EBA Engineering Consultants Ltd.

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YA-YA GRANULAR RESOURCES STUDY 1975

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ABSTRACT

This report presents, in two volumes, the findings of an exploratory drilling program carried out to evaluate the quality and quantity of borrow material in the Ya-Ya Lake esker-kame complex on Richards Island, N.W.T. The work was commissioned by the Arctic Petroleum Operators Association and field support was provided by Imperial Oil Limited.

The field program was conducted during April and early May of 1975. The Imperial Oil Becker hammer drill and a Mayhew 1000 rotary rig were used to obtain subsurface data. Grain size and moisture content analyses were performed in a field laboratory and aggregate analysis for purposes of concrete suitability testing was carried out in Edmonton.

The stratigraphy of this important source of construction material has been interpreted from the borehole logs. Zones of massive ground ice, up to 55 feet thick, were mapped throughout the borrow area. The granular material was found to be well graded sand and gravel containing few fines. The gravel is certainly suitable for all types of fill construction. Further testing is required to adequately assess its overall performance as a concrete aggregate.

The quantity of exploitable borrow materials has been conservatively estimated at 9.8 million cubic yards. It is advised that pit planning will be complicated by the presence of massive bodies of ground ice which will require consideration on an individual basis. It is recommended that the overall operation be monitored by an engineering geologist utilizing the data presented herein while supplementing this with actual field observations.

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1. INTRODUCTION

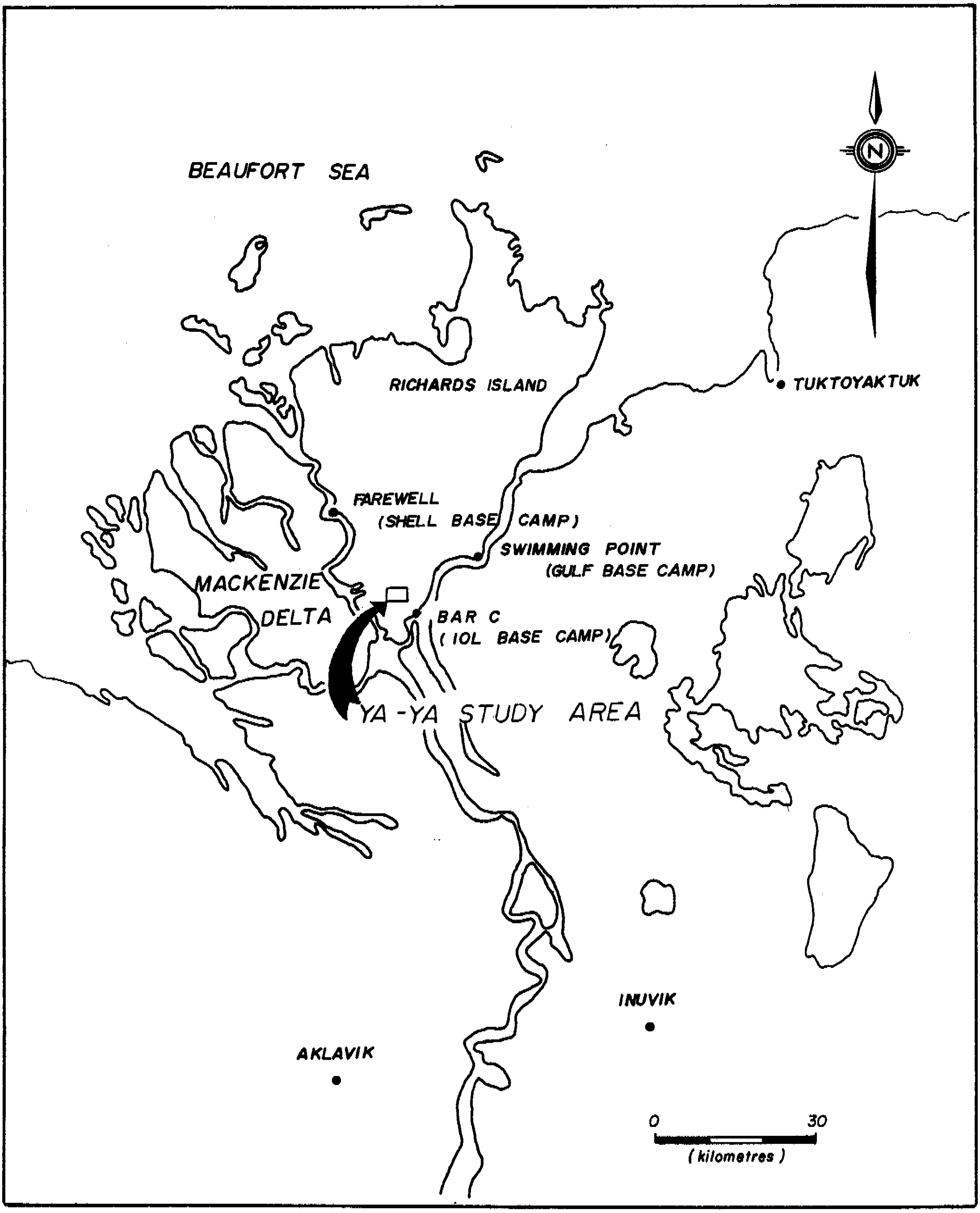
1.1 Scope

EBA Engineering Consultants Limited (EBA) was retained by Imperial Oil Limited (IOL) for the Arctic Petroleum Operators Association (APOA) to carry out an evaluation of the Ya-Ya gravel deposits in the area immediately south of Ya-Ya Lake on Richards Island, in the Mackenzie Delta. The study area is outlined on the location map, Figure 1. A need for this study arose in response to the high demand for granular fill and concrete aggregate in the northern part of the Mackenzie Delta. The study has included an estimate of the volume of recoverable granular borrow material, an assessment of the quality of the material and recommendations for exploitation of this important borrow source.

Several gravel borrow pits have been developed in the Ya-Ya esker complex during the last four years, primarily for the purpose of building exploratory drilling pads (Drawing B2, Appendix B). Most stockpiling operations were carried out during the summer months with gravel hauls commencing when it was safe to travel on ice and snow roads.

1.2 Previous Investigations

Some borrow evaluation drilling has been carried out in the Richards Island area by Imperial Oil Limited in conjunction with Gulf Oil during August, 1972. In addition a general inventory of granular deposits in the Richards Island area has been carried out by others for the Department of Indian and Northern Affairs (Reference 5) and the Arctic Petroleum Operators Association (Reference 4). Both of these surveys resulted in calculated volume estimates of gravel borrow in the western third of the Ya-Ya esker (Baseline A area). However, these results were based on only a few boreholes, and test pits of shallow penetration. With this



LOCATION PLAN

RICHARDS ISLAND, MACKENZIE DELTA

FIGURE 1

in mind a grid pattern of boreholes was established to enable accurate stratigraphic sections and contour maps to be made. Consequently a more reliable volume calculation was possible.

1.3 Field Drilling Program

1.3.1 General

The field drilling program commenced on April 19, 1975 and was terminated May 4, 1975. A total of 299 boreholes were completed during that time. Two rigs, the IOL Becker drill and MacDonald Drilling's Mayhew 1000, both with depth capabilities in the order of 100 feet were chosen for this study.

The accommodations and logistic support for drilling and engineering personnel were provided by Imperial Oil Limited at the construction camp on site (Site Location Plan).

1.3.2 Surveying

Previous drilling results and airphoto interpretation were combined to outline the extent of the esker-kame complex, which is shown on Drawing B2. A grid system was adopted to ensure easy identification and location of the boreholes. Three major baselines, namely A, B and C, were located in a manner that roughly parallels the trend of the ridges of exposed gravel. These major areas are outlined on Drawing B2 and the baselines are shown on Drawing's B3, B4 and B5. Canadian Engineering Surveys Limited was contracted to lay out the grid and determine borehole elevations.

The initial survey was carried out in a conventional manner using chain and transit to locate baselines and normal grid lines. Baselines were staked at 100 metre intervals and designated A 1+00, A 2+00 etc. The grid lines were staked at 50 metre intervals and assigned chainages south or north of the baseline, eg. 0+50N, 1+00S. All boreholes were designated solely on the basis of this grid system chainage. A typical borehole, designated as B 6+00, 2+50S, would be located as follows:

```
      B  6 + 00,          2 + 50 S
      |      |              |    |
      |      |              |    Southerly from baseline
Baseline B   |              250 metres from baseline
         600 metres from starting point along baseline
```

A level survey, referenced to Ya-Ya Lake ice level as 0 feet, was run at the completion of drilling to provide adequate information for profiling the cross-sections. The Motorola Mini-Ranger System was used to tie in major points along the baselines to existing monuments in the vicinity. The Mini-Ranger system, mounted on a Bombardier tracked vehicle, was also used to locate all boreholes after they were drilled.

1.3.3 Weather

The temperature encountered during this field program ranged from -10° C to +5° C. April consisted of generally clear skies with very little wind, however, during the last few days of the program, in May, fog and overcast conditions were encountered. No loss of drilling time was incurred due to adverse weather conditions. In general, there was continuous snow cover over the entire site with the exception of hill crests which were blown clear and the existing workings in the gravel pit. During the last five days of the program some melting occurred resulting in bare patches and soft snow conditions thus making snow vehicle transport quite difficult.

1.4 Equipment

1.4.1 Imperial Oil Limited Becker Rig

A Becker Hammer Drill (Appendix A, Plate 4), owned and operated by Imperial Oil Limited, was used in this program with relatively good success. The Becker drill is advanced by a diesel activated hammer which drives 8 foot sections of double walled 6" casing (nominal O.D.) into the ground. Compressed air is used to return cuttings to the surface inside the casing.

The cuttings were sampled at 4 foot intervals during the course of drilling. Samples were collected at the base of the cyclone which acts to dissipate the energy of the compressed air. When drilling in frozen material the sample was generally thawed. The thawing can be attributed to the high output air compressor which after a short period of operation heated the air and the double walled drill pipe through which the sample must pass.

Samples obtained from the Becker rig were found to have very little crushed or broken gravel, grain size analyses are therefore considered to be reliable. This was further verified by comparing grain size curves of both drill returned samples and test pit samples from near the surface. In some instances however the moisture content of frozen insitu gravel may be under estimated because of thawing and sample segregation.

The poor mobility of the Becker drill restricted the regions in which it could be utilized. The rig was mounted on a large sleigh pulled by a D-7 dozer. The rig and sleigh combination resulted in a high centre of gravity and was quite inflexible. The rig was therefore incapable of traversing the more hummocky terrain.

The Becker Rig was somewhat limited in drilling depth due to densification of the ground around the drill pipe caused by the driving vibration. This presented a serious risk of jamming the casing in the borehole. When such adverse drilling conditions were encountered the decision to terminate the hole was left to the driller. The maximum depth reached by the Becker rig was approximately 62 feet.

1.4.2 Mayhew 1000

The Mayhew 1000, a rotary, air return seismic drill rig was provided by MacDonald Drilling Limited on a contract with Imperial Oil Limited. The boreholes were drilled using tri-cone bits 4½ inches in diameter. The rig was mounted on a Foremost tracked carrier enabling it to negotiate steep inclines and moderate side slopes. All planned boreholes with reasonably flat drilling sites were reached by this rig.

The cuttings were sampled directly as they came to surface. It is believed that little melting occurred as shown by the recovery of several feet of clean white ice. The sampling technique had limitations since any breeze would tend to carry away ice crystals resulting in lower moisture content results. Moreover, crushing of the gravel to sizes less than 3/4 of an inch was apparent. Because of this, a great reliance was placed on the field geologist in estimating maximum aggregate size.

A maximum depth of 102 feet was drilled by the Mayhew in well bonded frozen granular material. Problems were encountered on the high, well-drained ridges where loose dry gravel caused the loss of air circulation. Holes drilled in very loose gravel generally had to be abandoned at shallow (4 to 5 ft.) depths due to caving of the borehole.

II. GEOLOGY OF THE STUDY AREA

2.1 Type of Landforms

The potential and existing borrow areas are located in a glacio-fluvial esker-kame complex with some outwash or wave modified features. A general surface geology of the area is shown by Drawing B1, Appendix B. Most of the relief is highly modified by massive ground ice formations. The gravel composing the esker kame complex has an ice content in the range of 5% to 15% however, massive ice, up to 55 feet thick and extending several hundreds of feet laterally, was found within the gravel body.

2.1.1 Eskers

The Ya-Ya Lake esker is composed of both single and multiple steep sided ridges reaching a maximum height of 135 feet above Ya-Ya Lake elevation (Drawings B1 and B2). The esker is dissected by a lake embayment as well as several transverse drainage courses. The flow of water at the time of deposition is believed to have been from the west to the east. The sand and gravel in the esker is well graded and clean with a maximum grain size of 3 inches. Several minor low-relief eskers, shown in Drawing B2 (Note 2.1.1), join the main feature at the east end of the study area.

Both massive ice formations and non-visible ice bonding the gravel are present. The massive ground ice appears to be extensive in all parts of the study area. The interpreted stratigraphy of the esker, showing these ground ice features, is included in Appendix C.

2.1.2 Kame Deposits

The esker ridges merge to form a complex topography with multiple knob-like topographic features best described as kames. Most of the features are in the order of 75 to 100 feet in diameter at the base with overall heights averaging 25 feet. Slope angles are in the order of 30° to 40° from the horizontal (Appendix A, Plates 2 and 3). Major concentrations of these features occur at the north end of Baselines A and B, with some evidence of kame-like features at the south-east end of Baseline B (Drawing B2, Notes 2.1.2 (a), (b)). It appears that the granular material found in kames is very similar in mineralogy and gradation as that in the eskers. However, the grain size distribution of the materials in general was found to be more variable with horizontal lenses of fine sand and silt being present.

2.1.3 Glacial Outwash/Glacial-Lacustrine Modified Terraces

The flat topped terrace-like formation near the north-west end of Baseline A appears to be a glacial-lacustrine modified beach terrace (Drawing B2, Note 2.1.3 (a)). The terrace consists primarily of well graded sand and gravel, silt till, and massive ground ice horizons. The silt and fine sand overburden becomes progressively thicker as the distance from the esker increases.

The flat area at approximately C 2+00 on Baseline C appears to have originally formed as a glacial outwash and has since been modified by lacustrine wave action (Drawing B2). The boreholes encountered up to eight feet of silt overlying ten or more feet of silty gravel and sand.

The small area south-east represents a widening of a tributary esker of the main esker at Baseline C. The original surface expression of this area has been changed by excavation for construction materials (Drawing B2, Note 2.1.3 (c)). It is believed, however, that the medium sand and traces of fine gravel materials are remnants of a glacial outwash feature.

Area D is an elevated flat plateau consisting of sand and fine gravel overlain by several feet of frozen silt and a surface veneer of gravel and cobbles (Drawing B2). The origin of this landform is poorly understood. There is some evidence of lacustrine reworking of the material.

2.2 Geological Origin

The previously described deposits are of a glacio-fluvial origin and possibly modified by glacio-lacustrine action. Both eskers and kames merge with outwash plains and lake modified terraces in the Ya-Ya Lake area. There is a possibility that some of the ridge-like features were deposited sub-glacially as crevasse filling. Several small linear ridges are believed to have formed this way. The glacial material is underlain by the preglacial silts and fine sands of the ancestral Mackenzie River Delta. This material in some cases has been pushed and deformed by glacial ice thrusting (Mackay, 1963, Reference 2). Stratigraphic cross-sections in Appendix C possibly show some deformation of these sands and silts.

2.3 Ground Ice

Massive ground ice occurs throughout the Ya-Ya Study Area. The occurrence of ground ice has been shown on the drawings, cross-sections and borehole logs (Appendices C and D). Sections of clean white bubbly ice up to 55 feet thick were encountered in boreholes. These ice masses were often located between the bottom of the gravel and the pre-glacial silts. It appears that this ice formed after glaciation and has aggraded beneath the granular material modifying the surface expression of the esker-kame complex greatly. The occurrence of pervious gravel layers and an abundant supply of lake water fits the theory proposed for the formation of massive bodies of tabular ground ice on the Tuktoyaktuk Peninsula (MacKay, 1971, Reference 3). Massive ice lenses appear to diminish in thickness at the flanks of the esker as the material becomes progressively finer.

Raised centre polygons each bounded by vertical ice wedging were evidenced in the northeast section of Baseline C, (Drawing B2, Note 2.3).

In the granular material itself, ice is usually visible as randomly oriented small veins. Allowances have been made for the drilling method in that only intact frozen samples have been considered in making this observation. Further, the same visible crystalline ice condition was observed in fresh exposures in the gravel workings. The frozen in-situ gravel is well bonded for the major part of the recoverable volume of the area. Upon thawing, the gravel has a typical moisture content of 5 to 10 percent.

Ice lenses up to 1/2 inch thick were encountered in the pre-glacial silts and silty fine sand underlying the sands and gravels of the esker-kame complex. This was evidenced by some large intact frozen chunks of fine material in the drill cutting return.

III. GRANULAR BORROW MATERIAL

3.1 Gradation

The material encountered in the Ya-ya Borrow Study ranges from medium grained sandy gravel with traces of silt to medium and coarse grained sand. The grain size analyses on several hundred samples (Appendix D) show that the material is generally well graded and it does not change substantially with depth or lateral extent. Material in the esker ridges is generally well graded sand and gravel with the surface covered with frost segregated cobbles. The kame deposits are much more variable with inclusions of silt and fine sand lenses within well graded sand and gravel. Isolated uniform medium grained sand pockets such as the one uncovered by excavation at B 18+00, 0+50S (Appendix A, Plate 6) are likely to occur sporadically within the esker complex.

Area C is located at the broadening of a minor meandering esker ridge, (Drawing B2, Note 2.1.3 (c)). This deposit may be a glacial outwash plain modified by glacio-lacustrine action. The material is generally a well graded sand with a trace of fine gravel. This represents a possible source of fine material for more specific applications.

Sporadic fine sand and silt lenses in the order of 3 to 5 feet thick have been encountered throughout the site during drilling. These however do not appear to pose major difficulties in their excavation and separation from the granular borrow materials.

3.2 Overburden and Surface Cover

In general the overburden exists as a very thin silt and organic cover on most of the unexcavated ridges. The vegetation consists of 2 foot high willows, some lichen and an assortment of labrador tea, berry bushes and grasses (Appendix A, Plates 1 and 3). The overburden thickens progressively away from the main ridges and is illustrated on the cross-section drawings in Appendix C. More dense vegetation is also encountered on the flanks of the esker-kame complex. For the major part of the borrow area a very minor amount of stripping is anticipated.

3.3 Estimate of Volume of Recoverable Borrow Material

Granular borrow material for the purpose of this study is defined as gravel and/or sand material with less than 10 percent silt content (minus No. 200 sieve, 0.074 mm) and generally a maximum of 20 percent dry weight finer than the number 40 sieve, (0.41 mm). To facilitate calculation of the volume of granular borrow available, the region was subdivided by cross sections at approximately 200 metre intervals along the baselines.

Several assumptions were made in calculating granular borrow material volumes at the Ya-Ya site. The calculations included:

a) The total volume of granular material present in the source.

b) Exploitable material restricted to granular material lying above adjacent lakes or major pond water elevations.

c) Recoverable material to be overlain by not more than six feet of massive ice, silt or peat overburden. In addition, restriction (b) was also placed on this calculation.

d) In addition to restriction (c) above it was assumed that five feet of cover (in most areas it will be granular material) will be left over massive ground ice.

Isopach maps showing thicknesses of recoverable granular material including all of the restrictions noted above (assumption d) were prepared. These are included in Appendix B on Drawings B3, B4 and B5.

3.3.1 Baseline A

The following volume of granular material estimates are listed in order as each assumption is applied (refer to subsection 3.3):

a) 7.9 million cubic yards
b) 5.3 million cubic yards
c) 4.7 million cubic yards
d) 4.2 million cubic yards

Although 101 testholes were drilled the volume and aerial extent of massive ground ice was difficult to establish for this area. Test pits or development excavations have not been made in this area; therefore it was not possible to inspect typical vertical exposed sections as in the existing pit. Areas of seemingly high ice content are indicated on Drawing B3. The massive ice content of these areas are such that development would require excavation through more than ten feet of ice or leave exposed areas of more than ten feet of ice.

A possible one million cubic yards of somewhat siltier granular material exists off the northern flanks of the esker (Drawing B2, Note 2.1.3 (a)). This deposit appears to be a combination of outwash plain and slope-wash deposit. Thick overburden may prevent efficient and economical recovery of the granular material in this area. This material is considered to be marginal and was therefore not included in volume estimates.

3.3.2 Baseline B

Volume estimates of granular borrow for this section of the study area, based on the assumptions a to d stated in subsection 3.3 are as follows:

a) 5.5 million cubic yards
b) 3.2 million cubic yards
c) 3.2 million cubic yards
d) 2.9 million cubic yards

A total of 89 boreholes were drilled in this area during the course of the field program. Cross-sections at specific intervals along the baseline are for the purpose of clarifying the interpreted stratigraphy of the deposit (Appendix C). The volume estimates do not include the material stock piled at the time of drilling. Massive ice is present throughout the area, in some instances within a few feet of the surface. The site plan (Drawing B2) gives the outline of the area which has been excavated. Areas underlain by massive ground ice are indicated on Drawing B4.

3.3.3 Baseline C

The deposit at Baseline C has been extensively exploited for granular material. A total of 99 boreholes were drilled in this area and the remaining volume of material has been estimated, based on the assumptions a to d stated in subsection 3.3, to be:

a) 3.8 million cubic yards
b) 3.1 million cubic yards
c) 2.7 million cubic yards
d) 2.5 million cubic yards

These calculations do not include stockpiles at the site. Drawing B5 indicates areas underlain by massive ground ice.

3.3.4 Area C

Only three testholes were drilled to define this small esker tributary and glacial lacustrine modified outwash plain, Drawing B2, Note 2.1.3 (c). Most of the fine granular material in this area appears to have been excavated recently. The remaining borrow material is estimated at about 200,000 cubic yards. For the most part no overburden exists in this area (Drawings B5 and B6).

3.3.5 Area D

A volume estimate was not prepared for Area D since the material was considered unsatisfactory for exploitation. Seven boreholes were drilled to delineate the extent of the deposit, the logs of which are enclosed in Appendix D. The results of the drilling showed that the material is generally of variable gradation, extremely variable in thickness and overlain by thick frozen silt and fine sand deposits. Massive bodies of ice were found to underlie the granular materials for most of Area D.

3.3.6 Total Granular Material Volume

The calculated volume of granular borrow material, as controlled by the four assumptions stated in subsection 3.3, are summarized in Table I.

TABLE I. SUMMARY OF COMPUTED GRANULAR MATERIAL VOLUME

AREA OR BASELINE	ASSUMED CONDITION (million cubic yards)			
	(a)	(b)	(c)	(d)
Baseline A	7.9	5.3	4.7	4.2
Baseline B	5.5	3.2	3.2	2.9
Baseline C	3.8	3.1	2.7	2.5
Area C	---	---	---	.2
Area D	---	---	---	---
TOTALS	17.2	11.6	10.6	9.8

3.4 Recovery and Handling

3.4.1 Winter Operations

In the past the gravel has been ripped by a dozer in the winter and pushed into stockpiles to thaw and drain during the summer. This type of recovery operation has not been used extensively due to the high cost of excavation.

At Baseline A and west end of Baseline B it may be possible to remove up to 20 feet of material from the crests of the esker and kames without involving an extensive ripping operation. The granular material, although frozen, was found to be dry and loose in these areas.

3.4.2 Summer Operations

Most recovery operations have been carried out during the summer months. The normal procedure followed simply consists of stripping and stock piling of the newly thawed material. This allows the material to drain rapidly and increases the depth of thawing in the deposit. The cycle of the operation depends on the rate of thaw with stockpiling operations beginning when the thaw front has progressed 1 to 2 feet into the deposit.

3.4.3 Treatment of Massive Ice

It is not possible to formulate general recommendations for the treatment of massive ice bodies within the gravel deposit. If possible the ice bodies should be avoided during pit development. However each ice body will have to be considered individually prior to pit development in specific areas.

Less extensive massive ice (within the granular material) at higher elevations may be stripped and wasted. In areas with 30 to 55 feet of massive ice underlying the granular material it is recommended that approximately five feet of soil be left on top of the ice (Appendix C). This should provide sufficient insulation to prevent excessive thawing. The development of thaw ponds within the pit working area will adversely affect the logistics of orderly pit development.

IV. QUALITY ASSESSMENT OF CONCRETE AND GRAVEL FILL AGGREGATES

4.1 General

Samples of aggregate were obtained to evaluate their suitability as concrete aggregates or for use as a gravel fill. Tests run on the samples included sieve analyses, petrographic examination, specific gravity, absorption and dry rodded density. Limited testing with respect to organic content, soluble sulphate content and sulphate soundness has also been performed. The results are reported in this section and their engineering implication discussed in general terms.

4.2 Soluble Sulphate Content and Sulphate Soundness Tests

The results of 9 Soluble Sulphate tests run on the materials are summarized in Table 2. All tests indicate a negligible degree of attack. Therefore, Type I Normal Portland Cement will be acceptable for mixes using these aggregates. However, in cases where concrete is in contact with natural soils these soils should be tested for sulphate concentrations.

One sulphate soundness test was run on an average sand and gravel sample. The computed weighted percentage loss was 2.9 percent (by weight). This degree of attack is considered to be negligible.

TABLE 2. SOLUBLE SULPHATE CONTENT

Test Pit Coordinates		Sulphate Content	Degree of Sulphate Attack
A 2 + 00	0 + 00 Surface	Nil	Negligible
A 12 + 00	0 + 50N	Nil	Negligible
B 11 + 00	3 + 00S	0.05	Negligible
B 14 + 00	3 + 50S	Nil	Negligible
B 18 + 00	0 + 15N	Nil	Negligible
B 20 + 00	2 + 00S	Nil	Negligible
B 23 + 00	0 + 50N	Nil	Negligible
C 13 + 00	2 + 00S	Nil	Negligible
C 22 + 00	2 + 00N	Nil	Negligible

4.3 Organic Content Tests

Five samples were tested to determine the organic content of the granular soils. Values ranged from 1.1% to 3.6% with an average value of 1.8% (Table 3). The sample from which the highest value was obtained is a near surface sample thus the higher loss on ignition was probably due to some lichens or other living organic matter. Eliminating this sample, the average would reduce to 1.4%. Based on these tests, the aggregate would be suitable for concrete.

TABLE 3. ORGANIC CONTENT BY WEIGHT

Test Pit Coordinates		Organic Content
A 2 + 00	0 + 00 Surface	3.6%
B 11 + 00	3 + 00S	1.4%
B 18 + 00	0 + 15N	1.4%
B 20 + 00	2 + 00S	1.1%
B 23 + 00	0 + 50N	1.7%

4.4 Dry Rodded Unit Weights

A summary of dry rodded unit weight determinations is included in Table 4. These values varied from 101.3 to 121.0 pounds per cubic foot (pcf) with an average value of 113.9 pcf. This information is required for the tentative concrete mix design presented in Subsection 4.9.

