Report No. 4871/1042 TR

A REPORT ON THE HYDROGRAPHIC & NAVIGATION ASPECTS OF CABLE ROUTE SURVEYS IN THE GRAND MANAN - DEER IS. AND POINT LEPREAU (N.B.) AREAS

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Under Separate Cover:

Head Harbour Passage Track Chart, Bathymetry Chart & Profiles

Grand Manan Passage Track Chart, Bathymetry Chart & Profiles

Pt. Lepreau Track Chart, Bathymetry Chart & Profiles

COMPUTING DEVICES COMPANY
A DIVISION OF CONTROL DATA CANADA, LTD
ComDev Marine

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Introduction

This Report and Appendix 'B' covers the ComDev Marine involvement in the Grand Manan Channel and Head Harbour Passage Cable Crossing Surveys undertaken in conjunction with Geomarine Associates Limited.

The offshore sub-bottom investigation off Point Lepreau is covered in Appendix 'A', under separate cover.

In these projects, ComDev Marine was sub-contracted to provide the navigation equipment and hydrographic expertise to fulfill the contract obligations and then subsequently to investigate, establish and correlate the various horizontal control networks in the operations area.

1. Summary of Events

Sept. 3.	Meeting with NBEPC in Fredericton, re Grand Manan Survey.
Sept. 8-11.	Reconnaissance of Survey area.
Sept. 12-15.	Research and preparation for survey in Dartmouth.
Sept. 16-18.	Mobilisation of Survey in Grand Manan. Fitting out of survey launch.
Sept. 18.	Setting up Trisponder stations at Wolves and West Quoddy Hd.
Sept. 19.	Operation testing of survey launch off Long Eddy Pt. Setting up Trisponder at Long Eddy Pt.
Sept. 20. (a.m.)	Launch to Black Harbour to pick up ORE spares.
(p.m.)	Commenced survey between Campobello Island and Grand Manan.
Sept. 21-23.	Carried out cable route survey.
Sept. 24.	Survey launch completed bottom sampling and photography.
Sept. 25.	Transferred survey base to Wilson's Beach on Campobello Island. Carried out horizontal control observations between Deer Island and Campobello.
Sept. 26.	Set up Trisponder stations at Leonardville Lt. and horizontal control station "CHOC".
Sept. 27.	Very dense fog. Attempted commencement of survey but experienced problems with water in antenna.
Sept. 28.	Commenced survey.

Oct. 2.	Completed survey.
Oct. 3.	Transferred Survey Base to Point Lepreau.
Oct. 3-11.	Carried out survey at Point Lepreau. For details see Appendix 'A'.
Oct. 11-14.	Consolidation of Survey Data with Geomarine.
Oct. 15-23.	Carried out additional horizontal Control for Grand Manan - Deer Island area. For details see Appendix 'B'.
Oct. 23.	Post Survey compilation commenced.

2. Pre-Survey Activity

2.1 Pre-Survey Conference

2.1.1 A meeting of Geomarine and ComDev Marine personnel with Mr. C. Gallant of NBEPC and Mr. A. Biggar of Montreal Engineering was held in Fredericton on September 3rd to finalize details of the Grand Manan - Campobello Island - Deer Island cable route surveys, during which the following points were resolved.

2.1.2 Routes to be surveyed

a) Deer Island to Campobello Island. Five lines across the channel concentrated in the Casco Island area with six check lines perpendicular to the across-channel lines.

One line parallel to an existing cable to be surveyed using side-scan sonar. This was requested by Mr. Biggar to determine if the cable is buried and was related to the cable laying project in Northumberland Strait scheduled for 1976.

b) Indian Island to Campobello Island. Two lines 1000 feet apart crossing the channel in the vicinity of the existing cable between Cherry Island and Bald Head. Two check lines to be run perpendicular to the across-channel lines.

c) Grand Manan to Campobello Island. The line designated "G" and one line each side at 1000 feet spacing. Three check-lines perpendicular to the across-channel lines.

2.1.3 Horizontal Control

It was hoped that existing horizontal control would be sufficient and adequate for the purpose of the survey and it was agreed that if additional control work was necessary this would be done by ComDev Marine personnel. A reconnaissance survey to attempt to locate existing control points and establish the extent of new control requirements was scheduled for September 8th. Prior to this, E. Williams and W. Latter of ComDev researched existing control information at the Canadian Hydrographic Service in Ottawa and at Bedford Institute in Dartmouth, N.S.

2.1.4 Tidal Reductions

After discussion it was decided that tidal reductions based on Secondary Port prediction would be adequate for the purposes of this survey.

2.1.5 Operations Schedule

Due to the lateness of the season it was stressed that operations should commence as soon as possible and the following projected schedule was drawn up.

September 4th	Research existing control information.
September 8th	Reconnaissance survey to locate existing control and decide on additional control requirements.
September 15th	Start mobilization.
September 18th	Start route surveys.
September 28th	Complete route surveys.

2.2 Pre-Survey Reconnaissance

On the morning of 8th September 1975, Mr. C. Gallant and Mr. R. Mundel of NBEPC, Mr. J. Stewart of Geomarine and Mr. E. Williams of ComDev Marine set out by helicopter from Fredericton to carry out a brief reconnaissance of the Grand Manan - Deer Island survey area. However, owing to low visibility in the Bay of Fundy, this had to be abandoned and the party resorted to vehicular transport.

A fishing vessel inspected at Dipper Harbour as a potential survey launch was found to be unsuitable. Mr. Gallant then returned to Fredericton, and the remainder of the party proceeded to Grand Manan. Another fishing vessel belonging to Mr. Green was inspected, and arrangements made for the hire of this vessel for the survey. Mr. Stewart then returned to Halifax.

Between September 9-11, R. Mundel and E. Williams carried out a reconnaissance of the Grand Manan - Deer Island survey area attempting to locate existing control stations and assess their suitability for the survey requirements. This task was hampered by the fact that there had been little activity by Government Agencies in the survey area in recent years, and many of the existing control points established in past years were unrecoverable or proved to be unsuitable for the survey. It should be noted that when the Canadian Hydrographic Service are carrying out a survey, sufficient control points are established throughout the survey area, and all prominent structures are co-ordinated. Such is the case at the southern end of Grand Manan in their operations in 1948-49.

As a result of the reconnaissance further research was carried out at Bedford Institute between September 12-15, attempting to gather additional horizontal control data for the provisionally selected trisponder sites. These sites tended to be Lighthouse structures, and are normally co-ordinated locations. In this case, only approximate positions were listed, and Mr. T.B. Smith of Bedford Institute warned us to treat the majority of the available horizontal control data with caution.

3. Survey Operations

The survey party was mobilised in Grand Manan in the week beginning 15th September according to the schedule drawn up at the pre-survey conference.

During the first few days, ORE personnel were given the opportunity to install their geophysical equipment in the launch, while the ComDev Marine personnel prepared and set up the navigation system at the Wolves, West Quoddy Head, and Long Eddy Point. The on-board navigation system was installed towards the end of the mobilisation period. Owing to the amount of geophysical equipment and the limited cabin space on the launch, the navigation system could only be installed in the fore-peak area of the vessel. The cockpit space was taken up with the deep tow sidescan winch and left no space for the navigation aids. Ideally, the winch should have been installed on the after deck but the outboard gallows on the launch would have required major reconstruction which could not be justified. For the duration of the survey, the surveyor was located in the fore-peak area tending the navigation equipment and owing to the noise of the boats engines, had to scramble through to the steering position to give the helmsman course alterations, that he could hear above the background noise. This caused a great deal of inconvenience and frustration to all crowded in the cabin space. Two intercom systems were tried out but could not compete against the engine noise.

