REPORT

ON THE

MODELLING AND MAPPING
OF
POTENTIAL GRANULAR RESOURCES FEATURES
IN THE
SOUTH-CENTRAL BEAUFORT SEA, N.W.T.

PREPARED BY

CHALLENGER SURVEYS & SERVICES LTD.

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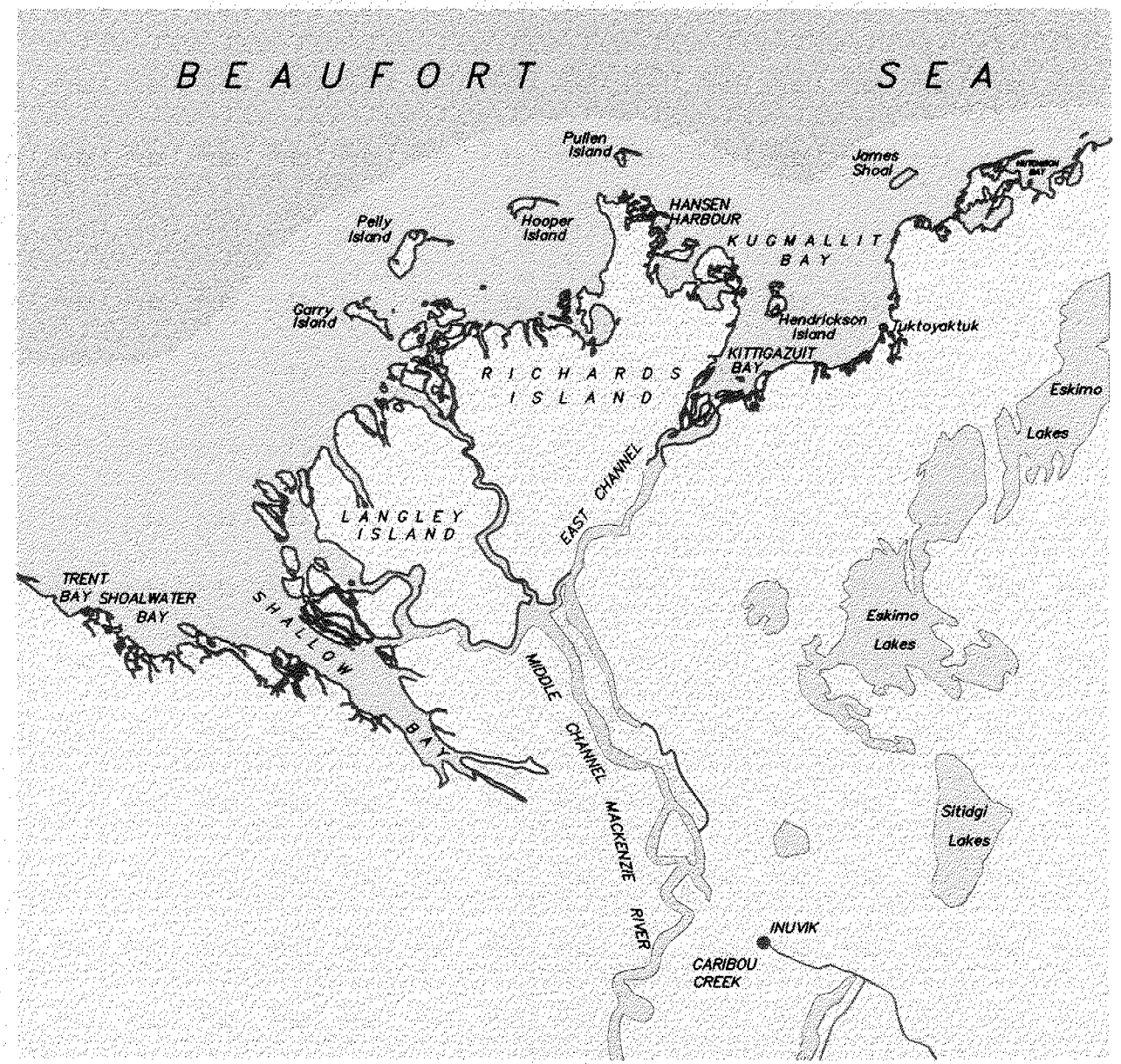

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190 - 7330 Fisher Street S.E.
Calgary, Alberta, Canada T2H 2H8
Bus: (403) 253-8101
Fax: (403) 253-1985

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April 4, 1995

Indian and Northern Affairs Canada
Les Terrasses de la Chaudiere, 6th floor
Hull, Quebec
K1A 0H4

Attention: **Mr. Bob Gowan**

Dear Mr. Gowan:

I am pleased to submit the final report on Modelling and Mapping of Potential Granular Resources Features in the South Central Beaufort Sea.

The report summarizes the work performed under DSS contract A7134-3-0049/01-ST. Portions of the deliverables required by this contract have been delivered under separate cover.

I have enjoyed working on this contract and trust you will find the information provided to be satisfactory and useful. If you have any questions please do not hesitate to contact me.

Yours truly,

David Thomson

David Thomson
Vice President and Calgary Operations Manager

Modelling and Mapping of Potential Granular Resources Features
in the
South-Central Beaufort Sea, NWT

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1.0 Introduction

As part of the Northern Oil and Gas Action Plan (NOGAP) the Department of Indian Affairs and Northern Development Canada (DIAND) is undertaking to prepare an inventory of seabed granular resources for the Beaufort Sea.

To support this undertaking, detailed bathymetric data is needed to more accurately define existing granular resources and to identify locations of potential new sources. Existing bathymetry maps in the area are intended for navigational purposes and do not show the level of detail needed for such interpretations.

The purpose of this project was to first acquire existing bathymetric data in digital form covering the study area. Secondly, the data was to be processed modeled and mapped in usable form for the purposes of identifying seabed features.

An additional task of providing survey positioning support to a field program was added to this contract. This task involved providing the positioning with GPS technology assisting the field program in collecting physical data and samples in the study area.

This study was carried out on behalf of the Department of Indian Affairs and Northern Development. Mr. Bob Gowan was the scientific officer for the project and terms and conditions for the contract are outlined on Contract A7134-3-0049/01-ST.

2.0 Background

As part of the NOGAP project A4, DIAND is preparing an inventory of seabed granular resources for the Beaufort Sea. This is being done in preparation for the eventual development of offshore hydrocarbon resources. Several granular resource management blocks have been identified, primarily based on geological, geophysical and geotechnical data collected by the resource exploration industry and the Geological survey of Canada. To date, approximately 40 million cubic metres of seabed granular materials has been used for construction of artificial islands and of supporting berms. Some primary granular sources (e.g., Issigak, Isserk and Ukalerk) have been found to consist of low relief seabed ridges, lying within a relatively narrow range of water depth.

Two previous NOGAP studies investigated the use of digital terrain models developed from digital hydrographic data. Digital models of the Western Beaufort (Yukon) continental shelf and the eastern (Erksak) portion of the central Beaufort were used to identify potential survey target areas and for general geological interpretation. These projects used digital terrain modelling techniques to generate different visual images that depicted the sea bottom. The different images included detailed contour plots and 3 dimensional meshed grids viewed in perspective. These grids were particularly useful in identifying subtle bathymetric features that were not readily apparent on contour plots.

The area examined under this study was the southern Akpak Plateau and adjacent areas of the Beaufort Sea, NWT. The study would be limited to the area where the Canadian Hydrographic service could provide digital data.

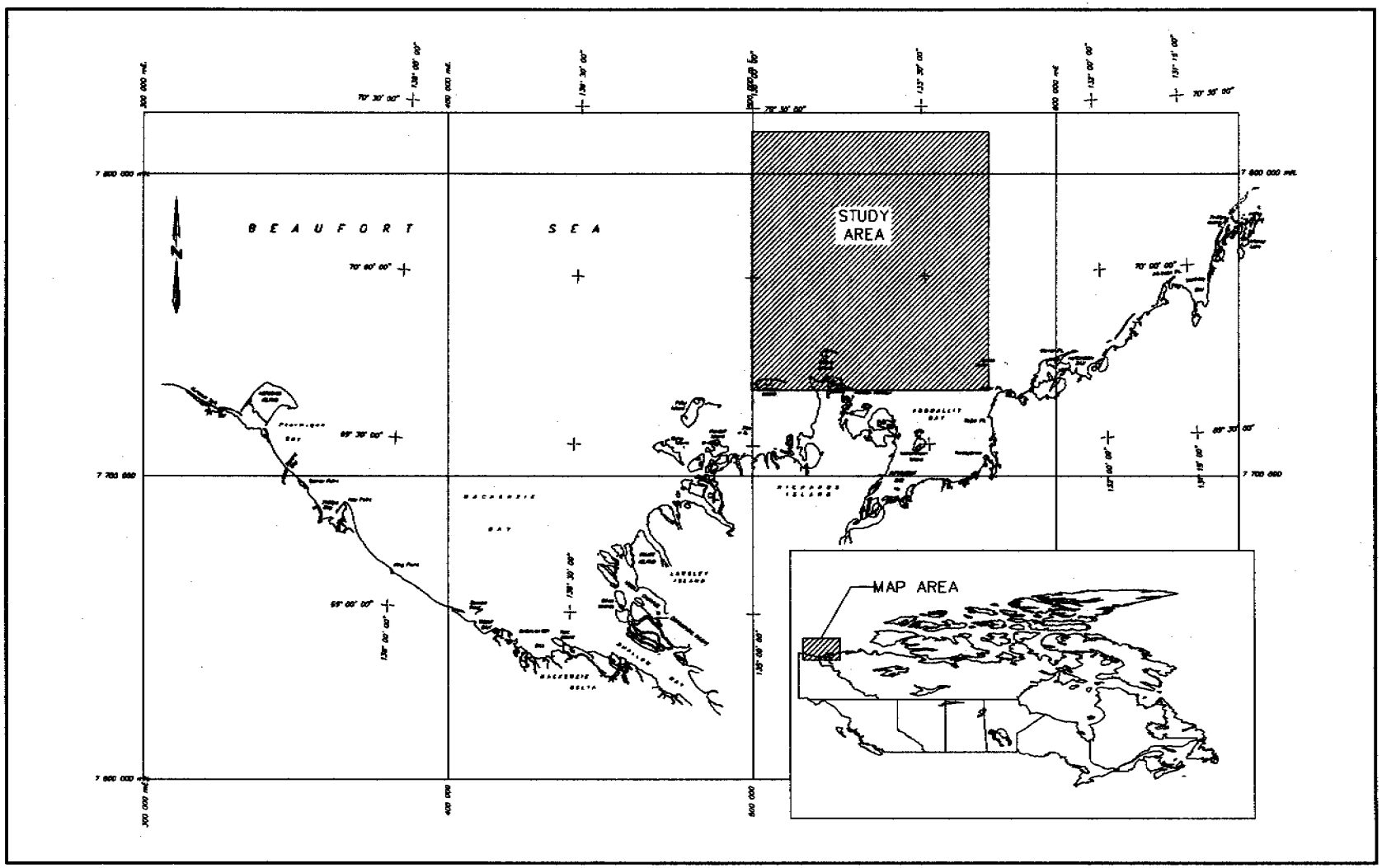

Figure 1
Study Area Location

3.0 Data Acquisition

Bathymetric data for this study was obtained from the Canadian Hydrographic Service. The data was collected on CHS field survey campaigns dating from 1978 to 1989. Except for an area surrounding Pullen Island, the data was predominately available in digital form.

Digital sounding data from 11 field sheets covered the area and are shown in figure 2. The data acquired covered an area greater than the area being studied by this project and is available if the study area needs to be expanded.

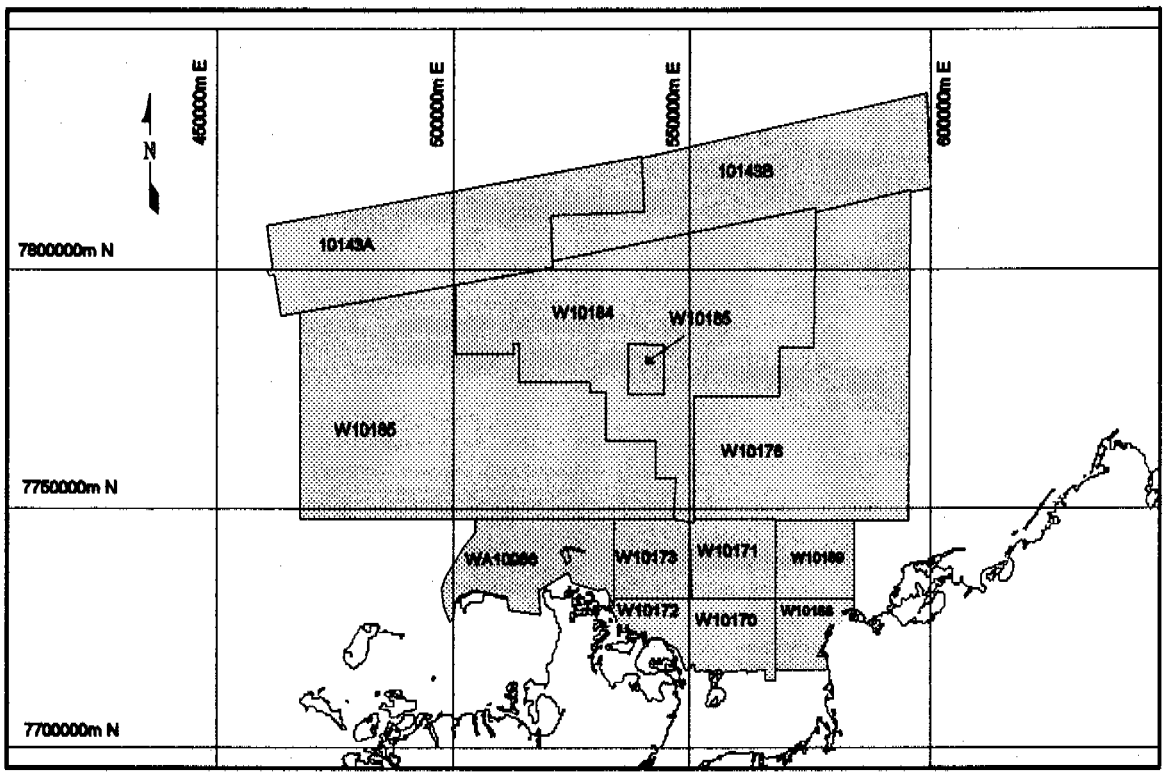

Figure 2
Field Sheet Coverage

The sounding data was extracted from the digital field map sheets maintained by the CHS. The data set is known as the "clean data set." Soundings in a "clean data set" have been edited and corrected for tidal fluctuation and variation in the velocity of sound in water. This data set is not considered to be "Navigational quality" as it may still contain some erroneous soundings, however the density of data makes it more suitable for detailed contouring.

Soundings from the following field sheets were acquired;

Field Sheet	Number of Soundings	Area of coverage Km^2	Scale	Comments
10143A	150595	1322	1:150000	Hudson 81 corridor survey
10143B	151410	1360	1:150000	Hudson 81 corridor survey
W10168	38189	177	1:20000	Tully 85
W10169	56429	273	1:20000	Tully 85
W10170	48631	278	1:20000	Tully 85
W10171	72507	306	1:20000	Tully 85
W10172	23183	142	1:20000	Tully 85
W10173	54728	288	1:20000	Tully 85
W10176	271478	2108	1:100000	Tully 85
W10184	154547	2367	1:100000	Tully 88
W10185	125217	2770	1:100000	Tully 89
Totals =	1146914	11391		

Table 1
CHS Digital Data Sets

Sounding line spacing was for the most part 100 metres. Sounding sampling along the line was approximately 50 to 75 metres. Although during a survey, sounding data is collected at a rate approaching every 1 to 2 metres along line, the data is then parsed into a more manageable interval of 50 metres. Soundings were in metres and decimetres for depths under 31 metres. Depths greater that 31 metres are rounded to the nearest metre. Soundings are shoal biased in areas where shoals have been examined. This occurred mostly in the Kugmallit Bay field sheets (1:20000 field sheets).

Depths in the area surrounding Pullen Island were not available in digital form. Digital data for this project was manually digitized from field sheet WA10086 .

The digital data sets were acquired directly from the CHS although permission to use the data had to be obtained from Nautical Data International, Inc. At the beginning of this study the Canadian Hydrographic Service was developing the infrastructure to support the

distribution of digital data products. The CHS was entering into an agreement with NDI granting them the right to license the use of CHS digital products to value added resellers and to end users. Users wishing to use CHS data were required to enter into a license agreement with NDI. Challenger entered into this agreement for the purposes of this study. A copy of the agreement is included in appendix "A".

A print of field sheet WA10086 was obtained from the CHS to provide coverage surrounding Pullen Island. Permission was sought from the CHS to digitize the field sheet. Since a relatively small portion of the field sheet was being digitized, the requirement for a formal licence agreement was waived. An understanding exists that this data is not to be resold or used for navigational purposes.

Survey Datum and Mapping Plane

All sounding positions are given in Universal Transverse Mercator coordinates (UTM, zone 8, central meridian = 135°). The survey datum is NAD27.

For the most part sounding launches were positioned with ARGO and could be considered accurate to 10-15 metres.