TABLE 4. DRY RODDED UNIT WEIGHT

Test Pit Coordinates			Dry Rodded Unit Weights (pcf)
A 12 + 00	0 + 50N		116.7
B 11 + 00	3 + 00S		108.8
B 14 + 00	3 + 50S		101.3
B 18 + 00	0 + 15N		119.7
B 20 + 00	2 + 00S		114.0
B 23 + 00	0 + 50N		121.0
C 13 + 00	2 + 00S		117.4
C 22 + 00	2 + 00N		112.1
		RANGE	101 - 121
		AVERAGE	113.9

4.5 Specific Gravity And Absorption

Seven samples were tested to determine the specific gravity and absorption values of the fine portion of the aggregate, and three samples were tested to obtain the same information for the coarse aggregate. The results of these tests are shown in Tables 5 and 6, respectively. These values are required for concrete mix design purposes (not undertaken). The results show the water absorption to be relatively low.

TABLE 5. SPECIFIC GRAVITY AND ABSORPTION--FINE AGGREGATES

Test Pit Coordinates	Bulk Sp. Grav.	Bulk Sp. Grav. (SSD)	Apparent Sp. Grav.	Absorption %
A 12 + 00 0 + 50N	2.599	2.642	2.718	1.68
A 12 + 00 0 + 50N	2.601	2.648	2.729	1.81
B 11 + 00 3 + 00S	2.498	2.545	2.621	1.89
B 11 + 00 3 + 00S	2.495	2.540	2.669	1.79
B 18 + 00 0 + 50N	2.502	2.546	2.618	1.77
B 18 + 00 0 + 50N	2.510	2.545	2.602	1.40
C 22 + 00 2 + 00N	2.570	2.612	2.684	1.65
AVERAGE	2.534	2.583	2.663	1.71

TABLE 6. SPECIFIC GRAVITY AND ABSORPTION--COARSE AGGREGATES

Test Pit Coordinates		Bulk Sp. Grav.	Bulk Sp. Grav. (SSD)	Apparent Sp. Grav.	Absorption %
B 11 + 00	3 + 00S	2.523	2.560	2.621	1.48
B 18 + 00	0 + 50N	2.527	2.561	2.615	1.33
C 22 + 00	2 + 00N	2.527	2.560	2.613	1.31
	AVERAGE	2.526	2.560	2.616	1.37

4.6 Minimum-Maximum Density of Granular Fill

Seven samples were tested to determine the minimum and maximum density of typical Ya-Ya gravel samples. The average values obtained were a minimum dry density of 110.1 pcf and a maximum dry density of 127.8 pcf. The values obtained are summarized in Table 7.

TABLE 7. MINIMUM-MAXIMUM DENSITY OF YA-YA GRAVEL

Test Pit Coordinates		Dry Density (pcf) Min.	Dry Density (pcf) Max.
A 2 + 00	0 + 00	109.4	127.2
A 12 + 00	0 + 50N	111.9	127.6
B 11 + 00	3 + 00S	105.7	125.3
B 18 + 00	0 + 50N	115.6	130.5
B 20 + 00	2 + 00S	111.5	128.4
C 13 + 00	2 + 00S	111.9	130.2
C 22 + 00	2 + 00N	104.9	125.6
	AVERAGE	110.1	127.8

Relative density for field compacted fills, as determined from Equation 1 is a method commonly used in evaluating the degree of compaction of cohesionless materials. Generally, relative densities between 70% (121.9) pcf) and 85% (124.8 pcf) are specified on most construction projects, depending on the type of support conditions expected from the completed pad or roadway.

$$\text{Relative Density \%} = \frac{\gamma_{max} \times (\gamma_{field} - \gamma_{min})}{\gamma_{field} \times (\gamma_{max} - \gamma_{min})} \times 100 \qquad \ldots (1)$$

where: γ_{max} = maximum dry density determined in the laboratory (127.8 pcf)

γ_{min} = minimum dry density determined in the laboratory (110.1 pcf)

γ_{field} = insitu density of the compacted fill determined in the field (pcf).

Experience with the placing and monitoring of gravel fill from Ya-Ya pit during winter conditions, was obtained during construction of IOL Adgo C-15 Drilling Island EBA, Reference[1]). The material, a sandy gravel, had been stockpiled during the summer and was placed during sub-freezing temperatures the following winter. It was found that lifts of 1½ to 2 feet, compacted by a vibratory drum roller reached an average relative density of 45 percent with a maximum recorded value of 50 percent. The maximum practical field density was achieved after about 3 passes of the compaction equipment and negligible additional benefit was achieved by prolonged compactive effort.

4.7 Petrographic Analyses

Petrographic analyses were performed on six samples which are considered to be representative of all the samples obtained. The results along with the average weighted composition of the constitutents are shown in Table 8.

The most common constituent is chert-chalcendony which may or may not be suitable for concrete. It would appear from the low values obtained in specific gravity and absoprtion tests that these aggregates are probably suitable, but this should be clarified by compressive strength, freeze-thaw, and soundness tests. The other constituents are all suitable aggregates for concrete (Appendix D, Petrographic Analyses).

4.8 Grain Size Analyses

Particle distribution was determined for nineteen test pit samples for aggregate assessment. The results are summarized in Table 9 and an envelope of the curves is shown in Figure 2. These tests show that the material is generally a well-graded gravel-sand containing a relatively small quantity of unacceptable fine material. If the pit was worked in such a manner as to eliminate the pockets of silt, the materials could be processed to meet CSA specifications for fine and coarse aggregate. The effective maximum size of material is between 1 and 1½ inches. When the fine and coarse aggregates are separated by screening, the silt and clay fraction could easily be separated. On small projects, pit run gravel can probably be used effectively for concrete aggregate.

TABLE 8. RESULTS OF PETROGRAPHIC EXAMINATION OF GRAVEL CONSTITUENTS

TEST PIT COORDINATES		Constituents (Weighted %)									
		1	1i	1ii	2i	2ii	3	4	5	6	7
A 2 + 00	0 + 00	10.01	17.81	34.26	13.12	5.33	8.89	9.61	0.10	0.79	0.08
B 14 + 00	3 + 50S	1.81	51.70	34.97	1.62	0.13	5.70	3.78	----	----	0.29
B 18 + 00	0 + 50N	9.49	7.27	38.27	12.87	4.05	5.53	15.99	----	----	6.53
B 23 + 00	0 + 50N	13.50	18.23	37.79	11.53	----	8.31	9.82	----	----	0.82
C 13 + 00	2 + 00S	17.53	10.98	39.11	5.44	1.08	10.05	14.93	----	----	0.88
C 22 + 00	2 + 00N	24.28	20.86	25.09	9.98	6.09	6.72	6.98	----	----	----
	AVERAGE	12.77	21.14	34.92	9.09	2.78	7.53	10.18	0.02	0.13	1.43

LEGEND

1. Quartzite
   i. Quartz
   ii. Chert-Chalcedony
2. Sandstone
   i. Competent
   ii. Friable
3. Basalt
4. Argillite-Siltstone
5. Conglomerate
6. Coal
7. Granite

TABLE 9. GRAIN SIZE ANALYSIS FOR AGGREGATE ASSESSMENT

Test Pit Coordinates		% Passing 3"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 10	No. 20	No. 40	No. 60	No. 100	No. 200
A 2 + 00	0 + 00	100	100	98.6	96.3	85.5	75.9	51.3	31.3	19.5	11.9	7.4	5.7	4.9
A 4 + 00	1 + 00S	100	100	80.6	58.8	57.8	45.8	27.3	5.8	1.2	0.7	0.5	0.3	---
A 4 + 00	2 + 00S	100	100	95.1	83.3	69.5	60.0	42.2	30.9	25.1	24.1	23.8	23.5	22.9
A 8 + 00	1 + 00N	76.8	76.8	64.3	53.9	40.9	32.4	18.0	10.6	7.2	5.5	4.1	3.0	1.9
A 12 + 00	0 + 50N	100	100	95.0	88.5	82.4	77.5	61.4	39.7	23.9	12.4	5.1	2.1	0.5
A 18 + 00	1 + 00N	100	100	87.1	67.4	49.3	44.8	43.0	41.7	39.7	36.1	29.8	21.6	10.5
	AVERAGE	96.1	100.0	86.8	74.7	64.2	56.1	40.5	26.7	19.4	15.1	11.8	9.4	6.8
B 6 + 00	2 + 50S	100	100	100	100	100	92.6	73.9	51.8	38.2	28.2	19.2	13.1	9.2
B 11 + 00	3 + 00S	100	100	97.5	95.6	89.5	80.9	55.3	31.5	14.7	5.3	2.3	1.5	1.0
B 14 + 00	2 + 00S	100	100	100	56.1	50.0	47.4	37.8	29.0	21.5	16.1	11.2	7.9	5.8
B 14 + 00	0 + 00	100	100	100	100	93.7	83.7	70.9	53.6	41.0	26.3	18.1	12.9	8.3
B 14 + 00	3 + 50S	100	100	100	100	98.7	96.4	90.7	86.5	82.9	68.4	15.1	1.9	0.0
B 14 + 00	3 + 00S	100	100	100	100	78.1	72.9	53.2	26.6	10.6	5.6	3.1	2.3	2.0
B 18 + 00	0 + 50N	100	100	88.1	84.6	79.6	69.8	48.0	35.1	21.8	9.6	4.2	2.9	2.5
B 20 + 00	2 + 00S	100	100	97.5	94.6	86.2	76.4	54.3	35.8	23.7	12.0	2.9	0.5	0.1
B 23 + 00	0 + 50N	100	100	94.5	89.6	82.3	76.8	60.7	44.4	32.4	24.7	21.4	19.8	18.7
B 26 + 00	14 + 00N	100	100	100	100	97.1	90.2	61.8	30.3	13.0	5.4	4.1	2.2	1.8
	AVERAGE	100.0	100.0	97.8	92.1	85.5	78.7	60.7	42.5	30.0	20.2	10.2	6.5	4.9
C 13 • 00	2 + 00S	100	100	90.5	85.4	77.5	68.7	47.9	28.4	18.4	10.0	4.6	2.7	1.9
C 22 + 00	2 + 00N	100	96.6	94.1	91.3	78.8	75.9	54.1	36.9	27.1	20.6	17.1	15.3	13.1
C 30 + 00	9 + 00N	100	79.0	79.0	74.7	63.2	51.3	28.8	18.6	14.5	11.7	9.9	7.6	4.2
	AVERAGE	100	91.9	87.9	83.8	73.2	65.3	43.6	28.0	20.0	14.1	10 5	8.5	6.4
	OVERALL AVERAGE	98.8	97.5	92.7	85.3	76.5	69.4	51.6	35.2	25.1	17.6	10.7	7.7	5.8

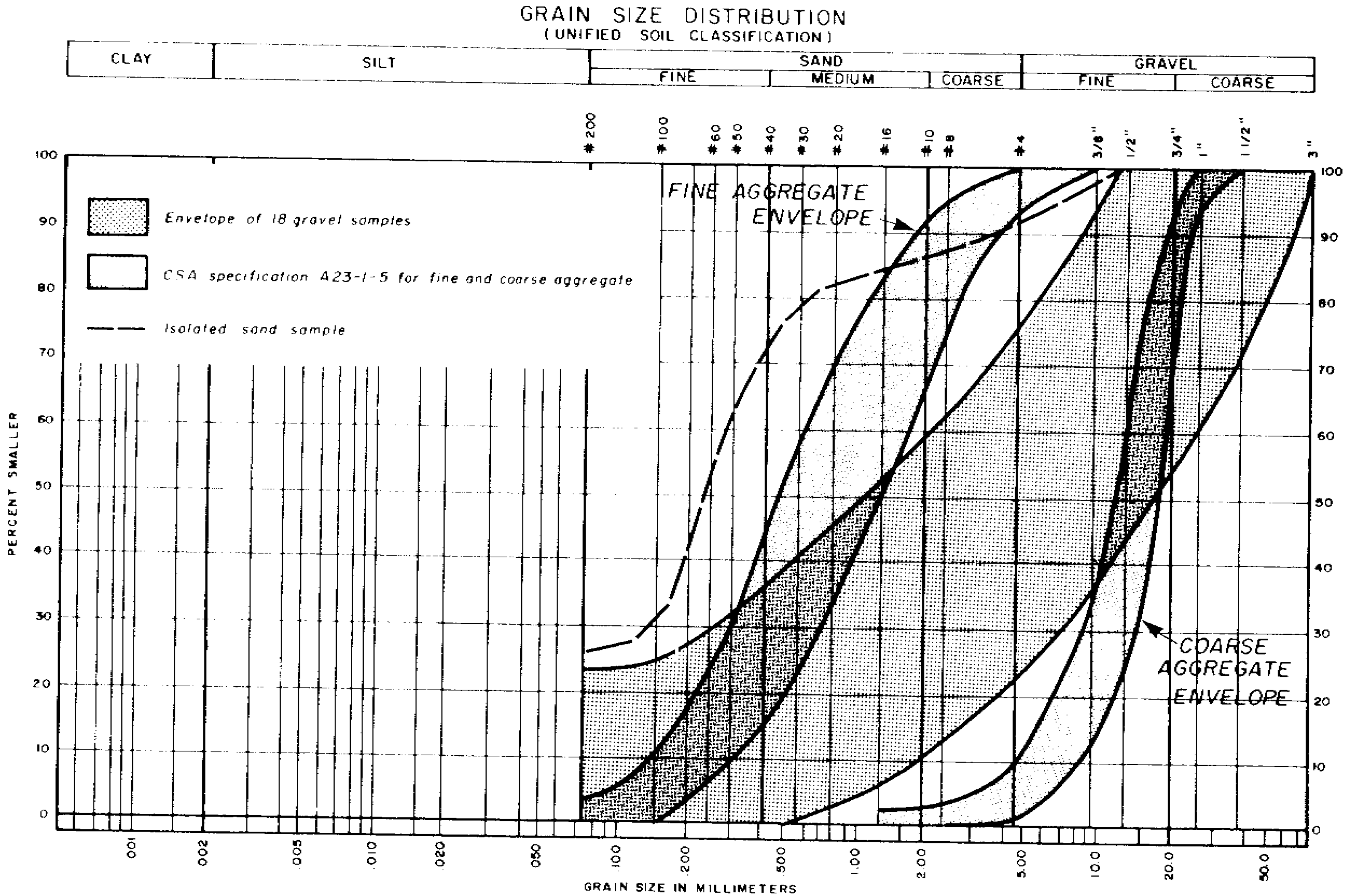


FIGURE 2 COMPOSITE GRAIN SIZE ENVELOPE

4.9 Concrete Mix Design

A typical concrete mix design has been prepared based on the following assumed properties.

Assume:
- a) Effective aggregate top size of 1½ inches
- b) 4% to 6% air entrainment
- c) Slump of 3 to 4 inches
- d) Design based on exposure conditions
- e) Type I Normal Portland Cement

The approximate quantities of materials per cubic yard of concrete that would be required are stated in Table 10.

TABLE 10. TYPICAL CONCRETE MIX PROPORTIONS

Constituent		Slabs, Pavements, etc.	Structural Members, Girders, Beams Piers, etc.
Cement (lb)		530	480
Water (lb)		265	265
Aggregate (lb)	Fine	1030	1050
	Coarse	2060	2090

The above porportions stated in Table 10 should be considered approximate only. Actual performance in the field requires that trial mixes be run in order that more precise properties are determined. These figures are presented solely to allow preparation of construction cost estimates.

4.10 Comments and Summary

It would appear from the test program completed to date that Ya-Ya gravel would be suitable for use in concrete. Further testing must be done to confirm these findings prior to undertaking large scale production of concrete aggregates. This test program would involve separation of the aggregates, further sieve analyses, a trial batch mix design and freeze-thaw tests. Los Angeles Abrasion tests should also be performed on the aggregate. Such testing is considered to be beyond the scope of this study.

The materials are excellent for use as granular fill. For summer construction programs a compacted relative density of 70% to 85% should easily be achieved with vibratory rollers when the material is placed and compacted in lifts. However, as discussed in Subsection 4.9, a relative density of about 50% can be expected when placing frozen fill.

V. LIMITATIONS AND RECOMMENDATIONS

The 1975 spring drilling and testing program at Ya-Ya Lake has led to several important findings. One of the major discoveries was the existance of massive ground ice which may pose problems to recovery operations. The many configurations of ground ice bodies present dictate that each section of the recovery area must be considered as a special case. It is suggested that sufficient cover be left in place to insulate the massive ground ice where exploitable gravel is not present below it.

Volume estimates have been made for the various sections of the esker-kame complex. A total figure of 9.8 million cubic yards has been arrived at for a modest estimate of recoverable granular material. These calculations take into considerations the water levels of adjoining lakes, amount of overburden and sufficient insulating cover left over massive ice bodies. The 'Land Reserve' as shown on Drawing B2, contains a large volume of borrow material which has been included in the calculation. The status of the material within the bounds of the 'Land Reserve' has not as yet been established.

The granular material throughout the site is of very similar gradation and mineralogy indicating a common source for all areas. This deposit was found to be suitable for general fill. Potentially deleterious material was encountered in significant quantities in the samples and therefore further tests are required to determine its suitability for concrete applications.

Finer material such as uniform medium grained sand is available in Area C and in sporatic isolated pockets throughout the esker-kame complex.

Consideration should be given to the effect of draining existing thaw ponds and the inpact of possible new thaw ponds on the environment. It is advisable in some cases to waste massive ice in order to recover the granular material below and prevent ponds from forming.

A legal survey defining the bounds of the granular material would be beneficial as development of this borrow source continues.

The planned exploitation of this deposit should be closely observed with the aid of cross-sections and contour maps found in Appendix B of this report. This may be achieved by a qualified engineering geologist on site who will be responsible for the interpretation of the drawings and overseeing the excavation operations. Continual mapping of fresh gravel exposures is advisable to supplement available borehole data.

Respectfully submitted,

EBA Engineering Consultants Ltd.

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D.W. Hayley, P. Eng.

KOS:lmh

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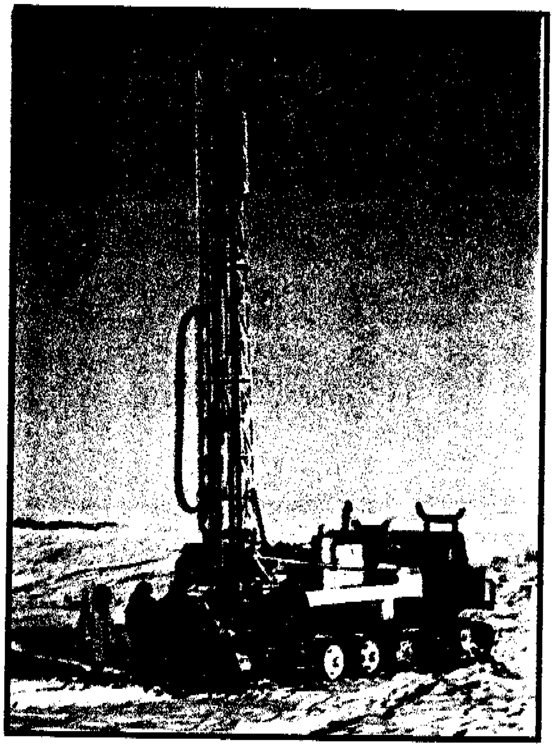

PLATE 1 'Mayhew 1000' drilling rig at A10 + 00, 2 + 50N
April 23, 1975

PLATE 2 Kame complex at Baseline B, B0 + 00 to B6 + 00
Photograph taken from Baseline A, A4 + 00.
April 25, 1975.

PLATE 3 Close up of kame structures on Baseline B of B4 + 00. April 25, 1975.

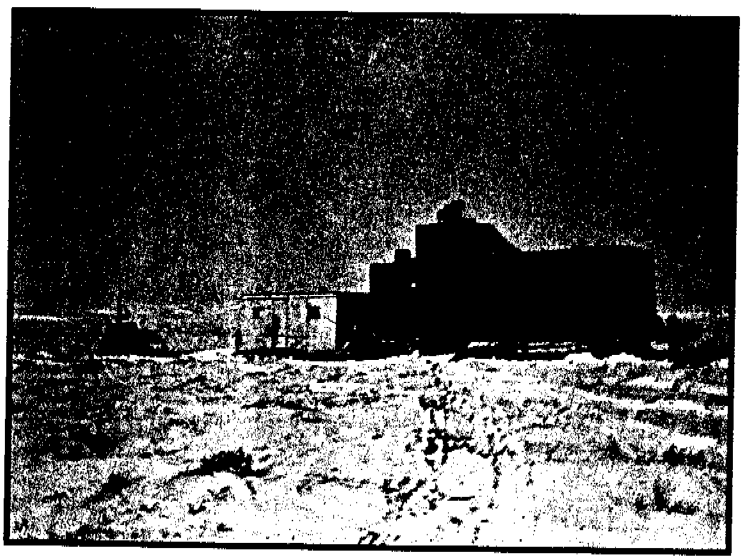

PLATE 4 Imperial Oil Becker Rig drilling on Baseline C at C4 + 00, 0 + 00. April 19, 1975.

PLATE 5 Stockpiled borrow material on Baseline C. Felt pen for scale. May 5, 1975.

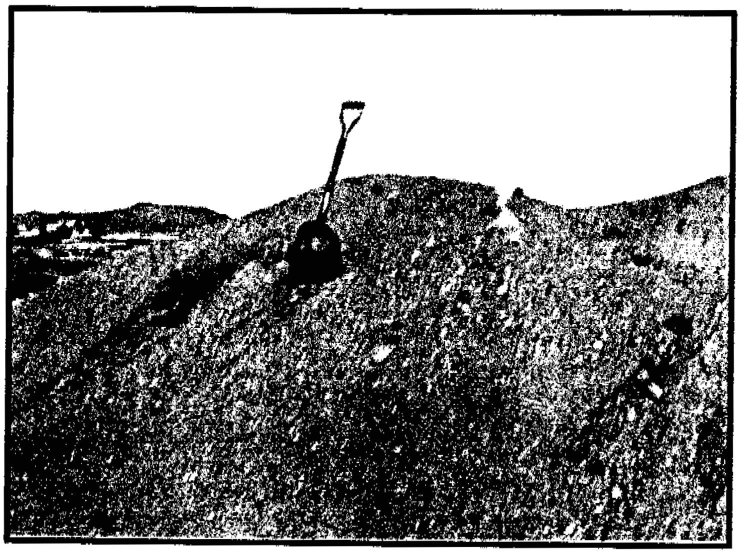

PLATE 6 Sand with trace of gravel in isolated pocket on Baseline B at approximately B 18 + 00, 0 + 50S. May 5, 1975.

PLATE 7 Large block of frozen borrow showing some sorting of the gravel and sand. Pen for scale. May 5, 1975.

PLATE 8 Sandy silt lense found on frozen exposure in gravel pit on Baseline B. Pen for scale. May 5, 1975.

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— E.B.A. Soil Samples 1975 —

Job No.: C-7851 | Appendix No.:

By: J.K. Smith | Checked:

AREA Baseline C YA YA Gravel Pit — Datum-Shoran ZONE 8, July, 1969 Adjustment

STATION		U.T.M CO-ORDINATES N	E		
26+00	500N	7 665 105	514 205 ND	Note: C.L.- Center Line	
26+00	525N	7 665 120	514 185	ND - Not drilled	
26+00	550N	7 665 135	514 165 ND		
26+00	600N	7 665 165	514 125		
26+00	650N	7 665 195	514 085 ND		
26+00	700N	7 665 225	514 045		
26+00	750N	7 665 250	514 040		
26+00	800N	7 665 290	514 000		
27+00	100N	7 664 780	514 465		
27+00	600N	7 665 085	514 065		
27+00	700N	7 665 145	513 990		
27+00	800N	7 665 260	513 950 ND		
28+00	450N	7 664 915	514 125 ND		
28+00	500N	7 664 945	514 085		
28+00	550N	7 664 975	514 045		
28+00	600N	7 665 005	514 005		
28+00	650N	7 665 055	513 980		
28+00	700N	7 665 090	513 940		
28+00	750N	7 665 120	513 900 ND		
28+00	780N	7 665 135	513 860		
28+00	800N	7 665 155	513 865 ND		
28+00	850N	7 665 185	513 825		
28+00	900N	7 665 215	513 785		
29+00	600N	7 664 925	513 945 ND		
29+00	900N	7 665 110	513 705		
29+00	1000N	7 665 170	513 625		
30+00	600N	7 664 845	513 885 ND		
30+00	650N	7 664 875	513 845		
30+00	700N	7 664 905	513 805 ND		
30+00	750N	7 664 935	513 765 ND		
30+00	800N	7 664 970	513 725 ND		
30+00	850N	7 665 000	513 685 ND		
30+00	900N	7 665 030	513 645		

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By: J.K. Smith | Checked:

AREA YA YA Gravel Pit, Isolated Borehole Groupings — Datum-Shoran ZONE 8, July, 1969 Adjustment

STATION		U.T.M CO-ORDINATES N	E		
C	1	7 665 870	516 210	Note: C.L. - Center Line	
C	2	7 665 865	516 250	ND - Not Drilled	
C	3	7 665 805	516 270		
D	1	7 666 160	513 800		
D	2	7 666 160	513 950		
D	2 (A)	7 666 195	513 930		
D	3	7 666 210	514 040		
D	4	7 666 130	514 030		
D	5	7 666 060	513 985		
D	6	7 666 335	513 890		

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AREA Baseline C YA YA Gravel Pit — Datum-Shoran July, 1969 Adjustment — ZONE 8

STATION		U.T.M CO-ORDINATES N	E	
10+00	150S	7 665 985	515 695	
10+00	100S	7 666 000	515 660	
10+00	50S	7 666 040	515 615	
10+00	C.L.	7 666 060	515 585	
10+00	50N	7 666 100	515 540	
11+00	100S	7 665 935	515 605	
11+00	C.L.	7 665 995	515 515	
11+00	50N	7 666 020	515 500	
12+00	150S	7 665 830	515 570	
12+00	100S	7 665 855	515 535	
12+00	50S	7 665 885	515 495	
12+00	C.L.	7 665 915	515 455	
13+00	C.L.	7 665 835	515 395	
13+00	50N	7 665 865	515 355	
14+00	100S	7 665 695	515 410	
14+00	50S	7 665 720	515 375	
14+00	C.L.	7 665 760	515 335	ND
14+00	25N	7 665 765	515 320	
14+00	50N	7 665 780	515 295	ND
15+00	C.L.	7 665 680	515 270	
16+00	250S	7 665 445	515 410	ND
16+00	200S	7 665 475	515 370	
16+00	100S	7 665 540	515 290	
16+00	C.L.	7 665 600	515 210	
17+00	C.L.	7 665 520	515 150	ND
18+00	150S	7 665 350	515 210	ND
	100S	7 665 385	515 165	ND
	50S	7 665 410	515 130	
	C.L.	7 665 440	515 090	ND
	50N	7 665 470	515 050	
	150N	7 665 530	514 970	
	200N	7 665 560	514 930	
19+00	C.L.	7 665 360	515 030	

Note: C.L. - Center Line
ND - Not drilled

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AREA Baseline C YA YA Gravel Pit — Datum-Shoran July, 1969 Adjustment — ZONE 8