In order to carry out the survey requirements, it was necessary to have the navigation, echosounder and geophysical equipment all running simultaneously. Invariably, minor problems were encountered with some of the equipment and those which involved the navigation are covered in Section 4.3. However, in this phase of the survey, loss of signal was experienced on foggy days at the extreme ranges of the coverage.

On completion of the Grand Manan Channel survey on September 24th, the base of operations was transferred to Wilson's Beach on the west side of Campobello Island. While the move was taking place ComDev Marine personnel were engaged in horizintal control observation to determine the co-ordinates of the newly established Trisponder locations at Deer Island Point, Leonardville Light and Notice Board.

During the computation of these co-ordinates there appeared to be some discrepancy in the published values of one or more of the existing stations used in the survey of the new stations. Since the time frame for completion of the survey did not permit further investigation at that time provisional co-ordinates were adopted and the survey proceeded. The discrepancy in the provisional values was confirmed when apparent shifts of up to 50 meters in boat position occurred when switching from one pair of Trisponder ranges to another. It was these discrepancies which necessitated the additional horizontal control survey described in Appendix 'B'.

The use of provisional co-ordinates during the operation undoubtedly resulted in some displacement of the actual lines from the intended lines but the extent of this displacement was not considered critical.

The Head Harbour Passage phase of the route survey was scheduled to commence on September 27th but problems with the Trisponder Master Unit on the launch delayed the start. The fault was traced to moisture in the waveguide of the antenna, probably due to very dense fog prevailing at the time, and although the fault was rectified in the field, a spare antenna unit was dispatched from Ottawa. The survey commenced on September 28th and was completed on October 2nd.

4. Equipment and Personnel

The following personnel were deployed by ComDev Marine in the operations: -

E.J. Lancaster-Williams	Hydrographic Surveyor
W.E. Latter	Electronic Technician

The following navigation and hydrographic equipment was supplied by ComDev Marine: -

1 Elac Echosounder and accessories

1 ComDev Trisponder System and accessories

1 Spare Remote

1 CA-1000 Tellurometer

1 Auto Plot System

1 Set Spares, Tools and Test Equipment

5. The Navigation System

5.1 General

The navigation system used was the ComDev Trisponder 202A interfaced to the ComDev Auto Plot System, similar to that used for the route surveys and cable laying exercises in the Northumberland Strait in 1974/75.

The Trisponder 202A is an automatic distance measuring system providing ranges of the survey vessel from two fixed locations on shore. The Auto Plot system converts these ranges to grid co-ordinates and displays the position of the vessel on an X-Y plotter on which the required survey lines have been preplotted. The survey launch is steered in such a manner as to maintain the plotter pen on the preplotted track.

5.2 Theoretical Factors Affecting Trisponder Range

A. Atmospheric Conditions Affecting the Radar Horizon

Radar waves are bent from a straight line in passing through the atmosphere. (See Fig. 1A). The amount of bending depends on the difference in density and amount of water vapor at various levels of the atmosphere.

The distance to the radar horizon is approximately 6% greater than to the optical horizon under 'standard' conditions. This phenomena occurs since radio waves undergo a greater downward bending than light waves.

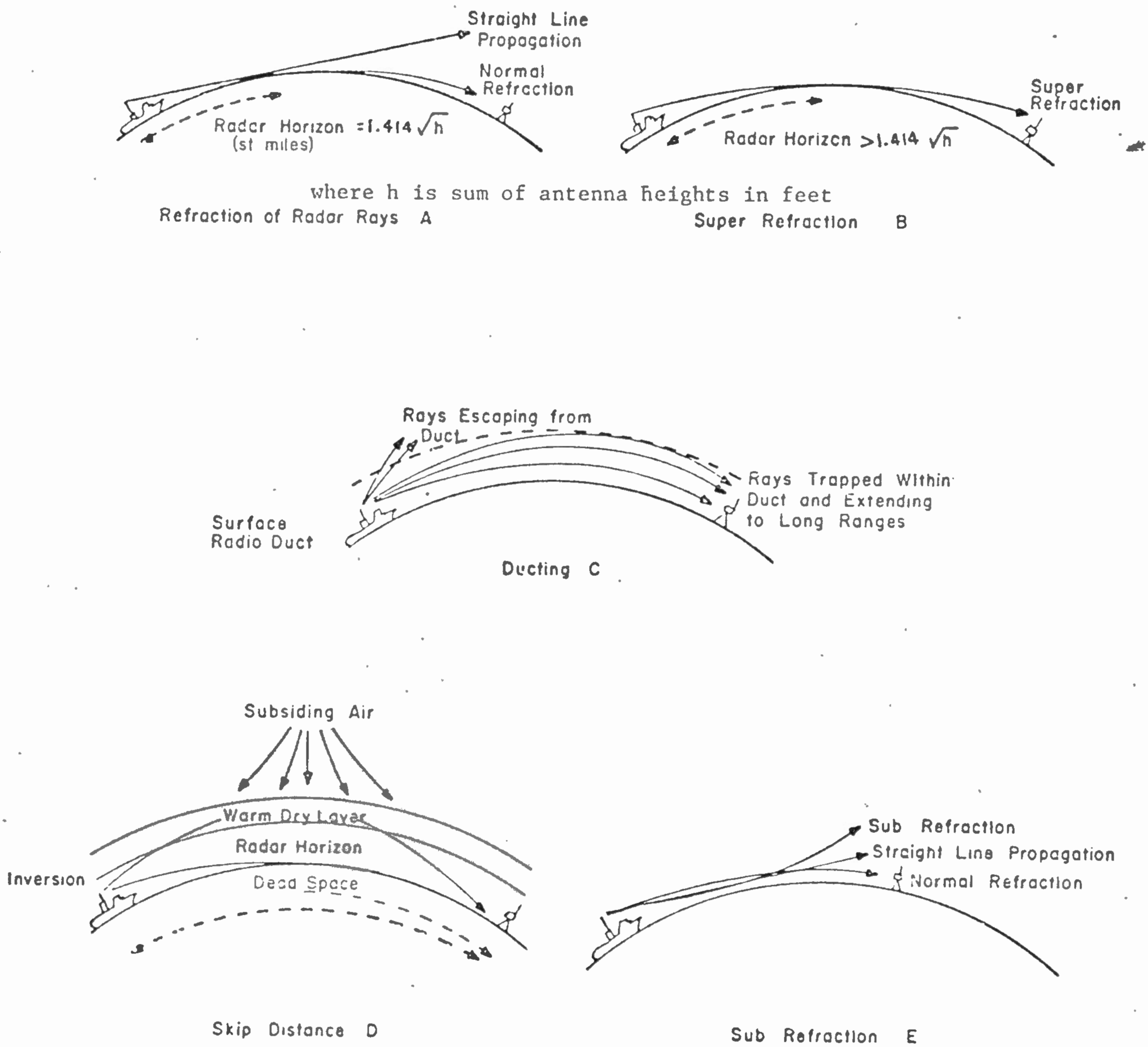

FIGURE 1. CONDITIONS AFFECTING TRISPONDER RANGES

In air whose surface dewpoint is higher than, or equal to, the sea-surface temperature, evaporation takes place from the sea into the air above it. Unless the air is very unstable, this evaporation produces a shallow layer of air, some tens of feet high, immediately above the sea surface, within which water vapor content decreases rapidly with height. This occurrence results in the partial trapping of near-horizontal rays from the radar, and has the effect of increasing radar ranges compared with 'standard' conditions. The conditions described above are more typical than 'standard' and occur widely over oceans.

