PROCEEDINGS OF THE
BEAUFORT SEA GRANULAR RESOURCES WORKSHOP

FEBRUARY 13 AND 14, 1992

SPONSORED BY:

INDIAN AND NORTHERN AFFAIRS CANADA
NATURAL RESOURCES AND ENVIRONMENT BRANCH

Part of the Northern Oil and Gas Action Program
(DSS File No. 038ST.A7134-0-0037)

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PART 1

REPORTS ON NOGAP REGIONAL STUDIES

Herschel Island Study
(NOGAP Project A4-01)

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1.0 Introduction

In 1984 and 1985, a series of studies were undertaken to locate and delineate potential areas for the future development of off-shore granular resources near Herschel Island, Yukon Territory. The work, carried out by M.J. O'Connor and Associates and EBA Engineering Consultants Ltd., was authorized by the Department of Indian and Northern Affairs and the studies were carried out in collaboration with the Geological Survey of Canada. In addition, the major petroleum operators assisted in the program by providing access to propriety data for incorporation in the synthesis of the geophysical and geotechnical data.

2.0 Geological Setting of the Area

The study area, shown in Figure 1, lies on the Natsek Plain, an area for which little sub-sea information was available prior to the DIAND Herschel Island study. Exposures on the Yukon Coastal Plain reveal sediments which are thought to pre-date the early Wisconsin glaciation. It has been suggested that these sediments were deposited during the non-glacial interval immediately preceding the early Wisconsin.

Sections of the pre-Wisconsin sediments exposed on Herschel Island reveal complex marine, deltaic, fluvial, lacustrine and even terrestrial depositional environments. It is thought that the early Wisconsin glaciation occurred greater than 40,000 years ago and may have been responsible for a major ice-thrusting event at Herschel Island. The Mackenzie Trough probably influenced the movement of the early Wisconsin ice sheet forming a lobe of ice to the northwest. The lobe is thought to have thrust sediments from Herschel Basin to form Herschel Island (Mackay, 1959).

Herschel Basin is separated from the Mackenzie Trough to the east by a submarine ridge or sill which joins Collinson Head to Kay Point. This ridge is thought to be an intact remnant of the original pre-Wisconsin marine sequence which escaped removal by the ice-thrusting event.

3.0 Methodology

A three-phase approach was carried out to determine the geological conditions:

- Marine geophysics to provide information on the nature of the soil conditions in the Herschel area.
- Marine geotechnical drilling to confirm the geological conditions interpreted from the seismic records and also to provide grain size distribution of the granular deposits.
- Synthesis of this data along with existing other regional data available.

3.1 Geophysical Program

The field data acquisition phase included coverage of the Herschel area by two vessels, the Norweta and the Banksland. The geophysical equipment included precision survey echo sounder, side scan sonar, sub-bottom profiler, boomer and air gun. Several hundred kilometres of data were collected over the study area between Collinson Head and Kay Point.

3.2 Geotechnical Program

The geotechnical field studies were carried out from the Arctic Kiggiak by EBA Engineering Consultants Ltd. Borehole locations were selected to determine the stratigraphy, both on Herschel Sill and Herschel Basin.

Four locations were investigated on the sill. At these locations, two boreholes were drilled and sampled to depths of 19.7 m and 5.7 m, while two probe holes were drilled to test the thickness of gravel at the other two locations. Surficial sediments at each of these locations were sampled using the grab dredge on the Arctic Kiggiak.

The additional two boreholes drilled within Herschel Basin were intended to test the possibility that some of the anomalous bathymetry within the basin may be due to glacially related granular resource deposits.

4.0 Sub-Sea Features in the Study Area & Their Granular Resource Potential

Four distinct sub-sea regions were identified and are shown in Figure 2. These included Herschel Basin, Herschel Sill, Yukon Coastal Shelf and the Babbage River Paleochannel.

