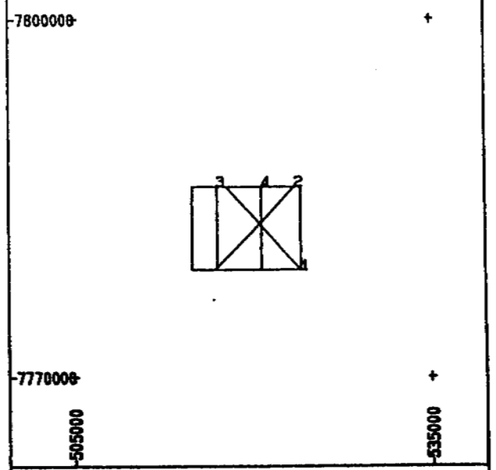


N 7789100
E 517000

LINE # 4
N 7779100
E 520680
AZ 000



N 7789100
E 520680



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON)
CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 50 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No. A7134-6-0038/01-ST	SHEET 4 OF 10
CSS JOB NO. S-617	DRAWING NO. S617-2A
CHALLENGER	SURVEYS & SERVICES LTD. EDMONTON - ALBERTA

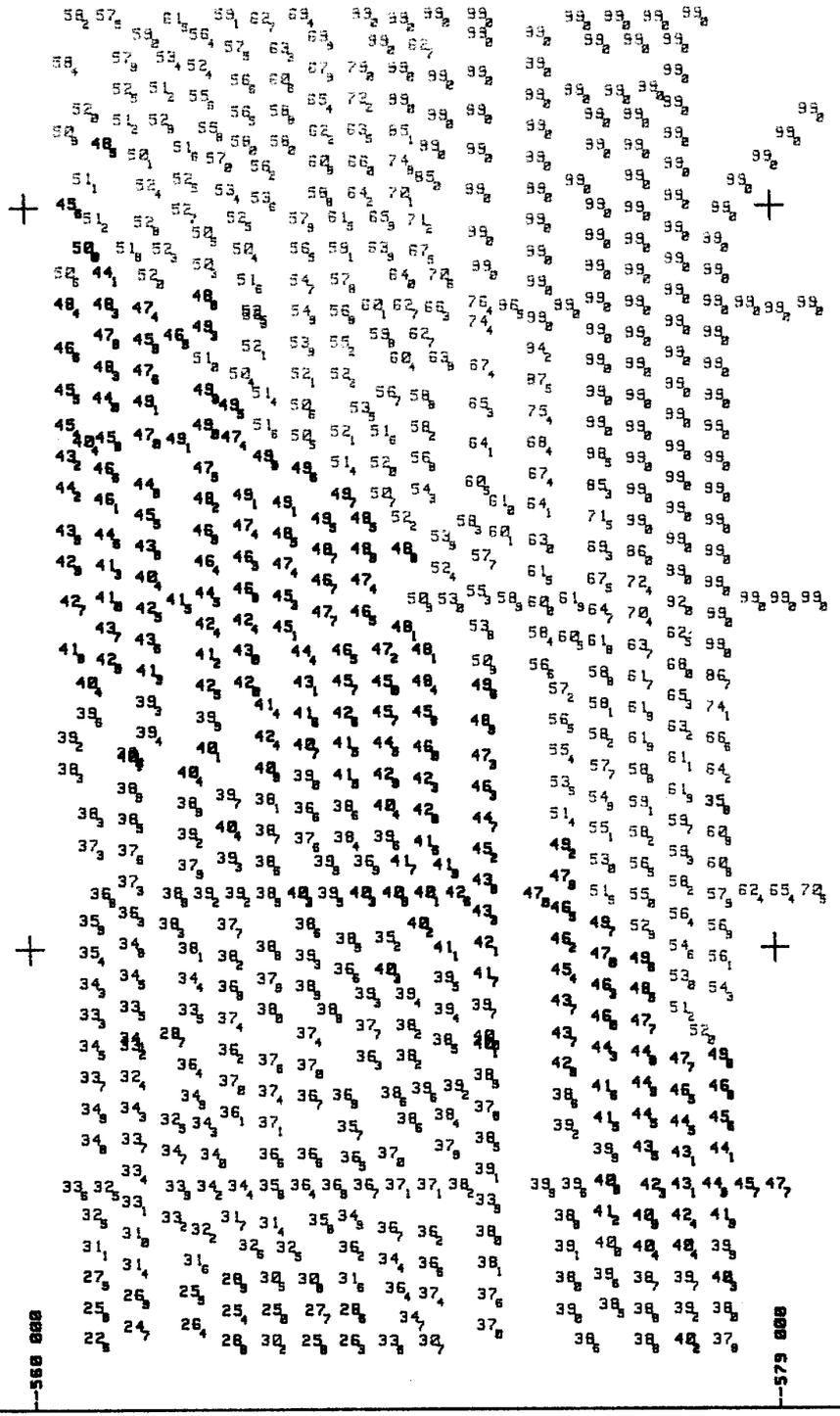
FIG. 15

--7 760 000

--7 741 000

--560 000

--579 000



BATHYMETRY PLOT

Scale: 1/150000

Dwg #: S617_3

- 7 - 20
- 20.1 - 30
- 30.1 - 40
- 40.1 - 50
- 50.1 - 99

FIG. 16

3.5.5 Area 4

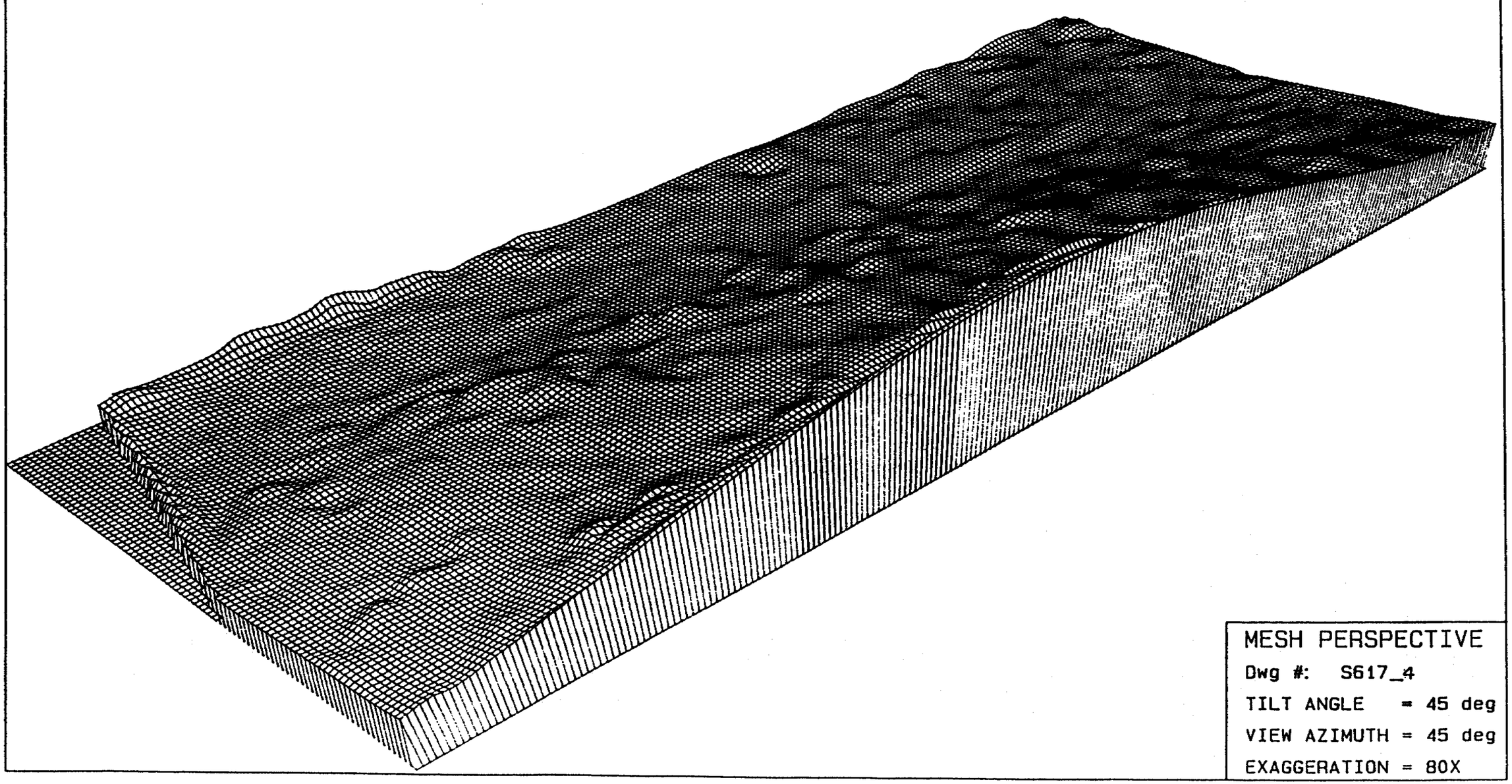
Area 4 covers the steep offshore face of the alluvial fan at the mouth of the Malcolm River and the relatively flat apron seaward from the fan. This area was identified by Challenger (1986), as the "brown area," and by Meagher (1986), as Prospect 1/1A. The fan itself is undoubtedly predominantly granular, based on onshore and coastal evidence and offshore grab samples, and it was likely deposited subaerially prior to sea level rising to its present position. (Meagher, 1986). The offshore portion of Area 4 is thought to be mainly fine-grained lacustrine or lagoonal sediments, although some grab samples contained sand and gravel-sized material. The latter probably represent thin deposits derived from reworking of the fan sediments.

The mesh perspective for Area 4 (Figure 17) is viewed down the surface of the fan, thus it reveals little about the fan. The small scale perspective (Figure 1) shows the surface to be dissected by relatively steep-sided channels. These are evident also in the profiles in Figure 19. Around the perimeter of the base of the fan, there are a series of low hummocks, depressions and shallow channels, which also appear in profile. Beyond this, is the shallow depression between the fan base and an inshore ridge located 10 km offshore (red area; Challenger, 1986). It is likely that fine sediments are currently accumulating in this depression. The hummocky areas around the base of the fan are considered to be the best prospects for granular resources in the offshore portion (Meagher's Prospect 1A) of Area 4.

3.5.6 Area 4A

This area is located east of Area 4, and offshore of the fan at the mouth of the Firth River, between the offshore portion of the Malcolm fan and Herschel Island. Meagher (1986) reports that this area is accumulating sediment that is transported by longshore currents. Figures 20 to 22 include a mesh perspective, bathymetry plot and profiles for Area 4A.

Like Area 4, this area contains a series of hummocks, depressions and channels in an otherwise smooth seabed. The channels are relatively well-defined and clearly south to north trending. In contrast to Area 4, a significant portion of the small scale bathymetric highs display a distinct east - west orientation. These features are believed to represent deposits formed by longshore currents, and as such are expected to have the greatest potential for containing granular material in this area.



MESH PERSPECTIVE
Dwg #: S617_4
TILT ANGLE = 45 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 80X

FIG. 17

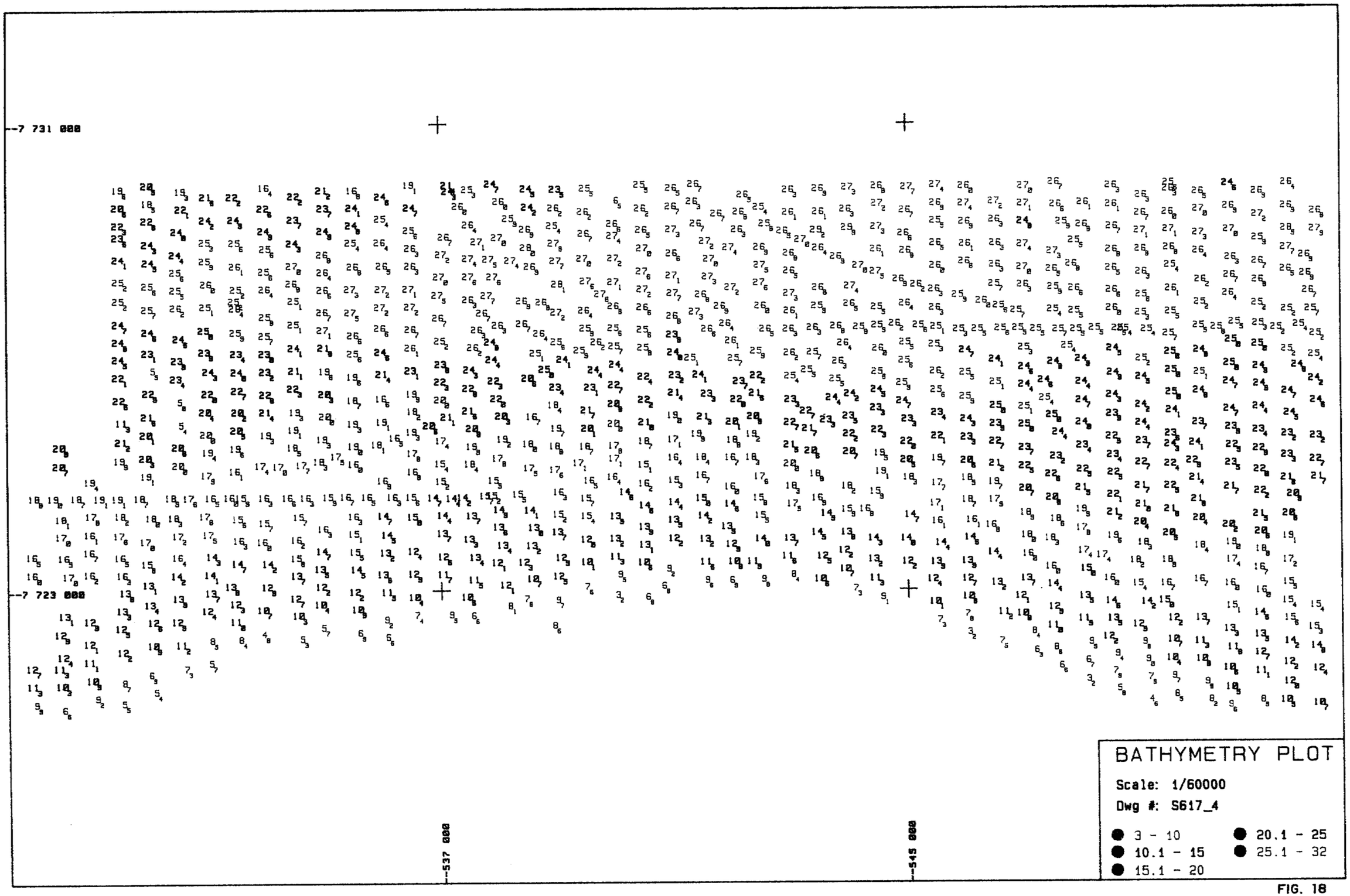
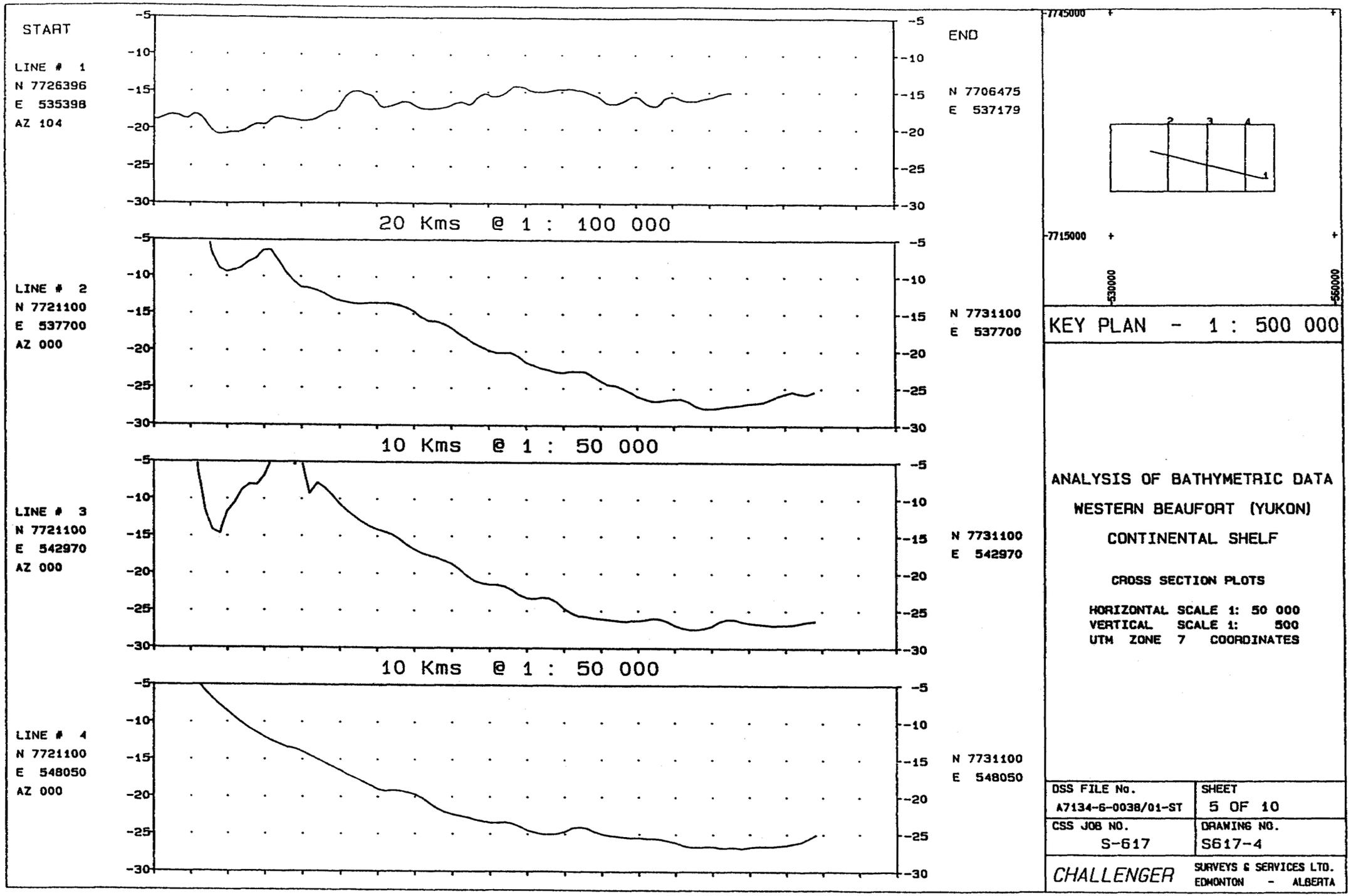

--7 731 000
--7 723 000
--537 000
--545 000
BATHYMETRY PLOT
Scale: 1/60000
Dwg #: S617_4
3 - 10
10.1 - 15
15.1 - 20
20.1 - 25
25.1 - 32

FIG. 18



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON) CONTINENTAL SHELF

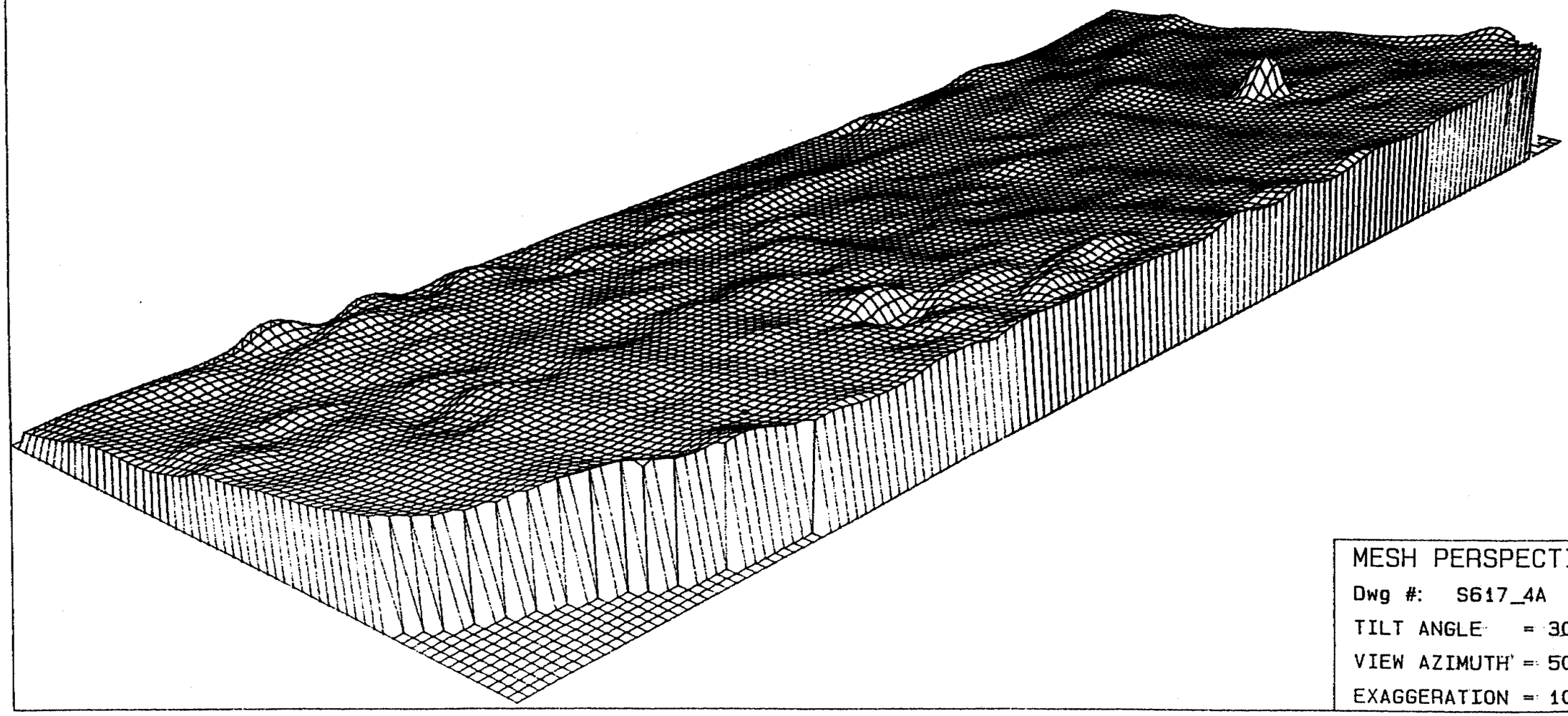
CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 50 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No.	SHEET
A7134-6-0038/01-ST	5 OF 10
CSS JOB NO.	DRAWING NO.
S-617	S617-4

CHALLENGER SURVEYS & SERVICES LTD.
EDMONTON - ALBERTA

FIG. 19



MESH PERSPECTIVE
Dwg #: S617_4A
TILT ANGLE = 30 deg
VIEW AZIMUTH = 50 deg
EXAGGERATION = 100X

FIG. 20

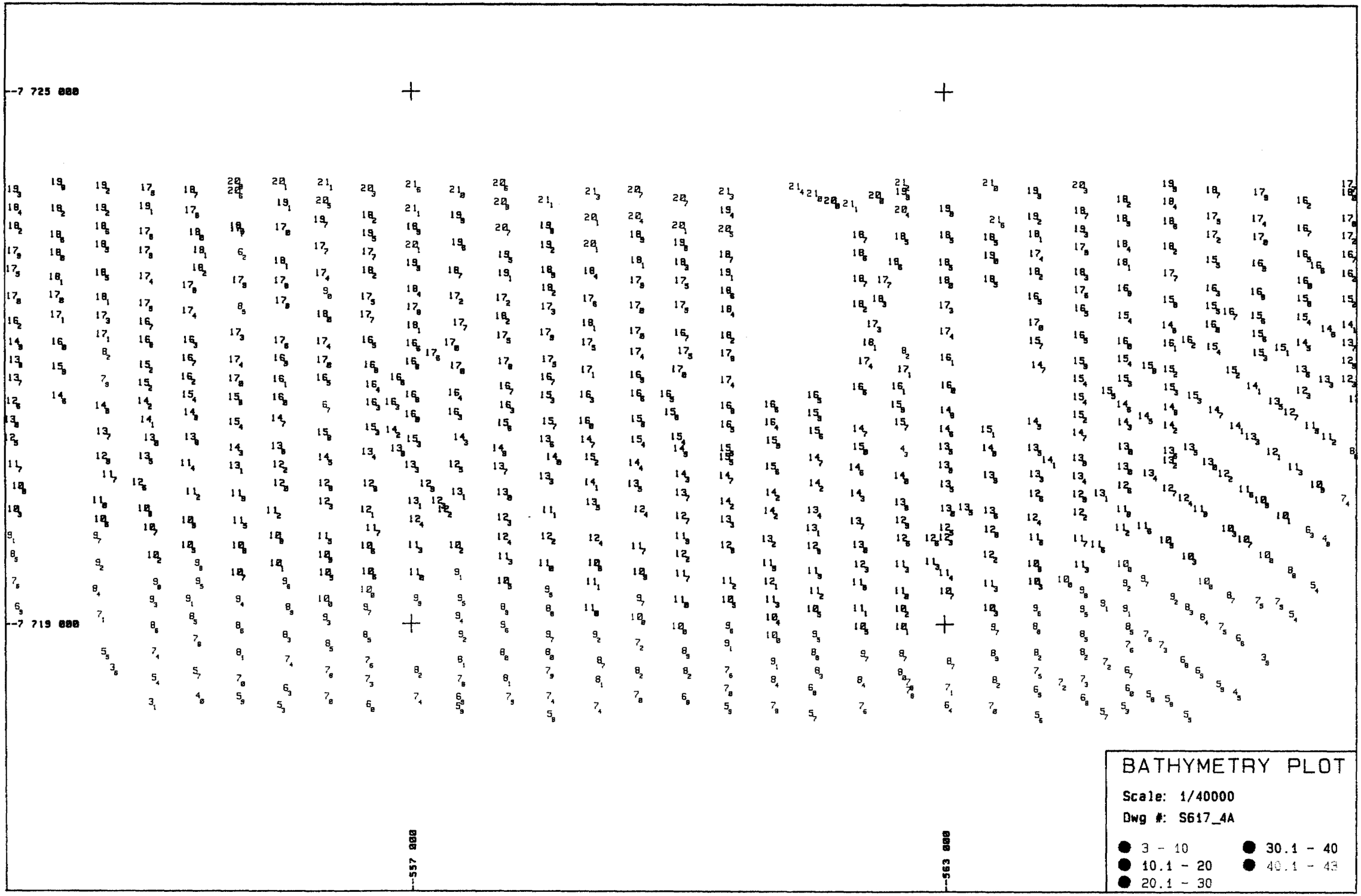
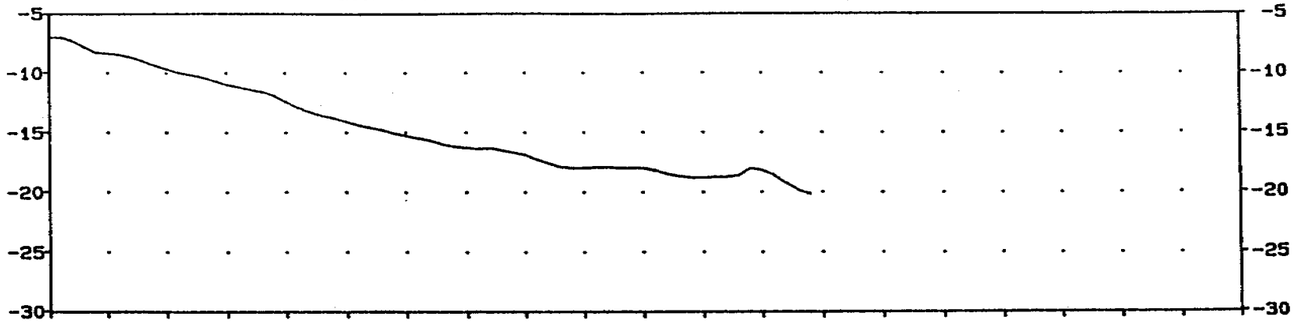

--7 725 000
--7 719 000
--557 000
--563 000
BATHYMETRY PLOT
Scale: 1/40000
Dwg #: S617_4A
3 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 43

FIG. 21

START

LINE # 1
N 7718092
E 559690
AZ 023

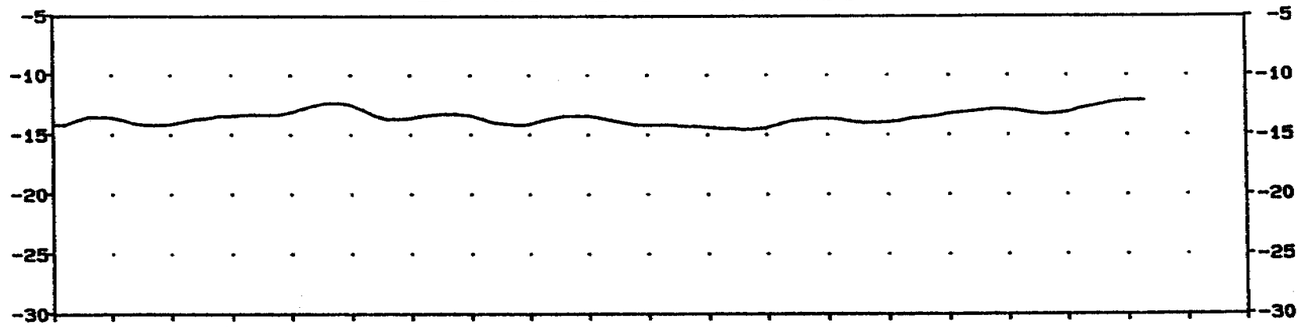


END

N 7714385
E 550402

10 Kms @ 1 : 50 000

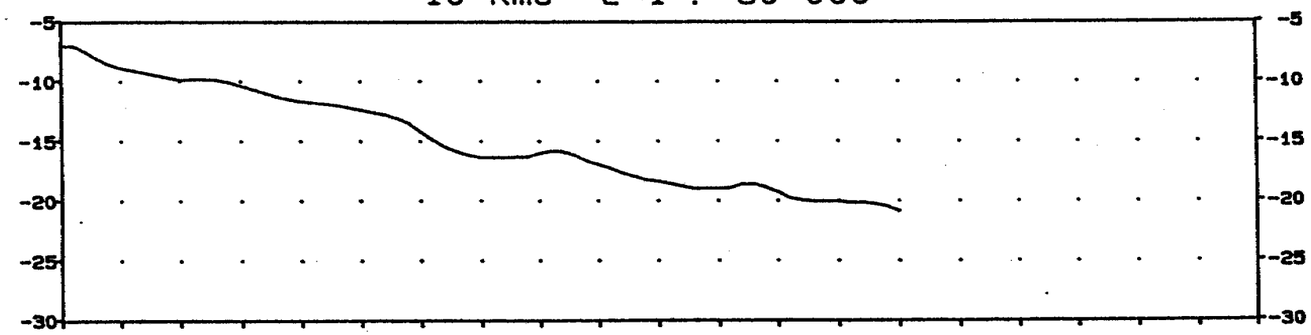
LINE # 2
N 7720990
E 555220
AZ 096



N 7722142
E 565153

10 Kms @ 1 : 50 000

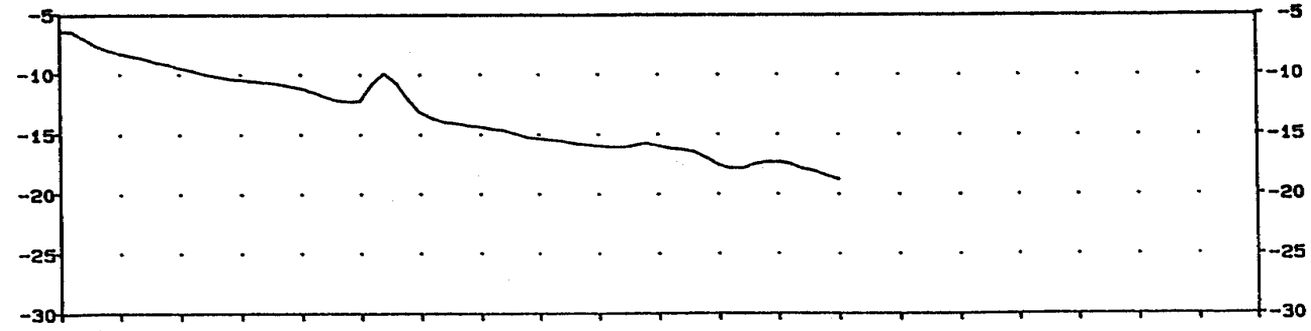
LINE # 3
N 7718873
E 553709
AZ 043



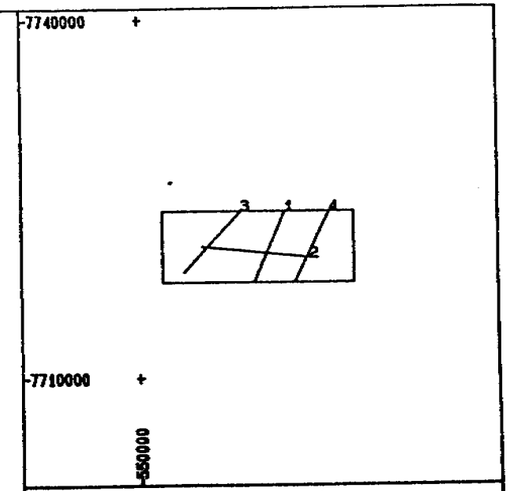
N 7727310
E 548340

10 Kms @ 1 : 50 000

LINE # 4
N 7718091
E 563045
AZ 026



N 7721686
E 572376



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON)
CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 50 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No. A7134-6-0038/01-ST	SHEET 6 OF 10
CSS JOB NO. S-617	DRAWING NO. S617-4A

CHALLENGER SURVEYS & SERVICES LTD. EDMONTON - ALBERTA

FIG. 22

3.5.7 Area 5

This area, located adjacent to Area 2, includes the eastern end of the outer ridge (Challenger, 1986; yellow area, Detail 5) and a low ridge extending from the outer ridge to the shelf edge. The latter is described as Prospect 19 by Meagher (1986). Also included is an area of seabed gravels, as determined from side scan data (Meagher, 1986). No samples have been obtained for this area, hence its prospectivity is entirely based on geophysical data.

The mesh perspective, bathymetry plot, and profiles in Figures 23, 24 and 25 do not contribute significantly to the delineation of the seabed features in this area. There are numerous irregular hummocks and depressions, and although no predominant orientation is evident from the perspective plot, some of the hummocks show a faint east - west trend. Along the eastern side of Area 5, adjacent to the margin of the Mackenzie Trough, there is a faint north - south trend. Due to the orientation of the perspective along the main axis of the low ridge (Prospect 19), this feature is not obvious. The profiles show local relief to be generally less than 2 m and most features are only 500 - 1000 m in width.

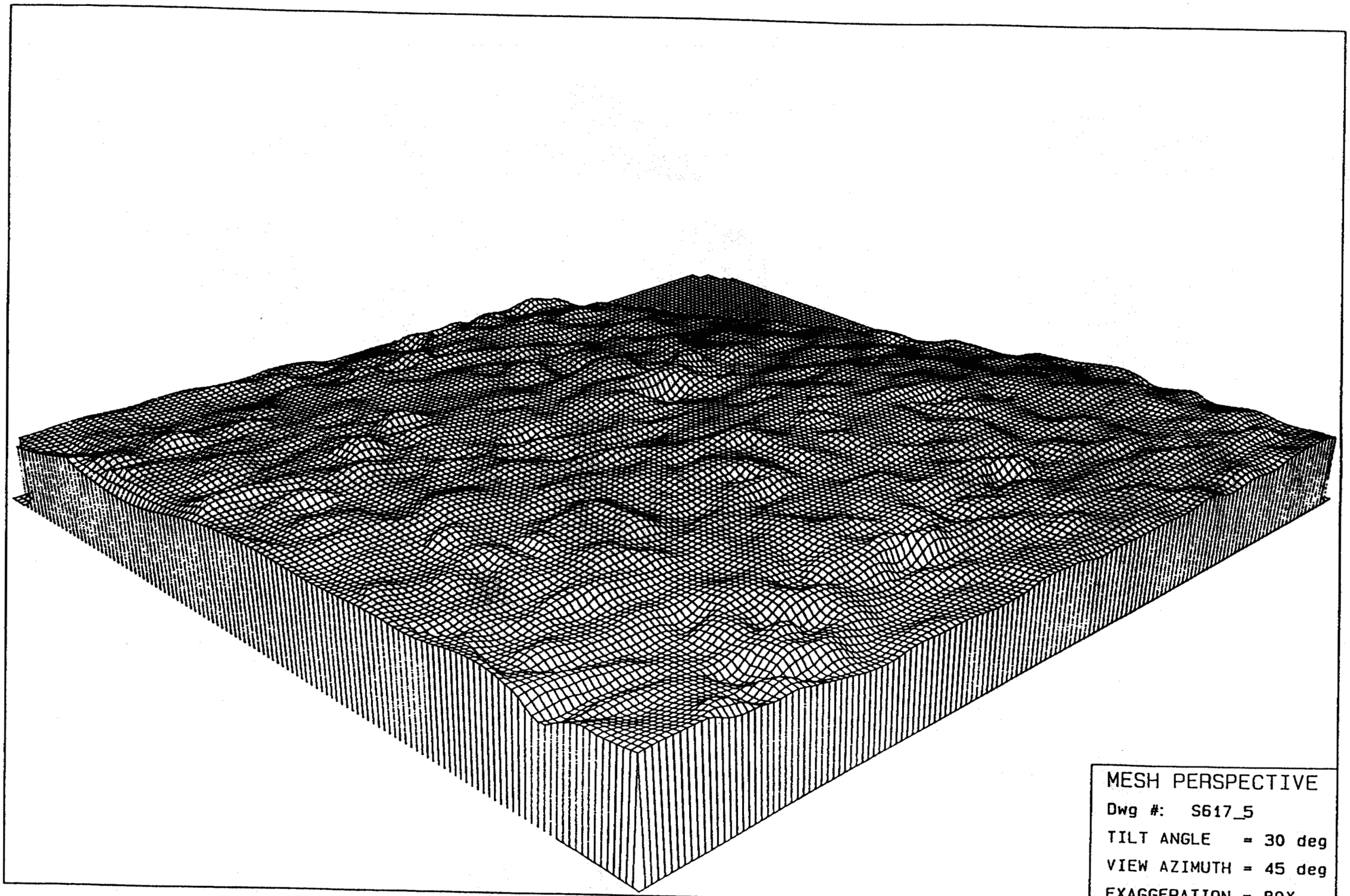
The areas containing seabed gravels are likewise not evident from the detailed bathymetric data. However, there appears to be a flat terrace, that is partially hidden by the higher shelf area in the foreground, along the shelf edge. The small scale mesh perspective, in Figure 1, shows a relatively smooth seabed on the narrow shelf-edge terrace in Area 5, and throughout the seabed gravel area delineated in Meagher (1986), including Area 3.

3.5.8 Area 6

This area includes the offshore extension of the alluvial fan - delta complex at Clarence Lagoon. It was designated Prospect 4 by Meagher (1986). A mesh perspective, bathymetry plot and profiles of the area are presented in Figures 26 to 28.

The mesh perspective (Figure 26) shows the steep front of the submerged alluvial fan/delta front, and several deeply incised channels. Several low, north - south trending ridges extend from the delta front to the offshore, and a larger, broad ridge extends to the northern end of Area 6. This latter feature is approximately 3 - 4 km long, about 1000 m wide and up to 3 m high. Meagher (1986) indicates that this ridge is connected to the shoreline (presumedly stratigraphically), but it appears to be separated bathymetrically by a low east - west trending bar and parallel troughs. The latter features probably represent some period of lower sea level. The flanks and northern end of this main offshore ridge also contain lower east - west trending features, no doubt related to still lower sea levels.

Like the offshore Malcolm fan (Area 4), it is probable that the north - south trending ridges represent deposition of coarse grained (probably gravel) alluvial sediment when sea levels were significantly lower, hence they are considered to be good prospects for containing granular resources. The adjacent, east - west trending features are probably reworked material derived from the main ridges. These low bars are also considered to be good prospects for better sorted granular material.



MESH PERSPECTIVE
Dwg #: S617_5
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 80X

FIG. 23

--7 779 000

--7 772 000

BATHYMETRY PLOT

Scale: 1/50000

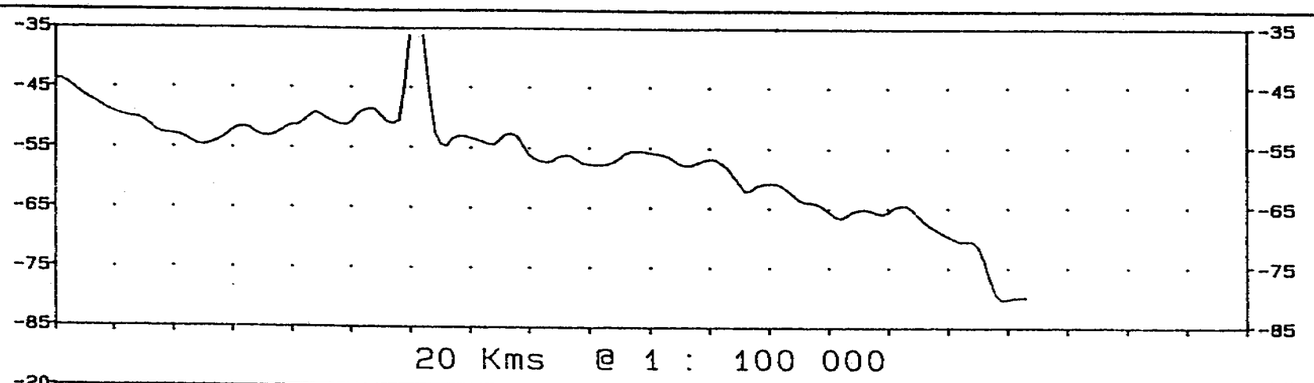
Dwg #: S617_5

- 27 - 35
- 35.1 - 45
- 45.1 - 55
- 55.1 - 65
- 65.1 - 99

FIG. 24

START

LINE # 1
N 7768079
E 550761
AZ 038

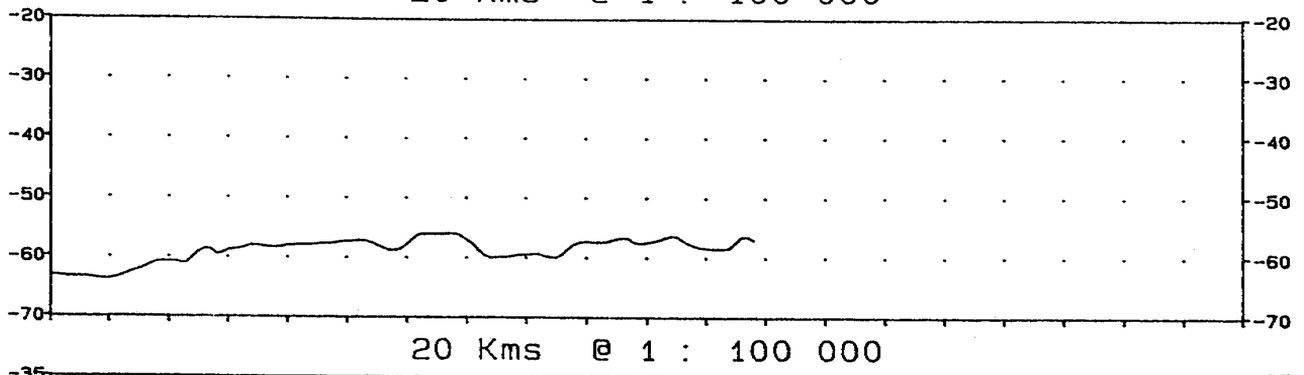


END

N 7788064
E 549974

20 Kms @ 1 : 100 000

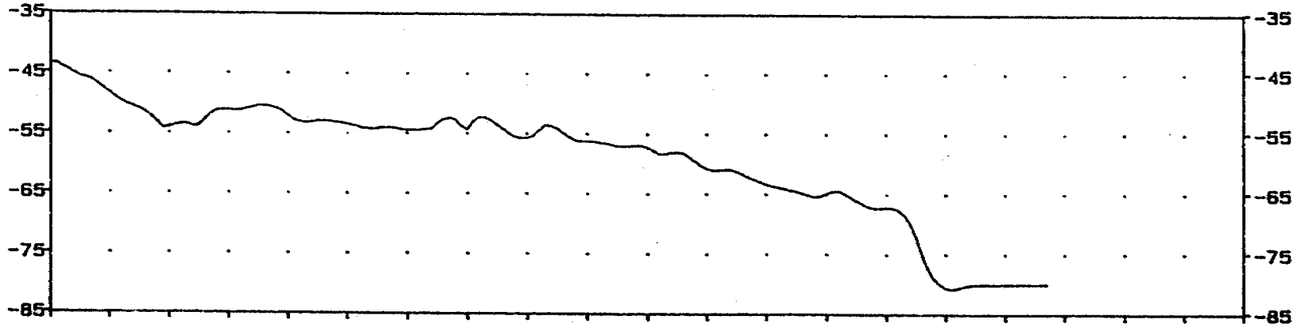
LINE # 2
N 7780300
E 552332
AZ 134



N 7770355
E 569684

20 Kms @ 1 : 100 000

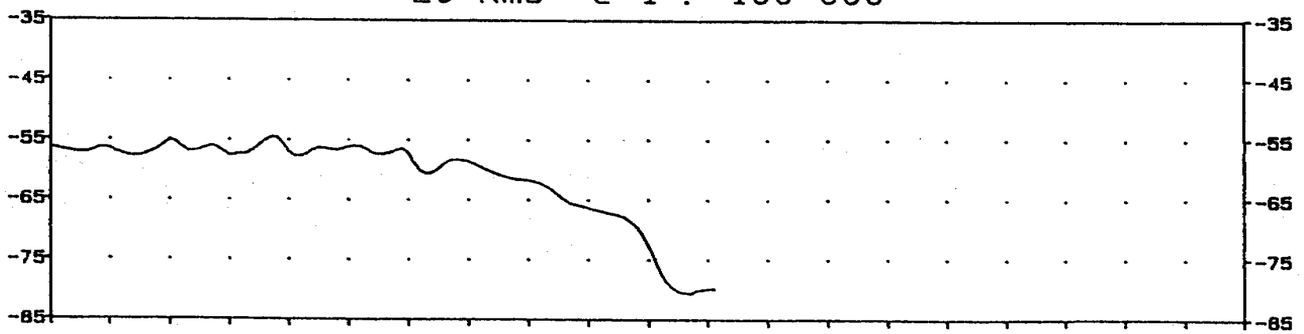
LINE # 3
N 7768062
E 550779
AZ 052



N 7765261
E 570582

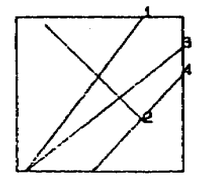
20 Kms @ 1 : 100 000

LINE # 4
N 7768073
E 556379
AZ 043



N 7783150
E 543238

7790000 +



7760000

545000 +

575000 +

KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA

WESTERN BEAUFORT (YUKON)

CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 100 000
VERTICAL SCALE 1: 1000
UTM ZONE 7 COORDINATES

DSS FILE No.	SHEET
A7134-6-0038/01-ST	7 OF 10
CSS JOB NO.	DRAWING NO.
S-617	S617-5

CHALLENGER SURVEYS & SERVICES LTD.
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FIG. 25

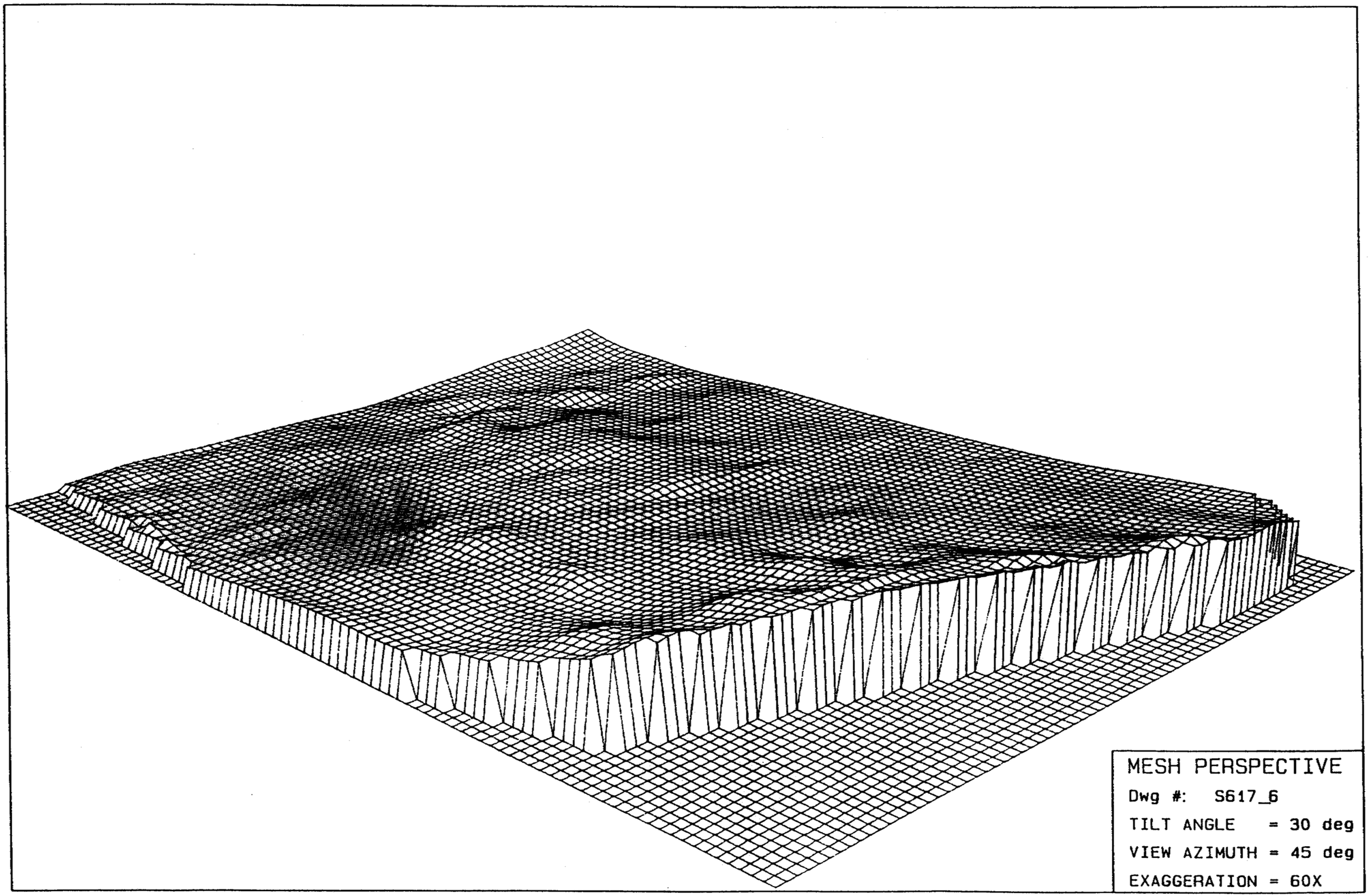

MESH PERSPECTIVE
Dwg #: S617_6
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 60X

FIG. 26

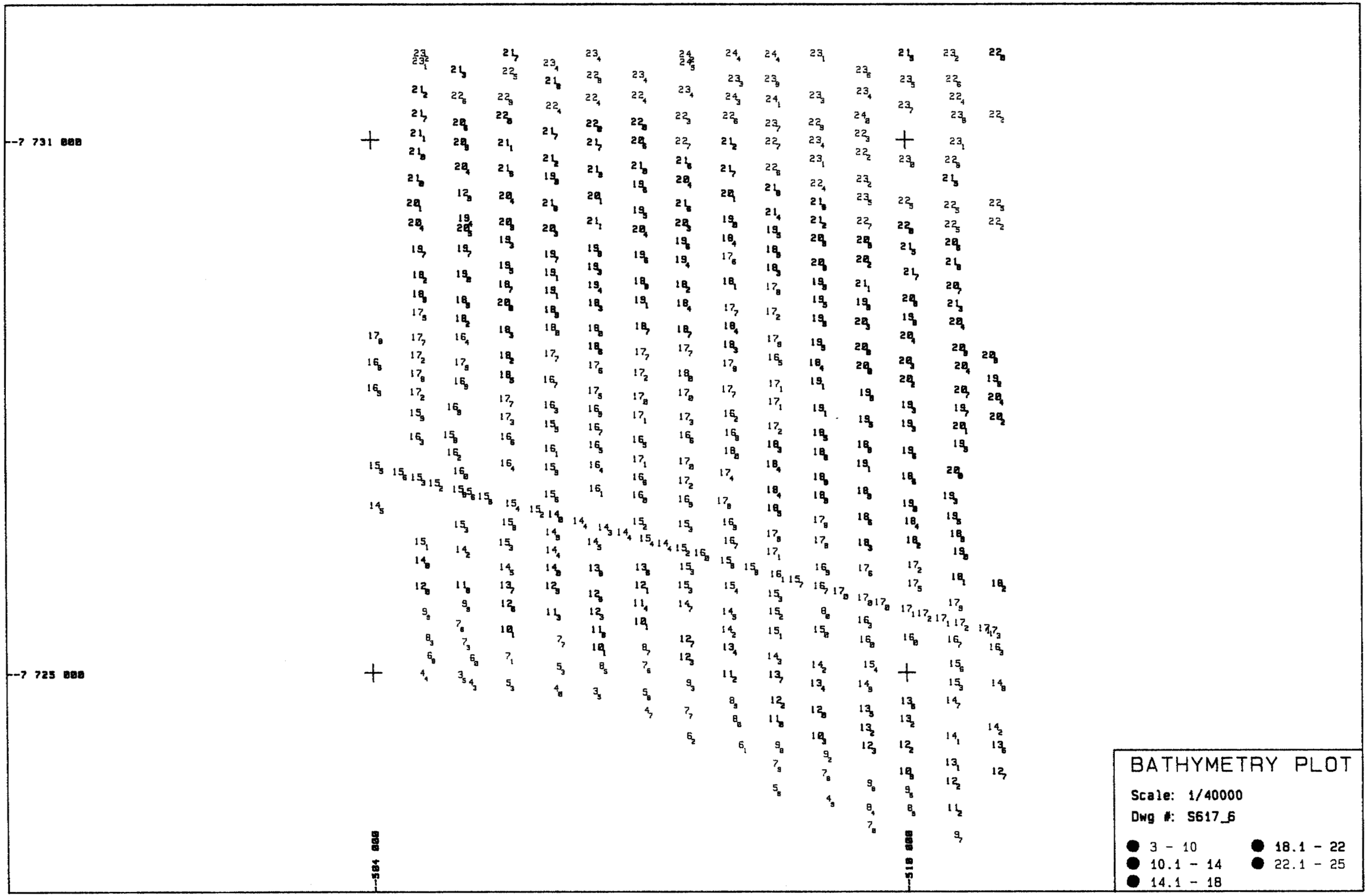
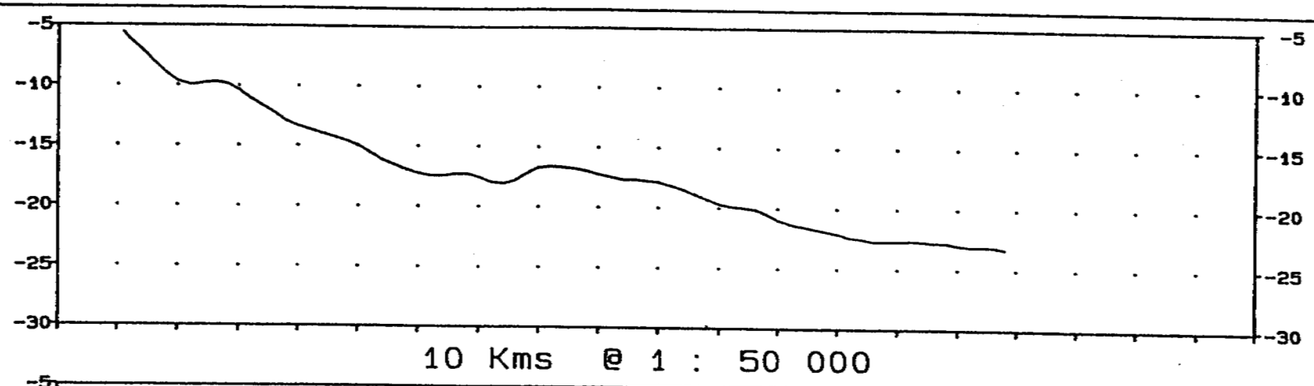

--7 731 000
--7 725 000
--504 000
--510 000
BATHYMETRY PLOT
Scale: 1/40000
Dwg #: S617_6
3 - 10
10.1 - 14
14.1 - 18
18.1 - 22
22.1 - 25

FIG. 27

START

LINE # 1
N 7724485
E 506154
AZ 032

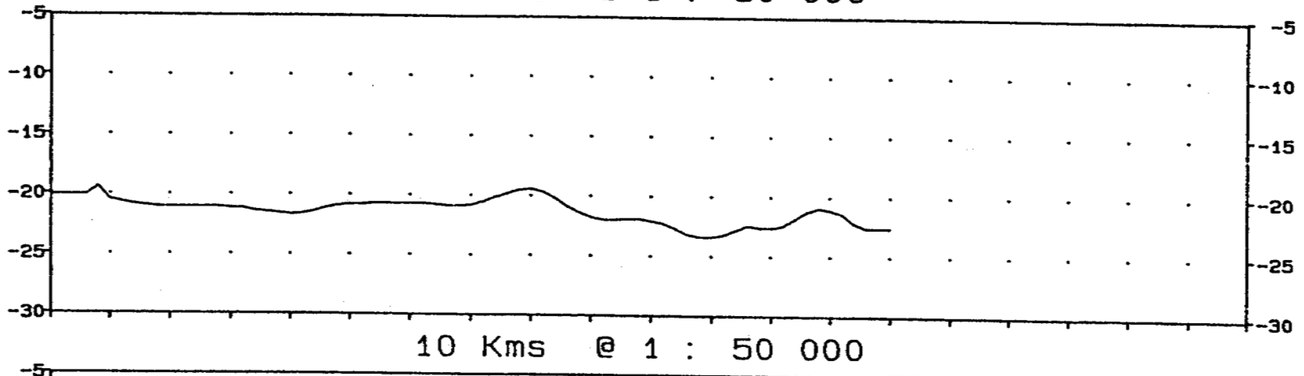


10 Kms @ 1 : 50 000

END

N 7730310
E 514283

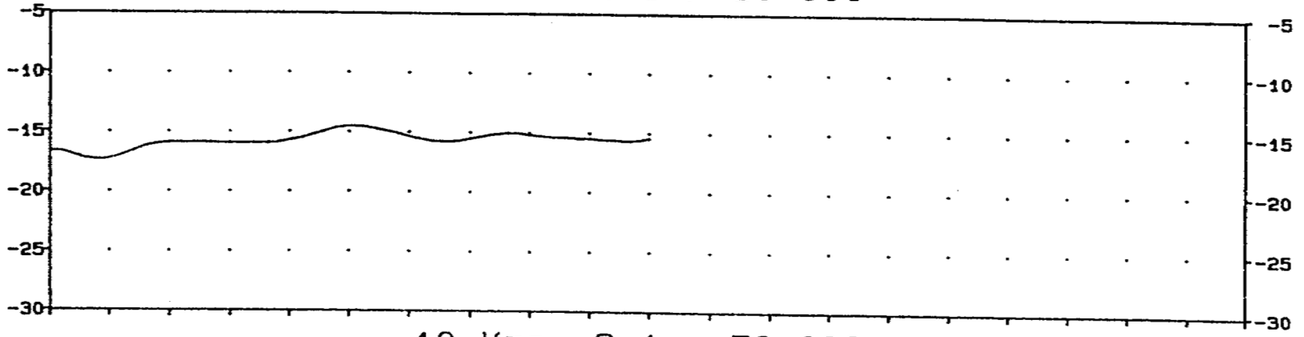
LINE # 2
N 7730175
E 504100
AZ 087



10 Kms @ 1 : 50 000

N 7738067
E 497958

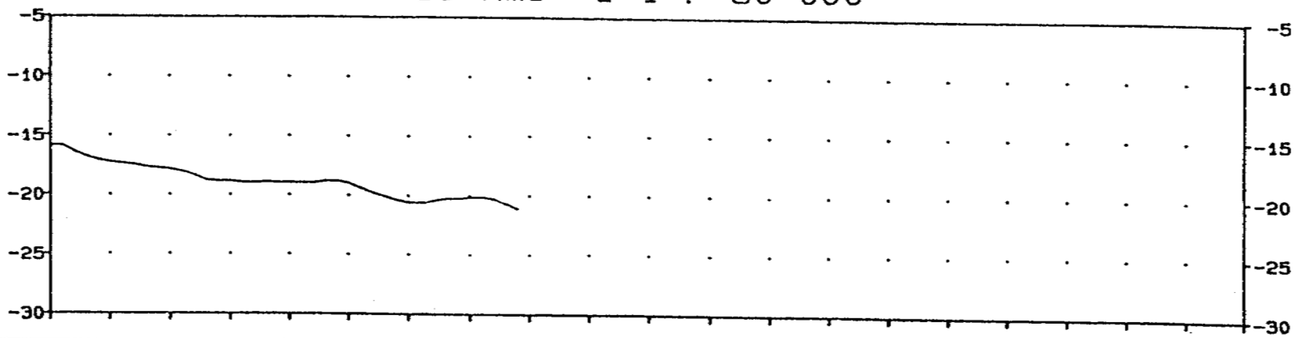
LINE # 3
N 7727947
E 505086
AZ 122



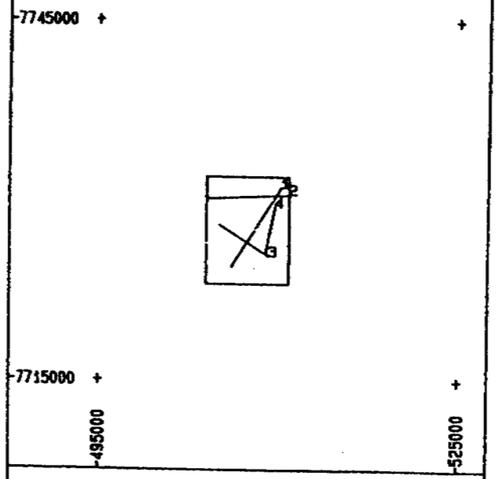
10 Kms @ 1 : 50 000

N 7720831
E 512112

LINE # 4
N 7725748
E 509021
AZ 012



N 7733097
E 502240



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON)
CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 50 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No. A7134-6-0038/01-ST	SHEET 8 OF 10
CSS JOB NO. S-617	DRAWING NO. S617-6
CHALLENGER	SURVEYS & SERVICES LTD. EDMONTON - ALBERTA

FIG. 28

3.5.9 Area 7

Area 7 is located approximately 7 km off the northwestern shore of Herschel Island, and at the eastern end of the inshore ridge (red area; Challenger, 1986) that extends parallel to the Yukon coast, about 10 km offshore. Both Challenger (1986) and Meagher (1986) have suggested that this ridge may be a stamukhi shoal formed by the scouring action of the winter ice pack against the landfast ice. The main ridge, which lies along the upper left side of the mesh perspective (Figure 29) appears to be gently undulating. Its height and relief diminishes in the central and eastern part of Area 7, and a relatively deep and steep sided trough separates the main ridge from a more hummocky area in the northeast corner of the mesh perspective.