STATION		U.T.M CO-ORDINATES N	E	
20+00	50S	7 665 250	515 010	
20+00	C.L.	7 665 280	514 970	
20+00	50N	7 665 320	514 930	
20+00	100N	7 665 350	514 890	ND
20+00	125N	7 665 360	514 870	
20+00	150N	7 665 370	514 850	ND
21+00	C.L.	7 665 200	514 910	
	100N	7 665 285	514 860	
	200N	7 665 355	514 790	
22+00	C.L.	7 665 120	514 845	
22+00	50N	7 665 150	514 810	
22+00	100N	7 665 180	514 765	
22+00	150N	7 665 225	514 720	
22+00	175N	7 665 245	514 710	
22+00	200N	7 665 255	514 685	
22+00	250N	7 665 285	514 650	
22+00	300N	7 665 320	514 615	
22+00	350N	7 665 350	514 555	
23+00	C.L.	7 665 040	514 785	
23+00	150N	7 665 135	514 670	
23+00	250N	7 665 230	514 640	
24+00	C.L.	7 664 960	514 725	
24+00	50N	7 664 990	514 685	
24+00	300N	7 665 170	514 485	
24+00	350N	7 665 195	514 445	
24+00	400N	7 665 170	514 505	
24+00	450N	7 665 195	514 460	
24+00	500N	7 665 265	514 330	
24+00	550N	7 665 295	514 290	ND
24+00	580N	7 665 330	514 280	ND
24+00	600N	7 665 325	514 250	
25+00	600N	7 665 245	514 188	
25+00	700N	7 665 300	514 145	

Note: C.L. - Center Line
ND - Not drilled

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—— E.B.A. Soil Samples 1975 ——

Job No. : C-7851 | Appendix No. :

By : J.K. Smith | Checked :

AREA Baseline B YA YA Gravel Pit

Datum-Shoran July, 1969 Adjustment **ZONE** 8

STATION		U.T.M CO-ORDINATES N	E	
22+00	150S	7 665 055	512 910	Note: C.L.- Center Line
	50S	7 665 145	512 945	ND - Not drilled
	0	7 665 190	512 965	
	50N	7 665 240	512 985 ND	
	100N	7 665 285	513 000	
	150N	7 665 330	513 020 ND	
	200N	7 665 380	513 040 ND	
23+00	0	7 665 155	513 060 ND	
	50N	7 665 200	513 075	
24+00	150S	7 664 980	513 095	
	100S	7 665 025	513 115 ND	
	50S	7 665 070	513 130	
	0	7 665 115	513 150 ND	
	50N	7 665 165	513 170	
	100N	7 665 210	513 190 ND	
	150N	7 665 255	513 205 ND	
	200N	7 665 295	513 210	
	250N	7 665 350	513 245	
25+00	0	7 665 080	513 245	
	100N	7 665 175	513 290	
	150N	7 665 220	513 300 ND	
	200N	7 665 265	513 320 ND	
	300N	7 665 360	513 355 ND	
	350N	7 665 405	513 375 ND	
	400N	7 665 450	513 390 ND	
	450N	7 665 500	513 410 ND	
	500N	7 665 545	513 430 ND	
26+00	0	7 665 045	513 335	
	100N	7 665 170	513 415	
	200N	7 665 230	513 410 ND	
	250N	7 665 275	513 430 ND	
	400N	7 665 415	513 485 ND	
	450N	7 665 460	513 505 ND	

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—— E.B.A. Soil Samples 1975 ——

Job No. : C-7851 | Appendix No. : 1-7851-M-9

By : J.K. Smith | Checked :

AREA Baseline C YA YA Gravel Pit

Datum-Shoran July, 1969 Adjustment **ZONE** 8

STATION		U.T.M CO-ORDINATES N	E	
0+00	C.L.	7 666 870	516 180 ND	Note: C.L.- Center Line
				ND - Not drilled
1+00	C.L.	7 666 790	516 120 ND	
2+00	200S	7 666 590	516 220 ND	
2+00	150S	7 666 620	516 180 ND	
2+00	100S	7 666 650	516 140 ND	
2+00	50S	7 666 680	516 100	
2+00	C.L.	7 666 710	516 060 ND	
3+00	100S	7 666 570	516 080	
3+00	C.L.	7 666 630	516 000	
4+00	100S	7 666 490	516 020 ND	
4+00	50S	7 666 505	515 990	
4+00	C.L.	7 666 555	515 940	
4+00	50N	7 666 585	515 900 ND	
4+00	100N	7 666 615	515 860 ND	
5+00	C.L.	7 666 475	515 880 ND	
6+00	C.L.	7 666 395	515 820 ND	
6+00	50N	7 666 425	515 780	
7+00	100S	7 666 255	515 835	
7+00	C.L.	7 666 315	515 755	
7+00	50N	7 666 345	515 715	
8+00	150S	7 666 120	515 825	
8+00	100S	7 666 170	515 775	
8+00	50S	7 666 195	515 740	
8+00	C.L.	7 666 235	513 695	
8+00	50N	7 666 260	515 660	
8+00	100N	7 666 295	515 625	
8+00	150N	7 666 325	515 575	
8+00	200N	7 666 350	515 545	
8+00	300N	7 666 410	515 465	
8+00	350N	7 666 435	515 430	
9+00	50S	7 666 098	515 725 ND	Not located in Field
9+00	C.L.	7 666 135	515 650	
9+00	50N	7 666 200	515 610	
9+00	100N	7 666 215	515 555 ND	
9+00	100S	7 666 085	515 725	

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IMPERIAL OIL LIMITED
— E.B.A. Soil Samples 1975 —

Job No.: C-7851 | Appendix No.:
By: J.K. Smith | Checked:

AREA Baseline B YA YA Gravel Pit
Datum-Shoran ZONE 8 July, 1969 Adjustment

Note: C.L. - Center Line
ND - Not Drilled

STATION		U.T.M CO-ORDINATES N	U.T.M CO-ORDINATES E	
7+00	0	7 665 750	511 575	
8+00	700S	7 665 065	511 405 ND	
	650S	7 665 110	511 425 ND	
	600S	7 665 155	511 440	
	550S	7 665 200	511 460	
	450S	7 665 295	511 500	
	400S	7 665 340	511 515	
	350S	7 665 390	511 535	
	0	7 665 715	511 665 ND	
9+00	450S	7 665 245	511 590	EBA-1S, 1000E
	325S	7 665 375	511 640	
	0	7 665 680	511 755 ND	
10+00	500S	7 665 175	511 665	
	450S	7 665 220	511 685	
	400S	7 665 265	511 700 ND	
	350S	7 665 315	511 720 ND	
	0	7 665 640	511 850 ND	
11+00	450S	7 665 185	511 775	
	400S	7 665 230	511 795	
	0	7 665 605	511 940	
12+00	500S	7 665 110	511 845	
	450S	7 665 145	511 865	
	400S	7 665 200	511 880	
	350S	7 665 245	511 905 ND	
	0	7 665 565	512 035	
12+50	375S	7 665 200	511 945	EBA-450S,1300S- Becker
13+00	450S	7 665 110	511 960	Mayhew
	350S	7 665 200	512 000	
	0	7 665 530	512 125	
14+00	500S	7 665 030	512 040 ND	
	450S	7 665 080	512 050 ND	
	400S	7 665 125	512 065	
	350S	7 665 170	512 090	
	300S	7 665 215	512 105	
	250S	7 665 265	512 125	
	200S	7 665 310	512 140	
	150S	7 665 355	512 160	
	100S	7 665 400	512 180	
	50S	7 665 445	512 195 ND	
	0	7 665 495	512 215	

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED
— E.B.A. Soil Samples 1975 —

Job No.: C-7851 | Appendix No.:
By: J.K. Smith | Checked:

AREA Baseline B YA YA Gravel Pit
Datum-Shoran ZONE 8 July, 1969 Adjustment

Note: C.L. - Center Line
ND - Not Drilled

STATION		U.T.M CO-ORDINATES N	U.T.M CO-ORDINATES E
15+00	250S	7 665 220	512 220
	150S	7 665 310	512 260
	50S	7 665 405	512 295
	0	7 665 455	512 310
16+00	300S	7 665 135	512 295
	250S	7 665 180	512 315
	200S	7 665 250	512 320
	150S	7 665 280	512 345
	100S	7 665 325	512 360
	50S	7 665 375	512 380
	0	7 665 420	512 400 ND
	50N	7 665 460	512 425
17+00	200S	7 665 190	512 425
	100S	7 665 285	512 465
	0	7 665 380	512 500
	50N	7 665 445	512 505
18+00	50S	7 665 295	512 575
	0	7 665 340	512 595 ND
	50N	7 665 390	512 600 ND
	75N	7 665 410	512 620
	100N	7 665 435	512 630 ND
	150N	7 665 480	512 650 ND
	250N	7 665 575	512 685 ND
19+00	150S	7 665 165	512 630
	0	7 665 305	512 685
20+00	200S	7 665 080	512 705
	150S	7 665 125	512 725 ND
	100S	7 665 175	512 740 ND
	50S	7 665 220	512 760 ND
	0	7 665 265	512 780 ND
	250N	7 665 500	512 870 ND
	300N	7 665 545	512 890 ND
21+00	0	7 665 230	512 870 ND
	100N	7 665 320	512 910 ND

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED
— E.B.A. Soil Samples 1975 —

Job No.: C-7851 | Appendix No.: 1-7851-M-9
By: J.K. Smith | Checked:

AREA YA-YA Gravel Pit Line A Datum-Shoran July, 1969 Adjustment **ZONE** 8

STATION	U.T.M CO-ORDINATES N	U.T.M CO-ORDINATES E	
23+35 800N	7 665 195	508 385	Note: C.L. - Center Line ND - Not drilled
23+50 800N	7 665 185	508 375	
22+00 235N	7 664 850	508 855	
22+10 205N	7 664 820	508 870	
22+50 150N	7 664 755	508 875	
22+75 35N	7 664 650	508 930	
Becker 400 50S	7 665 805	510 410	
Becker 400 100S	7 665 770	510 445	
Becker 400 150S	7 665 745	510 465	
Becker 400 200S	7 665 720	510 500	
15+95 310N	7 665 300	509 265	} Knoll North of Lake
16+00 300N	7 665 290	509 270	
18+05 450N	7 665 270	509 015	- Core Shack
16+25 460N	7 665 395	509 145	- 150 M NE Core Shack

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED
— E.B.A. Soil Samples 1975 —

Job No.: C-7851 | Appendix No.: 1-7851-M-9
By: J.K. Smith | Checked:

AREA Baseline B YA YA Gravel Pit Datume-Shoran July 1969, Adjustment **ZONE** 8

STATION		U.T.M CO-ORDINATES N	U.T.M CO-ORDINATES E	
0+00	0	7 665 010	510 925 ND	
1+00	100S	7 665 880	510 980 ND	Note: C.L. - Center Line ND - Not drilled
	50S	7 665 925	510 995 ND	
	0	7 666 975	511 015	
	50N	7 666 020	511 035	
	100N	7 666 065	511 055	
1+25	125N	7 666 080	511 085 ND	
2+00	100S	7 665 845	511 070	
	50S	7 665 890	511 090	
	0	7 665 935	511 110	
	50N	7 665 980	511 125	
	100N	7 666 025	511 150	
	200N	7 666 120	511 185	
3+00	0	7 665 900	511 200	
4+00	250S	7 665 630	511 200	
	200S	7 665 675	511 220	
	50S	7 665 815	511 275	
	0	7 665 860	511 295	
	50N	7 665 900	511 315	
	125S	7 665 740	511 245	
5+00	0	7 665 825	511 385	
6+00	525S	7 665 300	511 285	EBA-650S, 600E
	500S	7 665 320	511 295 ND	
	475S	7 665 345	511 305	EBA-550S, 600E
	450S	7 665 370	511 310 ND	
	400S	7 665 415	511 330	EBA-450S, 600E
	350S	7 665 460	511 350	
	250S	7 665 555	511 385	
	200S	7 665 600	511 405 ND	
	150S	7 665 645	511 425	
	100S	7 665 695	511 440	
	50S	7 665 740	511 455	
	25S	7 665 770	511 470	EBA-0S, 600E
	0	7 665 785	511 480 ND	
	50N	7 665 835	511 500	
	100N	7 665 880	511 510	
6+90	135N	7 665 870	511 610	EBA-200N, 600E

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED
E.B.A. Soil Samples 1975

Job No. : C-7851 | Appendix No. : 1-8751-M-9
By J.K. Smith | Checked :

AREA YA - YA Gravel Pit Line A | Datum - Shoran | ZONE 8 | July 1969, Adjustment

STATION		U.T.M CO-ORDINATES N			U.T.M CO-ORDINATES E		
16+00	350S	7	664	790	509	695	
16+00	300S	7	664	840	509	665	ND
16+00	250S	7	664	880	509	630	
16+00	200S	7	664	915	509	600	ND
16+00	150S	7	664	950	509	565	ND
16+00	100S	7	664	990	509	535	ND
16+00	50S	7	665	030	509	500	ND
16+00	C.L.	7	665	065	509	470	
16+00	50N	7	665	105	509	435	
16+00	100N	7	665	140	509	405	
16+00	150N	7	665	180	509	370	ND
17+00	C.L.	7	665	000	509	390	ND
18+00	200S	7	664	790	509	440	
18+00	150S	7	664	825	509	410	
18+00	100S	7	664	870	509	375	
18+00	50S	7	664	895	509	345	
18+00	C.L.	7	664	935	509	315	
18+00	50N	7	664	970	509	280	ND
19+00	C.L.	7	664	870	509	235	ND
20+00	400S	7	664	520	509	410	
20+00	350S	7	664	555	509	390	
20+00	300S	7	664	590	509	355	
20+00	250S	7	664	625	509	325	
20+00	200S	7	664	670	509	280	
20+00	150S	7	664	700	509	255	
20+00	125S	7	664	710	509	240	
20+00	100S	7	664	725	509	225	ND
20+00	75S	7	664	745	509	210	
20+00	50S	7	664	765	509	195	ND
20+00	C.L.	7	664	800	509	160	ND
20+00	50N	7	664	840	509	130	
20+00	150N	7	664	915	509	065	ND
21+00	C.L.	7	664	740	509	085	ND

Note: C.L. - Center Line
ND - Not Drilled

Canadian Engineering Surveys Co. Ltd.

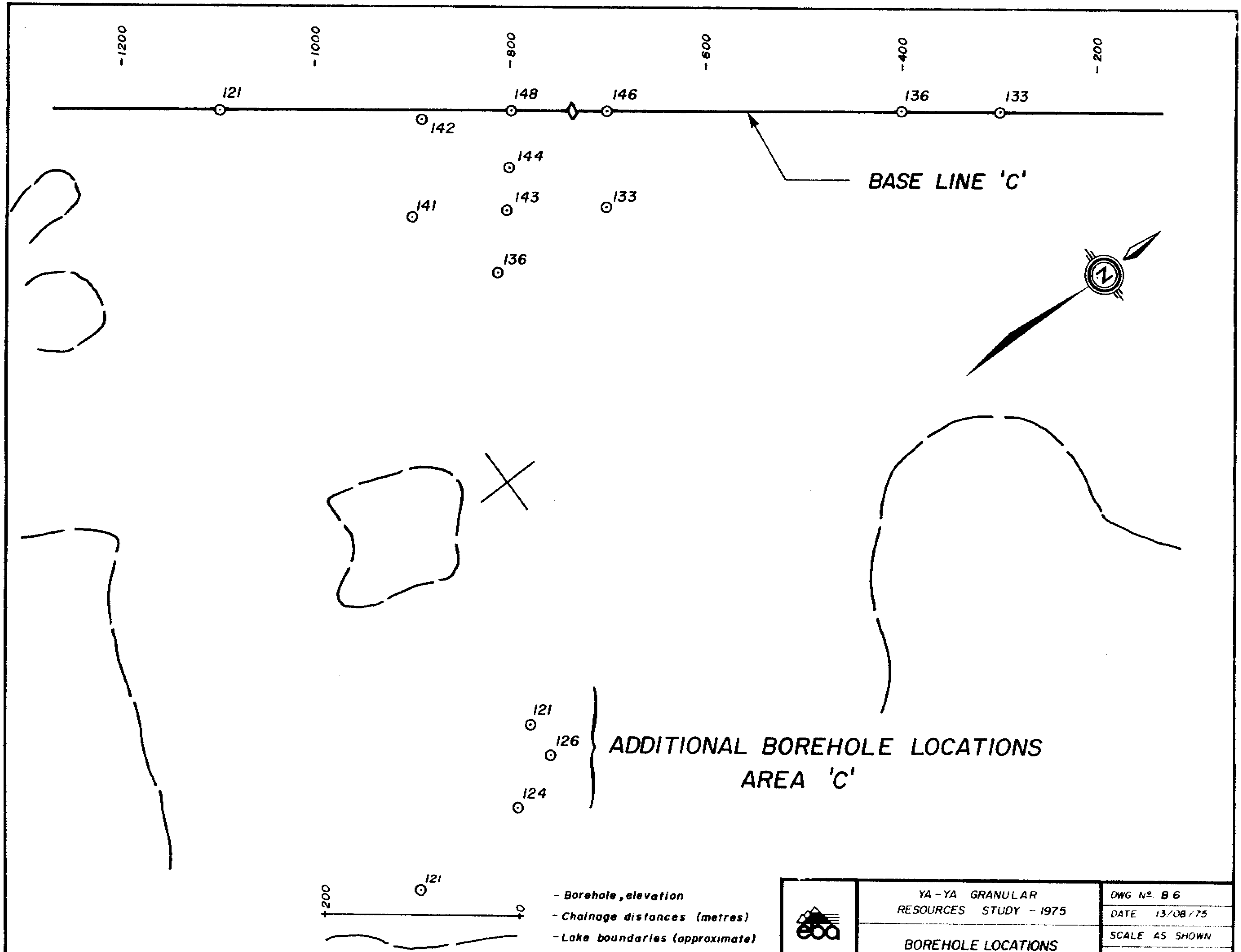
IMPERIAL OIL LIMITED
E.B.A. Soil Samples 1975

Job No. : C-7851 | Appendix No. : 1-7851-M-9
By : J.K. Smith | Checked :

AREA YA-YA Gravel Pit Line A | Datum - Shoran | ZONE 8 | July, 1969 Adjustment

STATION		U.T.M CO-ORDINATES N			U.T.M CO-ORDINATES E		
22+00	500S	7	664	385	509	270	
	100S	7	664	610	509	075	
	50S	7	664	635	509	040	
	C.L.	7	664	675	509	010	ND
23+00	C.L.	7	664	610	508	935	ND
20+00	200N	7	664	955	509	030	
20+50	200N	7	664	920	508	995	ND
21+00	200N	7	664	890	508	955	ND
21+15	200N	7	664	880	508	945	
22+50	200N	7	664	790	508	840	
23+00	200N	7	664	760	508	805	ND
23+50	200N	7	664	725	508	765	ND
21+20	100N	7	664	800	509	005	
19+50	350N	7	665	100	508	970	ND
20+00	350N	7	665	070	508	935	ND
20+50	350N	7	665	035	508	895	
21+00	350N	7	665	005	508	855	
21+50	350N	7	664	970	508	820	
22+00	350N	7	664	940	508	780	
22+50	350N	7	664	905	508	745	ND
23+00	350N	7	664	875	508	705	ND
19+50	370N	7	665	115	508	960	
21+20	400N	7	665	050	508	810	
21+40	400N	7	665	015	508	795	
21+85	400N	7	664	995	508	775	ND
20+00	500N	7	665	180	508	835	
19+50	600N	7	665	290	508	810	
20+00	600N	7	665	260	508	770	
20+50	600N	7	665	225	508	735	
21+00	600N	7	665	195	508	695	ND
21+50	600N	7	665	160	508	655	ND
22+00	600N	7	665	130	508	620	
22+50	600N	7	665	095	508	580	
23+00	600N	7	665	065	508	545	
21+65	600N	7	665	150	508	645	
22+16	600N	7	665	120	508	605	
19+50	800N	7	665	445	508	680	ND
20+00	800N	7	665	410	508	640	ND
20+50	800N	7	665	380	508	605	ND
21+00	800N	7	665	345	508	565	ND
21+50	800N	7	665	315	508	525	ND
22+00	800N	7	665	280	508	490	
22+50	800N	7	665	250	508	450	
23+00	800N	7	665	215	508	415	

Note: C.L. - Center Line
ND - Not Drilled



YA-YA GRANULAR RESOURCES STUDY - 1975

BOREHOLE LOCATIONS

DWG Nº	B 6
DATE	13/08/75
SCALE	AS SHOWN
JOB Nº	1-965.3

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED

E.B.A. Soil Samples 1975

Job No. : C - 7851 Appendix No. : 1-8751-M-9

By : J.K. Smith Checked :

AREA YA - YA Gravel Pit Line A

Datum - Shoran ZONE 8
July 1969, Adjustment

STATION		U.T.M. CO-ORDINATES N	E
16+00	350S	7 664 790	509 695
16+00	300S	7 664 840	509 665 ND
16+00	250S	7 664 880	509 630
16+00	200S	7 664 915	509 600 ND
16+00	150S	7 664 950	509 565 ND
16+00	100S	7 664 990	509 535 ND
16+00	50S	7 665 030	509 500 ND
16+00	C.L.	7 665 065	509 470
16+00	50N	7 665 105	509 435
16+00	100N	7 665 140	509 405
16+00	150N	7 665 180	509 370 ND
17+00	C.L.	7 665 000	509 390 ND
18+00	200S	7 664 790	509 440
18+00	150S	7 664 825	509 410
18+00	100S	7 664 870	509 375
18+00	50S	7 664 895	509 345
18+00	C.L.	7 664 935	509 315
18+00	50N	7 664 970	509 280 ND
19+00	C.L.	7 664 870	509 235 ND
20+00	400S	7 664 520	509 410
20+00	350S	7 664 555	509 390
20+00	300S	7 664 590	509 355
20+00	250S	7 664 625	509 325
20+00	200S	7 664 670	509 280
20+00	150S	7 664 700	509 255
20+00	125S	7 664 710	509 240
20+00	100S	7 664 725	509 225 ND
20+00	75S	7 664 745	509 210
20+00	50S	7 664 765	509 195 ND
20+00	C.L.	7 664 800	509 160 ND
20+00	50N	7 664 840	509 130
20+00	150N	7 664 915	509 065 ND
21+00	C.L.	7 664 740	509 085 ND

Note: C.L. - Center Line
ND - Not Drilled

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED

E.B.A. Soil Samples 1975

Job No. : C - 7851 Appendix No. : 1-7851-M-9

By : J.K. Smith Checked :

AREA YA-YA Gravel Pit Line A

Datum - Shoran ZONE 8
July, 1969 Adjustment

STATION		U.T.M. CO-ORDINATES N	E
22+00	500S	7 664 385	509 270
	100S	7 664 610	509 075
	50S	7 664 635	509 040
	C.L.	7 664 675	509 010 ND
23+00	C.L.	7 664 610	508 935 ND
20+00	200N	7 664 955	509 030
20+50	200N	7 664 920	508 995 ND
21+00	200N	7 664 890	508 955 ND
21+15	200N	7 664 880	508 945
22+50	200N	7 664 790	508 840
23+00	200N	7 664 760	508 805 ND
23+50	200N	7 664 725	508 765 ND
21+20	100N	7 664 800	509 005
19+50	350N	7 665 100	508 970 ND
20+00	350N	7 665 070	508 935 ND
20+50	350N	7 665 035	508 895
21+00	350N	7 665 005	508 855
21+50	350N	7 664 970	508 820
22+00	350N	7 664 940	508 780
22+50	350N	7 664 905	508 745 ND
23+00	350N	7 664 875	508 705 ND
19+50	370N	7 665 115	508 960
21+20	400N	7 665 050	508 810
21+40	400N	7 665 015	508 795
21+85	400N	7 664 995	508 775 ND
20+00	500N	7 665 180	508 835
19+50	600N	7 665 290	508 810
20+00	600N	7 665 260	508 770
20+50	600N	7 665 225	508 735
21+00	600N	7 665 195	508 695 ND
21+50	600N	7 665 160	508 655 ND
22+00	600N	7 665 130	508 620
22+50	600N	7 665 095	508 580
23+00	600N	7 665 065	508 545
21+65	600N	7 665 150	508 645
22+16	600N	7 665 120	508 605
19+50	800N	7 665 445	508 680 ND
20+00	800N	7 665 410	508 640 ND
20+50	800N	7 665 380	508 605 ND
21+00	800N	7 665 345	508 565 ND
21+50	800N	7 665 315	508 525 ND
22+00	800N	7 665 280	508 490
22+50	800N	7 665 250	508 450
23+00	800N	7 665 215	508 415

Note: C.L. - Center Line
ND - Not Drilled

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED
— E.B.A. Soil Samples 1975 —

Job No. : C-7851 | Appendix No. : 1-7851-M-9

By J.K. Smith | Checked :

AREA YA-YA Gravel Pit Line A

Datum - Shoran ZONE 8
July, 1969 Adjustment

Note: C.L. - Center Line
ND - Not Drilled

STATION		U.T.M CO-ORDINATES N			E		
1+00	100S	7	665	960	510	670	
2+00	250S	7	665	870	510	755	ND
	200S	7	665	890	510	710	
	150S	7	665	910	510	665	
	100S	7	665	935	510	620	
	50S	7	665	940	510	580	
	C.L.	7	665	980	510	540	
3+00	C.L.	7	665	910	510	455	
4+00	250S	7	665	710	510	565	
	200S	7	665	755	510	480	
	100S	7	665	765	510	440	ND
	75S	7	665	785	510	425	
	50S	7	665	805	510	410	
	C.L.	7	665	845	510	375	
5+00	C.L.	7	665	780	510	300	
	50N	7	665	815	510	270	ND
	100N	7	665	855	510	235	
5+50	50S	7	665	710	510	295	
6+00	50S	7	665	675	510	255	
6+00	C.L.	7	665	715	510	225	
6+00	45N	7	665	745	510	195	
6+00	75N	7	665	770	510	175	
6+00	100N	7	665	790	510	160	
7+00	C.L.	7	665	650	510	150	ND
8+00	150S	7	665	470	510	170	
8+00	100S	7	665	505	510	140	
8+00	75S	7	665	525	510	120	
8+00	25S	7	665	565	510	090	
8+00	C.L.	7	665	595	510	075	ND
8+00	50N	7	665	620	510	040	
8+00	100N	7	665	660	510	015	
8+00	150N	7	665	700	509	980	
8+00	200N	7	665	740	509	950	
8+00	250N	7	665	790	509	920	

Canadian Engineering Surveys Co. Ltd.