4.0 Data Preparation

The process of preparing the data for digital processing involved reformatting the data sets into a format more suitable for the software being used. The data sets were also parsed to reduce the size of the files and make them more manageable. All processing was done on an IBM computable 486 (66 megahertz) desktop computer with a 420-megabyte hard drive.

The following flow chart outlines the processes followed in preparing the data for processing.

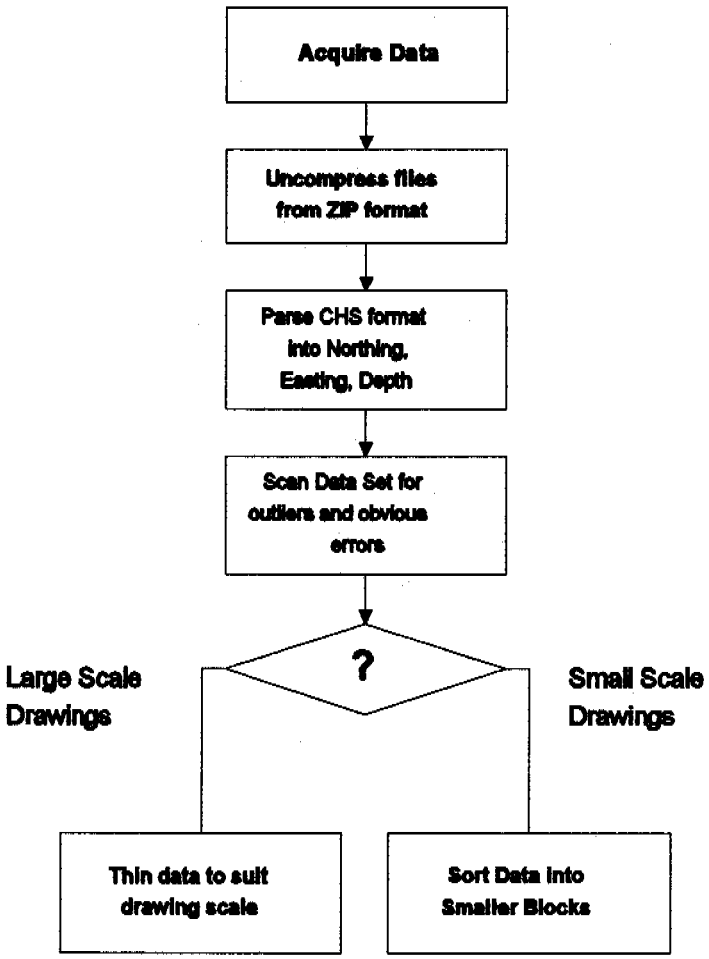

Figure 3
Data Preparation Flow Chart

The digital data received from the CHS was compressed into 11 files using PKZIP version 2.04c.

Each file was un-compressed into an ASCII computable text file. Un-compressed the files expanded into 89 megabytes of data. Each data file consisted of a file header indicating type of data, source and column headers. Data was formatted in a fixed field format of 80 characters per record.

```
Display for: SCRATCH$HYDROG:[WOODS.TUL85]W10172,      Date:  8-DEC-1993 11:56:55

Last editted:  8-DEC-1993 11:23

 KEY ========    ===== CHARTED  POSITION =====    ======== DEPTH   SOURCE

                  534929.030   7723020.710             1.1   WA10172
                  534986.940   7723023.750             1.1   WA10172
                  534995.070   7723059.320             1.4   WA10172
                  534894.490   7723071.510             1.4   WA10172
                  535195.220   7723083.700             1.2   WA10172
                  535201.320   7723120.280             1.4   WA10172
                  535081.430   7723137.550             1.1   WA10172
                  534902.620   7723147.710             1.6   WA10172
                  534994.060   7723173.110             1.6   WA10172
```

Figure 4
Clean Data Set File Structure

These large ASCII text files were then compressed into a more suitable format by removing the blank spaces used for formatting the data in the file. Comma delimited files of northing, easting and depth were created. These compressed files amounted to approximately 29 megabytes of data.

Next the data was screened for zero depths. Although the clean data set was acquired, some erroneous points still existed and had to be removed.

Conversion from geographic coordinates to a mapping plane coordinate system was not required. The data set was received in UTM zone 8 coordinates.

Data was further sorted into more manageable sizes for the two series of drawing scales. To accommodate the larger scale drawings the data was thinned. Sounding lines were measured at 100 metre intervals with a sounding spacing of between 30 to 50 metres. At a scale of 1:100000 this would translate to a line spacing of 1mm and a sounding every 0.3 to 0.5mm. To speed up processing time and reduce the size of files required the data was thinned to a minimum of 250 metres along a sounding line for the small scale drawings.

To accommodate the larger scale drawings the data was sorted into a series of 16 blocks

covering the study area. Limiting the size of each block was required to keep the size of the data blocks manageable. The software used to build a Triangulated Irregular Network was written by SoftDesk. Theoretically the software is capable of handling an unlimited volume of points, however as a practical matter, these very large files require a large amount of storage capacity and processing time. To keep the processing time manageable and generally under 12 hours per sheet the study area was subdivided into the 16 smaller blocks. This also kept the additional processing files required by the TINing process under 150megs.

Digitizing

Soundings in the areas surrounding Pullen Island were manually digitized from field sheet WA10086 . This field sheet was prepared at a scale of 1:100000 with a surveyed line spacing of approximately 1000 metres. Soundings along a survey line were spaced approximately every 500 metres. An area covering approximately 573 Km² was digitized. This amounted to 923 points that had to be digitized. A large digitizing table was used to preform the task. The area surrounding Pullen Island that was digitized is shown in figure 5.

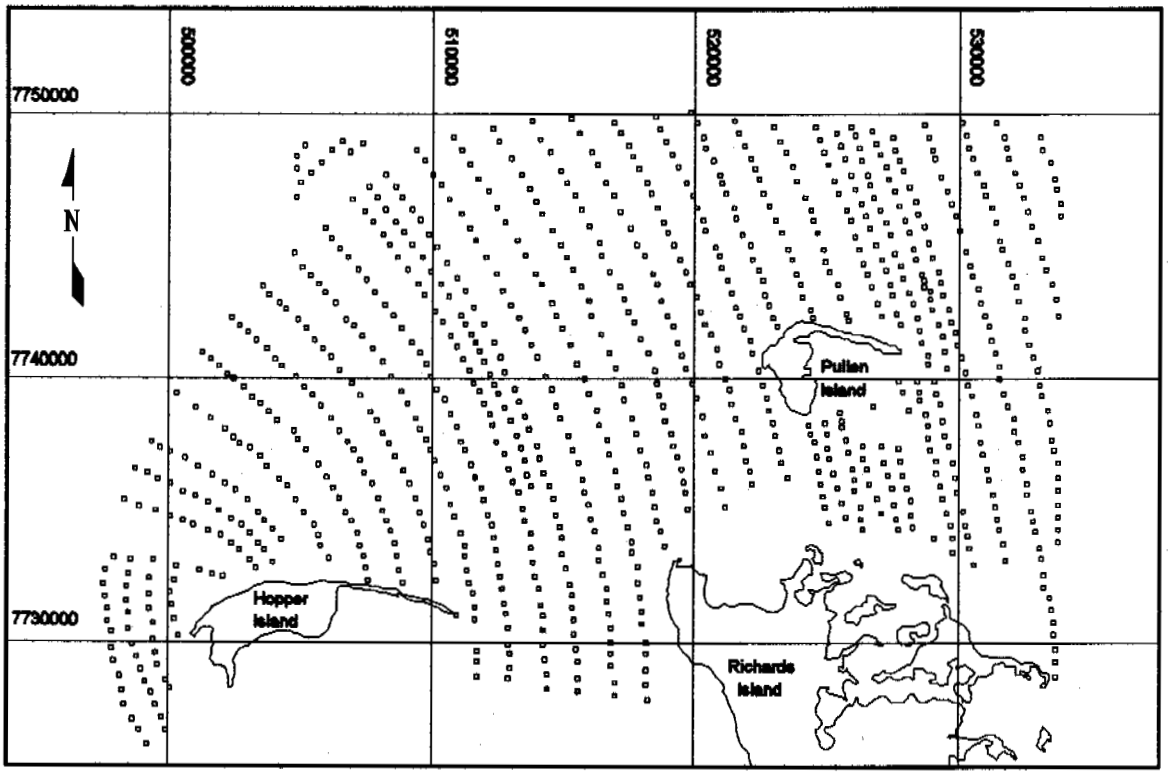

Figure 5
Soundings Manually Digitized

5.0 Data Processing

The Digital Terrain Modelling software used to produce the contour maps and mesh grid plots was written by SoftDesk. This software integrates fully with AUTOCAD and allows among other things the ability to take randomly spaced point data and prepare a digital terrain model or surface from which many products may be derived.

Randomly space point data is used to define a surface. The SoftDesk DTM package defines each surface as a Triangular Irregular Network (TIN). A Triangular Irregular Network is a common method of digitally representing three-dimensional surfaces. Points are connected into triangles that represent planar triangular faces. The points are connected optimally to make the triangles as nearly equilateral as possible. Since each vertex of the TIN is a surface point, a TIN honours all the points exactly. The planar faces of a TIN can subsequently be use to interpolate elevations for volumetric, isopaching, profiling, elevation analysis, contouring or as a surface to render.

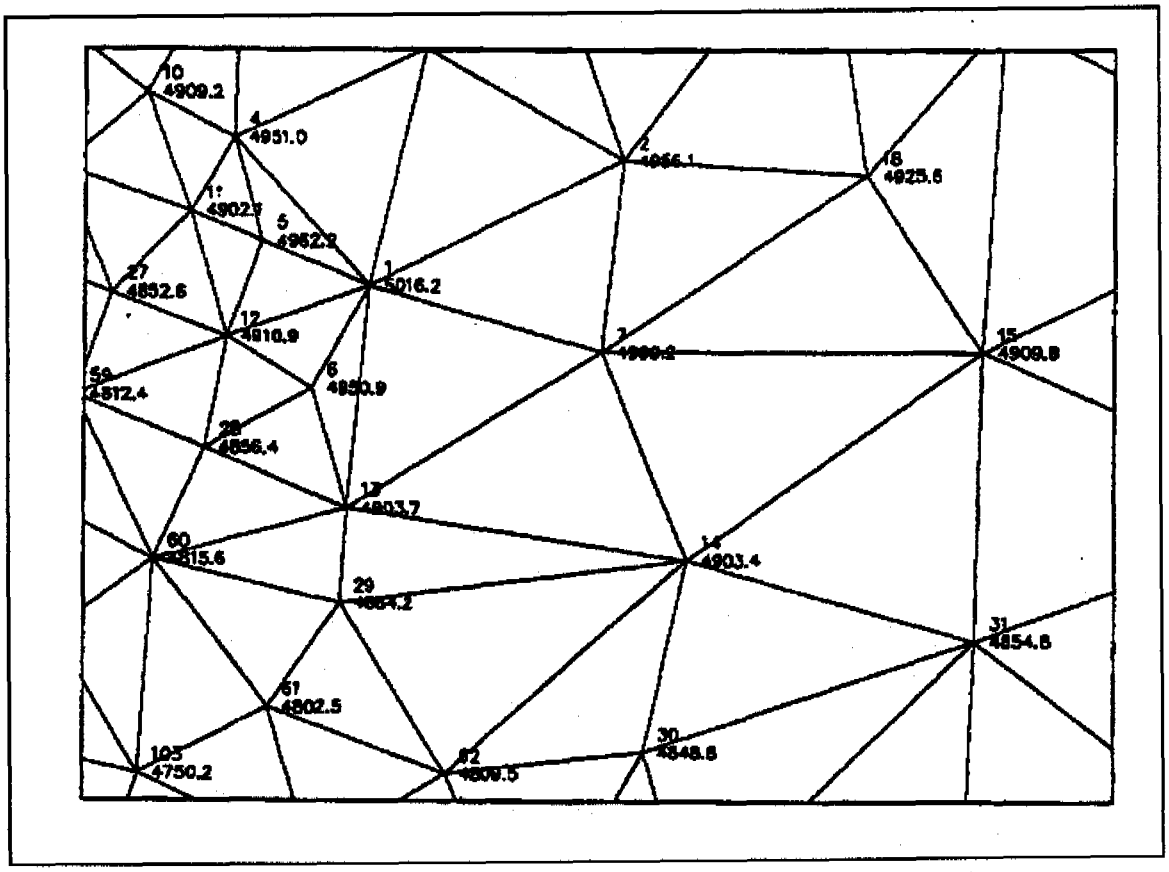

Figure 6
Triangulated Irregular Network

Two components of a TIN are point data and break lines. Breaklines represent abrupt discontinuities in the slope of a surface. Surface examples where breaklines may be applicable are features such as walls and ditches. When defining sea bottom topography break lines are generally not applicable. Sea bottoms tend to have no abrupt changes in slope and defining where they may exist is always a technical problem.

Two scales of drawing were prepared for this study. The small scale overview drawings showing the entire study area were prepared using a TIN developed from as reduced set of data. This data set was "thinned" so that no two points were closer than 250 metres.

The detailed drawings were derived from all data in each of the sixteen sub blocks in the study area. A limitation of computing time and disk spaced were the determining factors in deciding the size of the detailed study blocks.

6.0 Data Presentation

Data plots prepared from the digital bathymetry data complied under this study are contained in Appendix "B". The plots are in 11"x17" format and a list of the plots is contained in table 2.

Drawing Number	Type	Description
93-5631-1	Contour	One metre contour plan of entire study area.
All-DXB.DWG	Grid Mesh	250x250m grid mesh of entire study area
KEY.DWG	Key Plan	Key plan for detailed grid mesh drawings
1-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 1
2-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 2
3-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 3
4-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 4
5-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 5
6-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 6
7-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 7
8-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 8
9-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 9
10-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 10
11-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 11
12-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 12
13-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 13
14-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 14
15-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 15
16-DXB.DWG	Grid Mesh	100x100m grid mesh in perspective - Area 16

Table 2
11"x17" Drawings

Drawings 93-5631-1 and ALL-DXB.DWG were also presented in a D size format and provided under a separate cover.

To produce grid plots suitable for detailed examination, larger scale drawings were prepared. To accommodate this, the study area was broken into 16 subsets. The grids show on these plots are plotted at an interval of 100 by 100 metres. Figure 7 depicts the areas covered by each subset.

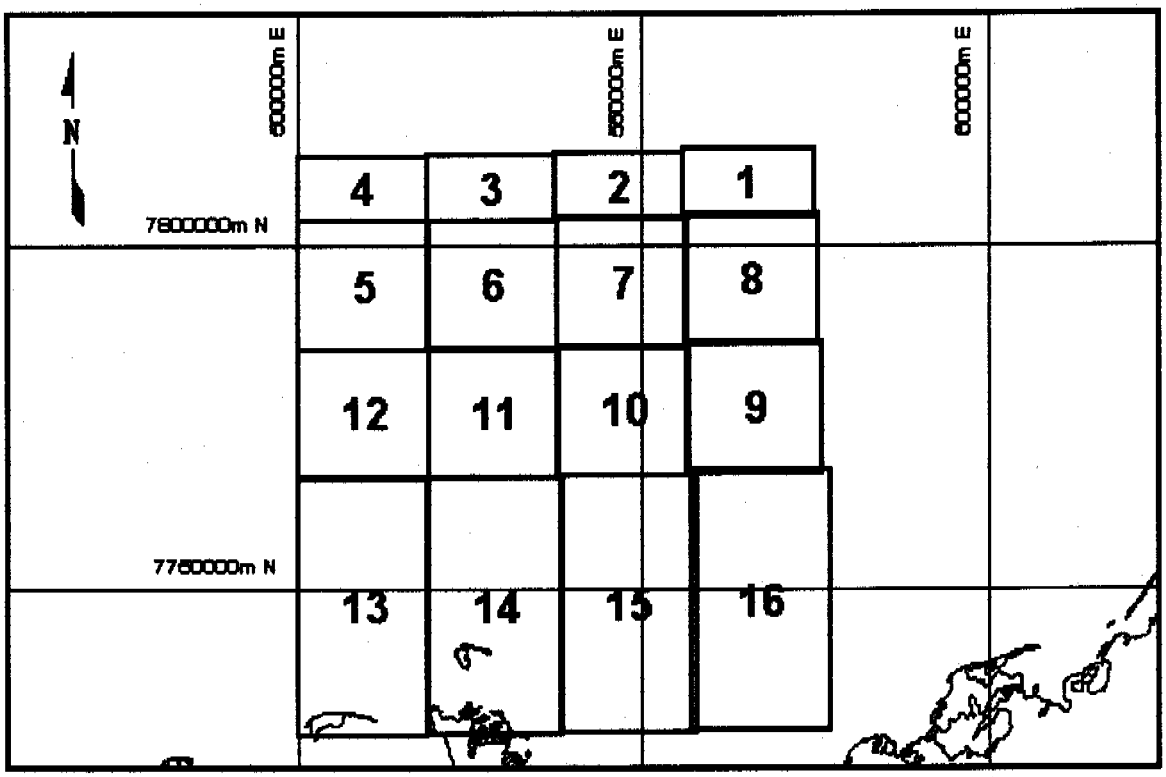

Figure 7
Grid Mesh Plots Location Plan

Digital Data Sets

The drawings prepared for this study are representative of the general topography of the study area. Further examination of sea bottom features is possible with use of the digital data sets provided as part of this study.