Accentuated downward bending occurs when temperature decreases with height less rapidly, and/or when water vapor content decreases with height more rapidly than in the 'standard' atmosphere. Either of these conditions (known as 'temperature lapse' and 'humidity lapse' respectively) will result in extended radar detection ranges. (See Fig. 1B). If both occur simultaneously, the effect is even more pronounced. This effect is known as 'super-refraction'.

If the bending downward is very large throughout a certain layer above the earth's surface, radar rays leaving the antenna nearly horizontal in this layer may be wholly or partially trapped within the layer. They will be guided around the earth's surface as far as the layer exists, to distances in excess of the 'standard' range. The region within which the rays are trapped is known as a 'radio duct'. Fig. 1C shows how a radio duct can extend considerably the coverage of a radar whose antenna is situated within it.

When warm and dry air from a land mass flows over a colder sea, a temperature inversion becomes established and there is also much evaporation into the lower layers of the air. Radio ducts are formed almost as soon as the air moves over the sea, and marked super-refraction may be the rule rather than the exception. Small intense ducts extending from 50 to 100 ft. above the sea surface may result in considerable super-refraction. These occur most frequently in sub-tropical latitudes, but also are experienced quite often in temperate latitudes, particularly in summer.

Another weather phenomenon which tends to increase radar range is 'subsidence'. This is a gradual sinking downward and spreading outward of air at high levels, which is most frequently found in regions of high barometric pressure such as anti-cyclones or ridges. The subsiding air becomes warmer and drier than the air below, and a temperature inversion is established as well as a large humidity lapse. This combination is very favourable to duct formation, and the nearly horizontal rays entering the inversion layer may be bent downward to such an extent that they are returned to the surface at very long ranges (Fig. 1C). The distance from the radar antenna to the nearest point at which an indirect ray returns to the surface is known as the 'skip distance', and the phenomenon is known as a 'skip effect'. If super-refraction associated with a radio duct is absent, there will be a blind zone between the zone of reception of the direct rays and that of the indirect rays. This is shown in Fig. 1D, and explains why ranges are sometimes detected at great distances, then disappear to be re-detected at normal distances.

Detection ranges are reduced when meteorological conditions are such that: -

a. Evaporation does not take place. When the surface dewpoint of the air is higher than the sea surface temperature, sea fog generally will occur.

b. The fall in temperature with height is very rapid. This is conducive to good visibility, but may reduce detection ranges.

The effect of these conditions on radar rays which are nearly horizontal is to cause straight-line propagation or to bend the rays upward, (see Fig.1E) giving reduced detection ranges of targets on or near the surface. This phenomenon is known as 'sub-refraction'.

Small reductions in radar range may occur in precipitation, fog, or sandstorms. Rainfall in any area between the Base and Remote units will appreciably reduce range, especially where the rain is heavy. Hail has a similar effect, but that of snow is somewhat less.

B. <u>Detection Range</u>

To obtain a given trisponder range, assuming the necessary power and receiver sensitivity is present, the heights of the Master Transponder and the Remote Transponder must be taken into account. The heights of the antennas may be any feasible ratio, but should obstructions exist between the Master and Remote, either the heights of the antennas must be raised or another remote station used.

Another factor affecting detection range is the Fresnel Zone clearance. In essence, this clearance is that necessary above the grazing surface of a flat land or ocean above an obstruction such as hills or mountain peaks.

A third factor affecting detection range is ground reflections. These reflections can cause a very important effect on the received wave. In the simplest case, the reflection causes attenuation and phase shift along the indirect path. When the wave from the direct path and indirect path converge at the receiving antennas, these two waves combine. If the combination of phase shift at the reflecting point and indirect path geometry cause a 180° reversal of the reflected signal with respect to the direct path - a null will be experienced.

The distance of a null from the remote station can be changed by altering the height of either antenna, but in these cases, it is often simpler to have an alternative station to provide coverage in these areas.

All radio navigation systems using radar frequencies are affected by the above factors, but the advantages of high accuracy and reliability far out weigh the disadvantages.

5.3 Operational Factors Affecting the Trisponder System

During the survey operations, several problems came to light that were peculiar to this project. The boomer and deep-tow sidescan sonar were connected to a separate power supply to the navigation equipment, but throughout the project, enough noise was picked up from the boomer to cause the navigation system to be disrupted. Various remedies were attempted which temporarily helped but did not eliminate the noise problem.

The Trisponder antenna on the survey vessel was mounted on a separate mast and located above the interference zone of the radar antenna and as far out on the boat's beam as possible to minimise the arc that was blocked by the vessel's mast. Owing to the height of this mast, it was impractical to mount the antenna unit on the top of the mast. In any case, the rolling motion of the boat would adversly affect the ranges at that height. During the survey operations, the blocking of the trisponder antenna by the mast did restrict the reception of one of the remote stations from time to time.

In foggy weather, the radar was required for safety reasons, and when close inshore, the Trisponder signals tended to be swamped by the radar signals reflected off the cliffs, reducing the effective navigation coverage under these conditions.

The Trisponder antenna on the survey launch proved to be defective under the conditions of excessive atmospheric moisture. Condensation inside the antenna built up to the point where the propagation of signal was blocked. A spare antenna was dispatched from Ottawa, but after drying out and field repairs, the new unit was not required.

5.4 The Operation of the Auto Plot System

The Auto Plot System reads the 1-second updated Trisponder ranges and converts these ranges into a grid position based on the co-ordinates of the two remote stations. With the rapid update of ranges, an instantaneous position of the survey vessel is obtained, and the direction of progress is readily seen. This system is ideal for use where a straight survey line is required, rather than a track that follows a range arc on one of the remote stations.

The Auto Plot System analyses the present position of the survey vessel against the last recorded fix and when the distance since the previous fix, or the time elapsed since the previous fix meets the predicted parameters, a new fix is initiated. A fix mark is generated to mark the echogram and any other peripheral recorders connected to the system.

During the survey operations, the boomer caused an intermittant build up of feed back noise which created havoc with the trisponder ranging and initiated spurious fix marks on all the records. At such times, the navigation system was isolated from the rest of the equipment and the geophysical records were marked by hand. With the extra amount of work this created, this was a retrograde solution, but no operational time could be spared to find a better solution for this problem.

5.5 Conclusions

On past projects this navigation system has worked well with various geophysical equipment. However, during this project, the cramped conditions on the launch undoubtedly contributed to a high degree to the problems we experienced in the field. It was impossible to isolate systems from one another to prevent signal crossover in the cables and the close proximity of the boomer was a constant source of electrical noise.

In the past projects, the layout of the equipment has enabled the sensitive components in the system to be isolated and screened from electrical noise.

This project has made it clear that on future projects of this multidisciplinary nature, the selection of the vessel and layout of equipment must be given a great deal more thought in the planning stage to both screening and isolation of electrical systems.

6. Post Survey Compilation

The Grand Manan Channel and Head Harbour Passage Surveys were replotted upon return to Ottawa, at a scale of 1/12000 using the corrected trisponder remote locations. (See Appendix 'B').