4.1 Herschel Basin

The deepest water depths were found in Herschel Basin where the bottom of the basin is enclosed by the 50 m isobath and with water depths up to 80 m. The east side of the basin has pingo like features that rise steeply to within 25 m of the sea surface. Geotechnical and geophysical studies showed that the floor of the basin consists of approximately 40 m of laminated silty clay overlying sand, stiff clay and gravel. Ice lensing observed in the surficial clay suggests that the basin was drained and the bottom sediments exposed for some period of time in the past. Although extensive sand and gravel layers were noted in the sub-sea bottom sediments, the extreme water depths and the presence of a thick surficial clay unit preclude the development of any granular resources in Herschel Basin.

4.2 Herschel Sill

The precise sub-surface conditions which underlie the sill joining Collinson Head to Kay Point were difficult to resolve acoustically, but surface sampling, test dredging and several geotechnical boreholes proved useful in determining the surficial geology. For the most part, the sill is comprised of the same terrain units which may be found near Collinson Head and Kay Point. The eroded remnants of these mainly stiff, fine grained sediments are locally covered by modern sand and gravel shoals up to 7 m or more in thickness along the crest. South of Collinson Head, the bore holes and probe holes drilled on the crest of the sill showed granular thickness of up to about 3.5 m (Figure 3). The granular material was made up of sand and gravel containing sub-rounded to sub-angular particles. The coarse grained deposits are underlain by a stiff silty clay sequence.

Maximum water depths along the crest reach 17 m, but most of the sill is much shallower (4 - 12 m). In addition to ice scours, the presence of ripple marks along the crest of the sill as well as in other areas of the study such as the coastal shelf, provided indirect evidence regarding the nature of the sea floor and distribution of surficial granular resources. On the west side of the shoal north of Kay point, well developed ripple trains were evident. The ripple marks were also helpful in delineating both the nature of the surficial sediments and the lateral limits of individual soil types. In Figure 4, the boundary between the sandy and clayey soils at the seabed are clearly defined.

Discontinuous ice-bonding is common in the fine grained soils which constitute the regional sill sediments, but is not expected to occur in the modern sand and gravel shoals. Almost 17,000,000 m^3 of granular material suitable for engineering purposes are already known to be located in these shoals. The present information suggests that an additional 70,000,000 m^3 are probably available at the seabed and another 40,000,000 m^3 of material may also be located, if it can be proven that the glaciofluvial features noted near Kay Point

also extend off-shore (Figure 5). Unfortunately, much of the granular resources on the sill are located in relatively shallow water depths, where conventional hopper trailer suction dredges may not be appropriate. Nevertheless, it is presumed that other technologies could be used for development if warranted by future granular resource requirements.

4.3 Yukon Coastal Shelf

The narrow coastal shelf which borders the north and west side of Herschel Basin was, like the Herschel Sill, difficult to map using high resolution seismic techniques because the water depths are shallow (less than 14 m) and the shelf is underlain by firm to stiff or dense materials which form part of the morainal, lacustrine or glaciofluvial sequences found along the coastline. Recent soft sediments appear to be absent in most areas, except near the basinward edge of the shelf. Geotechnical drilling conducted by Gulf Canada has verified that silty to gravelly sands may be found in certain areas near Stokes Point, but shallow ice-bonding was also present near the coastline. The most prospective area for future granular resource development appears to be located between Roland Bay and Catton Point, but no ground truth information is currently available in this area. Most of the present 9,750,000 m^3 of reserves on the shelf have been located by geotechnical boreholes. It is estimated that a total of 40,850,000 m^3 of sand and gravel may eventually be found on the shelf and along the coastline, if substantial additional drilling is conducted in the most prospective areas.

4.4 Babbage River Paleochannel

The drowned Babbage River Paleochannel does not appear to be generally prospective for development of seabed granular resources, especially in the deeper areas near Herschel Basin. The paleochannel may, however, contain some sand and gravel in the shallow waters near the Spring River or at greater depths below the seabed than were mapped during the present study. Total volume of these deposits is presently estimated to be only 3,500,000 m^3.