Two digital data sets are provided. Both are comma delimited ASCII files with each record being one sounding in Northing, Easting, Depth order.

Data files on disk have been compressed using program PKZIP version 2.04c. Files will be required to be un-compressed prior to using.
The **Bathymetric Data Sets** contained in file BEAUFORT.ZIP are the reformatted CHS clean data sets. The file are organized by CHS field sheets and comprise of all points received from the CHS. Each record is a comma delimited ASCII record of Northing,

Easting and depth. Spaces and redundant information has been removed in order to reduced the file size. Points must be considered to be randomly spaced along sounding lines.

The **Grid Data Set** contained in the file 200MGRID.ZIP is the interpolated grid data for the study area. Data points are interpolated on a 200 metre spacing. Each record is a comma delimited ASCII record of UTM Northing, Easting and depth. Interpolation of the grid had to be done in four quadrants thus the grids are not evenly interpolated at the same 200 metre spacing throughout the study area.

7.0 Survey Support for Ground Truthing

The initial results of this project were used to identify and delineate potential new granular resources and to identify potential target areas for additional geophysical surveys and ground truthing programs. Many features are identified by the subtle changes in seabed relief. To locate these features in the field for further examination a degree of accuracy in position is required which is at least as accurate as the system which positioned the bathymetry data.

As an extension to this contract, Challenger was to provide survey support to a winter field program. Challenger provided helicopter and ground supported positional surveys to sub-metre accuracy of geophysical lines and ground truthing sites.

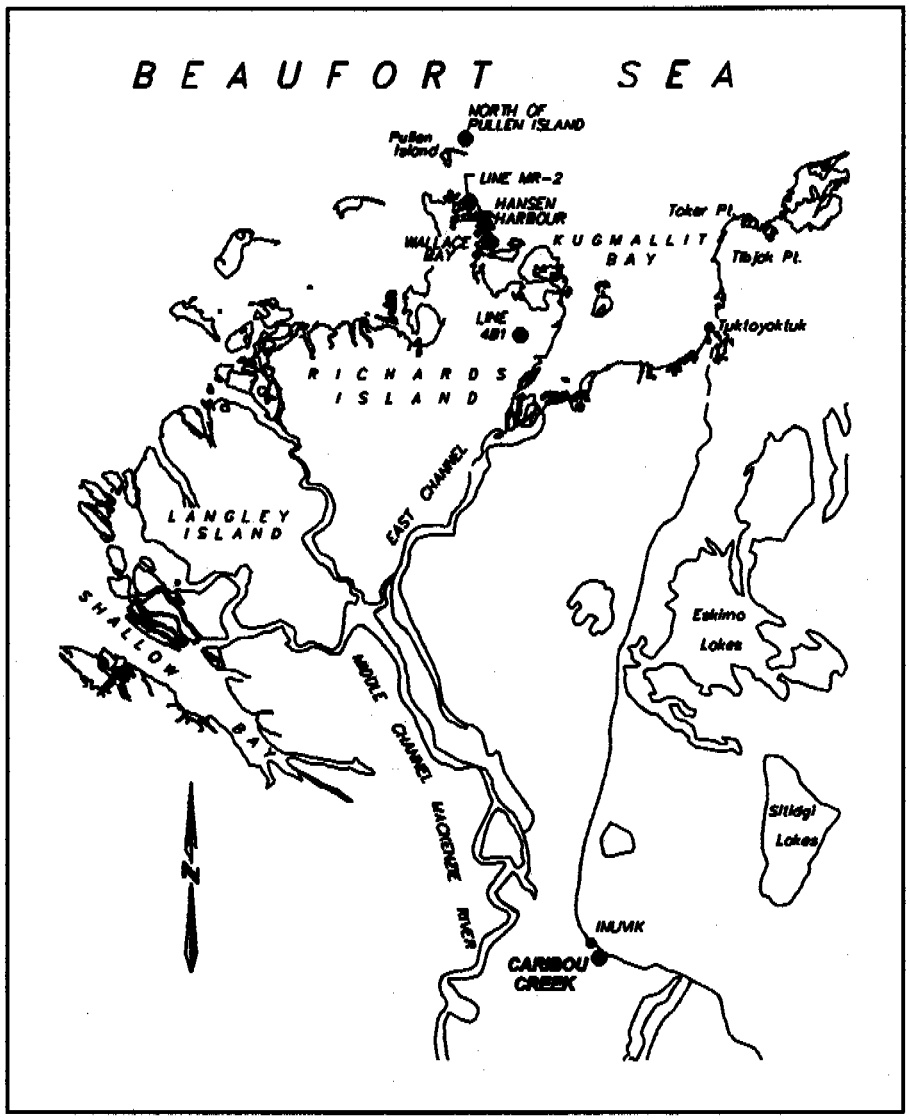

Figure 8
Ground Truthing Sites

Global Positioning System technology was used as the survey tool. Used in a kinematic mode the system is capable of yielding sub-metre results with a very short period of time. Utilizing GPS provided a cost-effective means of quickly determining the position of points to an accuracy of better than one metre.

GPS operating in a point positioning mode is accurate to within 100 metres. In a standard differential mode accuracy of within 5 metres are achievable. Challenger employed differential kinematic techniques to achieve sub metre accuracy. The improved accuracy was realized by employing Trimble 4000SSE receivers. The incremental costs of employing these receivers were relatively minor and the improvement in accuracy was great. This improves accuracy will improve the modelling of seabed features and future studies may be referenced to these sites with a greater degree of certainty.

7.1 Mobilization

On March 30, 1994 two Trimble 4000SSE geodetic grade P-Code GPS receivers with a surveyor were mobilized from Calgary to Inuvik. The surveyor and equipment arrived in Inuvik at 13:00 hrs. and immediately went on to set up and survey five boreholes in the Caribou Creek area south of Inuvik.

7.2 Caribou Creek Survey

The positions of five boreholes in the Caribou Creek area, 30 Kms. south of Inuvik, were confirmed with differential GPS. This survey took place on the same day the surveyor and equipment arrived in Inuvik. A temporary GPS base station was established near Caribou Creek from a Control monument in Inuvik (CCM-15). From this temporary base station five boreholes were surveyed. The survey was also tied into NWT survey control point 4009303.

Caribou Creek Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = March 30, 1994	
Point Number	Northing	Easting	Elevation	Description
1	7553690.5	562889.6	23.3	Control Point
101	7553409.6	563077.6	47.4	BH-28
102	7553397.4	563071.9	47.2	NWT Control Point
103	7553553.4	563023.8	44.4	BH-29
104	7553586.2	563104.9	42.7	BH-30
105	7554212.3	563155.5	44.5	BH-32
106	7554084.8	563124.3	44.9	BH-31
107	7583057.2	552780.3	23.5	Control Point (CCM-15)

Table 3
Caribou Creek Survey

7.3 Pullen Survey Control

The coordinates of CLS C/14 were determined from control point Pullen-4. An error in the published elevation of Pullen-4 is suspected. Using the published value of 38.1m ASL resulted in ice elevations consistently at 8.1 metres elevation. The elevation subsequently used for Pullen-4 was lowered to 30.0 metres.

Survey Control			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = March 31, 1994	
Point Number	Northing	Easting	Elevation	Description
200	7740670.2	522978.2	27.7	CLS Post C/14
300	7740609.3	522891.3	30.0*	Pullen-4 (Elevation adjusted)

Table 4
Pullen Survey Control

7.4 North of Pullen Island Survey

In an area North of Pullen Island fifteen bore holes were surveyed. Points were surveyed using kinematic techniques using a base station located on CLS Post C/14. All points were measured to the ice surface.

North of Pullen Island Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = March 31, 1994	
Point Number	Northing	Easting	Elevation	Description
301	7746098.6	524298.4	-0.1	BH-2
302	7751507.8	537165.4	0.1	BH-7
303	7751537.4	535938.2	0.1	BH-6
304	7751507.6	534082.7	0.0	BH-8
305	7750910.7	533631.4	0.0	BH-9
306	7750899.2	534164.8	0.0	BH-10
307	7750906.0	534679.3	0.0	BH-11
308	7749873.9	536489.3	0.0	BH-12
309	7749858.4	535654.7	0.0	BH-13
310	7749883.3	534913.2	0.0	BH-14
311	7749856.8	534276.7	0.1	BH-15
312	7749496.9	534832.7	0.0	BH-5
313	7746653.3	535344.9	0.0	BH-4
314	7746466.5	534579.8	0.1	BH-3
315	7745632.1	522548.7	0.0	BH-1

Table 5
North of Pullen Island Survey

7.5 Line MR-2 Survey

Five boreholes and 3 points along a seismic line were surveyed alone line MR-2. The GPS base station at CLS C/14 was used as a coordinate reference.

Line MR-2 Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = March 31, 1994	
Point Number	Northing	Easting	Elevation	Description
401	7722379.4	531181.4	18.0	BH-23
402	7732701.8	529470.0	0.0	BH-19
403	7732575.0	529347.7	0.2	BH-18
404	7732509.4	529272.4	0.3	BH-17
405	7732423.8	529201.3	0.5	BH-16
406	7732104.6	529131.8	12.0	MR-2-E
407	7732245.0	529007.7	2.7	MR-2-C
408	7732450.5	528752.0	24.2	MR-2-W

Table 6
Line MR-2 Survey

7.6 Hansen Harbour Survey

The points surveyed in Hansen Harbour were surveyed kinematically for a base station located on point 401 (BH-23 on line MR-2).

Hansen Harbour Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = March 31, 1994	
Point Number	Northing	Easting	Elevation	Description
501	7725517.8	528538.8	9.8	HH-1(W)
502	7725704.8	528863.0	23.0	HH-2
503	7725830.0	529104.2	9.3	HH-3
504	7725932.6	529300.6	13.8	HH-4
505	7725995.0	529442.3	15.2	HH-5
506	7726001.5	529643.9	26.8	HH-6
507	7726086.5	529804.8	21.0	HH-7
508	7726110.9	529995.6	8.7	HH-8
509	7726101.5	530160.4	13.7	HH-9
510	7726116.9	530222.7	11.9	HH-10
511	7726160.9	530314.9	14.4	HH-11
512	7726148.6	530525.0	19.5	HH-12
513	7726151.4	530547.9	17.9	HH-13
514	7726156.5	530599.7	21.0	HH-14
515	7726194.3	530745.6	14.3	BH-24
516	7726269.6	530844.9	6.0	HH-15
517	7726331.2	531124.9	10.1	BH-25
518	7726354.3	531192.3	10.3	HH-16(E)
519	7726285.8	531358.4	5.5	HH-17
520	7726051.6	531681.1	0.2	HH-18 (End of Line)

Table 7
Hansen Harbour Survey

7.7 Wallace Bay Survey

The points surveyed in Wallace Bay were surveyed kinematically for a base station located on point 401 (BH-23 on line MR-2).

Wallace Bay Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = April 1, 1994	
Point Number	Northing	Easting	Elevation	Description
601	7722263.5	531718.2	16.5	WB-SOUTH
602	7723186.4	532527.8	20.4	WB-1
603	7723132.6	532459.5	12.5	WB-2
604	7723017.1	532307.6	23.7	BH-21
605	7723136.1	532145.4	24.8	BH-20
606	7723073.1	531976.0	15.3	WB-3
607	7722988.0	531705.5	23.4	BH-22
608	7722961.0	531517.3	18.0	WB-4
609	7722867.4	531455.5	17.4	WB-5 (Top of Slope)
610	7722733.6	531286.4	6.9	WB-6
611	7722551.9	531212.7	20.4	WB-7
612	7722447.9	531183.0	17.3	WB-8 (End of Line)

Table 8
Wallace Bay Survey

7.8 Hansen Harbour - North Bay Survey

The following points surveyed between Hansen Bay and North Bay were surveyed kinematically for a base station located on point 401 (BH-23 on line MR-2).

Hansen Harbour - North Bay Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = April 1, 1994	
Point Number	Northing	Easting	Elevation	Description
701	7725850.2	531236.9	5.3	HH-S-EM-34
702	7726030.4	531212.4	0.0	HH-NORTH BAY
703	7725630.5	531284.5	20.4	HH-P1
704	7725687.9	531390.9	22.9	BH-26
705	7725713.0	531438.2	23.8	HH-P2
706	7725730.8	531507.9	23.0	HH-P3
707	7725820.3	531607.1	7.1	HH-P4
708	7725865.5	531645.2	10.7	HH-P5
709	7725955.2	531680.7	4.5	HH-P6 (End of Line)

Table 9
Hansen Harbour - North Bay Survey

7.9 Line 4B1 Survey

The following points surveyed on line 4B1 were surveyed kinematically for a base station located on point 801 (End of line on line 4B1). This point was derived from point 401 (BH-23 on line MR-2).

Line 4B1 Survey			Coordinates = UTM Zone 8 (CM=135°W) Datum = NAD27 Date of Survey = April 1, 1994	
Point Number	Northing	Easting	Elevation	Description
801	7705549.0	539469.6	12.2	4B1 (End of Line)
802	7703635.3	538643.3	11.7	4B1-1 (EAST-BOL)
804	7704050.7	538232.0	22.8	BH-27
805	7704133.2	538125.5	15.6	4B1-3(Shot on Ice)
806	7704203.4	538016.6	19.8	4B1-4
807	7704205.8	537905.8	21.1	4B1-5
808	7704348.1	538104.2	19.8	4B1-6
809	7704453.3	538175.3	21.1	4B1-7 (Aborted BH)
810	7704619.4	538368.4	12.7	4B1-8
811	7704800.0	538483.2	13.3	4B1-9
812	7704940.9	538631.4	12.7	4B1-10 (Top of Slope)
813	7704986.7	538674.5	7.8	4B1-11
814	7705095.9	538838.8	7.1	4B1-12 (Shot on Ice)
815	7705178.0	538943.6	7.8	4B1-13 (Toe of Slope)
816	7705200.7	538963.7	12.2	4B1-14
817	7705218.5	539118.9	13.1	4B1-15
818	7705291.2	539265.3	10.2	4B1-16

Table 10
Line 4B1 Survey

7.10 Field Survey Plans

A series of six drawings showing the points surveyed during the field program were prepared. Table 11 lists the drawings prepared.

Drawing Number	Description
93-5631-2	Borehole Location Plan - Line 4B1 survey
93-5631-3	Borehole Location Plan - Wallace Bay survey
93-5631-4	Borehole Location Plan - Hansen Harbour survey
93-5631-5	Borehole Location Plan - Line MR2 survey
93-5631-6	Borehole Location Plan - North of Pullen Island survey
93-5631-7	Borehole Location Plan - Caribou Creek survey

Table 11
Field Survey Plans

These drawings with the Mylar original were delivered under a separate cover.

8.0 Recommendations

The data plots presented as part of this report are intended as a general overview of sea bottom topography of the study area. It is intended that these plots be used to identify the existence and general location of sea bottom bathymetric anomalies. Further examination and mapping of each anomaly will be required. Other features may become apparent when the model is viewed from a different angle.

In its' entirety, the data sets used for this study are very large. Examination of features identified from the plots in this report should be made on smaller subsets of the larger database. Database programs such as dBase or FoxPro can be used to extract rectangular blocks of data from the complete set. Desktop GIS software such as MapInfo or InFocus will allow searches of data within more complicated polygons.

Two data sets have been provided with this report. The CHS clean data set is the most dense and will yield the most accurate representation on the feature being mapped. Using data extracted from this data set will require contouring and gridding software capable of processing randomly spaced data points. Many such packages now exist for the PC environment. One such package is QuickSurf available from Schreiber Instruments.

Grid data interpolated at a 200 metre spacing in file 200MGRID.TXT can be used with mapping software not capable of processing randomly spaced data. Depth values have been interpolated from the CHS clean data set and some reduction in resolution can be expected.

The digital data acquired for this study should be archived in a GIS for use in future studies. Considerable effort has been made to obtain the data from the CHS and this should not go to waste. The data compiled in previous studies should also formulate part of the GIS. This bathymetric data is a suitable base for future engineering studies.

9.0 Conclusion

Accurate knowledge of sea bottom topography is fundamental in analyzing granular resource potential in offshore areas. Topography serves as a background for studies of the sub-bottom and assists in identifying subtle trends or rises in the seafloor.

Accurate representation of sea bottom topography is dependent on bathymetric surveys. The Canadian Hydrographic Service has surveyed most navigable Canadian waters. These surveys were intended to identify hazards to navigation but the bathymetric data sets collected are useful for geological and engineering purposes. Quality bathymetric data in digital form, derived from Canadian Hydrographic Service surveys can now be obtained from Nautical Data International. This will simplify the process of acquiring future data sets.

With the emergence of desk top software capable of generating and displaying digital terrain data the acquisition and preparation of the digital data sets will continue to be useful. The ASCII format of the data sets will allow the data to be integrated easily into other application software.

The graphical products presented in this report are intended as an overview of the study area. The digital data set allows the user the ability to examine features in detail and generate graphical images suited for the particular study undertaken.