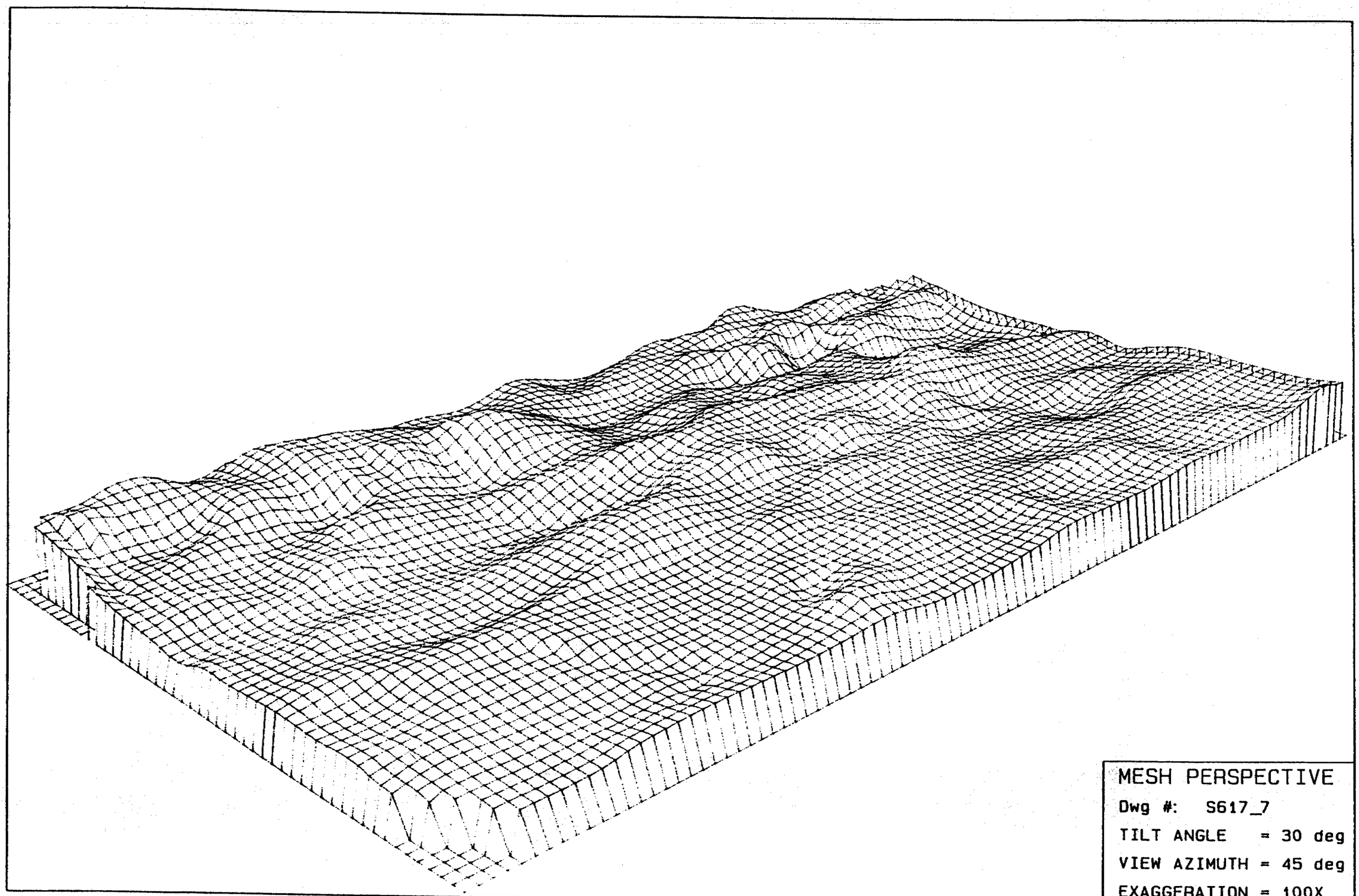
Meagher's (1986) Prospect 5 falls within the south-central portion of Area 7, but it is not well-defined on the mesh perspective due to a gap in the bathymetry data (Figure 30). This feature lies slightly to the south of the main ridge, and at a different orientation, hence it may be a separate feature (Meagher, 1986). Prospect 5 is described as a flat-topped plateau with steep sides, particularly to the north. Profiles in Figure 31 show local relief of up to 8 m between the crest of Prospect 5 and the trough along its northern edge.

The hummocky zone in the northeast corner of Area 7 is also evident on the profiles. Its proximity to the postulated offshore ice limit (orange area; Challenger, 1986) suggests that its origin could be related to glaciation.

3.5.10 Area 8

Area 8 contains a portion of the series of low relief, subparallel ridges located about 20 km offshore (green area; Challenger, 1986). These features were thought to resemble distributary mouth deposits, or alternatively, relict stamukhi shoals. Meagher (1986) has identified Prospect 14 in this area, based limited grab sampling. The mesh perspective for this area is shown in Figure 32, and a bathymetry plot and profiles constitute Figures 33 and 34, respectively.

The detailed bathymetric data offers only limited insight to the origin or granular resource prospectivity of this area. Although there appears to be a faint east - west trend, no distinct features that might contain granular materials are obvious in the mesh perspective (Figure 32). The east - west trending profiles (Figure 34) exhibit very little relief, but two or three gently sloping highs are detected. The north - south trending profiles show a series of more steeply sloping highs that suggest an origin related to coastal processes.



MESH PERSPECTIVE
Dwg #: S617_7
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 29

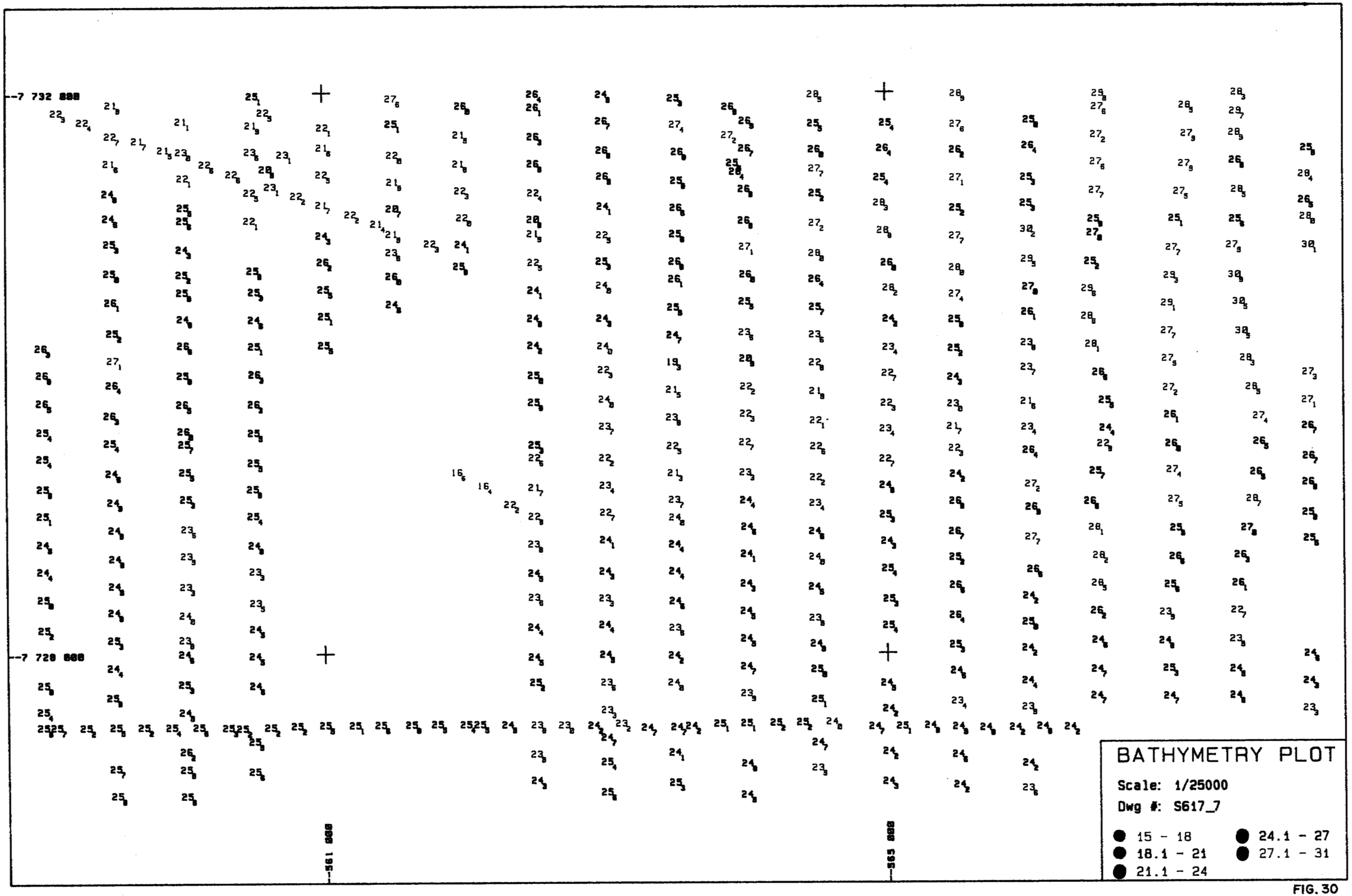
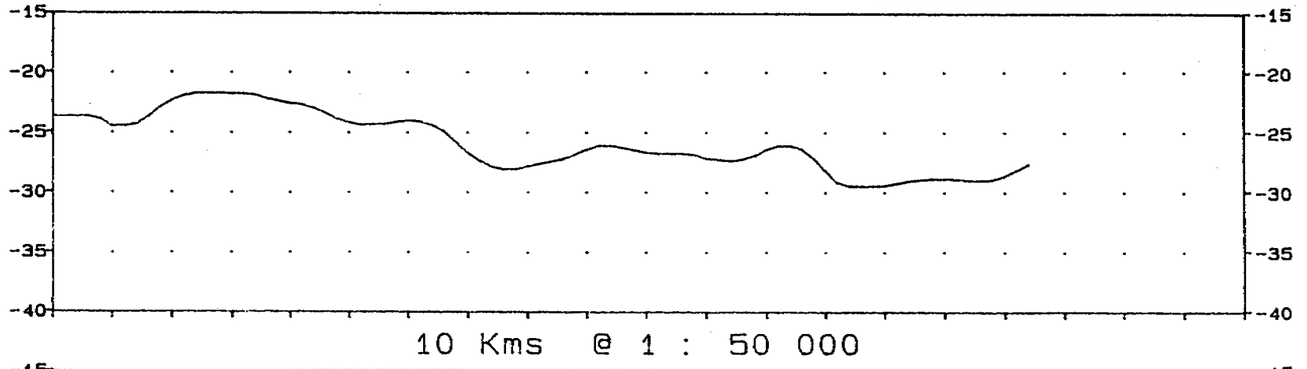

-7 732 888
-7 728 888
561 888
565 888
BATHYMETRY PLOT
Scale: 1/25000
Dwg #: S617_7
15 - 18
18.1 - 21
21.1 - 24
24.1 - 27
27.1 - 31

FIG. 30

START

LINE # 1
N 7731975
E 560047
AZ 104

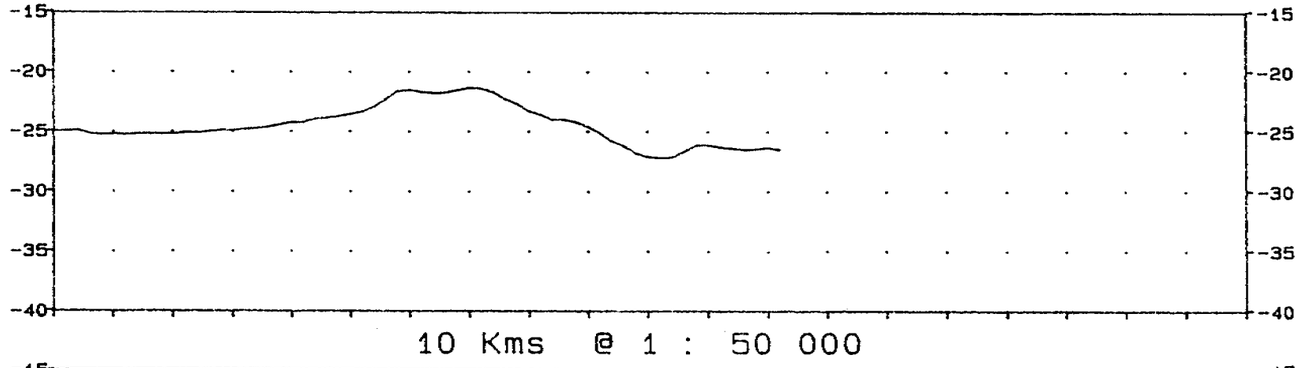


10 Kms @ 1 : 50 000

END

N 7723423
E 554863

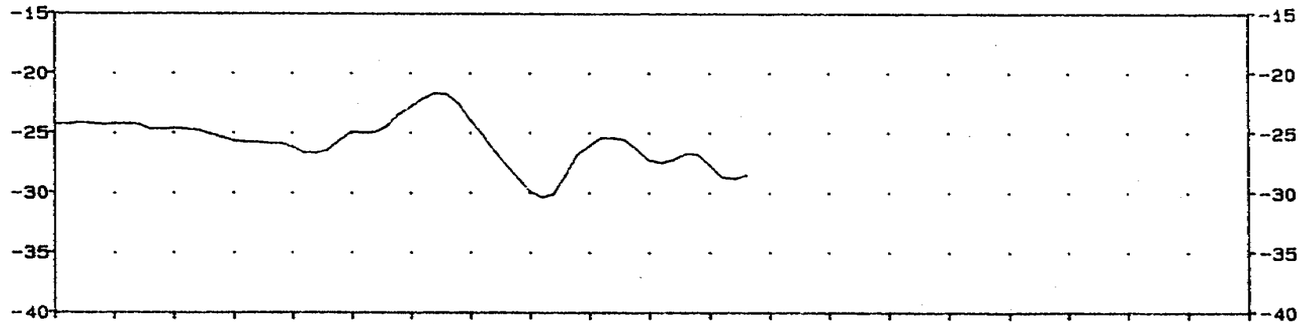
LINE # 2
N 7727081
E 561549
AZ 036



10 Kms @ 1 : 50 000

N 7728613
E 551667

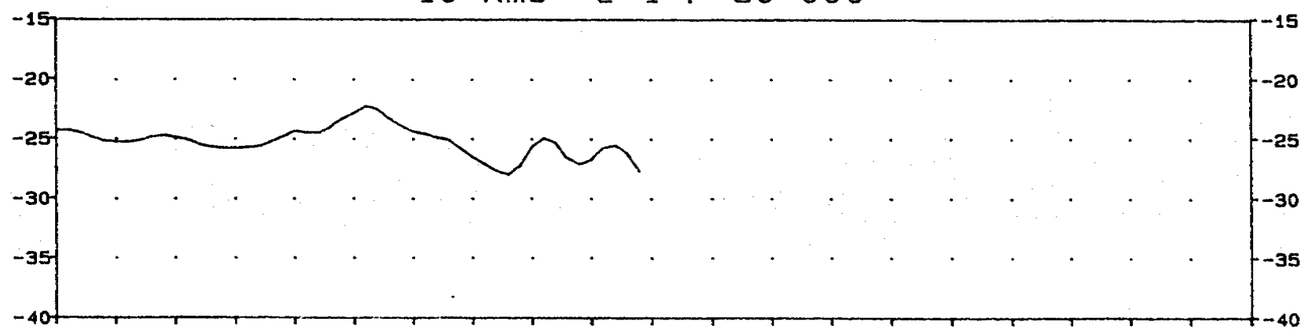
LINE # 3
N 7727085
E 564286
AZ 033



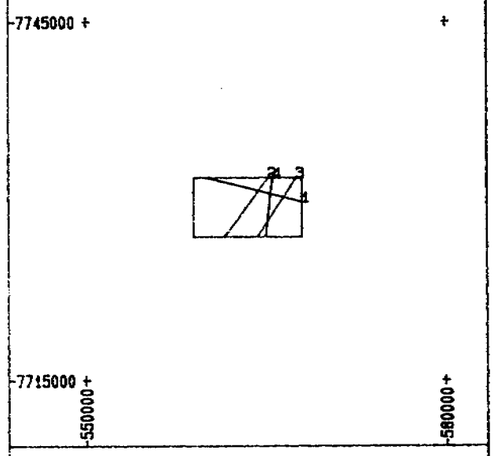
10 Kms @ 1 : 50 000

N 7722836
E 573338

LINE # 4
N 7727100
E 564927
AZ 007



N 7733718
E 572424



KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA

WESTERN BEAUFORT (YUKON)

CONTINENTAL SHELF

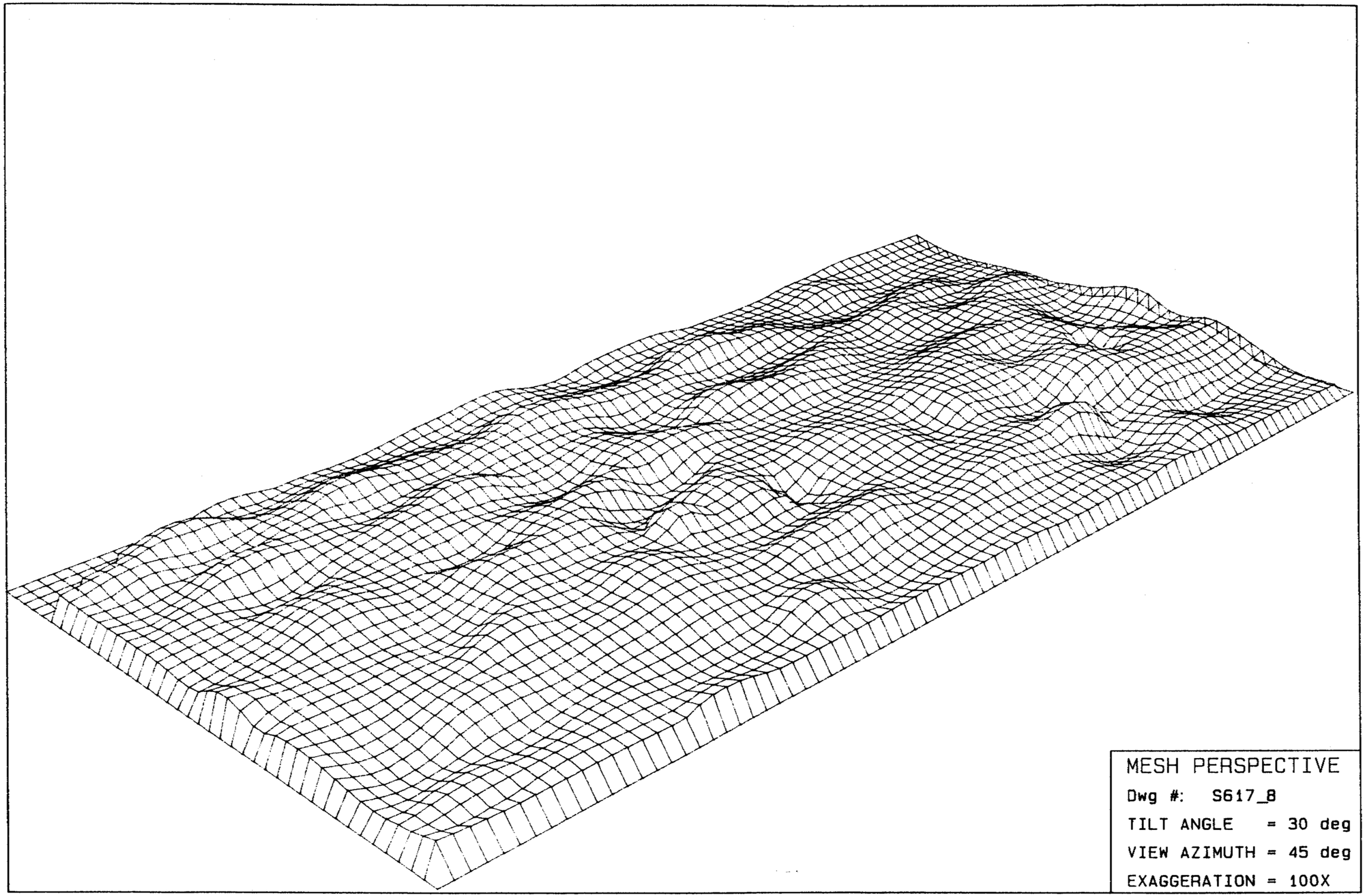
CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 50 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No.	SHEET
A7134-6-0038/01-ST	9 OF 10
CSS JOB NO.	DRAWING NO.
S-617	S617-7

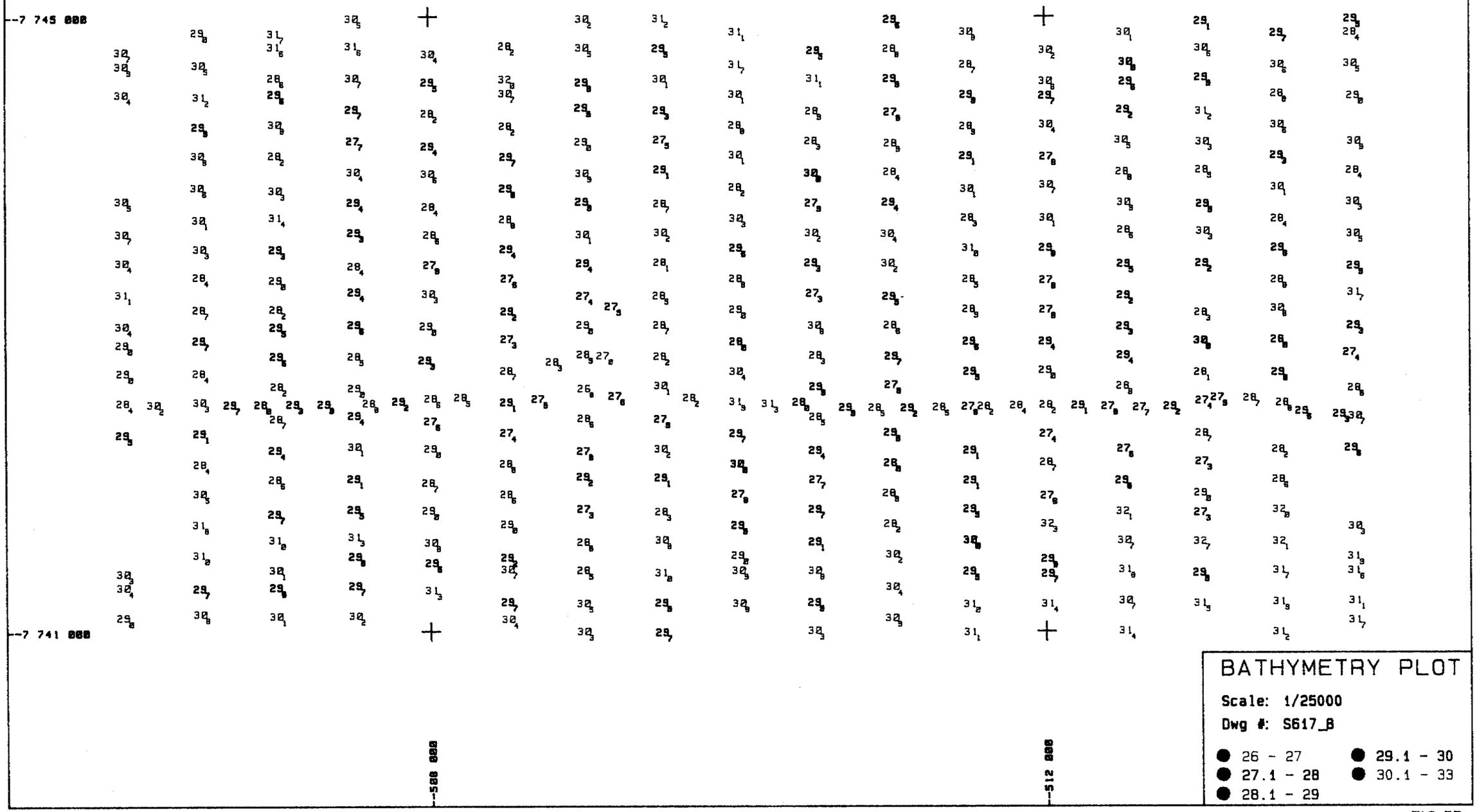
CHALLENGER SURVEYS & SERVICES LTD. EDMONTON - ALBERTA

FIG. 31



MESH PERSPECTIVE
Dwg #: S617_8
TILT ANGLE = 30 deg
VIEW AZIMUTH = 45 deg
EXAGGERATION = 100X

FIG. 32



BATHYMETRY PLOT

Scale: 1/25000

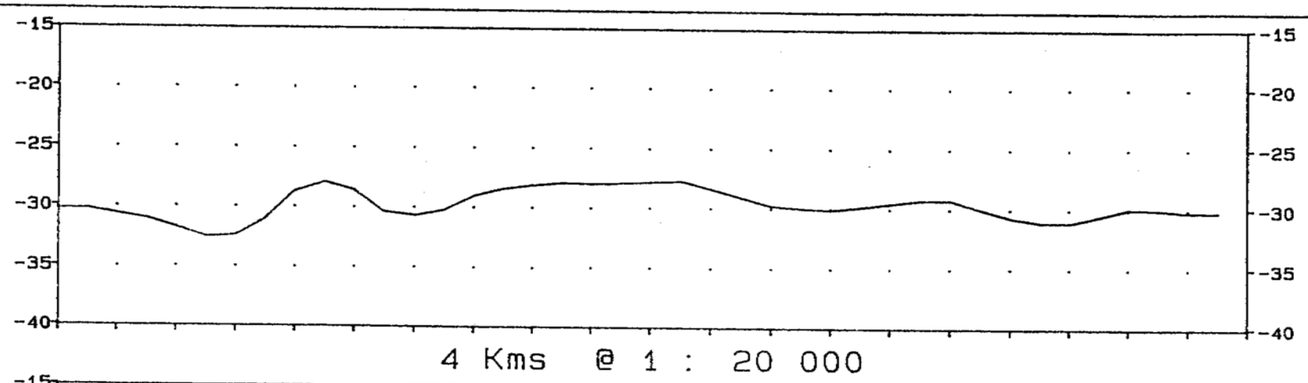
Dwg #: S617_8

- 26 - 27
- 27.1 - 28
- 28.1 - 29
- 29.1 - 30
- 30.1 - 33

FIG. 33

START

LINE # 1
N 7741100
E 511950
AZ 006

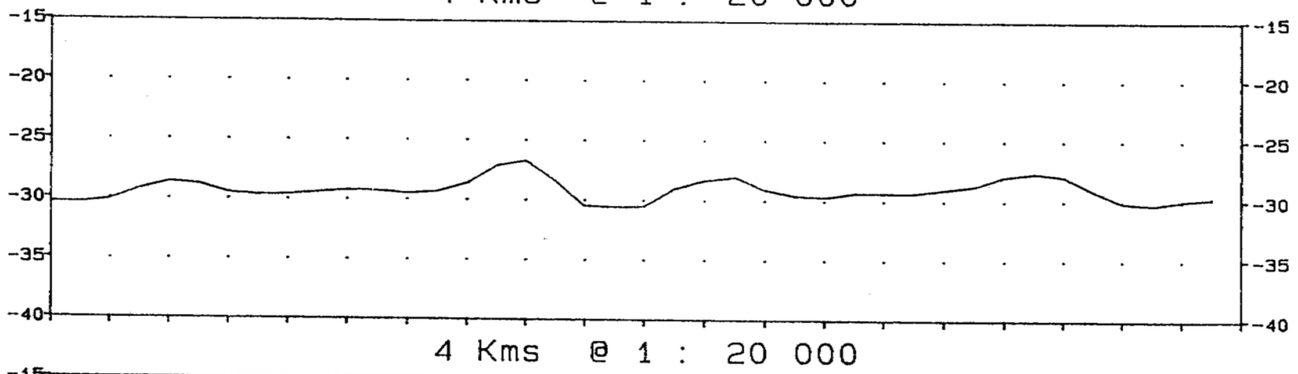


END

N 7744942
E 510838

4 Kms @ 1 : 20 000

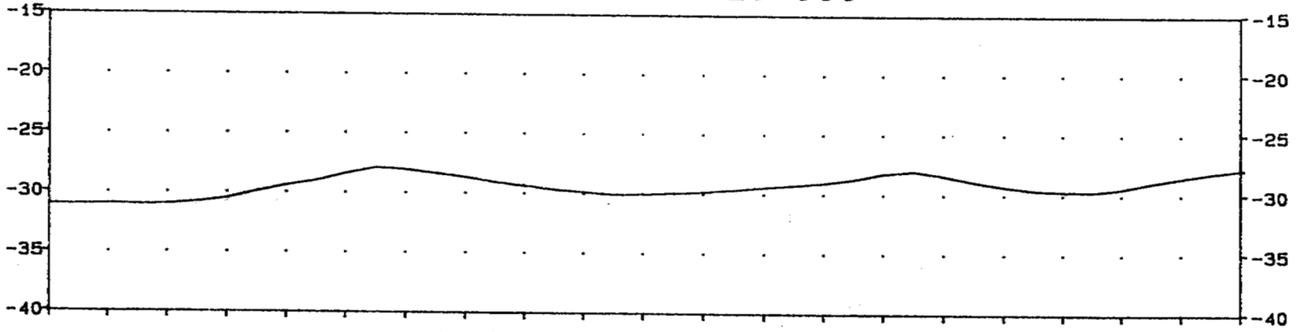
LINE # 2
N 7741100
E 508856
AZ 009



N 7737847
E 511184

4 Kms @ 1 : 20 000

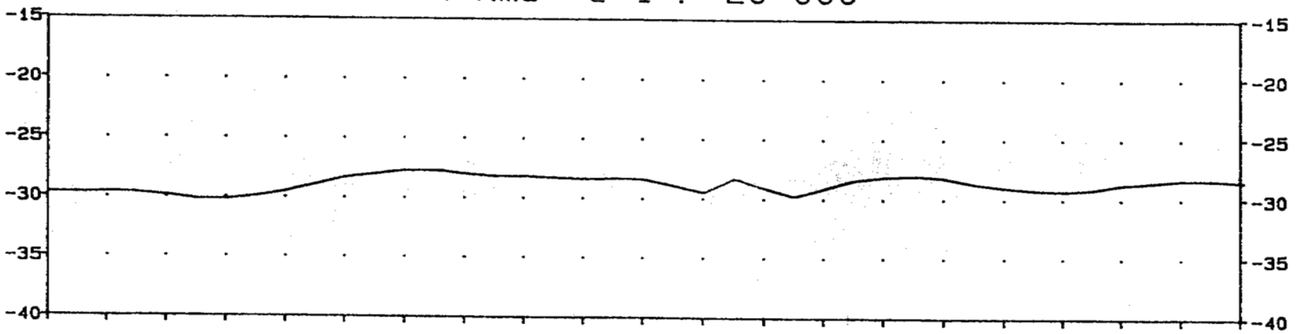
LINE # 3
N 7744826
E 508732
AZ 116



N 7741573
E 511060

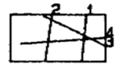
4 Kms @ 1 : 20 000

LINE # 4
N 7742567
E 506800
AZ 086



N 7741046
E 503100

7760000 +



7730000 +

500000 508856

KEY PLAN - 1 : 500 000

ANALYSIS OF BATHYMETRIC DATA
WESTERN BEAUFORT (YUKON)
CONTINENTAL SHELF

CROSS SECTION PLOTS

HORIZONTAL SCALE 1: 20 000
VERTICAL SCALE 1: 500
UTM ZONE 7 COORDINATES

DSS FILE No.	SHEET
A7134-6-0038/01-ST	10 OF 10
CSS JOB NO.	DRAWING NO.
S-617	S617-8

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FIG. 34

3.6 Alternative Analysis Method

The previous section shows that the division of the study area into smaller portions for detailed study allows more precise location of individual bathymetric features than can be achieved with the mesh of the entire area (figure 1). The smaller DTM can be manipulated more easily to provide any number of perspective orientations, or of conventional contoured or colour coded spot bathymetry plots and profiles which can be used to overcome the previouly indicated major limitation of the mesh; that is, their inability to quantify the features. Additionally, the DTM can be manipulated efficiently to investigate potential alternative methodologies for identifying, locating, and quantifying subtle bathymetric features. Ideally, the method should achieve this in a single plot for the study area.

In any representation of seabed topography on a two dimensional medium, the presence of a regional slope tends to obscure smaller scale, local features. this effect is more significant where spot bathymetries must be grouped, as in conventional contour plans, and especially so in those that are sufficiently detailed to show subtle features. The southern Beaufort Sea has been divided into a limited number of physiographical regions, most of which are characterized by, among other physical parameters, a relatively low and uniform regional slope. It is, therefore, feasible to remove the regional slope component from the DTM node point bathymetries, and plot the residual values. This will make any features which deviate from the regional slope appear as more distinctive entities which can, if necessary, be plotted with a more detailed contour interval or a higher vertical exaggeration.

Area 1 which has both relief and a measurable slope over its limits was chosen as the area to test out an alternative detection method. Figure 35 outlines the parameters used for the plane definition while figure 36 shows the normal mesh of this area.

The technique used was mesh plots of the trend-surface residuals. The approach taken is as follows: Using various points around the data base an average surface defining the mean slope of the data base was defined. In this data set the surface was comprised of 3 triangular planes. A mesh of this mean sloped surface was generated and is denoted in figure 37 as (Average Slope Surface). This grid was subtracted from the normal area 1 grid. A new surface was then defined with grid node values representing the residuals from the mean slope. Then in order to detect any features that may have gone unnoticed in the normal grid set a mesh of the slope trend residual grid was generated.

The calculated bathymetric residual surface was then plotted using both mesh perspective (figure 38) and contouring (figure 39) methods. For comparative purposes, a plot of the original DTM surface is also shown as figure 40.

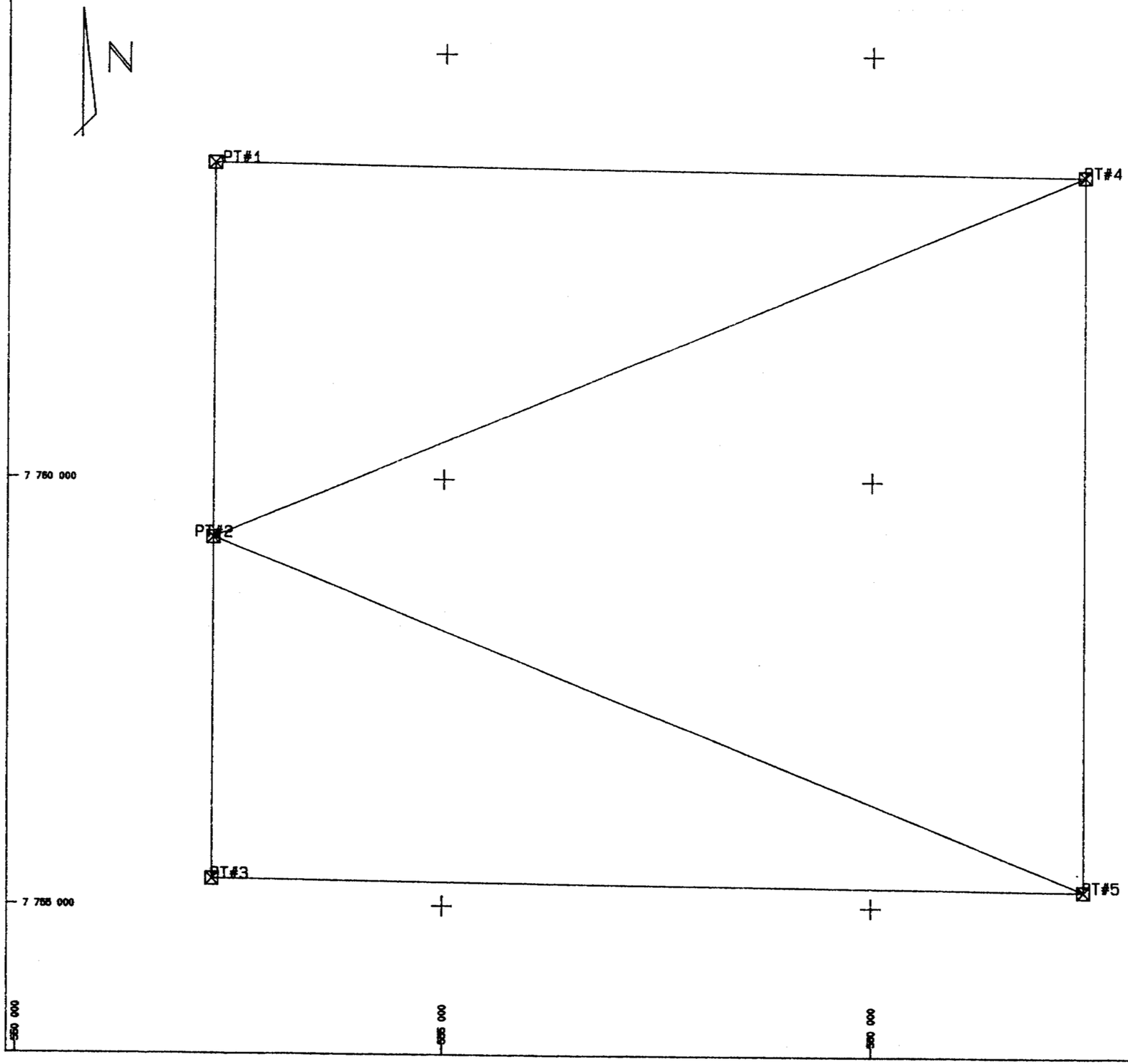
In all of the plots, the major, roughly T-shaped feature, for which detailed study area 1 was selected, is readily apparent. However, with the removal of the regional slope, its boundaries and its hummocky topography are more evident.

On the basis of this limited investigation, it can be seen that the removal of regional slope is a useful method of

detecting bathymetric anomalies that may be missed in conventional contouring. The residual contour plan allows the features to be located easily and quantified in terms of general extent. However, in most instances, additional profiling or volume calculation manipulations of the DTM would still be required, and the presentation is still less pleasing than the mesh perspectives.

When the mesh perspective method of data presentation is available, the need for slope removal is reduced, although the extent of features may be clarified with mesh perspectives of residual bathymetric data. Through variation of the viewing azimuth and perspective, the mesh perspective can provide essentially the same visual effect as slope removal, and without the additional calculation required to determine regional slope planes.

It was therefore decided that the mesh perspective method would to be used as the primary method of detection of bathymetric anomalies in the Erksak borrow area.



LEGEND & NOTES

THE AVERAGE TREND SURFACE CONSISTS OF THREE TRIANGULAR PLANES. THE NODE VALUES ARE:

PT#	NORTHING	EASTING	DEPTH
PT#2	7763700	552300	60m
PT#2	7759300	552300	48m
PT#3	7755300	552300	43m
PT#4	7763600	562500	54m
PT#5	7755200	562500	46.5m

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COORDINATE BASIS FOR THE AVERAGE SLOPE SURFACE

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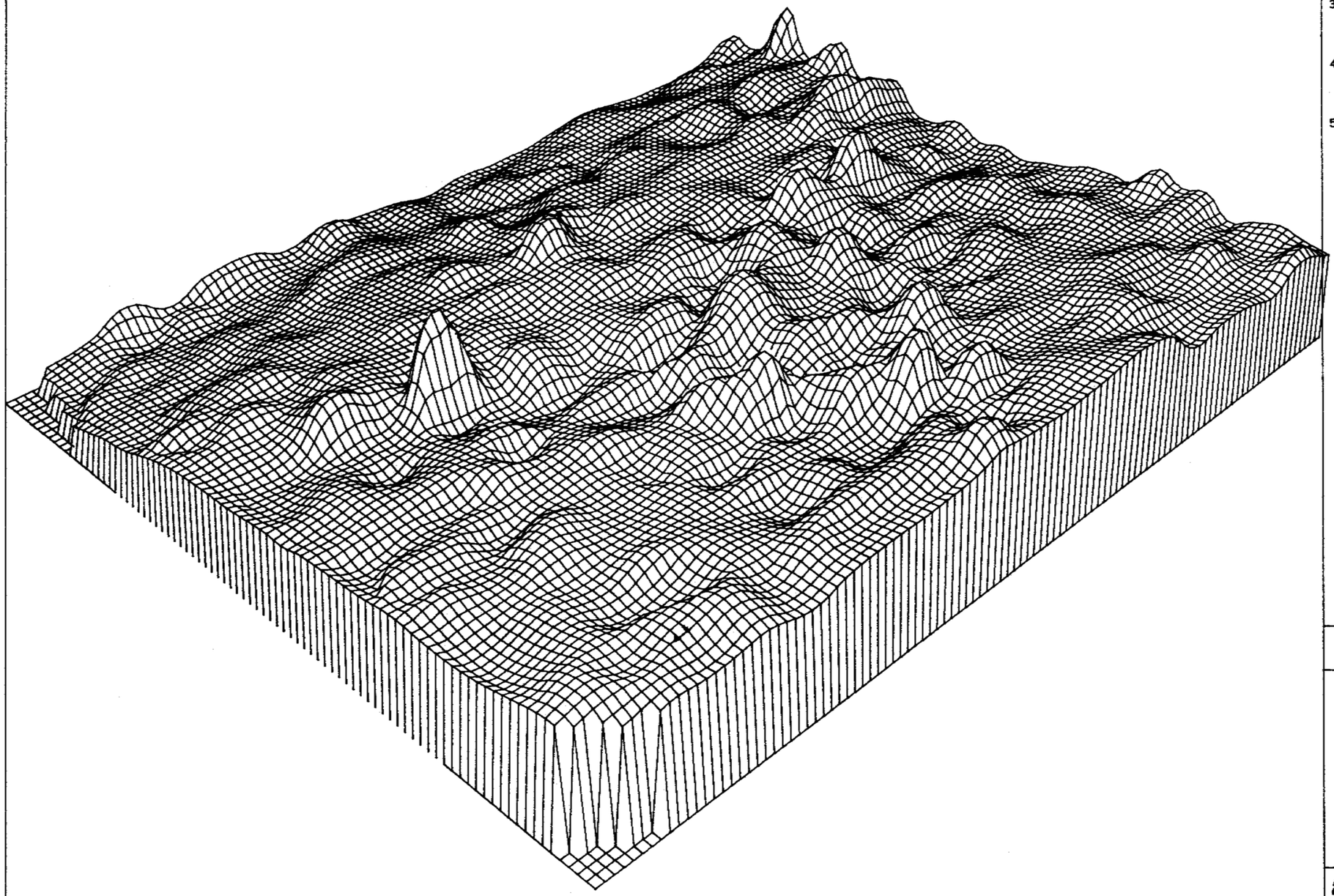
SCALE : 1 : 50000

JOB NO : S-617

DATE : 2 MAY 1988

FIG. 35



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED ON THE YUKON SHELF DATA BASE.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 45 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
4. THIS PLAN CONSTITUTES ONE OF A SET OF THREE PLANS SHOWING THE EFFECT OF THE REMOVAL OF THE AVERAGE SLOPE COMPONENT FROM A DATA BASE.
5. THIS PLAN SHOWS THE NORMAL MESH OF DATA SET 1.

INDIAN & NORTHERN AFFAIRS CANADA

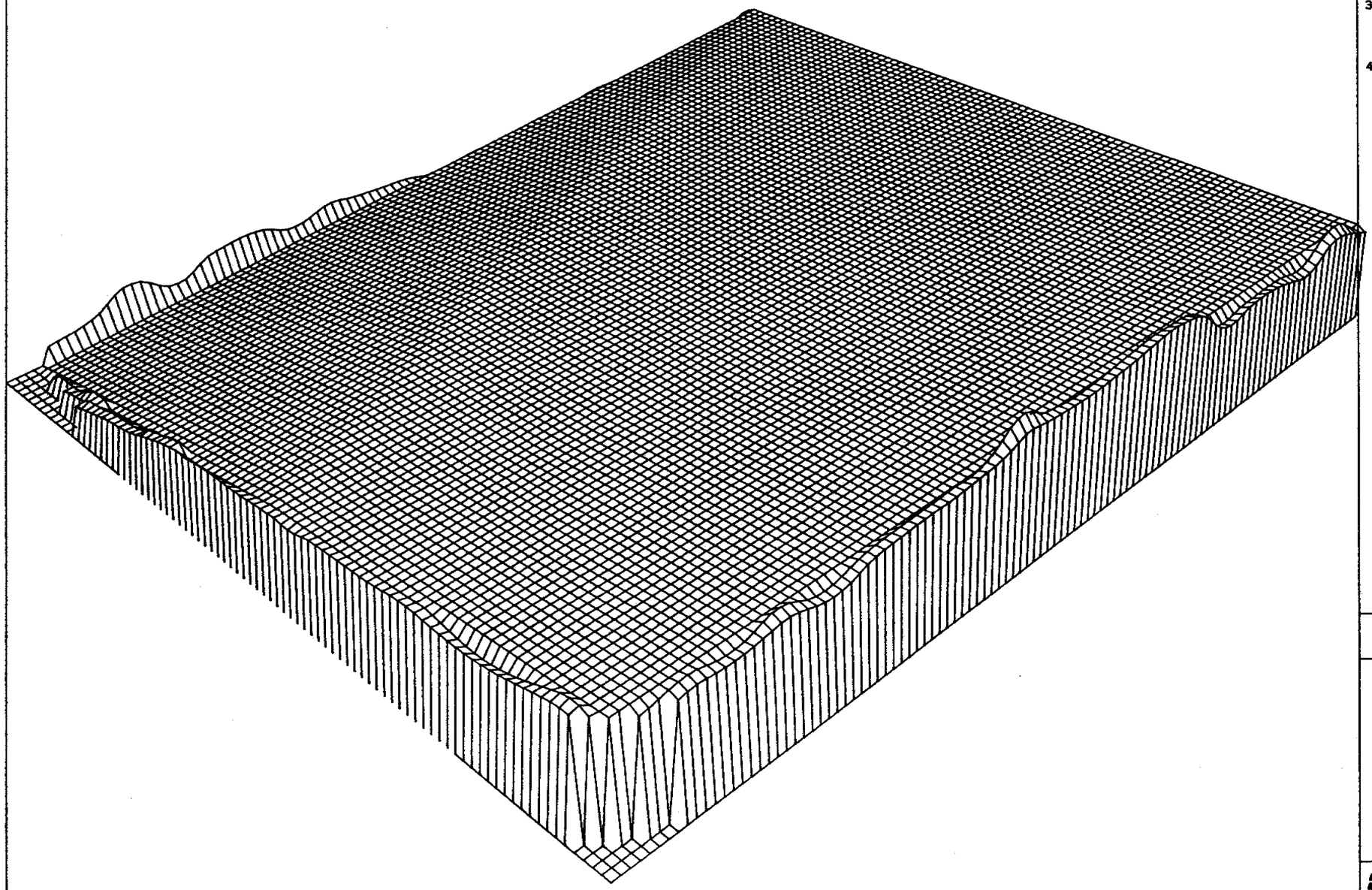
BATHYMETRIC MESH PERSPECTIVE
ZONE #1
YUKON SHELF

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE :	JOB NO :
1 : 2000	S-617
DATE : 28 APR 1988	

FIG. 36



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF A MEAN SET OF PLANES USED TO REMOVE THE SLOPE COMPONENT FROM YUKON SHELF DATA BASE.
2. THE MESH IS DERIVED FROM A DIGITAL MODEL BASED ON THREE TRIANGULAR PLANES THAT BEST APPROXIMATE THE MEAN SURFACE FOR THIS DATA SET.
3. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 45 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
4. THIS PLAN CONSTITUTES ONE OF A SET OF THREE PLANS SHOWING THE EFFECT OF THE REMOVAL OF THE AVERAGE SLOPE COMPONENT FROM A DATA BASE.

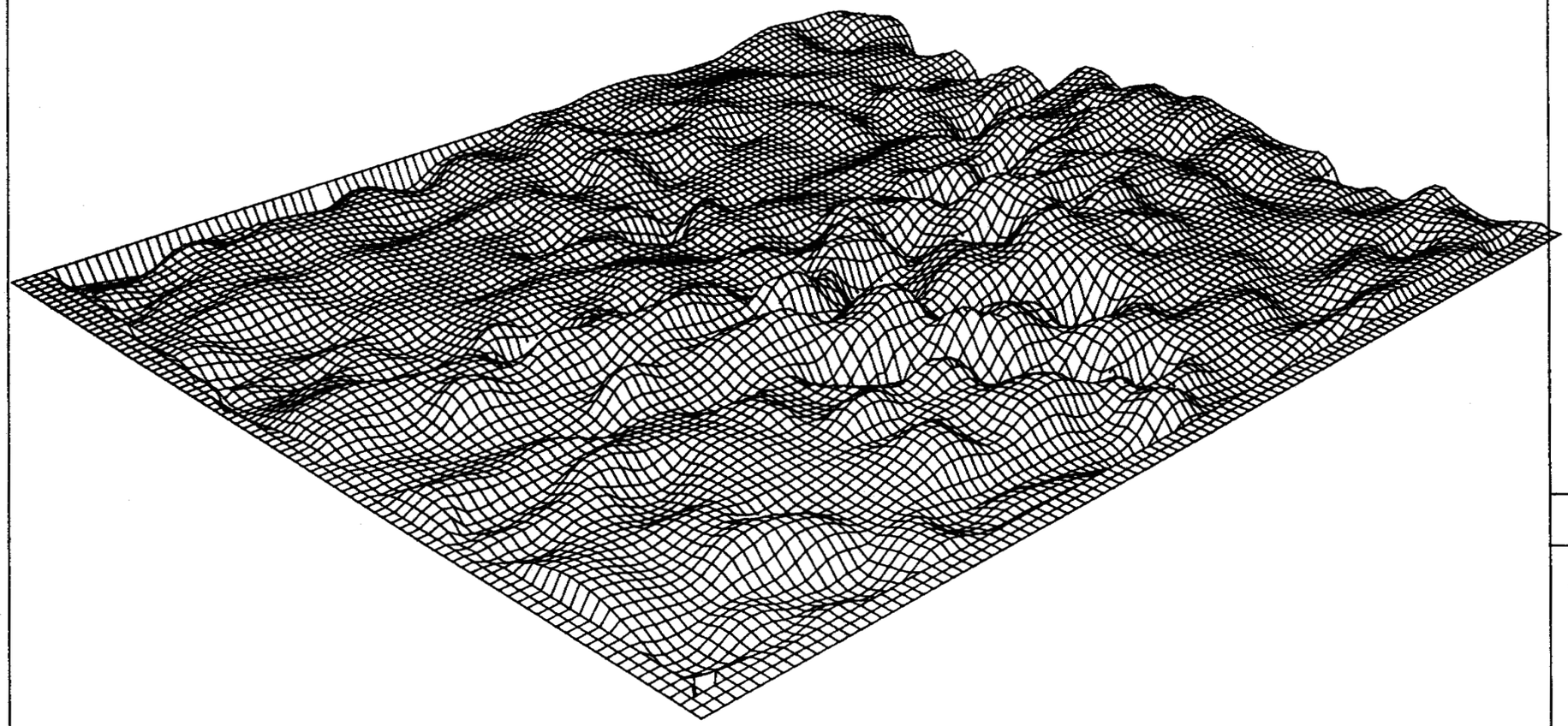
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
AVERAGE SLOPE SURFACE
YUKON SHELF

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD.	SCALE : 1 : 2000	JOB NO : S-617
	DATE : 28 APR 1988	

FIG. 37



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE DIFFERENCE BETWEEN THE MEAN SLOPED PLANE AND THE NORMAL PERSPECTIVE DATA SET.
2. THE MESH IS DERIVED FROM A DIGITAL MODEL BASED ON THE DIFFERENCE BETWEEN THE THREE FACES MEAN SLOPED PLANE AND THE ACTUAL DIGITAL MODEL FOR THIS AREA.
3. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 45 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
4. THIS PLAN CONSTITUTES ONE OF A SET OF THREE PLANS SHOWING THE EFFECT OF THE REMOVAL OF THE AVERAGE SLOPE COMPONENT FROM A DATA BASE.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE NO.1 (YUKON SHELF)
OF
TREND SURFACE RESIDUALS

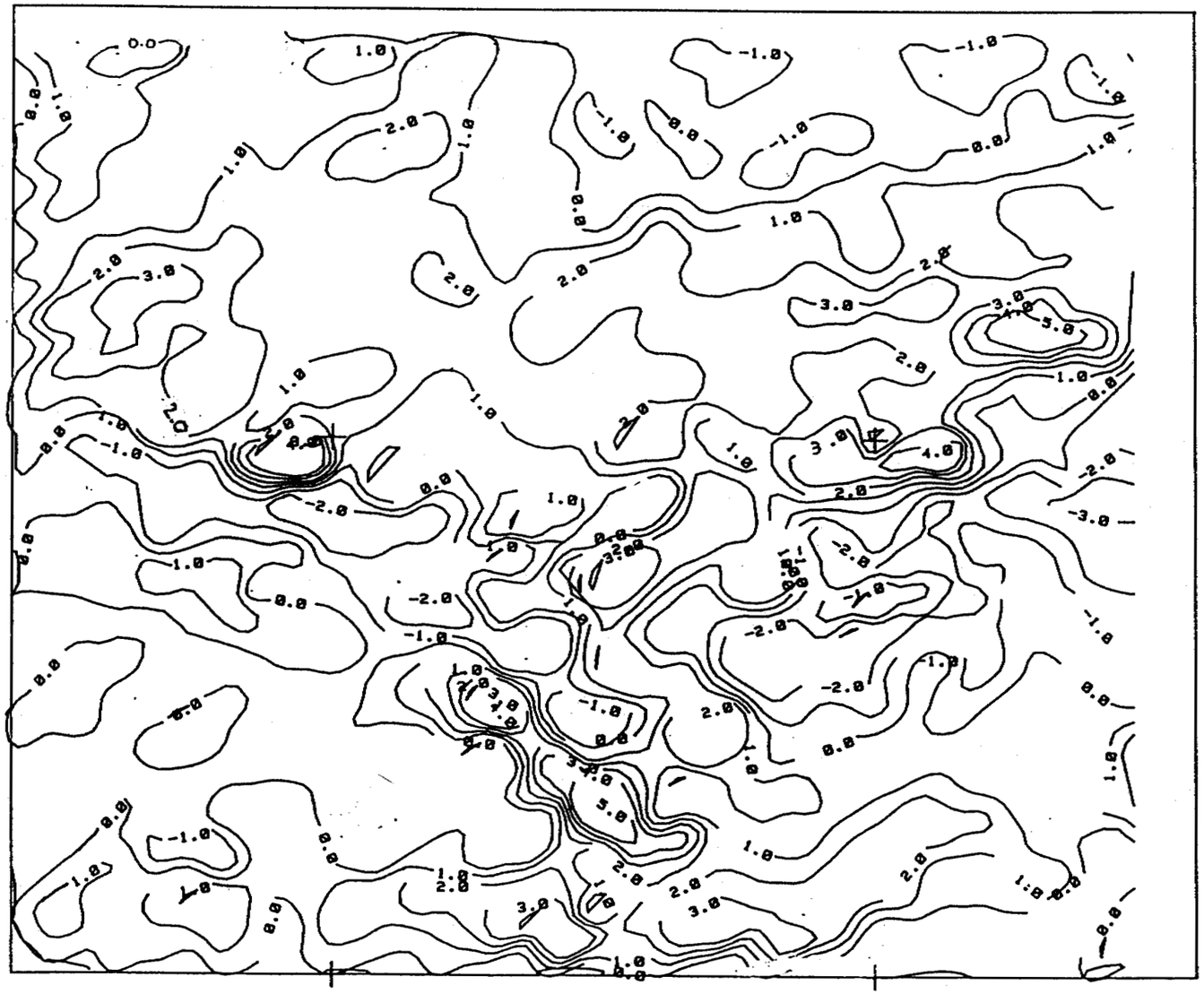
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD.