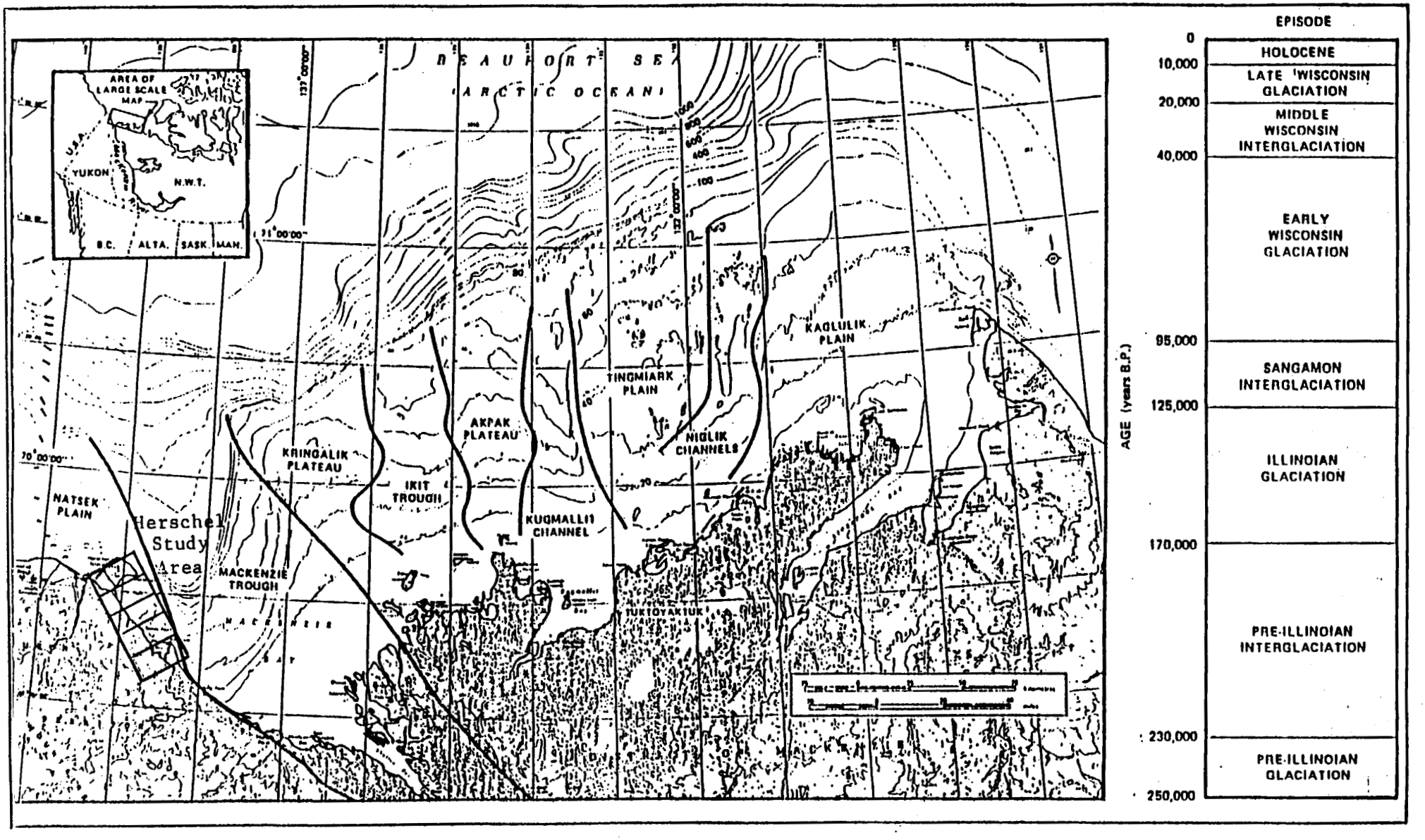


Figure 1. **Herschel Island Study Area and Physiographic Regions of the Beaufort Sea with Geologic Time Scale.**