IMPERIAL OIL LIMITED
— E.B.A. Soil Samples 1975 —

Job No. : C-7851 | Appendix No. : 1-7851-M-9

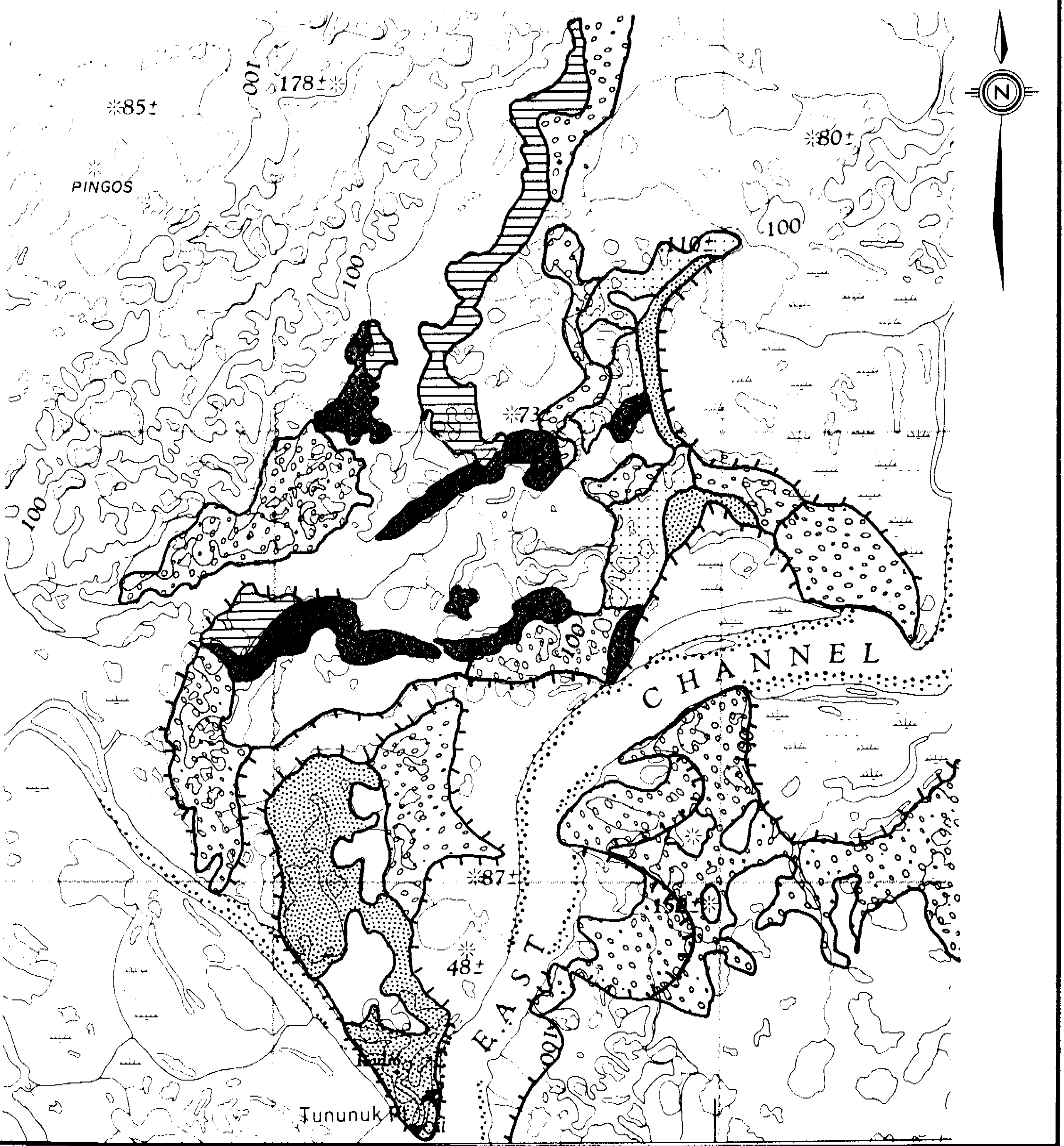
By J.K. Smith | Checked :

AREA YA-YA Gravel Pit Line A

Datum-Shoran ZONE 8
July, 1969 Adjustment

Note: C.L. - Center Line
ND - Not Drilled

STATION		U.T.M CO-ORDINATES N			E		
9+00	C.L.	7	665	520	509	995	ND
10+00	100S	7	665	370	509	990	
10+00	50S	7	665	415	509	955	
10+00	C.L.	7	665	455	509	925	
10+00	50N	7	665	490	509	890	
10+00	100N	7	665	530	509	855	
10+00	150N	7	665	565	509	825	
10+00	200N	7	665	600	509	790	
10+00	250N	7	665	645	509	760	
11+00	C.L.	7	665	390	509	845	ND
12+00	250S	7	665	145	509	920	
12+00	200S	7	665	170	509	900	
12+00	50S	7	665	285	509	800	ND
12+00	C.L.	7	665	325	509	770	ND
12+00	15N	7	665	335	509	760	
12+00	50N	7	665	365	509	740	
12+00	100N	7	665	400	509	705	ND
12+00	150N	7	665	435	509	670	
12+00	200N	7	665	475	509	640	ND
12+00	250N	7	665	510	509	605	
13+00	C.L.	7	665	260	509	695	ND
14+00	350S	7	664	940	509	845	
14+00	300S	7	664	975	509	810	
14+00	250S	7	665	005	509	780	
14+00	100S	7	665	115	509	680	ND
14+00	50S	7	665	160	509	650	
14+00	C.L.	7	665	190	509	615	
14+00	50N	7	665	250	509	575	
14+00	100N	7	665	270	509	550	ND
14+00	150N	7	665	305	509	520	
15+00	C.L.	7	665	130	509	540	ND



LEGEND

GLACIOFLUVIAL

- coarse grained granular material
- sand and gravel
- sand or sand with fines

GLACIOLACUSTRINE

- sand and gravel

MARINE

- sand or sand with fines
- defined boundaries
- former stream cut escarpment

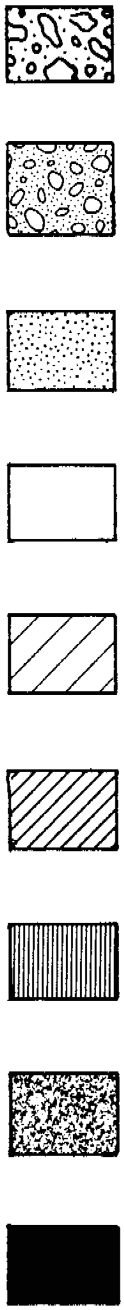
0 1 2
MILES

REGIONAL SURFICIAL GEOLOGY
Ya Ya LAKE - TUNUNUK AREA

(FROM SURFICIAL GEOLOGY AND LANDFORMS MACKENZIE DELTA 107C-W1/2, GSC OPEN FILE 96)

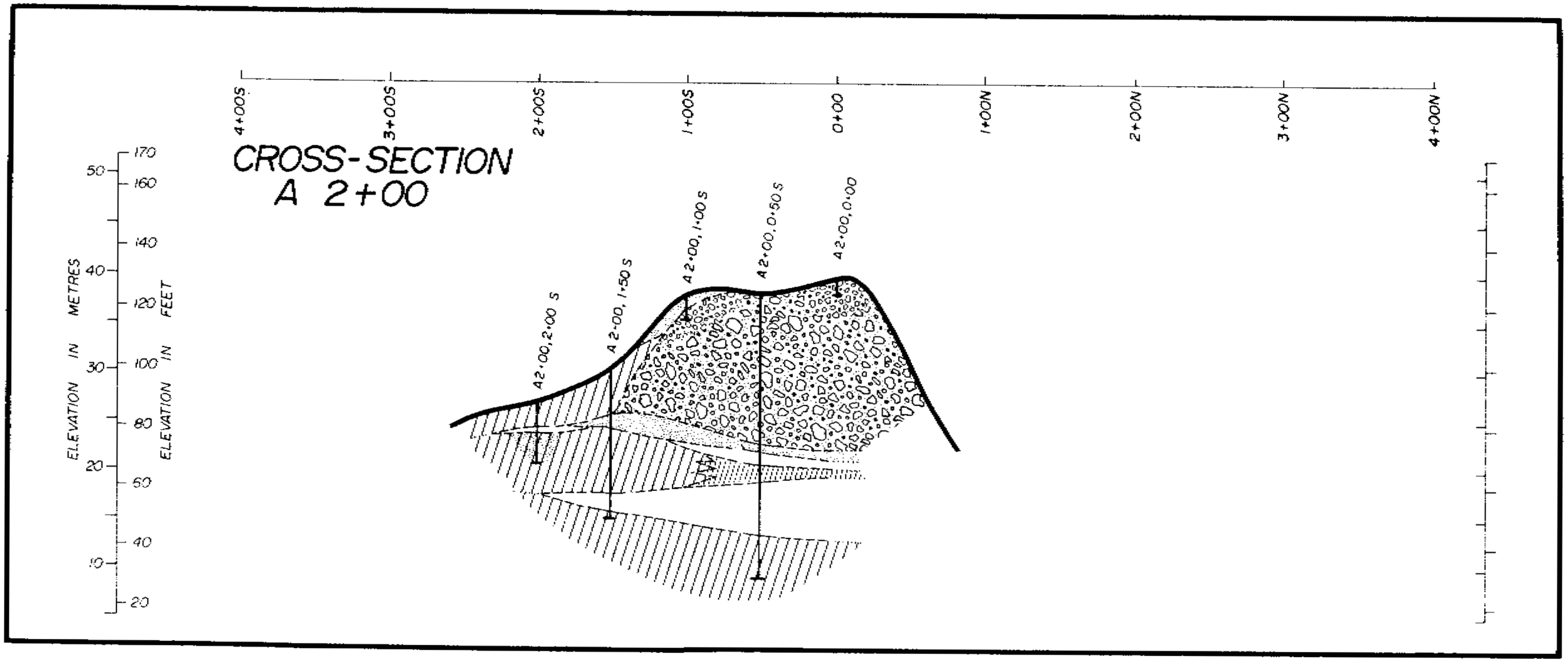
DWG. NO. B-1

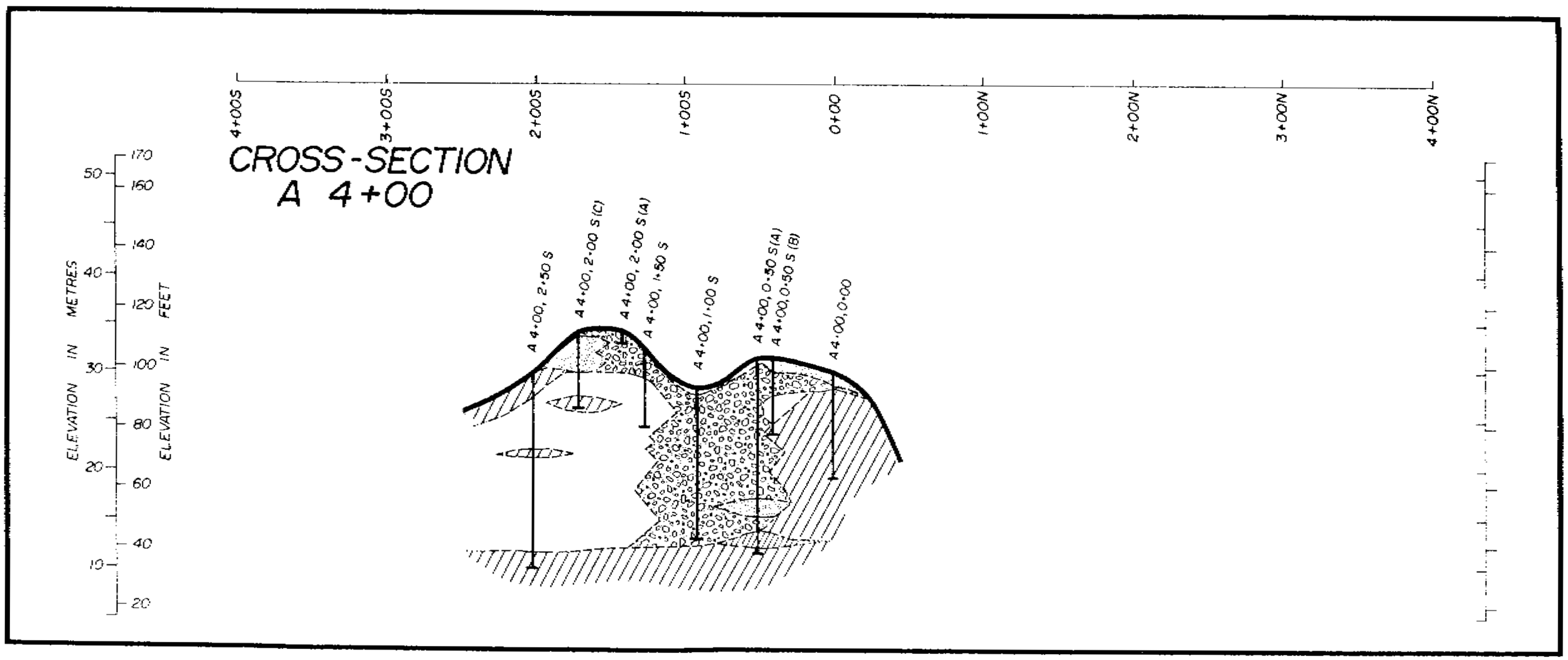
Legend For Cross-Sections



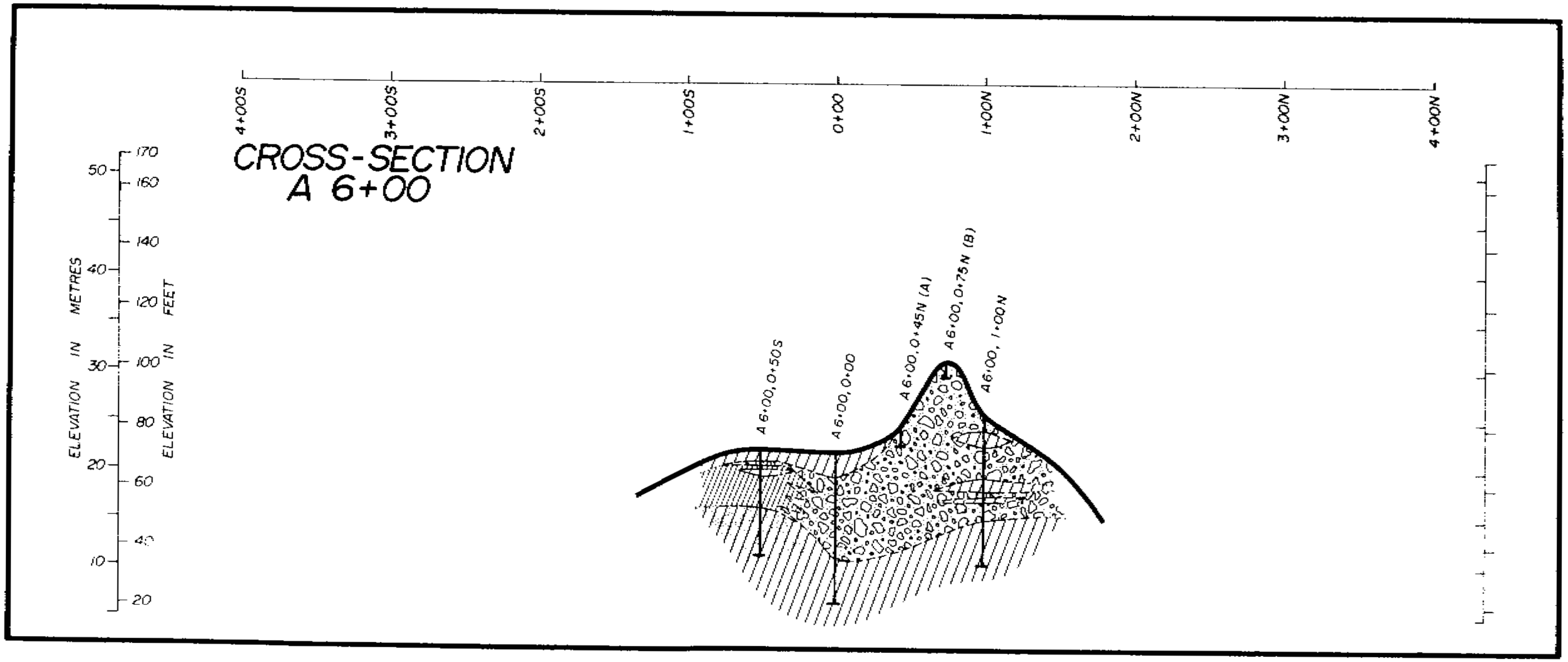
- Gravel
- Sand & Gravel
- Sand
- Ice
- Silt
- Silt & Ice
- Clay
- Peat
- Coal

NOTE : Stratigraphy between boreholes has been assumed.

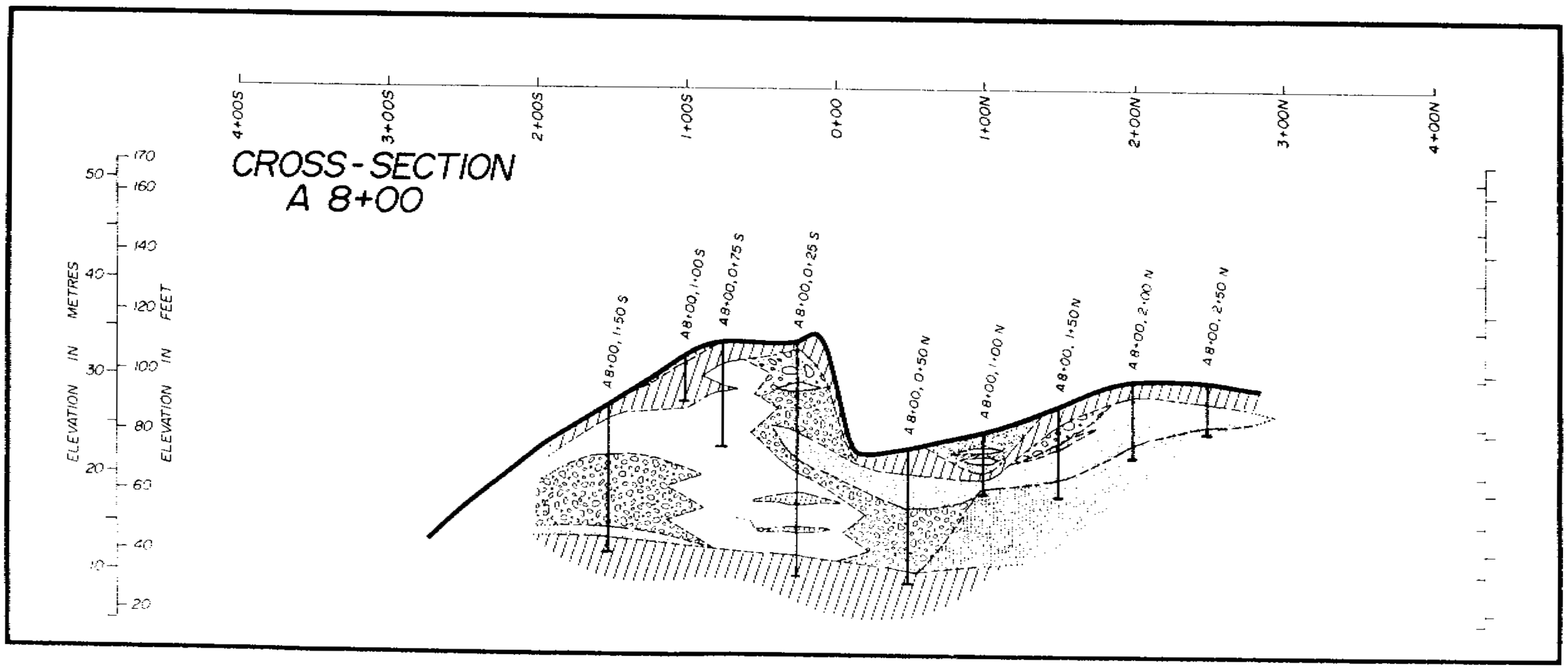

CROSS-SECTION
A 2+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
A2+00,2+00 S
A2+00,1+50 S
A2+00,1+00 S
A2+00,0+50 S
A2+00,0+00

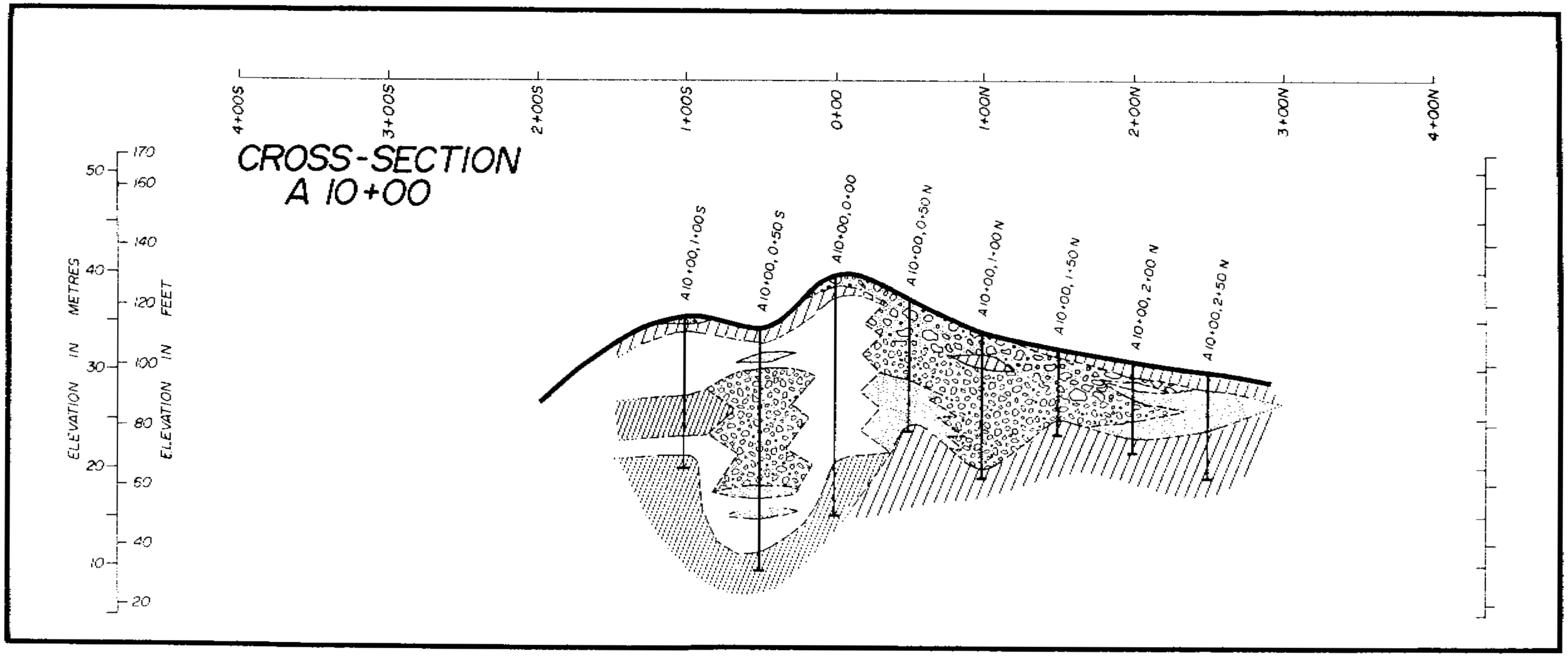

CROSS-SECTION
A 4+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
A 4+00, 2+50 S
A 4+00, 2+00 S (C)
A 4+00, 2+00 S (A)
A 4+00, 1+50 S
A 4+00, 1+00 S
A 4+00, 0+50 S (A)
A 4+00, 0+50 S (B)
A 4+00, 0+00