SCALE :	JOB NO :
1 : 2000	S-617
DATE : 28 APR 1988	

FIG.38

N



LEGEND & NOTES

1. PLOT SHOWS DIFFERENTIAL BATHYMETRIC CONTOURS OF DETAILED INVESTIGATION SITE #1 FROM THE YUKON SHELF DATA BASE.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PUPROSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 7.
4. CONTOURS ARE PLOTTED AT 1 METER INTERVALS FROM DIFFERENTIAL CONTOUR LEVEL -4.0 TO +5.0.
5. THE DIFFERENTIAL CONTOUR DATA BASE WAS ARRIVED AT BY REMOVING A PLANE REPRESENTING THE MEAN SLOPED SURFACE OVER THE AREA, FROM THE ORIGINAL RAW DATA BASE. THE RESULTING SURFACE THEN REPRESENTS THE TREND SURFACE. THE PLOT SHOWS THE CONTOURS OF THE VARIATIONS FROM THE MEAN PLANE. THE CONTOURS RESULT FROM EITHER AN ILL DEFINED MEAN PLANE OR FROM FEATURES IN THE DATA BASE THAT DO NOT FIT WITH THE TREND SURFACE.

INDIAN & NORTHERN AFFAIRS CANADA

DIFFERENTIAL CONTOURS
ZONE #1
YUKON SHELF

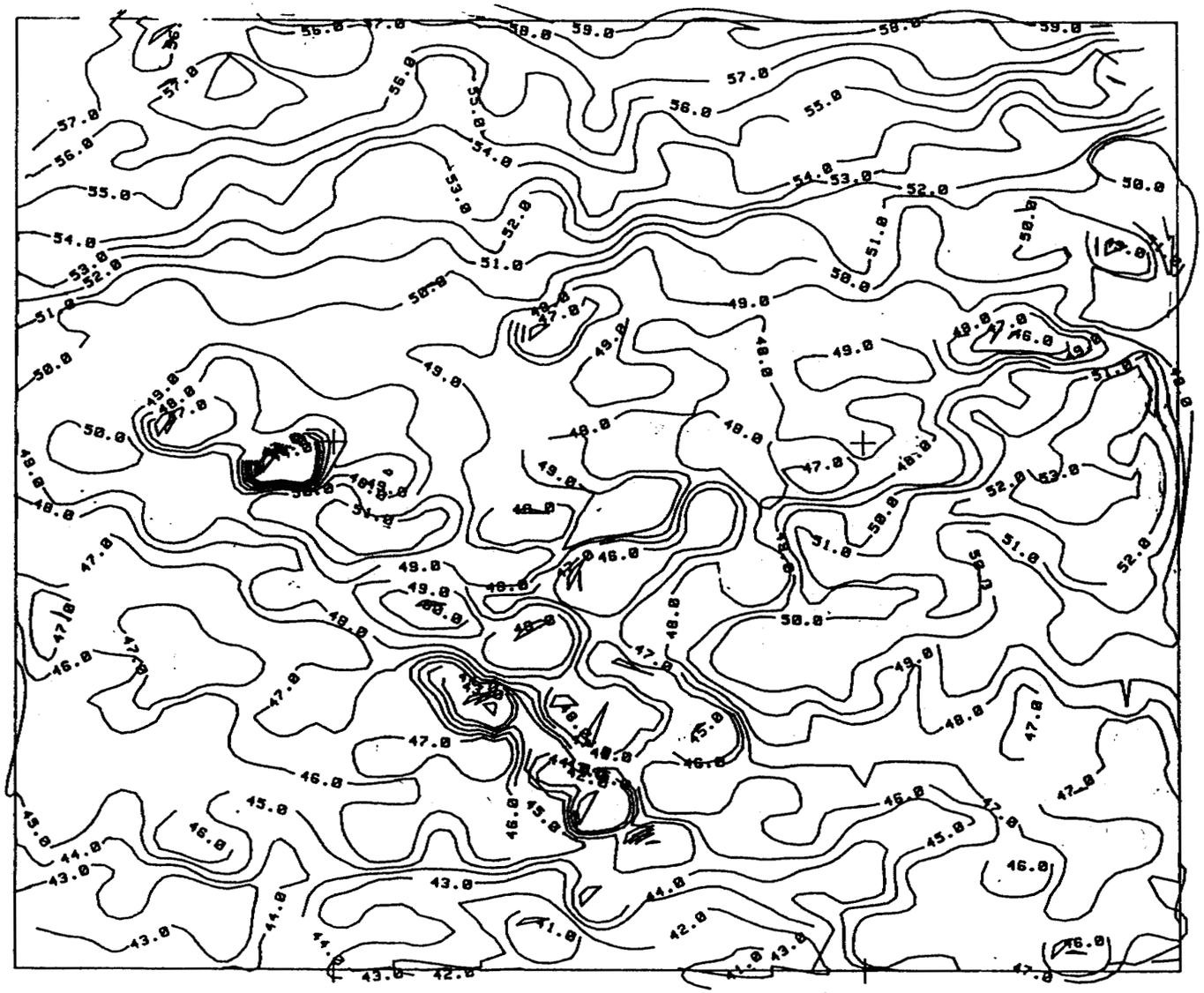
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE :	JOB NO :
1 : 50000	S-617
DATE : 3 JUN 1988	

FIG. 39

N



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC CONTOURS OF DETAILED INVESTIGATION SITE #1 FROM THE YUKON SHELF DATA BASE.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PUPROSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 7.
4. CONTOURS ARE PLOTTED AT 1 METER INTERVALS FROM CONTOUR LEVEL 41.0 TO LEVEL 59.0.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC CONTOURS
ZONE #1
YUKON SHELF

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 50000	JOB NO : S-617
	DATE : 3 JUN 1988	

FIG. 40

4.0 PRELIMINARY EVALUATION, ERKSAK BORROW AREA BATHYMETRY

4.1 Area Selection

Phase II of the contract involved the selection of a further area for processing. The selection was made in conjunction with the scientific authority and was based on the general granular resource potential of the area, the availability of digital data, and the likelihood of detecting additional bathymetric features which might contain seabed granular resources.

The south central portion of the Beaufort Sea continental shelf, between about 132 degrees and 133 degrees 30' west longitude, is believed to contain vast quantities of granular materials at, or near the seabed. This area is significant in that it has been, in recent years, a primary source of granular borrow for construction of hydrocarbon exploration structures. The failure of the Nerlerk berm which contained finer sands from further north on the Tingmiark Plain (Nerlerk Borrow Block) has driven island builders shoreward and placed greater demands on the Erksak area.

DIAND has defined a preliminary borrow management block for this region, designated the Erksak Borrow Block. The Erksak Borrow Block is enclosed by the following four points, referenced in the Universal Transverse Mercator (and geographic) coordinates:

NW: Zone 8; 550 000; 7 800 000 (70-18-10N; 133-40-15W)
NE: Zone 8; 609 000; 7 800 000 (70-17-04N; 132-06-15W)
SE: Zone 8; 609 000; 7 750 000 (69-50-12N; 132-09-57W)
SW: Zone 8; 565 000; 7 750 000 (69-51-04N; 133-18-33W)

The southern part of the Erksak block includes a series of

sub-parallel southwest to northeast trending ridges which tend in a more northerly direction further offshore, in the vicinity of the Kogyuk, Tingmiark and Ukalerk sites. These features may be relic barrier islands or bars, but a number of other possible origins have been suggested. Detailed delineation of these sand ridges, and identification of other features which might assist in the development of geomorphic process models to explain the origin and extent of the granular deposits was therefore recommended by the scientific authority.

4.2 Source Data Assessment

In selecting a source for the data it was a concern that the data be as clean as possible. Some problems with the previous data set for the Yukon Shelf were encountered. An initial assessment of data quality was required to ensure that this did not occur with the new area. Data available from the Canadian Hydrographic Service in Sidney B.C. for the Erksak grid area was reviewed by the CHS and stated to be in good order.

4.3 Data Integration to the HP Micro-computer

The data received from the CHS was in 9-track magnetic tape form and had to be moved onto the HP system. Time was leased on a VAX11-751 computer. A FORTRAN routine was written on the VAX that compressed each 9-track record into an X,Y,Z data block. The data was dumped in 1 Megabyte blocks via a 9600 baud serial link to the HP9816 computer where it was stored in record format on a 15 Megabyte hard drive. In total just over 273000 data points were transferred to the HP system. This is almost twice as much data as was used in the Yukon Shelf area.

The data was stored in 9 files containing 30000 records and 1 file containing just over 3000 records. There was no sorting of data into areas at this time.

4.4 Check Plot

An 11 X 17 plot at a scale of 1:400 000 was plotted showing the distribution of the data base. The points were simply plotted as dots and only one out of 10 was sent to the plotter. Still, this process took over 7 hours as only 1 point/second could be plotted. Within the data base, the data distribution was relatively even, and fully adequate fo the type of analysis proposed.

5.0 DETAILED ANALYSIS, THE ERKSAK BORROW AREA BATHYMETRY

5.1 Main Digital Terrain Model

Once it was determined that there was enough data to continue with the processing of this area, it was necessary to generate the large mesh perspective plot of the whole area. Even in the new software there is a limit to the quantity of data that can be processed at one time. Because the Erksak database exceeded this limit, the data was broken into smaller areas. Each was viewed at the same azimuth, tilt and exaggeration. Finally after processing, each data set was linked mathematically. A large plot of the whole area was then done on our E size plotter. This differs from, and improves upon the data presentation of, the previous Yukon Shelf data in that each section of the previous plot had to be physically linked. Under close scrutiny, the linked edges could be noticed. This large plan was then sent to the scientific authority for use in defining areas of interest and selecting selecting profile lines in each area. An 11 X 17 reproduction of the mesh is shown in figure 41.

5.2 Significant Bathymetric Features

The Erksak Borrow Block, in the southern portion of the Tingmiark Plain physiographical region, includes an upland area of generally fine sands which are blanketed or veneered with a generally small, but highly variable, thickness of recent marine sediments. The granular deposits (also commonly known as the Ukalerk sands) represent one of the main granular borrow areas presently being exploited in the Beaufort Sea.

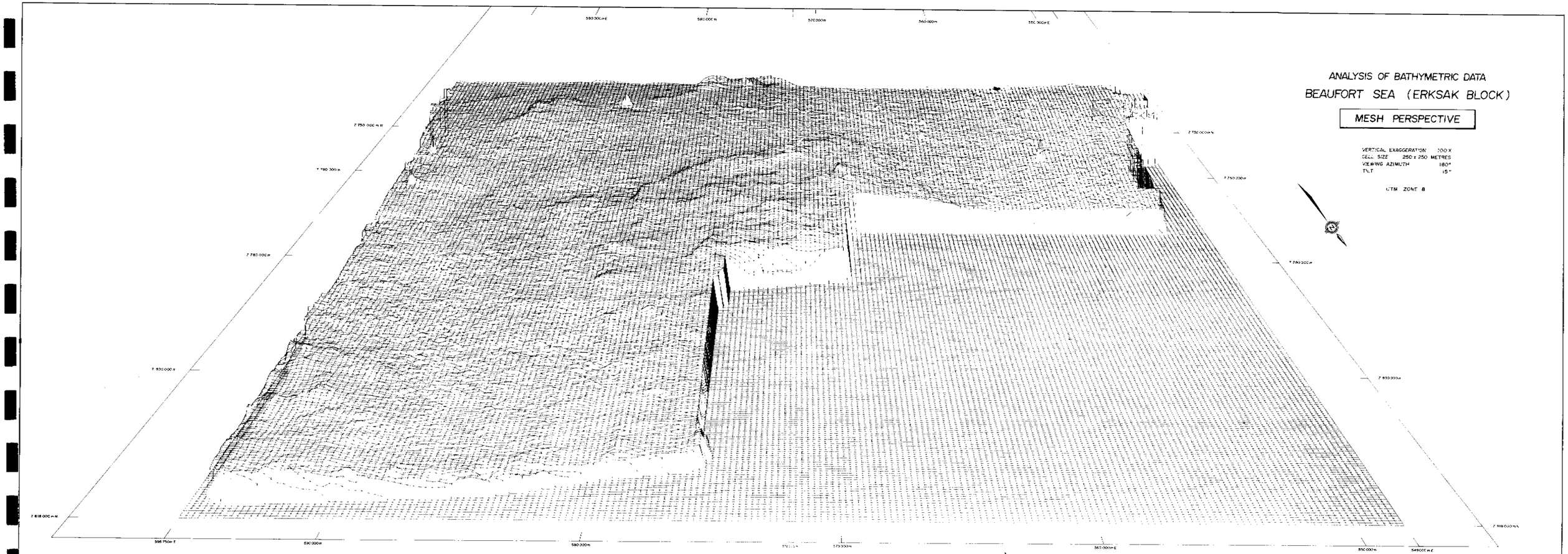
In the Erksak block, the Tingmiark Plain slopes at an average rate of 0.5m per km in a general northerly direction. North of the Kogyuk, Tingmiark and Ukalerk wellsites, the slope is generally slightly greater, and tending to the northwest. Relatively steeper slopes are present to the west, along the boundary between the Tingmiark Plain and the Kugmallit Channel, and locally, in association with a series of ridges located mainly in the southern and western portions of the study area.

The above mentioned series of ridges are the most distinguishable bathymetric features on a relatively complex, but low local relief, seabed surface. These features are generally relatively long and narrow, and they occur as a group of sub-parallel ridges, oriented in a southwest-northeast or north-south direction, approximately parallel to the margin of the Kugmallit Channel. The ridges appear to have relatively steeper southeastern or eastern flanks. Local relief associated with these features is generally in the order of 2 m to 5 m.

The northern portion of the study area consists of numerous hummocky features of varying areal extent and relief. None of these features appear to be especially significant in terms of potential source areas for granular resources.

5.3 Selection of Further Analysis Areas

Areas of interest for further processing were selected in consultation with the scientific authority on the basis of the significant features identified on the large mesh perspective of the study area. Six principal areas and an additional two extensions of the principal areas were



AM-11 D)

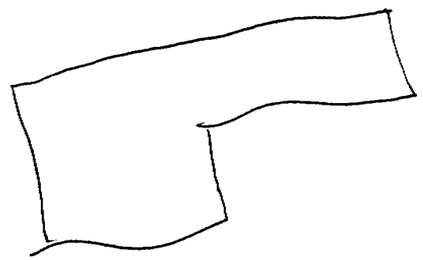


FIG. 41

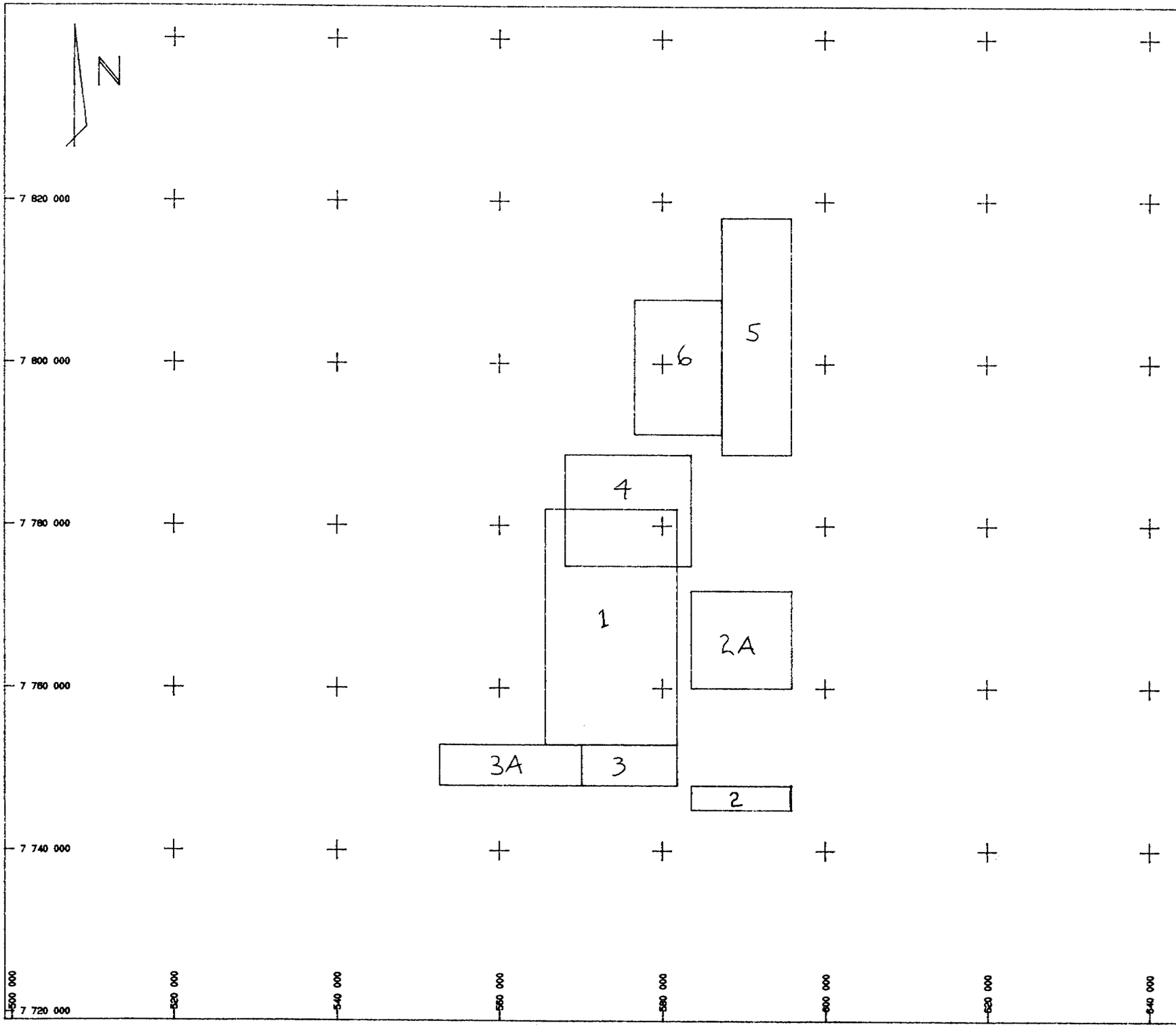
outlined on the mesh perspective. Table 3 lists the coordinates of the boundaries of the 8 selected areas. Figure 42 is a plan showing the outline of the detailed study areas within the Erksak Block.

Area	UTM Zone	North	East	South	West
1	8	7 782 000	581 750	7 753 000	565 600
2	8	7 748 000	595 750	7 745 000	583 500
2A	8	7 772 000	595 750	7 760 000	583 500
3	8	7 753 000	581 750	7 748 000	570 000
3A	8	7 753 000	570 000	7 748 000	552 500
4	8	7 788 750	583 500	7 775 000	568 000
5	8	7 818 000	595 750	7 788 750	587 250
6	8	7 807 875	587 250	7 791 250	576 500

This table lists the four boundaries that define each of the 8 study areas of the Erksak Borrow area data base. All coordinates are listed in UTM zone 8 coordinates.

" Coordinates of Detailed Study Areas, Erksak Block "

Table 3



LEGEND & NOTES

INDIAN & NORTHERN AFFAIRS CANADA

PLAN SHOWING
DETAILED STUDY AREAS
AT ERKSAK BORROW SITE

CHALLENGER SURVEYS & MAPPING LTD

SCALE :	JOB NO :
1 : 500000	S-617
DATE :	DWG # :
2 MAY 1988	

FIG. 42

Area 1 includes a long narrow ridge extending from near the southwestern corner of the identified block in a northeasterly direction to the eastern side of the block and then northerly to the northeast corner. Also included in this area is a relatively complex series of apparently overlapping northeast-southwest and north-south trending, short ridges near the eastern Tingmiark Plain - Kugmallit Channel boundary.

Area 2 is approximately centred on one relatively shorter northeast-southeast trending ridge, and includes a series of smaller sub-parallel features on either side of the main feature.

Area 2A is a located north of the above block and appeared to include a number of low relief features oriented in an east-west direction, rather than the predominant north-south trend.

Area 3 outlines a major northeast-southwest trending ridge extending south of the study area. Several minor north-south trending bathymetric highs are also evident in this area.

Area 3A is an extension of the above area into the southern portion of Kugmallit Channel.

Area 4, which partially overlaps Area 1, includes the complex series of features near the physiographical region boundary, described under Area 1. This area extends north of Area 1 to determine if the north-south portion of the long narrow main ridge in Area 1 can be detected further north.

Area 5, in the northeast corner of the study area covers a series of hummocky features, including several, in the

southern portion of the block, which show some north-south elongation. At the extreme north, several features have an apparent east-west trend.

Area 6, located in relatively deeper waters to the west of Area 5, is generally flatter, and shows no apparent orientation of the minor bathymetric features evident on the large perspective.

5.4 Data Sorting and Thinning

A print of the mesh perspective with the areas of interest and profile lines drawn on was used as the basis for the sorting of the data. As with the Yukon data, the northing and easting were scaled off the perspective. Using sorting routines 10 files were created. Based on past experience and the check plot we realized that there would be to much data in each area and the results would be down line biased unless thinning was performed. As the data was being sorted it was automatically thinned prior to insertion into the file. This approach saved alot of time as compared to the previous technique where two passes at the data had to be made, one to sort and one to thin.

5.5 Plan Production

Plans for all 8 areas were produced. The plans sets included; mesh perspectives, coloured bathymetrys, profiles and profile location plots. There was no optimum viewing azimuth at which all the areas could be viewed and have the subtle bathymetric features portrayed as in the Yukon Shelf area. Each area was treated individually and an optimum viewing azimuth for that area was selected

after checking the meshs at 0, 45, 90, 135, 180, 225, 270, and 315 degrees. The horizontal profile scale was selected such that the profile fit on the sheet. The vertical scale was chosen so that the bathymetric features could be seen. Table 4 outlines the plans produced and parameters used for each plan in the Erksak Borrow Block.

5.6 Analysis of Detailed Study Areas

Detailed analysis of the bathymetric data for the Erksak borrow area was complicated by a number of factors: the lack of areally extensive features of significant relief, the relatively complex microrelief of the area, and the absence of a geological framework for the study area.

The small scale mesh perspective (Figure 41) shows relatively few significant bathymetric features in the Erksak area. Detailed mesh perspectives, bathymetry plots and profiles of the narrow, southwest to northeast-trending ridges in Area 1 (Figures 43-48), Area 2 (Figures 49 - 55) and Area 3 (Figures 62 - 68) and of the hummocky area shown in Area 1 and Area 4 (Figures 75 - 81) reveal that even these features are difficult to model and analyze. The main ridges, which are thought to protrude through recent soft marine seabed sediments, may contain sand. Their origin is uncertain, but it is speculated that they are related to coastal processes active at each location during various stages of marine transgression. Local relief, even over distances of several kilometres, rarely exceeds 4 - 5 m, and most of the distinguishable features are typically in the order of 2 m high.

Due to the limited relief, all of the detailed study areas were modelled at a vertical exaggeration of 200 times. However, because the microrelief on many of the above

features (e.g. Area 1; Figure 47) is also in the order of 1 - 2 m, further evaluation of the most significant bathymetric anomalies was not possible. In other areas (e.g. Area 2A, Figures 56 - 61; and Areas 5 and 6, Figures 82 - 94), the same magnitude of microrelief makes it difficult to distinguish any features other than a few random hummocks and depressions.

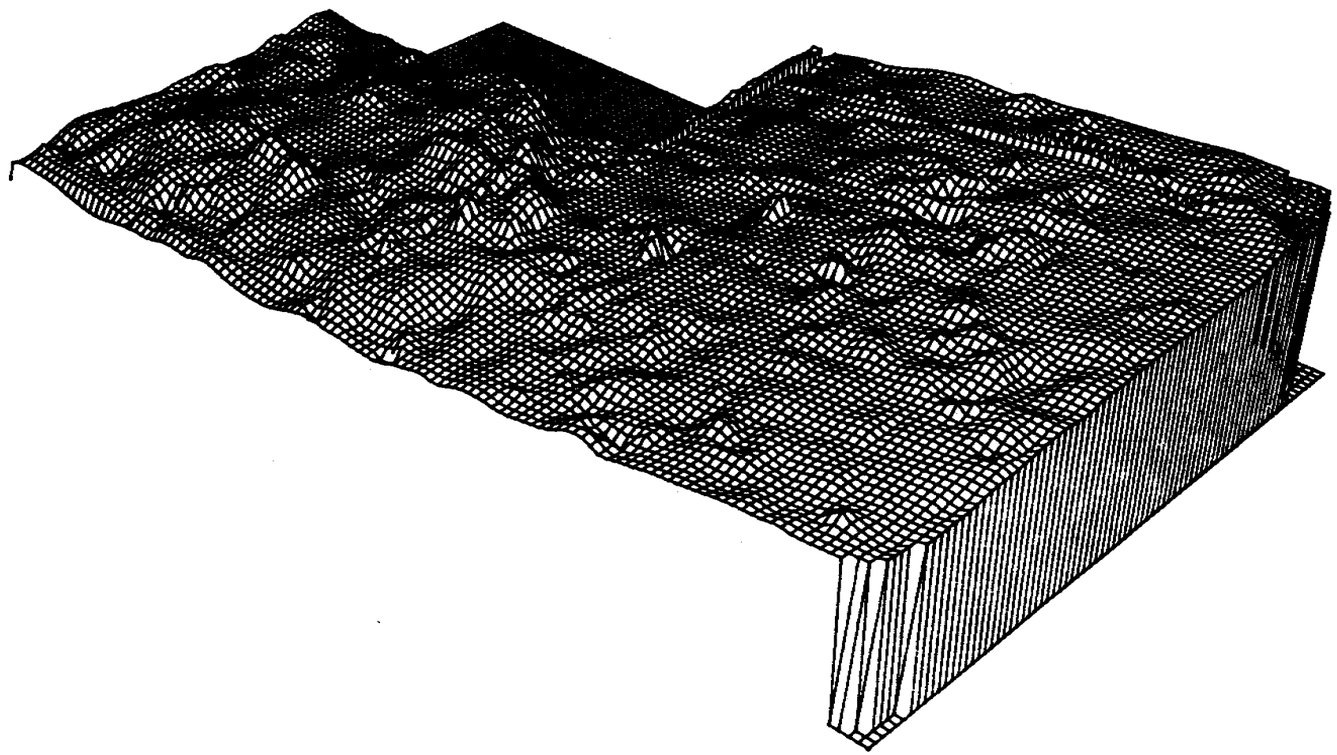
Further analysis of the bathymetric data is not possible until the regional geological framework of the Erksak area is available. It is likely that information on the outcroppings of stratigraphic units and sample descriptions would provide new insight to both major and minor bathymetric features. This type of analysis was beyond the scope of the present study.

However, the regional and detailed bathymetric data from this study should, when compared to the geological data, assist in the assessment of the granular resource potential of the Erksak area.

AREA	PLAN TYPE	SCALE	PARAMETERS View	Tilt	Exag.
1	Mesh	N/A	45	30	200X
1	Bathymetry	1:175 000			
1	Profile Key Plan	1:200 000			
1	Profile Plans (3)	horz. 1:100 000 vert. 1:100			
2	Mesh	N/A	135	30	200X
2	Mesh	N/A	45	30	200X
2	Bathymetry	1:75 000			
2	Profile Key Plan	1:75 000			
2	Profile Plans (3)	horz. 1:75 000 vert. 1:200			
2A	Mesh	N/A	135	30	200X
2A	Mesh	N/A	315	30	200X
2A	Bathymetry	1:75 000			
2A	Profile Key Plan	1:75 000			
2A	Profile Plans (2)	horz. 1:75 000 vert. 1:200			
3	Mesh	N/A	315	30	200X
3	Mesh	N/A	45	30	200X
3	Bathymetry	1:50 000			
3	Profile Key Plan	1:50 000			
3	Profile Plans (3)	horz. 1:50 000 vert. 1:200			
3A	Mesh	N/A	315	30	200X
3A	Mesh	N/A	45	30	200X
3A	Bathymetry	1:50 000			
3A	Profile Key Plan	1:50 000			
3A	Profile Plans (2)	horz. 1:25 000 vert. 1:200			
4	Mesh	N/A	315	30	200X
4	Mesh	N/A	135	30	200X
4	Bathymetry	1:75 000			
4	Profile Key Plan	1:75 000			
4	Profile Plans (3)	horz. 1:75 000 vert. 1:200			
5	Mesh	N/A	135	30	200X
5	Mesh	N/A	45	30	200X
5	Bathymetry	1:150 000			
5	Profile Key Plan	1:150 000			
5	Profile Plans (2)	horz. 1:100 000 vert. 1:200			
6	Mesh	N/A	90	30	200X
6	Mesh	N/A	45	30	200X
6	Bathymetry	1:75 000			
6	Profile Key Plan	1:75 000			
6	Profile Plans (3)	horz. 1:75 000 vert. 1:200			

" Plan Plot Parameters, " Erksak Borrow Block "

Table 4



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 45 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE

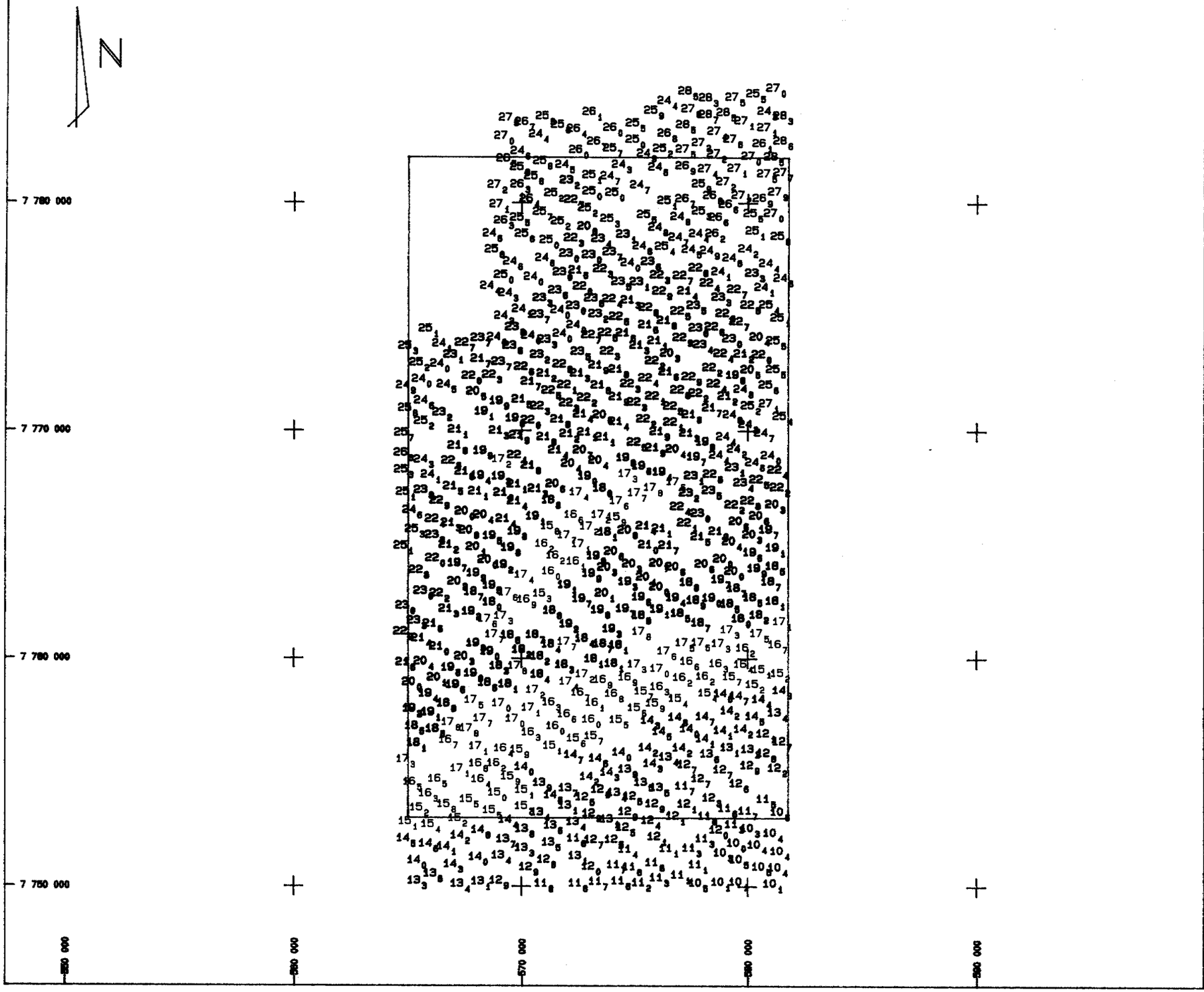
ZONE #1

ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 25 DEC 1987	DWG # : M-1-1

FIG. 43



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #1. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE ->

9.0 - 11.9	BLACK
12.0 - 14.9	GREEN
15.0 - 17.9	BLUE
18.0 - 20.9	PURPLE
21.0 - 23.9	RED
24.0 - 30.0	BROWN

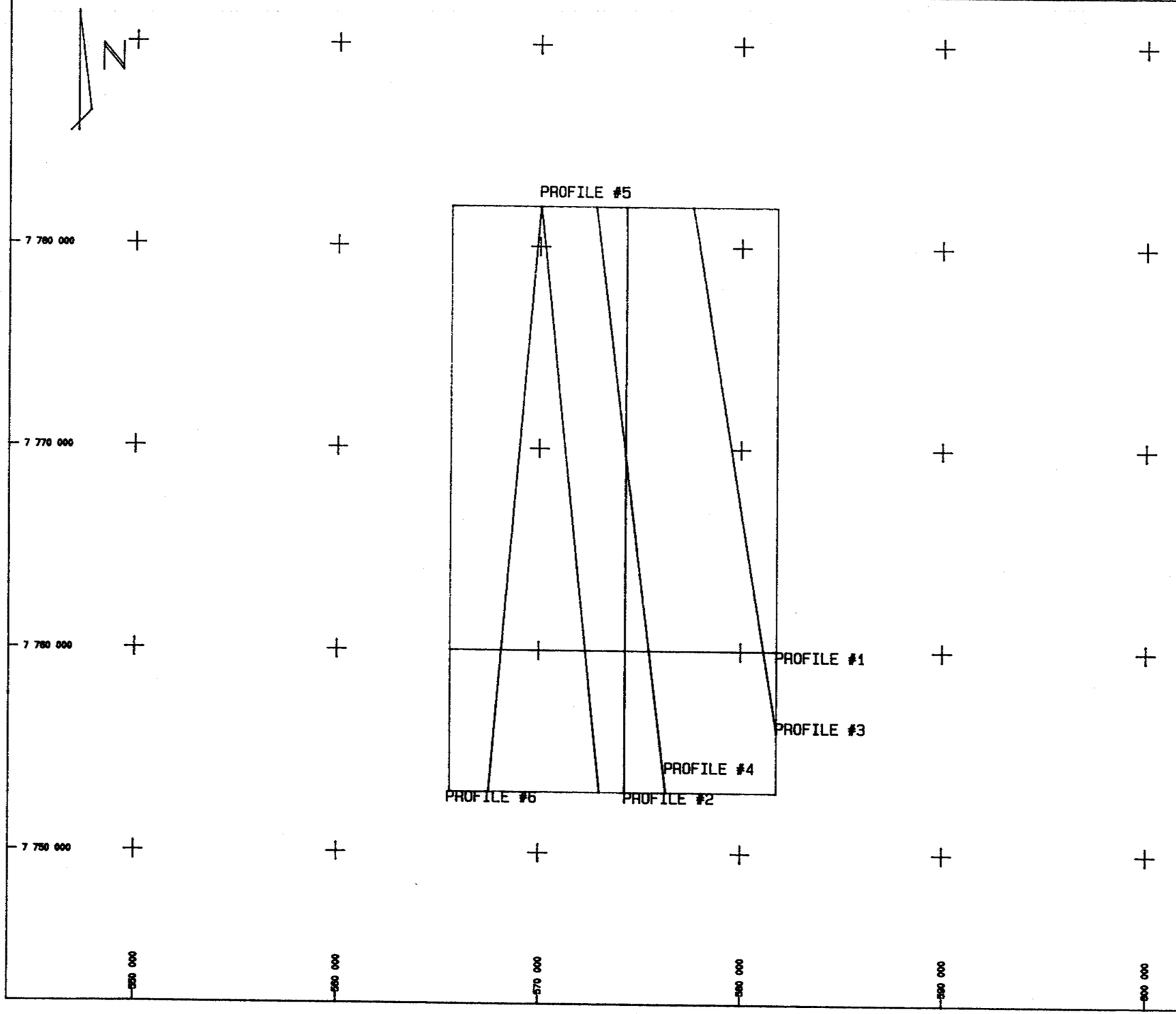
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC DATA PLOT
ZONE #1
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 175000	JOB NO : S-617
	DATE : 25 DEC 1987	DWG # : B-1-1

FIG. 44



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #1.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7767500 E. 573675
6. PROFILE CO-ORDINATES

	START	END
#1	N.7760000 E. 581750	N.7760000 E. 565000
#2	N.7753000 E. 574250	N.7782000 E. 574250
#3	N.7756000 E. 581750	N.7782000 E. 577500
#4	N.7753000 E. 576250	N.7782000 E.572750
#5	N.7753000 E. 573000	N.7782000 E. 570000
#6	N.7753000 E. 567500	N.7782000 E. 570000

INDIAN & NORTHERN AFFAIRS CANADA

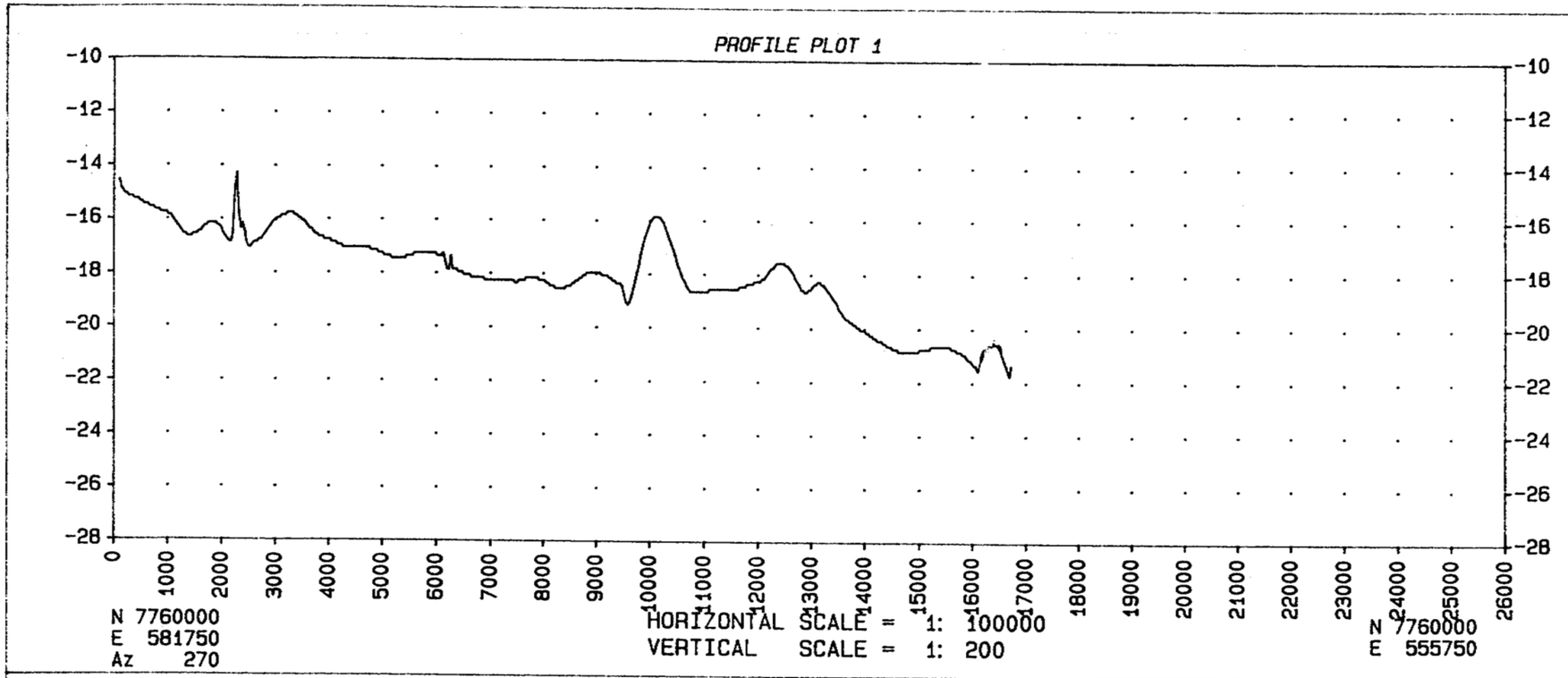
BATHYMETRIC PROFILE KEY PLAN
ZONE #1
ERKSAK BORROW BLOCK

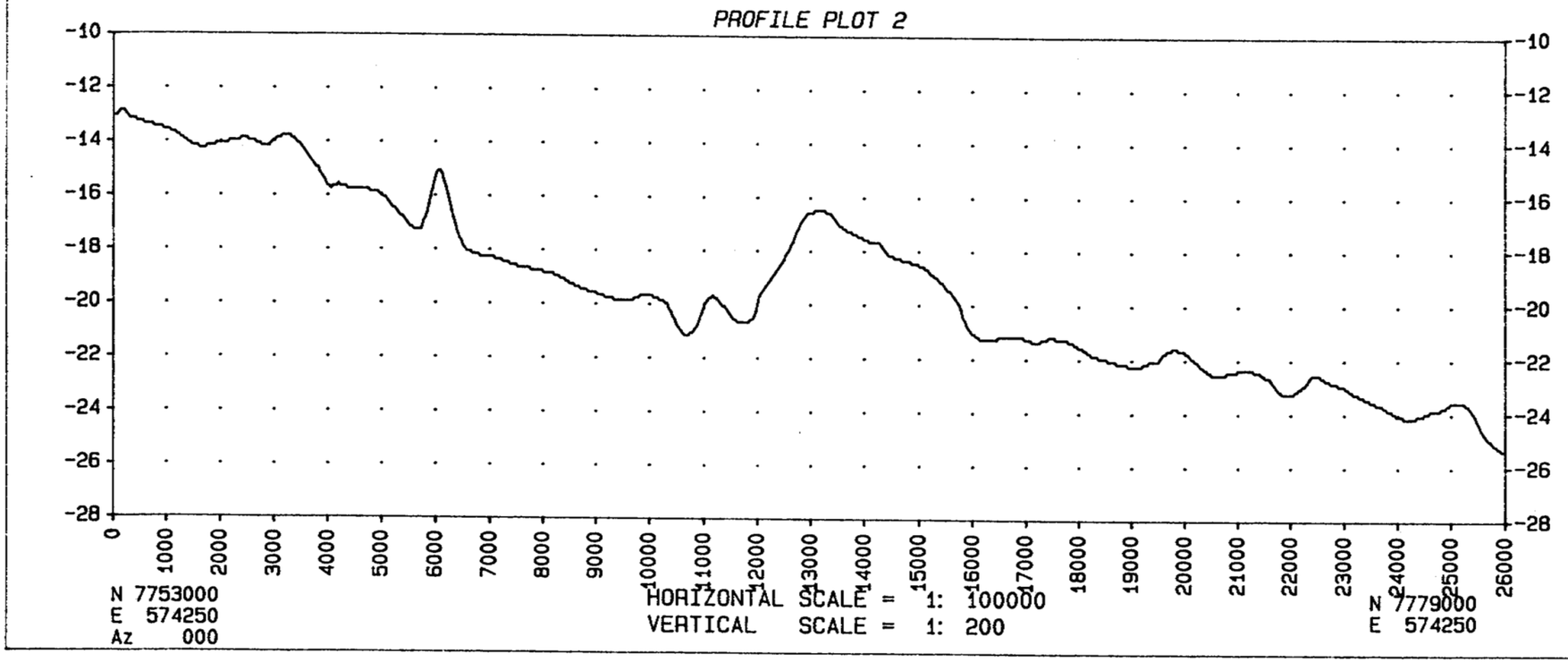
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

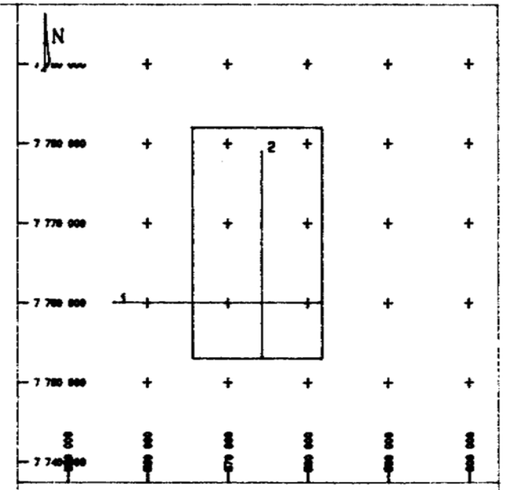
CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 200000	JOB NO : S-617
DATE : 25 DEC 1987	DWG # : X-1-1

FIG. 45







KEY PLAN - 1 : 750000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

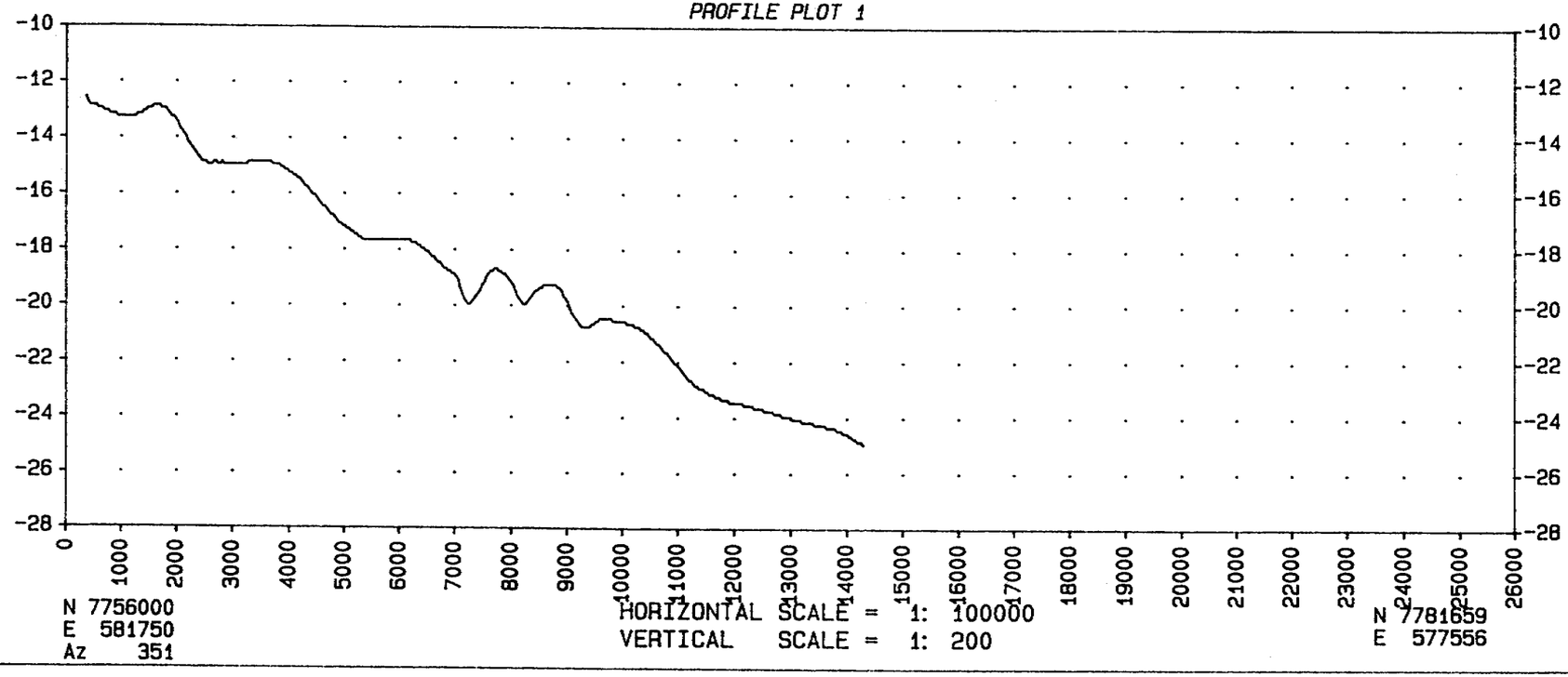
BATHYMETRIC PROFILES
ZONE #1
ERKSAK BORROW BLOCK

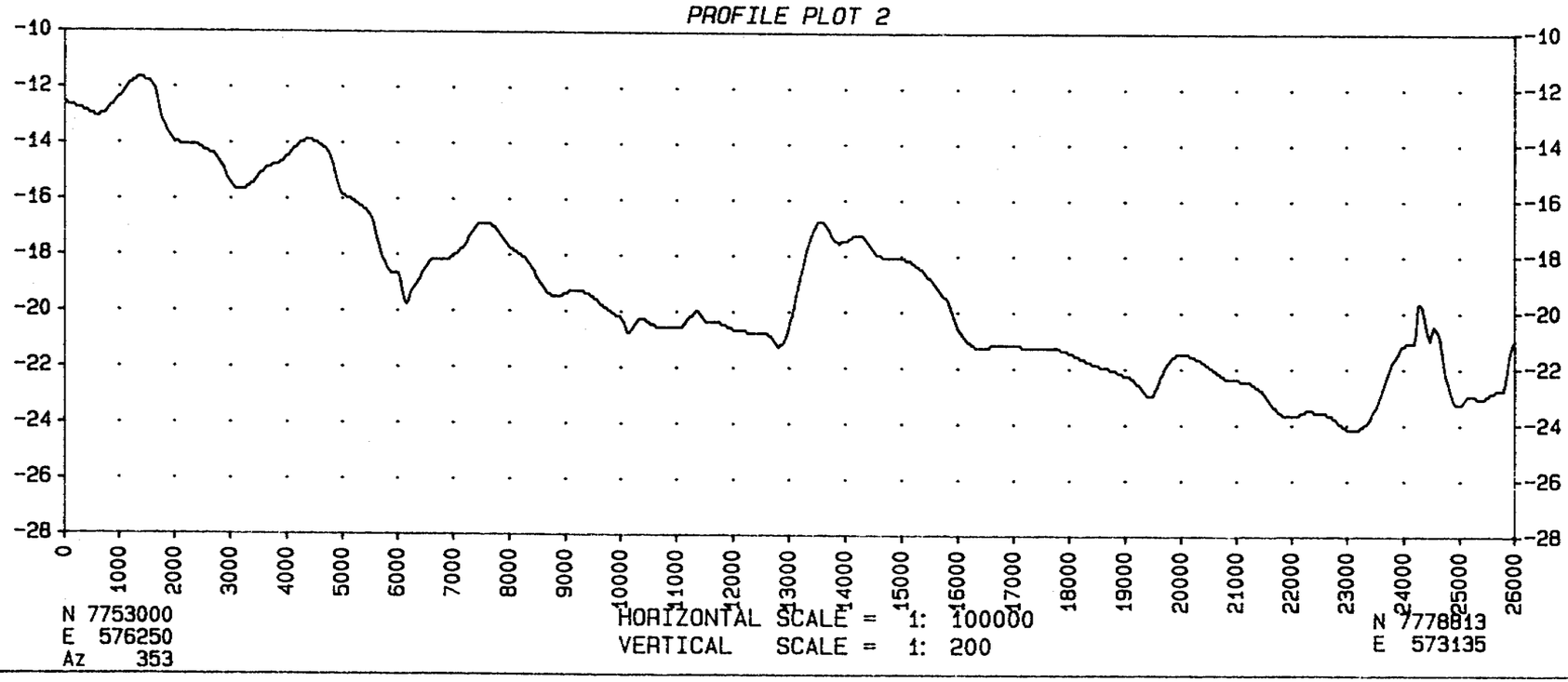
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