End User Licence Agreement
Non-Navigation Uses

THIS AGREEMENT, made in duplicate

BETWEEN

Nautical Data International, Inc.
Bally Rou Place, 280 Torbay Road
P.O. Box 127
St. John's, NF
A1C 5H5

hereinafter referred to as "The Licensor"

AND

Challenger Surveys and Services Ltd.
190, 7330 Fisher St. S. E.
Calgary, Alberta
T2H 2H8

hereinafter referred to as "The Licensee"

WHEREAS:
The Licensee is interested in obtaining digital bathymetric data from Canadian Hydrographic Service (hereinafter referred to as "CHS") field sheets 10168, 10169, 10170, 10171, 10172, 10173, 10176, 10184, 10185 and 10143 (hereinafter referred to as "The Product"), for the production of a digital terrain model to serve as a base map to delimit potential target areas for granular material as a part of a study on behalf of Indian and Northern Affairs (hereinafter referred to as "The Purpose").

AND WHEREAS:
The Licensor has been authorized by CHS to grant rights and licences for the use of data from CHS products.

NOW THEREFORE it is agreed as follows:

1. The Licensor grants The Licensee a non-exclusive, non-assignable right, hereinafter referred to as "The Licence" to use The Product only for The Purpose.

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8. The Licensor does not warrant or guarantee the accuracy, completeness or currency of The Product.

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10. This Agreement constitutes the entire agreement between The Licensor and The Licensee.

This Agreement has been executed by The Licensor and The Licensee through their duly authorized representatives.

LICENSOR: NAUTICAL DATA INTERNATIONAL, INC.

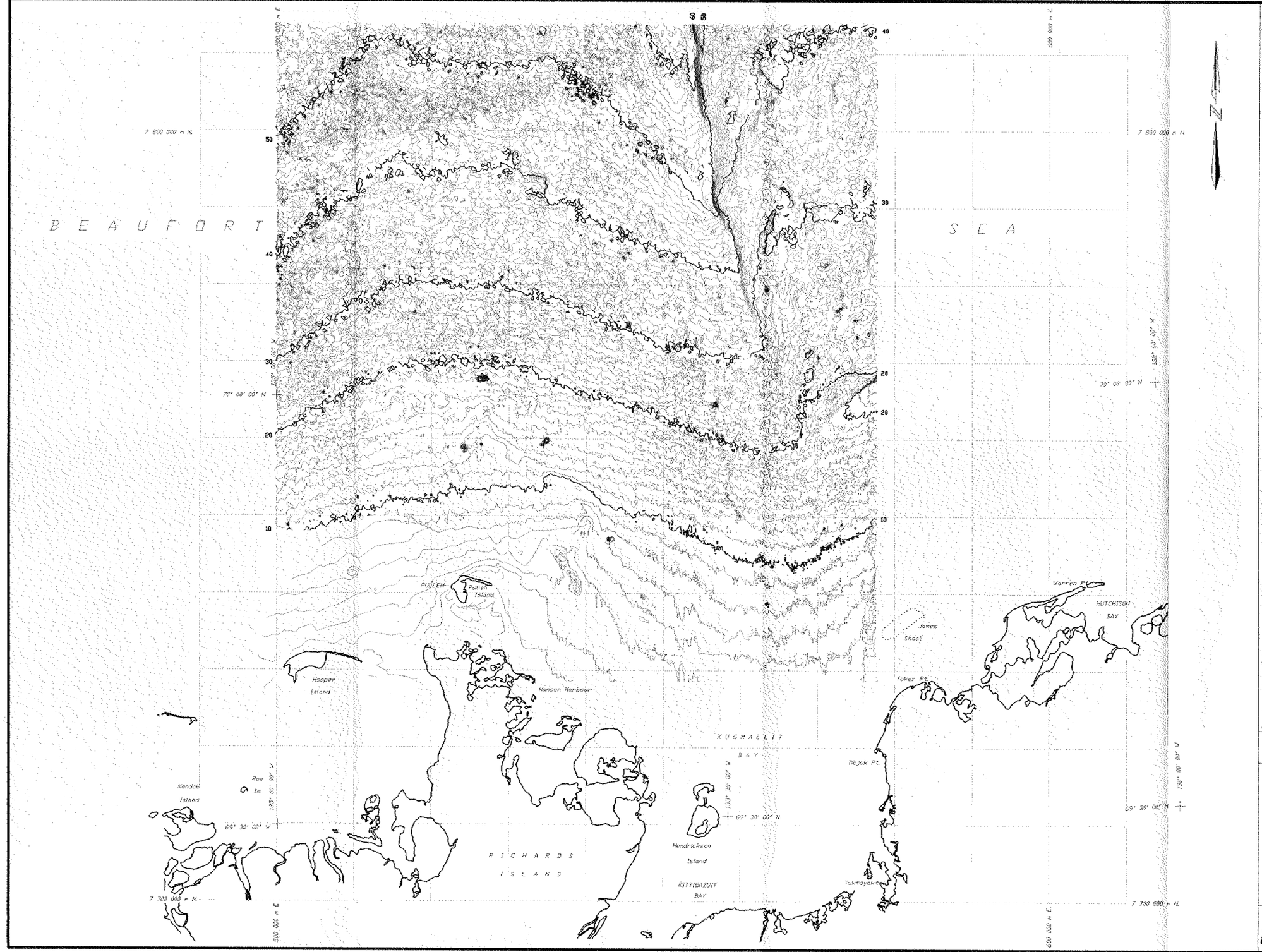
Per: Brian Terry Title: President & CEO

Date: January 6/94

LICENSEE: CHALLENGER SURVEYS AND SERVICES LTD.

Per: David Thomson Title: Project Manager

Date: December 29, 1993



LEGEND & NOTES

1. U.T.M. COORDINATES ARE REFERRED TO N.A. 1927 DATUM, V.A.D. '72 ADJUSTMENT.
2. U.T.M. COORDINATES ARE ZONE 8, CENTRAL MERIDIAN 135° W. LONGITUDE.
3. CONTOURS DERIVED FROM CHS CLEAN DATA AND INTERPOLATED WITH SOFTDESK.
4. LAT./LONG. GRID POSITIONS ARE SHOWN.
5. CONTOUR INTERVAL = 1m

KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

CONTOUR PLAN OF BATHYMETRIC DATA

BEAUFORT SEA PROJECT

CHALLENGER SURVEYS & SERVICES LTD.

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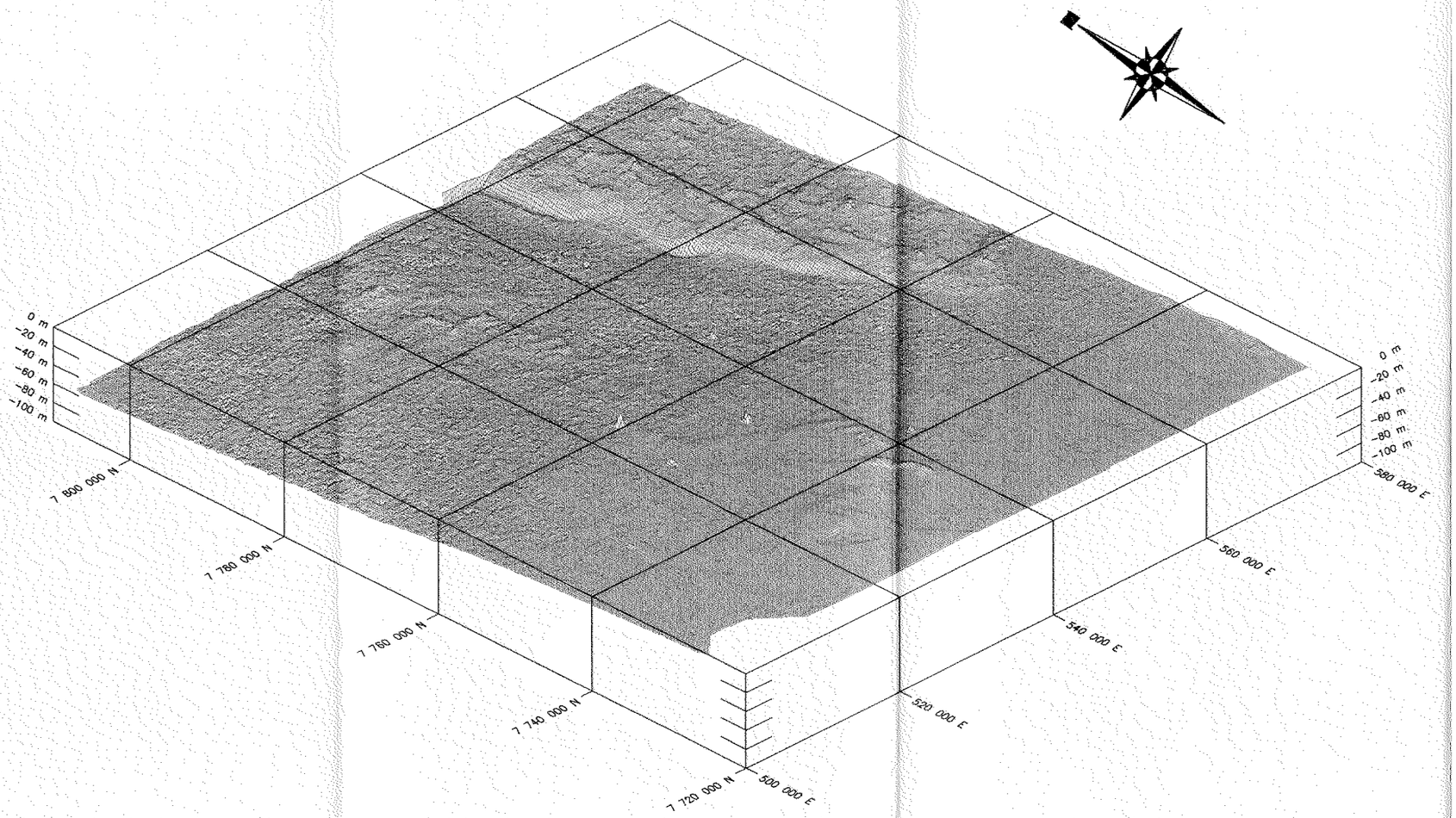
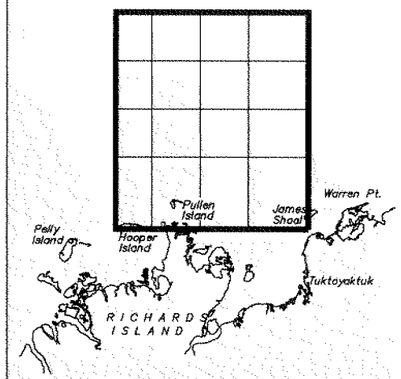
DATE: 15 FEB 94	DWG #: 5631-1.DWG



LEGEND & NOTES

1. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 225 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
2. BATHYMETRIC DATA DERIVED FROM CANADIAN HYDROGRAPHIC SERVICE FIELD SURVEYS
3. GRID CELL SIZE IS 250m X 250m



KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

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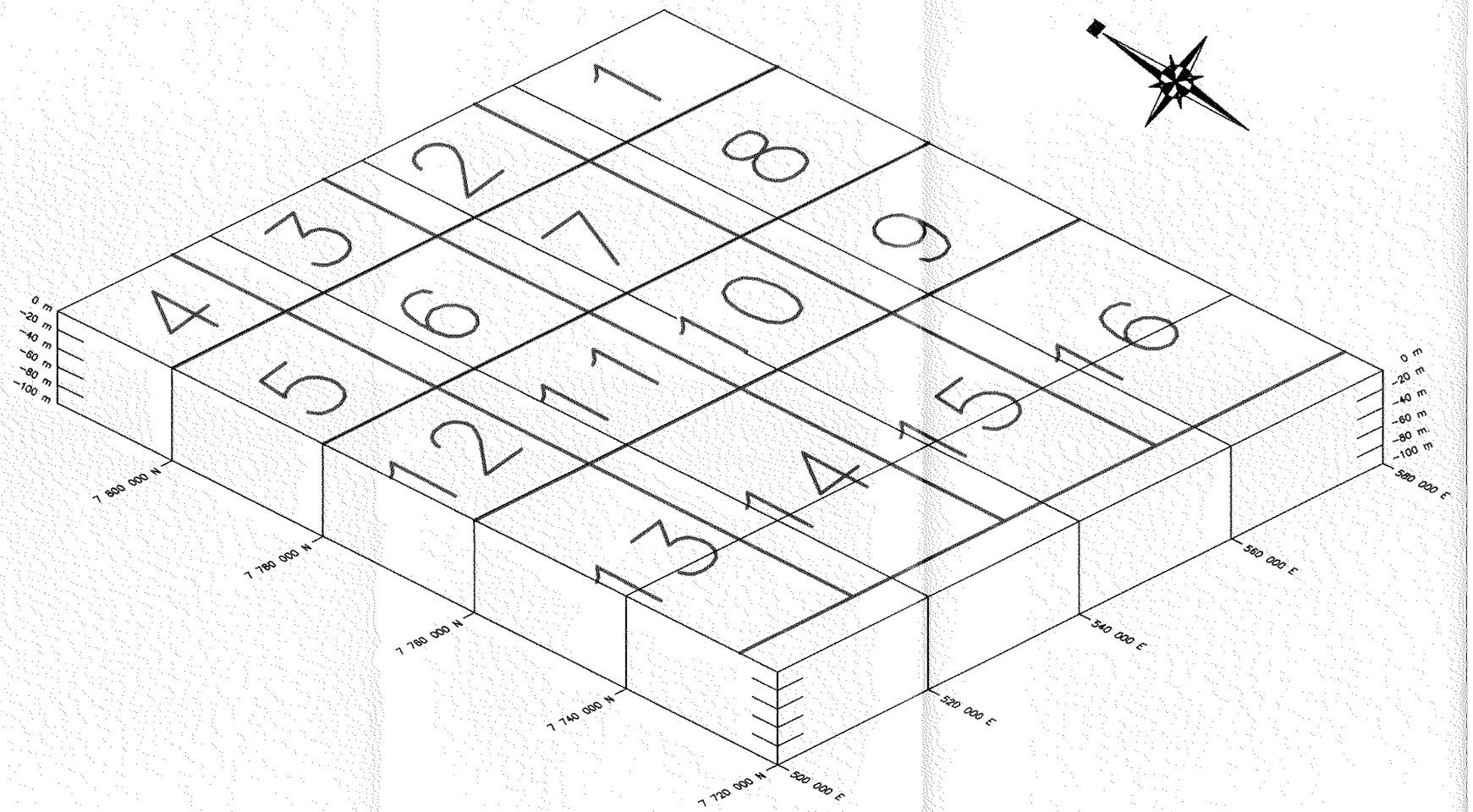
DATE: 20 MAR 95	DWG # : ALL-DXB.DWG



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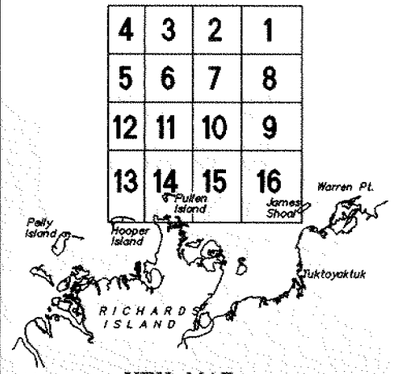
   VERTICAL EXAGGERATION = 100 TIMES



KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

KEY MAP

OF

BATHYMETRIC DATA

BEAUFORT SEA

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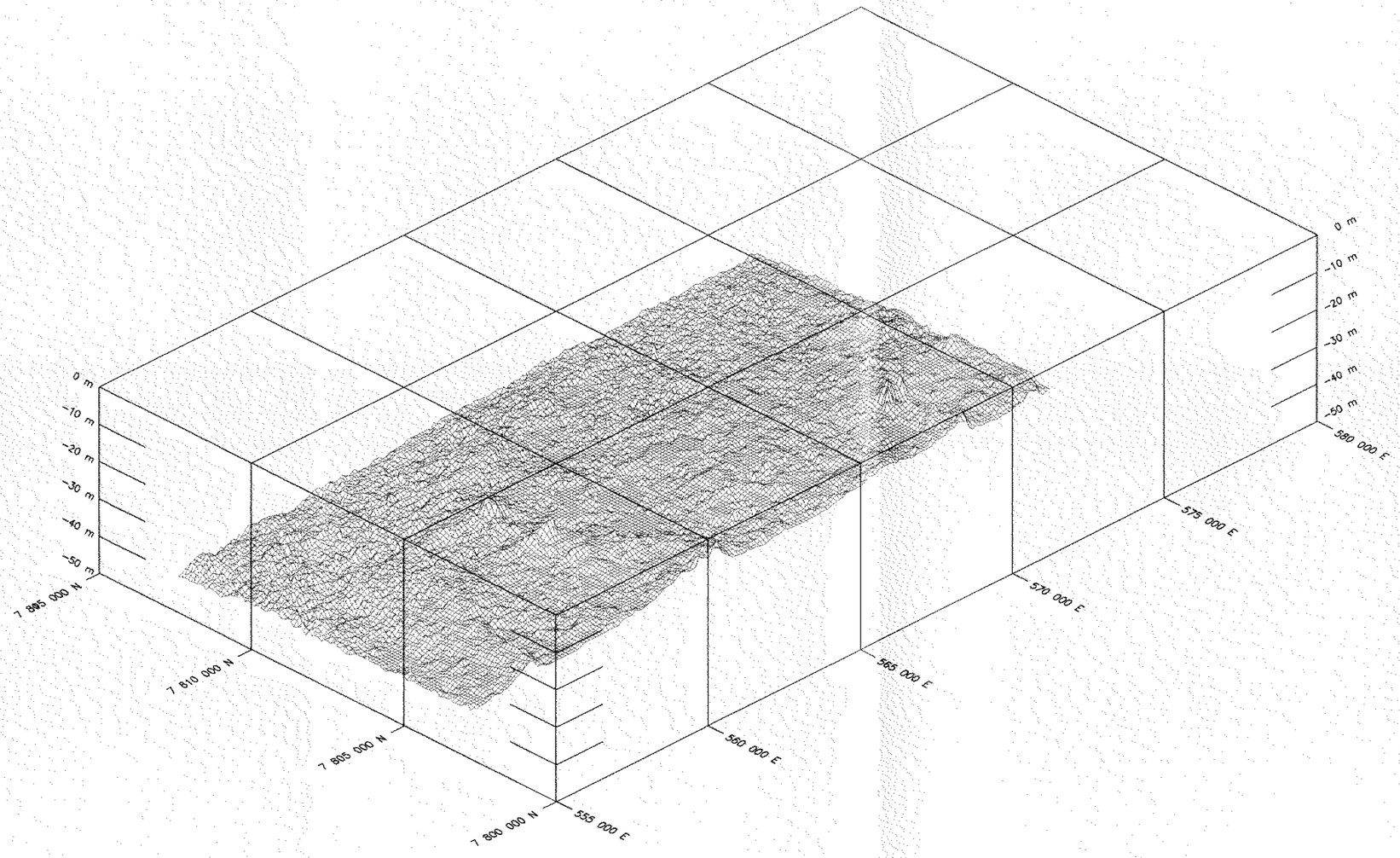
	DATE: 20 MAR 95	DWG # : KEY.DWG



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   VIEWING AZIMUTH IS 225 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
2. BATHYMETRIC DATA DERIVED FROM CANADIAN HYDROGRAPHIC SERVICE FIELD SURVEYS
3. GRID CELL SIZE IS 100m X 100m

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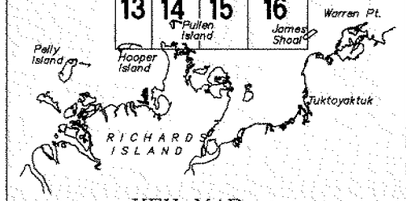

KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD	SCALE: N.T.S.	JOB NO: 93-5631
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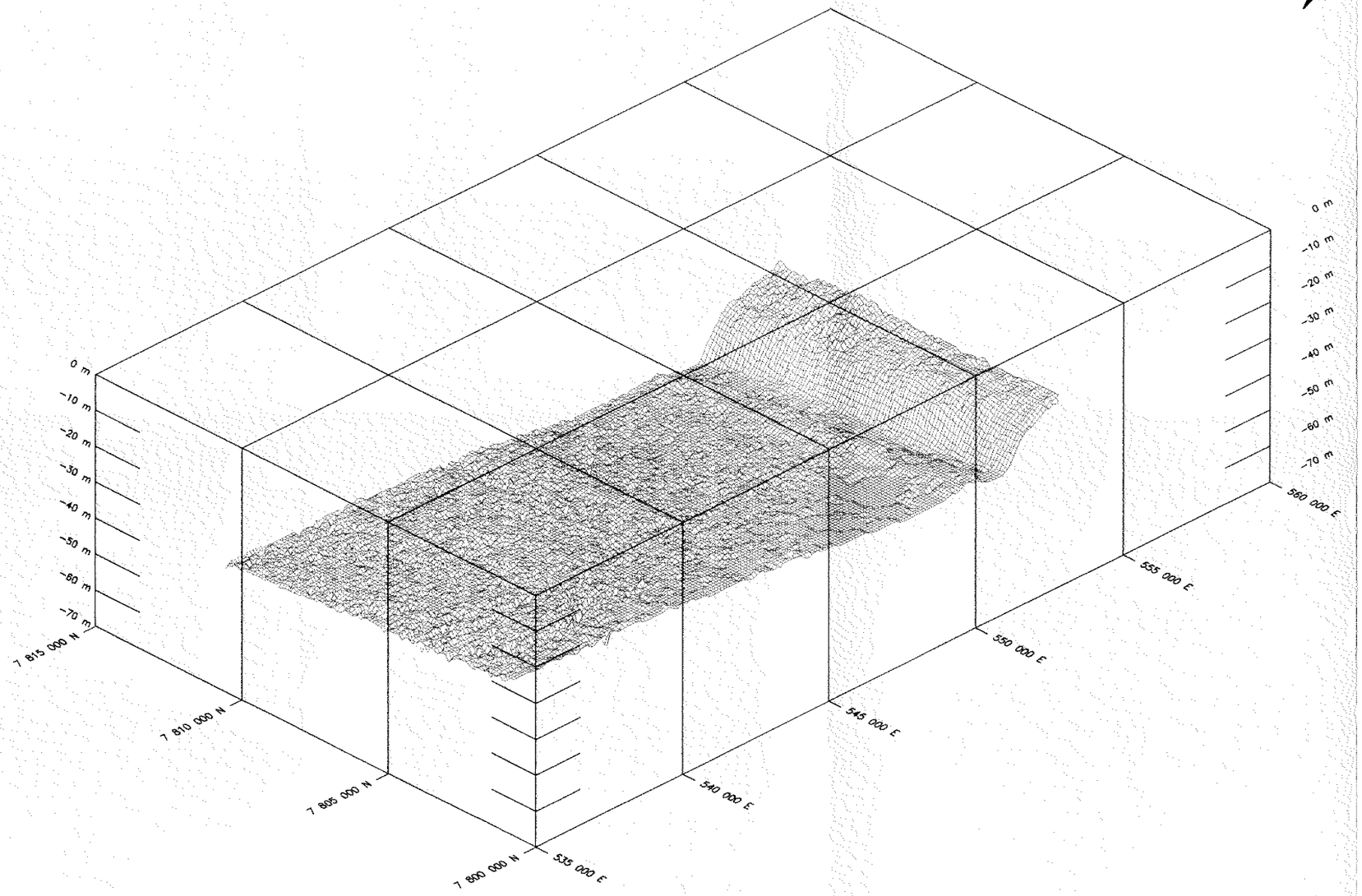

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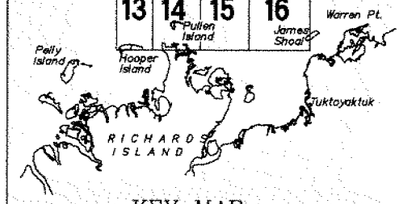

KEY MAP
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INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD

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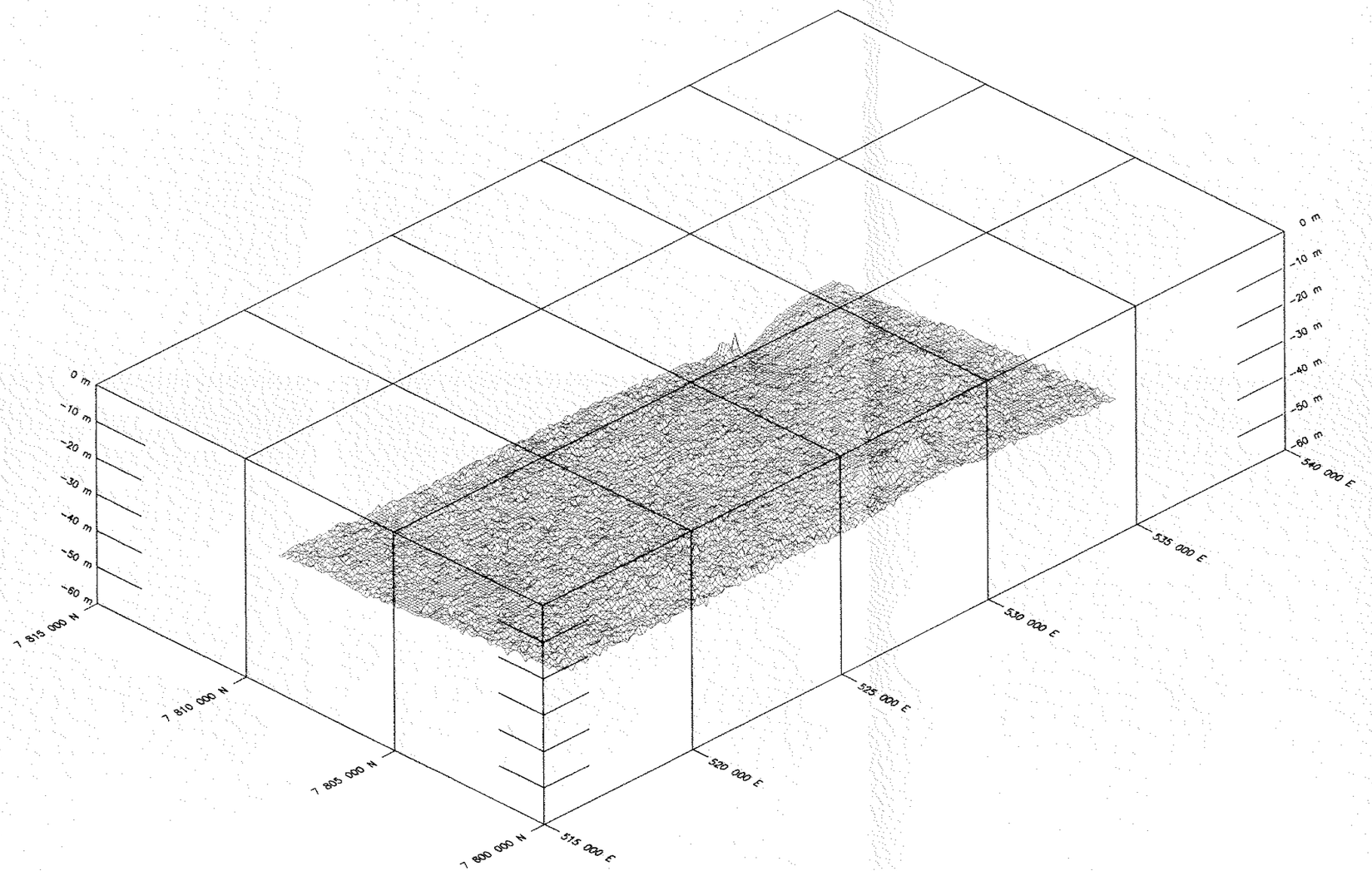
DATE: 15 FEB 94	DWG # : 2-DXB.DWG



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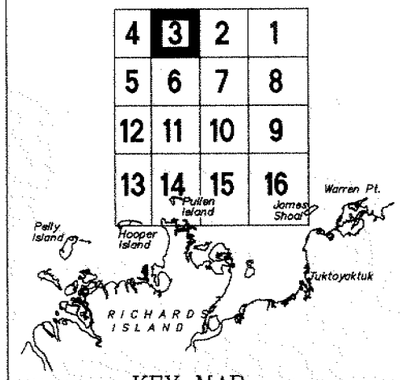

KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

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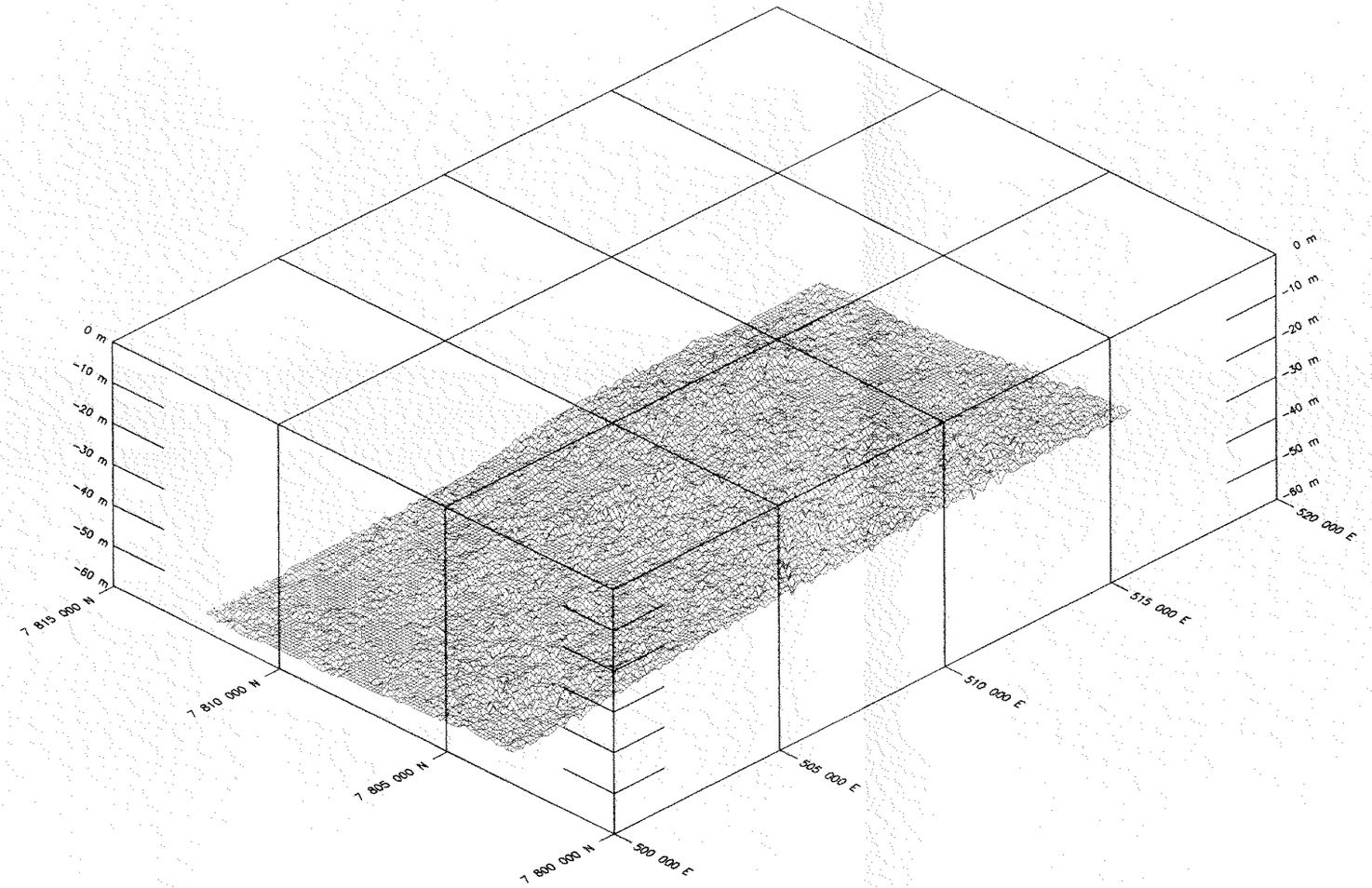

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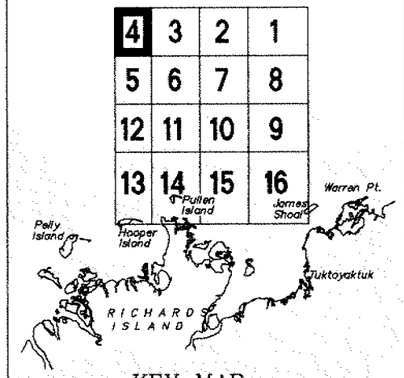
2. BATHYMETRIC DATA DERIVED FROM CANADIAN HYDROGRAPHIC SERVICE FIELD SURVEYS
3. GRID CELL SIZE IS 100m X 100m



KEY MAP
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INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
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BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