The hydrography and profiles were reduced to Geodetic Datum at St. John, N.B., using secondary port predictions for North Head, Grand Manan, and Wilson's Beach and Campobello Island.

Owing to the depths encountered on the survey line, it was impractical to plot the profiles at a vertical scale of 1/120. After consultation with Geomarine, the profiles were plotted at a vertical scale of 1/240.

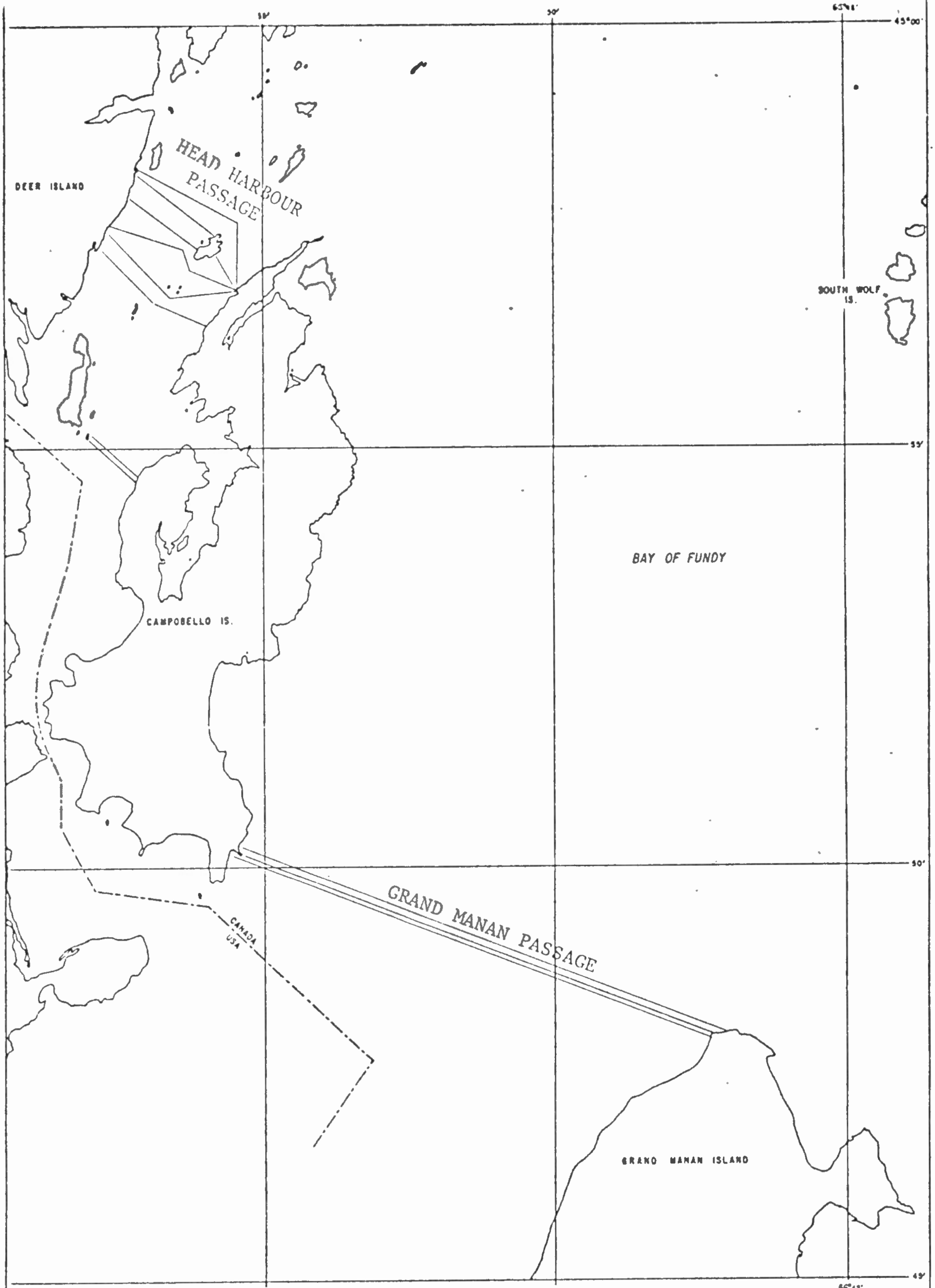

FIGURE 2. CABLE CROSSING ROUTES

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APPENDIX 'A'

POINT LEPREAU SURVEY

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Introduction

This Report covers ComDev Marine's involvement in the seismic and bathymetric survey carried out in conjunction with Geomarine Associates at Point Lepreau, New Brunswick in October 1975, for the proposed intake and discharge routes for the NBEPC Nuclear Plant.

During the project, the NBEPC Project Engineer, Mr. M. Mosher, accompanied the survey team and co-ordinated our requirements ashore with the NBEPC Nuclear Plant organisation.

1. Summary of Events

Sept. 3. - Meeting with NBEPC in Fredericton re the Point Lepreau Survey.

Oct. 3. - Remobilisation of survey team at Point Lepreau.
- Reconnoitred area and selected existing control stations for Trisponder locations.
- Set up Trisponder remotes around Duck Cove.

4. - Sea conditions too rough for boat work.

5. - Commenced survey operations in Duck Cove but hampered by presence of drilling barge and deterioration of sea conditions.

6. - Sea conditions too rough for boat work.

7. - NBEPC surveyors establish two new stations in Duck Cove.
- Continued survey operations in Duck Cove.

8. - Completed survey operations in Duck Cove.
- Transferred Trisponder remotes to Indian Cove to preselected sites.

9. - Commenced survey operations in Indian Cove but work hampered by presence of drilling barge until late afternoon.
- Completed survey operations.

10. - Demobilisation

11. - Returned to Halifax.

2. Description of Events

A. Pre-Survey Conference

A meeting of Geomarine and ComDev Marine personnel with Mr. M. Mosher of NBEPC was held in Fredericton on September 3, 1975 in order to finalise the requirements of the Point Lepreau survey. The following points were resolved.

1. Lines to be surveyed

A total of eight survey lines to be run, three lines in Indian Cove, and five lines in Duck Cove.

Line No.	N.B. Grid Co-ordinates	Bearing of Line
1	477 650 N 1012000E	S 78.00 E
2	478 035 N 1012000E	S 35.00 E
3	477 510 N 1012000E	S 35.00 E
4	476 985 N 1012000E	S 35.00 E
5	475 800 N 1012000E	S 30.00 E
6	476 565 N 1010000E	S 51.00 W
7	477 335 N 1010000E	S 51.00 W
8	476 950 N 1010000E	S 51.00 W

An additional nine tie lines were required by Geomarine to correlate the survey lines to one another.

2. Control Work

Mr. Mosher agreed to provide information on the control used on the previous surveys in the area, and any additional control would be put in by NBEPC surveyors working at the Nuclear site.

3. Reduction of Bathymetric Data

A tide gauge has been installed by MacLaren Atlantic at Dipper Harbour, and it was hoped to use this tidal data to reduce the bathymetric data collected on this project.

(On completion of the project it was found that this tide gauge was non-operational and the bathymetric data was reduced to Geodetic datum at St. John, N.B., using secondary port predictions for Dipper Harbour.)