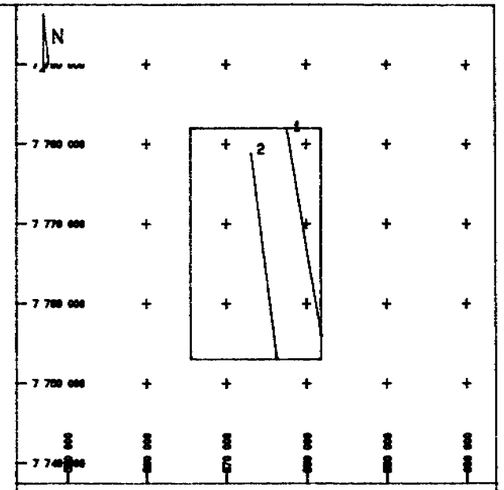
CHALLENGER SURVEYS & SERVICES LTD

DATE : 25 DEC 1987	JOB NO : S-617
	DWG # : P-1-1

FIG. 46







KEY PLAN - 1 : 750000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

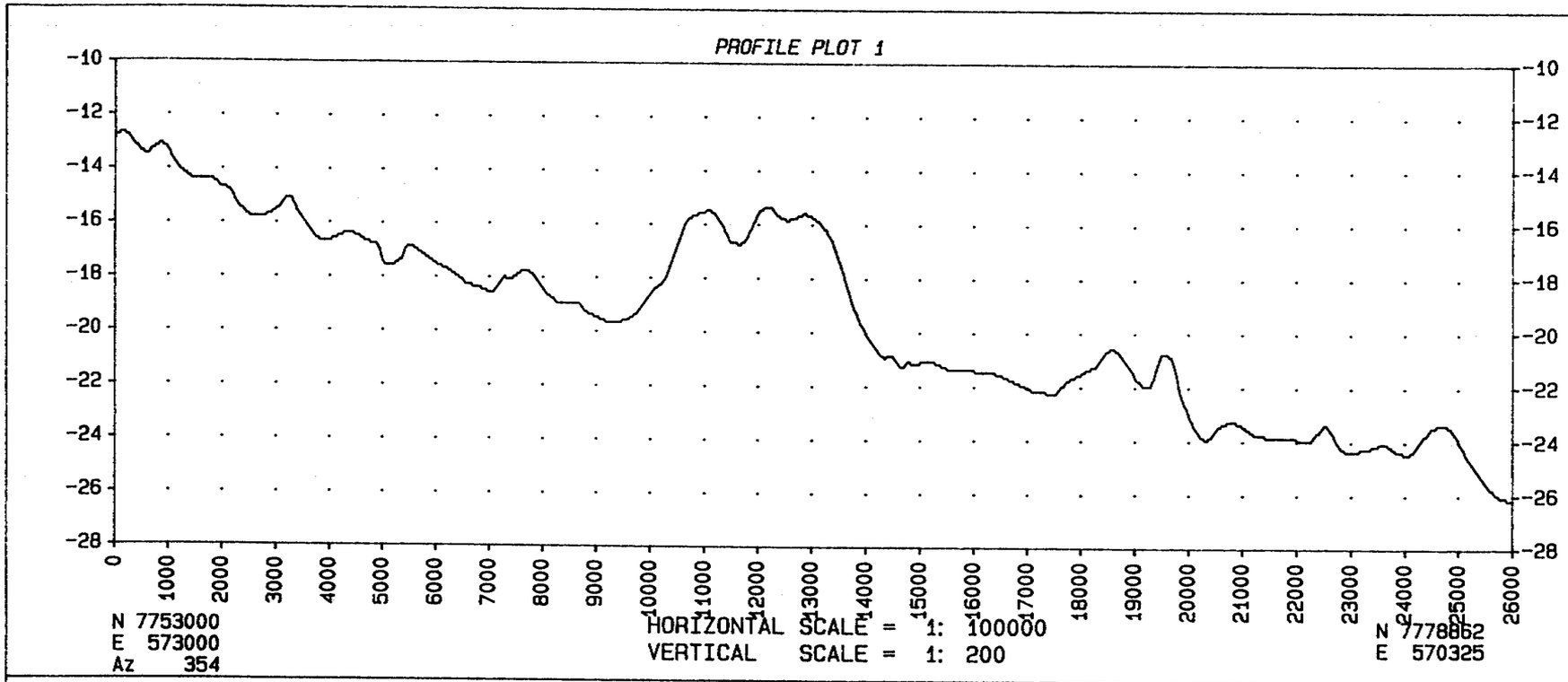
INDIAN & NORTHERN AFFAIRS CANADA

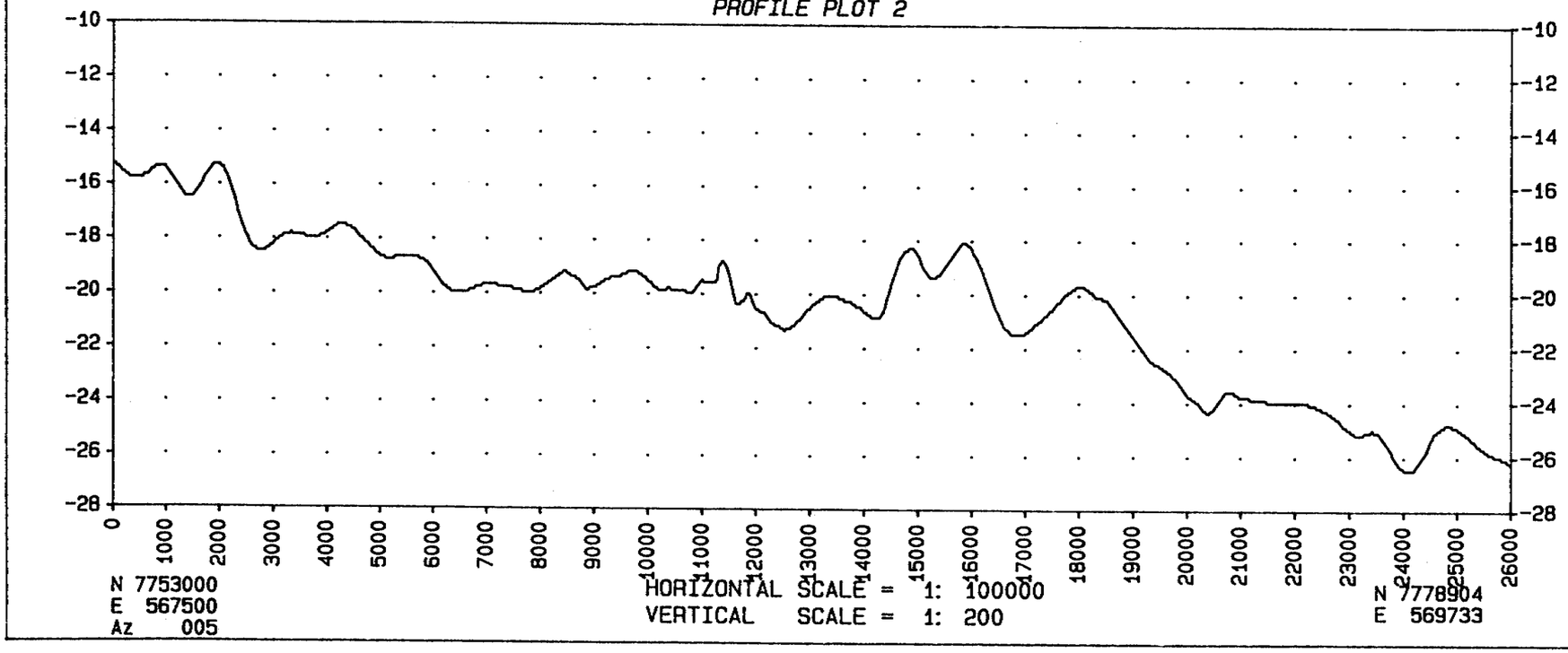
BATHYMETRIC PROFILES
ZONE #1
ERKSAK BORROW BLOCK

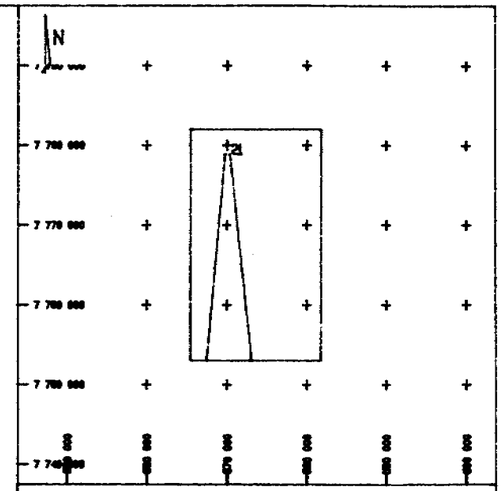
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD		JOB NO : S-617
	DATE : 25 DEC 1987	DWG # : P-1-2

FIG. 47







KEY PLAN - 1 : 750000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

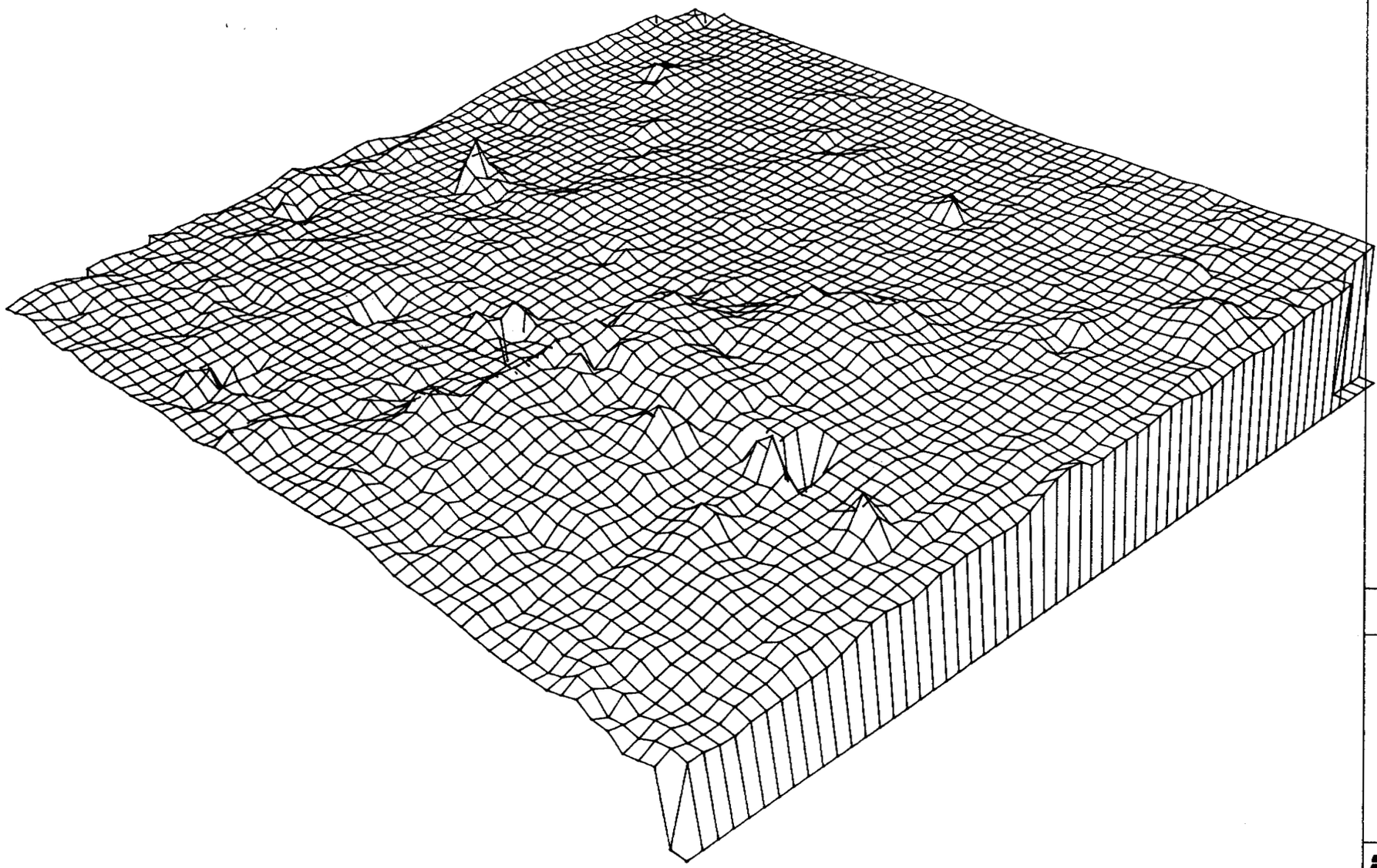
BATHYMETRIC PROFILES
ZONE #1
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

JOB NO : S-617
DATE : 25 DEC 1987
DWG # : P-1-8

FIG. 48



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 135 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE

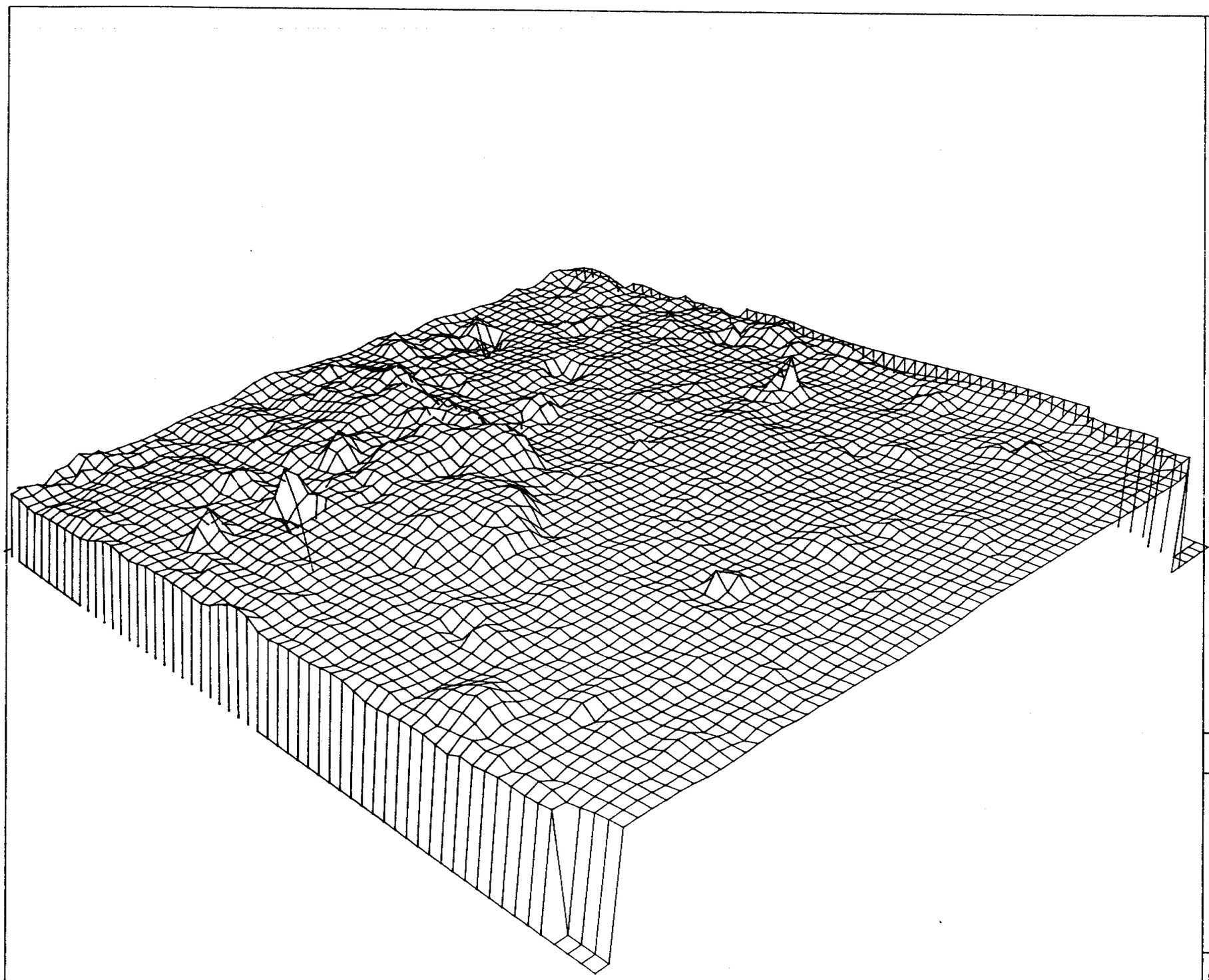
ZONE #2

ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 20 DEC 1987	DWG # : M-2-1

FIG. 49



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 45 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE

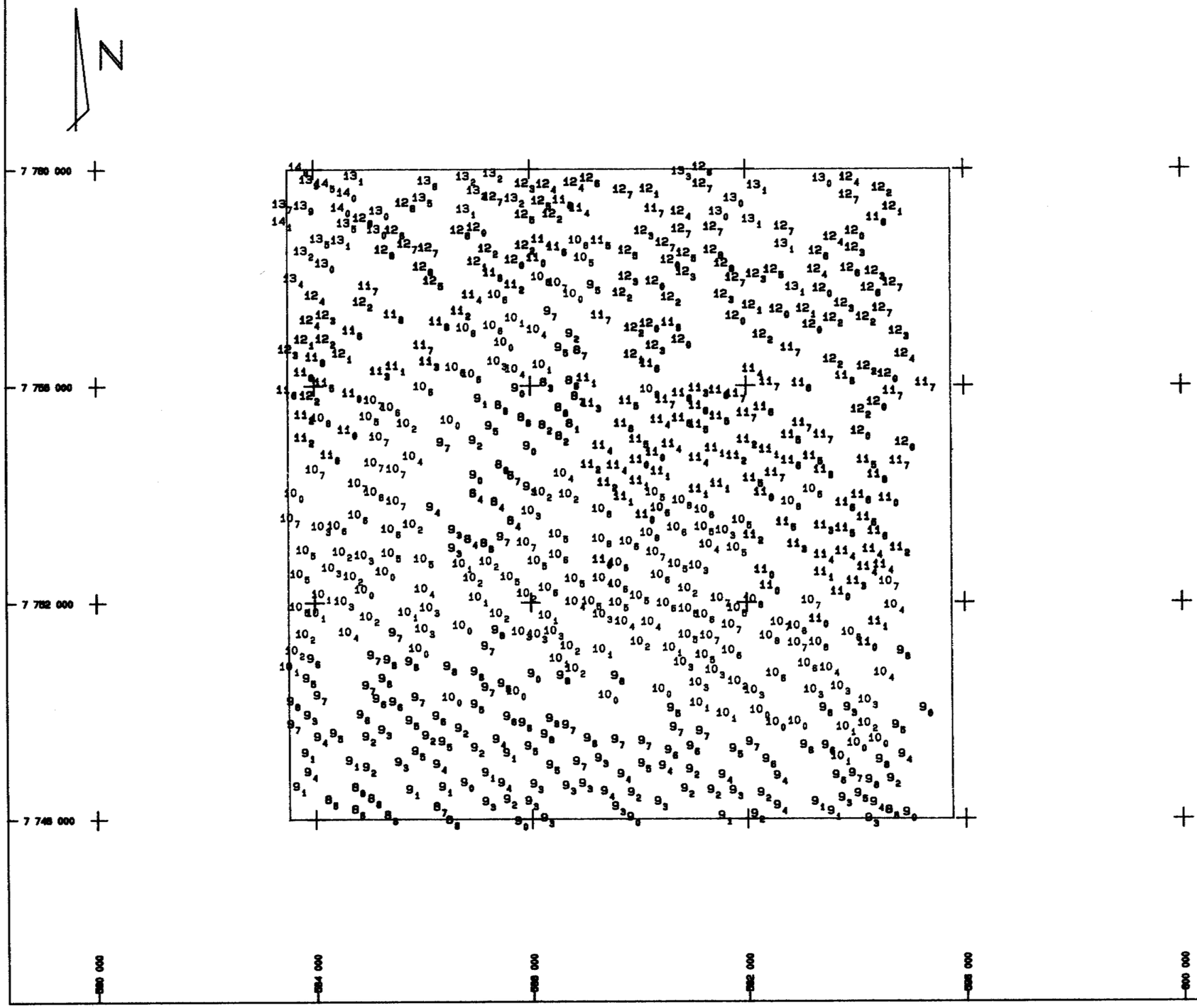
ZONE #2

ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 20 DEC 1987	DWG # : M-2-2

FIG. 50



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #6. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE ->

8.0 - 8.9	BLACK
9.0 - 9.9	GREEN
10.0 - 10.9	BLUE
11.0 - 11.9	PURPLE
12.0 - 12.9	RED
13.0 - 15.9	BROWN

INDIAN & NORTHERN AFFAIRS OF CANADA

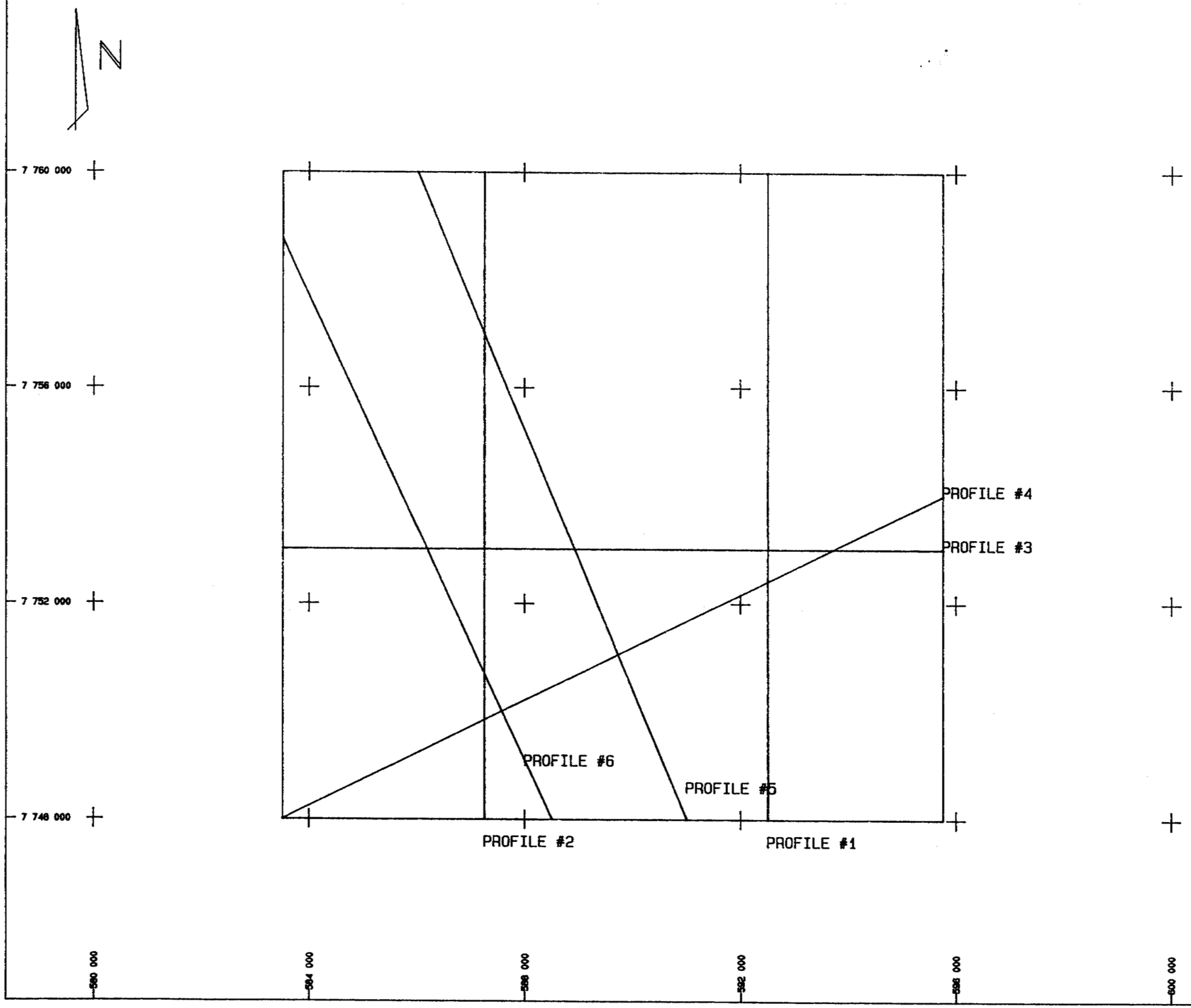
BATHYMETRIC DATA PLOT
ZONE #2
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & ENGINEERING LTD

SCALE : 1 : 75000	JOB NO : S-617
DATE : 20 DEC 1987	DWG # : S-2-1

FIG. 51



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #2.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7754000 E.589625
6. PROFILE CO-ORDINATES

	START	END
#1	N.7748000 E. 592500	N.7760000 E. 592500
#2	N.7748000 E. 587250	N.7760000 E. 587250
#3	N.7753000 E. 595750	N.7753000 E. 583500
#4	N.7754000 E. 595750	N.7748000 E. 583500
#5	N.7748000 E. 591000	N.7760000 E. 586000
#6	N.7748000 E. 588500	N.7758750 E. 583500

INDIAN & NORTHERN AFFAIRS CANADA

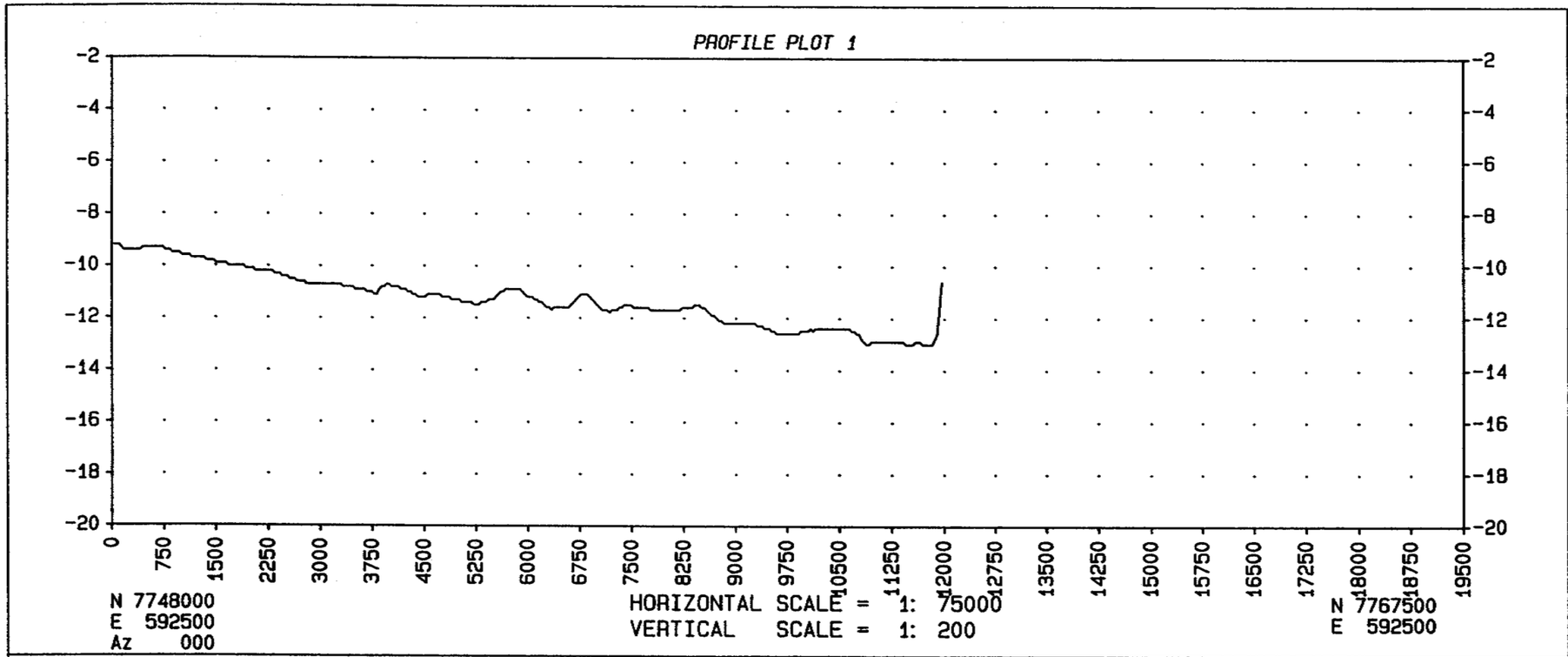
BATHYMETRIC PROFILE KEY PLAN
ZONE #2
ERKSAK BORROW BLOCK

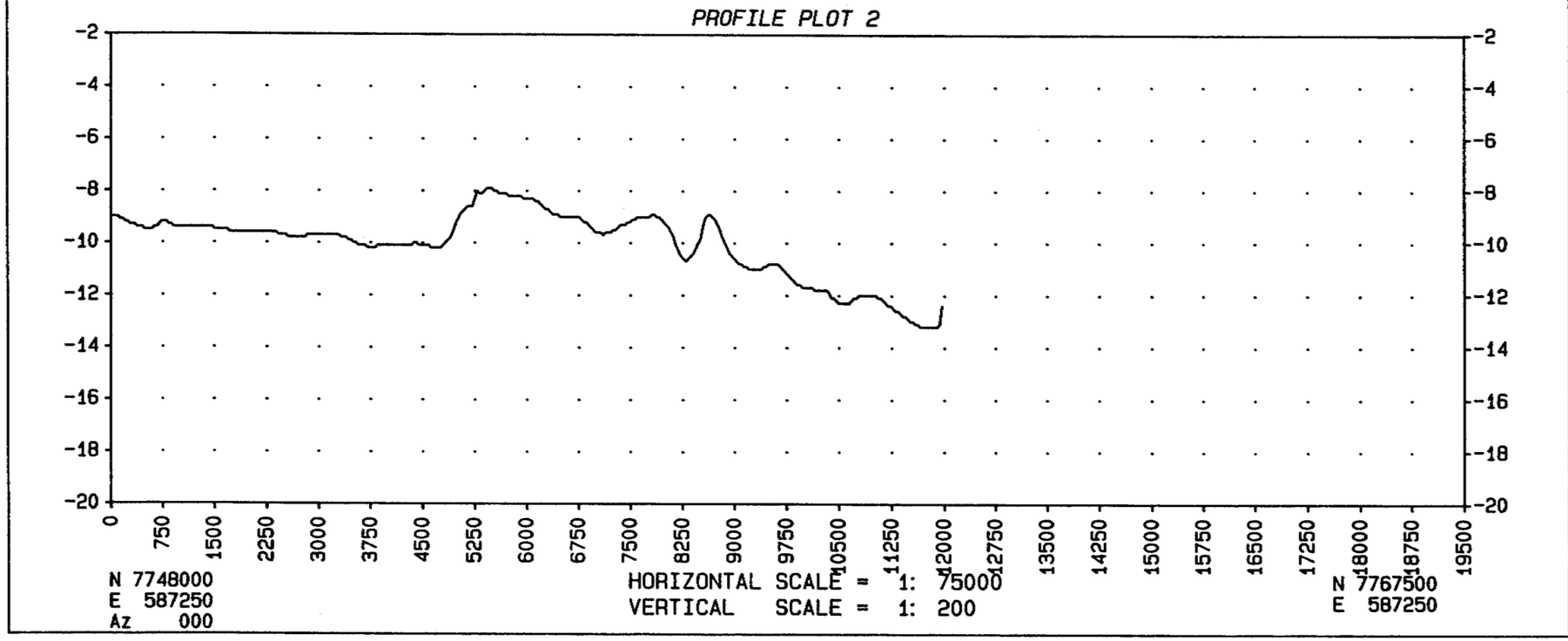
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

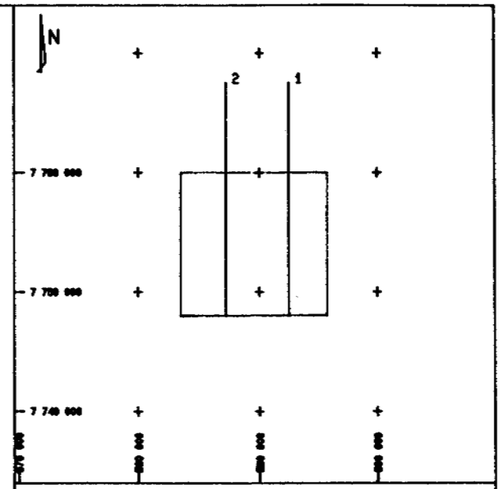
CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 75000	JOB NO : S-617
DATE : 20 DEC 1987	DWG # : X-2-1

FIG. 52







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #2
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

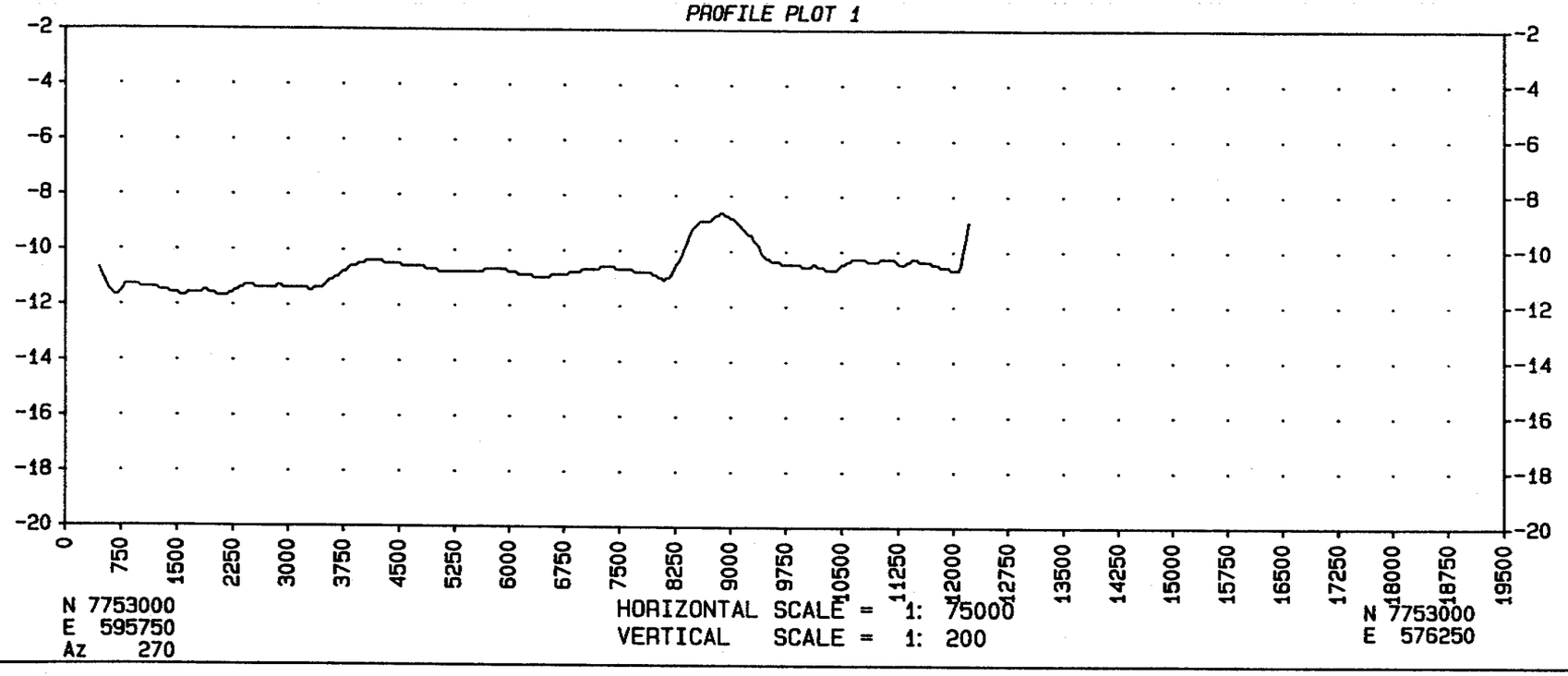
DATE : 20 DEC 1987

JOB NO : S-617

DWG # : P-2-1

FIG. 53

PROFILE PLOT 1

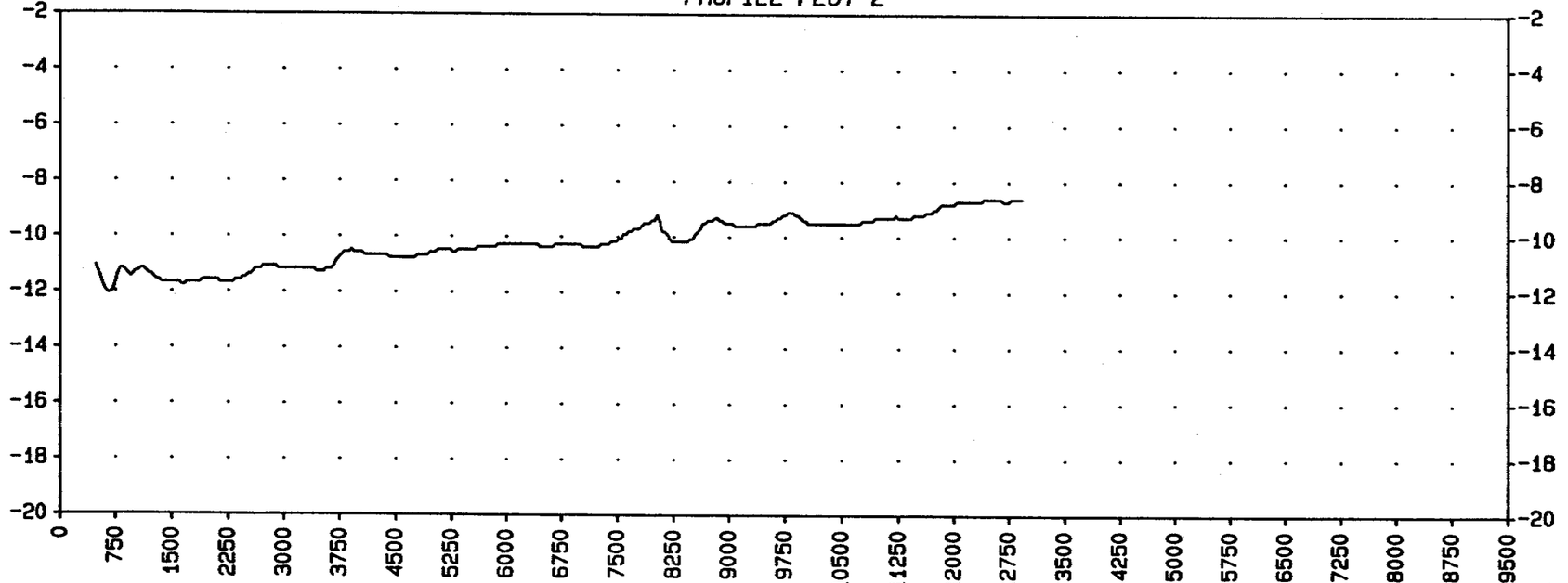


N 7753000
E 595750
Az 270

HORIZONTAL SCALE = 1: 75000
VERTICAL SCALE = 1: 200

N 7753000
E 576250

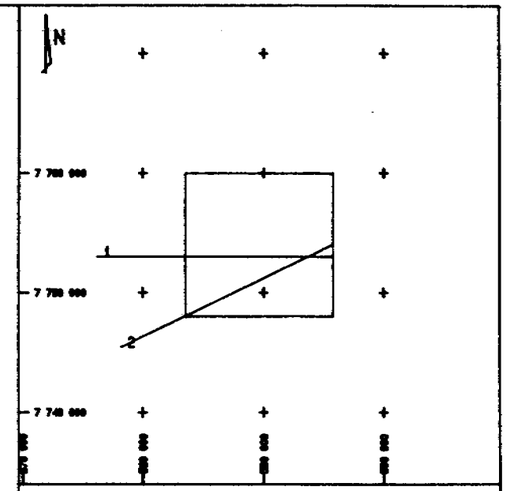
PROFILE PLOT 2



N 7754000
E 595750
Az 244

HORIZONTAL SCALE = 1: 75000
VERTICAL SCALE = 1: 200

N 7745423
E 578238



KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #2
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

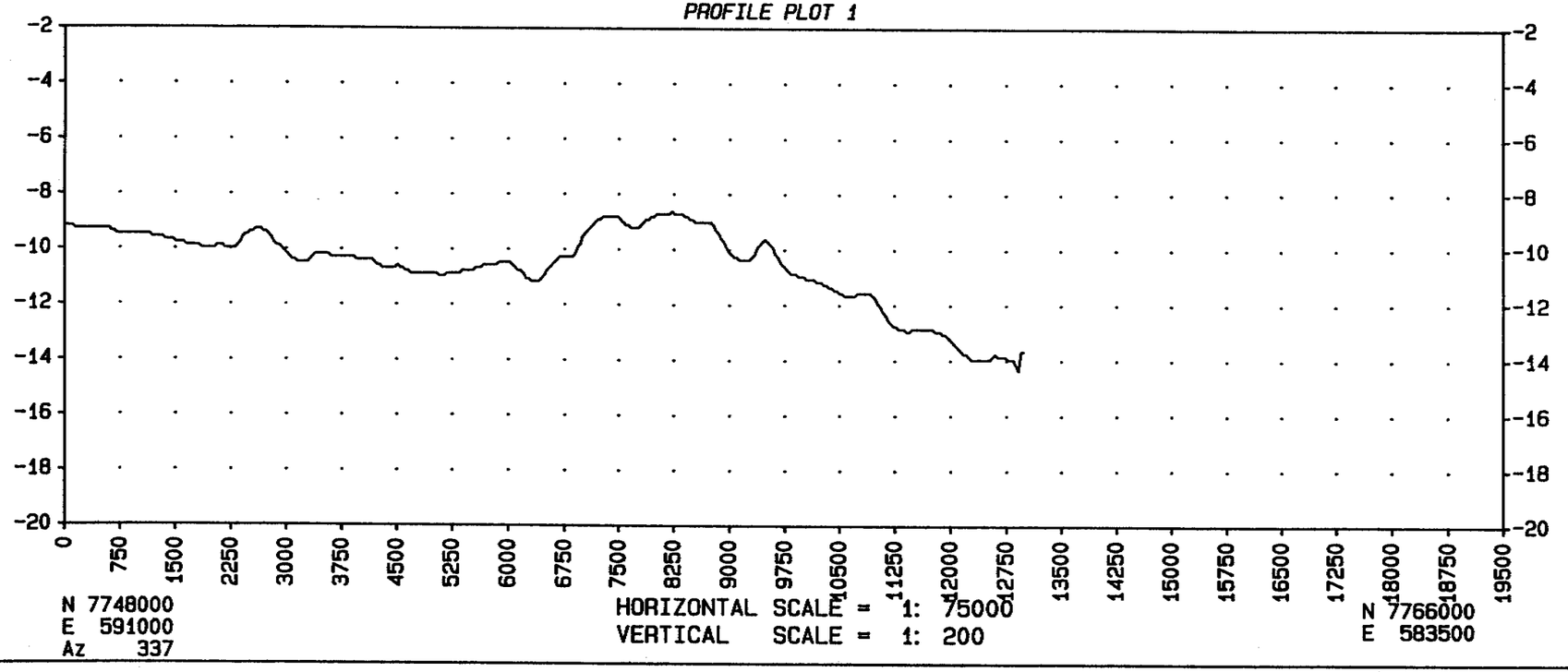
DATE : 20 DEC 1987

JOB NO : S-617

DWG # : P-2-2

FIG.54

PROFILE PLOT 1

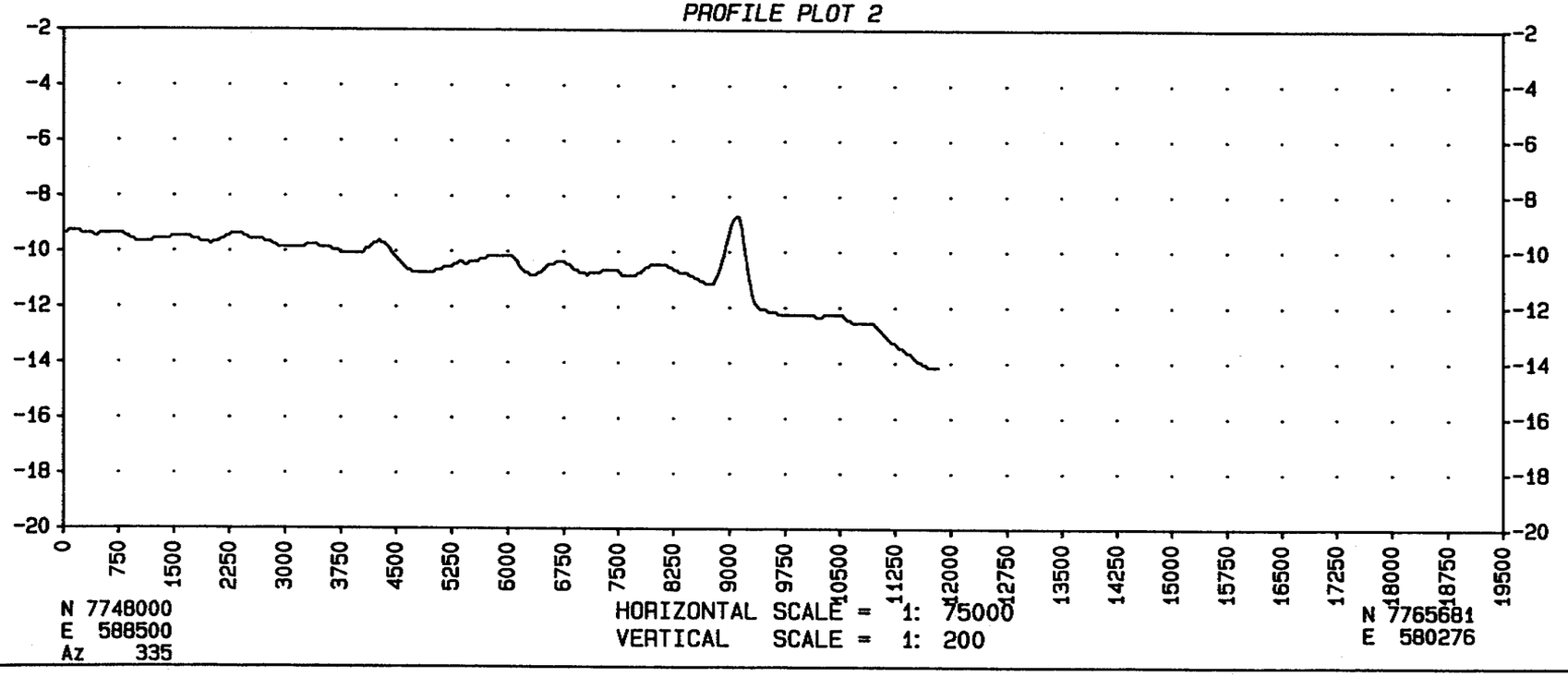


N 7748000
E 591000
Az 337

HORIZONTAL SCALE = 1: 75000
VERTICAL SCALE = 1: 200

N 7766000
E 583500

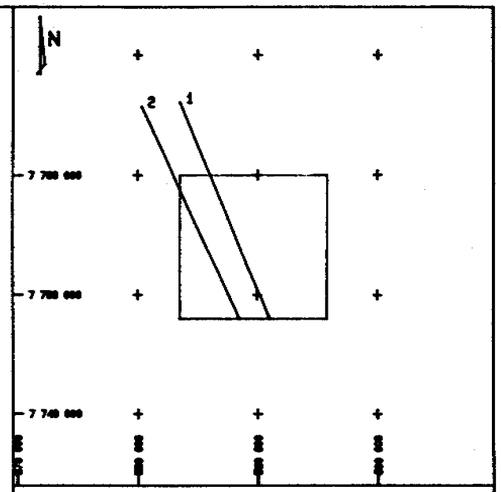
PROFILE PLOT 2



N 7748000
E 588500
Az 335

HORIZONTAL SCALE = 1: 75000
VERTICAL SCALE = 1: 200

N 7765681
E 580276



KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #2
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

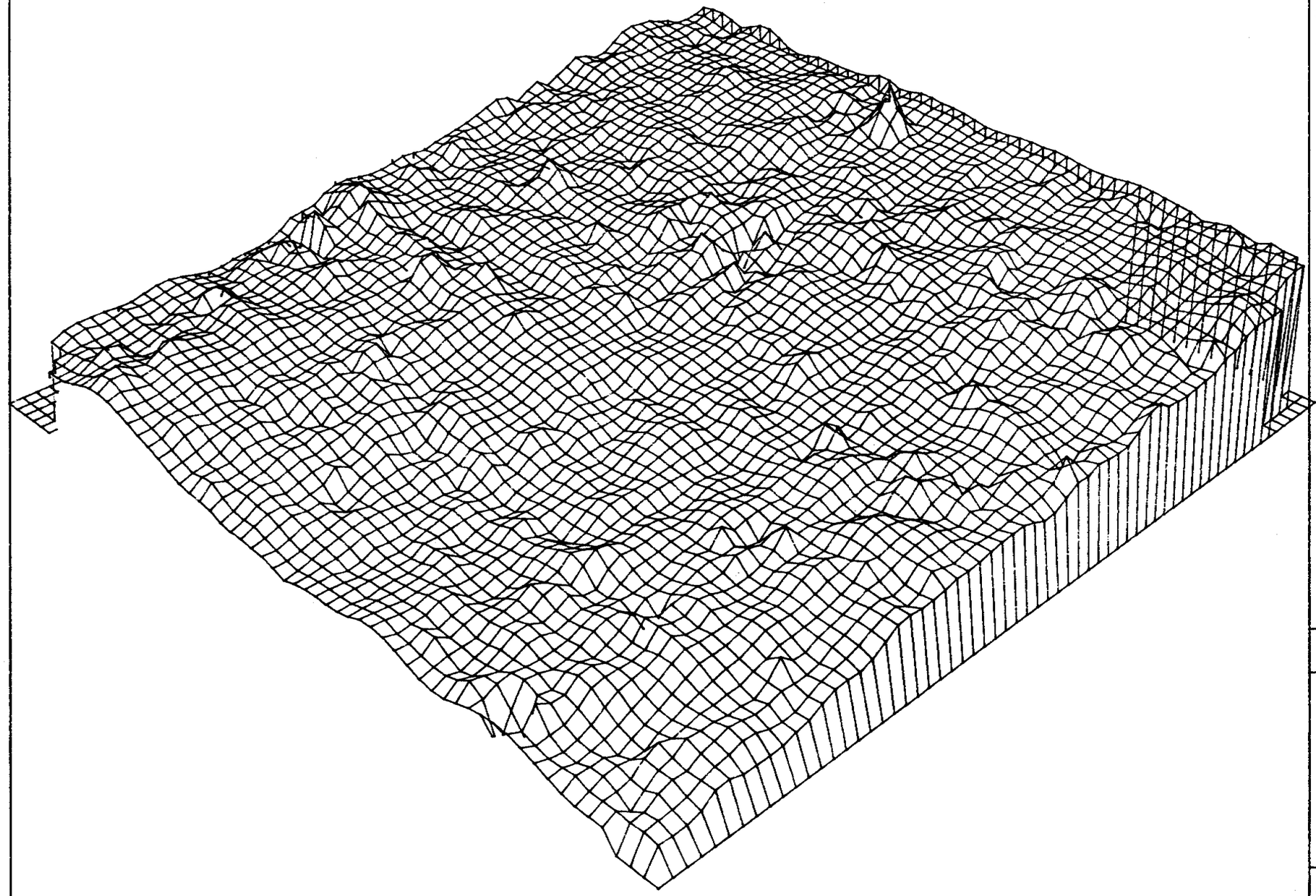
CHALLENGER SURVEYS & SERVICES LTD

DATE : 20 DEC 1987

JOB NO : S-817

DWG # : P-2-3

FIG. 55



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 135 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

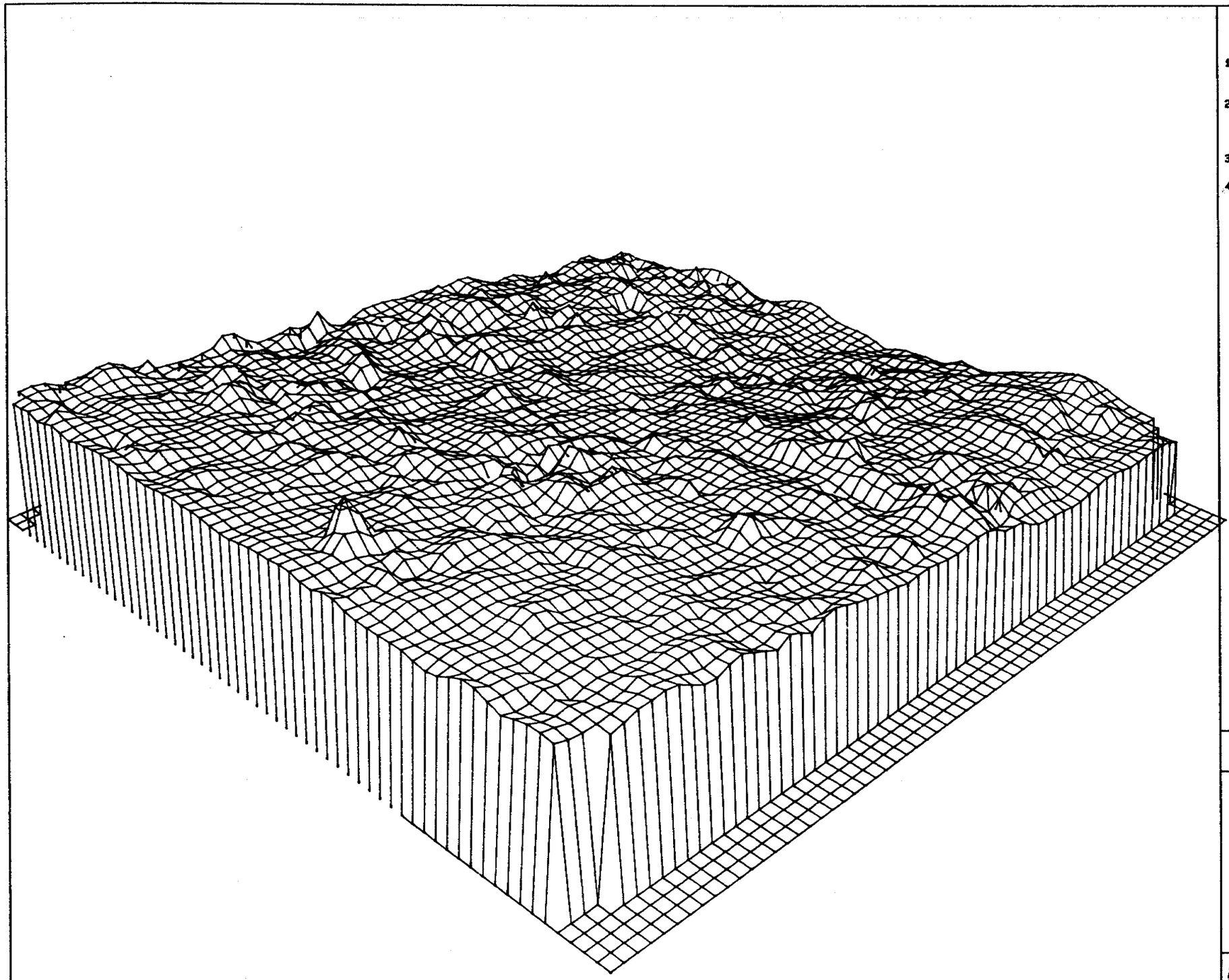
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #2A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 20 DEC 1987	DWG # : M-2A-1

FIG. 56



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 315 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

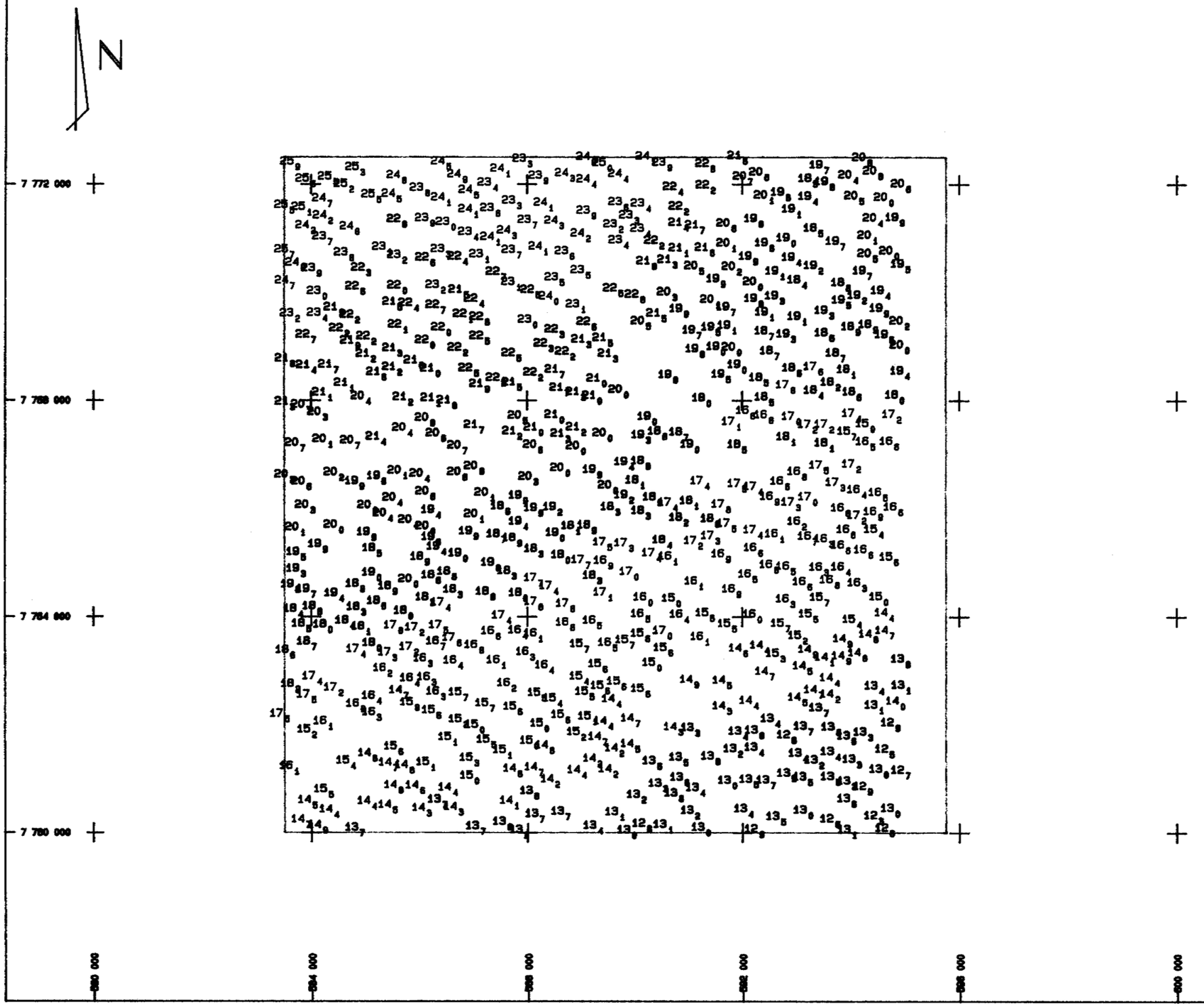
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #2A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 20 DEC 1987	DWG # : M-2A-2

FIG. 57



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #2A. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE -> 12.0 - 13.9 BLACK
14.0 - 15.9 GREEN
16.0 - 17.9 BLUE
18.0 - 20.9 PURPLE
21.0 - 22.9 RED
23.0 - 30.0 BROWN

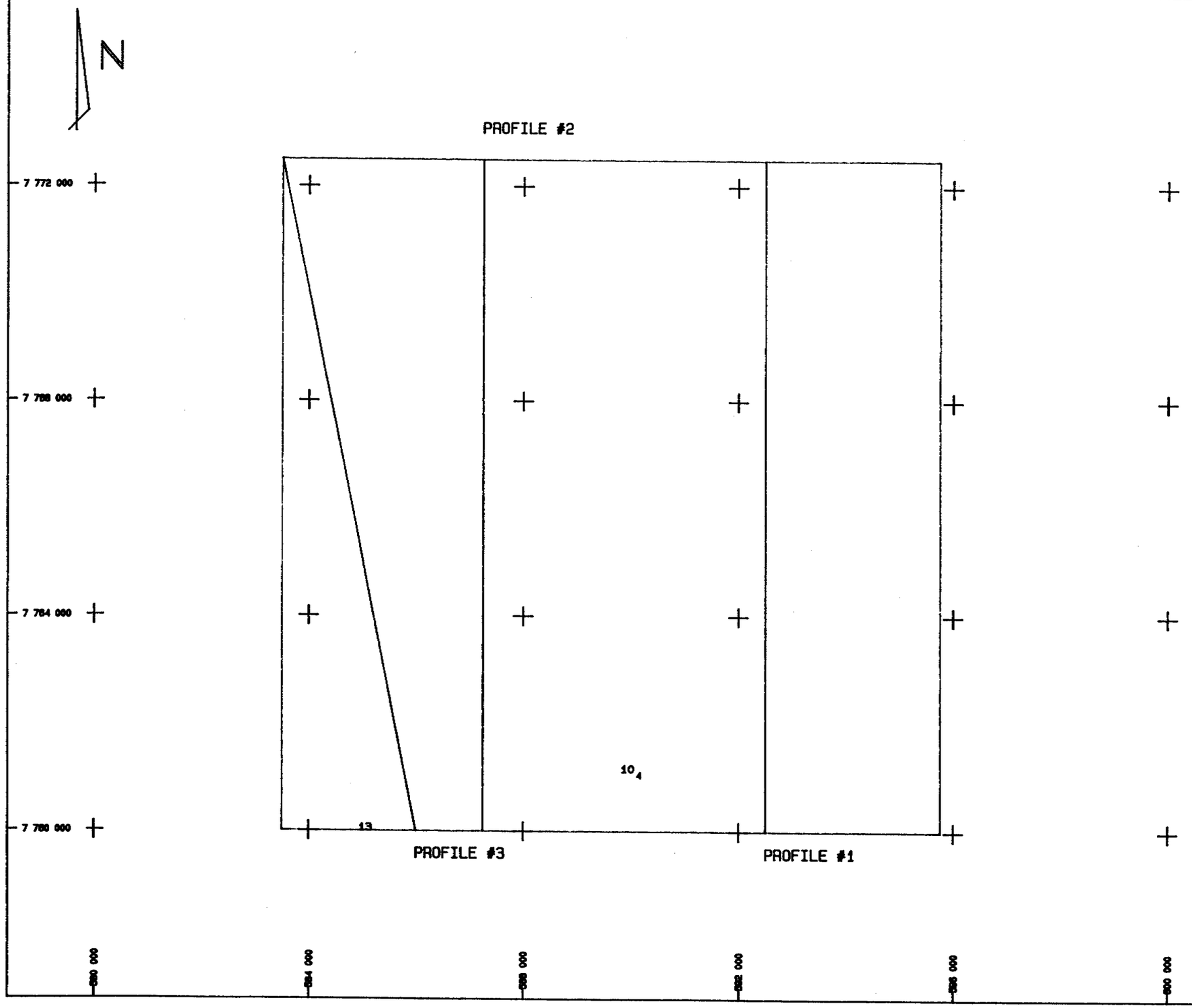
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC DATA PLOT
ZONE #2A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER	SCALE : 1 : 75000	JOB NO : S-617
	DATE : 20 DEC 1987	DWG # : B-2A-1