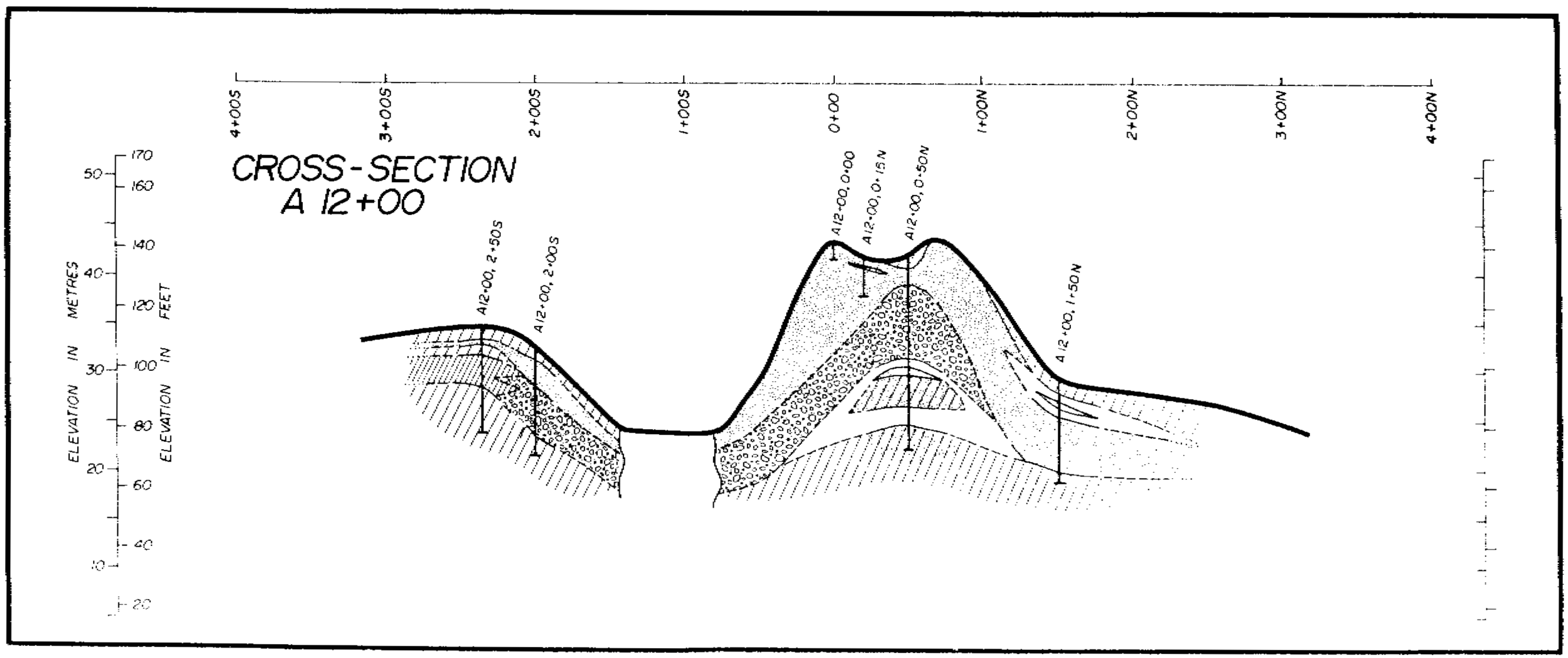
CROSS-SECTION A 6+00

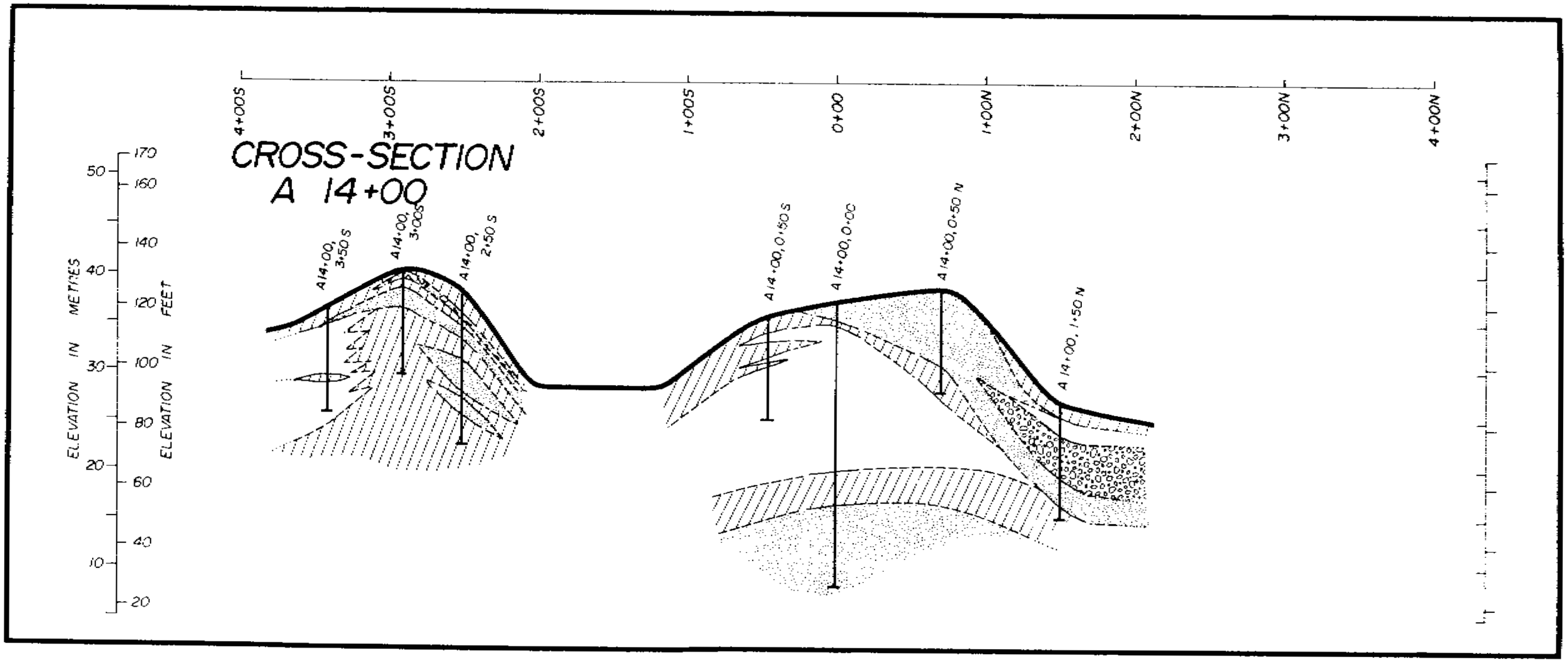


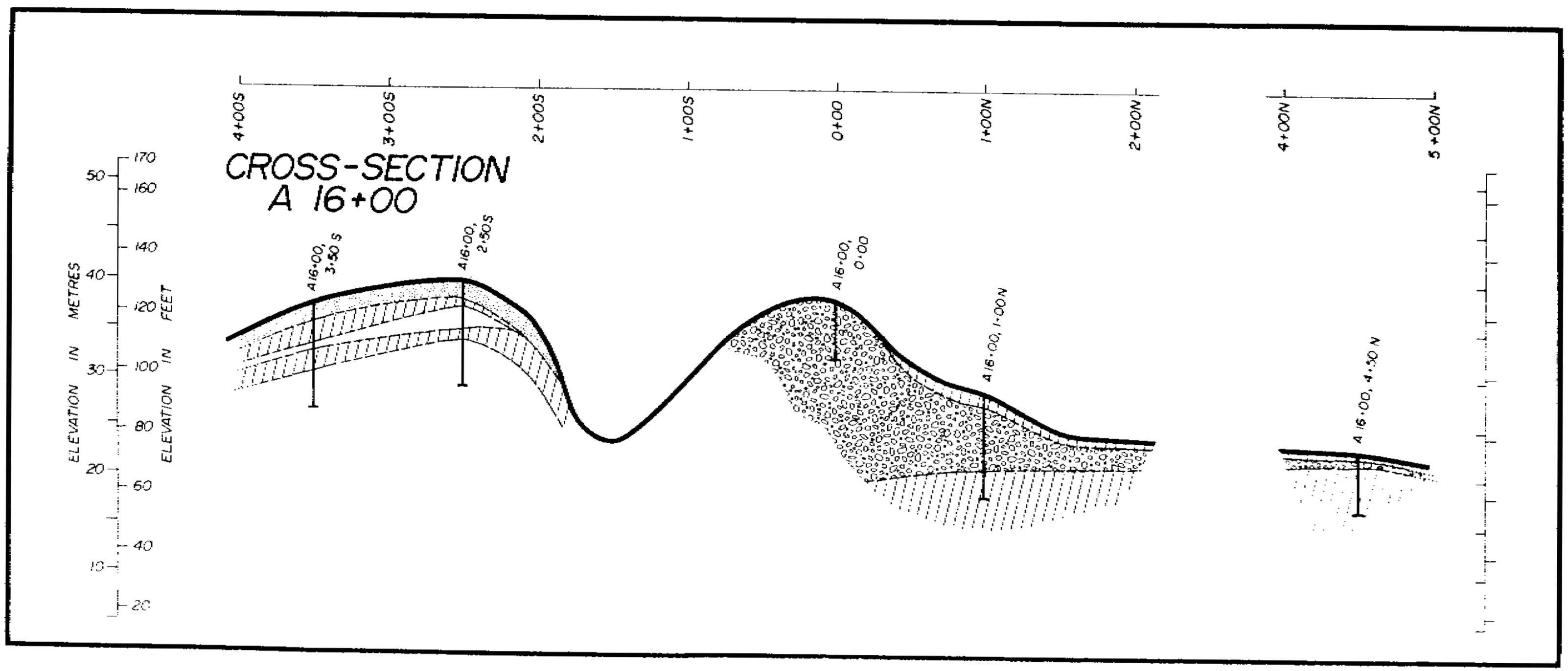
CROSS-SECTION A 8+00

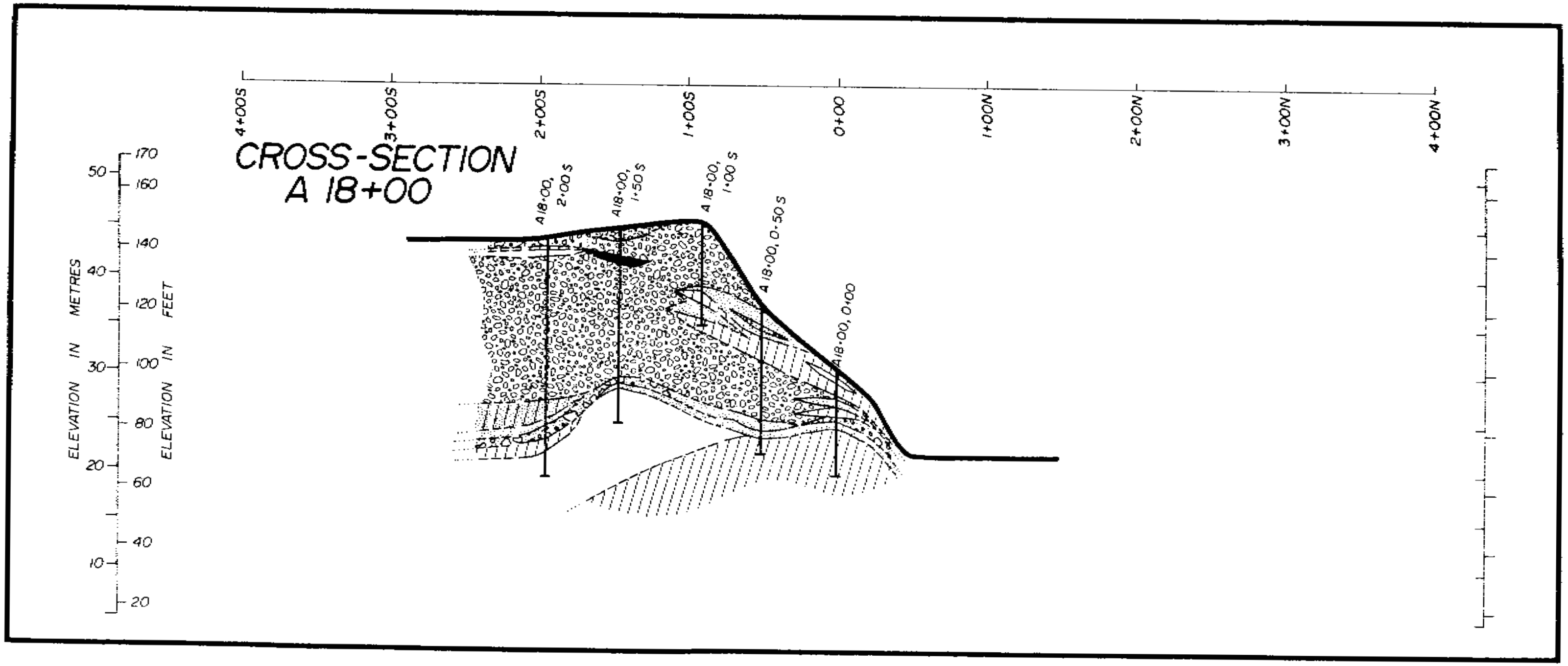


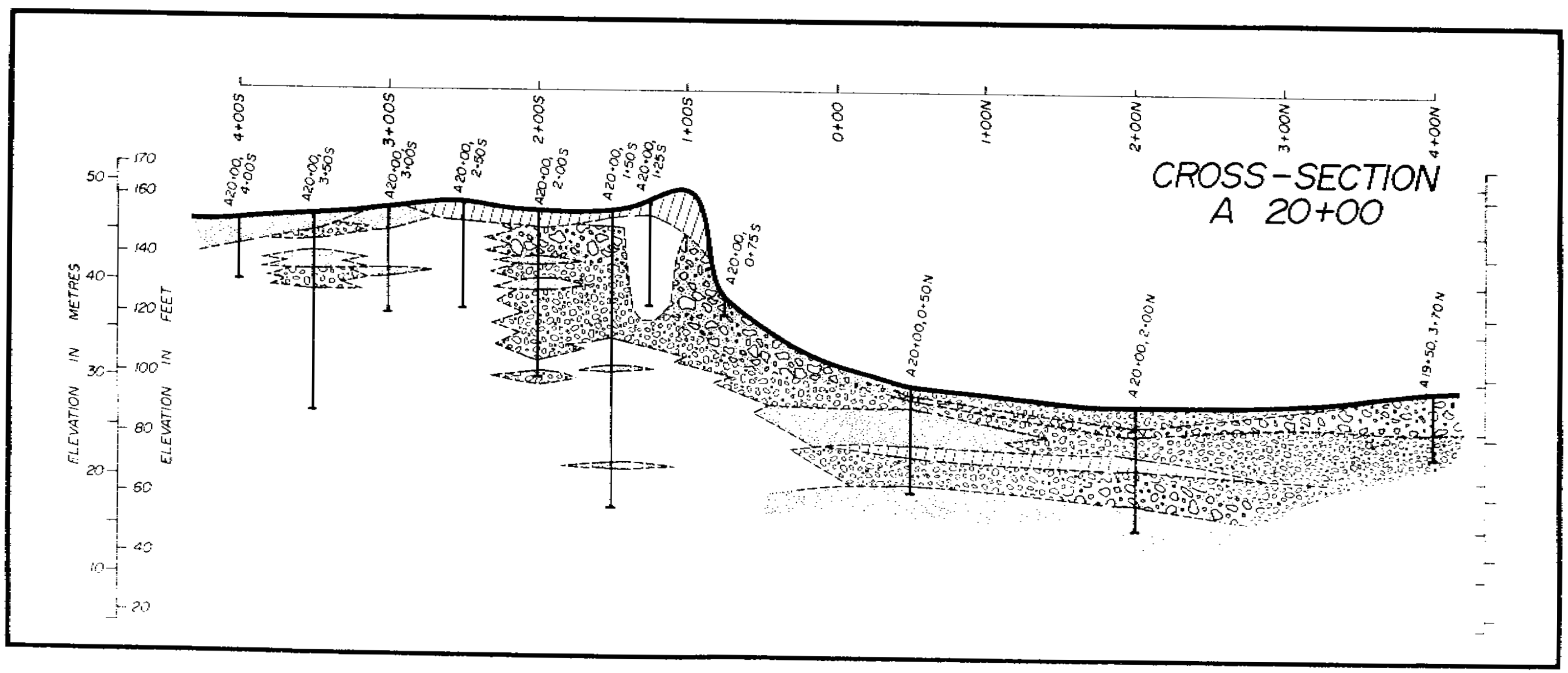

CROSS-SECTION
A 10+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
A10+00,1+00S
A10+00,0+50S
A10+00,0+00
A10+00,0+50N
A10+00,1+00N
A10+00,1+50N
A10+00,2+00N
A10+00,2+50N

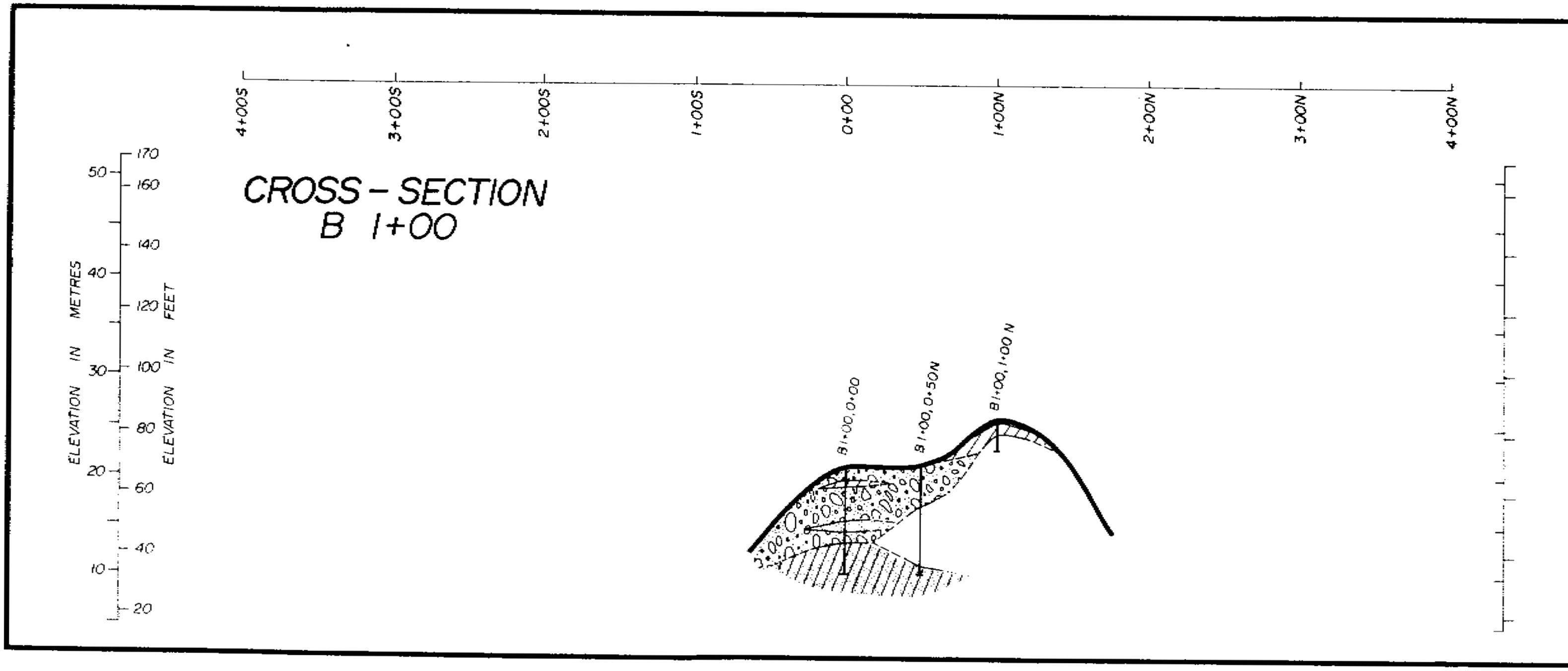

CROSS-SECTION
A 12+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
A12+00,2+50S
A12+00,2+00S
A12+00,0+00
A12+00,0+15N
A12+00,0+50N
A12+00,1+50N


CROSS-SECTION
A 14+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

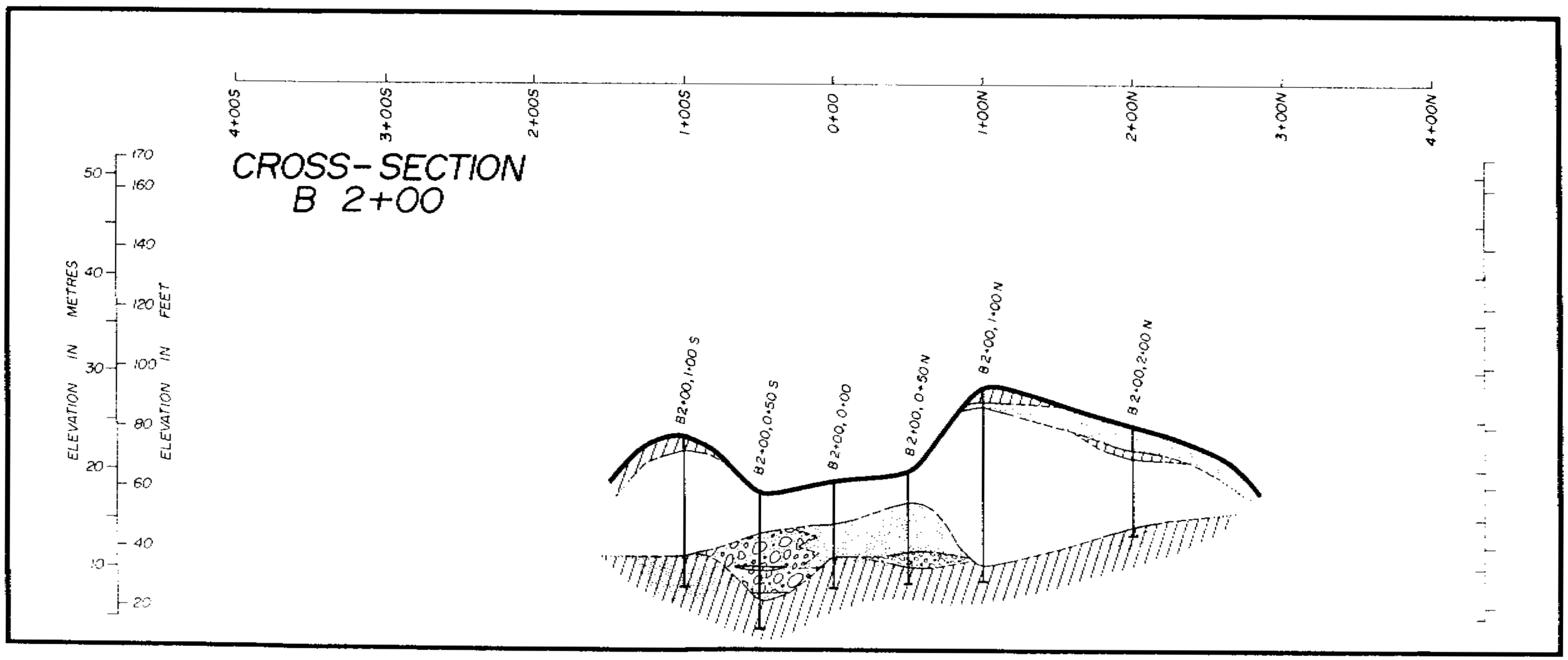

CROSS-SECTION
A 16+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
4+00N
5+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20


CROSS-SECTION
A 18+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
A18+00, 2+00 S
A18+00, 1+50 S
A18+00, 1+00 S
A18+00, 0+50 S
A18+00, 0+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

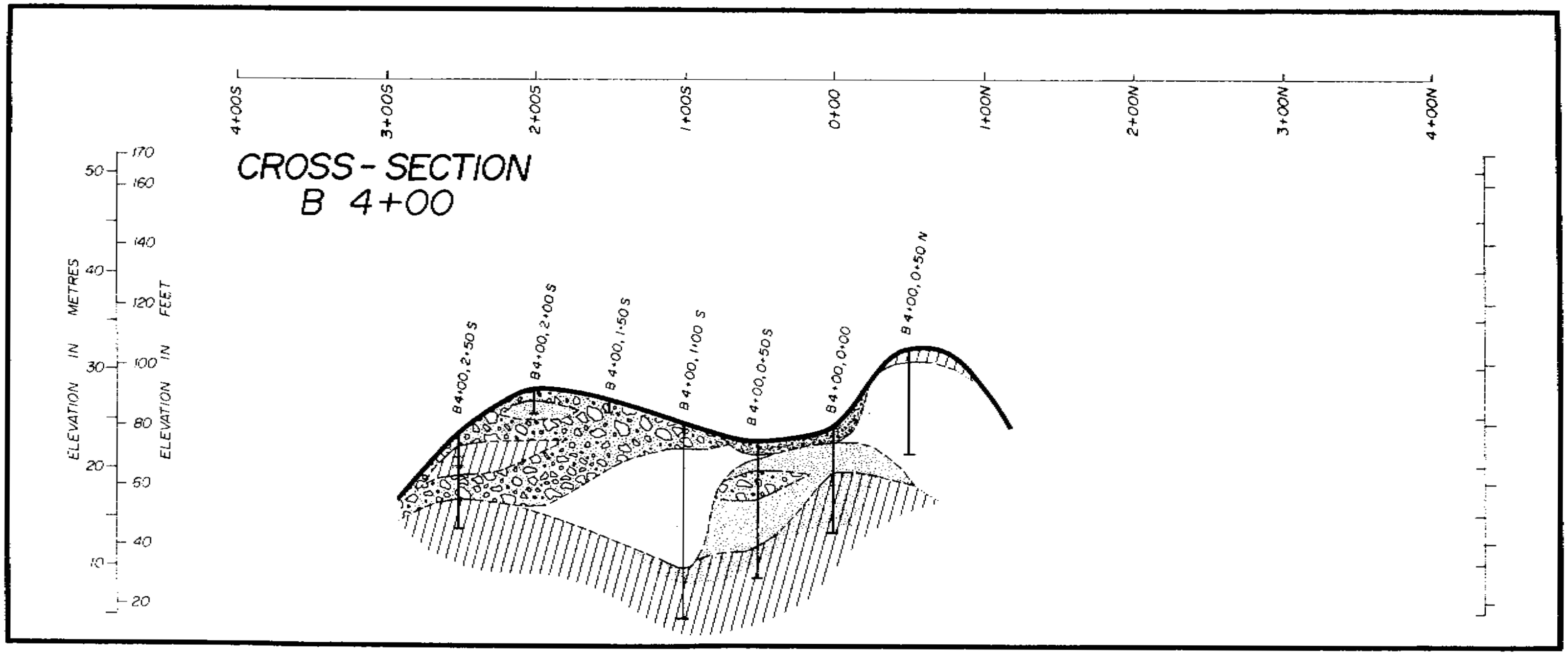

CROSS-SECTION
A 20+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
A20+00, 4+00S
A20+00, 3+50S
A20+00, 3+00S
A20+00, 2+50S
A20+00, 2+00S
A20+00, 1+50S
A20+00, 1+25S
A20+00, 0+75S
A20+00, 0+50N
A20+00, 2+00N
A19+50, 3+70N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

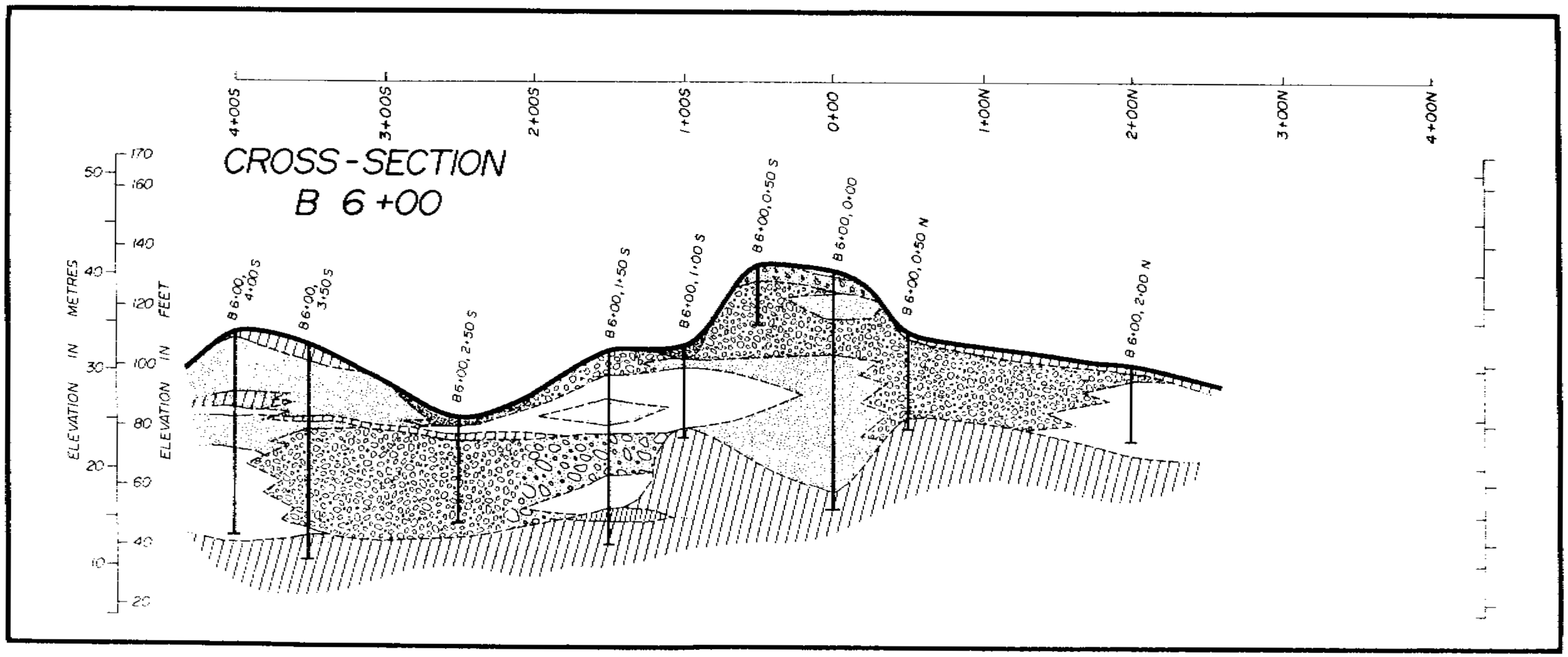


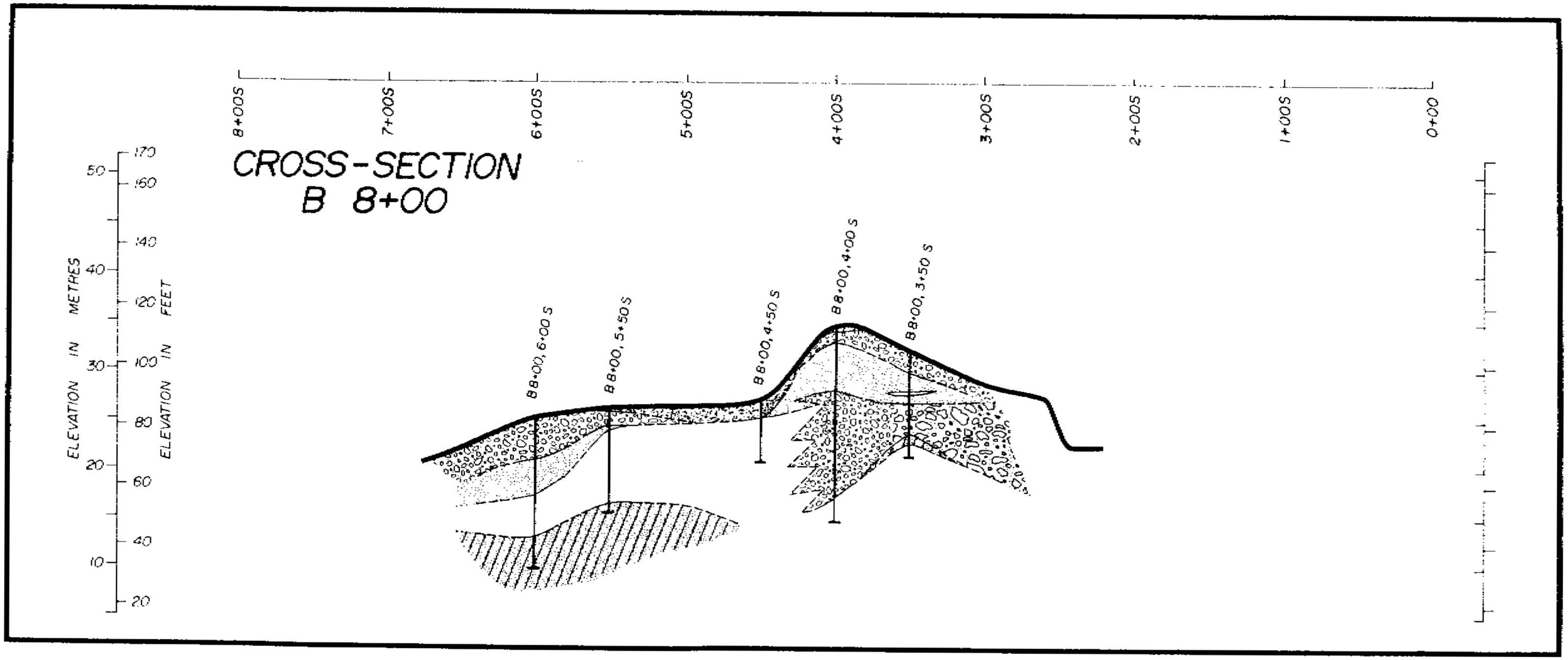
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
CROSS - SECTION
B 1+00
ELEVATION IN METRES
ELEVATION IN FEET
B1+00,0+00
B1+00,0+50N
B1+00,1+00N