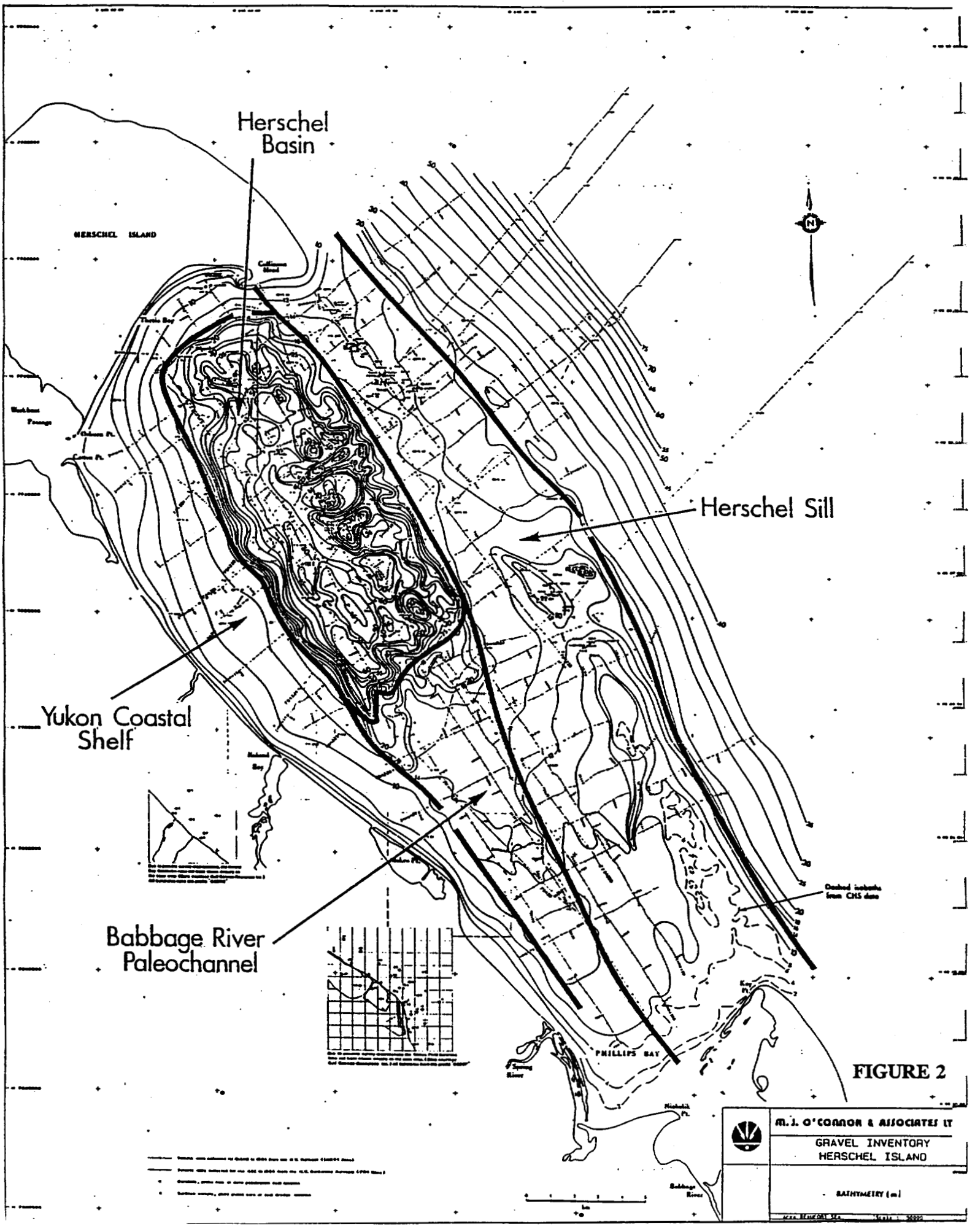