B. Pre-Survey Preparation

Owing to the fact that the navigation system operates in metric units, it was decided that the simplest method of carrying out the survey was to convert all N.B. grid co-ordinates in feet into the metric equivalent, and base the survey on these values. The co-ordinates of the Trisponder locations used are as follows: -

Station	N.B. Grid		Metric Equivalent	
	E.	N.	E.	N.
C-14-1	1008638.57	477037.36	307433.036	145400.987
C-15	1010037.86	474592.35	307859.540	144655.748
Line 8 (Off set station)	1010415.748	477265.358	307974.720	145470.481
C-19	1012229.071	477058.945	308527.421	145407.566
C-19-SW	1012000.00	476900.00	308457.600	145359.120
C-19-3	1013689.632	479557.627	308972.600	146169.165
New Point	1011663.28	476135.16	308354.968	145125.997
X	1012109.984	477836.171	308491.123	145644.465
XI	1015349.915	479608.461	309478.654	146184.659

C. Survey Operations

Upon completion of the Grand Manan Channel and Head Harbour Passage cable route surveys, the fishing vessel "Bonney Brook" and survey team remobilised at Point Lepreau on the morning of 3rd October.

With the assistance of the NBEPC surveyors working at the Nuclear Plant, a reconnaissance was carried out of the available control stations along the coastline of the Point. It was agreed that two further control points be surveyed in by NBEPC on the north shore of Duck Cove in order to provide better navigation coverage in the survey area.

During the remainder of that day, the Trisponder remotes were set up on selected control stations around Duck Cove.

The following morning the launch left Dipper Harbour for Duck Cove but found the sea conditions too rough in the cove to carry out any survey work in the vicinity of the submerged rock outcrops.

On 5th October, survey operations in Duck Cove were commenced, but the arrival of the drilling barge in the middle of the survey area restricted the amount of work we were able to achieve. However, later that day, the sea conditions deteriorated and stopped work for the day. These conditions prevailed well into the following day also.

On 7th October the survey proceeded using the existing control stations while the NBEPC surveyors put in the two additional control stations that were required. The Trisponder remotes were then transferred to these new stations in preparation for the following day.

The survey in Duck Cove was completed by noon on 8th October and the Trisponder remotes were then transferred across to Indian Cove.

On 9th October, while the launch proceeded to Indian Cove, ComDev Marine personnel contacted the NBEPC surveyors for the co-ordinates of an additional station that we were required to use on the west side of the Point. By the time the launch had arrived at Indian Cove, the drilling barge had again stationed itself in the middle of the survey area and hampered progress on the survey for most of the day. However, in the late afternoon, the barge returned to Dipper Harbour and enabled the remainder of the survey to be completed that evening.

The following day the equipment was demobilised and the launch returned to Grand Manan.

3. Equipment and Personnel

The following personnel were deployed by ComDev Marine in the operations: -

E.J. Lancaster-Williams	Hydrographic Surveyor
W.E. Latter	Electronic Technician

The following navigation and hydrographic equipment was supplied by ComDev Marine: -

1 Elac Echosounder and accessories

1 ComDev Trisponder System and accessories

1 Spare Remote

1 CA-1000 Tellurometer

1 Auto Plot System

1 Set Spares, Tools and Test Equipment

4. Post-Survey Compilation

The Point Lepreau surveys were replotted upon return to Ottawa at a scale of 1/2400. This scale was agreed upon by Geomarine in consultation with NBEPC as being the largest scale consistant with the accuracy of interpolation of data from the echosounder and geophysical records.

The hydrography and profiles were reduced to Geodetic datum at St. John, N.B., using secondary port predictions for Dipper Harbour.

The profiles were plotted at a vertical scale of 1/120.

APPENDIX 'B'

REPORT ON ADDITIONAL HORIZONTAL CONTROL SURVEY FOR THE GRAND MANAN, CAMPOBELLO, DEER ISLAND CABLE ROUTE SURVEYS.

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Introduction

Owing to the necessity to commence and complete the cable crossing surveys before the deterioration of sea and weather conditions towards the end of the survey season, there was insufficient time to carry out the necessary control work prior to the mobilisation of the survey in the field. Time permitted only a brief reconnaissance to be made of the area to determine likely locations for the Trisponder remote stations.

These locations were chosen to give good coverage in the survey areas, and were on known control stations wherever possible. Existing control stations in the survey area originates from six different agencies, and the co-ordinate values of these stations are not necessarily correlated with the values of neighbouring stations.

During the survey, discrepancies were noted between the positions of the survey vessel when using different combinations of Trisponder remote stations indicating in this case, errors in the co-ordinate values used.

On completion of the marine work it was therefore imperative that a programme of horizontal control observations should be carried out in order to tie the trisponder locations together in a single self checking network.

Section 1.

The Existing Horizontal Control

The existing horizontal control in the area originates from six different agencies: -

1) Geodetic Survey of Canada (G.S.C.)
2) Canadian Hydrographic Service (C.H.S.)
3) Topographic Survey (TOPO.)
4) New Brunswick Provincial Survey (N.B.P.S.)
5) International Boundary Commission (I.B.C.)
6) New Brunswick Electric Power Commission (N.B.E.P.C.)

These agencies each establish control stations to suit their individual needs, and the majority of stations were not suitable for the requirements of this survey. During the reconnaissance, previously selected stations proved to be unsuitable or irrecoverable.

It was hoped during the initial planning stage for this survey to make full use of previously co-ordinated lighthouse structures for the majority of the trisponder locations with a commanding view over the survey area, and with a readily available power supply at most structures to keep the batteries charged. However, the CHS had not been recently in the area and only approximate positions were available from government agencies.

A revised selection of trisponder locations was made, making use of the control stations available, and establishing new stations where required. The following stations were used during the survey: -

Long Eddy Lt. Ho.	Grand Manan	Co-ordinates from NBEPC
Wolves 18107	S. Wolf Island	" " GSC
Whitehorse	Whitehorse Is.	" " GSC
Head Harbour Lt. 18127	Campobello Island	" " GSC
16781	Campobello Island	" " NBPS
16755	"	" " "
16761	"	" " "
16765	"	" " "
Notice Board	"	New Station
Leanordville Lt.	Deer Island	New Station
Choc (1110)	"	Co-ordinates from CHS
Deer Island Pt. Lt.	"	New Station

The following stations were reconnoitred but not used.

Station	Source	Remarks
Campobello		
E. Campobello 18109	GSC	Inaccessible to vehicular transport.
Han	CHS	Not found.
Head Harbour Lt. 18127	GSC	Wrongly positioned.
Frians Head	IBC	Not found.
Owen	CHS	Not found.
W. Campobello 18111	GSC	Found, but blocked by trees.
1700	NBEPC	Not found.
Campobello	IBC	Found, but not of use.
16782	NBEPC	Destroyed.
Grand Manan		
Indian 1131	CHS	Destroyed.
Post 48 Dark Harbour	Topo	Destroyed.
Grand Manan	IBC	Not found.
Ash 1118	CHS	Not found.
Bishop 1119	CHS	Not found.
Grand Manan 09101	GSC	Found, but blocked by trees.

DEER ISLAND

MONUMENT RECORD

SURVEYS AND MAPPING BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

FILE CODE 44-66 NW

MONUMENT CHOC (1110)

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE			
FIELD OFFICER		LATITUDE	44 56 52.738		
TYPE OF SURVEY	Triangulatio	LONGITUDE	66 58 14.531		
SOURCE	Hydrographic	DATUM	N.A. 1927		
MONUMENT TYPE	Rock Post	UTM NORTHINGS	4,979,958.09		
DATE PLANTED	194[illegible]	UTM EASTINGS	660,059.12		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS	134.0'		
THEODOLITE		LEVELLING METHOD			

CHOC (1110)

Description: The station is situated on a summit just north of Chocolate Cove, Deer Island, N.B. It is marked by a Canadian Hydrographic rock post cemented in a granite boulder. This station can readily be reached by boat to the wharf in the cove and from the shore across from the wharf there is a path that leads to the summit where the station is located.