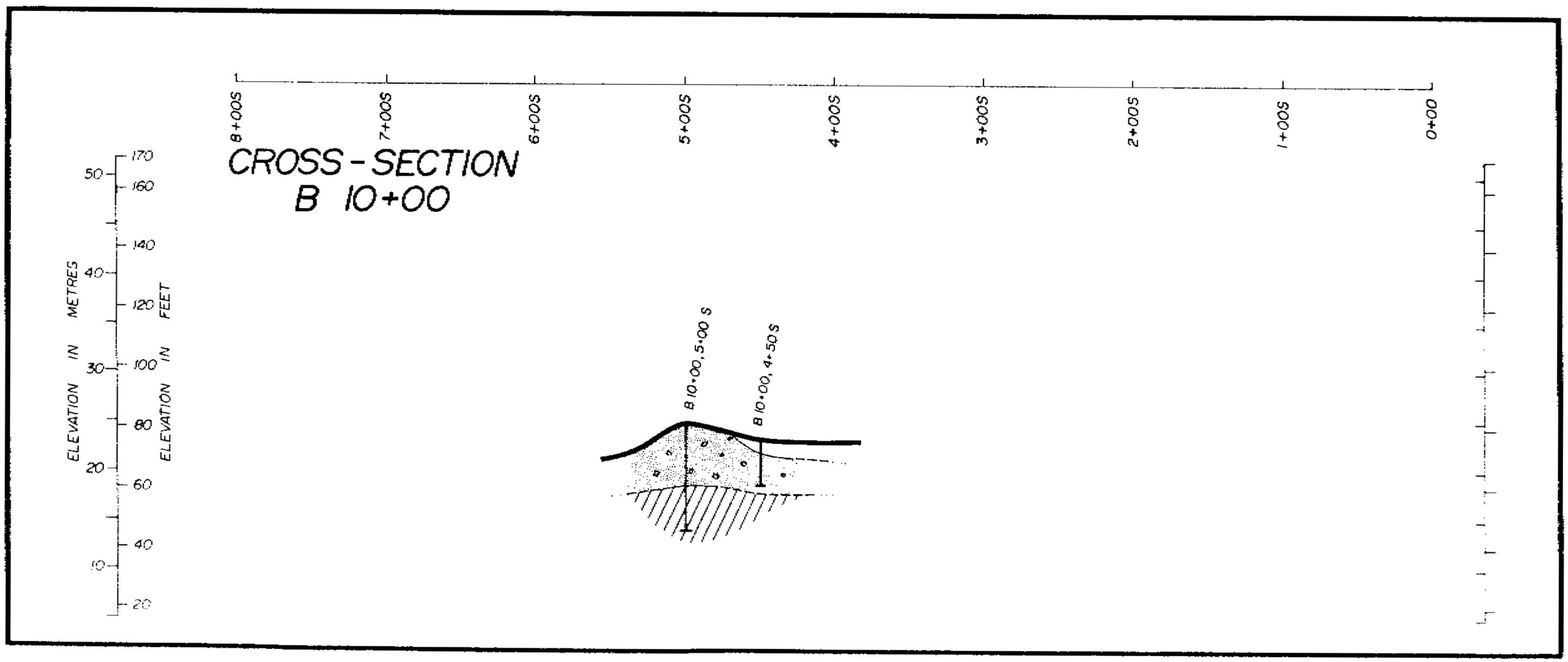


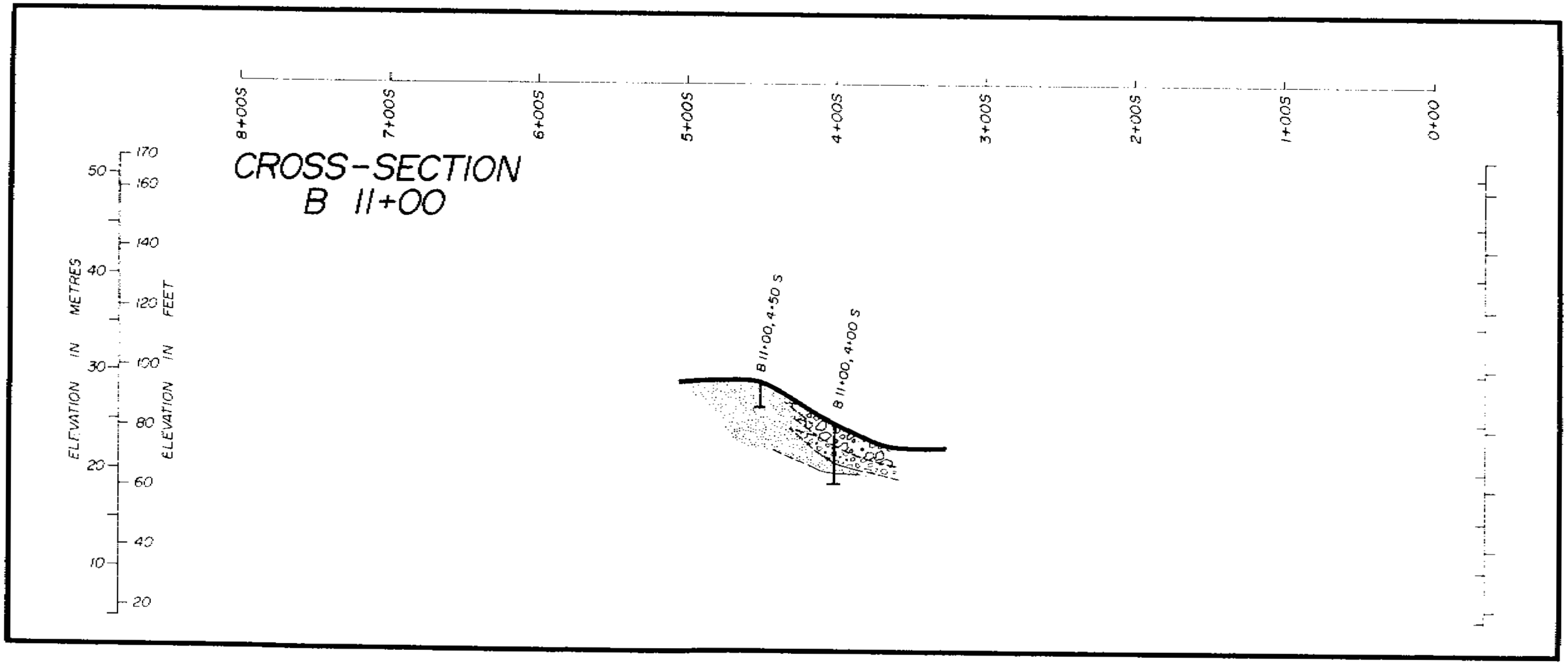
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
CROSS- SECTION
B 2+00
ELEVATION IN METRES
ELEVATION IN FEET
B2+00,1+00 S
B2+00,0+50 S
B2+00,0+00
B2+00,0+50N
B2+00,1+00N
B2+00,2+00 N

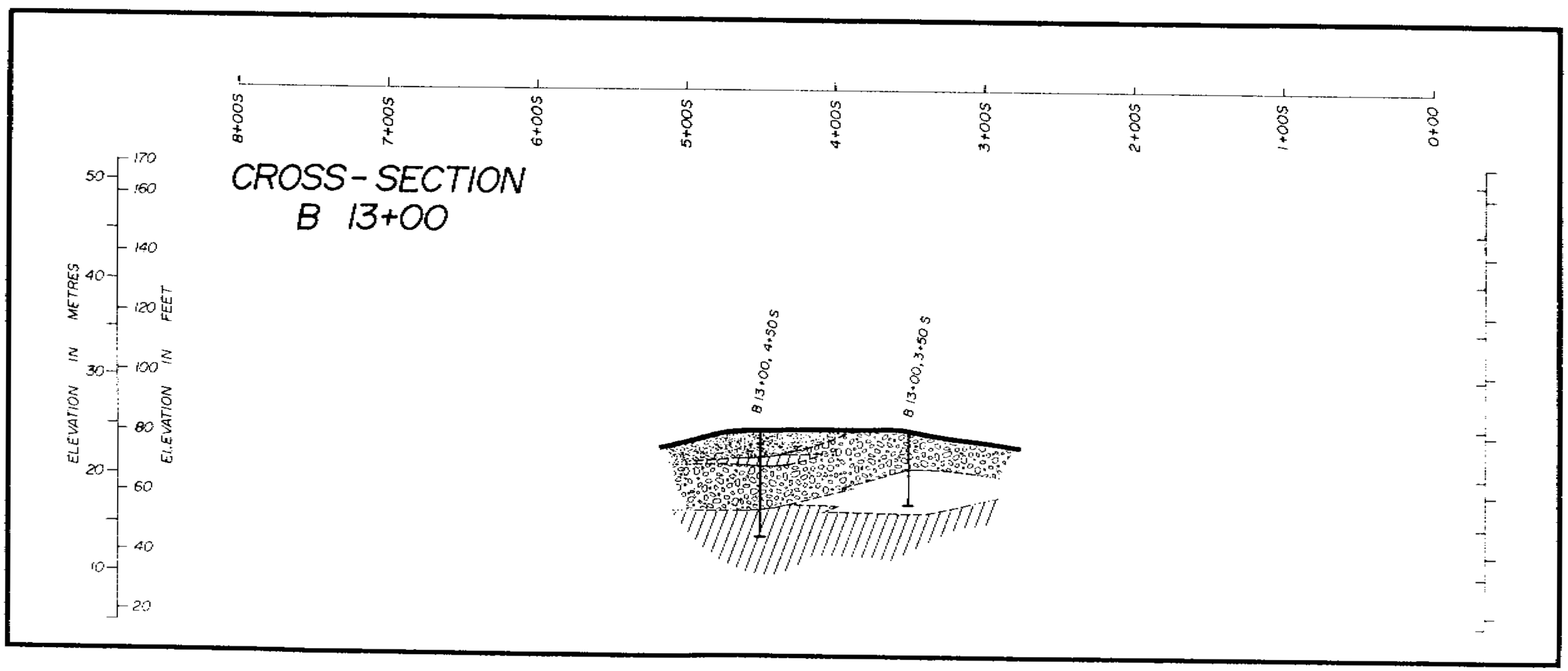

CROSS-SECTION
B 4+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
B4+00,2+50S
B4+00,2+00S
B4+00,1+50S
B4+00,1+00S
B4+00,0+50S
B4+00,0+00
B4+00,0+50N

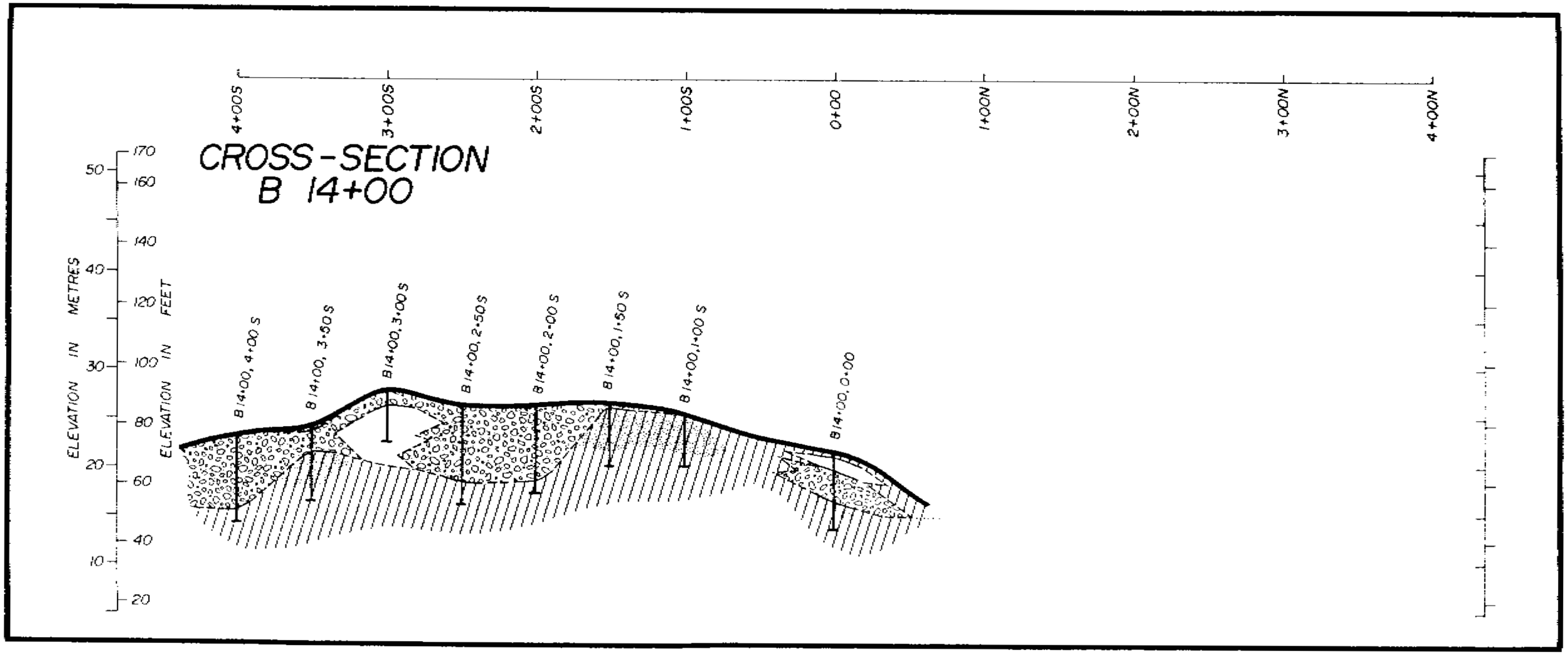

CROSS-SECTION
B 6+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
B6+00,4+00S
B6+00,3+50S
B6+00,2+50S
B6+00,1+50S
B6+00,1+00S
B6+00,0+50S
B6+00,0+00
B6+00,0+50N
B6+00,2+00N

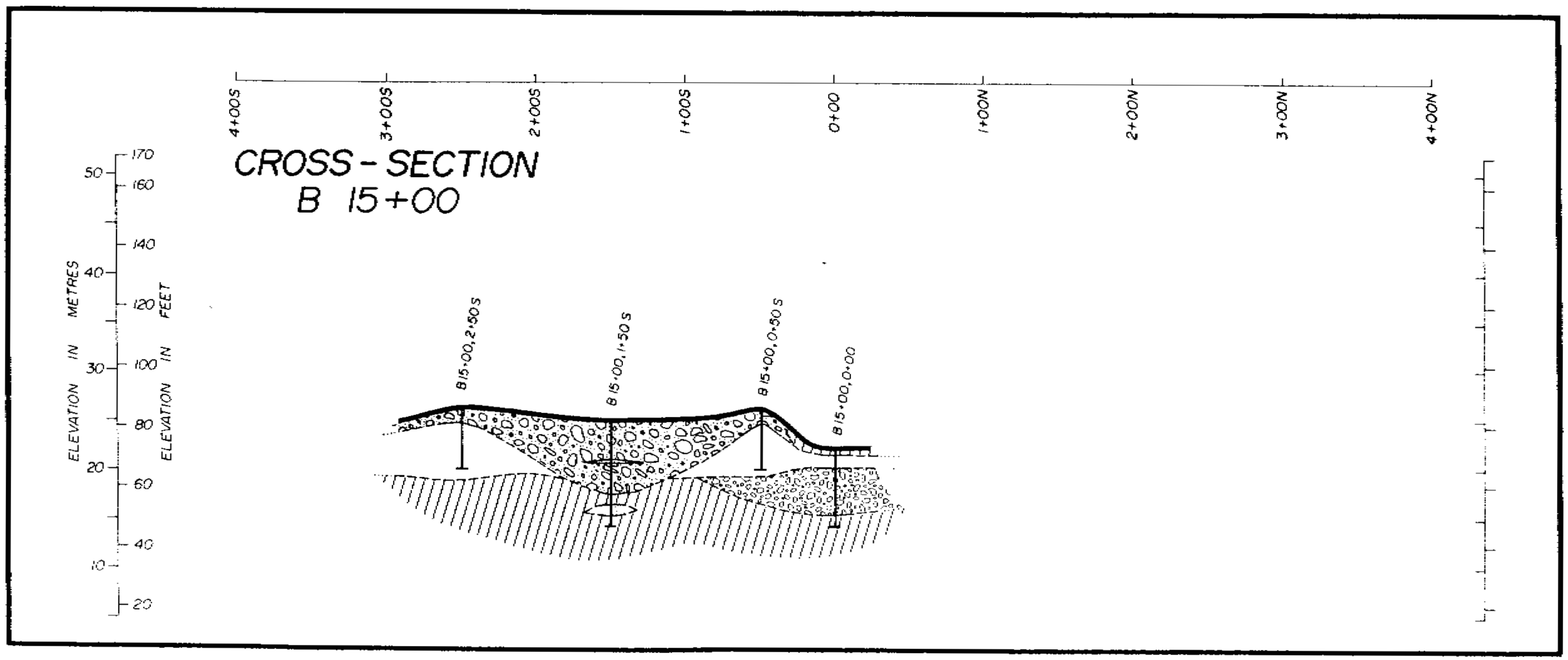

CROSS-SECTION
B 8+00
8+00S
7+00S
6+00S
5+00S
4+00S
3+00S
2+00S
1+00S
0+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B8+00, 6+00 S
B8+00, 5+50 S
B8+00, 4+50 S
B8+00, 4+00 S
B8+00, 3+50 S

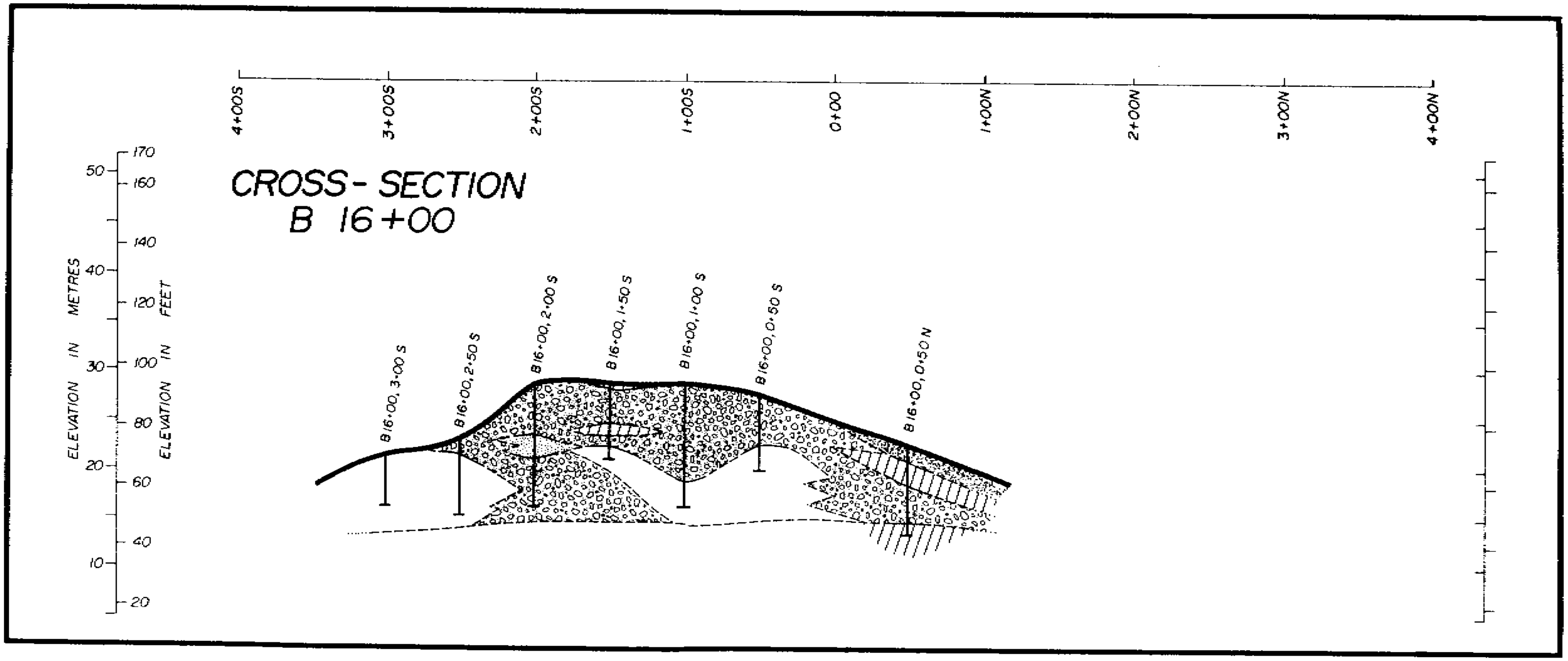

CROSS-SECTION
B 10+00
8+00S
7+00S
6+00S
5+00S
4+00S
3+00S
2+00S
1+00S
0+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B 10+00, 5+00 S
B 10+00, 4+50 S

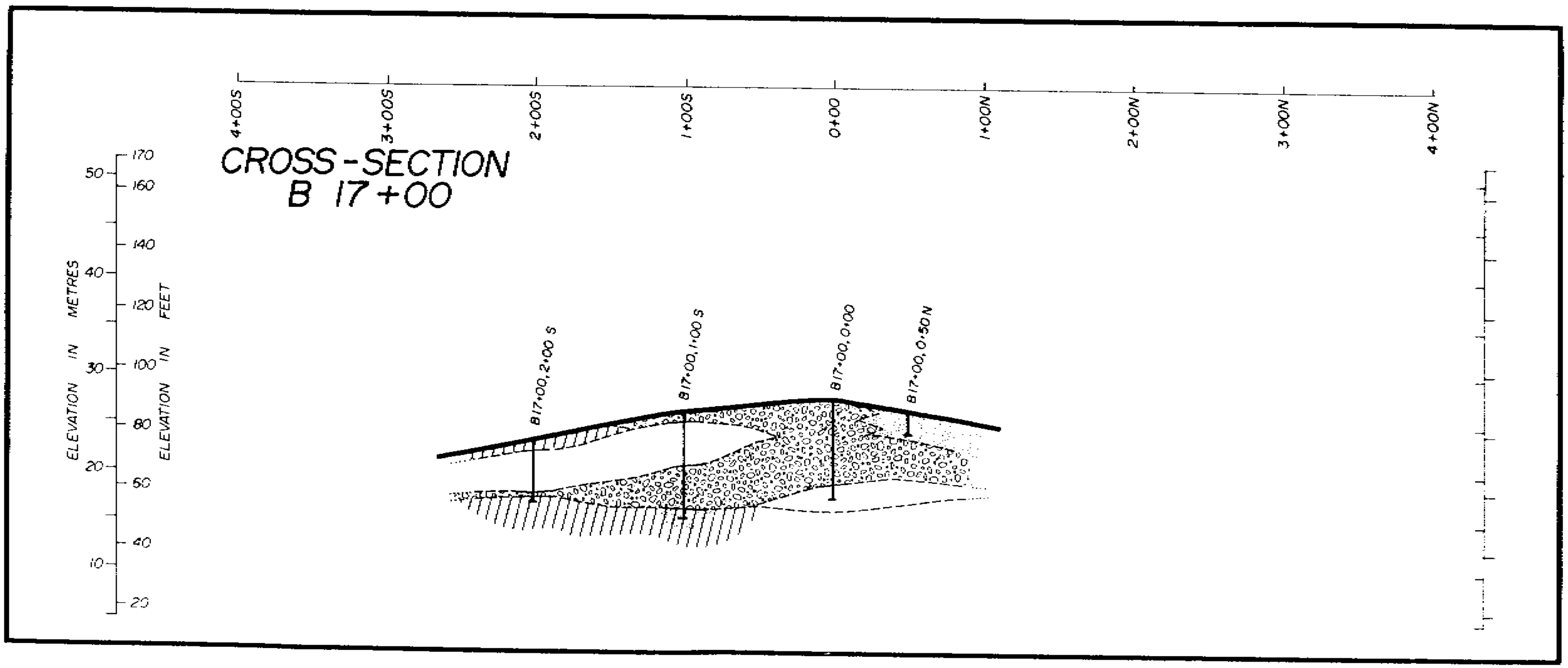

CROSS-SECTION
B 11+00
8+00S
7+00S
6+00S
5+00S
4+00S
3+00S
2+00S
1+00S
0+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B 11+00, 4+50 S
B 11+00, 4+00 S