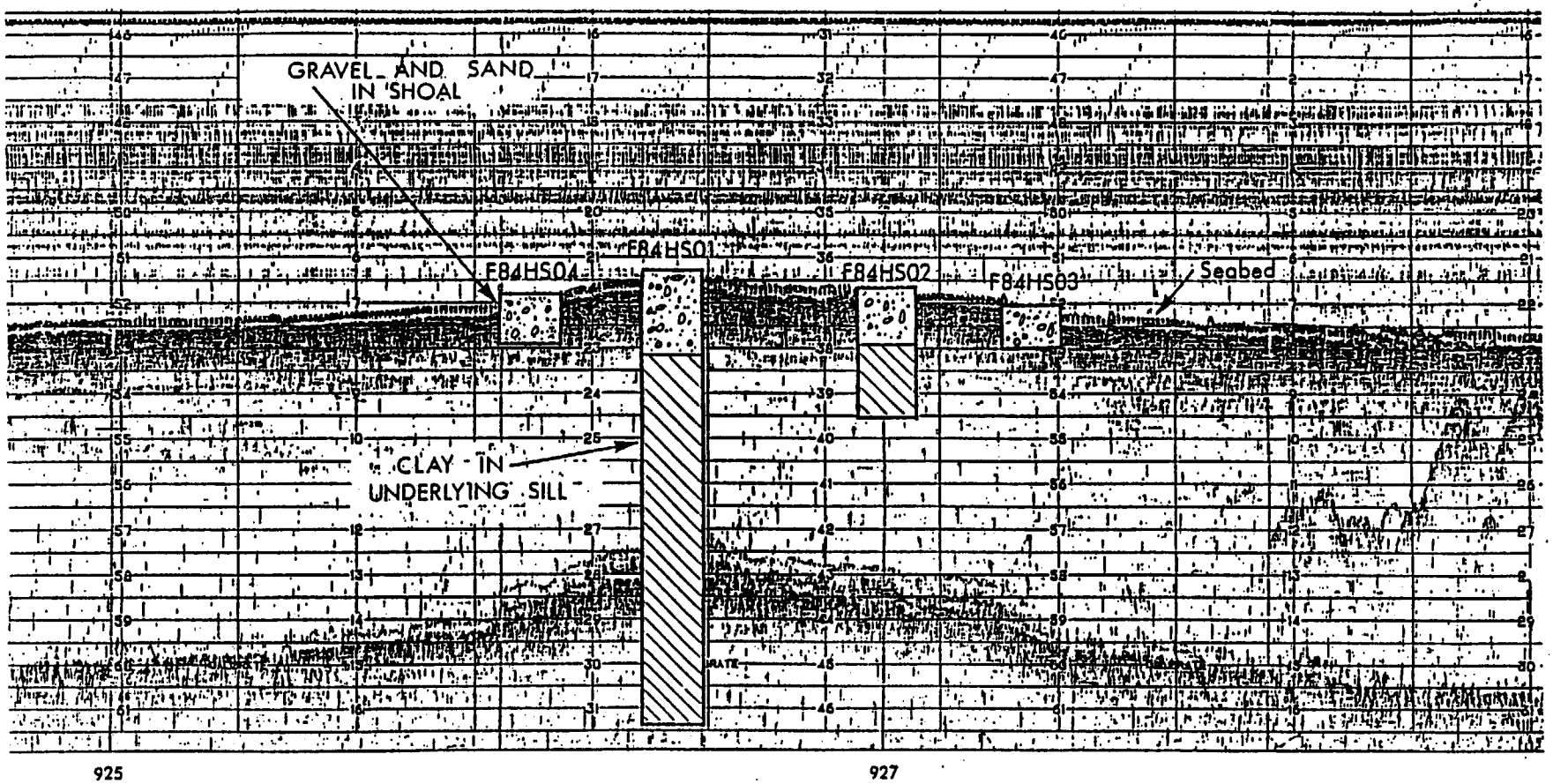