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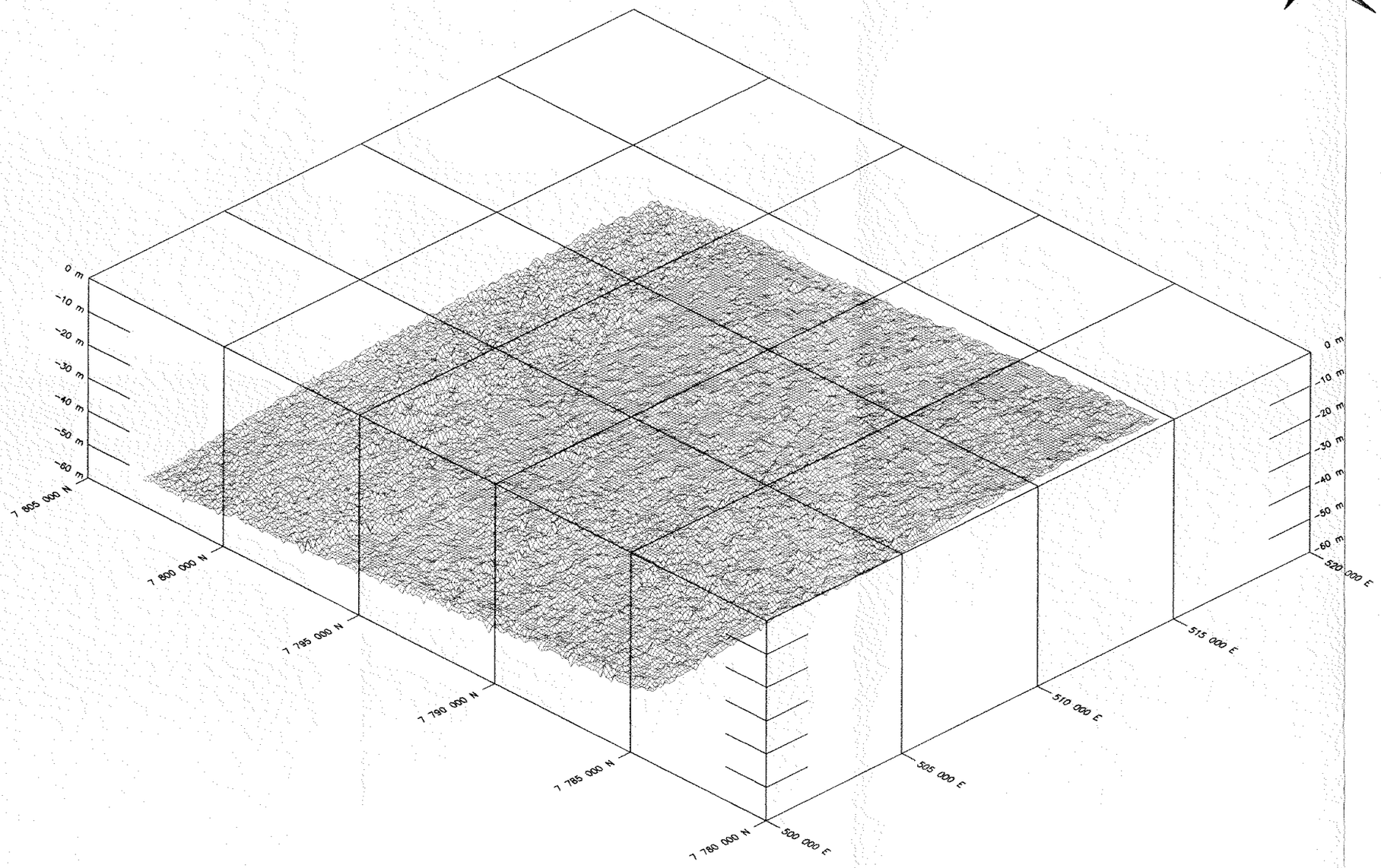

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2. BATHYMETRIC DATA DERIVED FROM CANADIAN HYDROGRAPHIC SERVICE FIELD SURVEYS
3. GRID CELL SIZE IS 100m X 100m

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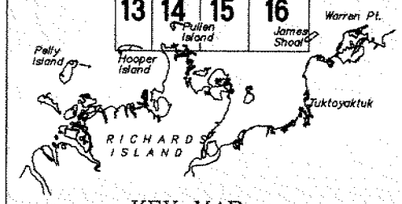

KEY MAP
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INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
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BATHYMETRIC DATA
BEAUFORT SEA

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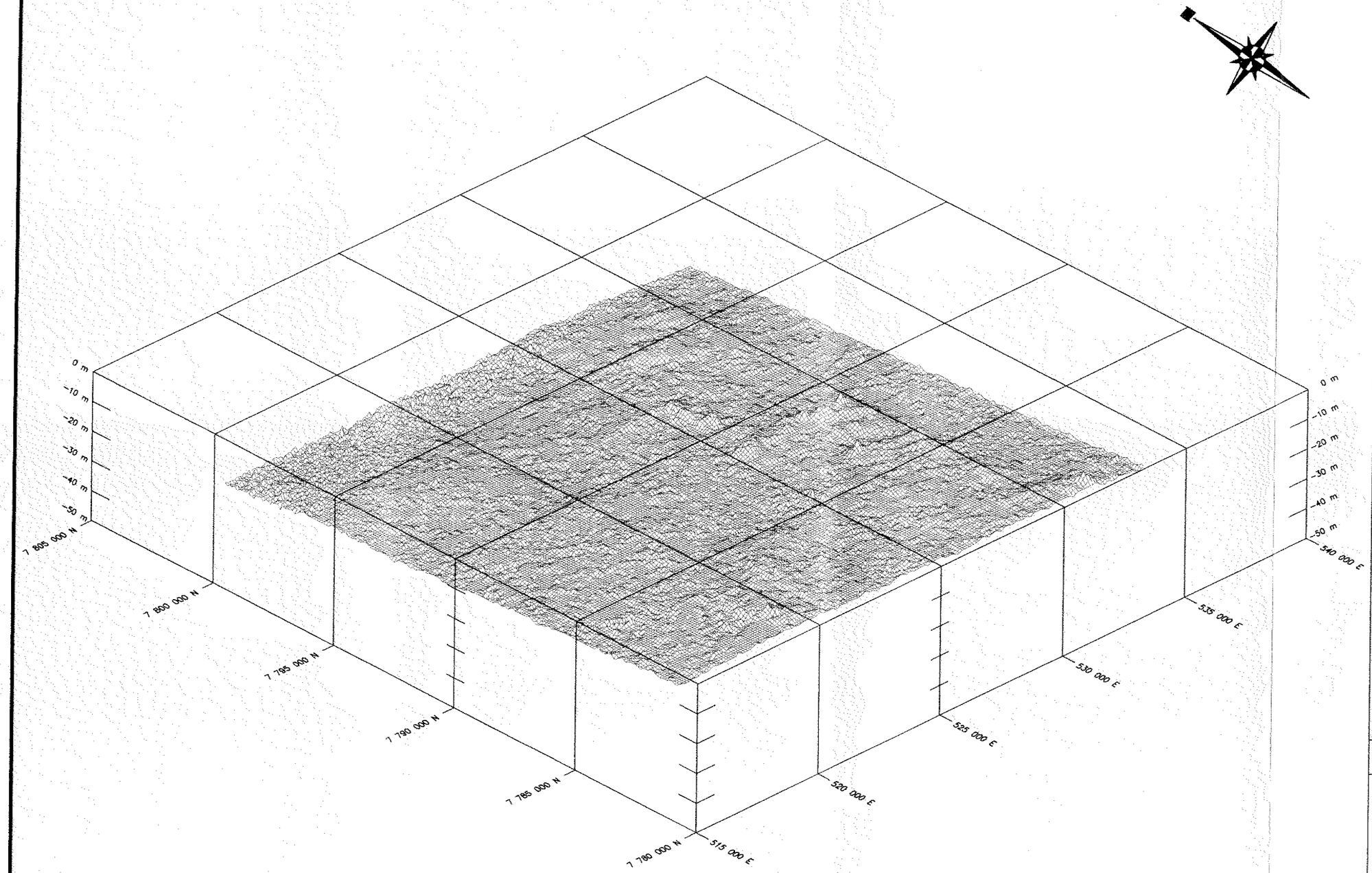

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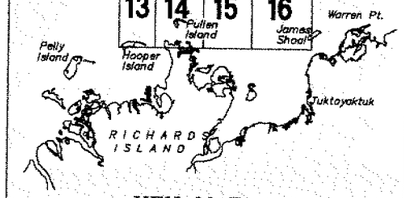

KEY MAP
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INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD

SCALE: N.T.S.	JOB NO: 93-5631
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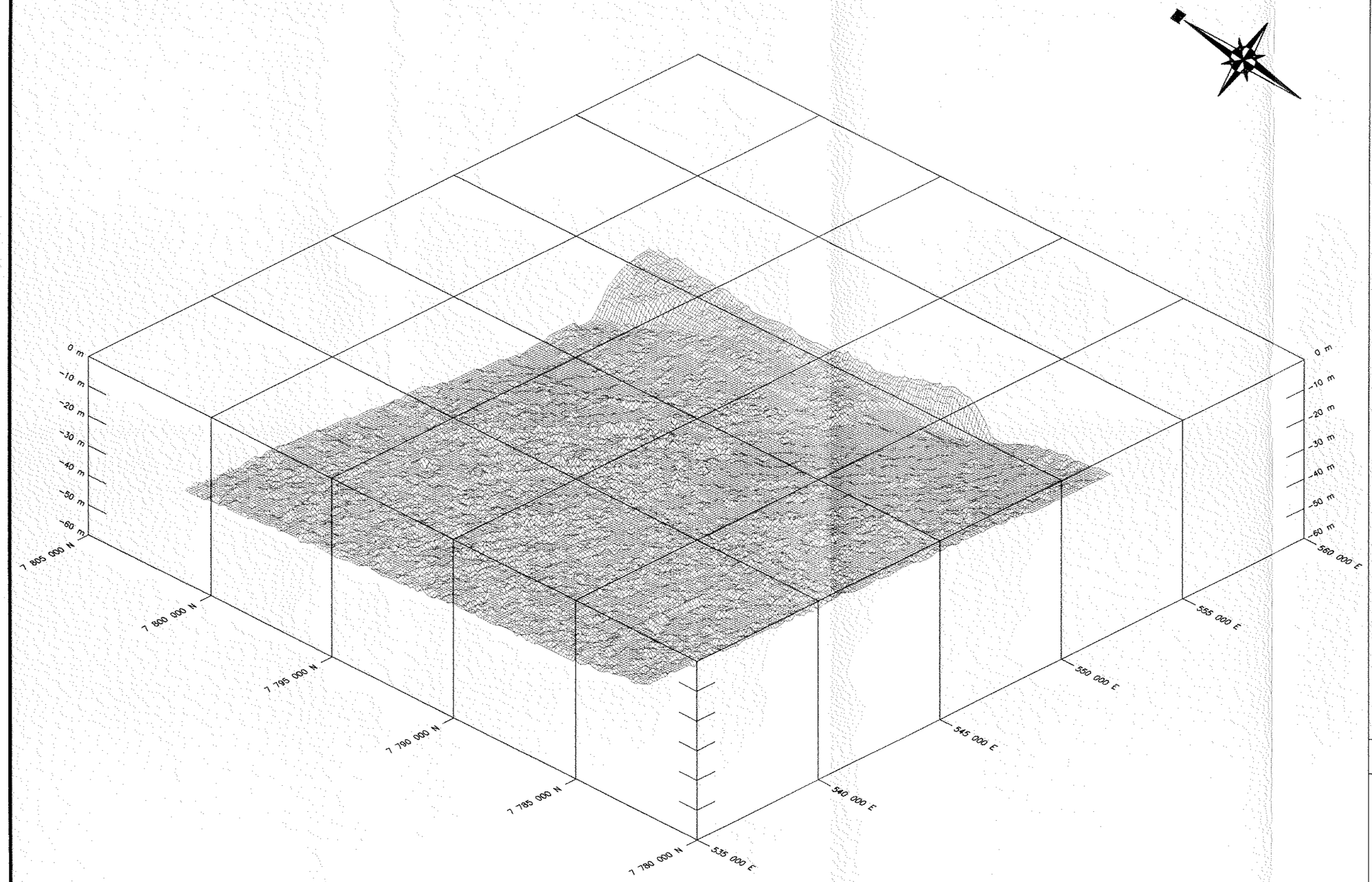

LEGEND & NOTES

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3. GRID CELL SIZE IS 100m X 100m

4	3	2	1
5	6	**7**	8
12	11	10	9
13	14	15	16

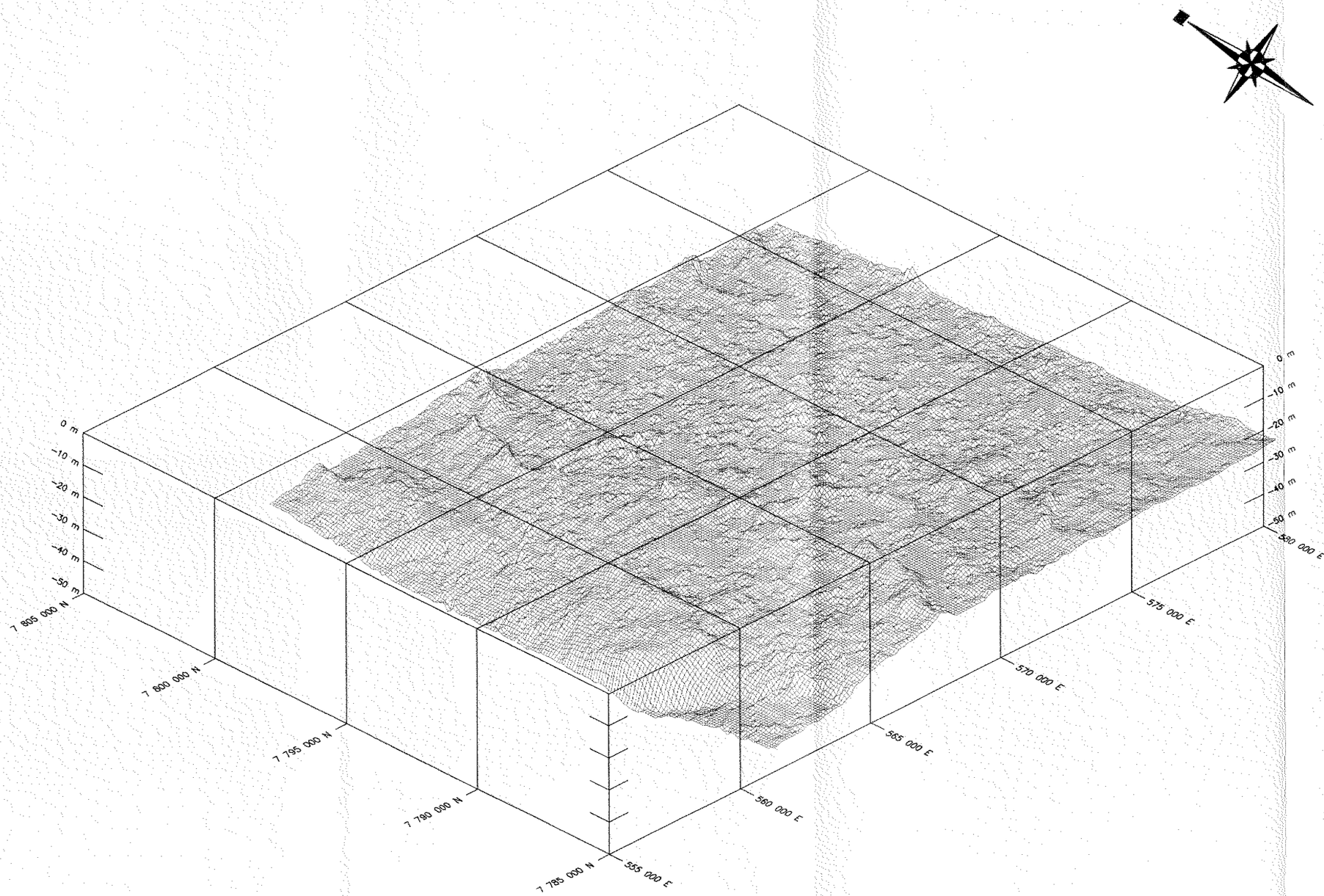
KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

SCALE: N.T.S.	JOB NO: 93-5631
DATE: 15 FEB 94	DWG # : 7-DXB.DWG



LEGEND & NOTES

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3. GRID CELL SIZE IS 100m X 100m

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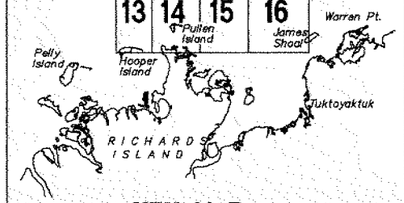