MONUMENT RECORD

SURVEYS AND MAPPING BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

#18106

FILE CODE 44-66 NW

MONUMENT WHITEHORSE

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE			
FIELD OFFICER		LATITUDE	44 59 30.760		
TYPE OF SURVEY	Triangulation	LONGITUDE	66 52 20.916		
SOURCE	Geodetic	DATUM	N.A. 1927		
MONUMENT TYPE	Bronze Tablet	UTM NORTHINGS	4,984,032.88		
DATE PLANTED	1918-1962	UTM EASTINGS	667,710.09		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS	100.0		
THEODOLITE		LEVELLING METHOD	(Trig)		

Whitehorse

Description: Located on the summit of a small gull island in Passamaquoddy Bay, situated halfway between the eastern end of Campobello Island and Bliss Island. Reached by launch from any of the harbours in the bay, the nearest being Head Harbour, three miles distant on the island of Campobello. Marked by a bronze tablet surrounded by a triangle and stamped with the station number 18106. A reference arrow is cut in a nearby outcrop of rock. Note: There was a wooden tripod over the station mark in 1962.

Elevation: 100.0' (TRIG)

MONUMENT RECORD

SURVEYS AND MAPPING BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

#18107

FILE CODE 44-66 NW

MONUMENT WOLVES

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE			
FIELD OFFICER		LATITUDE	44 56 11.987		
TYPE OF SURVEY	Triangulation	LONGITUDE	66 44 05.109		
SOURCE	Geodetic	DATUM	N.A. 1927		
MONUMENT TYPE	Bronze Tablet	UTM NORTHINGS	4,978,193.68		
DATE PLANTED	1918-1962	UTM EASTINGS	678,738.18		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS	None		
THEODOLITE		LEVELLING METHOD			

Wolves

Description: Located on the southern end of South-West Wolf Island in Charlotte county, N.B. The island is the most southerly of a group known as "The Wolves", off the eastern end of Grand Manan Channel, Bay of Fundy. Reached by launch from any of the harbours in the bay, the nearest being Welchpool on Campobello Island from which it is distant about 17 miles. The point of 145.88 feet from the centre of the lighthouse tower on a rounded outcrop of grey granite. The station is coincident with a previous station of the U.S. Coast and Geodetic Survey. Marked by a copper bolt surrounded by a triangle, and stamped with the station number 18107 in 1962. Note: The top of the tablet has been removed. The stem marks the station.

MONUMENT RECORD

TOPOGRAPHICAL SURVEY
SURVEYS AND MAPPING BRANCH
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

FILE CODE 44-66 NW

7 28127

MONUMENT HEAD HARBOUR L

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE	Aug., 1961		
FIELD OFFICER		LATITUDE	44 57 29.50		
TYPE OF SURVEY	Triang.	LONGITUDE	66 54 01.22		
SOURCE	Geodetic	DATUM	N.A. 1927		
MONUMENT TYPE	L.H.	UTM NORTHINGS	4,980,233.8		
DATE PLANTED	1918	UTM EASTINGS	665,610.7		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS			
THEODOLITE		LEVELLING METHOD			

Head Harbour L.H.

Description: Situated on the outermost rock of East Quoddy Head, northeast of Campobello Island, Charlotte County, N.B.

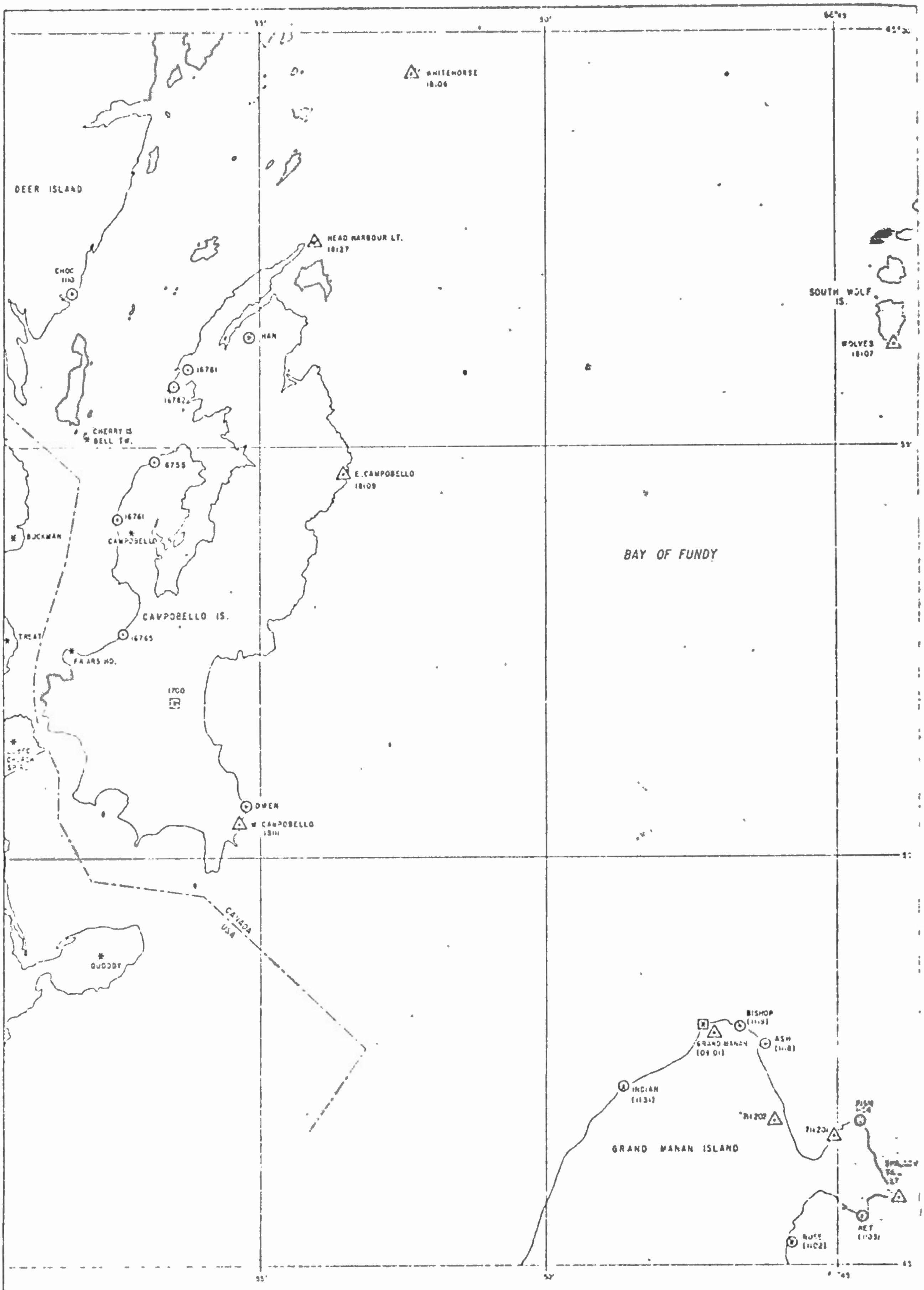

Fig. A. PERTINENT KNOWN CONTROL STATIONS

△ G.S.C.   ⊙ HYDROGRAPHIC
⊙ . B   ⊡ TOPOGRAPHIC
* I.B.C.   ⊡ N.B.E.P.C.