FIG. 58



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #2A.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7766250 E.589625
6. PROFILE CO-ORDINATES

	START	END
#1	N.7760000 E. 592500	N.7772500 E. 592500
#2	N.7760000 E. 587250	N.7772500 E. 587250
#3	N.7760000 E. 586000	N.7772500 E. 583500

INDIAN & NORTHERN AFFAIRS CANADA

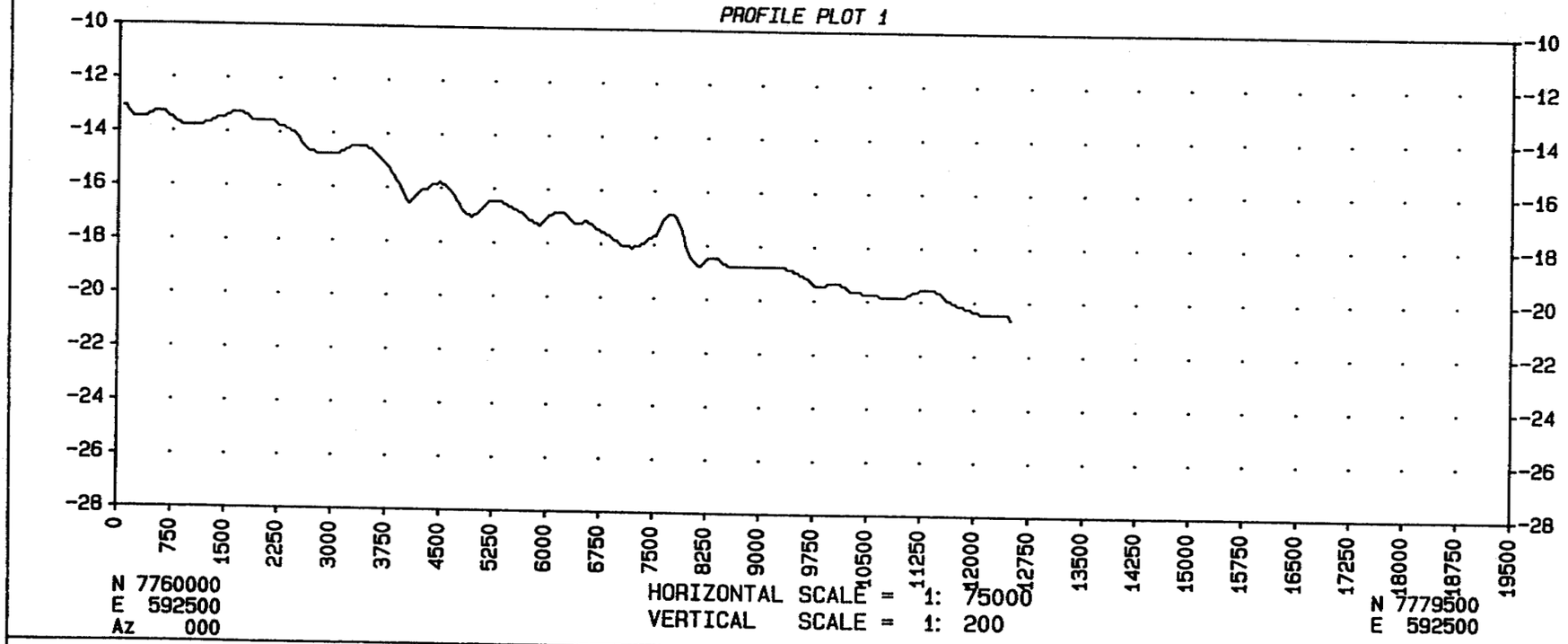
BATHYMETRIC PROFILE KEY PLAN
ZONE #2A
ERKSAK BORROW BLOCK

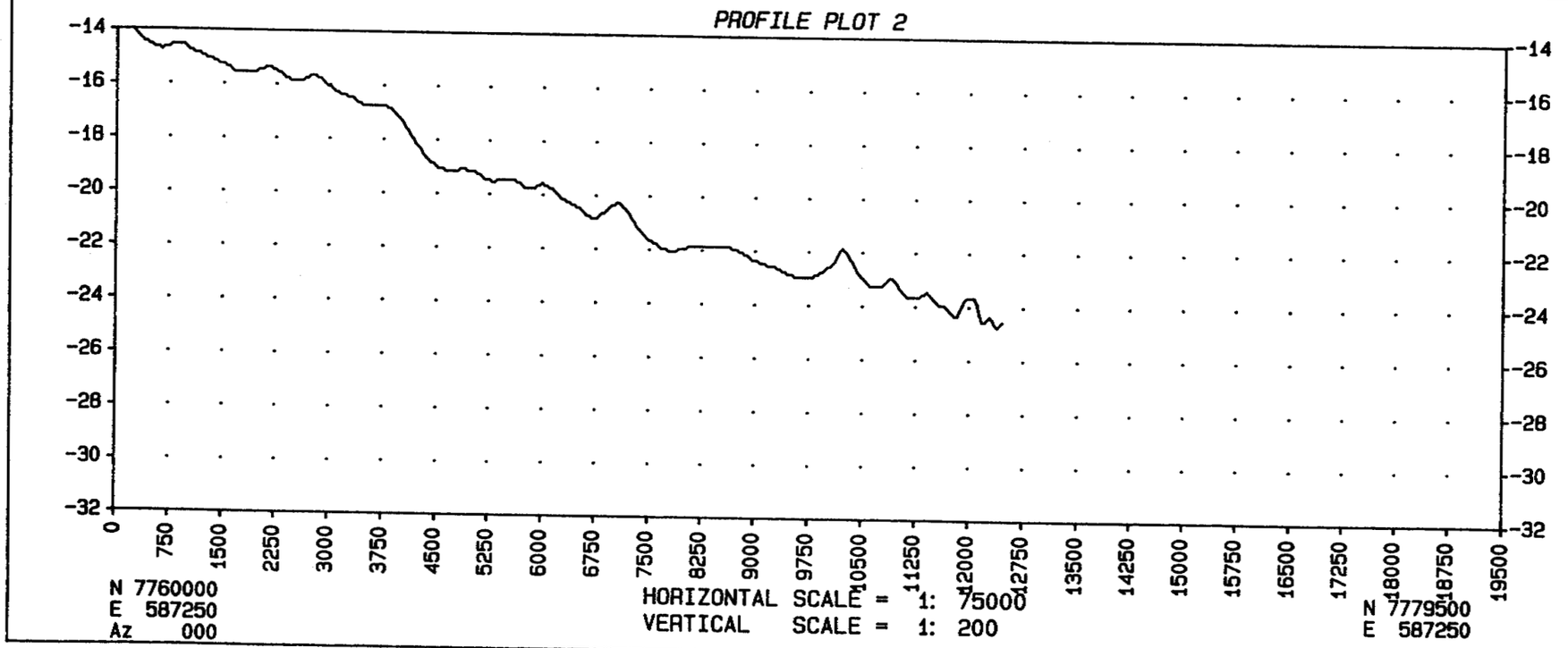
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

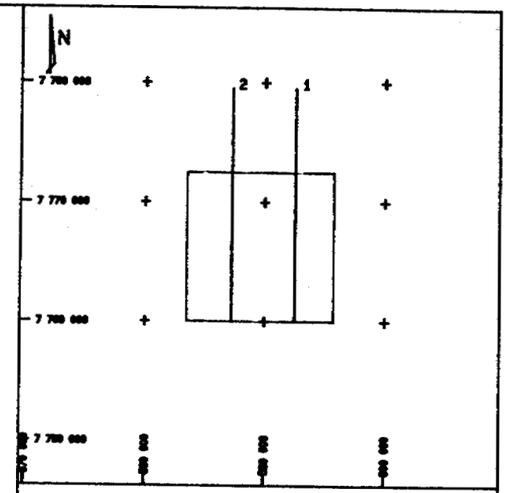
CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 75000	JOB NO : S-617
DATE : 20 DEC 1987	DWG # : X-2A-1

FIG. 59







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

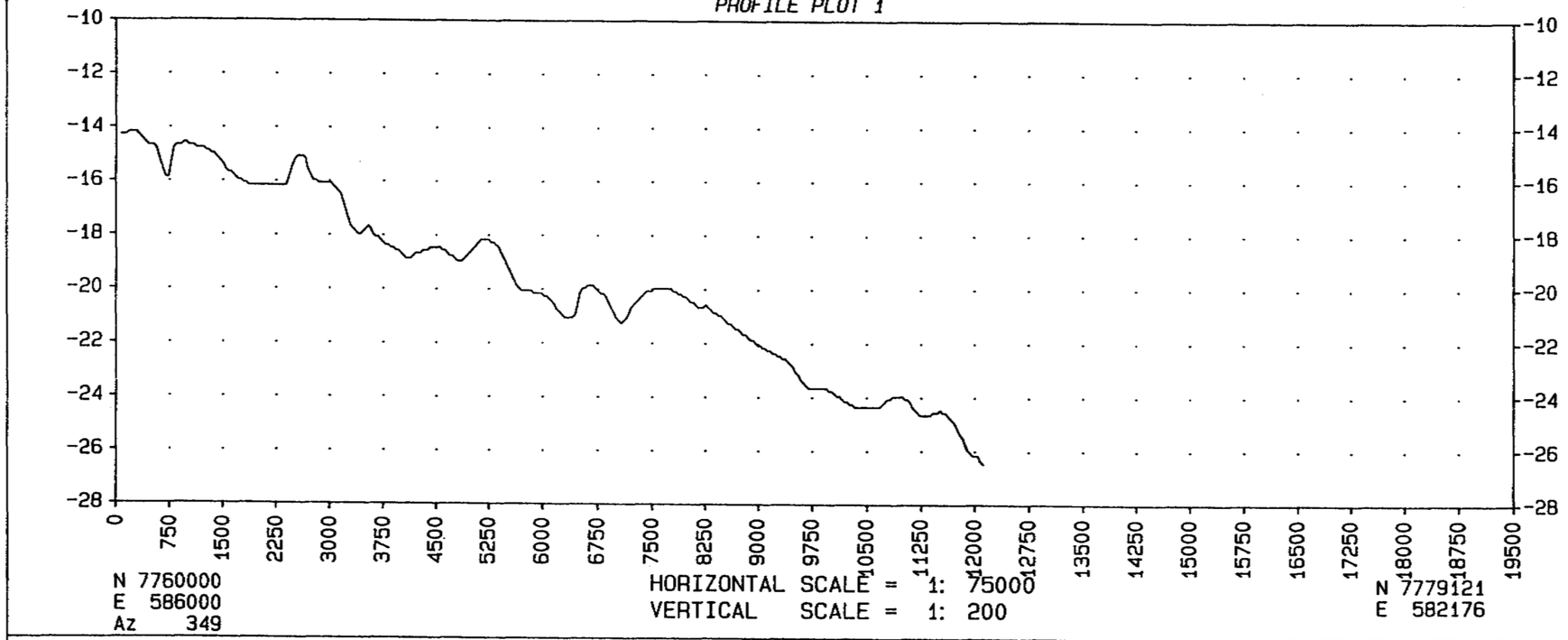
INDIAN & NORTHERN AFFAIRS CANADA

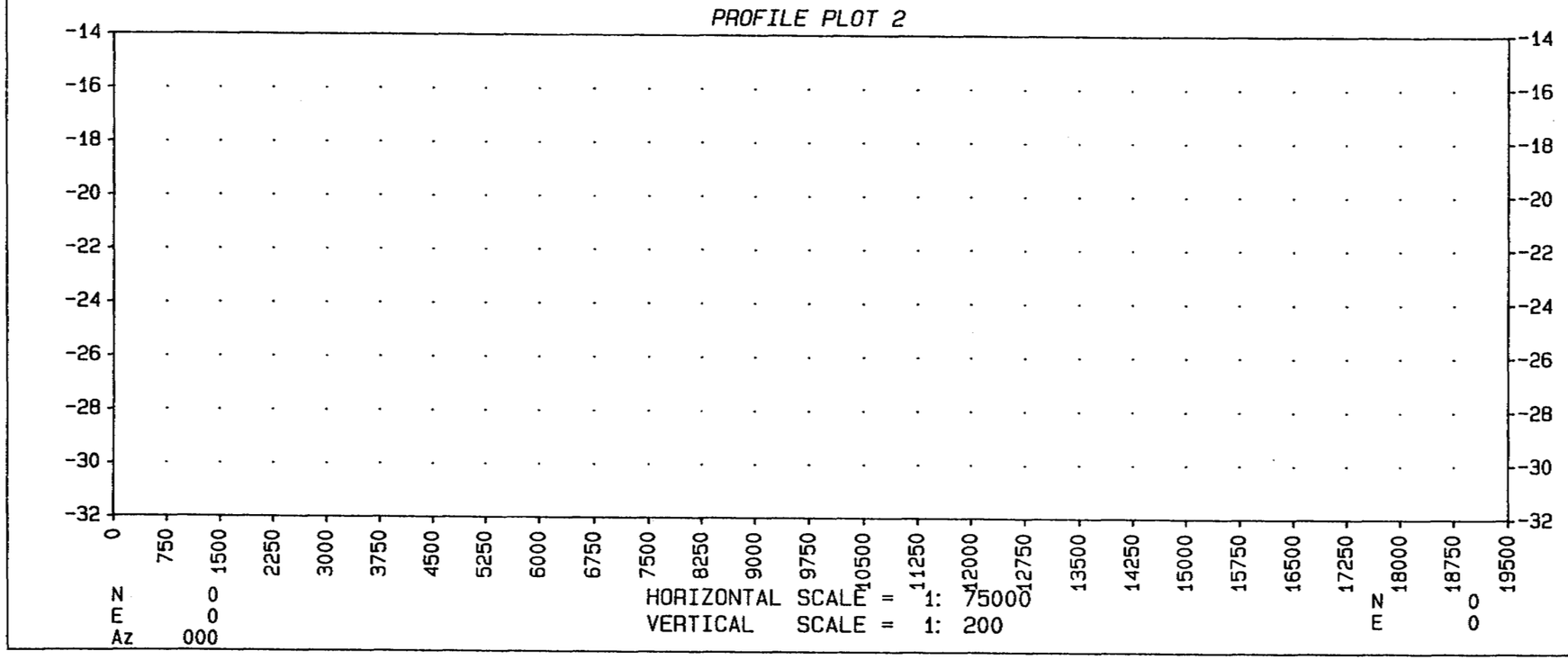
BATHYMETRIC PROFILES
ZONE #2A
ERKSAK BORROW BLOCK

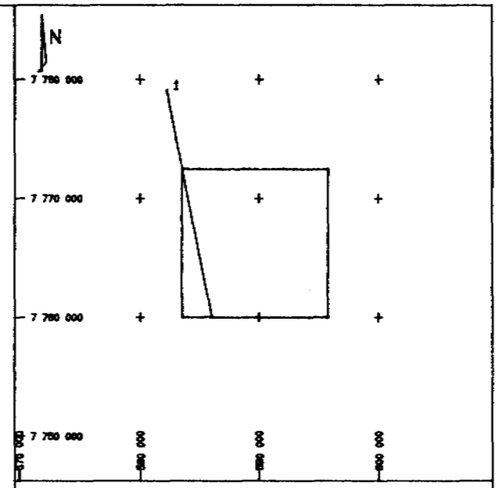
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD.		JOB NO : S-617
	DATE : 20 DEC 1987	DWG # : P-2A-1

FIG. 60







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

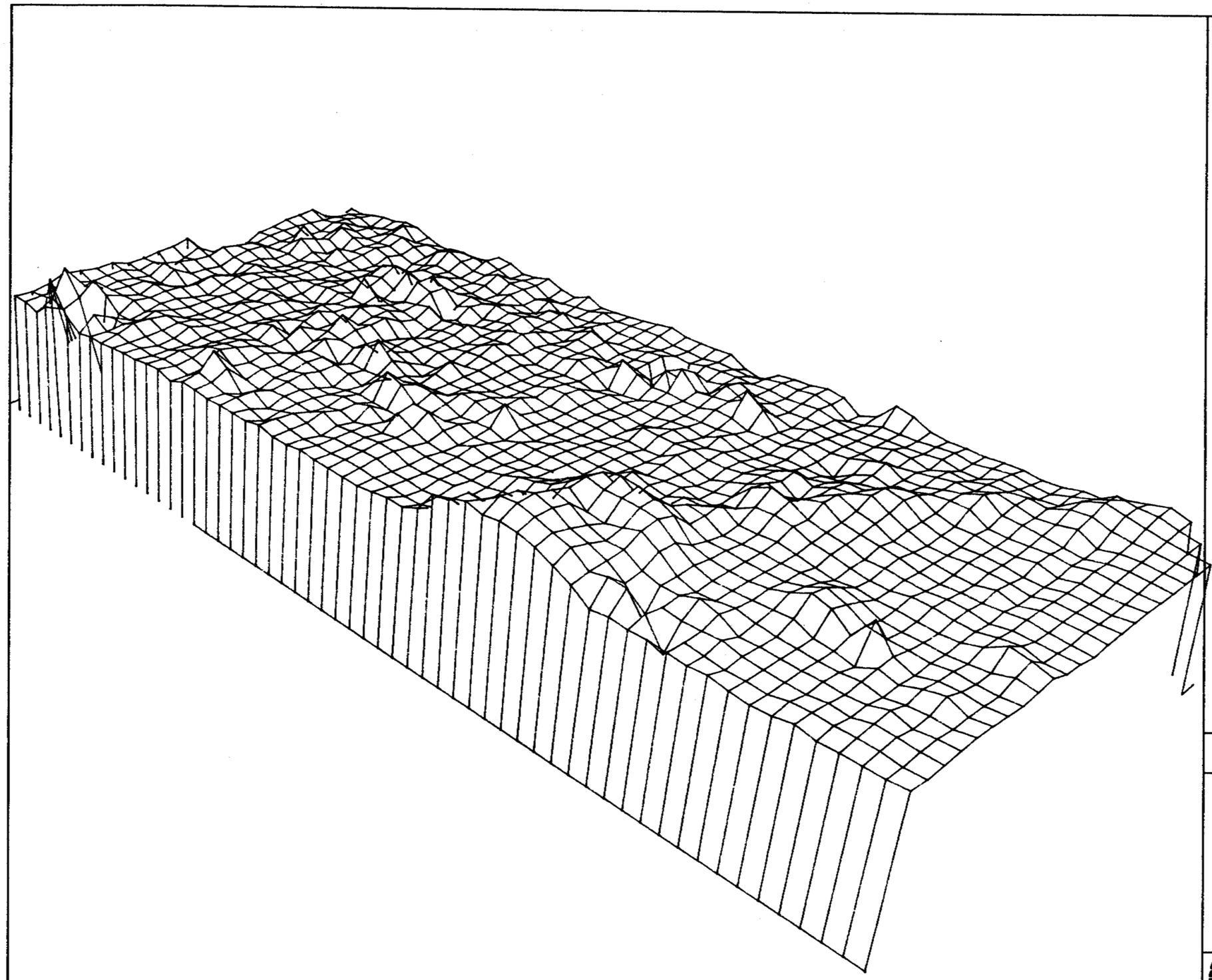
BATHYMETRIC PROFILES
ZONE #2A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD.

JOB NO : S-617
DATE : 20 DEC 1987
DWG # : P-2A-2

FIG. 61



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 315 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS CANADA

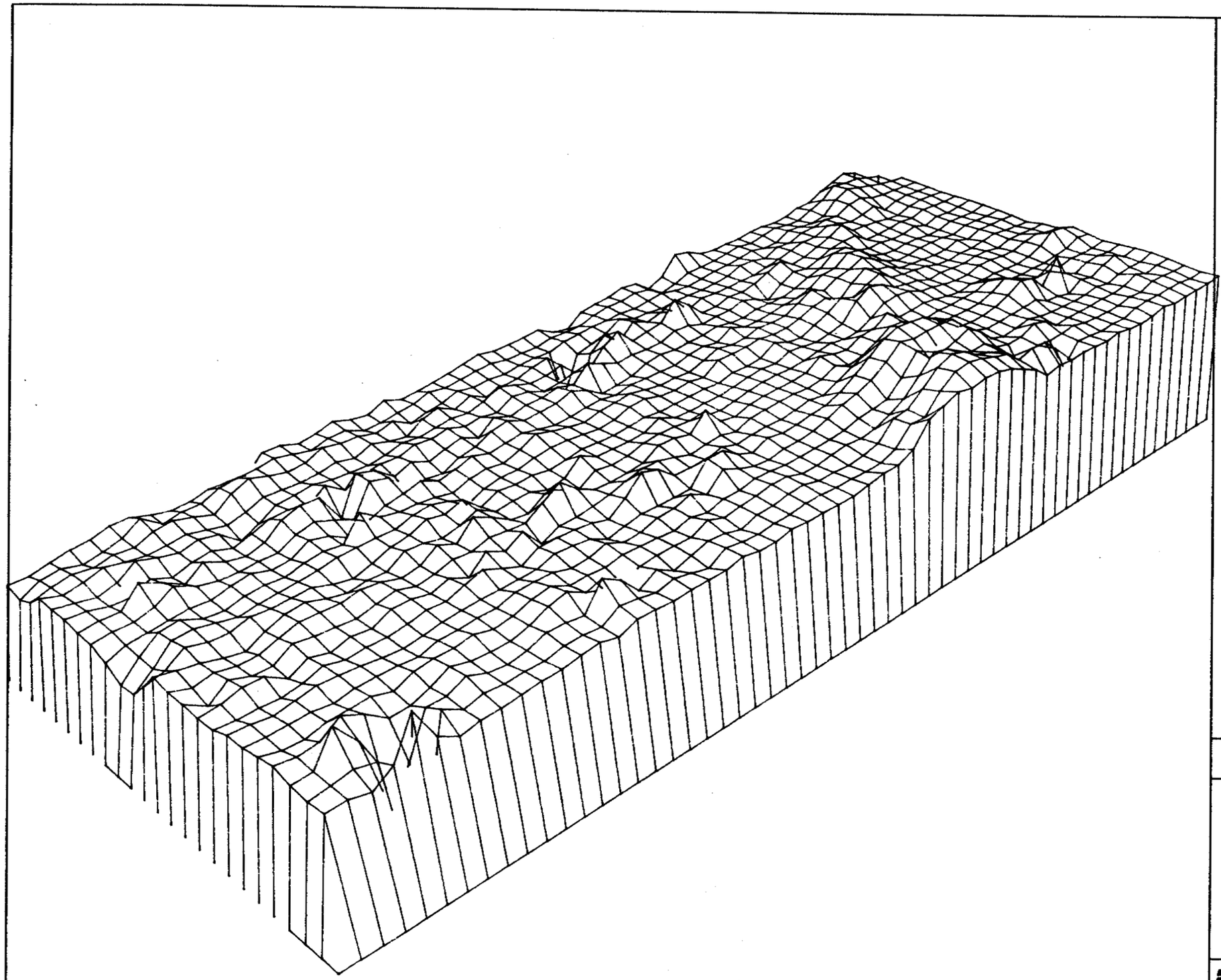
BATHYMETRIC MESH PERSPECTIVE
ZONE #3
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE :	JOB NO :
1 : 100000	S-617
DATE :	DWG # :
24 DEC 1987	M-3-1

FIG. 62



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 45 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

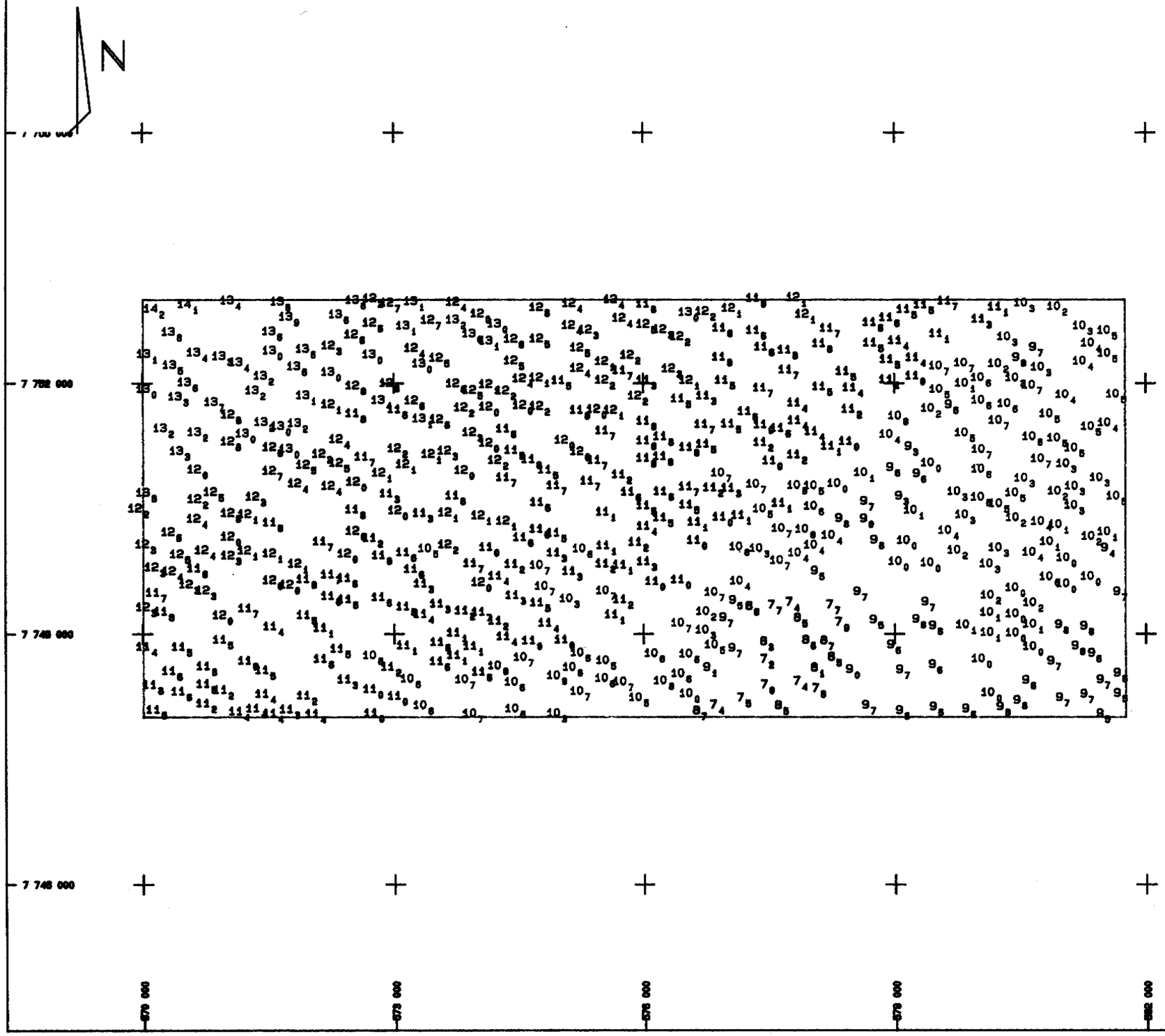
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #3
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & MAPPING LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 24 DEC 1987	DWG # : M-3-2

FIG. 63



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #3. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE ->

7.0 - 8.9	BLACK
9.0 - 9.9	GREEN
10.0 - 10.9	BLUE
11.0 - 11.9	PURPLE
12.0 - 12.9	RED
13.0 - 15.9	BROWN

INDIAN & NORTHERN AFFAIRS CANADA

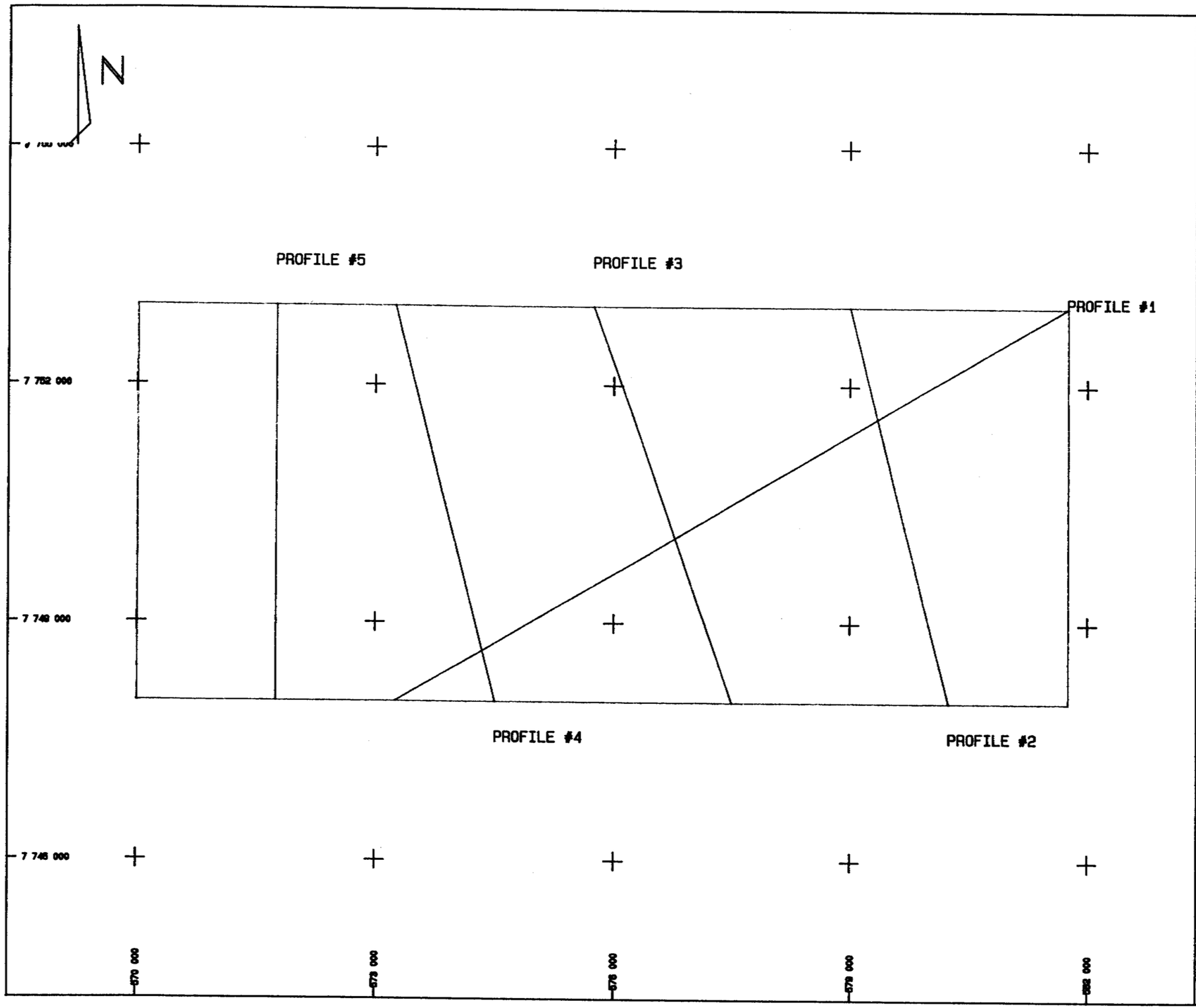
BATHYMETRIC DATA PLOT
ZONE #3
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 50000	JOB NO : 9-617
DATE : 24 DEC 1987	DWG # : B-3-1

FIG. 64



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #3.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7750500 E.575875
6. PROFILE CO-ORDINATES

	START	END
#1	N.7753000 E. 581750	N.7746000 E. 573250
#2	N.7746000 E. 580250	N.7753000 E. 579000
#3	N.7746000 E. 577500	N.7753000 E. 575750
#4	N.7746000 E. 574500	N.7753000 E. 573250
#5	N.7746000 E. 571750	N.7753000 E. 571750

INDIAN & NORTHERN AFFAIRS CANADA

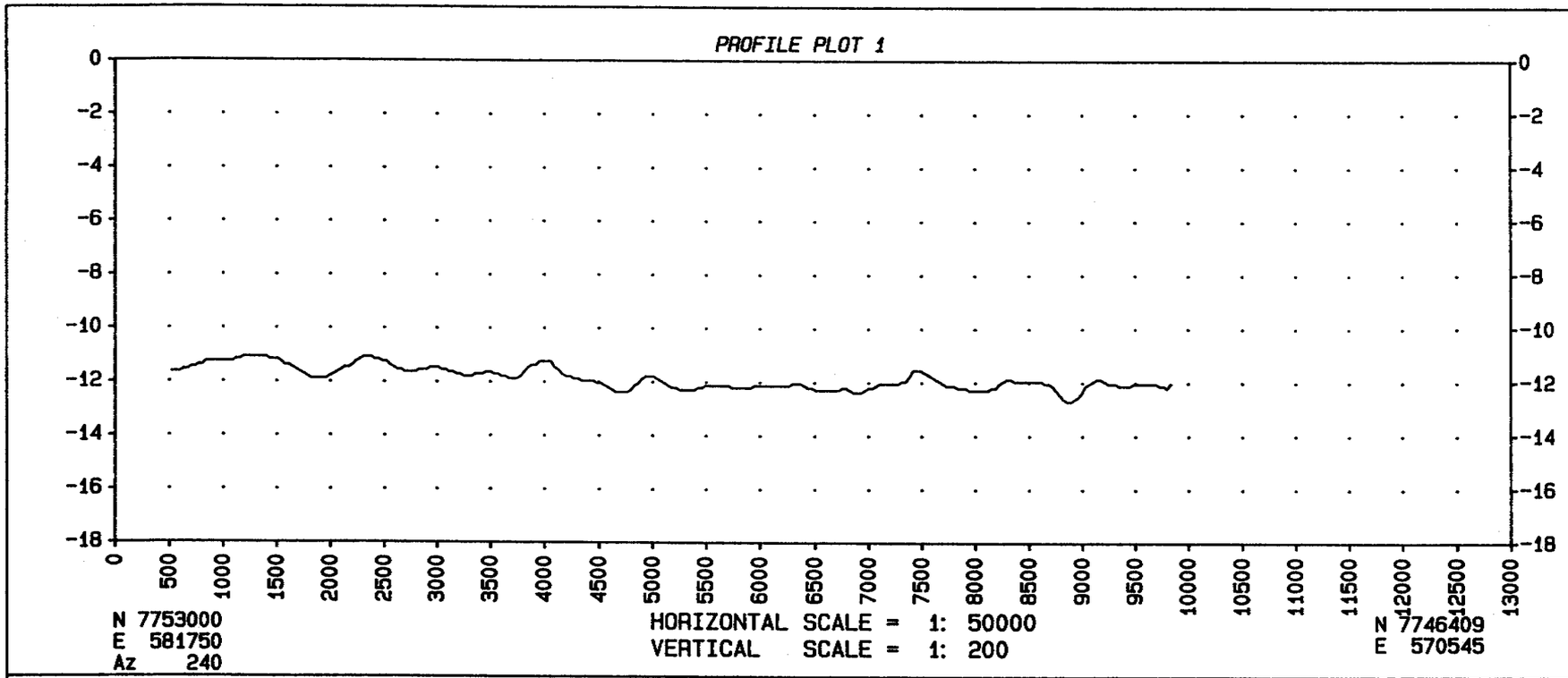
BATHYMETRIC PROFILE KEY PLAN
ZONE #3
ERKSAK BORROW BLOCK

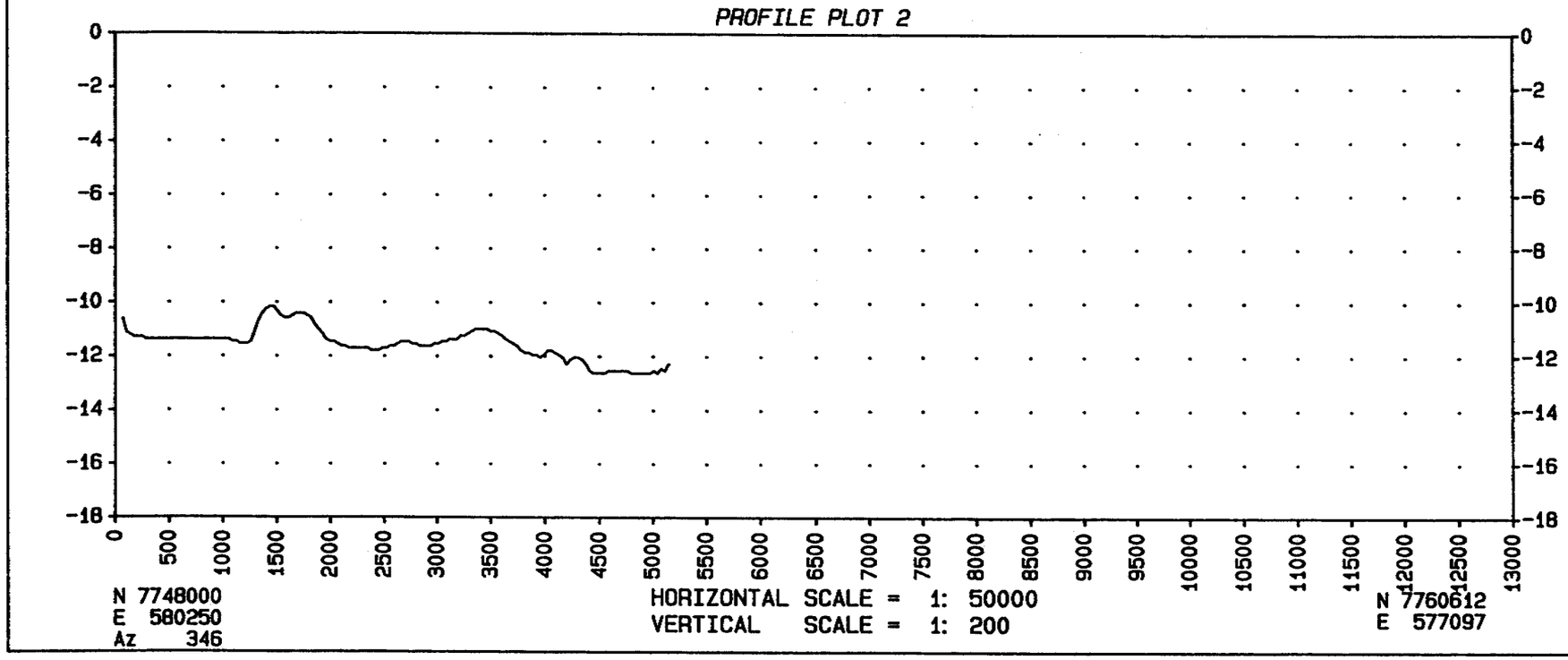
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

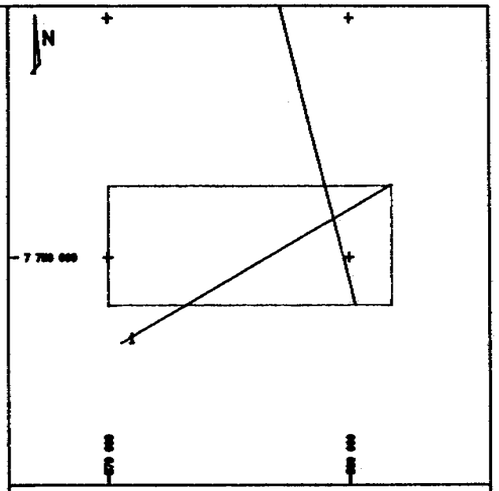
CHALLENGER SURVEYS & SERVICES LTD

SCALE :	JOB NO :
1 : 50000	S-617
DATE : 24 DEC 1987	DWG # : X-3-1

FIG. 65







KEY PLAN - 1 : 250000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

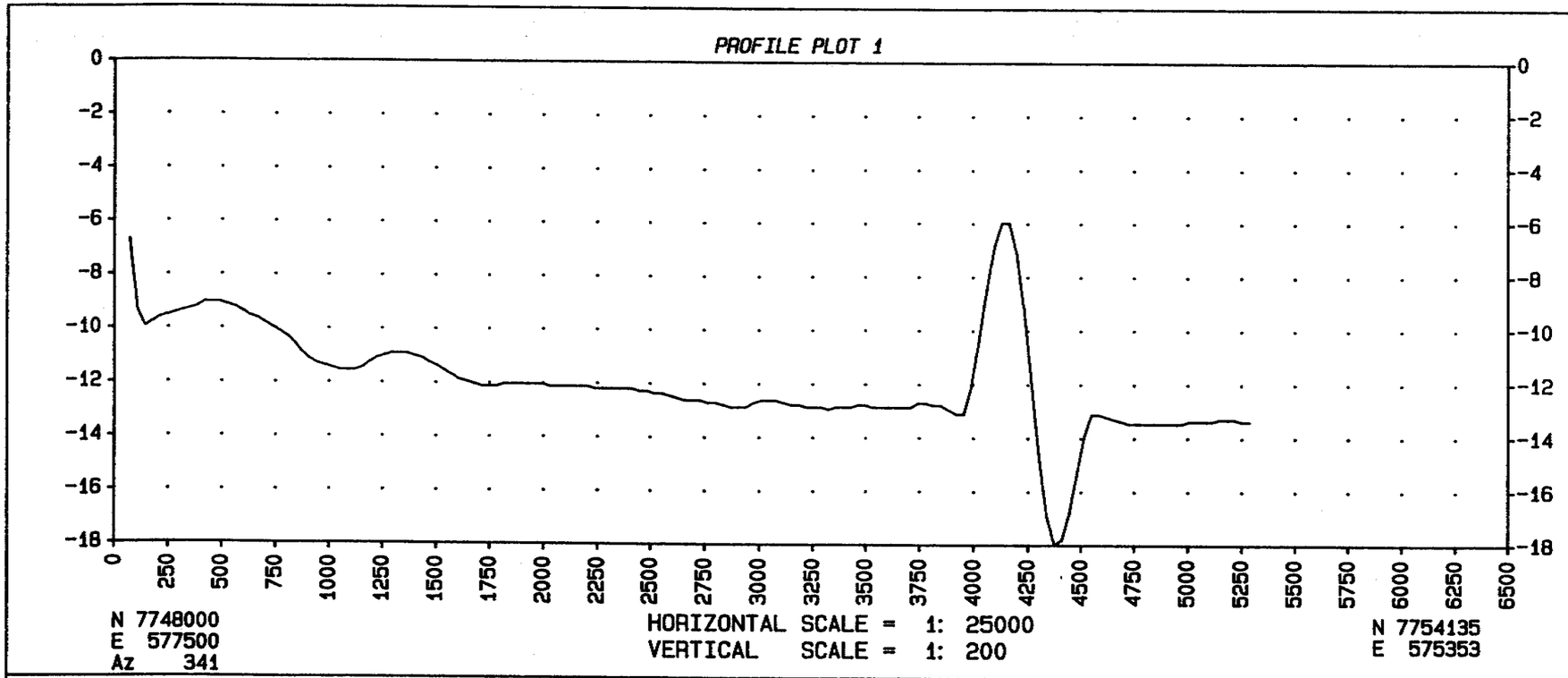
BATHYMETRIC PROFILES
ZONE #3
ERKSAK BORROW BLOCK

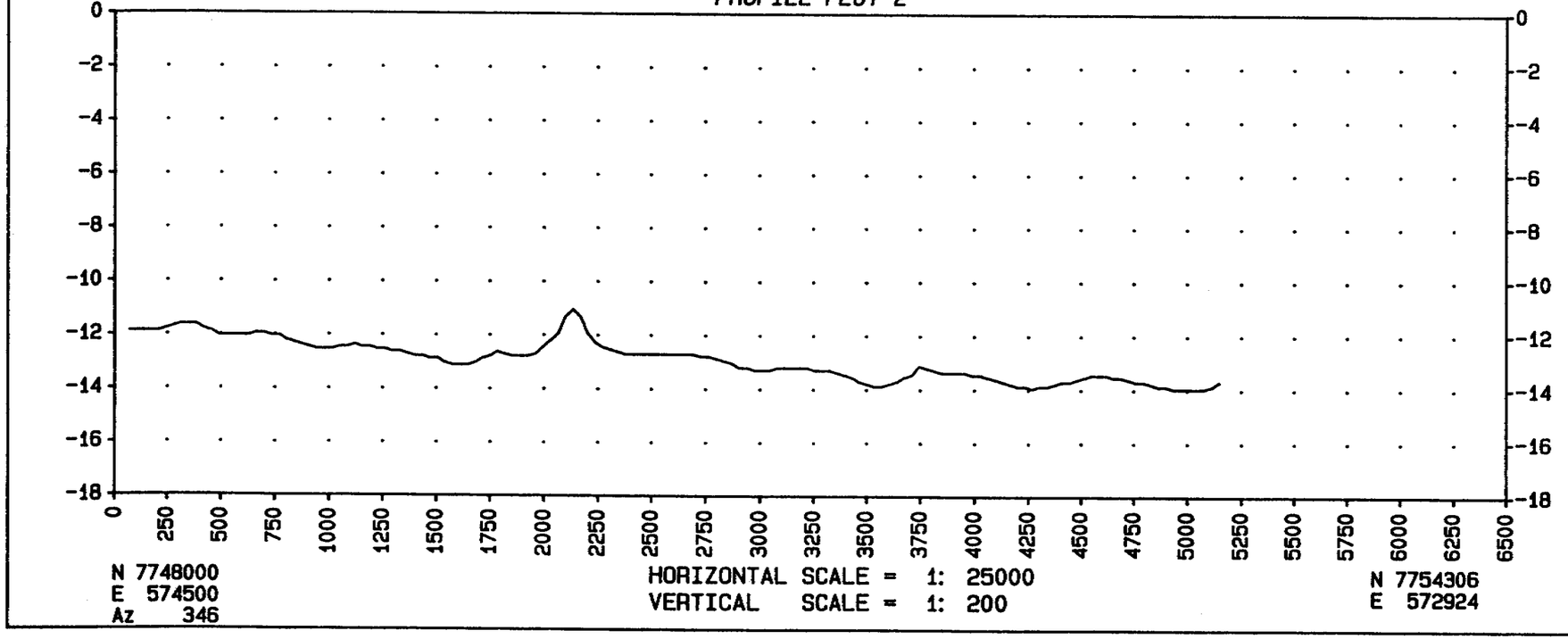
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

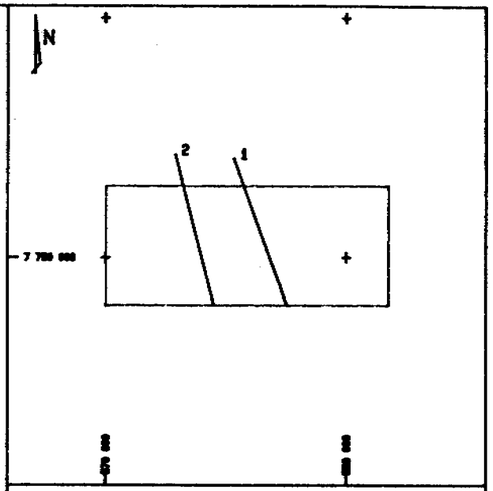
CHALLENGER SURVEYS & SERVICES LTD

JOB NO : 8-617
DATE : 24 DEC 1987
DWG # : P-3-1

FIG. 66







KEY PLAN - 1 : 250000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #3
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

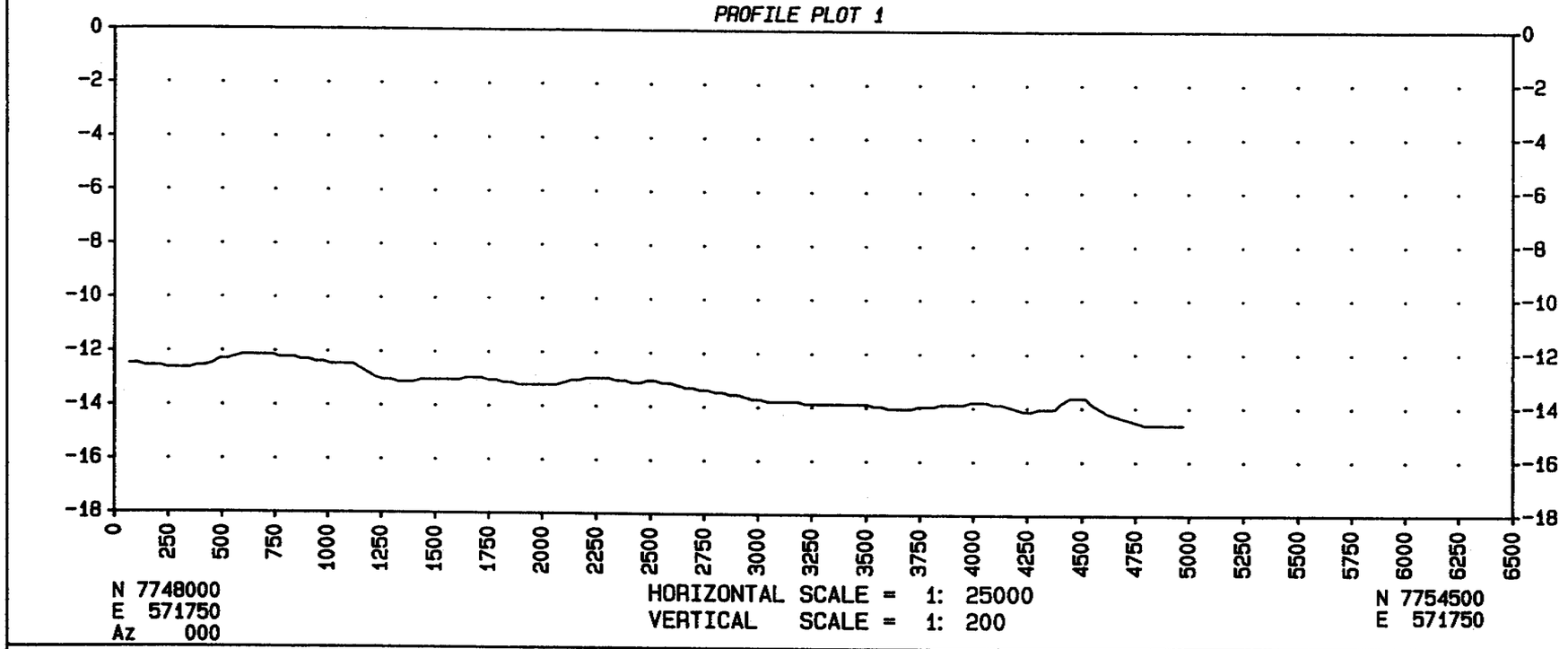
CHALLENGER SURVEYS & SERVICES LTD

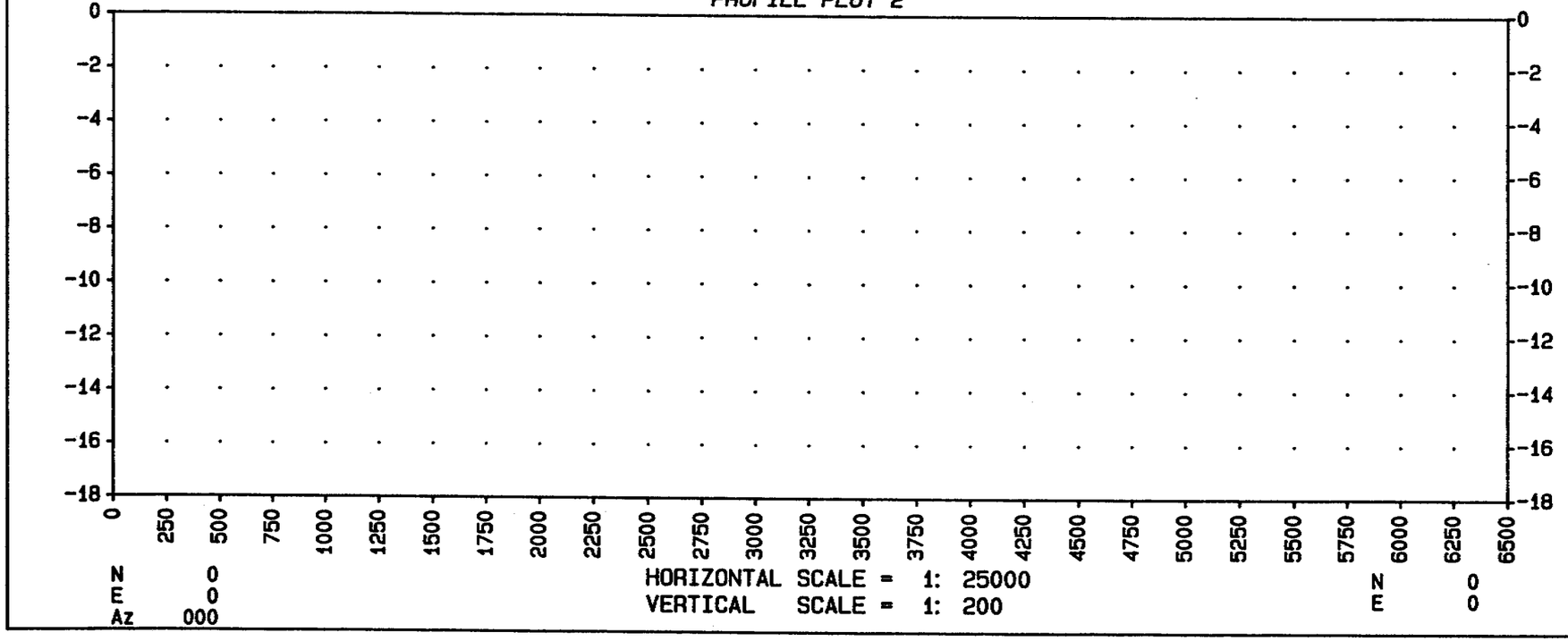
DATE : 24 DEC 1987

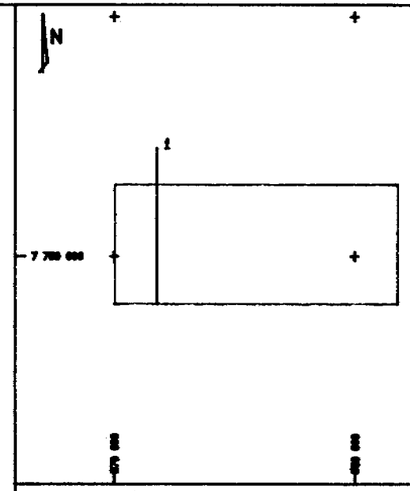
JOB NO : S-617

DWG # : P-3-2

FIG. 67







KEY PLAN - 1 : 250000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #3
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

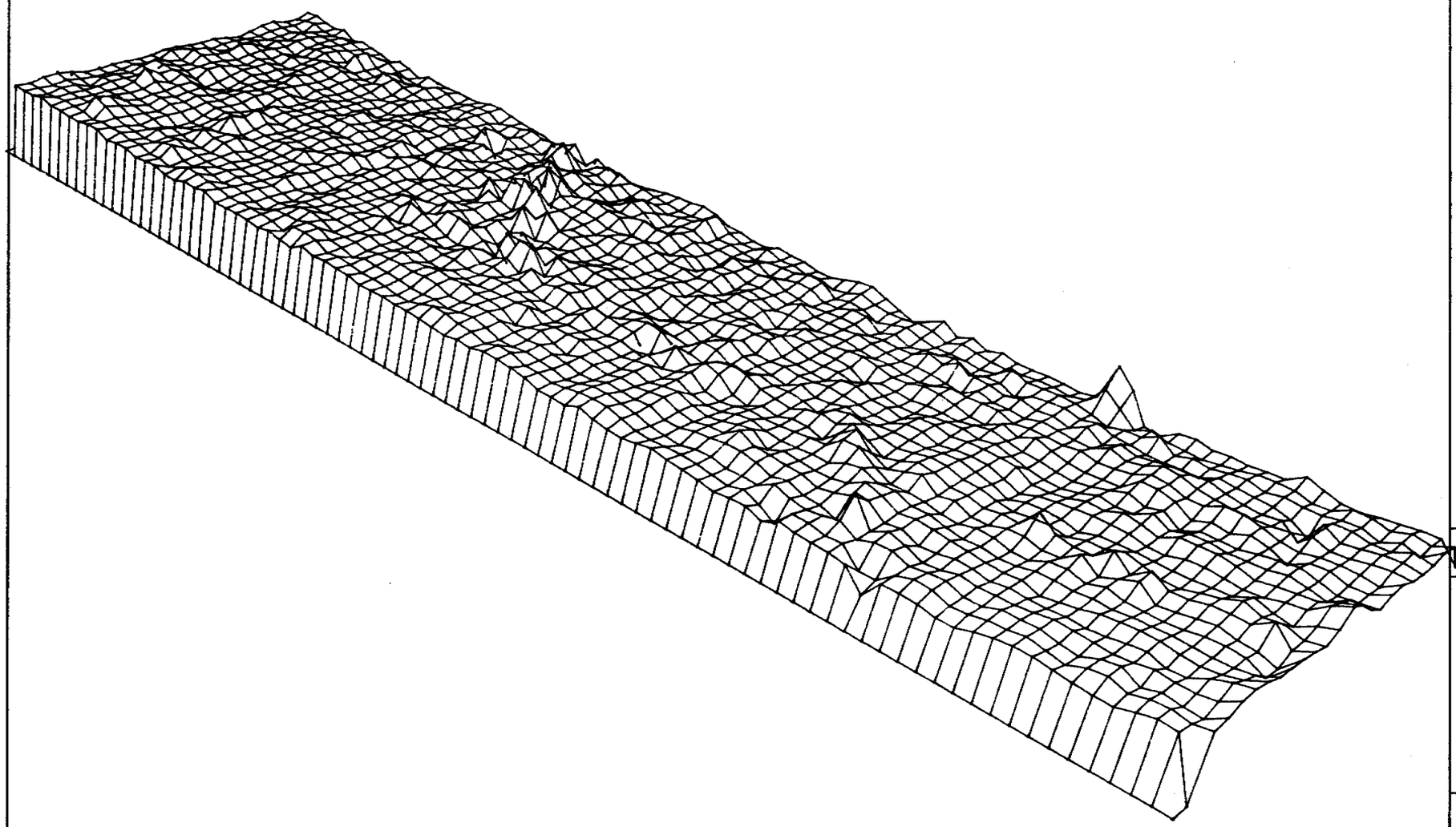
CHALLENGER SURVEYS & SERVICES LTD.