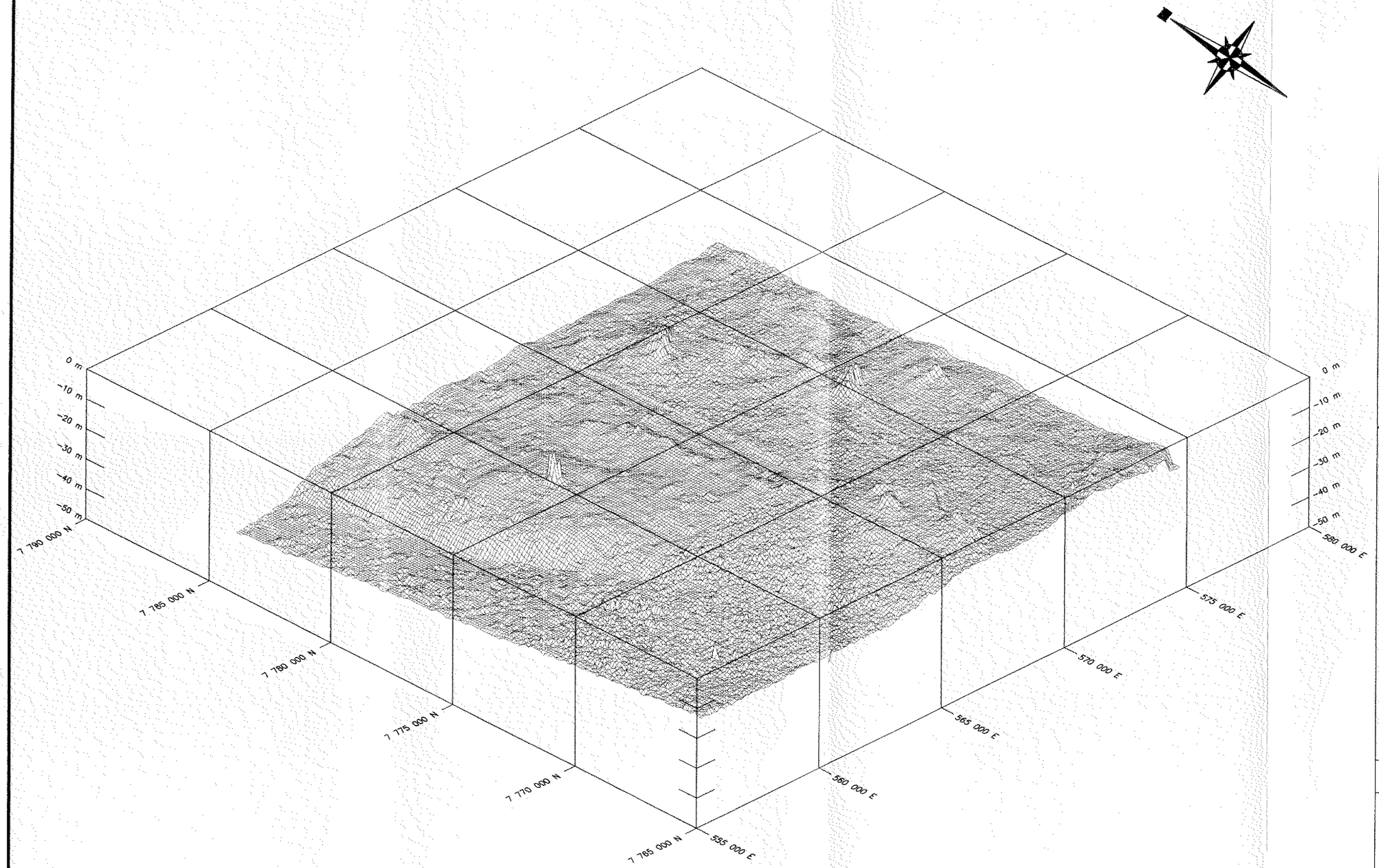
KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

SCALE: N.T.S.	JOB NO: 93-5631
DATE: 15 FEB 94	DWG # : 8-DXB.DWG



LEGEND & NOTES

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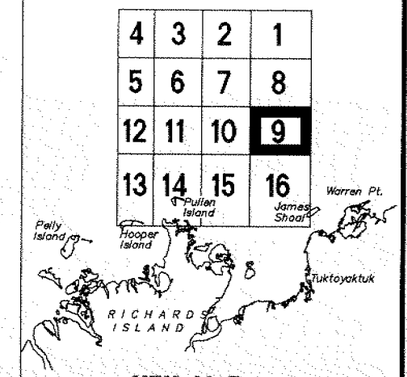

KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

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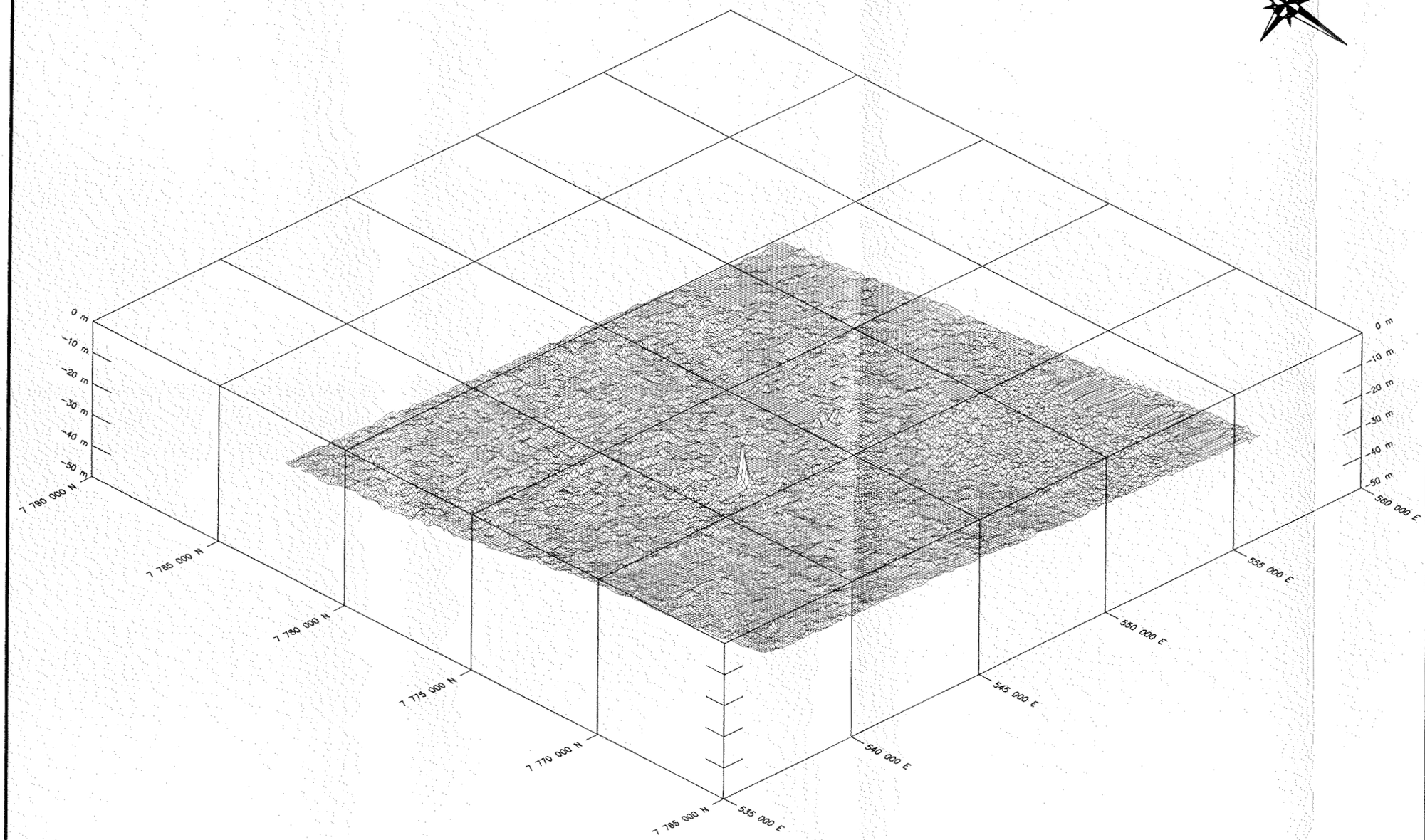
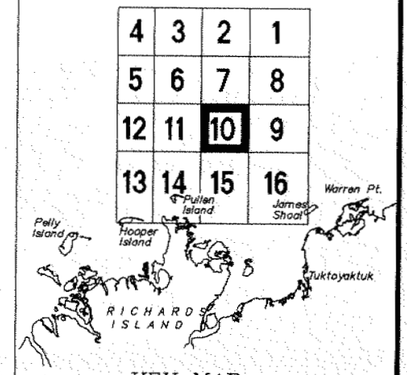


LEGEND & NOTES

1. VIEW IS FROM 30 DEGREES ABOVE THE HORIZON
   VIEWING AZIMUTH IS 225 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
2. BATHYMETRIC DATA DERIVED FROM CANADIAN HYDROGRAPHIC SERVICE FIELD SURVEYS
3. GRID CELL SIZE IS 100m X 100m



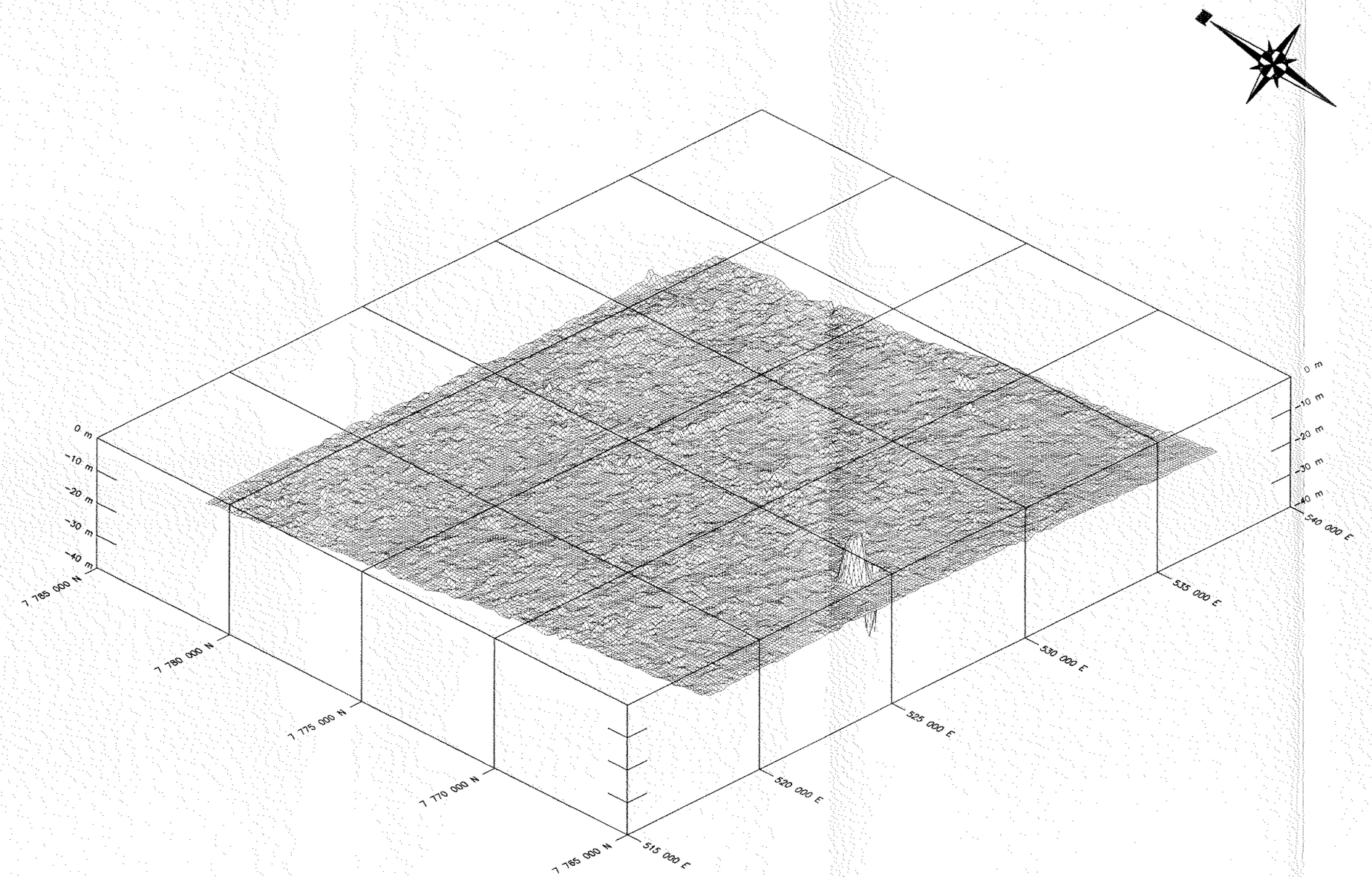
KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

SCALE: N.T.S.	JOB NO: 93-5631
DATE: 15 FEB 94	DWG #: 10-0X8.DWG



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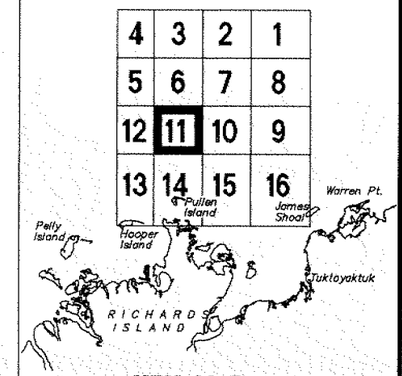

KEY MAP
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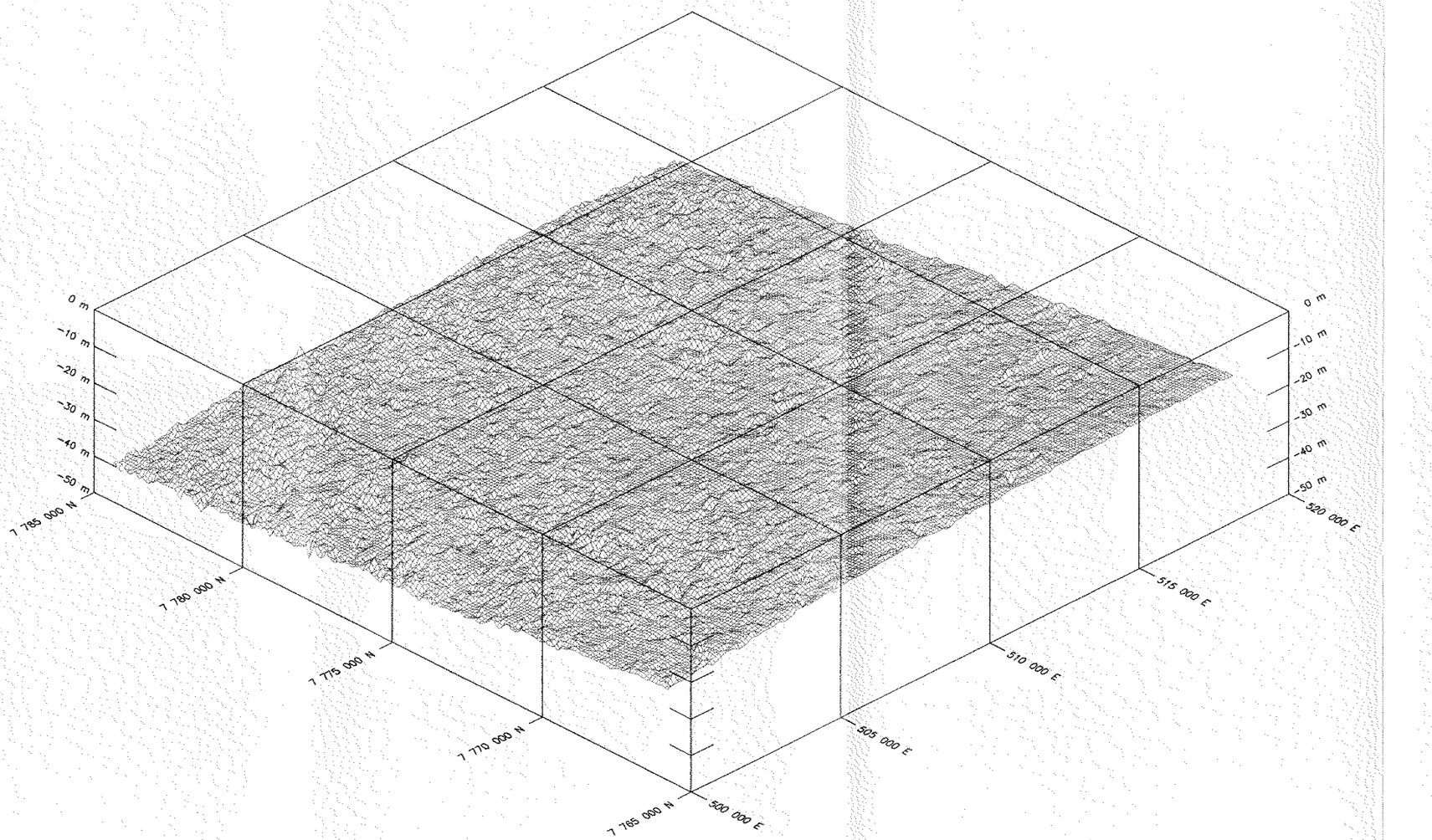
INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD	SCALE: N.T.S.	JOB NO: 93-5631
	DATE: 15 FEB 94	DWG # : 11-DXB.DWG



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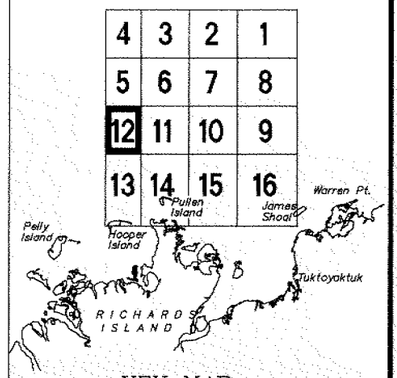