Section 2.

Methodology

It was planned to base the observed network of horizontal control on a series of interlinked geometrical figures that would be self-checking for gross errors. A base line between two GSC first order control stations, Wolves and Whitehorse, was established. Upon the accuracy of these positions depended the scaling and orientation of the network. The braced quadrilateral taking in stations Whitehorse, Wolves, Long Eddy and Head Harbour Lt. Ho. provided a mathematically rigorous method to tie Long Eddy into the network, without incurring an appreciable depreciation in accuracy over the long distances. The western end of the network tied into three known stations, Choc, 16781, and 16755, to give comparison between this present work and past work by other agencies.

Angular measurements were taken at each of the trisponder locations to prominent station marks erected at the unmarked stations, using a 1 second theodolite. At most of these locations, a false station had to be established, and considerable care was taken in order that little error was introduced by such an offset. All theodolite observations were carried out using the methods and techniques accepted by the Geodetic Survey of Canada to achieve at least third order accuracy of work or better.

The base line distance was measured by tellurometer to confirm the base line length, and several other key distances were measured also, to provide a check on the final calculated distances.

In the past, the stations used that had been established by the different agencies, were probably not tied into an all embracing network. For this reason, it was decided to use the co-ordinate values of this present work for the survey, rather than the existing values. It can be seen in Section 5 that the difference in the values will not affect the plotting of the work. During this control work, access to the offshore islands and transportation between Deer Island and Campobello was achieved by the use of local fishing boats.

The control work was progressed with the minimum of down time possible, but 3½ days down time was experienced due to bad weather or unfavourable visibility conditions.

Section 3

Equipment And Personnel

The additional control observations were carried out by the following personnel:-

E.J. Lancaster-Williams	-	Surveyor in charge
M. Lambert	-	Assistant

The following equipment was used:-

1	Kern DKM 2-A and tripod
1	CA1000 Tellurometers and tripods
1	Hire car
6	Station Markers

Section 4

Chronology

15 October

1200 Personnel arrived St. John's airport.

p.m. Moved into 45th Parallel Motel, Deer Island.

16 October

Low visibility, thunder and rain all day.

Arranged hire of local fishing boat.

17 October

Erected survey marker at Choc.

Completed observations at Wolves and Whitehorse.

M. Lambert landed at Wilsons Beach, Campobello.

18 October

Low visibility and rain all day.

19 October

Completed observations at Choc and Leonardville on Deer Island.

20 October

a.m. E.J.L. Williams transferred to Campobello.

Completed observations at Notice Board.

p.m. Low visibility and rain all afternoon.

21 October

Strong winds and haze prevent productive work.

22 October

a.m. Completed observations at Head Harbour Lt.

p.m. E.J.L. Williams transferred to Grand Manan.

Haze and oncoming dusk prevent observations at Long Eddy.

23 October

a.m. Completed observations at Long Eddy.

p.m. Returned to St. John's Airport and returned to Ottawa.

Section 5

Summary of Observations and Adjustment

Description of Stations Co-ordinated

WOLVES

Bronze tablet No. 18107 established by GSC, situated 145.88 ft. SW of South Wolf Island Light House.

WHITEHORSE

Bronze tablet No. 18106 established by GSC, situated on the summit of Whitehorse Island.

HEAD HARBOUR LT. HO.

Centre of Light.

LONG EDDY LT. HO.

Centre of Light.

LEONARDVILLE LT. HO.

Centre of Light.

CHOC

Bronze tablet No. 1110 established by CHS, situated on a summit just north of Chocolate Cove.

DEER ISLAND PT. LT.

Centre of Light.

STATION 16781

Bronze tablet No. 16781 established by New Brunswick Provincial Survey, situated on the summit of a small hill behind Wilsons Beach Church.

NOTICE BOARD

The SW support of a NBEPC Notice Board warning of Submarine Cables.