DATE : 24 DEC 1987

JOB NO : S-617

DWG # : P-3-3

FIG. 68



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 315 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

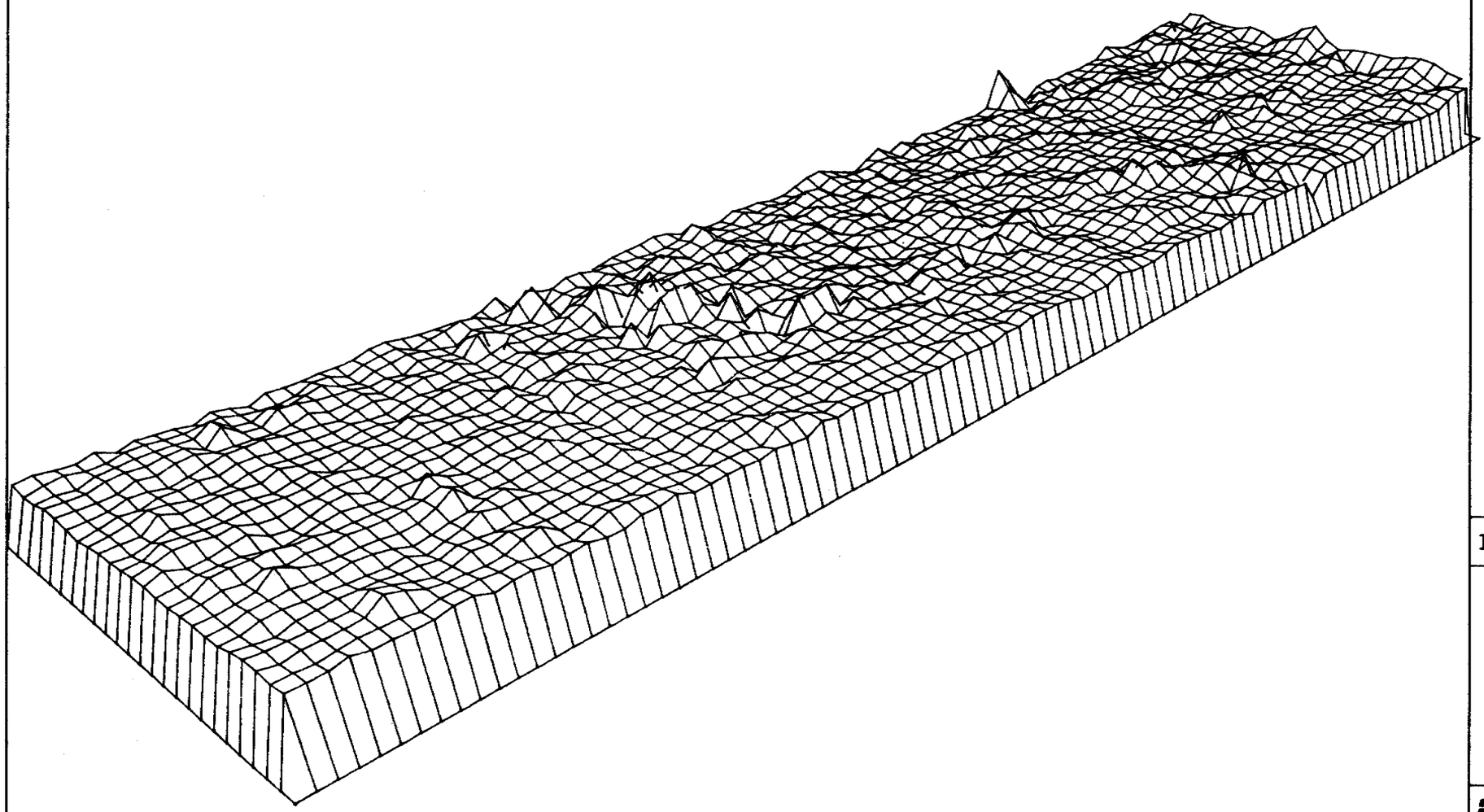
INDIAN & NORTHERN AFFAIRS OF CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #3A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD.	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 19 DEC 1987	DWG # : M-3A-1

FIG. 69



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 45 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

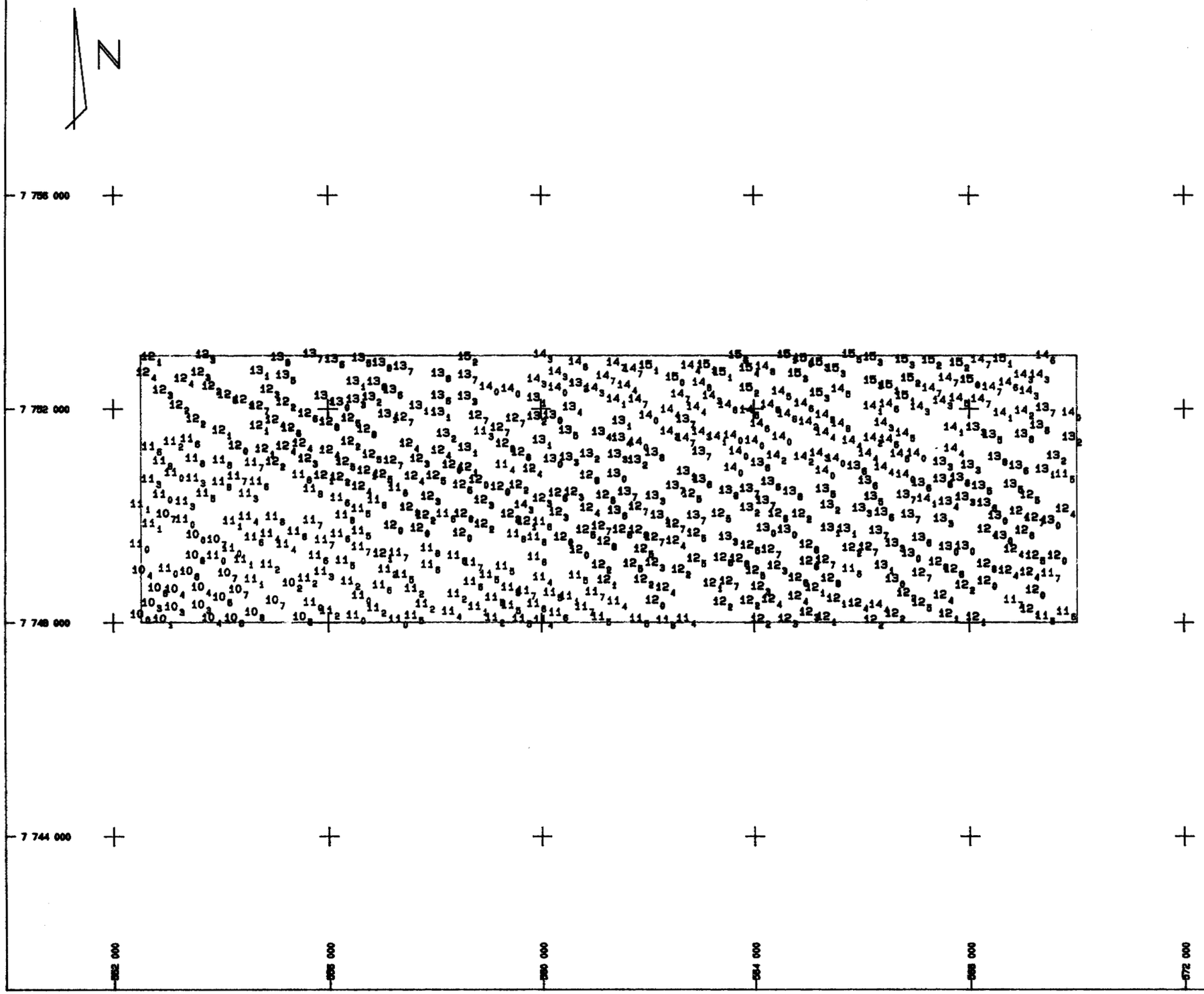
INDIAN & NORTHERN AFFAIRS OF CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #3A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 19 DEC 1987	DWG # : M-3A-2

FIG. 70



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #3A. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE -> 10.0 - 10.9 GREEN
11.0 - 11.9 BLUE
12.0 - 12.9 PURPLE
13.0 - 13.9 RED
14.0 - 14.9 BROWN
14.9 - 16.0 BLACK

INDIAN & NORTHERN AFFAIRS OF CANADA

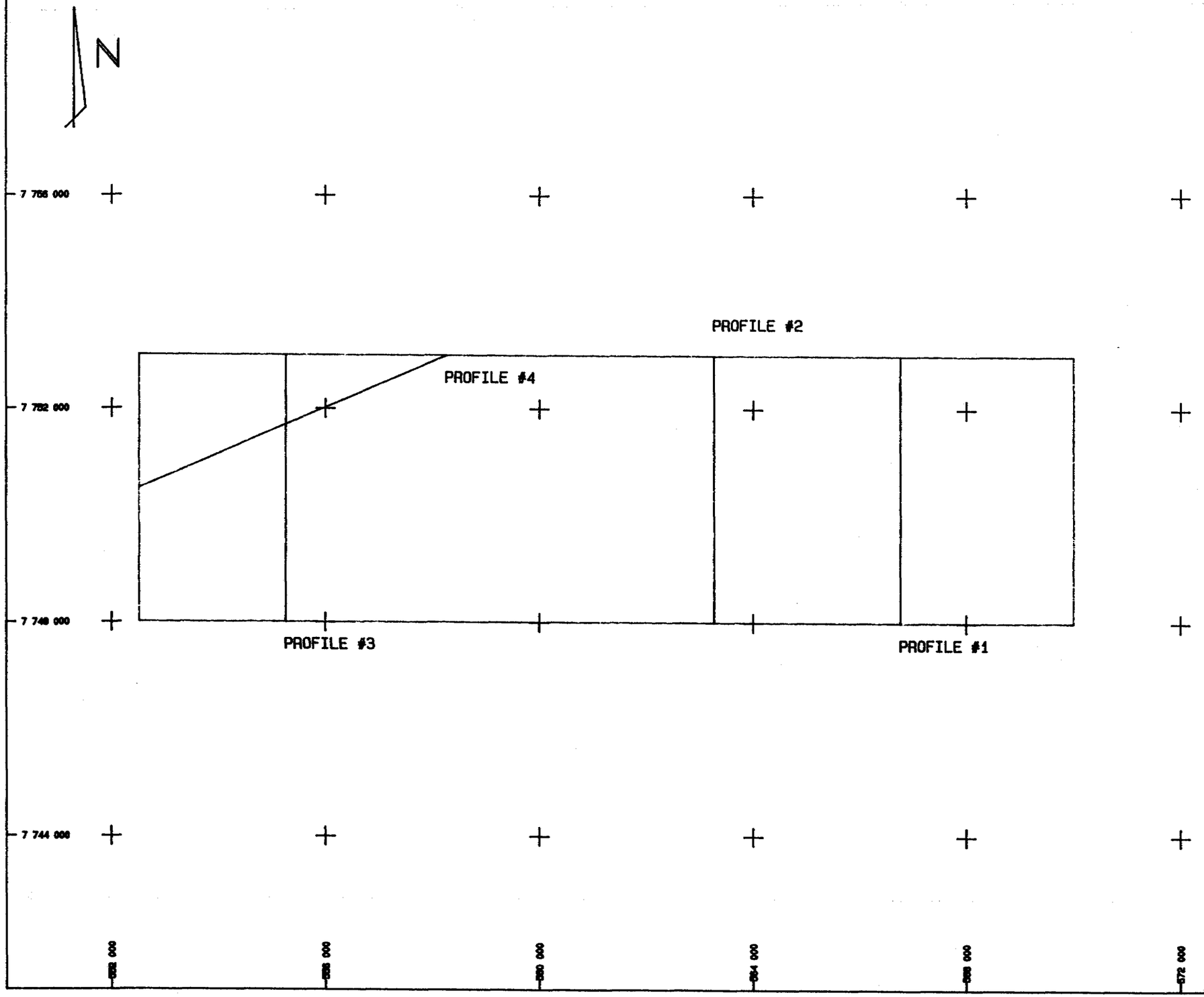
BATHYMETRIC DATA PLOT
ZONE #3A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER ENGINEERING & SURVEYING LTD.

SCALE :	JOB NO :
1 : 75000	9-617
DATE :	DWG # :
19 DEC 1987	B-3A-1

FIG. 71



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #3A.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTON FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7750500 E.561250
6. PROFILE CO-ORDINATES

	START	END
#1	N.7748000 E. 566750	N.7753000 E. 566750
#2	N.7748000 E. 563250	N.7753000 E. 563250
#3	N.7748000 E. 559250	N.7753000 E.559250
#4	N.7753000 E. 559250	N.7750500 E. 562500

INDIAN & NORTHERN AFFAIRS OF CANADA

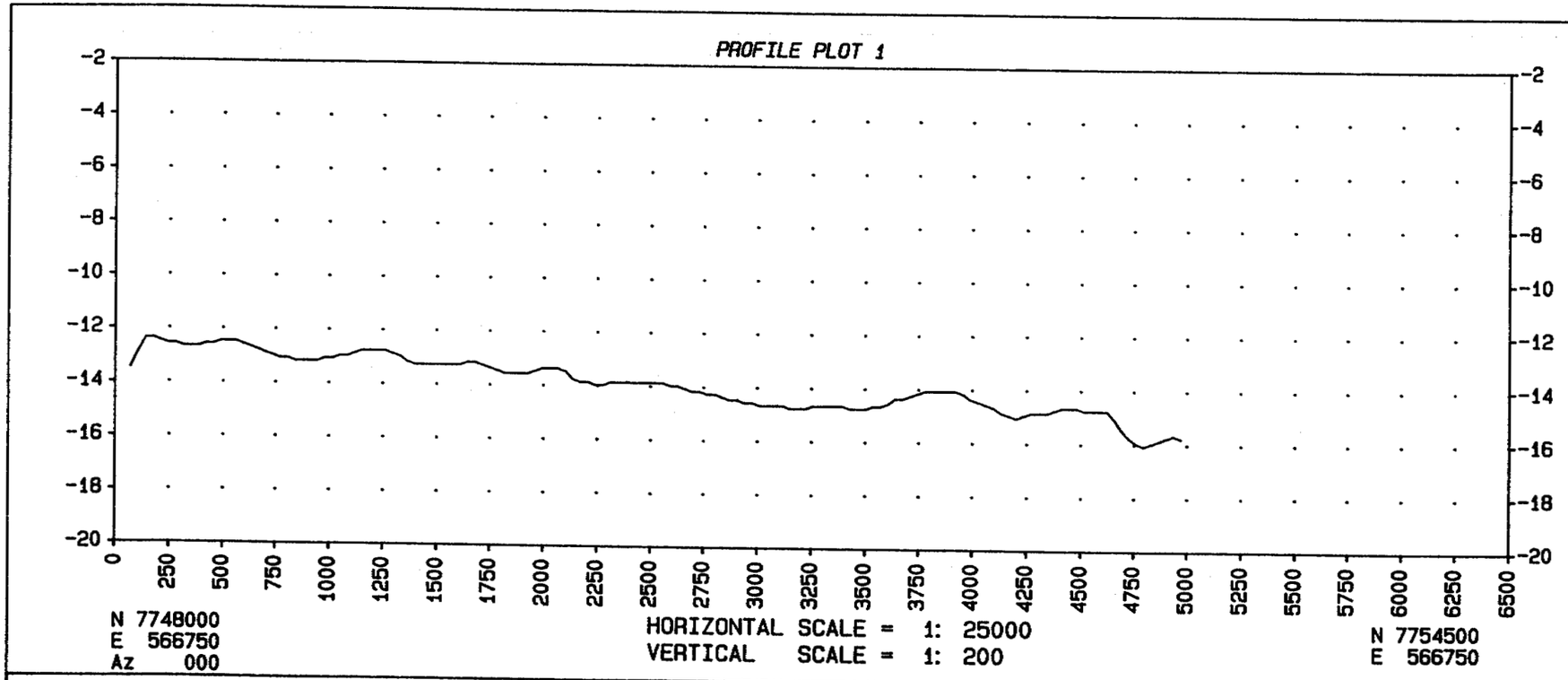
BATHYMETRIC PROFILE KEY PLAN
ZONE #3A
ERKSAK BORROW BLOCK

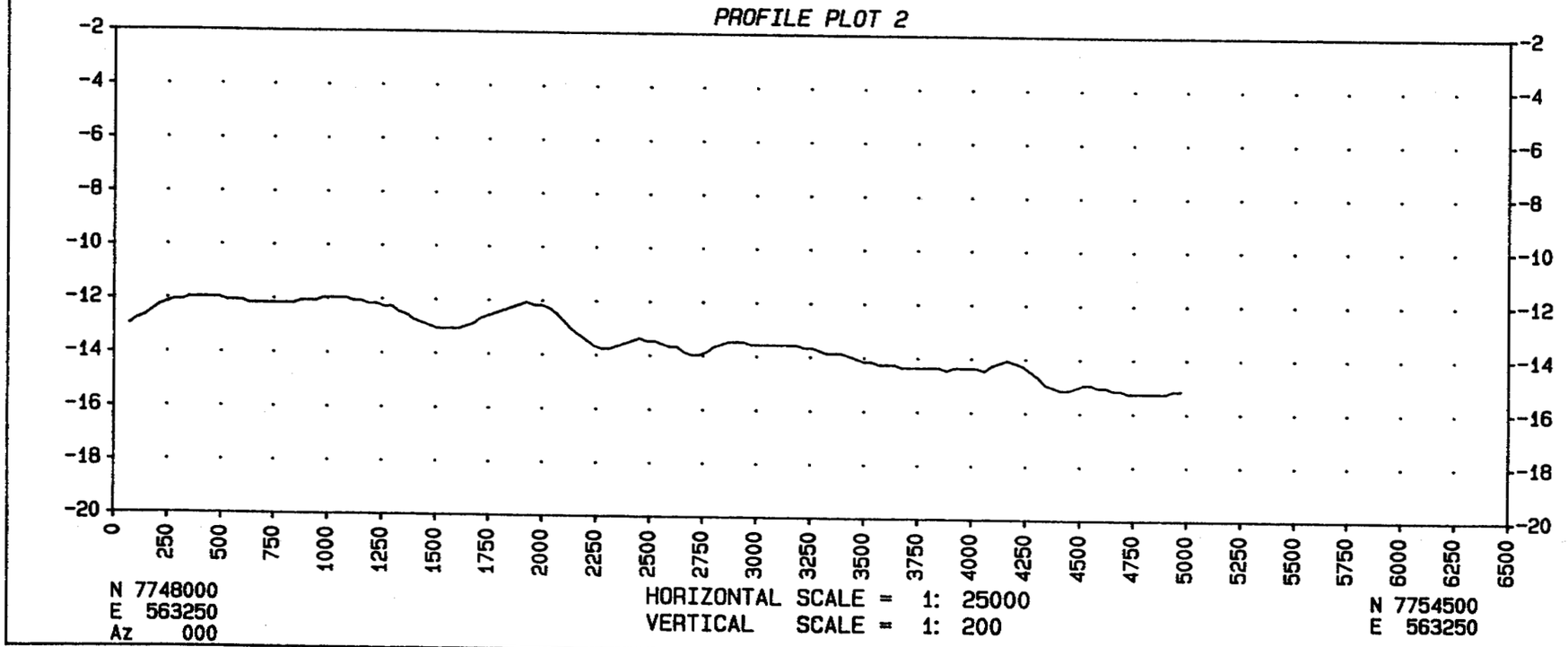
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

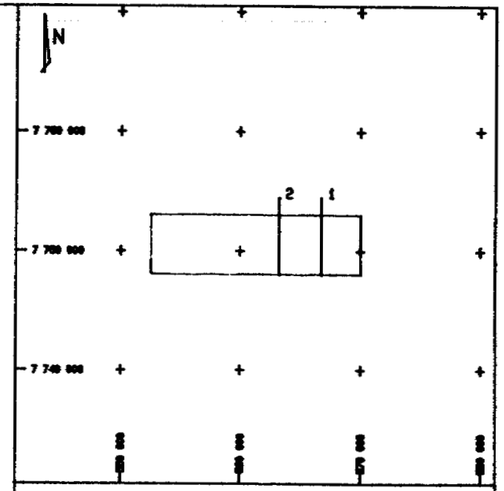
CHALLENGER

SCALE :	JOB NO :
1 : 75000	S-617
DATE : 19 DEC 1987	DWG # : X-3A-1

FIG.72







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #3A
ERKSAK BORROW BLOCK

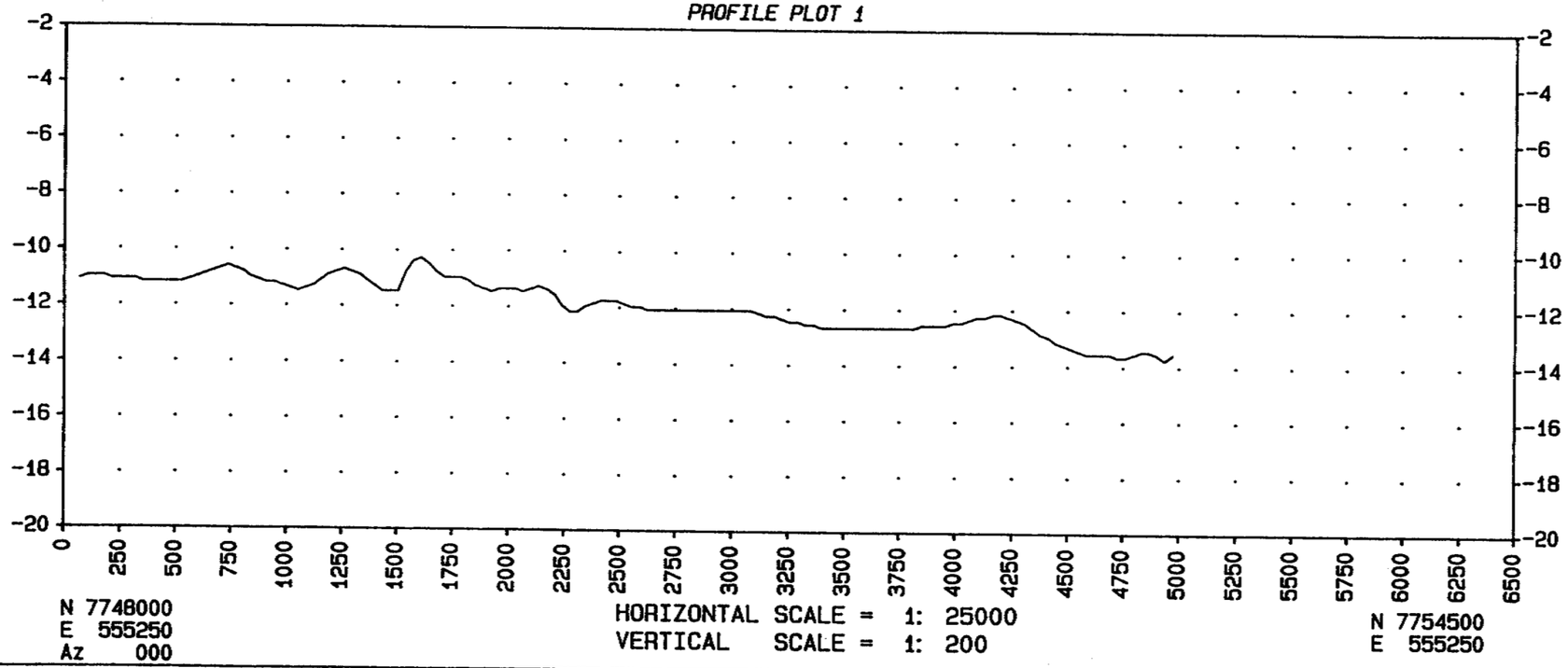
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & MAPPING LTD

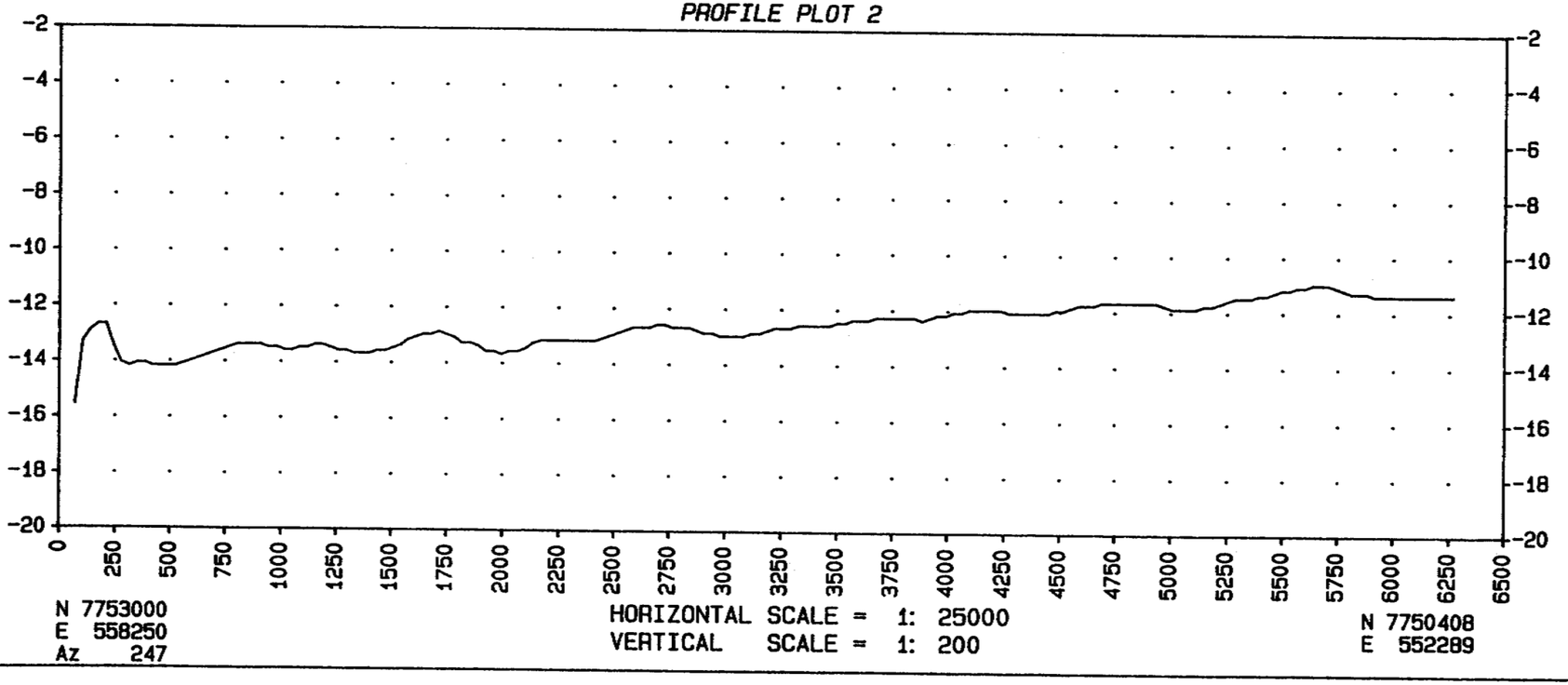
	JOB NO : 8-617
DATE : 20 DEC 1987	DWG # : P-3A-1

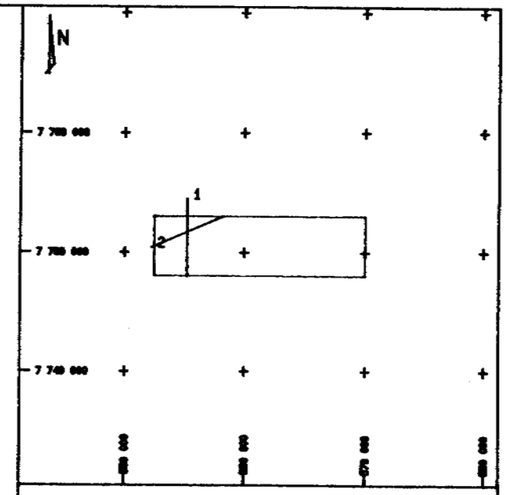
FIG. 73

PROFILE PLOT 1



PROFILE PLOT 2





KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

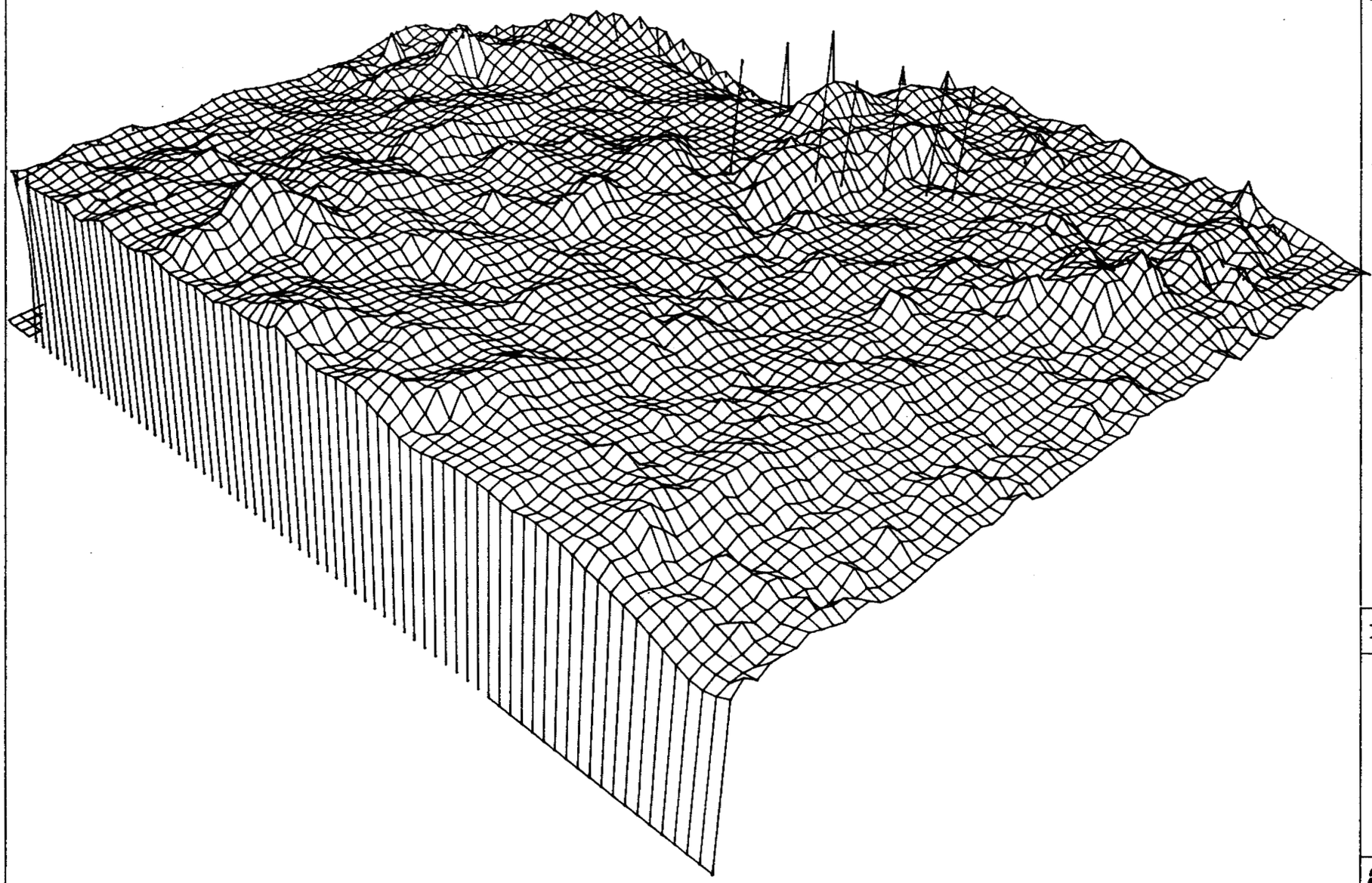
BATHYMETRIC PROFILES
ZONE #3A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

JOB NO : S-617
DATE : 20 DEC 1987
DWG # : P-3A-2

FIG. 74



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 315 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS OF CANADA

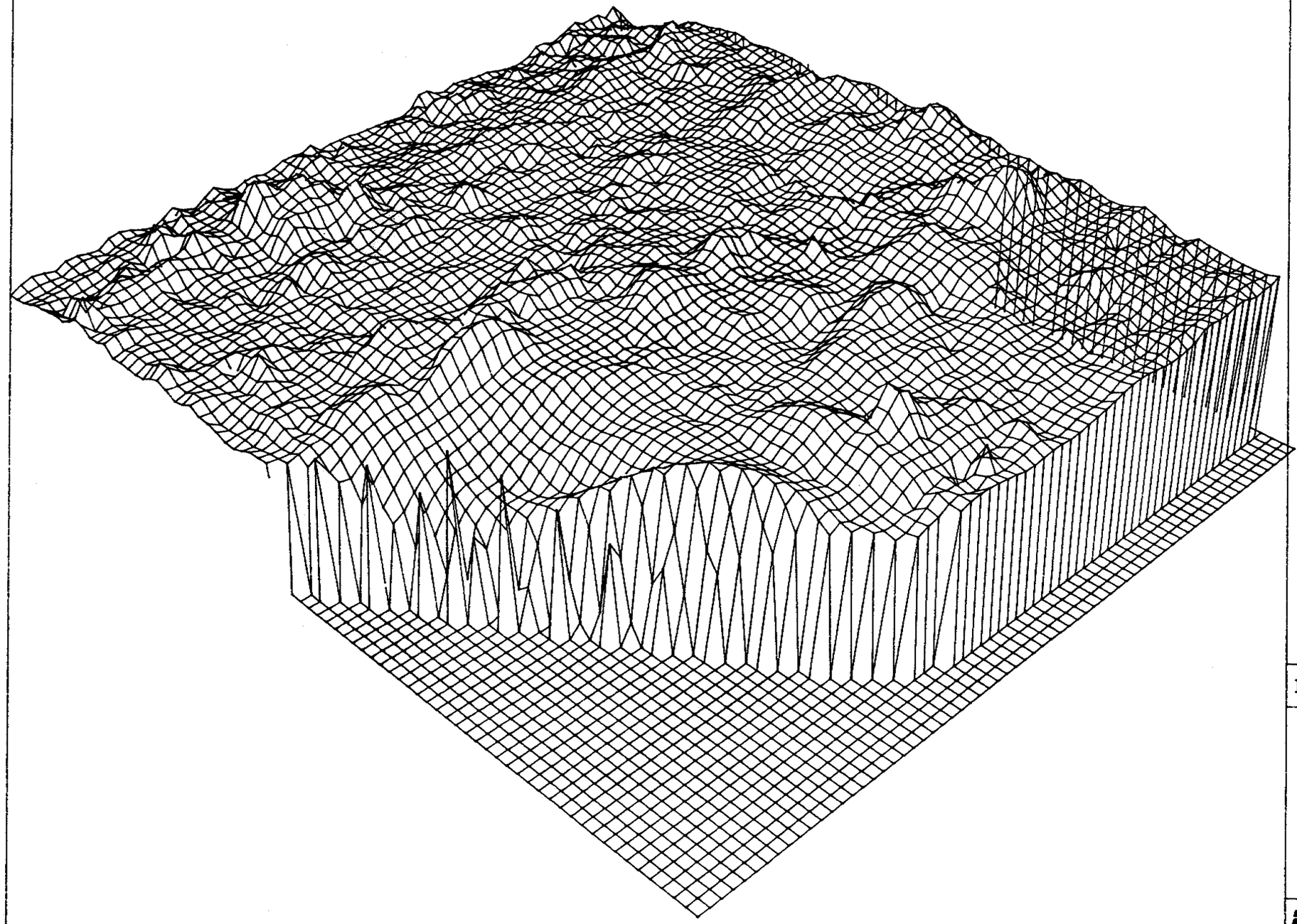
BATHYMETRIC MESH PERSPECTIVE
ZONE #4
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE :	JOB NO :
1 : 100000	S-617
DATE :	DWG # :
19 DEC 1987	M-4-1

FIG. 75



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 135 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS OF CANADA

BATHYMETRIC MESH PERSPECTIVE

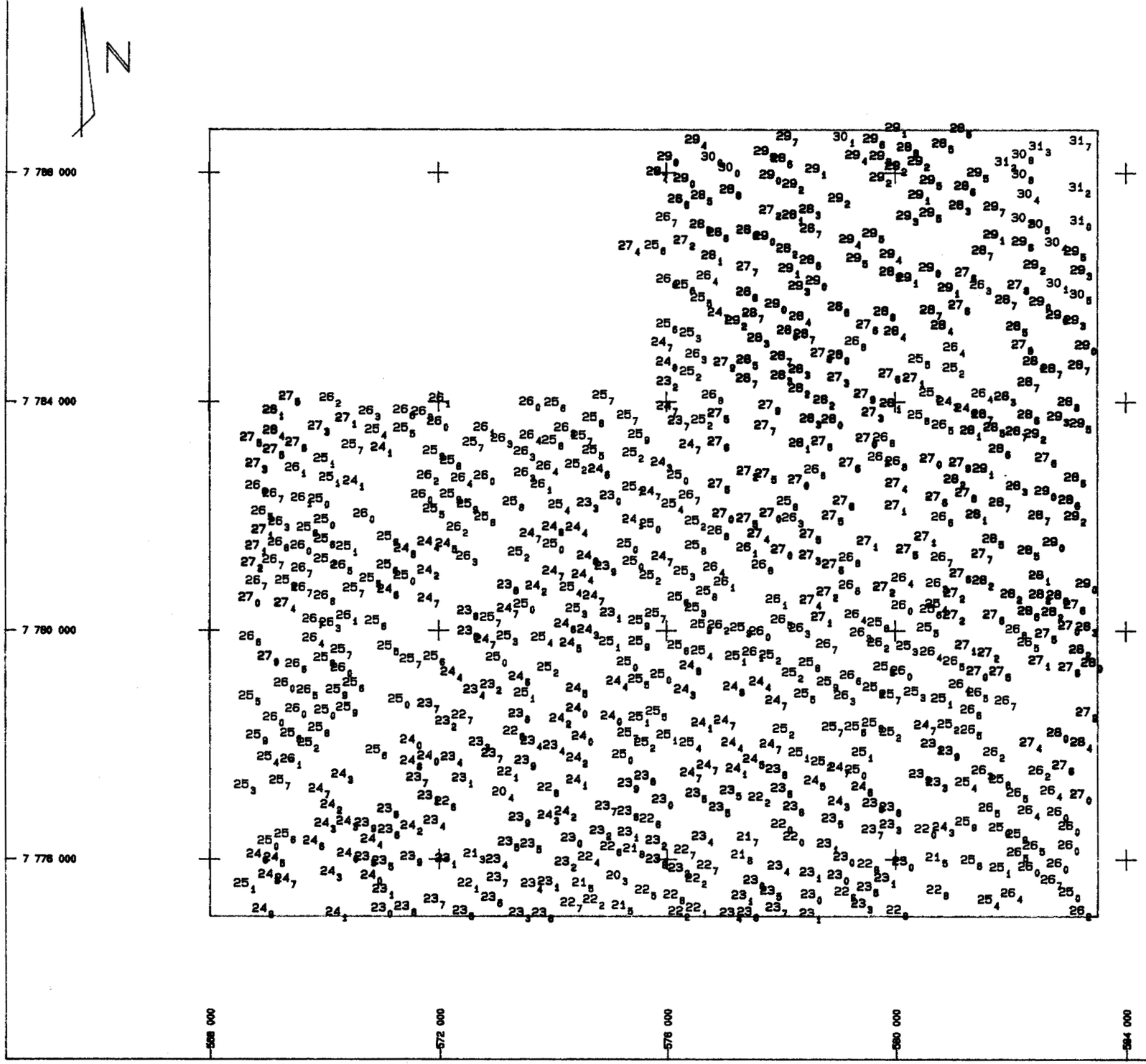
ZONE #4

ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100000	JOB NO : S-617
	DATE : 19 DEC 1987	DWG # : M-4-2

FIG. 76



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #4. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE ->
20.0 - 22.9 BLACK
23.0 - 24.9 GREEN
25.0 - 26.9 BLUE
27.0 - 28.9 PURPLE
29.0 - 29.9 RED
30.0 - 35.0 BROWN

INDIAN & NORTHERN AFFAIRS OF CANADA

BATHYMETRIC DATA PLOT
ZONE #4
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER ENGINEERING & SURVEYING LTD.

SCALE :	JOB NO :
1 : 75000	S-617
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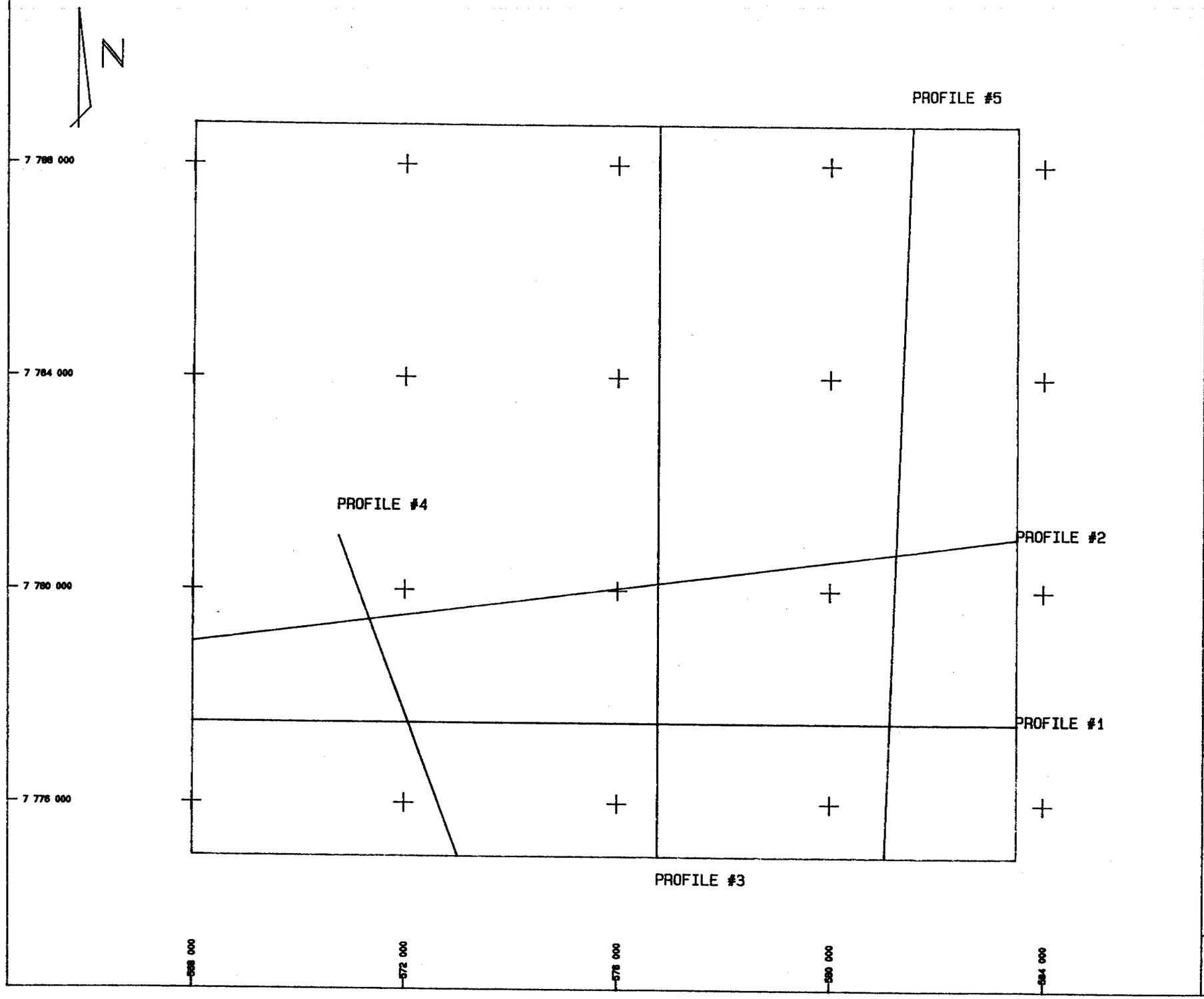
19 DEC 1987	B-4-1

FIG. 77



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #4.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7781875 E.575750
6. PROFILE CO-ORDINATES

	START	END
#1	N.7777500 E. 583500	N.7777500 E. 568000
#2	N.7781000 E. 583500	N.7779000 E. 568000
#3	N.7775000 E. 576750	N.7788750 E. 576750
#4	N.7775000 E. 573000	N.7781000 E. 570750
#5	N.7775000 E. 581000	N.7788750 E. 581500

INDIAN & NORTHERN AFFAIRS OF CANADA

KEY PLAN

BATHYMETRIC PROFILES

ZONE #4

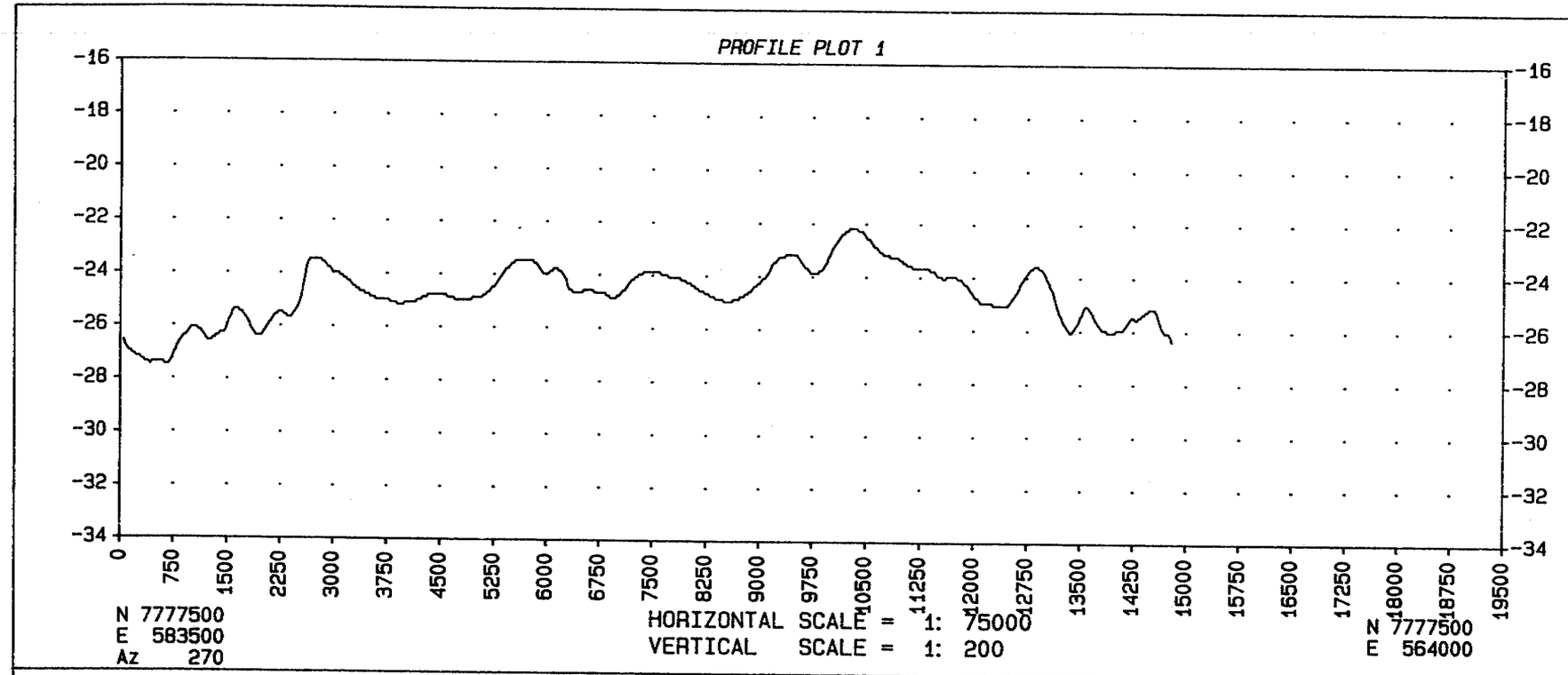
ERKSAK BORROW BLOCK

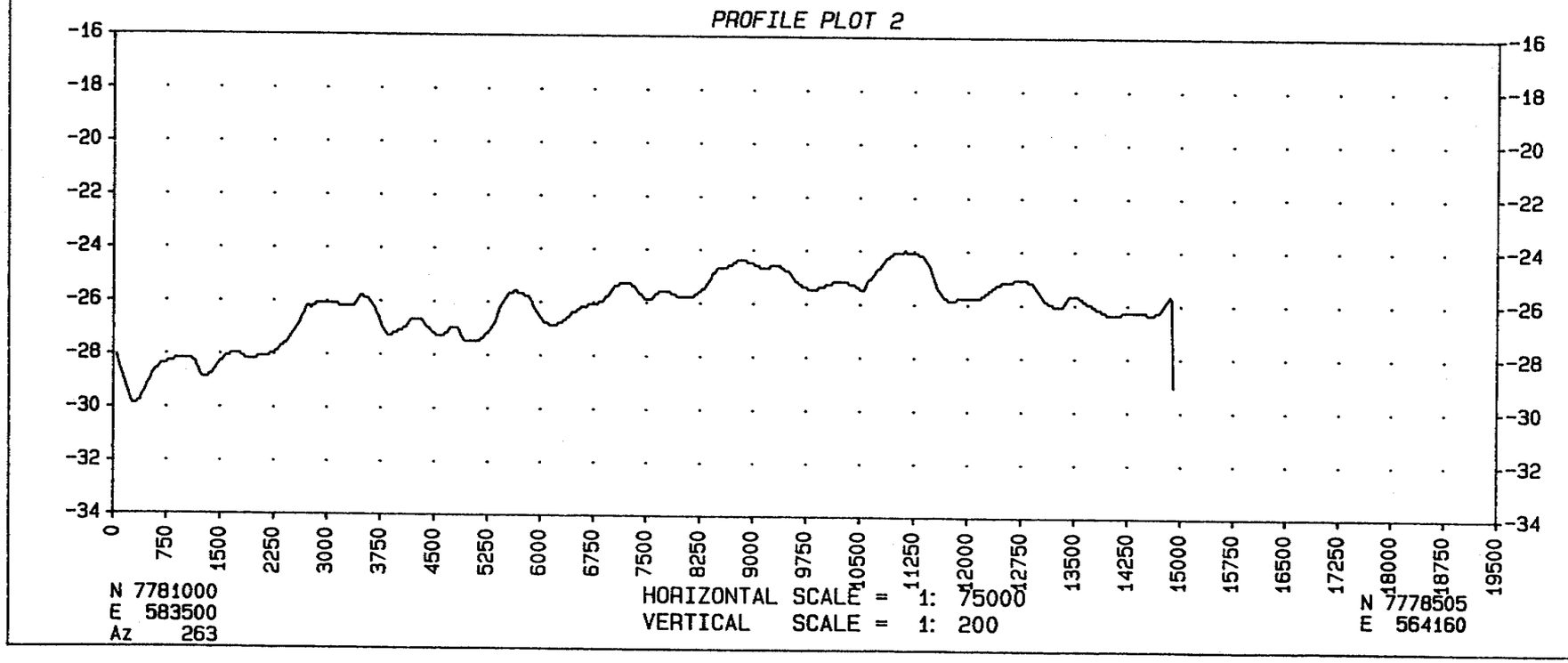
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

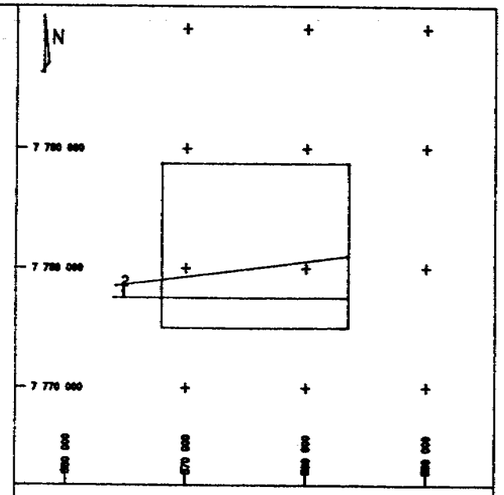
CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 75000	JOB NO : S-617
DATE : 19 DEC 1987	DWG # : X-4-1

FIG. 78







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS OF CANADA

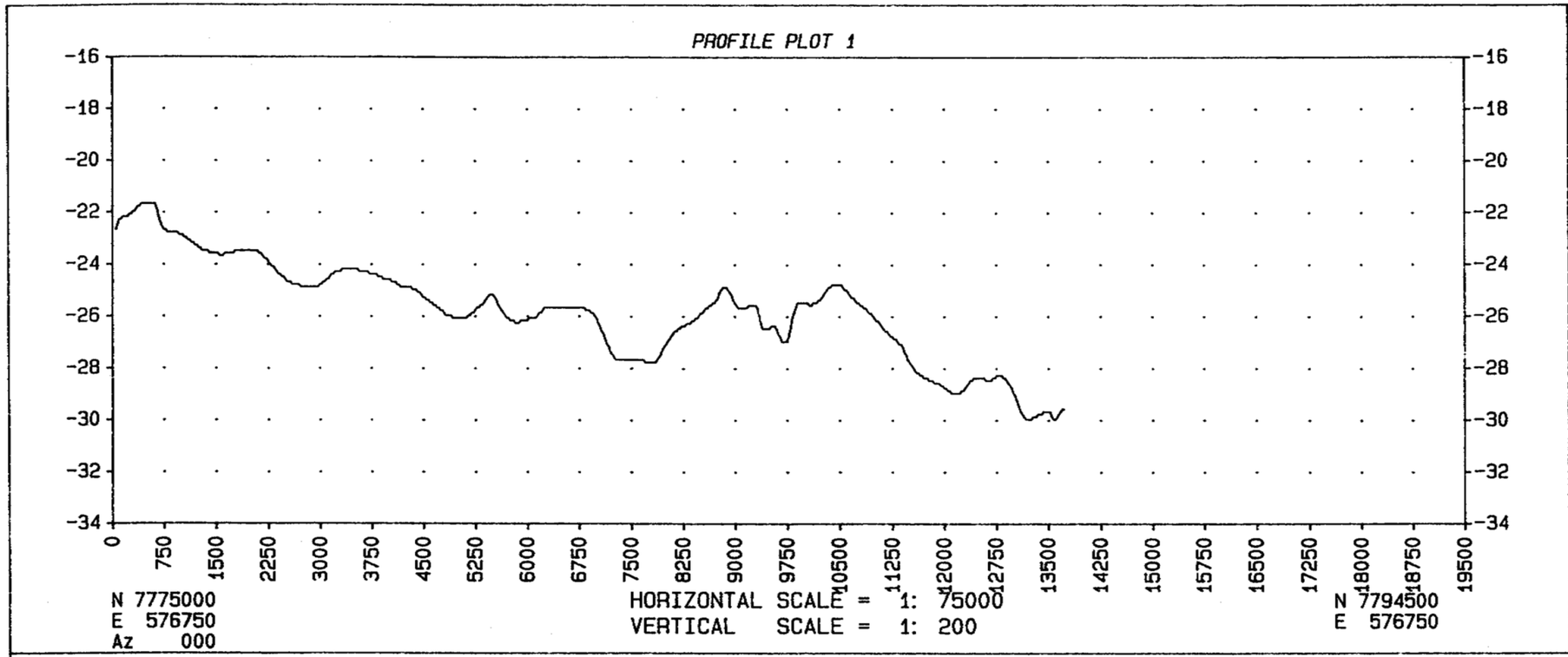
BATHYMETRIC PROFILES
ZONE #4
ERKSAK BORROW BLOCK

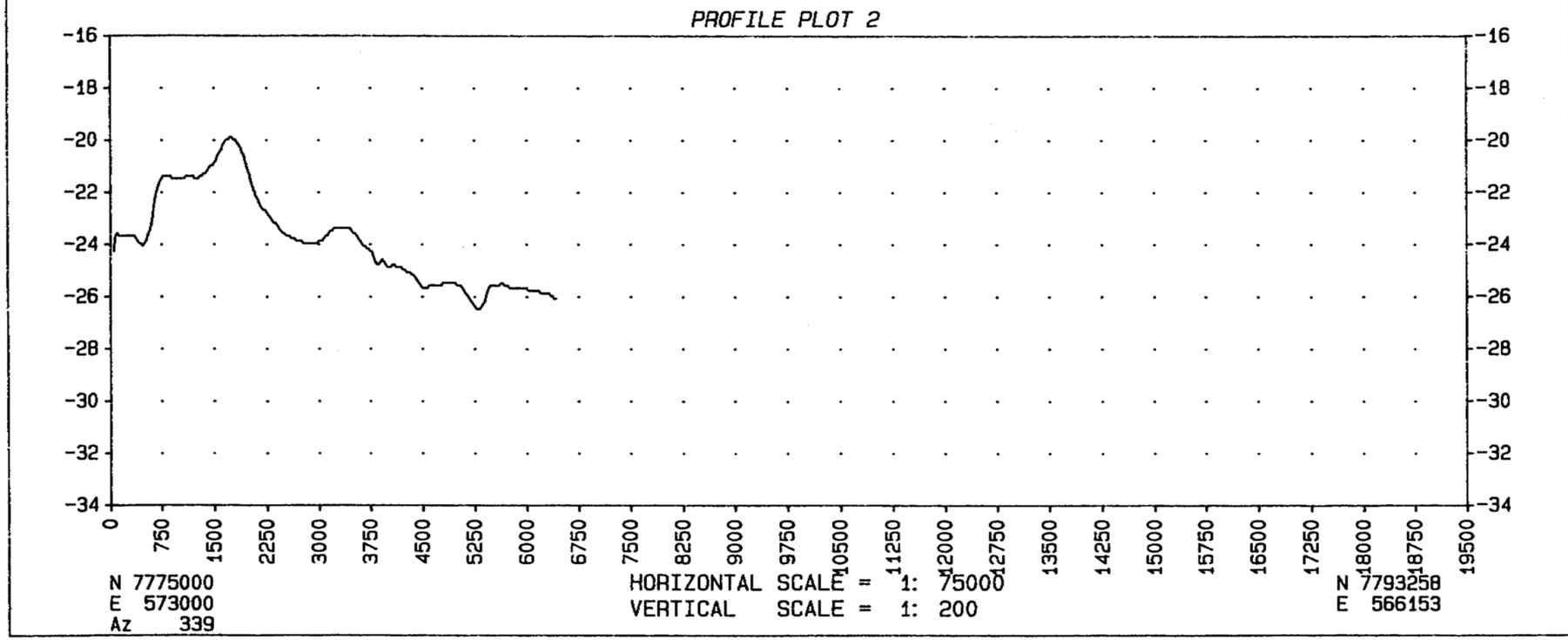
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

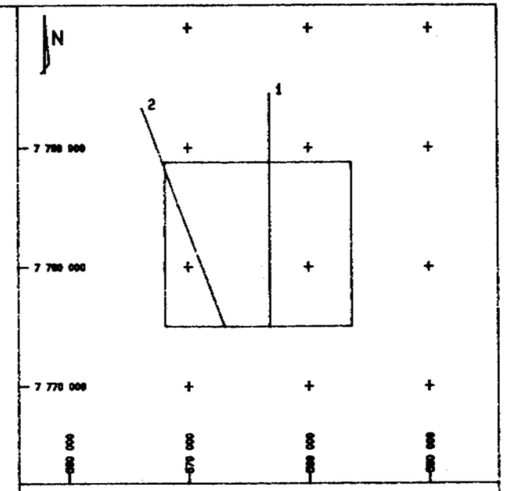
CHALLENGER SURVEYS & SERVICES LTD.