Herschel Basin
HERSCHEL ISLAND
Herschel Sill
Yukon Coastal Shelf
Babbage River Paleochannel
PHILLIPS BAY
Dashed isobaths from CHS data
M. J. O'CONNOR & ASSOCIATES LT
GRAVEL INVENTORY
HERSCHEL ISLAND
BATHYMETRY (m)

FIGURE 2



100m

IHR 845

Stratigraphy of the Shoal South of Collinson Head	M.J. O'CONNOR & ASSOCIATES LTD
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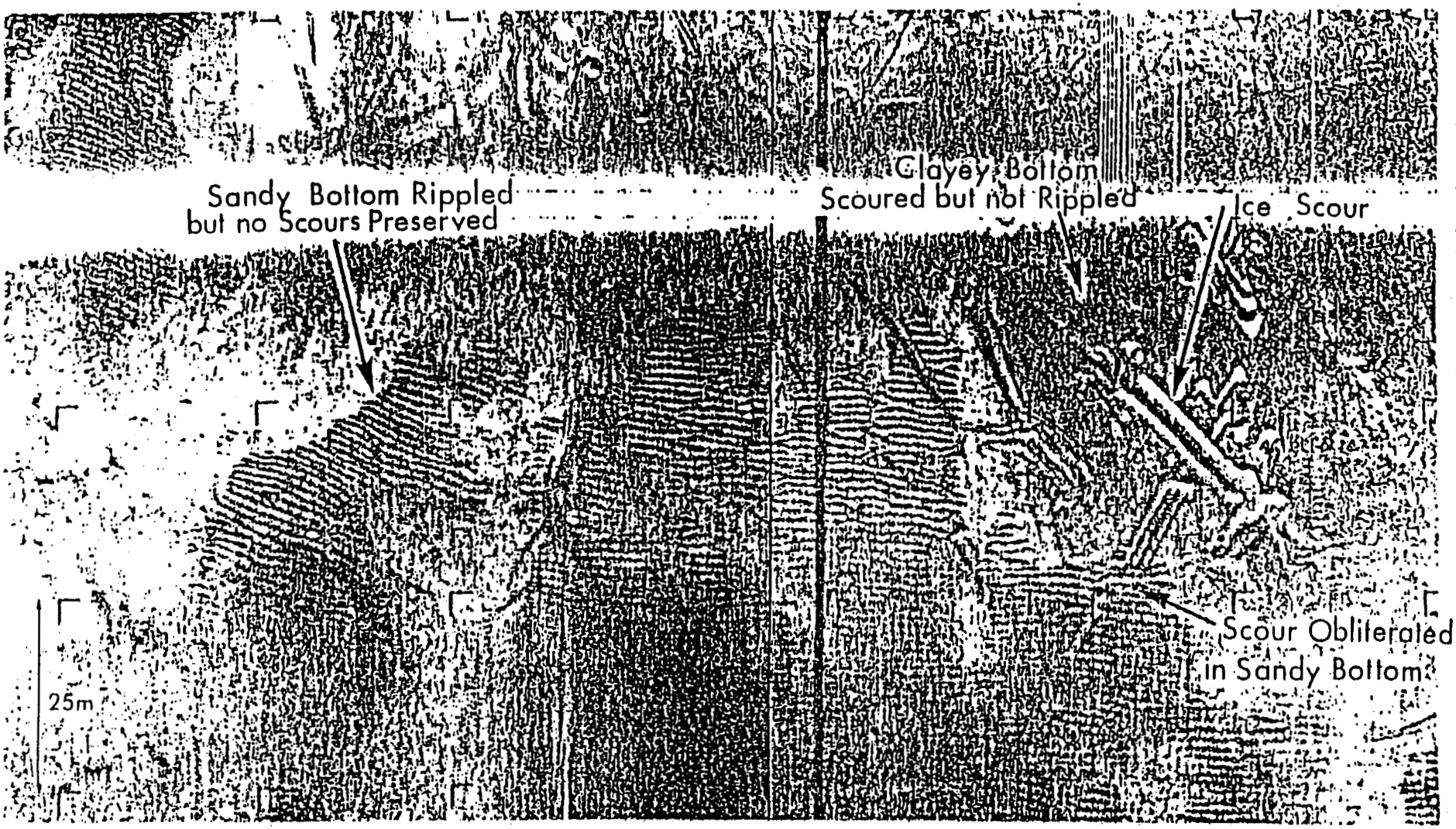
STRATIGRAPHY OF THE SHOAL SOUTH OF COLLINSON HEAD

FIGURE 3



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Ripple Marks Delineate
Seabed Soil Type