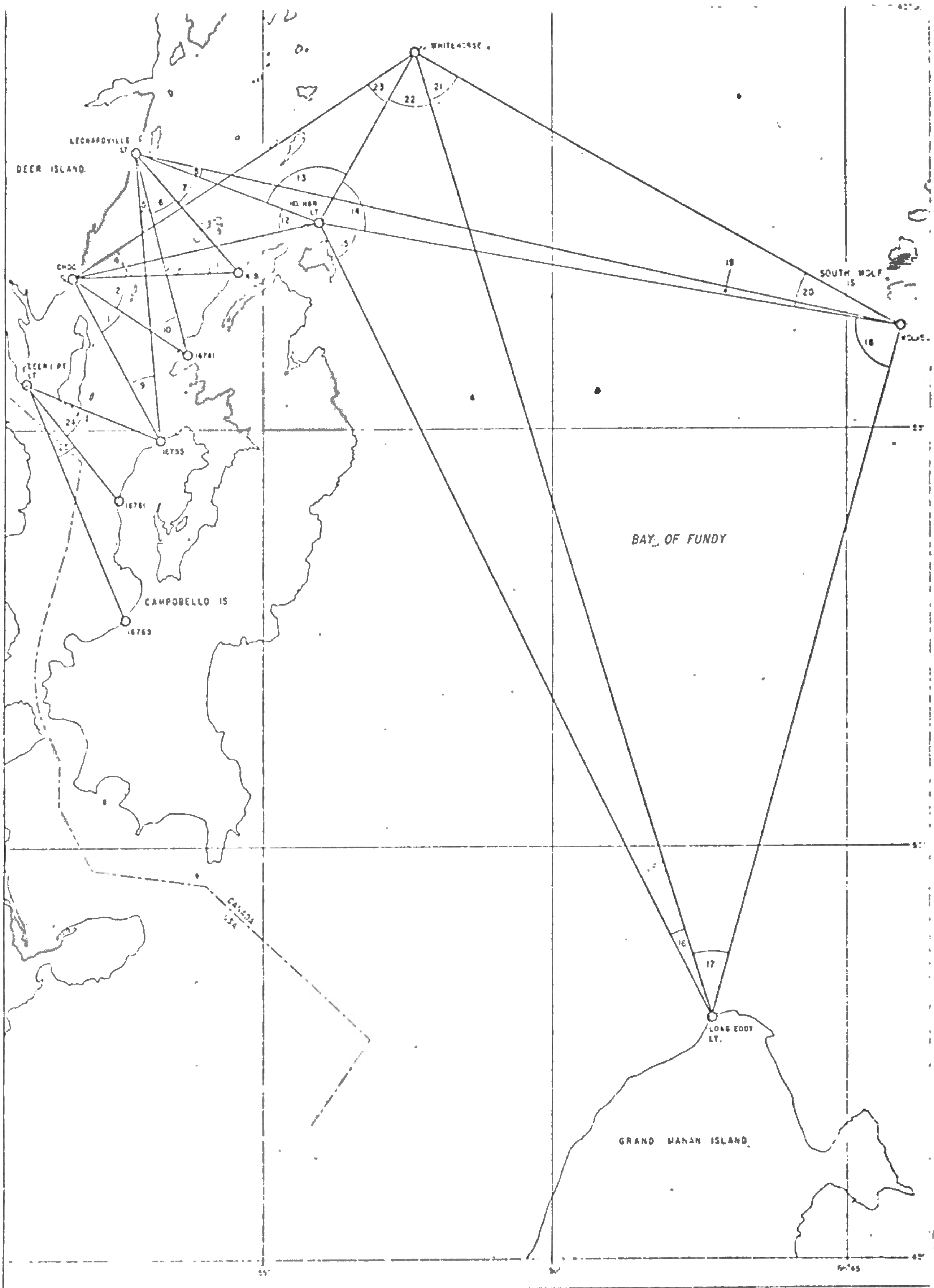

Fig. B. NETWORK OF ADDITIONAL HORIZONTAL CONTROL

CONDITION EQUATIONS USED FOR LEAST SQUARES ADJUSTMENT

A)	(14) +(22) -(18) -(17)	= 0
B)	(15) +(16) -(20) -(19) -(21)	= 0
C)	(14) +(15) +(16) +(17) +(18) +(19) +(20) +(21) +(22) - 360	= 0
D)	(8) +(13) +(14) +(19) -180	= 0
E)	(7) +(12) -(11) -(3)	= 0
F)	(6) +(7) +(12) -(10) -(2) -(3)	= 0
G)	(5) +(6) +(7) +(12) -(1) -(2) -(3) -(9)	= 0
H)	(5) +(6) +(11) -(1) -(2) -(9)	= 0
I)	(6) +(11) -(2) -(10)	= 0
J)	(5) +(10) -(1) -(9)	= 0
L)	(4) +(12) +(13) +(23) -180	= 0
K)	Sin(14) Sin(21) Sin(18) Sin(16)/Sin(15) Sin(17) Sin(20) Sin(22)	= 1

Summary of Observed Angles, Corrected for False Station, & (t-T)

Angle No.	Corr. Observed Angle	Least Squares Correction	Final Adjusted Angles
1	30 43 44.1	+0.6001	30 43 44.7001
2	31 54 28.4	+2.9005	31 54 31.3005
3	11 51 50.4	-1.0981	11 51 49.3019
4	20 58 43.5	-0.3927	20 58 43.1073
5	14 44 33.5	-1.2003	14 44 32.2997
6	26 13 22.5	-2.9005	26 13 19.5995
7	27 43 47.4	+1.0981	27 43 48.4981
8	3 26 14.6	+0.4727	03 26 15.0727
9	20 07 33.0	+0.6001	20 07 33.6001
10	36 06 43.1	+2.9005	36 06 46.0005
11	41 48 01.7	-3.9985	41 47 57.7015
12	25 55 57.8	+0.7053	25 55 58.5053
13	105 39 55.2	+0.0801	105 39 55.2801
14	69 44 12.7	-2.1256	69 44 10.5744
15	52 36 28.9	-0.4674	52 36 28.4326
16	9 29 37.3	-1.0103	09 29 36.2897
17	32 32 01.8	-0.5948	32 32 01.2052
18	85 21 54.8	-0.7275	85 21 54.0725
19	1 09 38.6	+0.4728	01 09 39.0728
20	19 14 28.5	-2.5302	19 14 25.9698

Summary of Observed Angles, Corrected for False Station, & (t-T) Cont'd

Angle No.	Corr. Observed Angle	Least Squares Correction	Final Adjusted Angles
21	42 51 41.6	-2.8475	42 51 38.7525
22	48 09 47.2	-2.4967	48 09 44.7033
23	27 25 23.5 *	-0.3927	27 25 23.1073
24	26 50 38.2	-------	26 50 38.2
25	15 25 36.5	-------	15 25 36.5

* Calculated

Summary of Calculated Co-ordinates

STATION	TRIAL CO-ORDINATES		FINAL CO-ORDINATES	
WOLVES 18107	4,978,193.68N	678,738.18E	4,978,193.68N	678,738.18E
WHITEHORSE 18106	4,984,032.88	667,710.09	4,984,032.88	667,710.09
LONG EDDY LT.	4,962,867.0	675,338.2	4,962,833.41	675,108.60
HEAD HARBOUR LT.	4,980,233.8	665,610.7	4,980,196.22	665,590.07
LEONARDVILLE LT.	(4,981,220.0	661,230.0)	4,981,226.82	661,216.13
CHOC	4,978,958.09	660.089.12	4,978,958.99	660,088.63
NOTICE BOARD	(4,979,060.0	663,790.0)	4,979,011.04	663,766.13
16781	4,977,277.47	662,876.30	4,977,278.22	662,875.11
16755	4,975,282.96	662,057.29	4,975,285.53	662,056.10
DEER ISLAND PT. LT.	4,976,407.2	659,002.0	4,976,414.50	658,994.29
16761	4,974,006.45	661,230.48		
16765	4,971,494.13	661,550.65		

Owing to Trisponder Stations being offset from the calculated positions listed above, the co-ordinates of the trisponder stations are as follows.

TRISPONDER SITE	NORTHINGS	EASTINGS
WOLVES	4,978,193.68	678,738.18
WHITEHORSE	4,984,032.88	667,710.09
LONG EDDY	4,962,834.52	675,106.42
HEAD HARBOUR LT.	4,980,200.45	665,582.31

Cont'd

TRISPONDER SITE	NORTHINGS	EASTINGS
LEONARDVILLE LT.	4,981,226.35	661,217.52
CHOC	4,978,959.48	660,088.44
NOTICE BOARD	4,979,011.04	663,766.13
16781	4,977,278.49	662,875.26
DEER ISLAND PT.	4,976,413.87	658,992.57

Summary of Measured Distances

DISTANCE	CORRECT OBS. GRID DIST.	CALC. GRID DISTANCE
WOLVES-WHITEHORSE	12,478.125	12,478.583
CHOC-NOTICE BOARD	3,678.634	3,677.868
LEONARDVILLE-HEAD HARBOUR LT.	4,492.669	4,493.716
LONG EDDY LT-HEAD HARBOUR LT.	19,802.778	19,800.747
WHITEHORSE-HEAD HARBOUR LT.	4,383.412	4,383.428
DEER PT-16765	5,544.590	5,544.819
DEER PT-16761	3,286.316	3,286.221

Section 6

Conclusions

The least squares adjustment of the horizontal Control network applied corrections to the observed angles to make the network geometrically correct. The measured distances give an indication of the accuracy of the adjusted network. However, these distances were measured soley to provide a check, and are "coarse" readings. To bring the distance measurement into the same order of accuracy as the angular measurements, an average of many "fine" readings would have to be taken, and then a least squares adjustment by variation of co-ordinates would have been applied.

The accuracy of the final co-ordinate values may be approximately ascertained by the analysis of the worst case.

The longest observed line is Whitehorse to Long Eddy, being 22453 m. long. The largest error in the braced quadrilateral is 2.85 secs of arc.

Applying such an offset over that distance gives a subtended distance at Long Eddy of 0.31 m. It is therefore probable that the co-ordinates have an accuracy better than 1 metre.

Attention is therefore drawn to the differences of co-ordinates of the following stations to those published:-

1. <u>Head Harbour Lt. House</u>

Published GSC values	4,980,233.8N	665,610.7E
Calculated values	4,980,196.22N	665,590.07E
Differences	37.58	20.63
Distance Difference	42.87m.	

2. <u>Long Eddy Lt. House</u>

Published NBEPC values	4,962,867.0N	675,338.2E
Calculated values	4,962,833.41N	675,108.60E
Differences	33.59	229.60
Distance Difference	232.04m.	

It was these errors that resulted in the requirement of additional Horizontal Control in the survey area.

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