JOB NO : S-617
DATE : 19 DEC 1987
DWG # : P-4-1

FIG. 79







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS OF CANADA

BATHYMETRIC PROFILES
ZONE #4
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

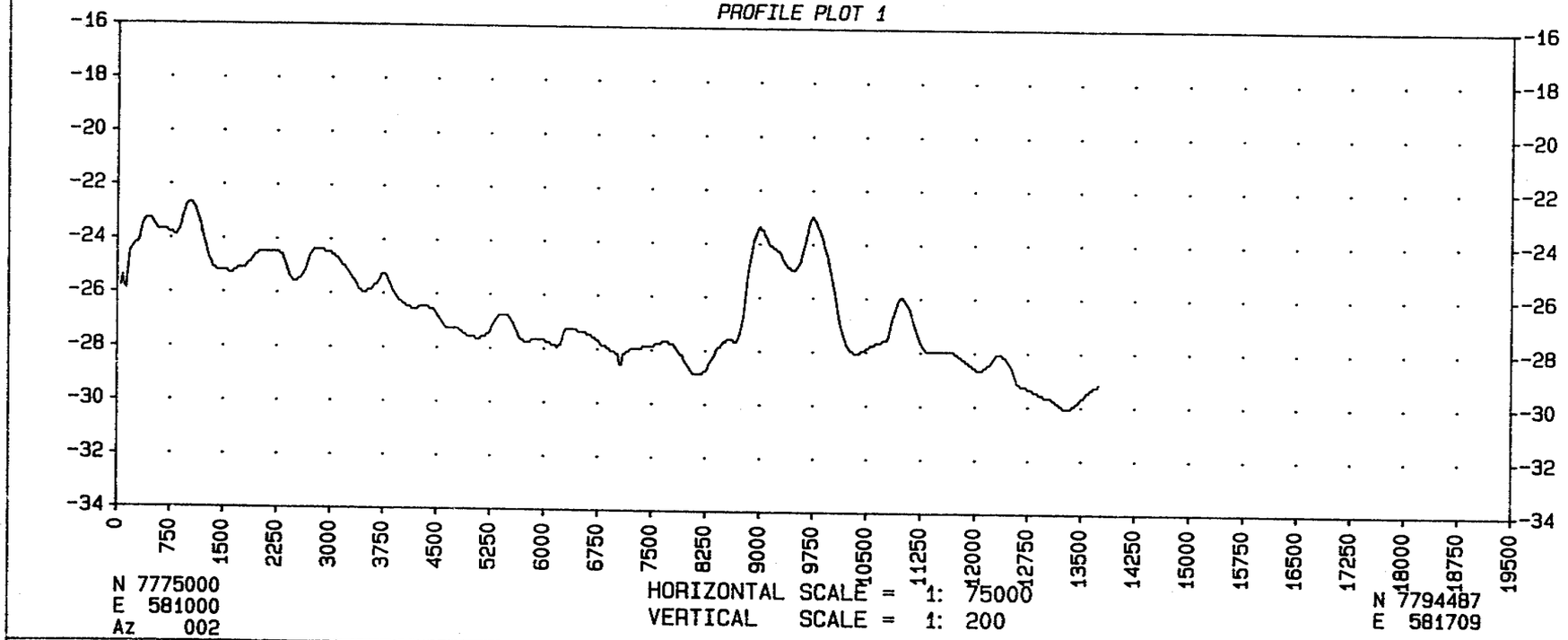
CHALLENGER SURVEYS & SERVICES LTD

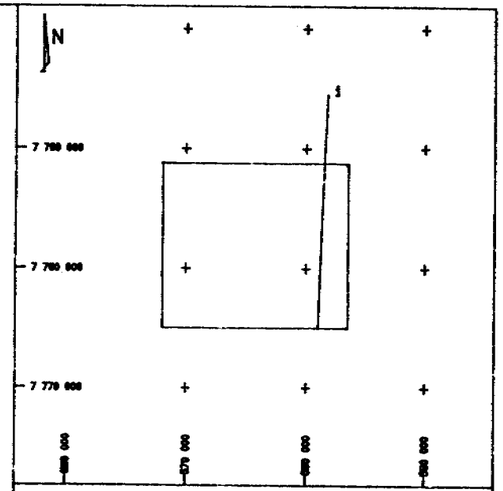
DATE : 19 DEC 1987

JOB NO : S-617

DWG # : P-4-2

FIG. 80

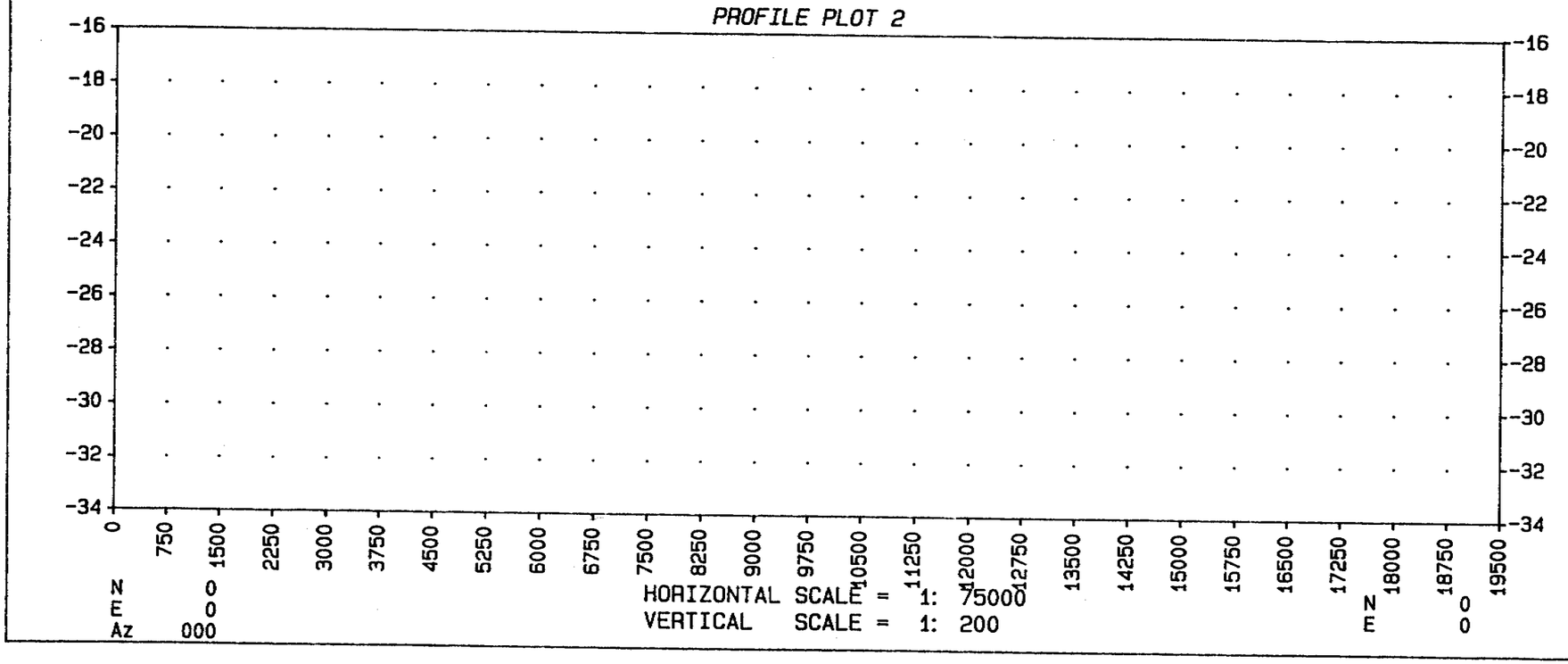




KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.



INDIAN & NORTHERN AFFAIRS OF CANADA

BATHYMETRIC PROFILES
ZONE #4
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

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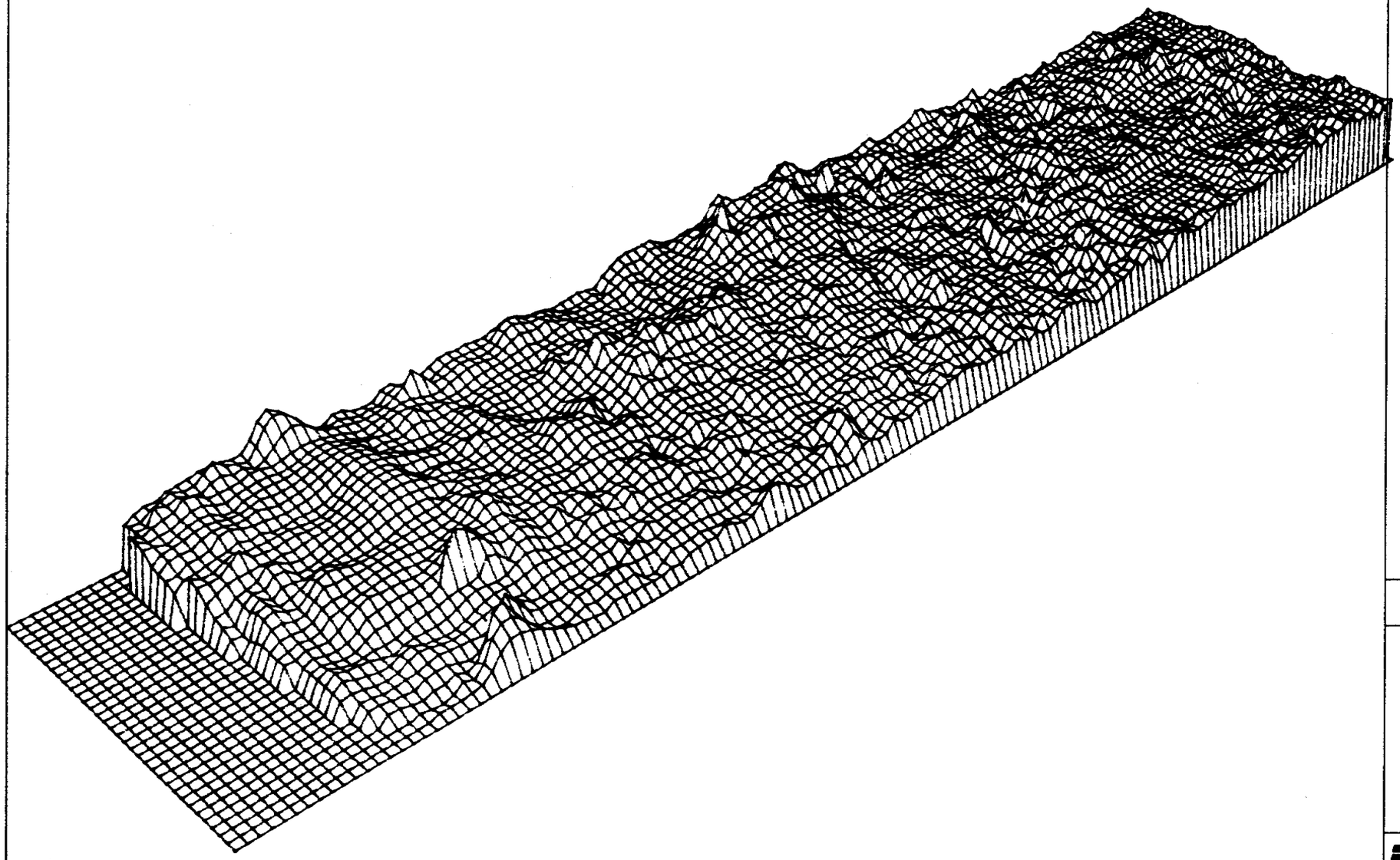
DATE : 19 DEC 1987
DWG # : P-4-3

FIG. 81



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 135 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

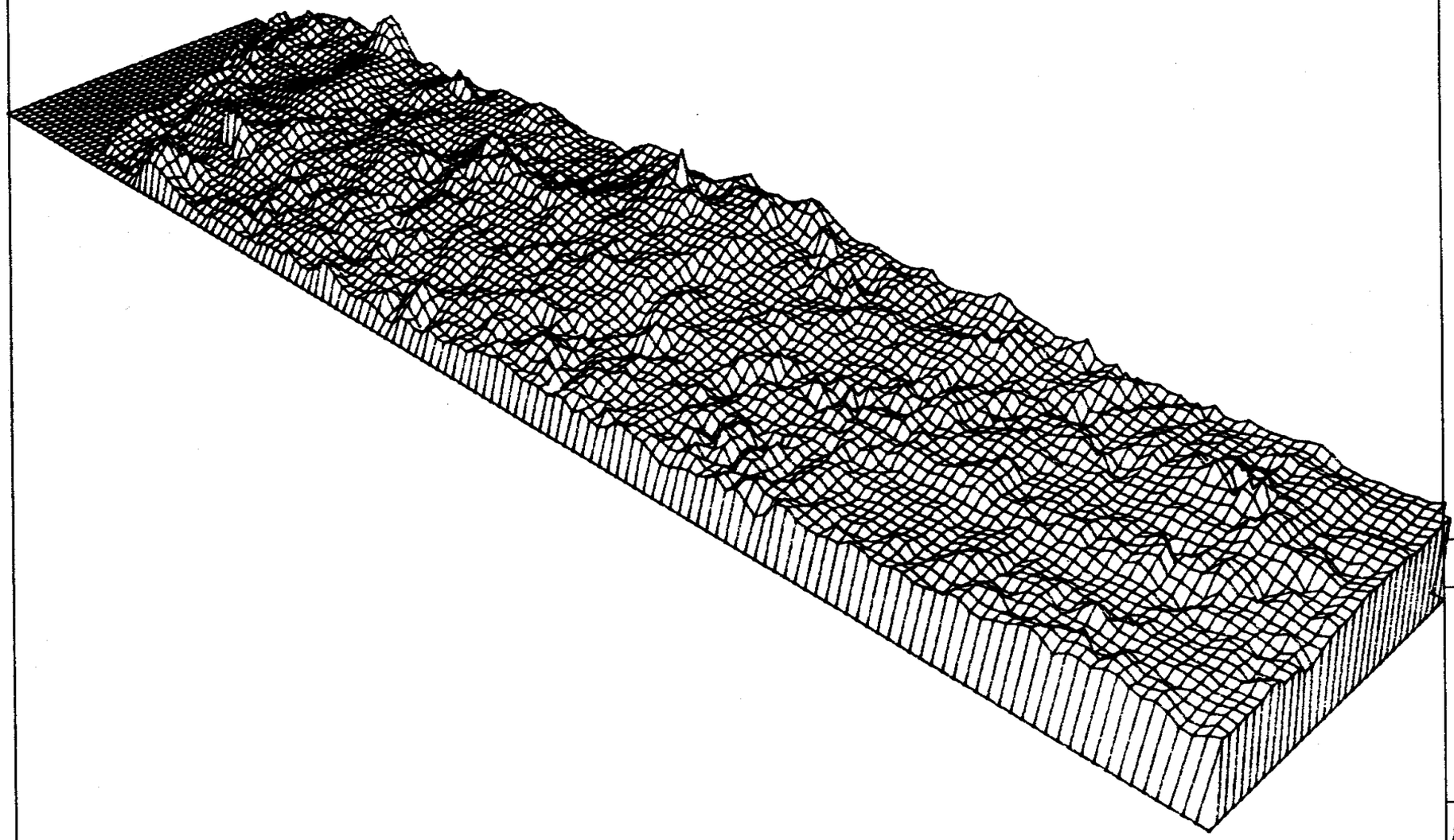
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #5
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 100	JOB NO : S-617
	DATE : 4 JAN 1988	DWG # : M-5-1

FIG. 82



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 45 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE

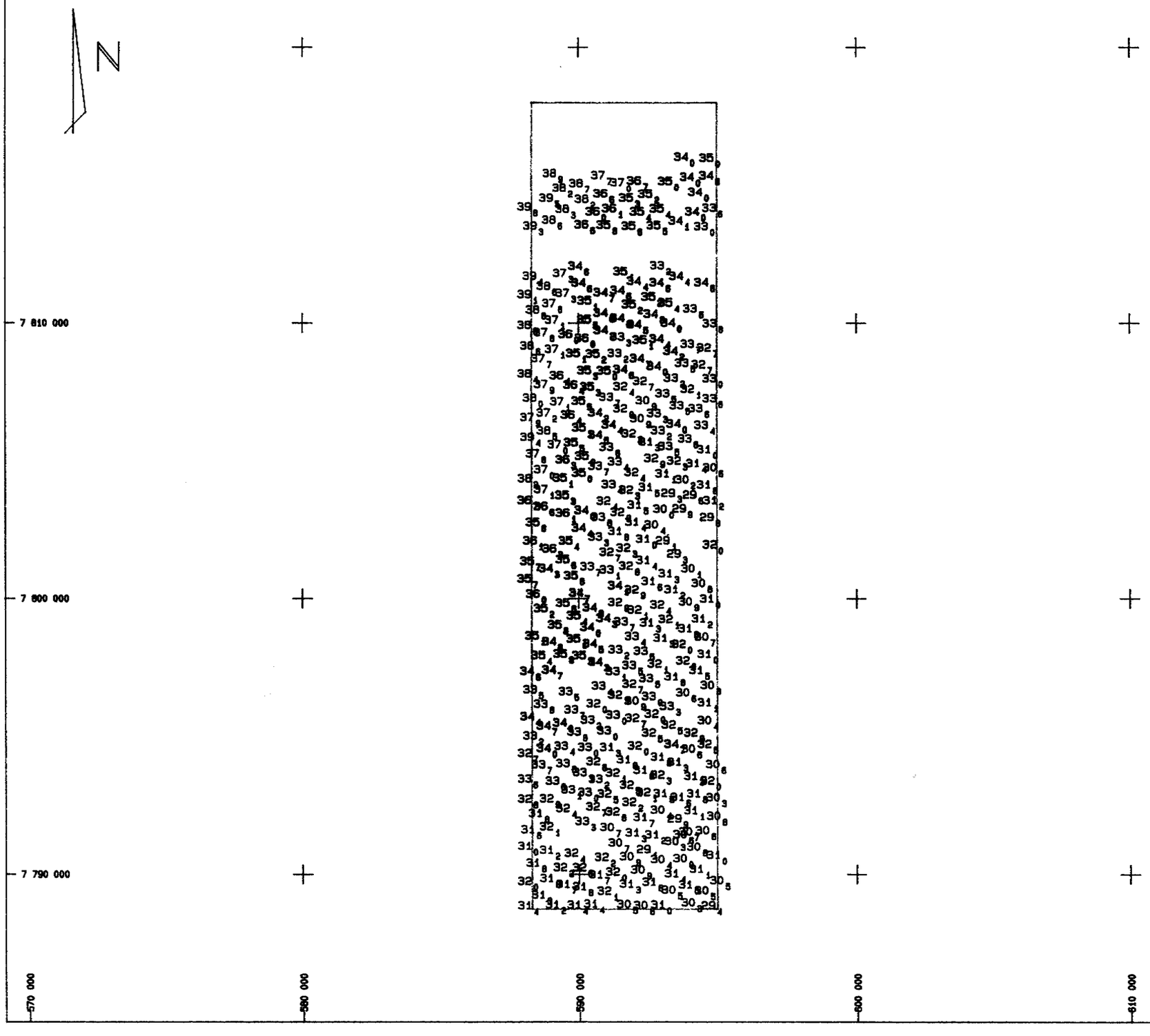
ZONE #5

ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEY & ENGINEERING LTD.	SCALE : 1 : 100	JOB NO : S-617
	DATE : 4 JAN 1988	DWG # : N-5-2

FIG. 83



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #5. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE -> 29.0 - 31.9 BLACK
32.0 - 33.9 GREEN
34.0 - 34.9 BLUE
35.0 - 35.9 PURPLE
36.0 - 36.9 RED
37.0 - 40.0 BROWN

INDIAN & NORTHERN AFFAIRS CANADA

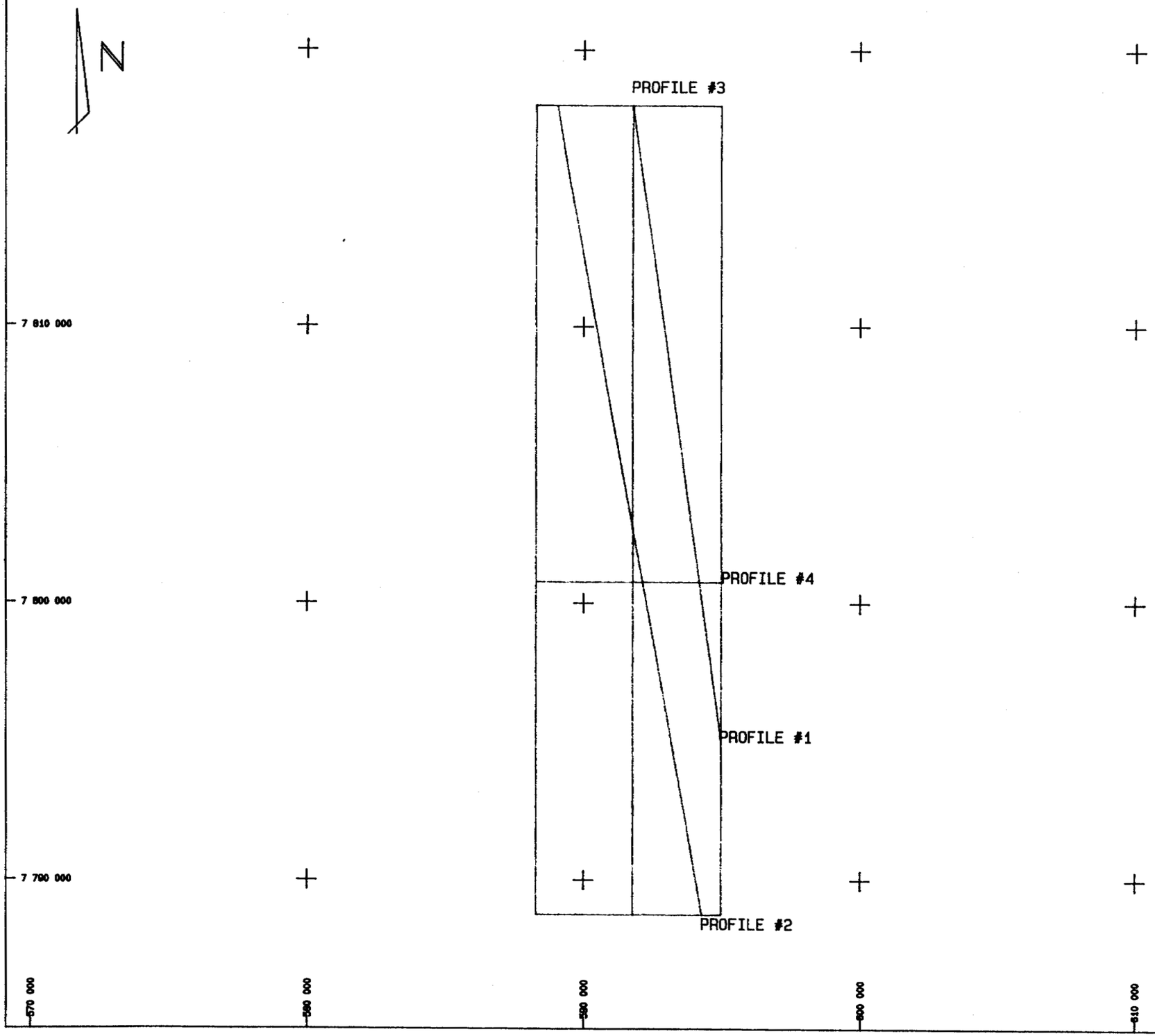
BATHYMETRIC DATA PLOT
ZONE #5
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER

SCALE :	JOB NO :
1 : 150000	S-617
DATE :	DWG # :
3 JAN 1988	B-5-1

FIG. 84



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #5.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7803375 E.591600
6. PROFILE CO-ORDINATES

	START	END
#1	N.7795000 E. 594950	N.7818000 E. 591750
#2	N.7788750 E. 594250	N.7818000 E. 589000
#3	N.7788750 E. 591750	N.7818000 E. 591750
#4	N.7800750 E. 594950	N.7800750 E. 588250

INDIAN & NORTHERN AFFAIRS CANADA

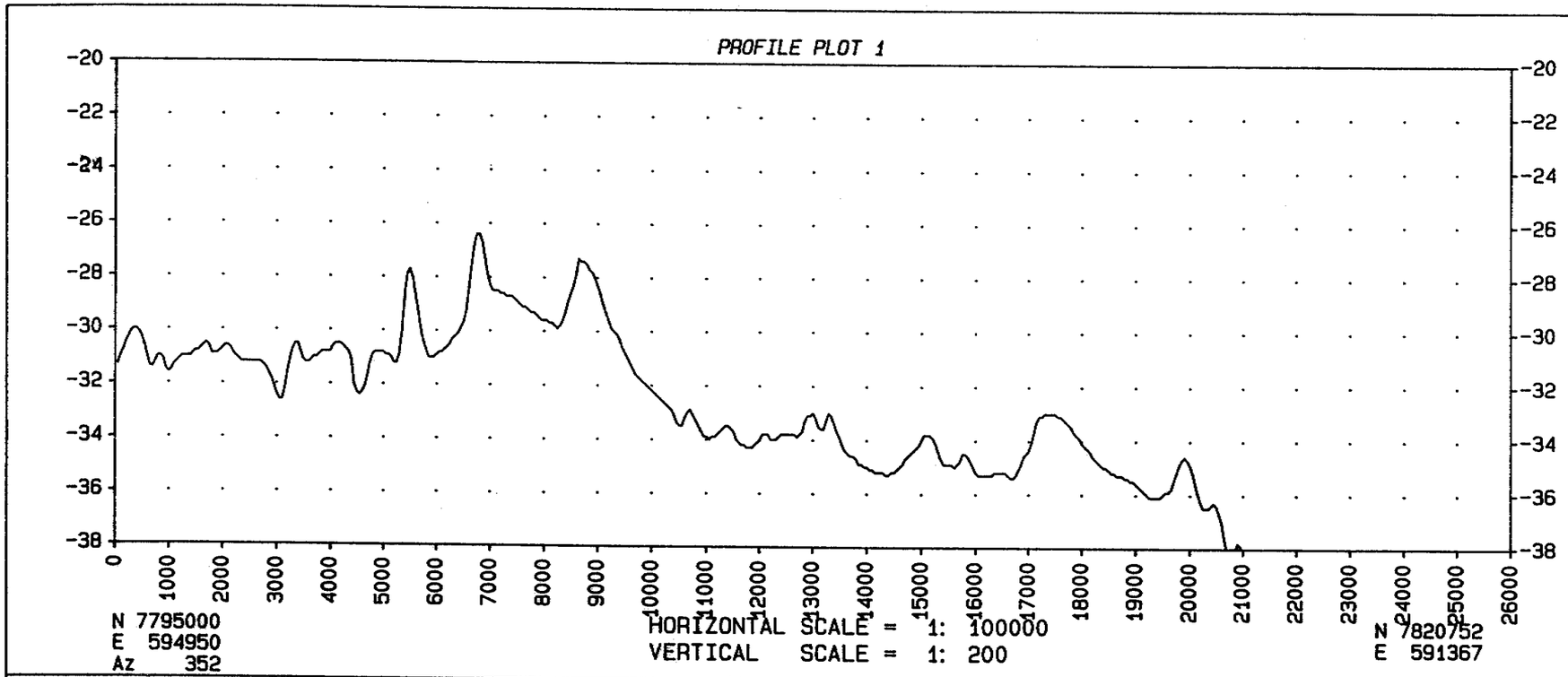
BATHYMETRIC PROFILE KEY PLAN
ZONE #5
ERKSAK BORROW BLOCK

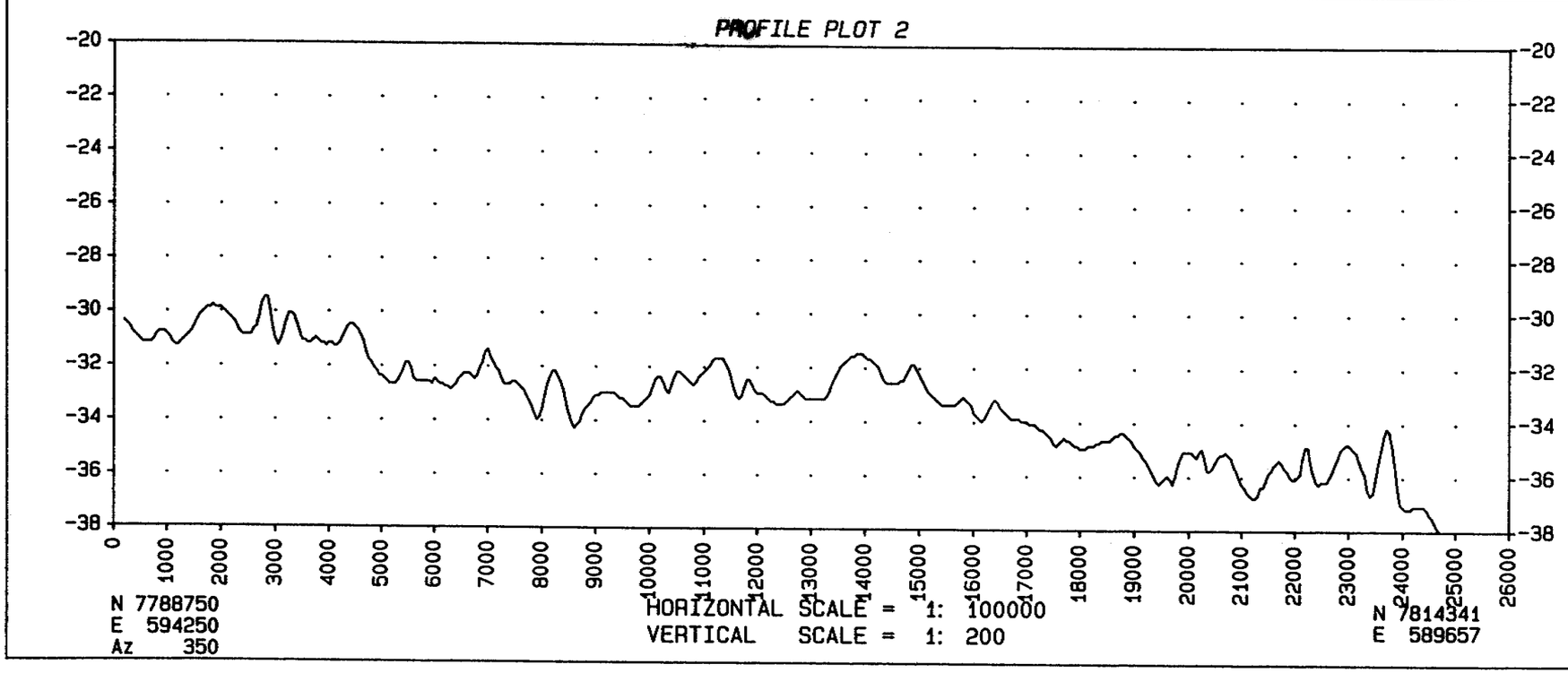
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

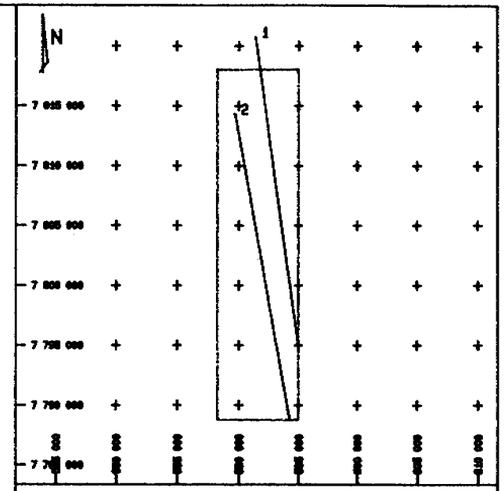
CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 150000	JOB NO : S-617
DATE : 4 JAN 1988	DWG # : X-5-1

FIG. 85







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

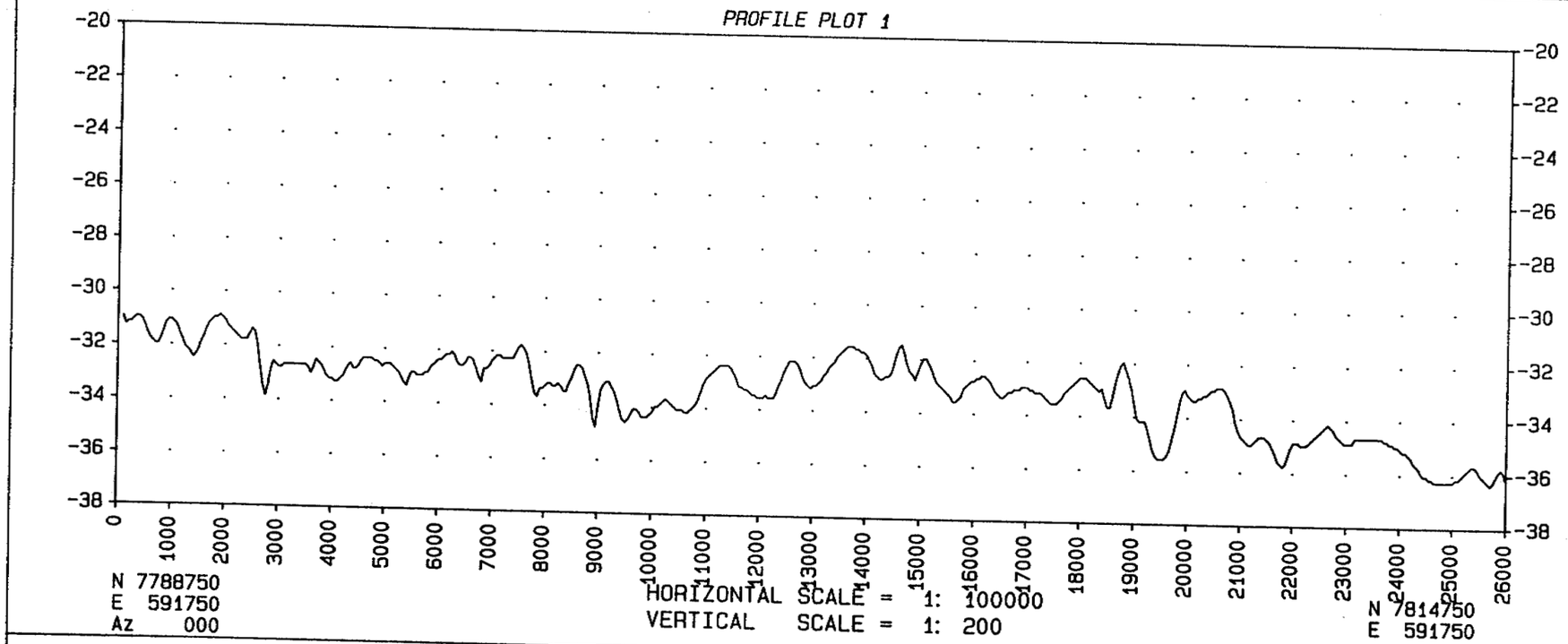
BATHYMETRIC PROFILES
ZONE #5
ERKSAK BORROW BLOCK

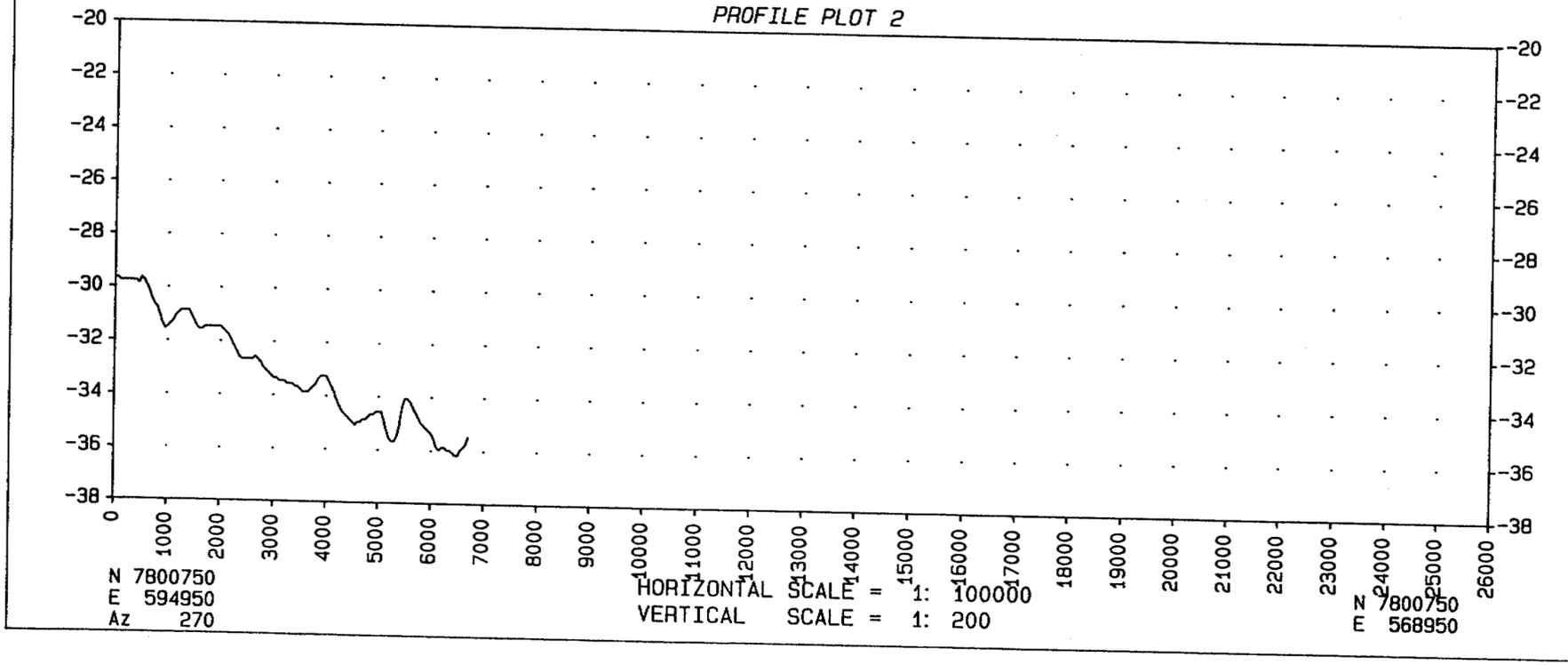
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

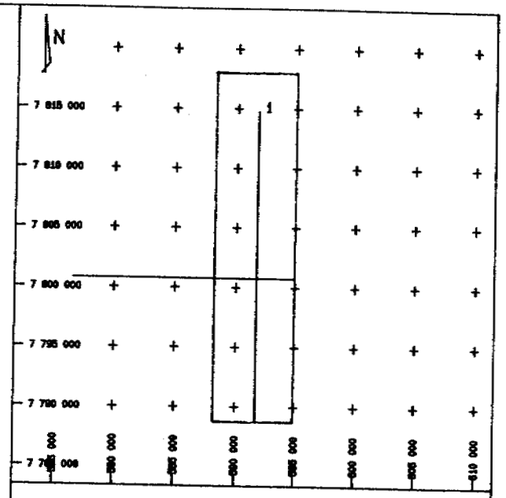
CHALLENGER SURVEYS & SERVICES LTD

	JOB NO : S-617
DATE : 4 JAN 1988	DWG # : P-5-2

FIG. 86







KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #5
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

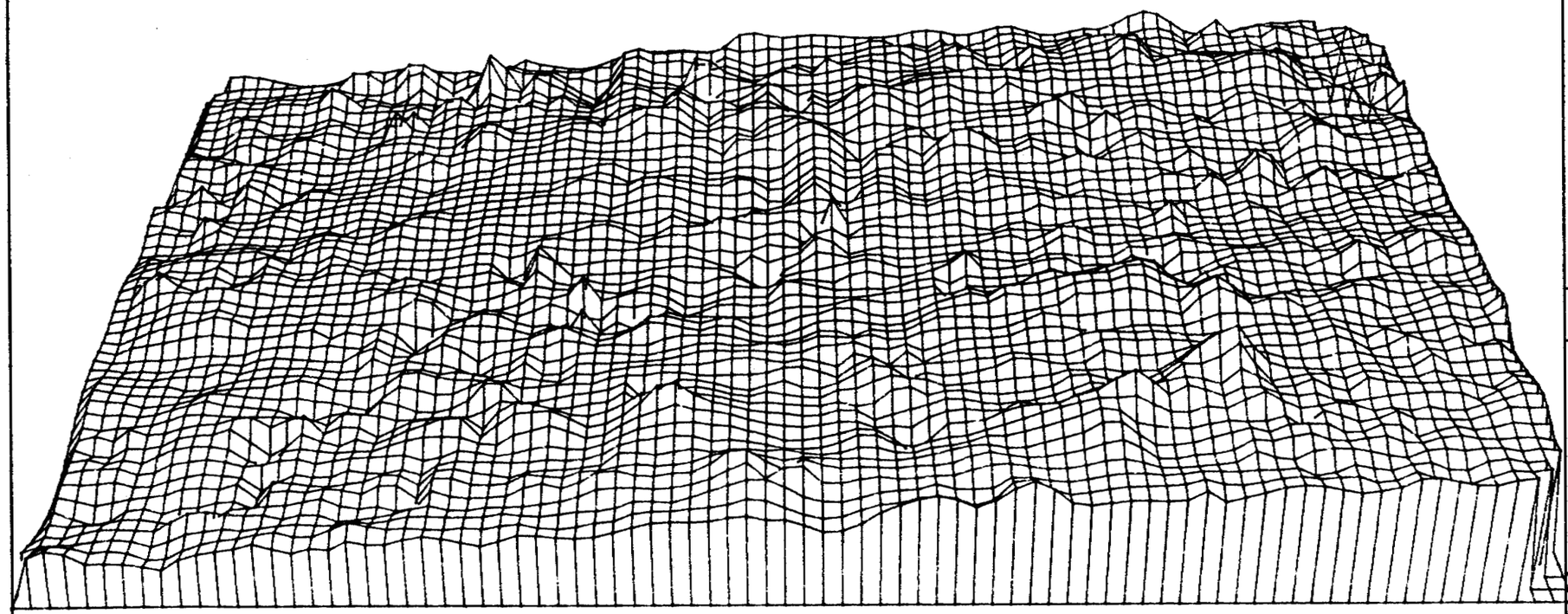
CHALLENGER SURVEYS & SERVICES LTD

	JOB NO : S-617
DATE : 4 JAN 1988	DWG # : P-5-1

FIG. 87

LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 90 DEGREES
   VERTICAL EXAGGERATION 200 TIMES



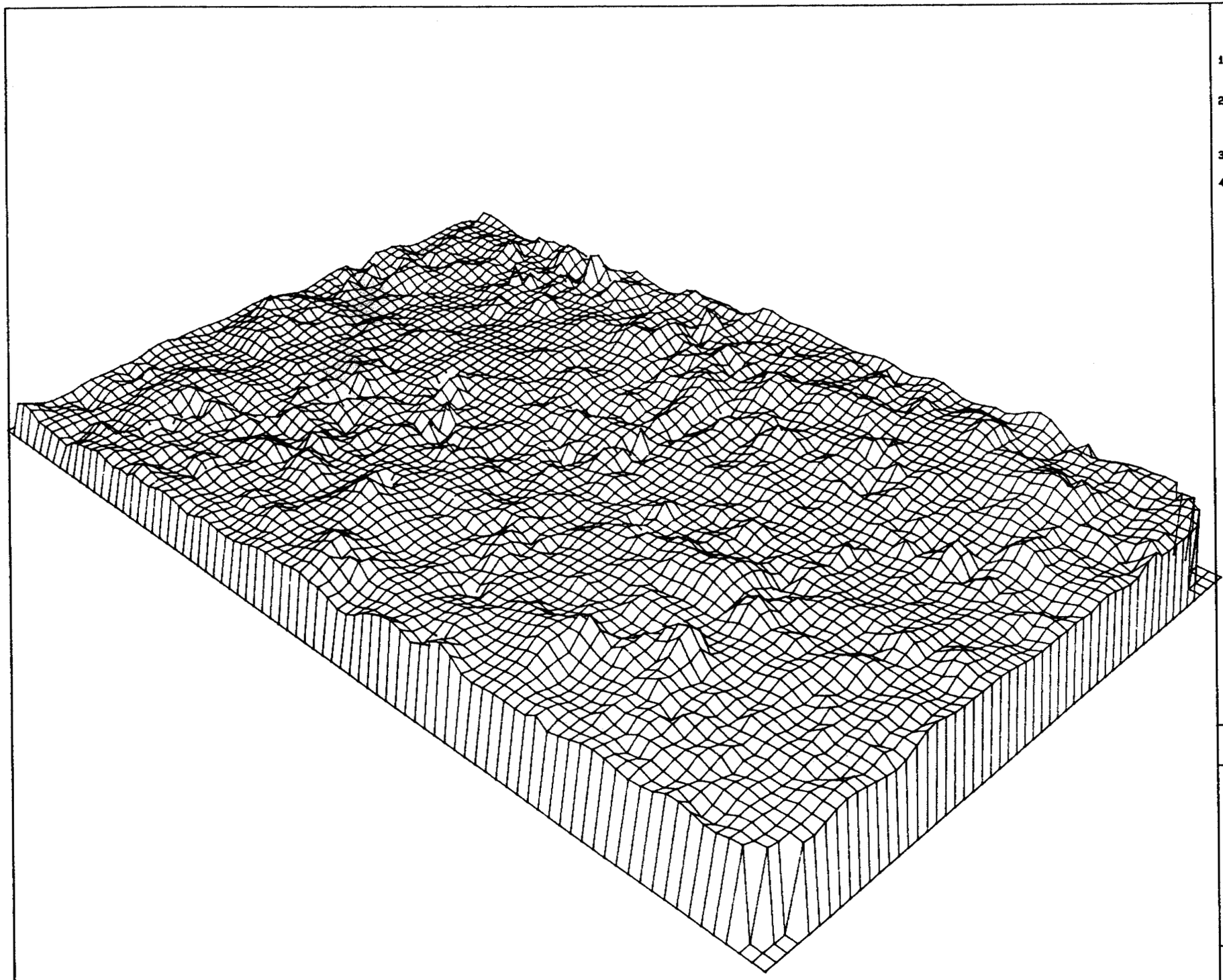
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #6
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE :	JOB NO : S-617
	DATE : 24 DEC 1987	DWG # : M-6-1

FIG. 88



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED WITHIN THE ERKSAK BORROW BLOCK.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. VIEW IS FROM 30 DEG ABOVE HORIZON
   AZIMUTH OF 45 DEGREES
   VERTICAL EXAGGERATION 200 TIMES

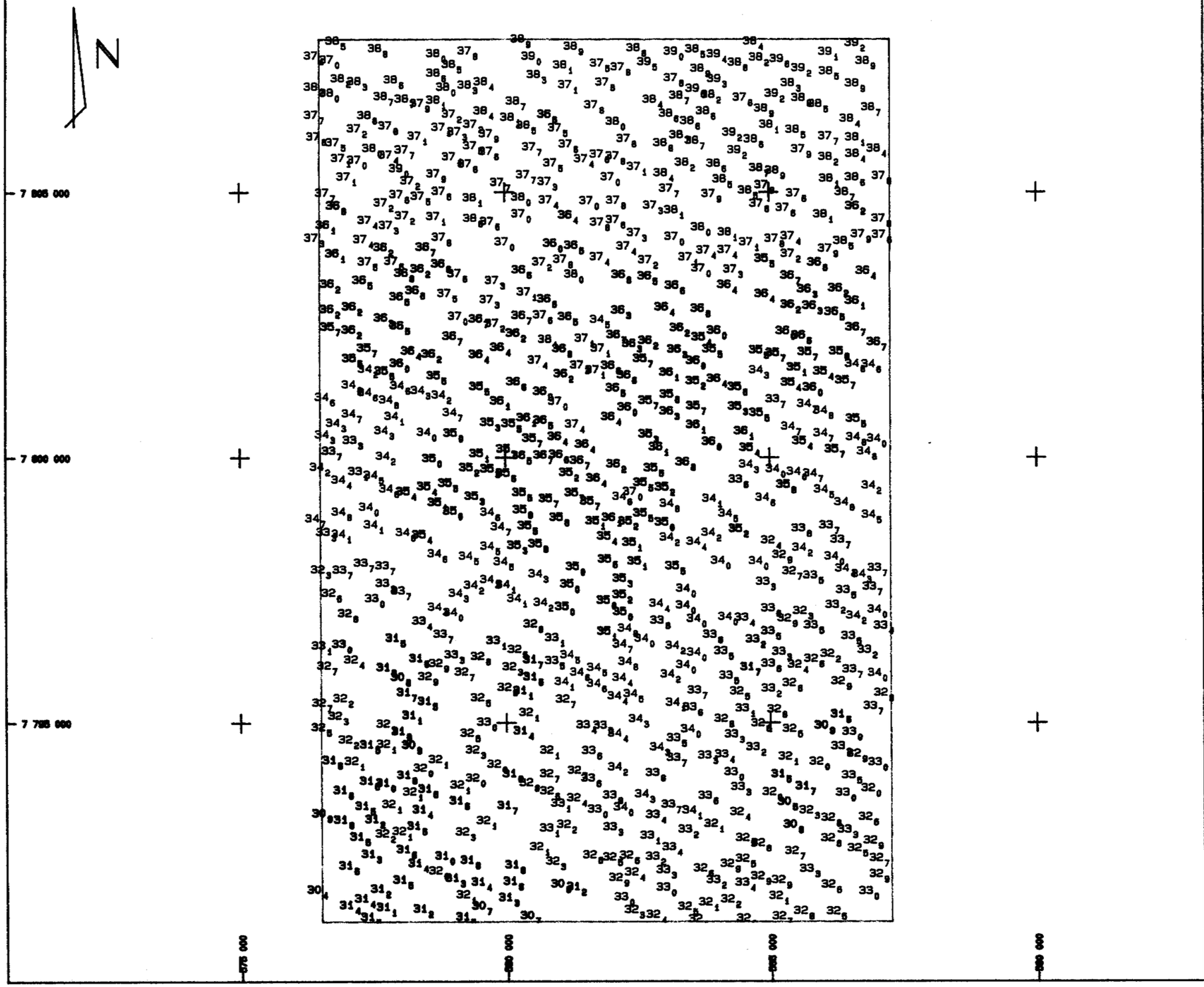
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE #6
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE :	JOB NO : S-617
	DATE : 24 DEC 1987	DWG # : M-6-2

FIG. 89



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC DATA LOCATED WITHIN ZONE #6. DATA IS THINNED TO AVOID OVERPLOTS.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8
4. DATA SHOWN IS LOCATED WITHIN THE ERKSAK BORROW BLOCK.