FIGURE 4

M.J. O'CONNOR & ASSOCIATES LTD.	
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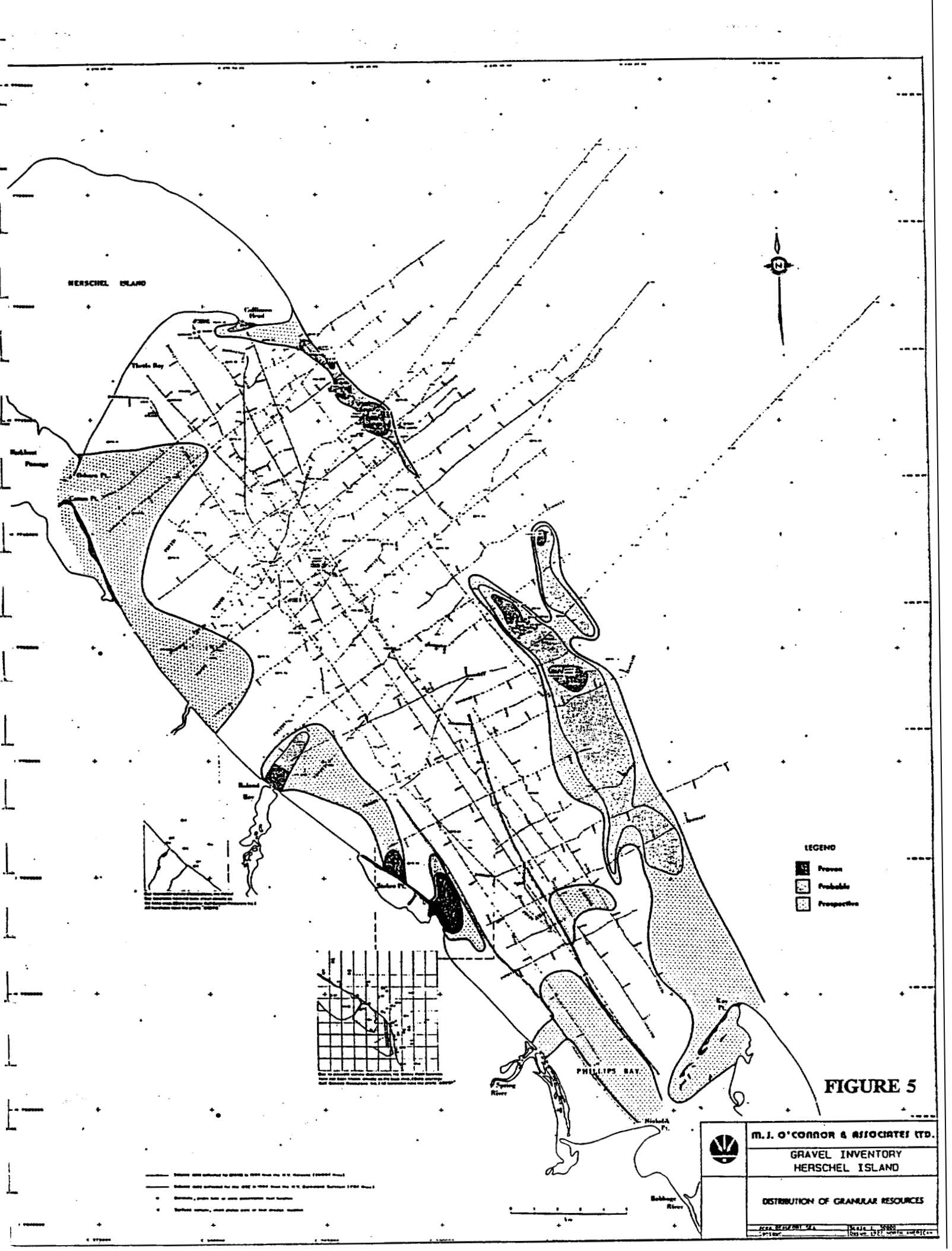

FIGURE 5

M. J. O'CONNOR & ASSOCIATES LTD.

GRAVEL INVENTORY
HERSCHEL ISLAND

DISTRIBUTION OF GRANULAR RESOURCES