KEY MAP
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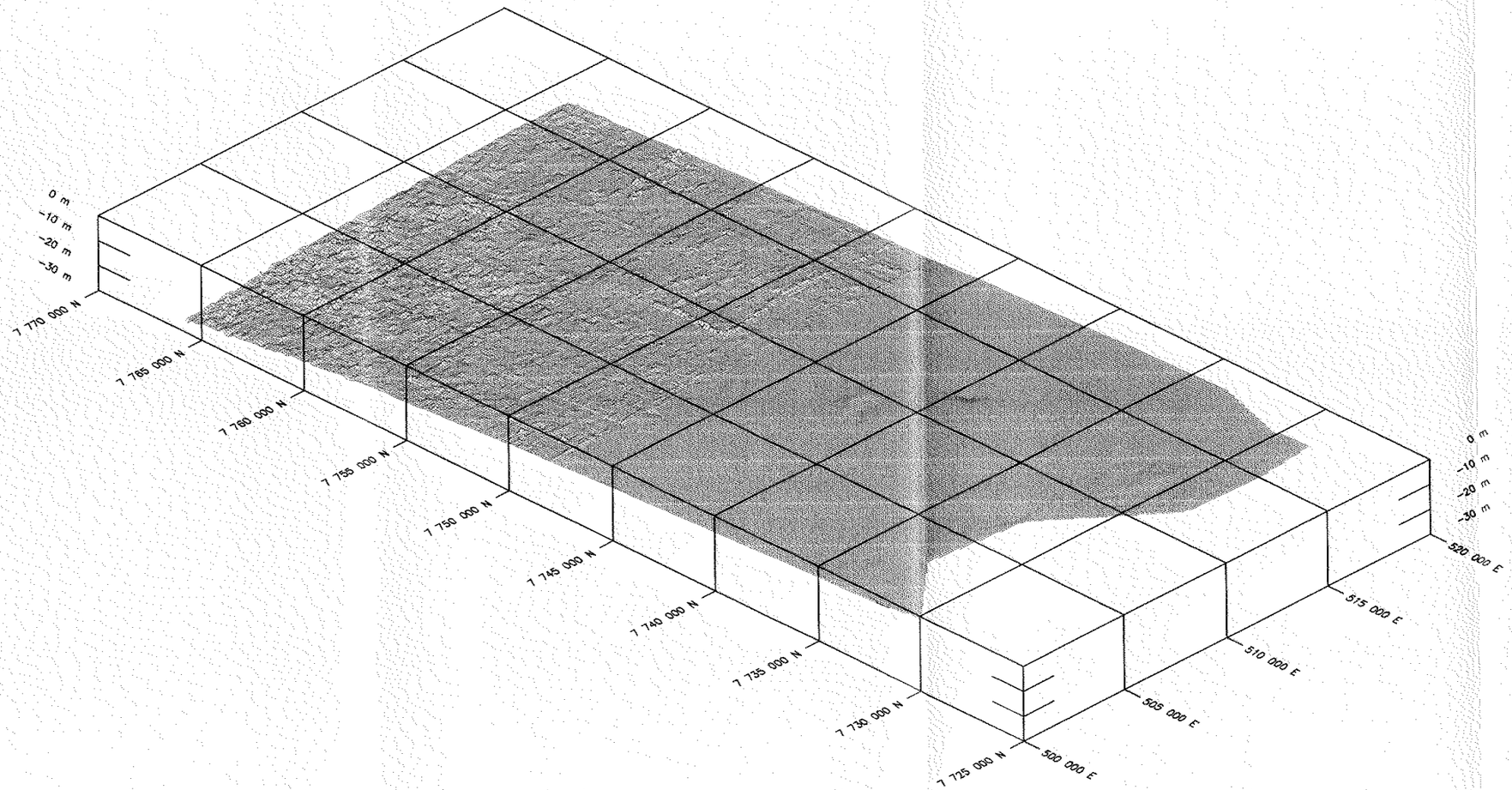
INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.	SCALE: N.T.S.	JOB NO: 93-5631
	DATE: 15 FEB 94	DWG #: 12-DXB.DWG



LEGEND & NOTES

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   VIEWING AZIMUTH IS 225 DEGREES
   VERTICAL EXAGGERATION = 100 TIMES
2. BATHYMETRIC DATA DERIVED FROM CANADIAN HYDROGRAPHIC SERVICE FIELD SURVEYS
3. GRID CELL SIZE IS 100m X 100m

4	3	2	1
5	6	7	8
12	11	10	9
13	14	15	16

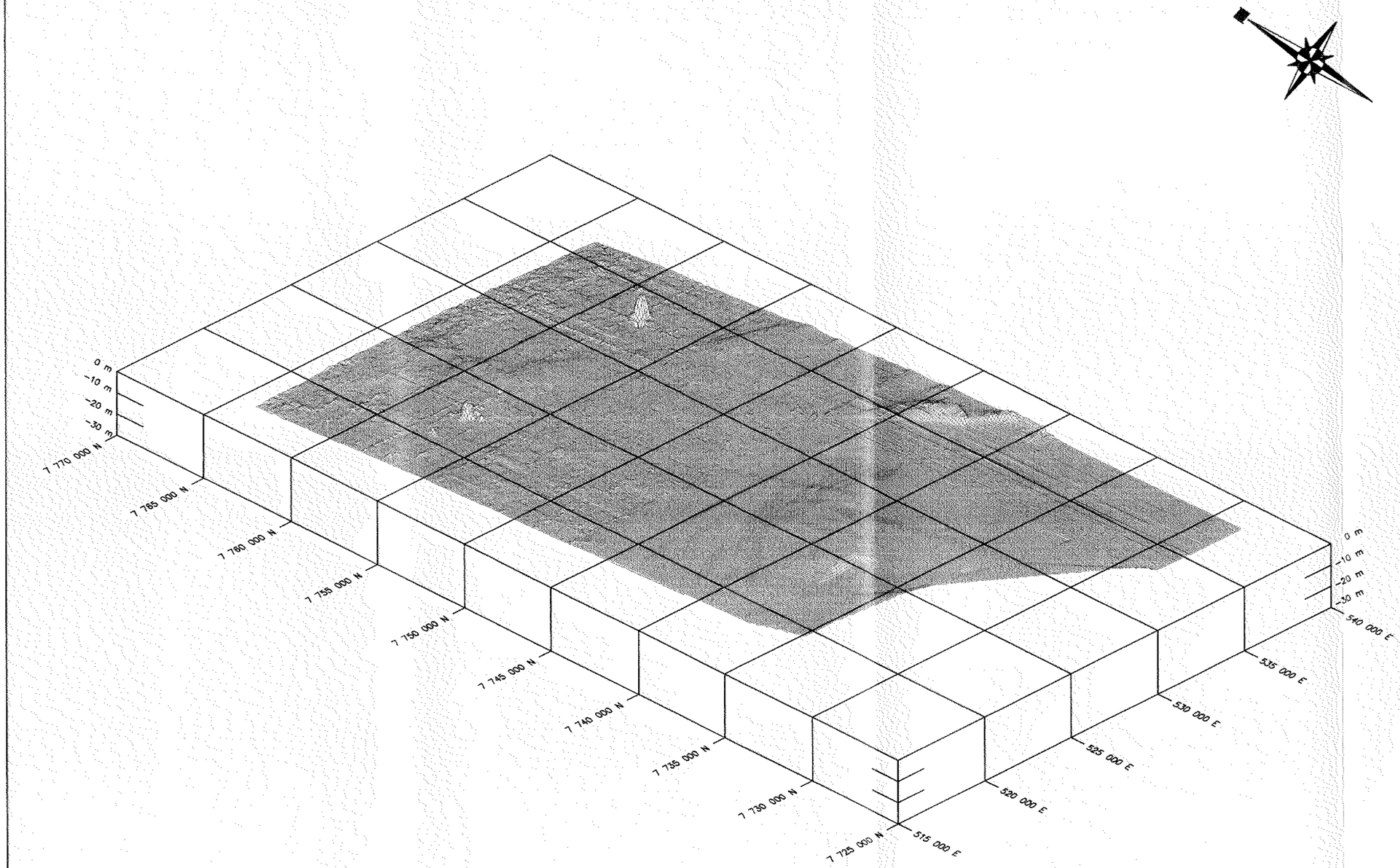
KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

SCALE: N.T.S.	JOB NO: 93-5631
DATE: 15 FEB 94	DWG # : 13-DXB.DWG



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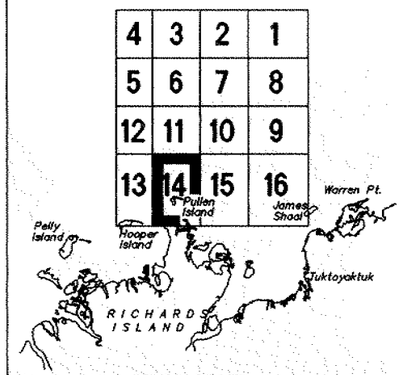

KEY MAP
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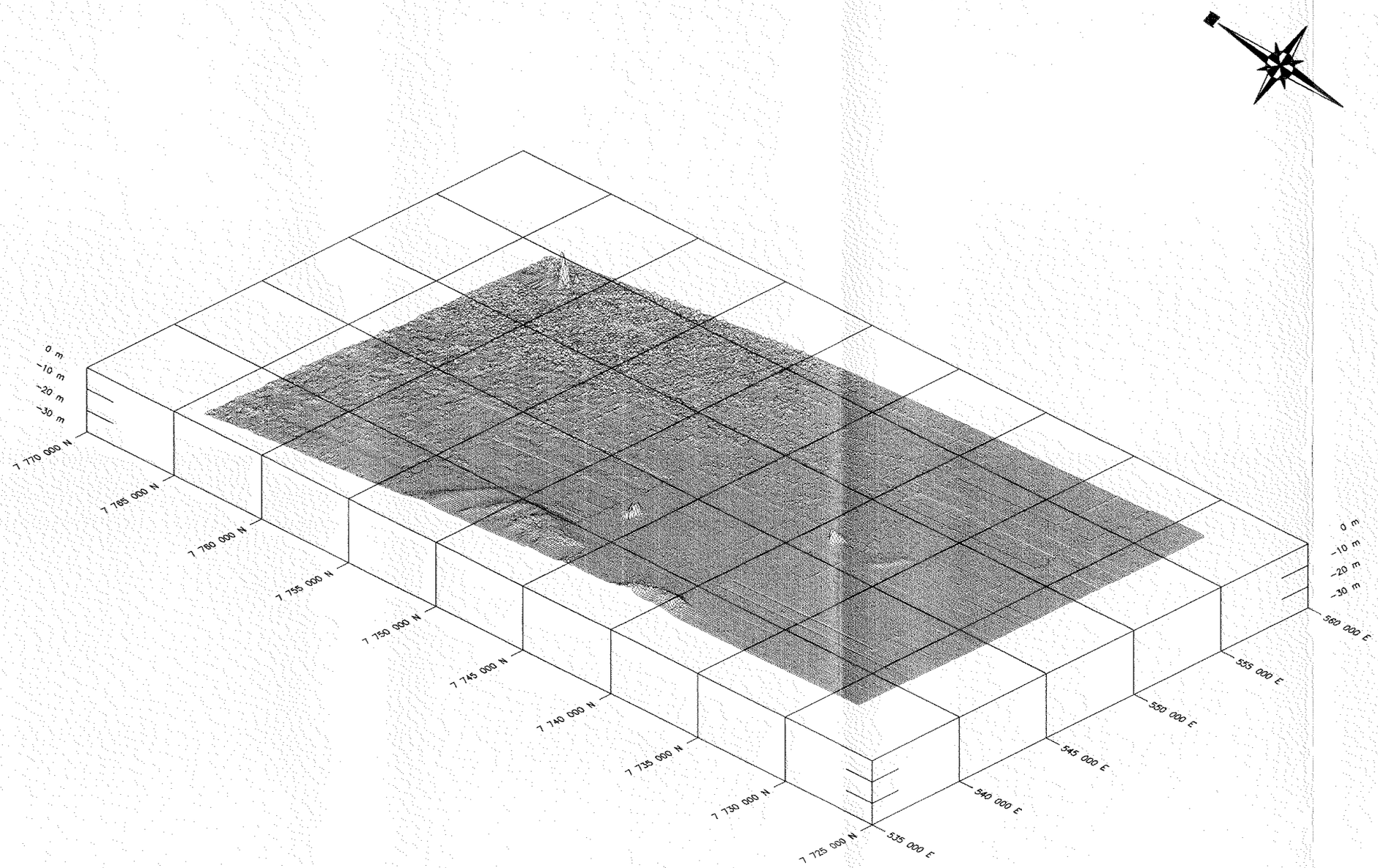
INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.	SCALE: N.T.S.	JOB NO: 93-5631
	DATE: 15 FEB 94	DWG # : 14-0XB.DWG



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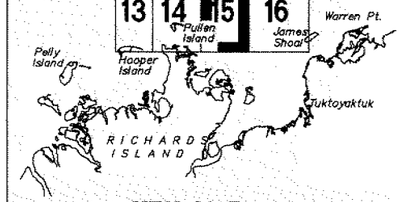
3. GRID CELL SIZE IS 100m X 100m

4	3	2	1
5	6	7	8
12	11	10	9
13	14	15	16



KEY MAP
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INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
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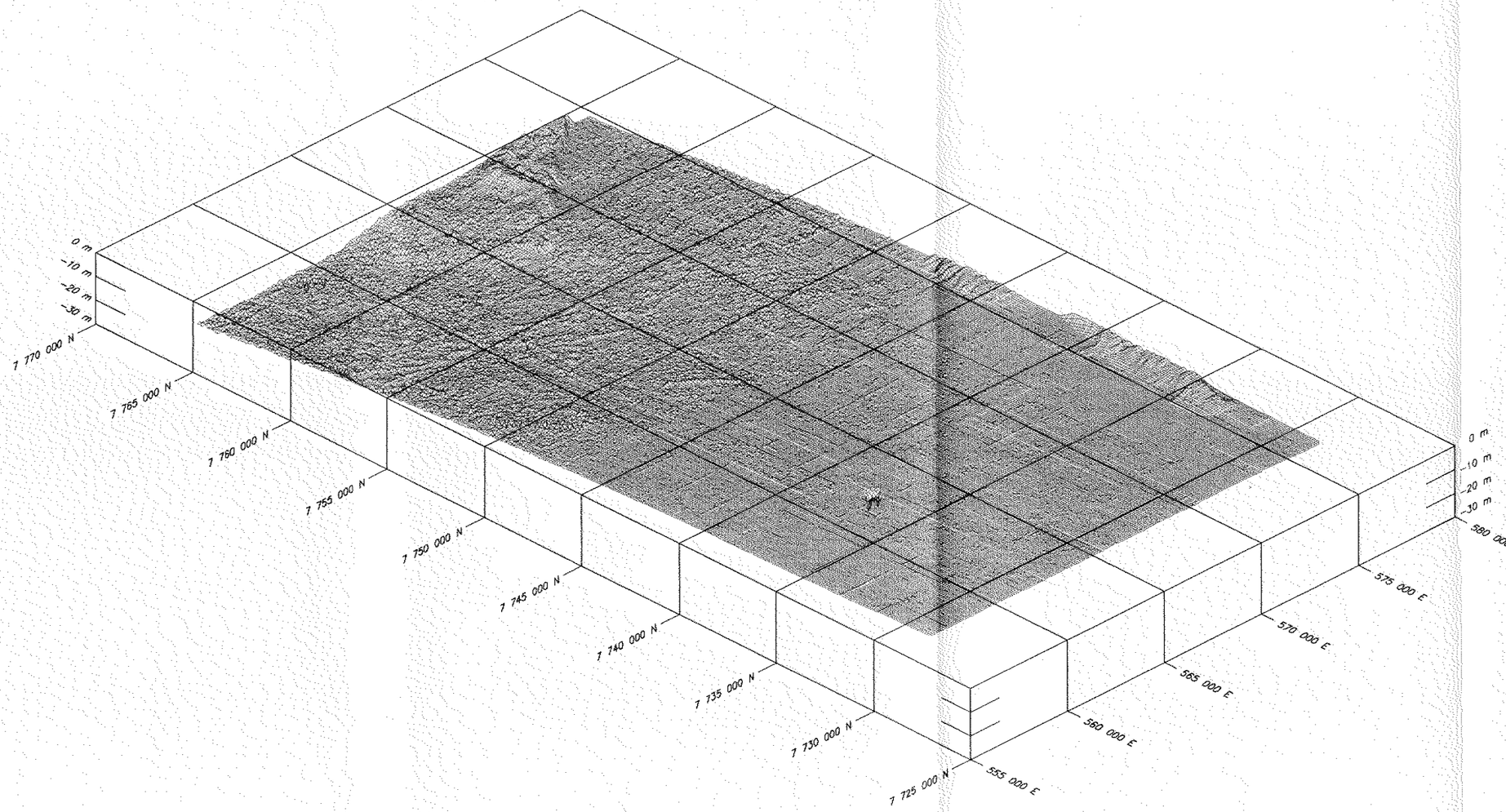
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.

SCALE: N.T.S.	JOB NO: 93-5631
DATE: 15 FEB 94	DWG # : 15-DXB.DWG



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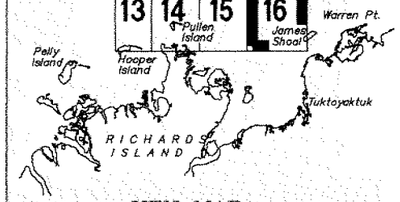
4	3	2	1
5	6	7	8
12	11	10	9
13	14	15	**16**



KEY MAP
NOT TO SCALE

INDIAN AND NORTHERN AFFAIRS CANADA

GRID MESH
PERSPECTIVE VIEW
OF
BATHYMETRIC DATA
BEAUFORT SEA

CHALLENGER SURVEYS & SERVICES LTD.	SCALE: N.T.S.	JOB NO: 93-5631
	DATE: 15 FEB 94	DWG # : 16-DXB.DWG