BATHYMETRY COLOR CODE ->
30.0 - 31.9 BLACK
32.0 - 33.9 GREEN
34.0 - 34.9 BLUE
35.0 - 35.9 PURPLE
36.0 - 36.9 RED
37.0 - 40.0 BROWN

INDIAN & NORTHERN AFFAIRS CANADA

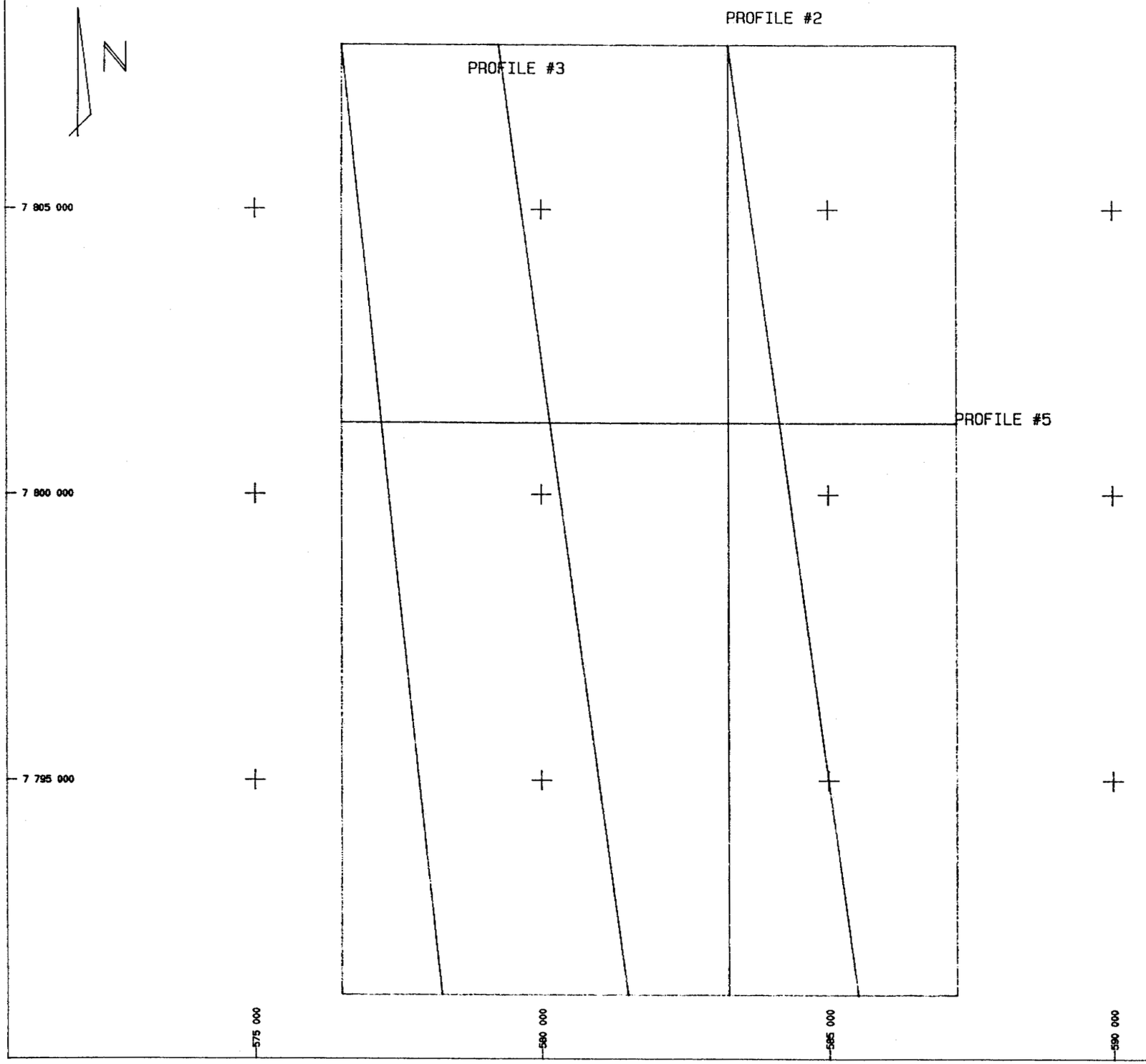
BATHYMETRIC DATA PLOT
ZONE #6
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER

SCALE :	JOB NO :
1 : 75000	8-617
DATE :	DWG # :
24 DEC 1987	8-6-1

FIG. 90



LEGEND & NOTES

1. PLOT SHOWS THE LOCATION OF BATHYMETRIC PROFILES IN ZONE #6.
2. PROFILE LOCATIONS DERIVED FROM A PERSPECTIVE DRAWING AND GENERALLY CROSS SEA BOTTOM FEATURES DETECTED FROM THE DRAWING.
3. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
4. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8, CENTRAL MERIDIAN 135 DEGREES.
5. CHART CENTER N.7799500 E.581875
6. PROFILE CO-ORDINATES

	START	END
#1	N.7791250 E. 585500	N.7807875 E. 583250
#2	N.7791250 E. 583250	N.7807875 E. 583250
#3	N.7791250 E. 581500	N.7807875 E. 579250
#4	N.7791250 E. 578250	N.7807875 E. 576500
#5	N.7801250 E. 587250	N.7801250 E. 576500

INDIAN & NORTHERN AFFAIRS CANADA

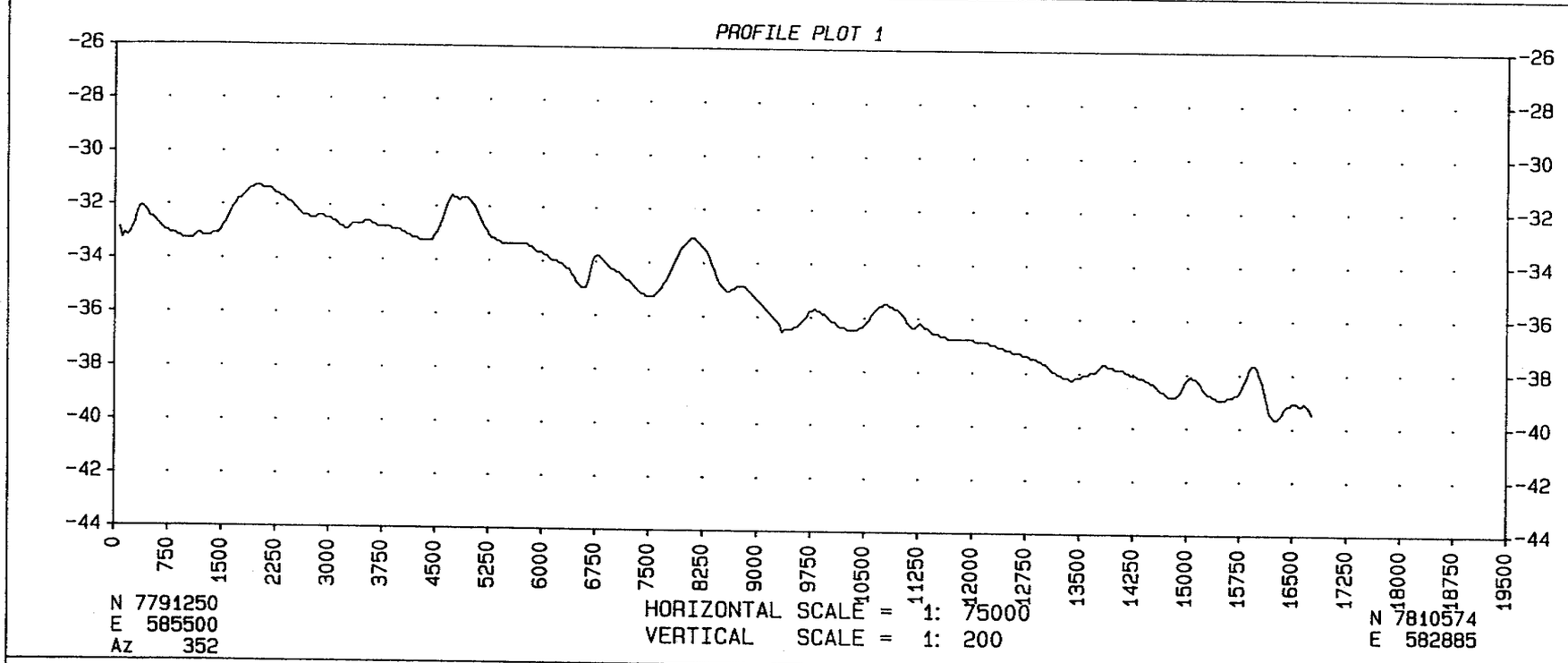
BATHYMETRIC PROFILE KEY PLAN
ZONE #6
ERKSAK BORROW BLOCK

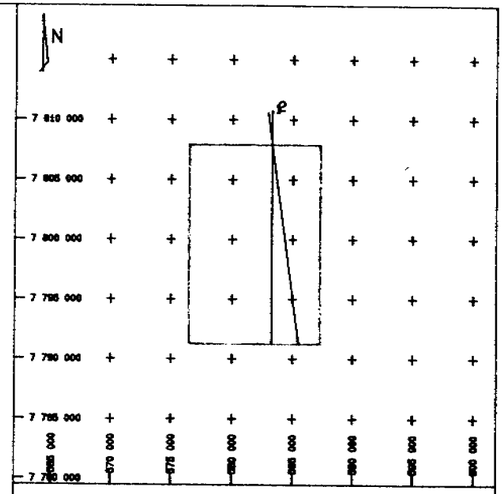
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD.

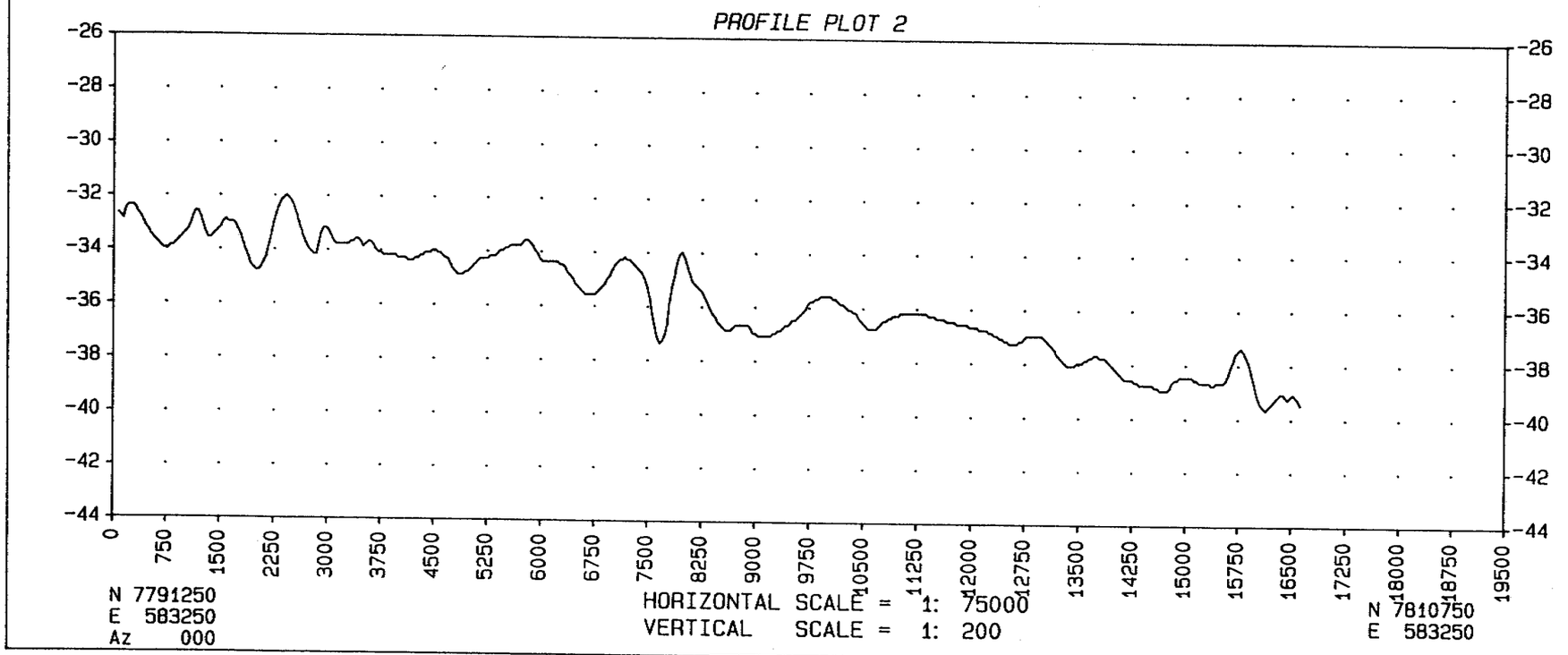
SCALE : 1 : 75000	JOB NO : S-617
DATE : 24 DEC 1987	DWG # : X-6-1

FIG. 91





KEY PLAN - 1 : 500000



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

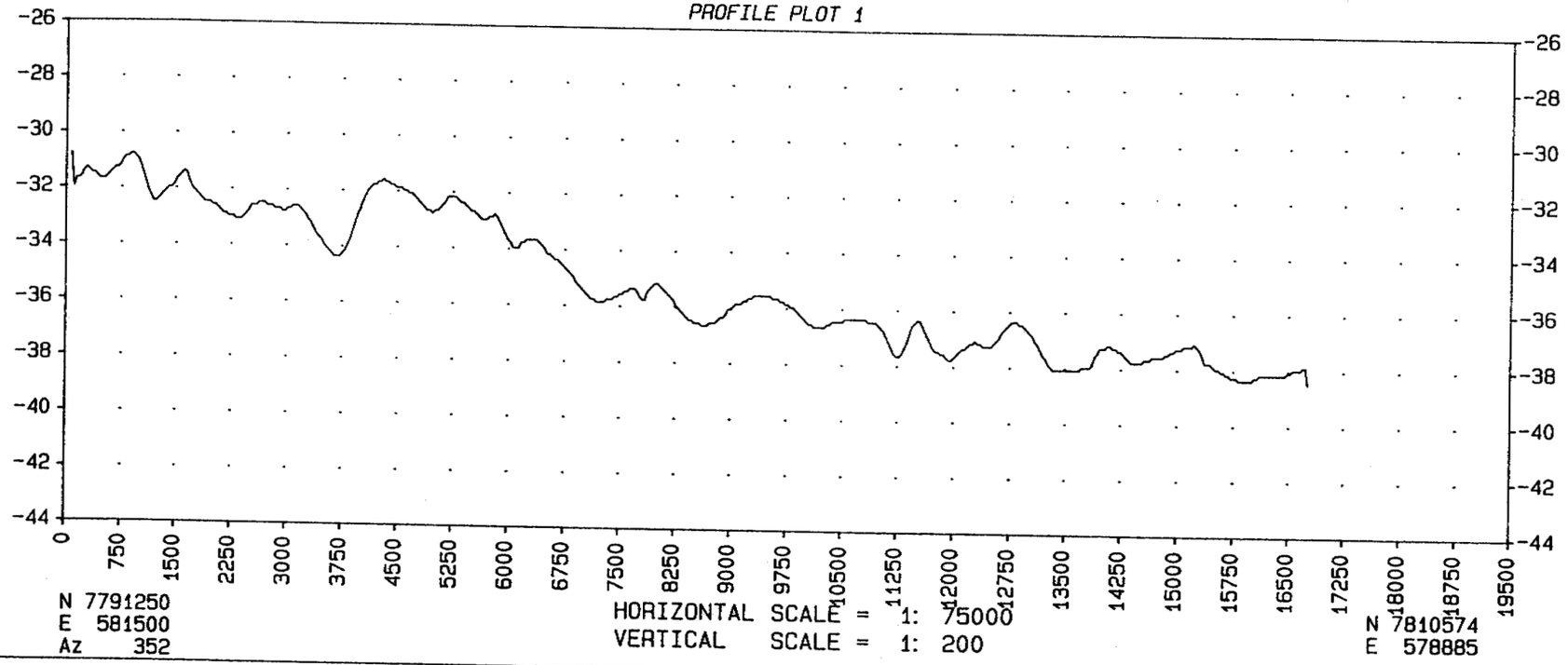
BATHYMETRIC PROFILES
ZONE #6
ERKSAK BORROW BLOCK

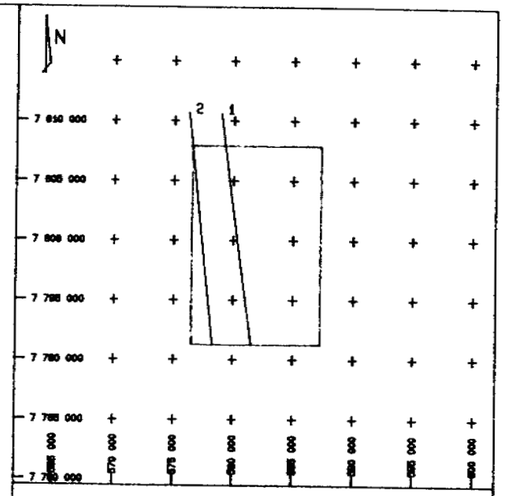
COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

	JOB NO : S-617
DATE : 24 DEC 1987	DWG # : P-6-1

FIG. 92

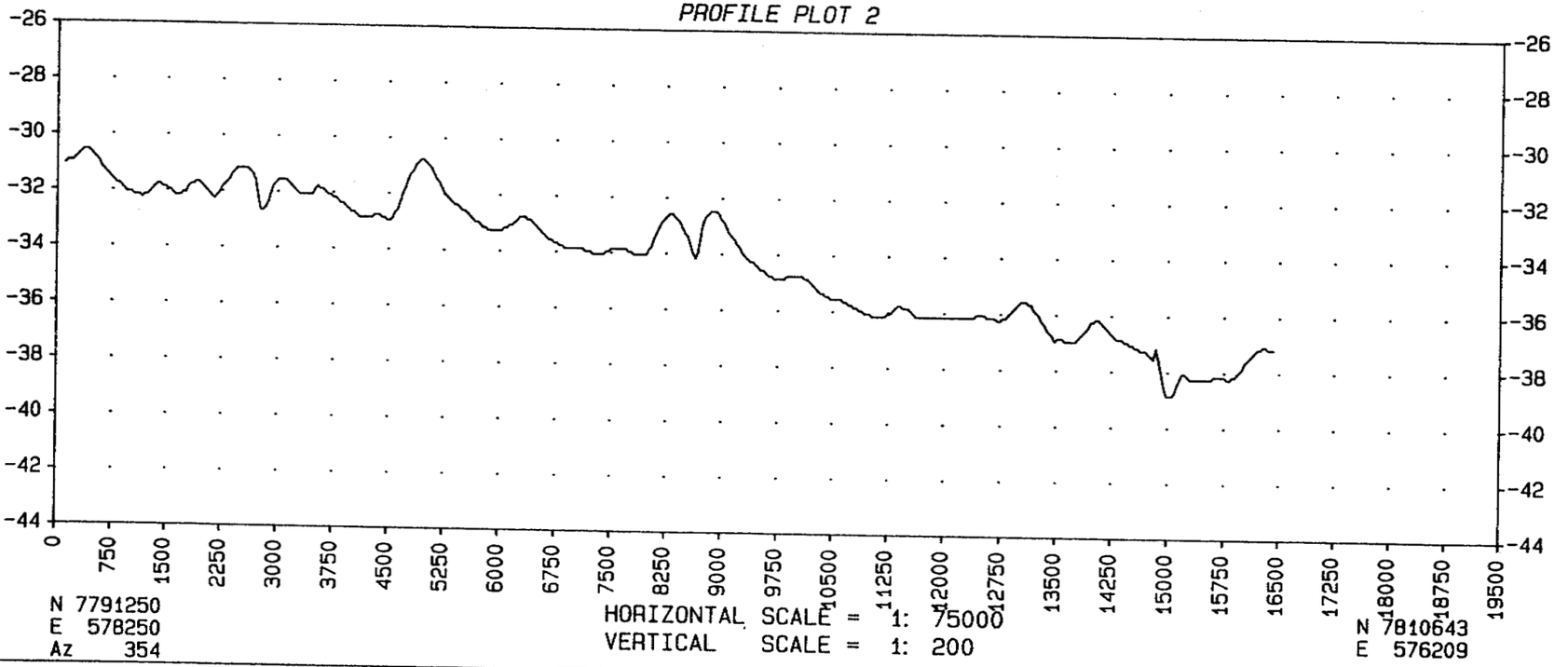




KEY PLAN - 1 : 500000

LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.



INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC PROFILES
ZONE #6
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

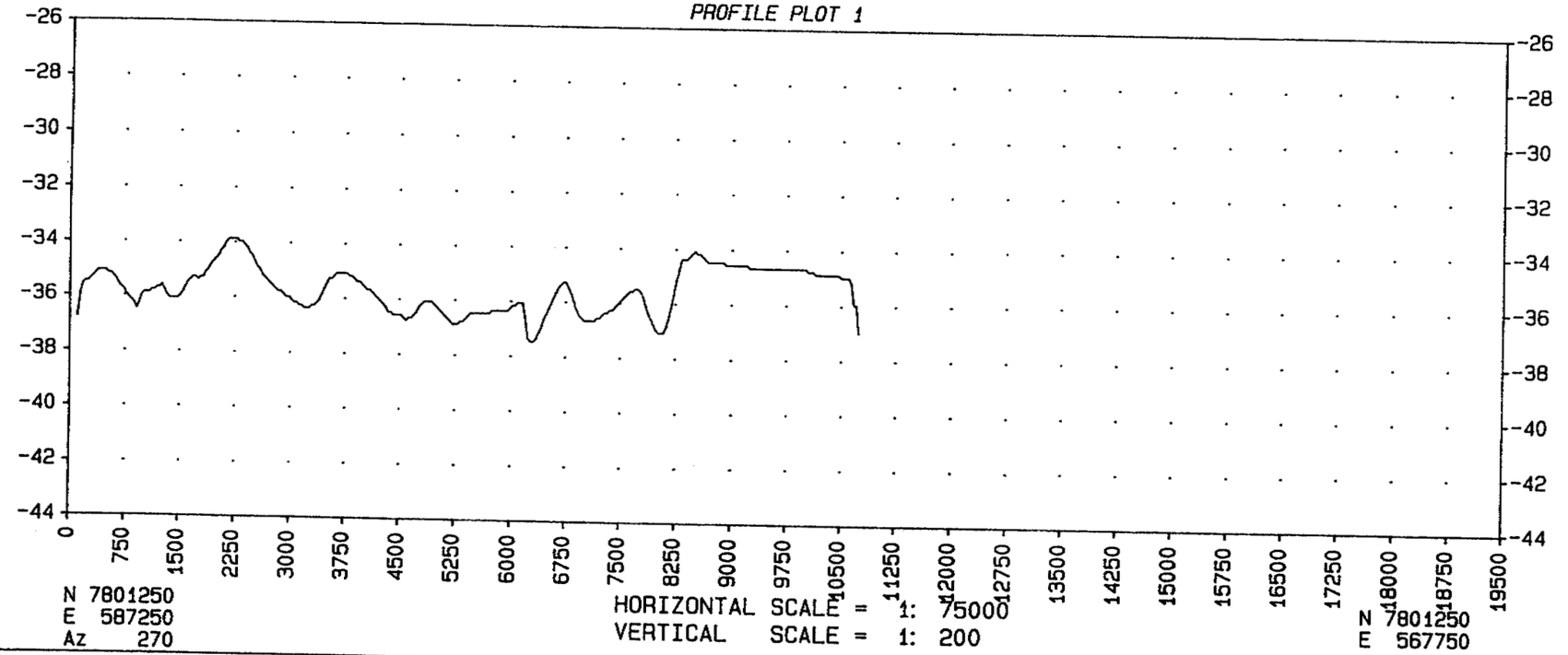
JOB NO : S-617
DATE : 24 DEC 1987
DWG # : P-6-2

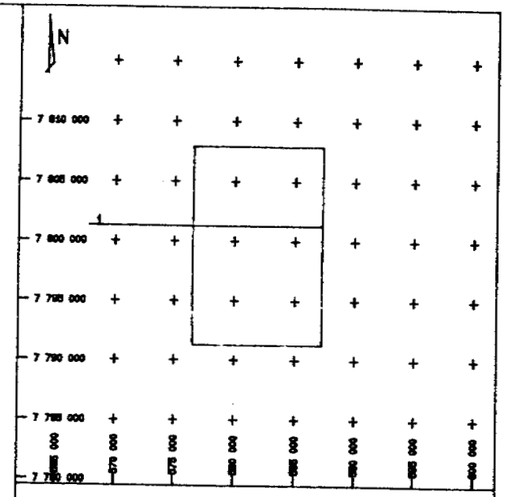
FIG. 93

5.7 Alternative Analysis Method

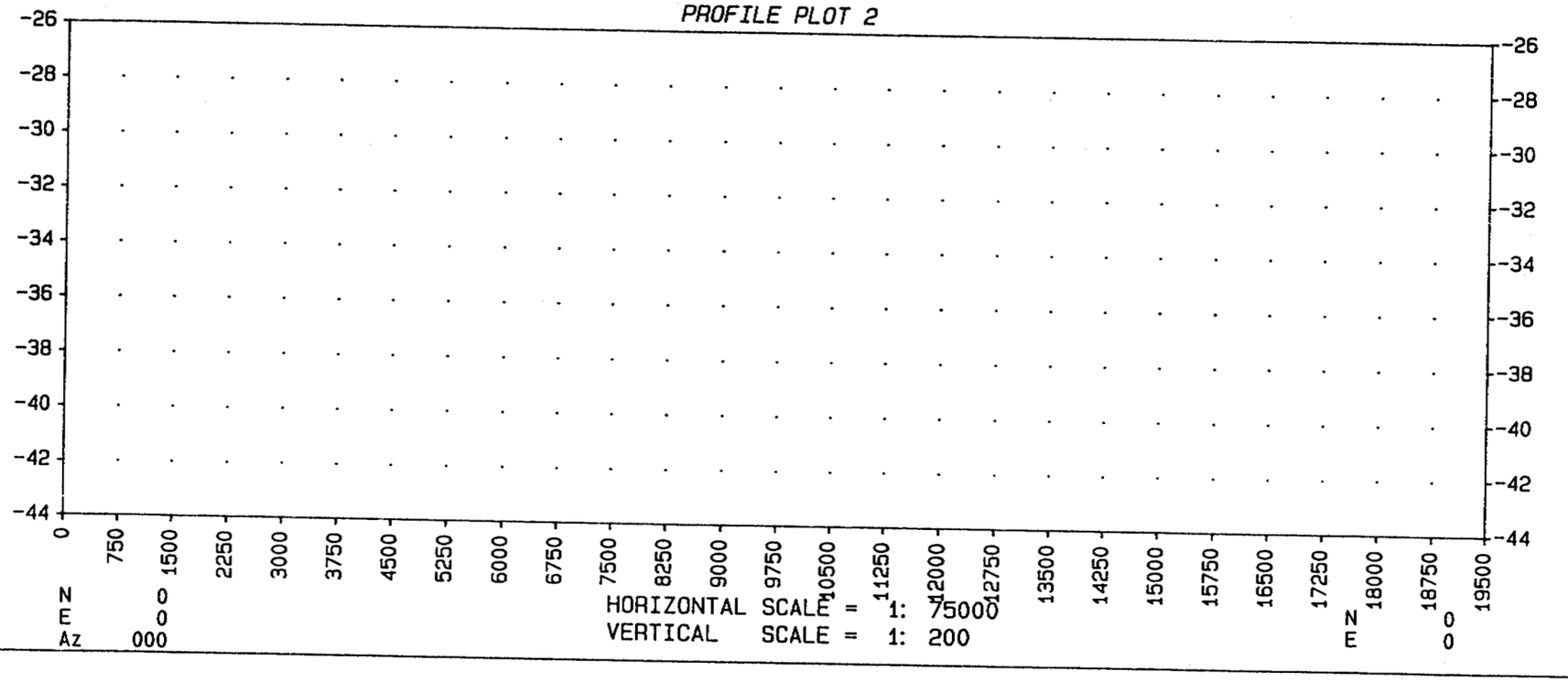
Area 2A of the Erksak data block was selected for the testing of the alternative analysis method. The mean plane defining the trend surface consisted of two triangular planes. A mesh of this sloped surface is shown if figure 97. This surface was then removed from the normal grid data base leaving a surface composed of residuals from the mean.

The calculated residual (trend) surface was plotted using both contouring (figure 99) and mesh perspective (figure 98) methods. For comparative purposes a plot of the original DTM surface is shown in figure 96 (mesh) and figure 100 (contour).





KEY PLAN - 1 : 500000



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC PROFILES INTERPOLATED FROM DIGITAL BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICES.
2. PROFILES ARE LOCATED WITHIN THE ERKSAK BORROW BLOCK.
3. CO-ORDINATES SHOWN ARE U.T.M. CO-ORDINATES ZONE 8 CENTRAL MERIDIAN 135 DEGREES.

INDIAN & NORTHERN AFFAIRS CANADA

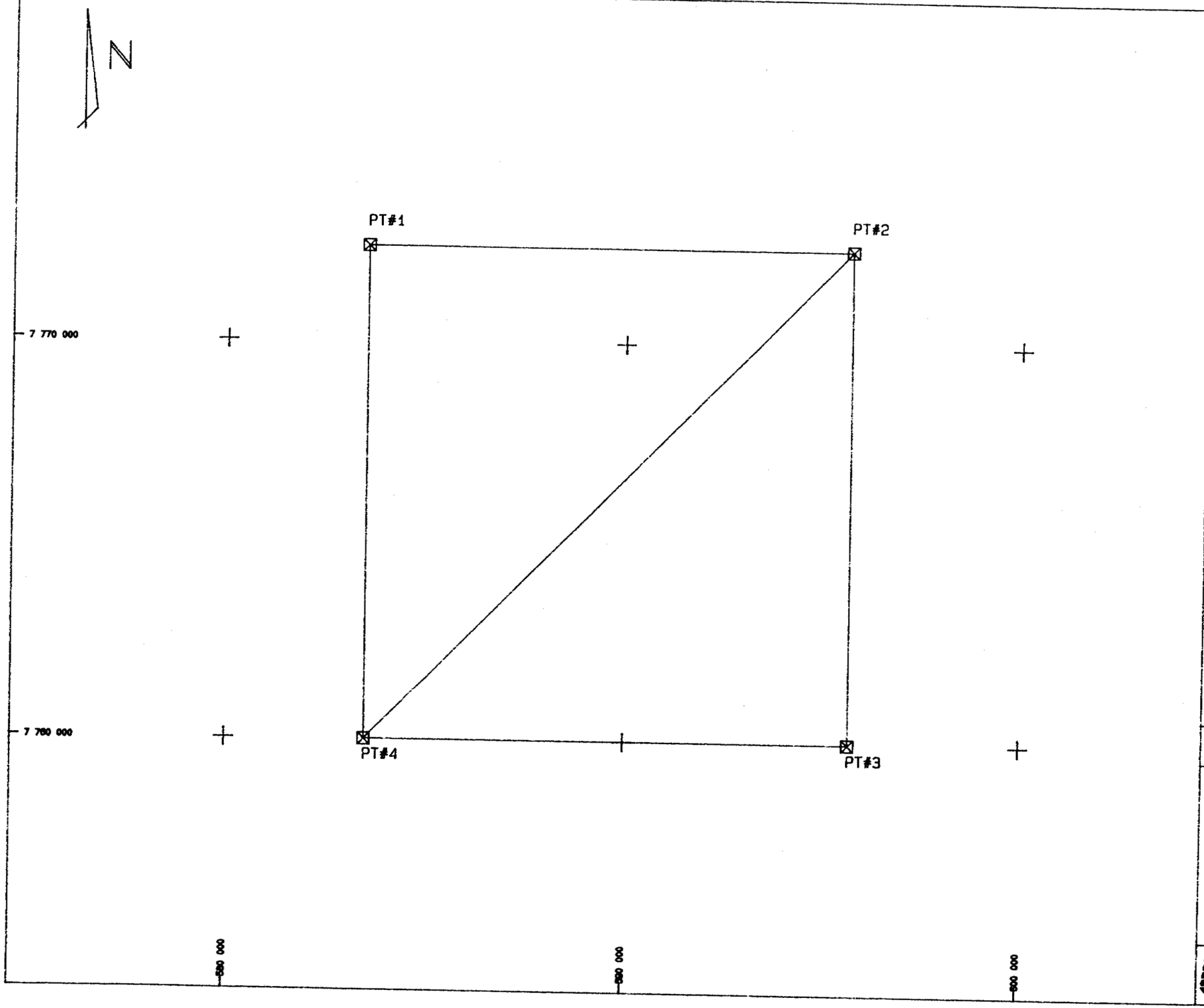
BATHYMETRIC PROFILES
ZONE #6
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

	JOB NO : S-617
DATE : 24 DEC 1987	DWG # : P-6-3

FIG. 94



LEGEND & NOTES

THE AVERAGE TREND SURFACE CONSISTS OF TWO TRIANGULAR PLANES. THE NODE VALUES ARE:

PT#	NORTHING	EASTING	DEPTH
PT#1	7772400	583500	25.7
PT#2	7772400	595700	20.8
PT#3	7760000	595700	12.4
PT#4	7760000	583500	14.55

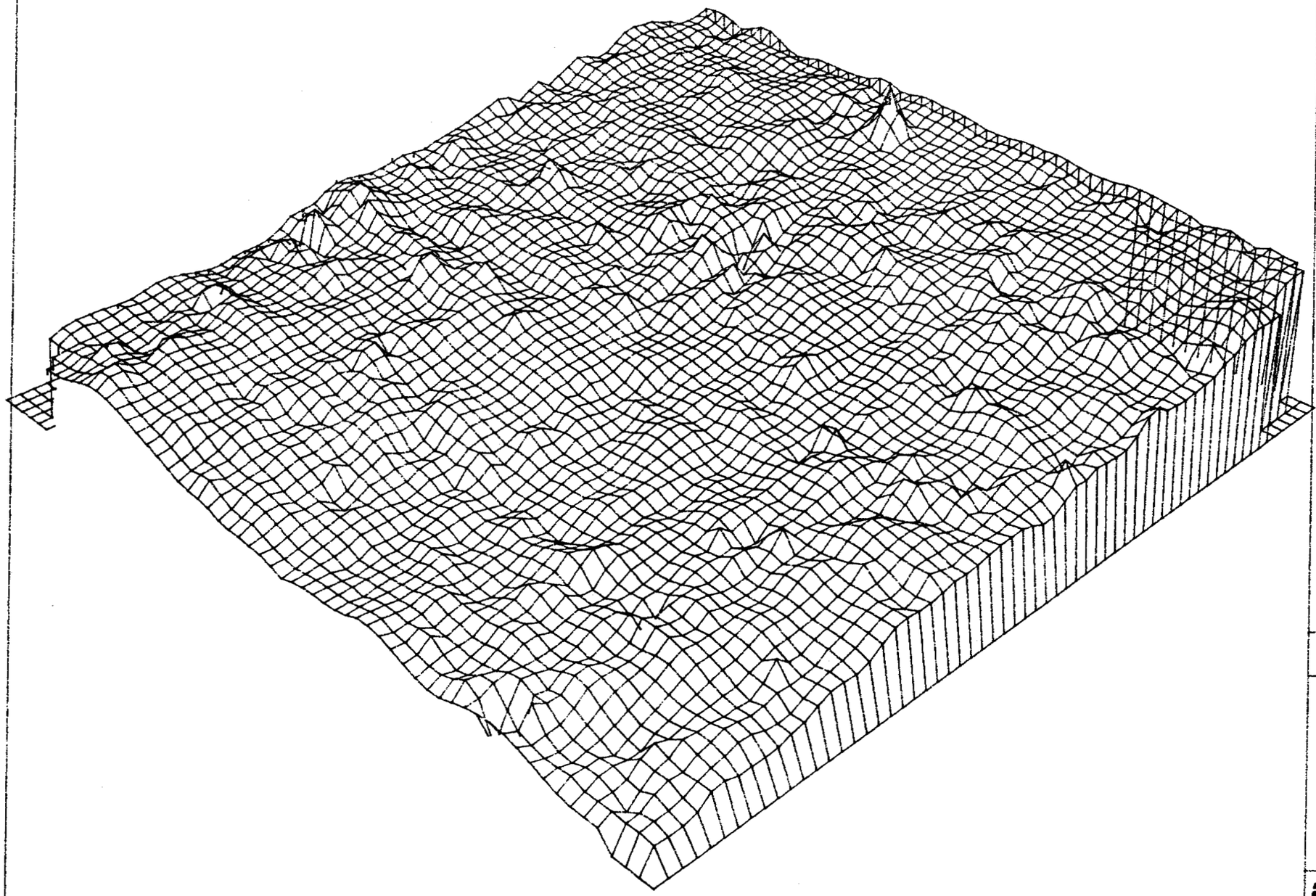
INDIAN & NORTHERN AFFAIRS CANADA

COORDINATE BASIS FOR
THE AVERAGE SLOPE SURFACE

CHALLENGER SURVEYS & SERVICES LTD.

SCALE : 1 : 100000
JOB NO : S-617
DATE : 10 MAY 1988
DWG # :

FIG. 95



LEGEND & NOTES

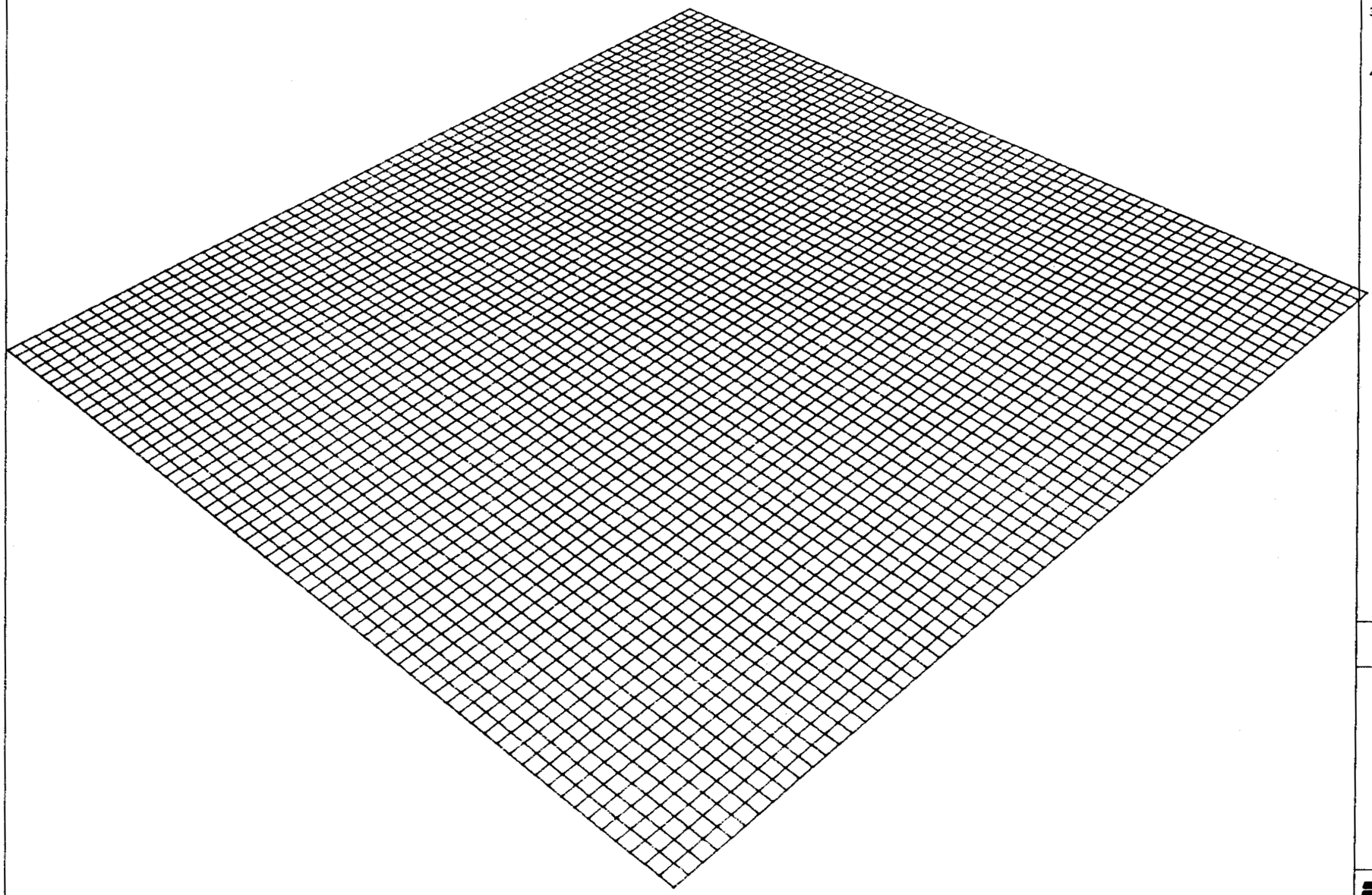
1. PLOT SHOW A MESH PERSPECTIVE VIEW OF THE SEA BOTTOM LOCATED AT THE ERKSAK BORROW AREA.
2. MESH IS DERIVED FROM A DIGITAL MODEL BASED ON BATHYMETRIC DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE.
3. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 135 DEGREES
   VERTICAL EXAGGERATION = 200
4. THIS PLAN CONSTITUTES ONE OF A SET OF THREE PLANS SHOWING THE EFFECT OF THE REMOVAL OF THE AVERAGE SLOPE COMPONENT FROM A DATA BASE.
5. THIS PLAN SHOWS THE NORMAL MESH OF DATA SET 1.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
ZONE 2A
ERKSAK BORROW AREA

CHALLENGER SURVEYS & ENGINEERING LTD	SCALE : 1 : 500000	JOB NO : S-617
	DATE : 12 MAY 1988	DWG # :

FIG. 96



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF A MEAN SET OF PLANES USED TO REMOVE THE SLOPE COMPONENT FROM THE ERKSAK DATA BASE.
2. THE MESH IS DERIVED FROM A DIGITAL MODEL BASED ON TWO TRIANGULAR PLANES THAT BEST APPROXIMATE THE MEAN SURFACE FOR THIS DATA SET.
3. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 135 DEGREES
   VERTICAL EXAGGERATION = 200 TIMES
4. THIS PLAN CONSTITUTES ONE OF A SET OF THREE PLANS SHOWING THE EFFECT OF THE REMOVAL OF THE AVERAGE SLOPE COMPONENT FROM A DATA BASE.

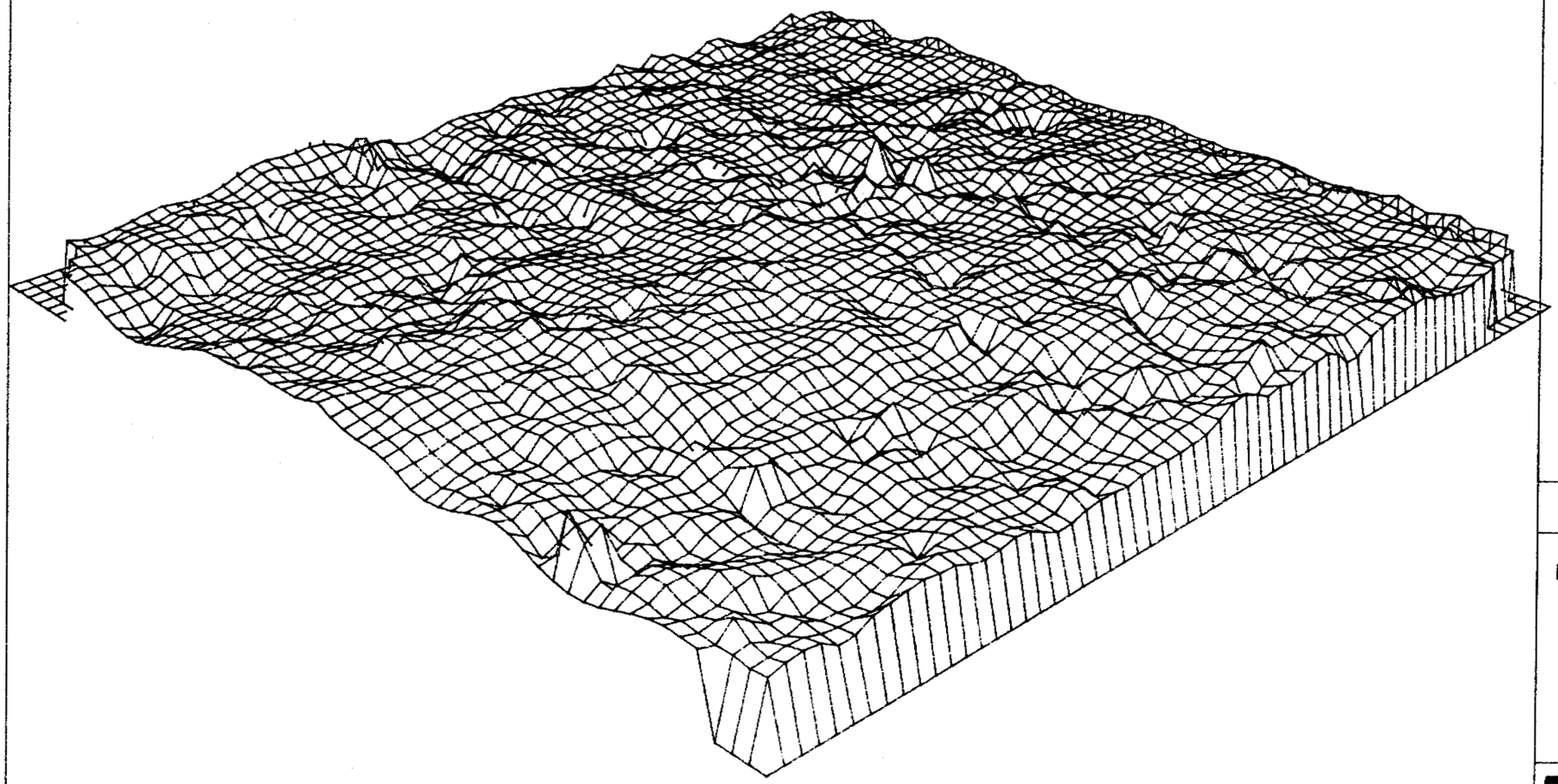
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE
AVERAGE SLOPE SURFACE
ERKSAK BORROW AREA

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 500000	JOB NO : S-617
	DATE : 12 MAY 1988	DWG # :

FIG. 97



LEGEND & NOTES

1. PLOT SHOWS A MESH PERSPECTIVE VIEW OF THE DIFFERENCE BETWEEN THE MEAN SLOPED PLANE AND THE NORMAL PERSPECTIVE DATA SET.
2. THE MESH IS DERIVED FROM A DIGITAL MODEL BASED ON THE DIFFERENCE BETWEEN THE TWO FACES MEAN SLOPED PLANE AND THE ACTUAL DIGITAL MODEL FOR THIS AREA.
3. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 135 DEGREES
   VERTICAL EXAGGERATION = 200 TIMES
4. THIS PLAN CONSTITUTES ONE OF A SET OF THREE PLANS SHOWING THE EFFECT OF THE REMOVAL OF THE AVERAGE SLOPE COMPONENT FROM A DATA BASE.

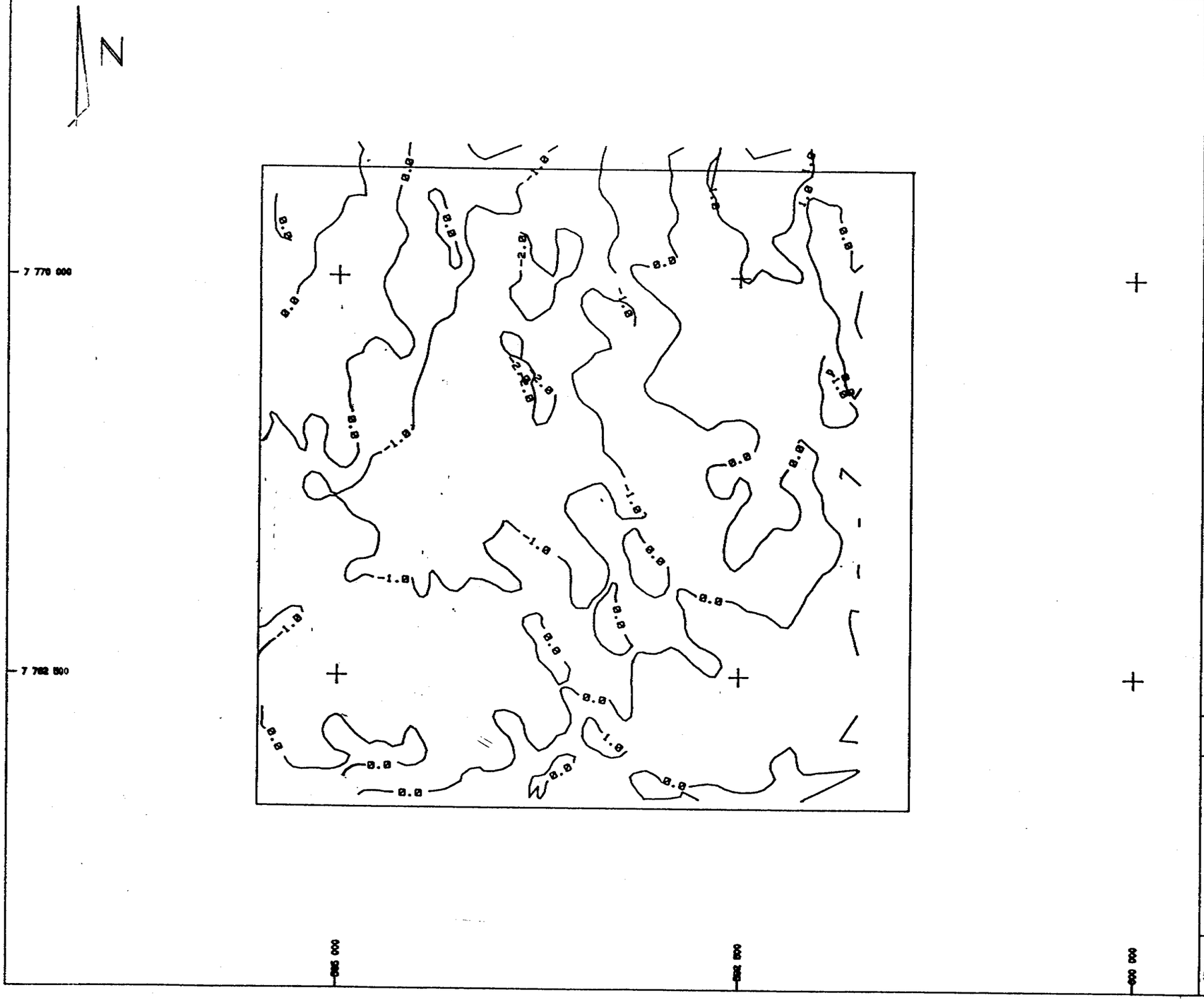
INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC MESH PERSPECTIVE ZONE NO. 2A (ERKSAK BLOCK) OF TREND SURFACE RESIDUALS

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD	SCALE : 1 : 500000	JOB NO : S-617
	DATE : 12 MAY 1988	DWG # :

FIG. 98



LEGEND & NOTES

1. PLOT SHOWS DIFFERENTIAL BATHYMETRIC CONTOURS OF DETAILED INVESTIGATION SITE #2A FROM THE ERKSAK BORROW BLOCK DATA BASE.
2. DATA SHOWN WAS OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. DATA IS FOR ENGINEERING PURPOSES ONLY AND IS NOT TO BE USED FOR NAVIGATION PURPOSES.
3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8.
4. CONTOURS ARE PLOTTED AT 1 METER INTERVALS FROM DIFFERENTIAL CONTOR LEVEL -2.0 TO +1.0.
5. THE DIFFERENTIAL CONTOUR DATA BASE WAS ARRIVED AT BY REMOVING A PLANE REPRESENTING THE MEAN SLOPED SURFACE OVER THE AREA, FROM THE ORIGINAL RAW DATA BASE. THE RESULTING SURFACE THEN REPRESENTS THE TREND SURFACE. THE PLOT SHOWS THE CONTOURS OF THE VARIATIONS FROM THE MEAN PLANE. THE CONTOURS RESULT FROM EITHER AN ILL DEFINED MEAN PLANE OR FROM FEATURES IN THE DATA BASE THAT DO NOT FIT WITH THE TREND SURFACE.

INDIAN & NORTHERN AFFAIRS CANADA

DIFFERENTIAL CONTOURS
ZONE #2A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE :	JOB NO :
1 : 75000	S-617
DATE :	DWG # :
6 JUN 1988	

FIG. 99

6.0 EVALUATION OF RESULTS

6.1 Techniques Used

The techniques used in this study verified the initial findings that showed mesh grid plots provided a visual image of the seabed which is useful for general geological interpretation and identification of the presence of subtle bathymetric anomalies. In this study improved DTM algorithms were used to analyze detailed study areas in the Yukon Shelf data base. These methods were then applied to an additional study area namely the Erksak Borrow block.

An alternative analysis method based on residual plots from an averaged sloped surface was undertaken. Plots of the data set in the form of contours and mesh perspectives were used in the analysis of this new technique. An enhancement of the subtle features that may have been obscurred in processing by the average slope contours and mesh of the surface, was the goal of this alternative analysis technique.

The contours, and meshes of the alternative analysis test areas in the Yukon Shelf and Erksak Borrow area can be found in section 3.6 and 5.7 of this report. The mesh of the residuals, of these test areas did not readily show any features that were not apparent on the normal mesh of the raw data for that area. However the contour plans of the residual plots, which can be used in quantifying features, were less cluttered and the features were easier to interpret than the normal contour plots of the area.

A series of profiles crossing each area was generated for the purpose of aiding in the determination of the magnitude of any features that were prominent within a

detailed site.

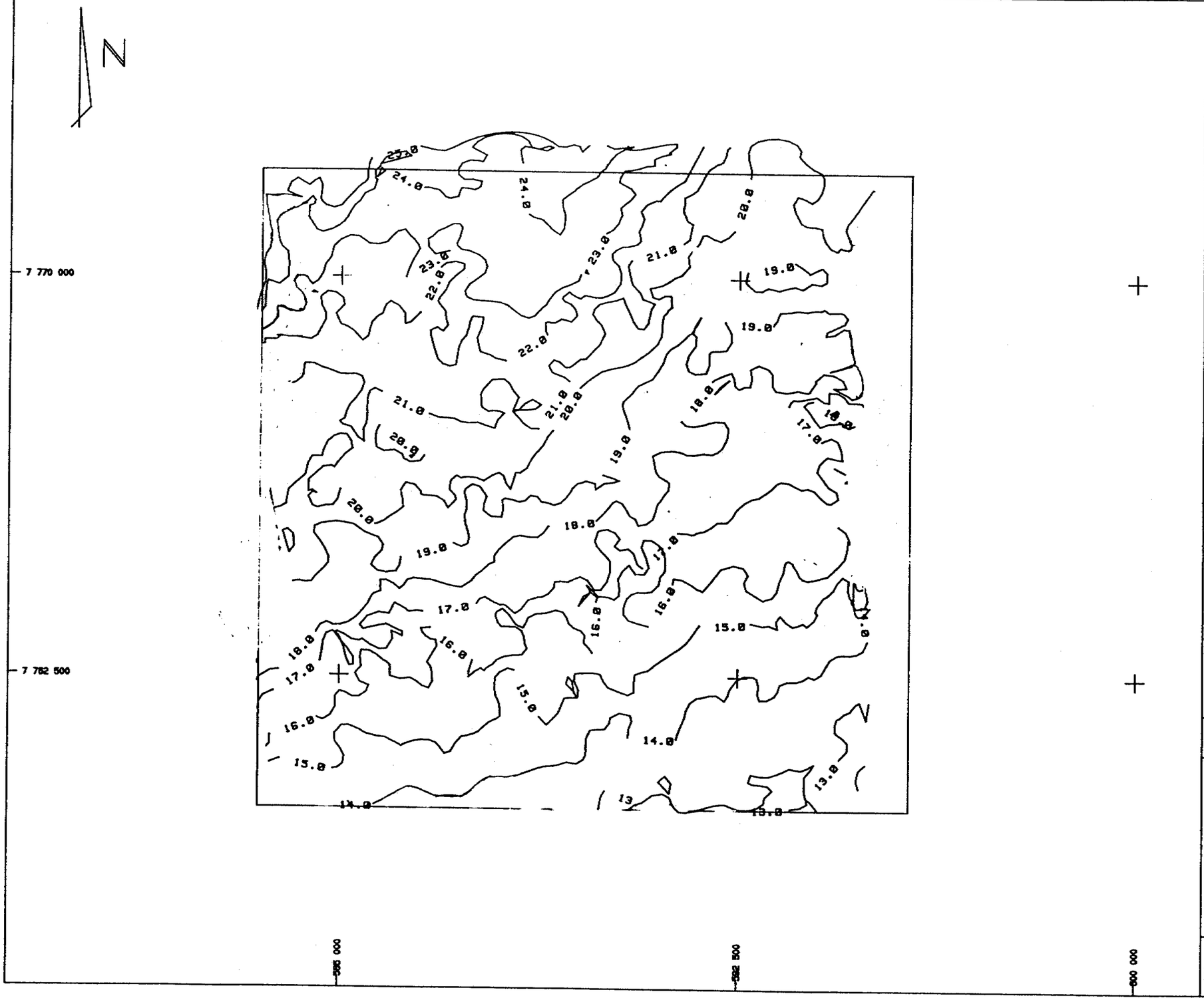
The color coded bathymetry charts were used as a reference plan to show the depths and to graphically define the relief in the detailed area. Additionally the bathymetry plans showed the raw data density and distribution and were used when analyzing the mesh perspectives to define locations where data extrapolation took place.

The two large scale meshes, one covering the Yukon Shelf and the other covering the Erksak borrow area were useful in the study in that they gave a snapshot of the entire data base and could be used in sketching out areas of interest for further study.

6.2 Major Features

Once the main features of the region have been identified on the small scale regional mesh perspective, it is relatively easy to focus on these features for more detailed analysis. The smaller digital terrain model can then be used more efficiently to view the features from any number of perspectives and azimuths. This provides a visual representation of the features that is similar to that obtained from aerial oblique photography of terrestrial features. An appreciation of morphology is considered to be valuable to the interpretation of their origin and composition.

The detailed analysis of the main features of the Yukon Shelf has shown that the detailed mesh perspectives and profiles, used in conjunction with geophysical - geological - stratigraphic data, can provide additional insight to the interpretation of landform features, geomorphic processes and surficial geology of the area. On



LEGEND & NOTES

1. PLOT SHOWS BATHYMETRIC CONTOURS OF DETAILED INVESTIGATION SITE #2A FROM THE ERKSAK BORROW BLOCK DATA BASE.
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3. CO-ORDINATES SHOWN ARE U.T.M. ZONE 8.
4. CONTOURS ARE PLOTTED AT 1 METER INTERVALS FROM CONTOUR LEVEL 13.0 TO LEVEL 25.0.

INDIAN & NORTHERN AFFAIRS CANADA

BATHYMETRIC CONTOURS
ZONE 2A
ERKSAK BORROW BLOCK

COMPUTER ANALYSIS
OF BATHYMETRIC DATA

CHALLENGER SURVEYS & SERVICES LTD

SCALE : 1 : 75000	JOB NO : S-617
DATE : 6 JUN 1988	DWG # :

FIG. 100

the other hand, it is not possible to classify features in terms of origin and landform without geophysical or geological information, as in the case of the Erksak area.

The results of this study indicate that it would be most productive to undertake bathymetric analysis in conjunction with geological-granular resource assessment studies. The bathymetric data could be used to identify bathymetric anomalies as targets for more detailed interpretations of geophysical data. Similarly, areas of surface outcropping of stratigraphic units that might contain coarse materials could then be modelled in detail to identify potential areas of reworking by waves or currents.

7.0 APPLICATIONS

The techniques used in this report were applied successfully in the detection of subtle bathymetric highs that may not be apparent on field sheets or contour maps of an area. The application of these techniques, with respect to this project, was to locate potential granular resources which could be defined for possible use by the hydrocarbon exploration companies in their island construction programs. The above techniques may, however, have some additional uses. This section of the report outlines these possible applications.

Underwater Pipelines

During the construction of underwater pipelines, knowledge of the seabed structure and topography is important. Performing the processing techniques, as detailed in this report, on the raw data base would allow for a 3d graphic (mesh), enhanced numeric (color bathymetry) and quantifiable (contour and profiles) view of the proposed pipeline area. Although it is impossible to define the seabed composition without taking physical samples by coring etc., it is possible to predict, based on the meshed bathymetry, the slopes of the profiles the depth of water etc., what the seabed is probably composed of and isolate those areas that still require a physical investigation.

Detailed Monitoring of Underwater Construction Projects

The software and hardware system that was used in this analysis of bathymetric data was originally developed for use in the monitoring of underwater island contruction in the Beaufort Sea. The cost to find, retreive and place a cubic meter of sand on an island site is high enough that

the resource companies had to demand a very sophisticated system for the monitoring of the construction program. Using all the plot products of the DTM processing package affords just such monitoring system.

8.0 RECOMMENDATIONS FOR FURTHER DEVELOPMENT

The processing package used for this project is implemented on HP computers. The original software was written for use in the offshore to be used in near realtime post-processing of bathymetric data. During this project a great deal of time was spent looking at each mesh from different angles and exaggerations in an attempt to find the optimum viewing location. Currently, this optimum viewing azimuth is decided upon in a subjective manner by the user of the system.

Challenger feels that a future project for DIAND should be the implementation of the mesh portion of the processing package, on an IBM micro-computer. With the software on a PC then virtually anyone with access to the raw data base could view the mesh perspective at any orientation or vertical exaggeration.

9.0 CONCLUSIONS

With the ever increasing demand for the non-renewable hydrocarbon based resources comes the inevitable expanded exploration of Canada's offshore. Presently in the Beaufort Sea all drilling operations are based off either sacrificial beach islands or submerged berms constructed from sand collected from various borrow sites. The currently identified borrow sites have limited supplies which have been shown to be rapidly depleting. As the exploration in the Beaufort expands additional requirements for the granular resources will be evident. As the need for sand increases so does the need for any techniques which can be defined to aid in the locating and quantifying of these granular resources. A useful technique for this undertaking technique has been developed and expanded upon in this report. If this technique is used in conjunction with geophysical/geological stratigraphic data it will be very useful in any future granular resouce assessments in the Beaufort Sea area.

REFERENCES

Challenger, 1986. "Analysis of Bathymetric Data, Western Beaufort (Yukon) Continental Shelf." (NOGAP Project A4-04). Report prepared for Indian and NOrthiern Affairs Canada, Ottawa, by Challenger Surveys and Services Ltd., Edmonton, July, 1986. 45 pages, Appendix (unpaged), Enclosure.

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