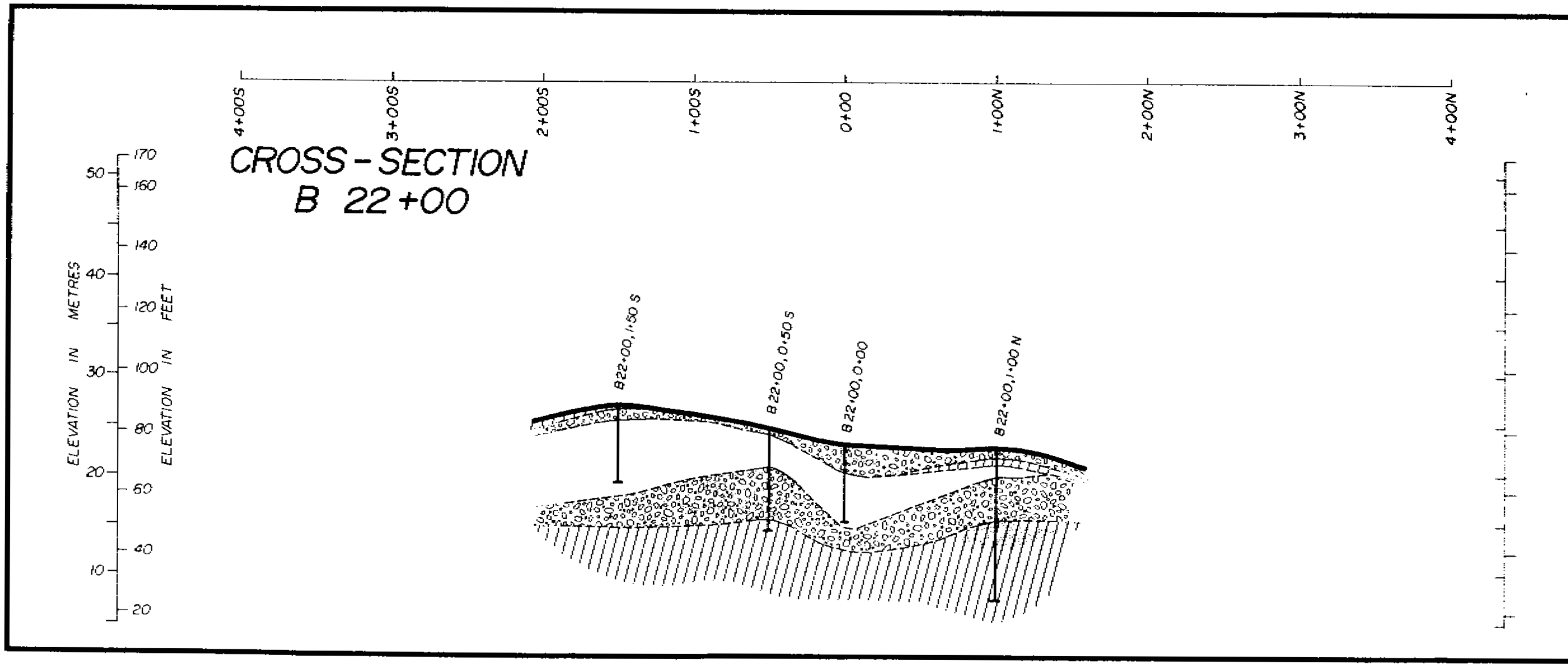

CROSS-SECTION
B 13+00
8+00S
7+00S
6+00S
5+00S
4+00S
3+00S
2+00S
1+00S
0+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B 13+00, 4+50S
B 13+00, 3+50 S

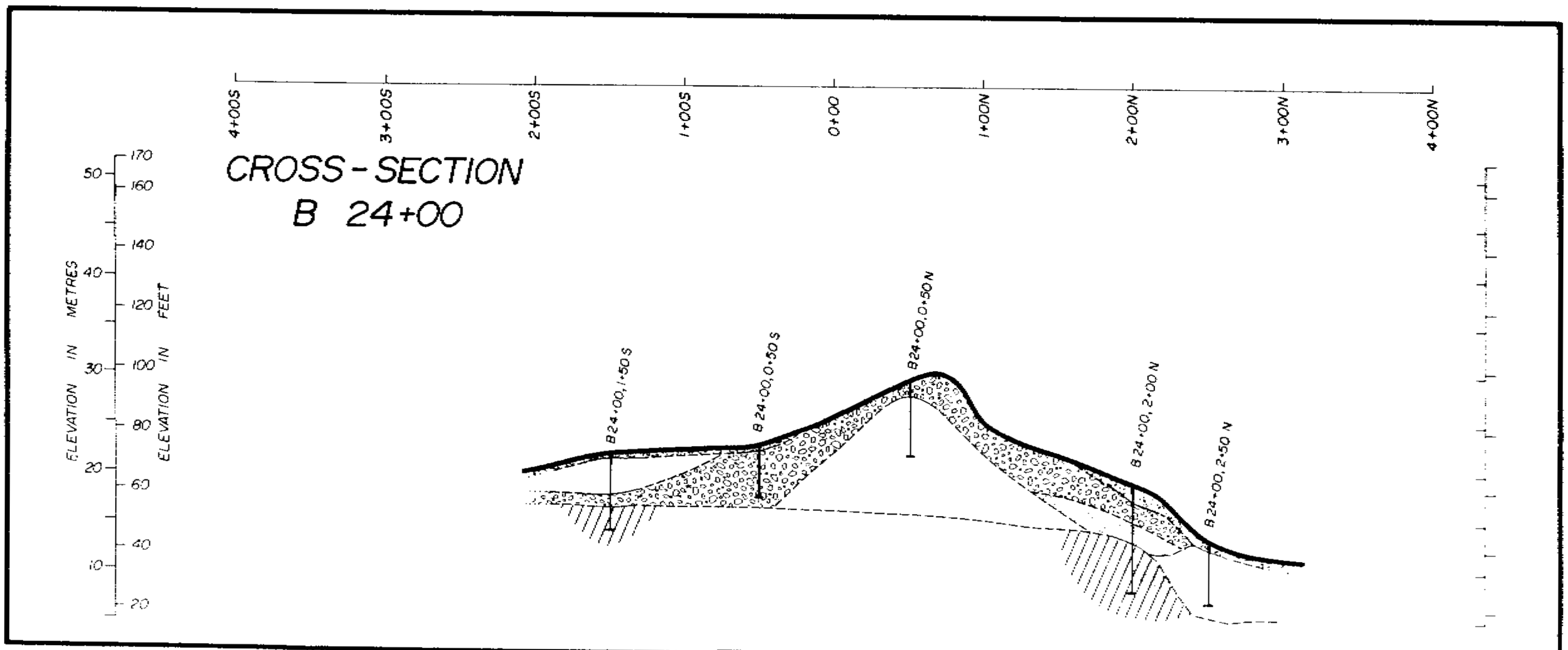

CROSS-SECTION
B 14+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B14+00, 4+00 S
B 14+00, 3+50 S
B14+00, 3+00 S
B 14+00, 2+50 S
B 14+00, 2+00 S
B 14+00, 1+50 S
B 14+00, 1+00 S
B14+00, 0+00

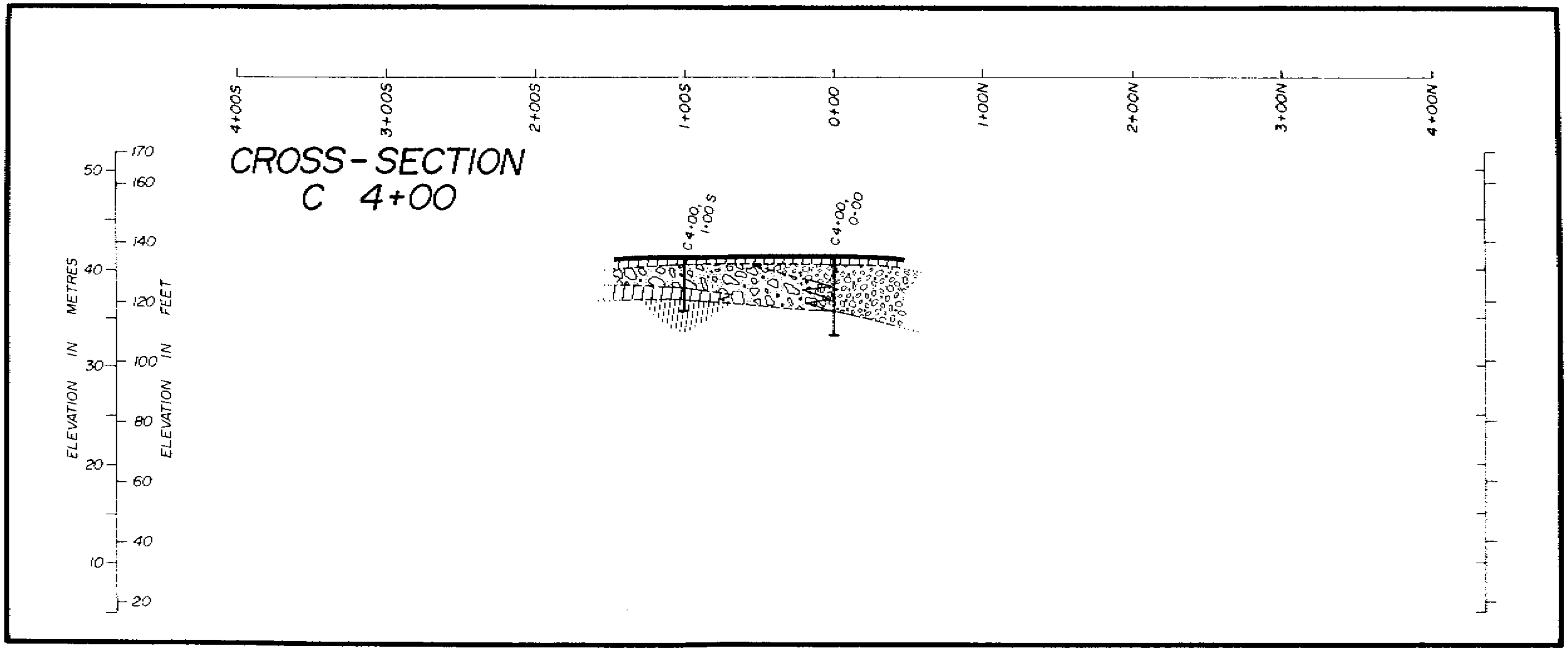

CROSS-SECTION
B 15+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B15+00, 2+50 S
B15+00, 1+50 S
B15+00, 0+50 S
B15+00, 0+00

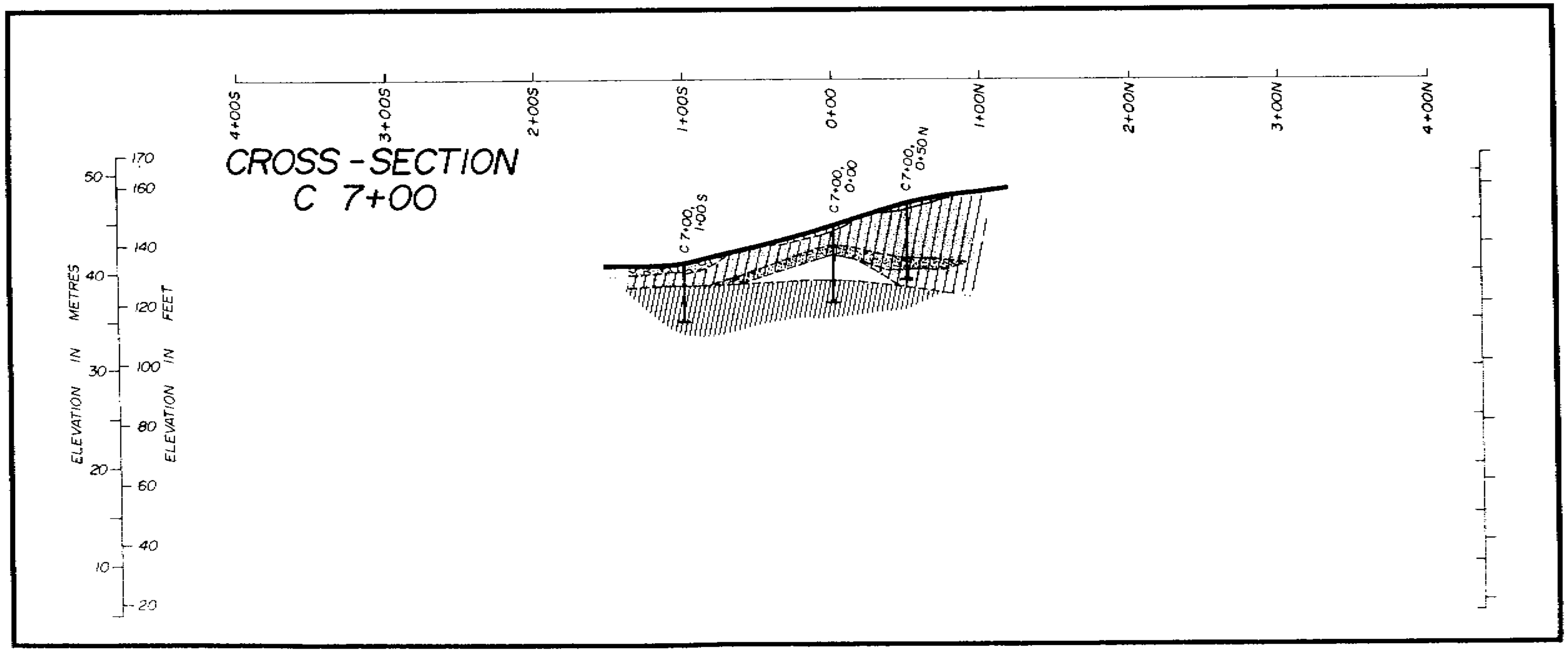

CROSS-SECTION
B 16+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B16+00, 3+00 S
B16+00, 2+50 S
B16+00, 2+00 S
B16+00, 1+50 S
B16+00, 1+00 S
B16+00, 0+50 S
B16+00, 0+50 N


CROSS-SECTION
B 17+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B17+00, 2+00 S
B17+00, 1+00 S
B17+00, 0+00
B17+00, 0+50 N


4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
CROSS-SECTION
B 22+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B22+00,1+50 S
B 22+00,0+50 S
B 22+00,0+00
B 22+00,1+00 N


4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
CROSS-SECTION
B 24+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
B 24+00,1+50 S
B 24+00,0+50 S
B 24+00,0+50 N
B 24+00, 2+00 N
B 24+00, 2+50 N


CROSS-SECTION
C 4+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C4+00, 1+00 S
C4+00, 0+00
ELEVATION IN METRES
50
40
30
20
10
ELEVATION IN FEET
170
160
140
120
100
80
60
40
20


CROSS-SECTION
C 7+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C7+00, 1+00 S
C7+00, 0+00
C7+00, 0+50 N
ELEVATION IN METRES
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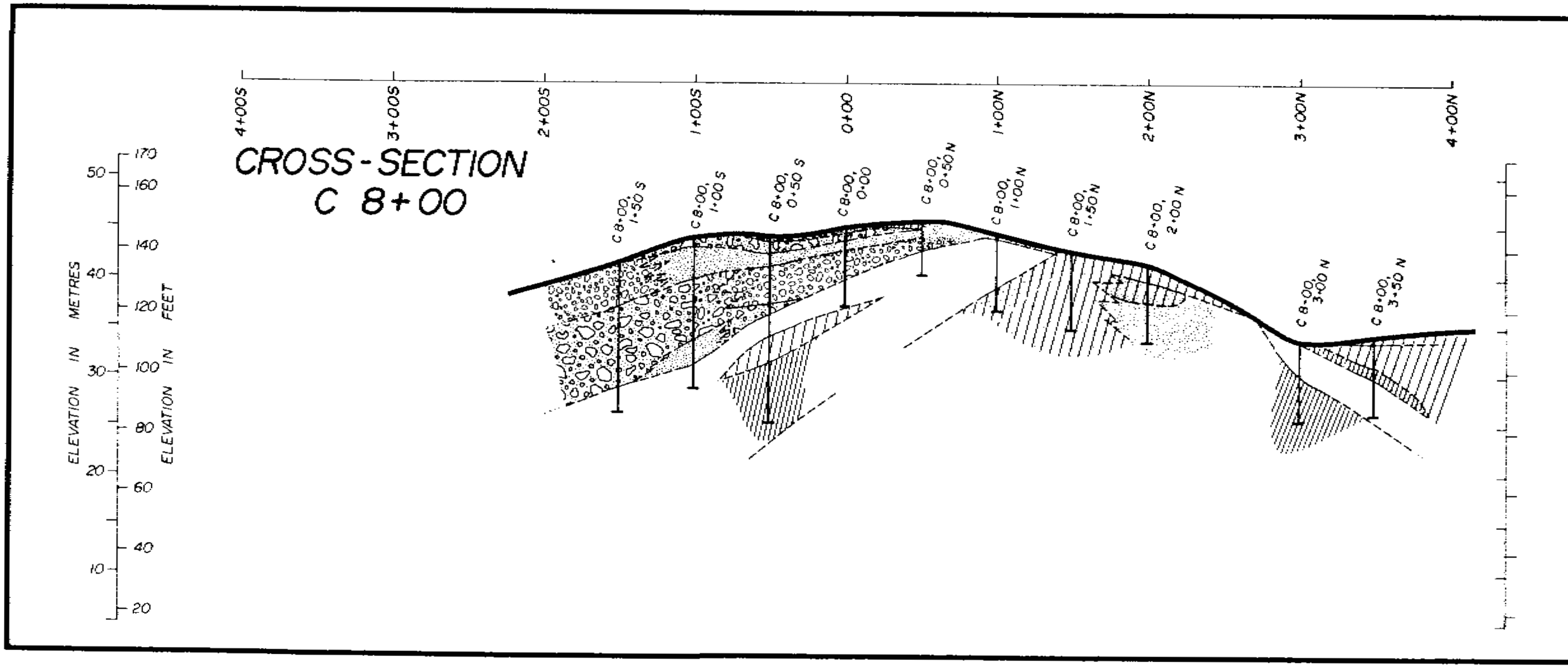
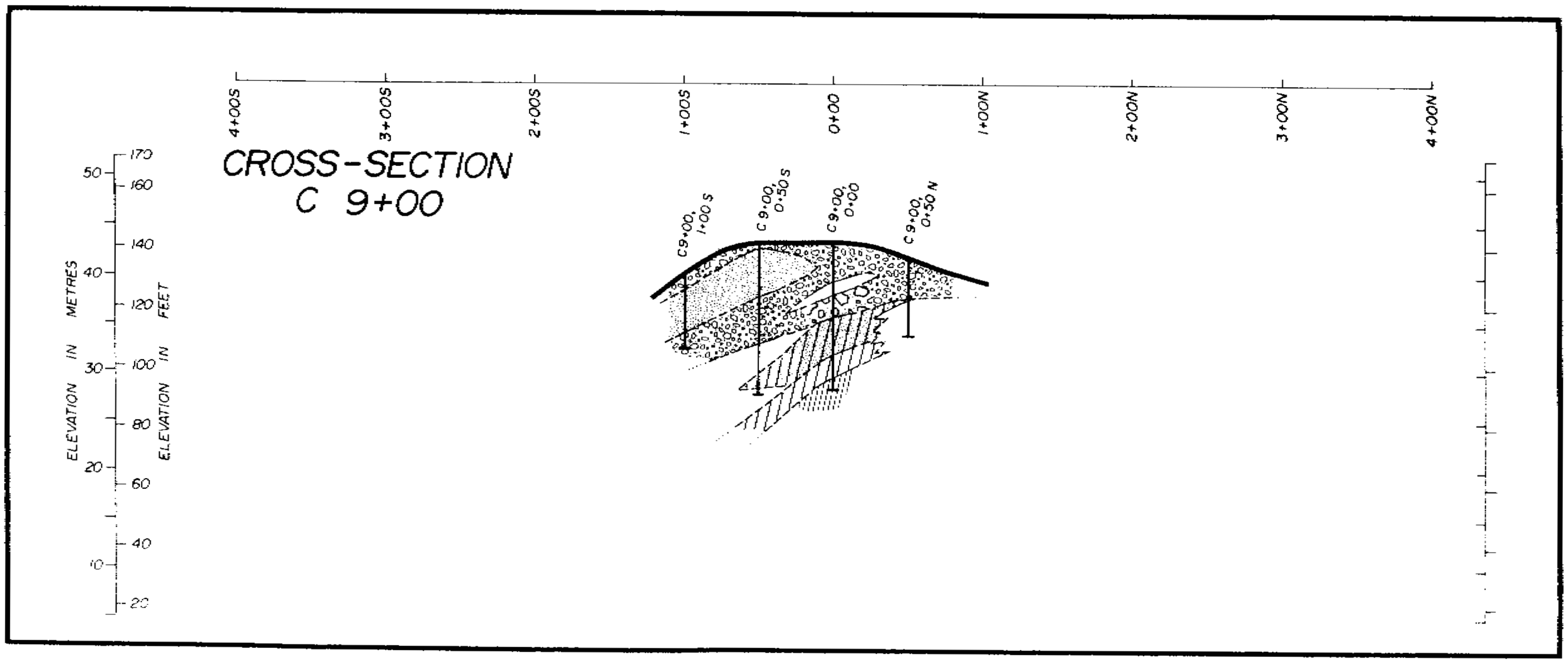
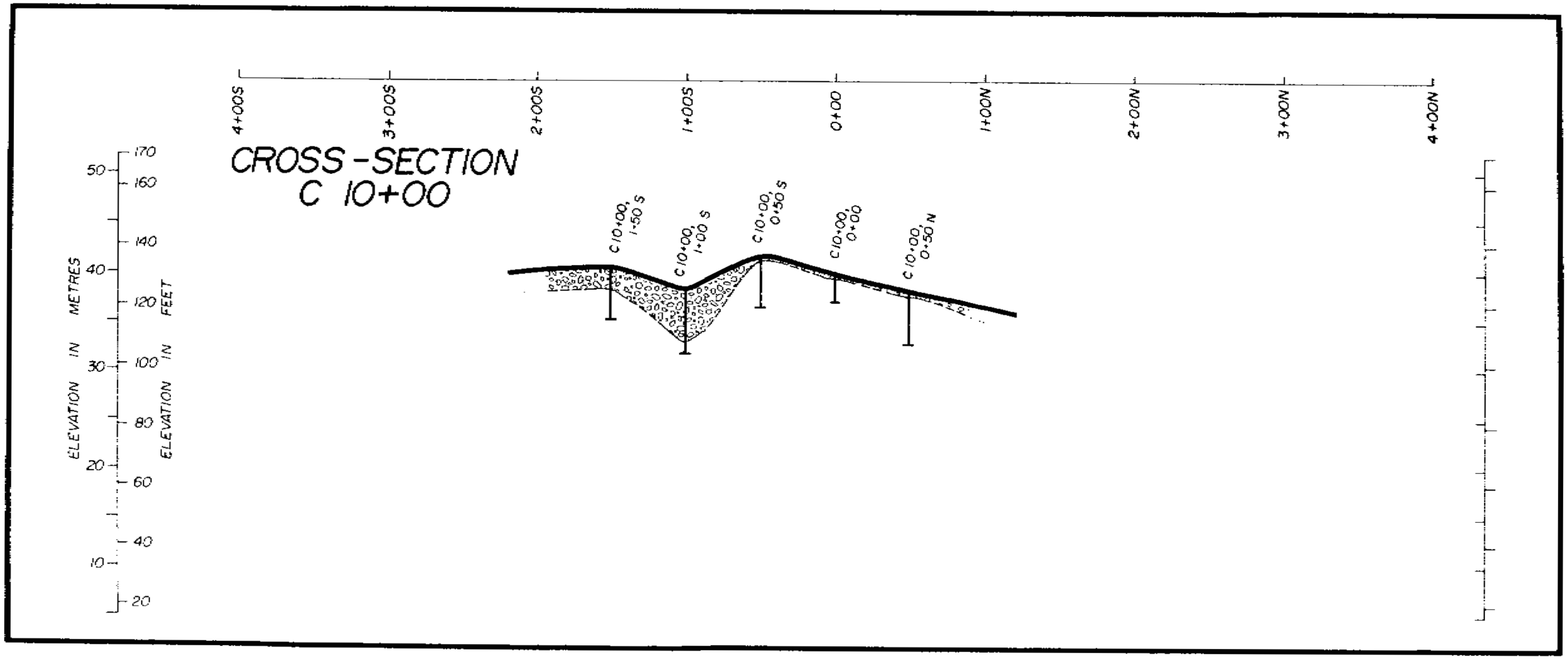
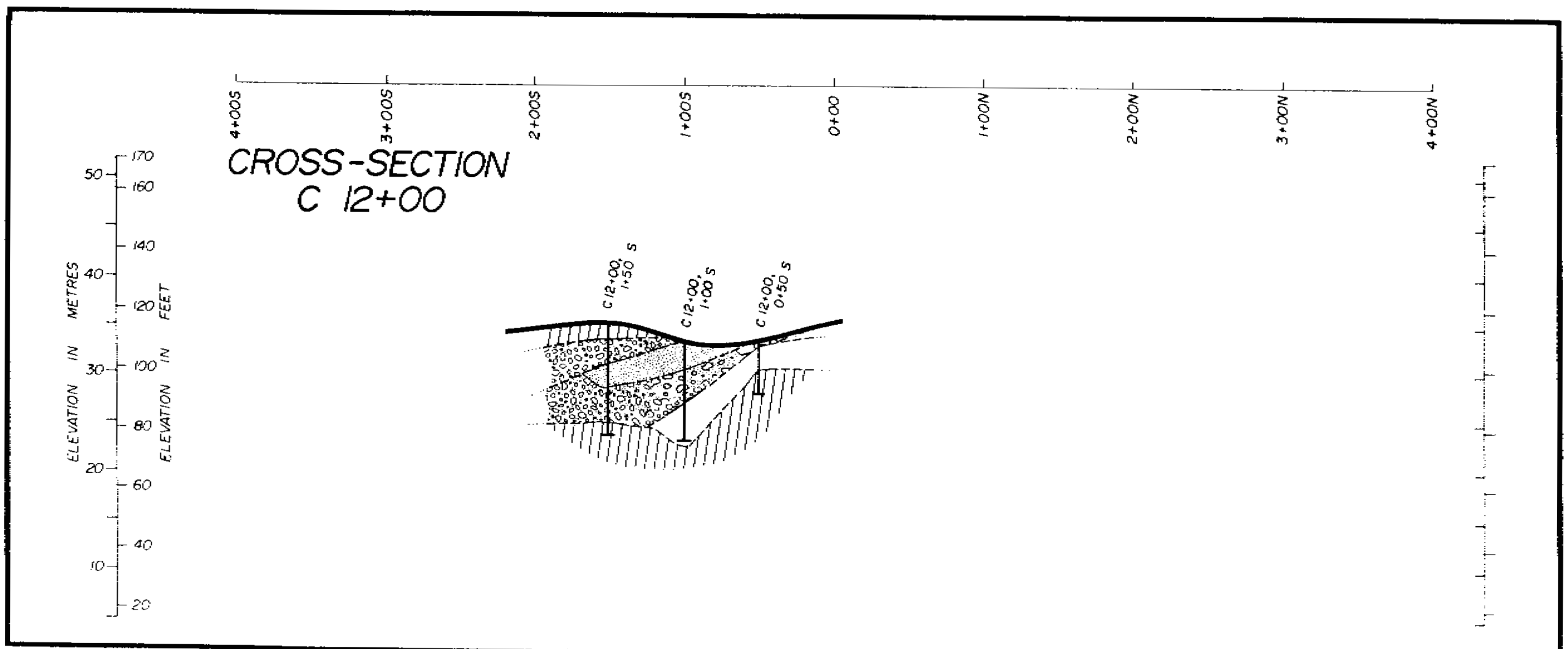
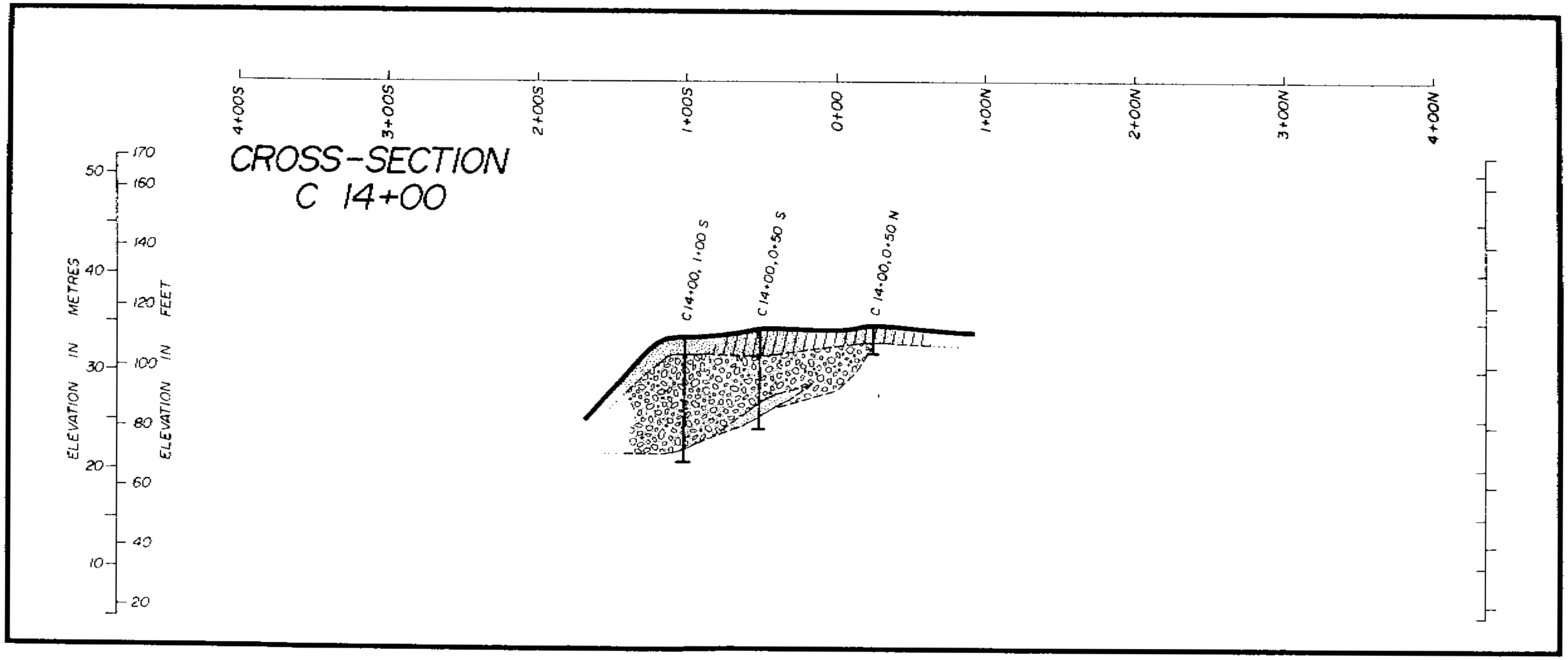
40
30
20
10
ELEVATION IN FEET
170
160
140
120
100
80
60
40
20


CROSS-SECTION
C 8+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C8+00, 1+50 S
C8+00, 1+00 S
C8+00, 0+50 S
C8+00, 0+00
C8+00, 0+50 N
C8+00, 1+00 N
C8+00, 1+50 N
C8+00, 2+00 N
C8+00, 3+00 N
C8+00, 3+50 N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

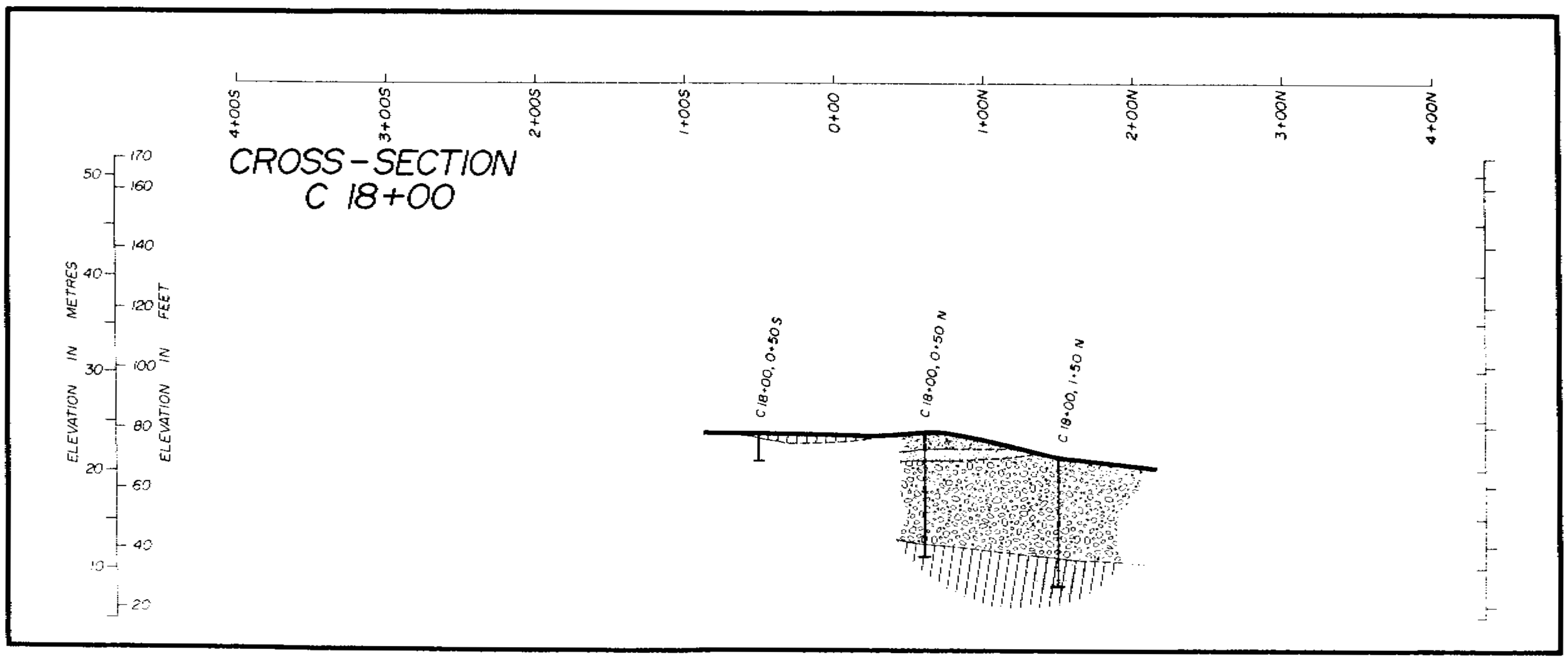

CROSS-SECTION
C 9+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C9+00, 1+00 S
C9+00, 0+50 S
C9+00, 0+00
C9+00, 0+50 N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20


CROSS-SECTION
C 10+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C 10+00, 1+50 S
C 10+00, 1+00 S
C 10+00, 0+50 S
C 10+00, 0+00
C 10+00, 0+50 N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

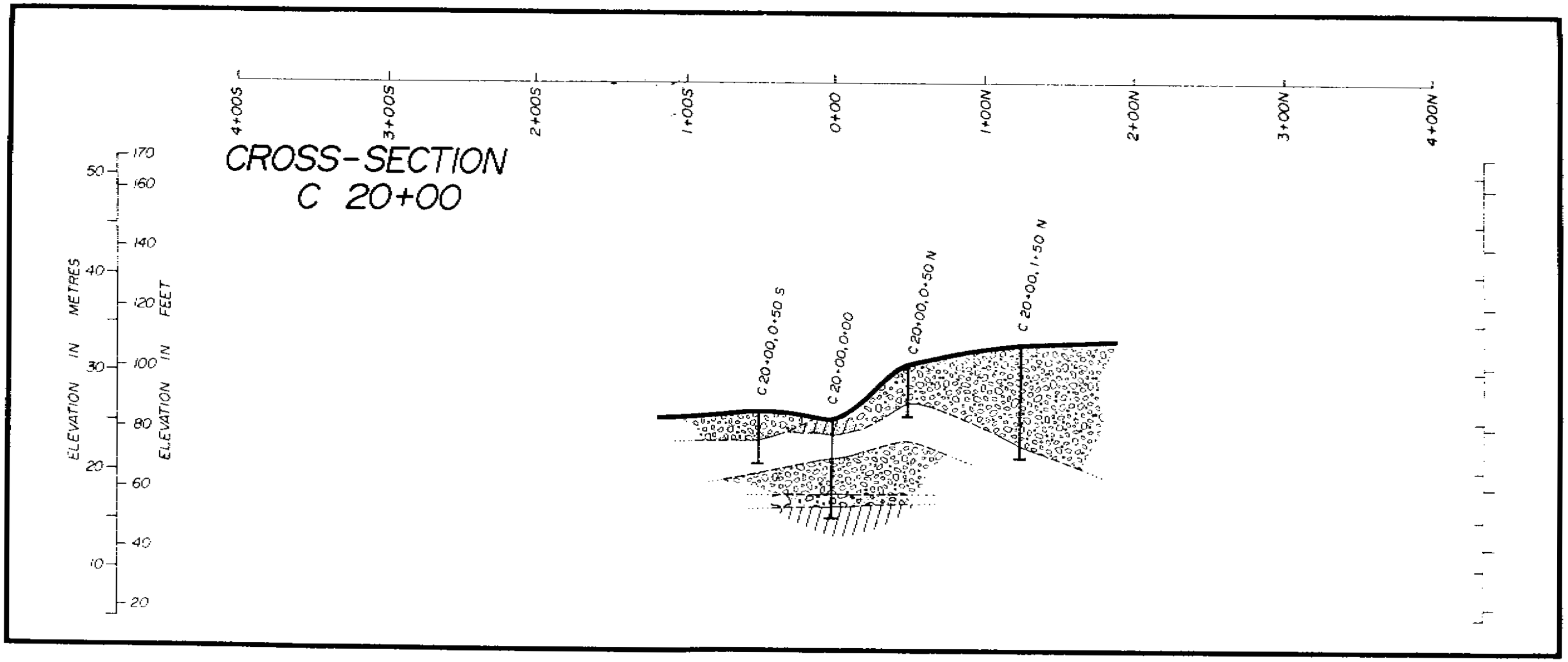

CROSS-SECTION
C 12+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C 12+00, 1+50 S
C 12+00, 1+00 S
C 12+00, 0+50 S
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

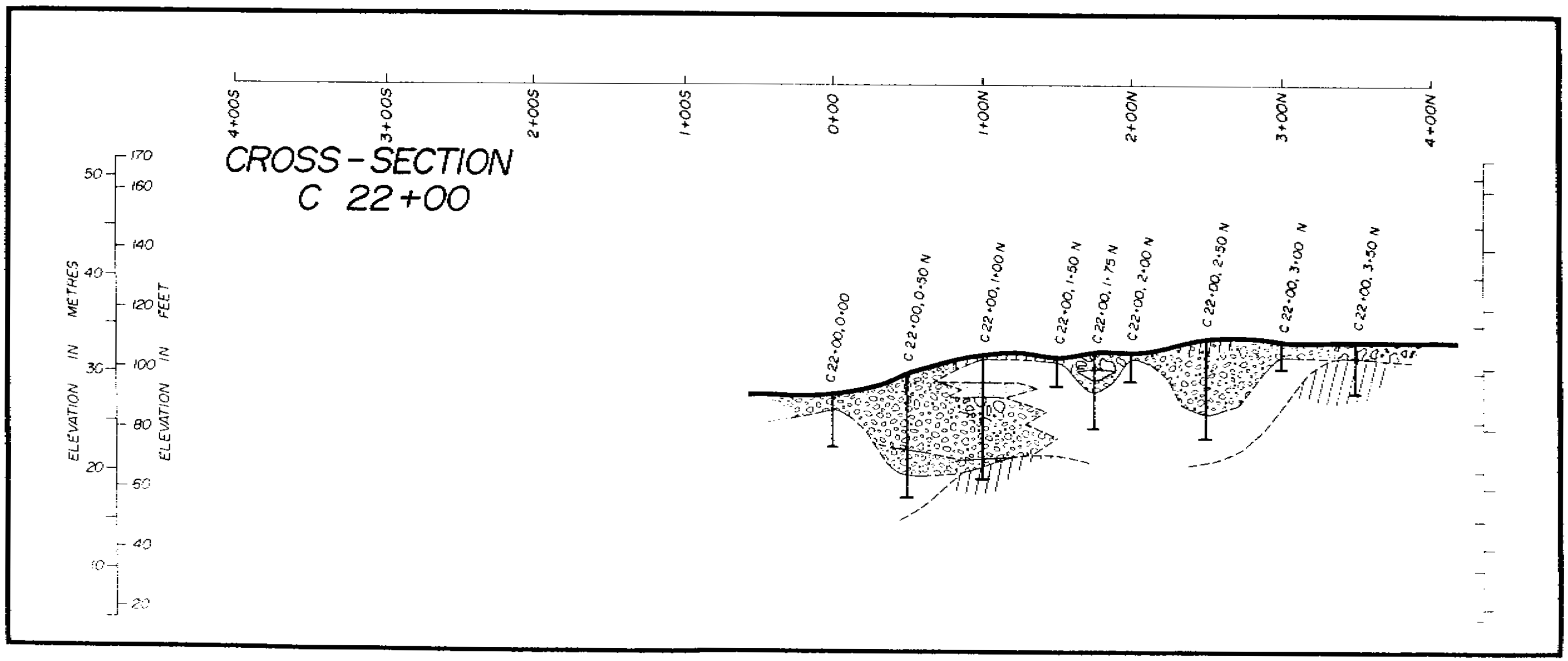


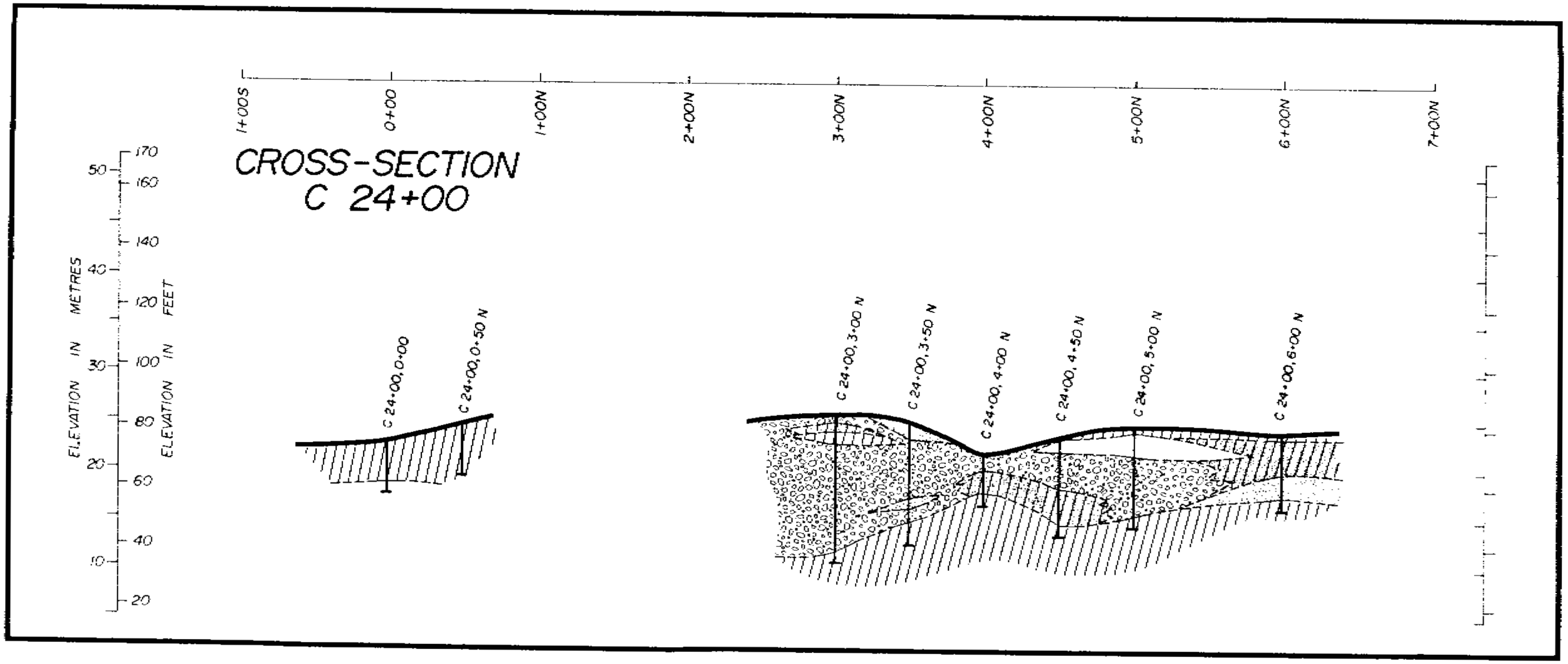
CROSS-SECTION
C 14+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C 14+00, 1+00 S
C 14+00, 0+50 S
C 14+00, 0+50 N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

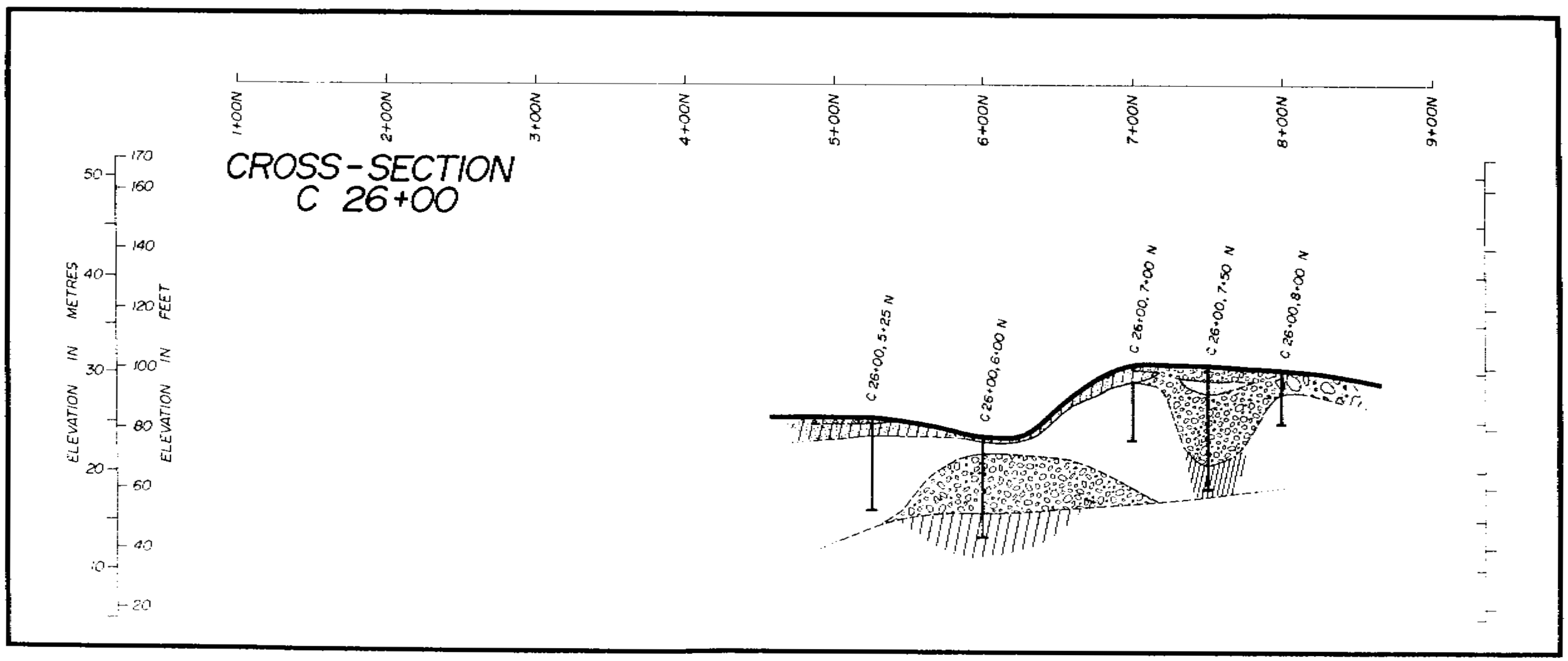


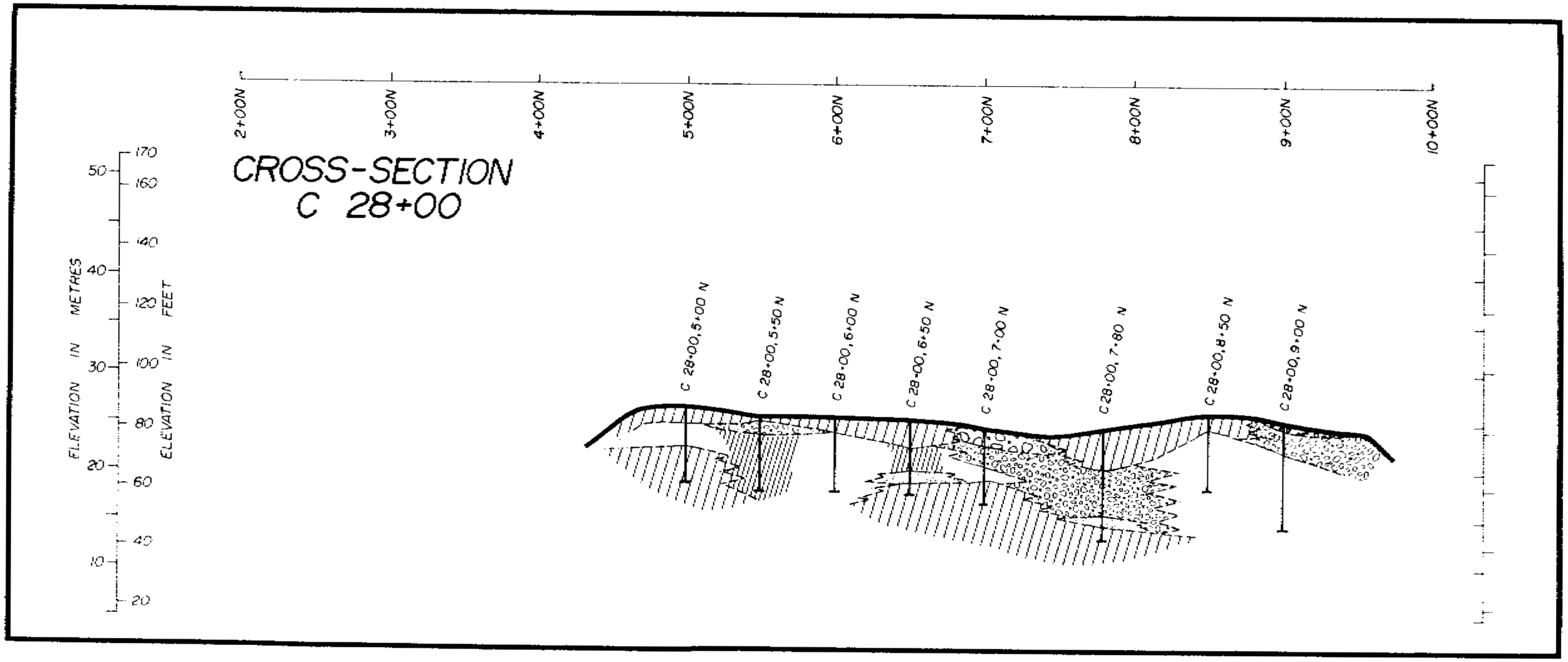
CROSS-SECTION
C 18+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
C 18+00, 0+50 S
C 18+00, 0+50 N
C 18+00, 1+50 N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20

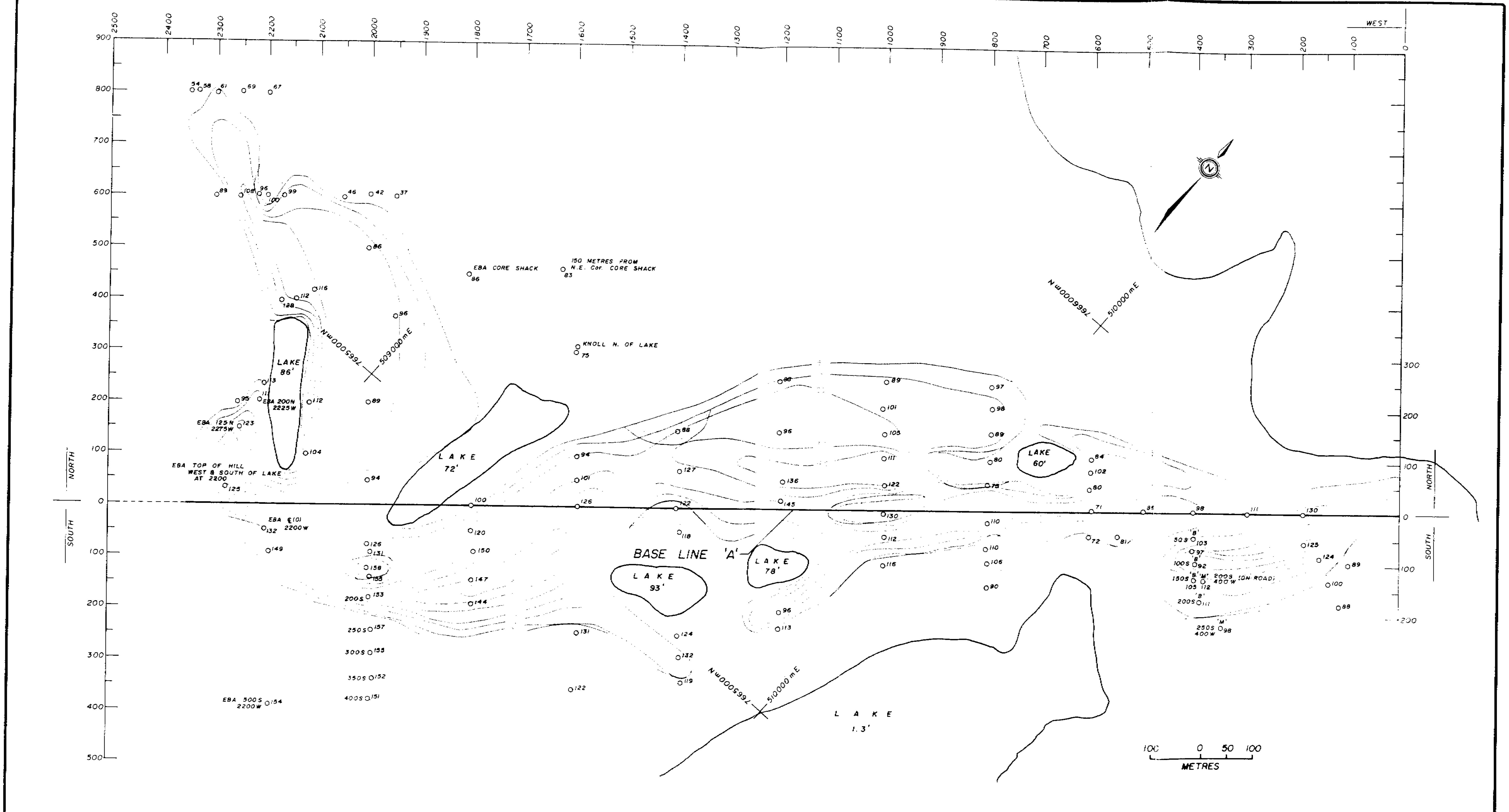

CROSS-SECTION
C 20+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
C 20+00, 0+50 S
C 20+00, 0+00
C 20+00, 0+50 N
C 20+00, 1+50 N


CROSS-SECTION
C 22+00
4+00S
3+00S
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
C 22+00, 0+00
C 22+00, 0+50 N
C 22+00, 1+00 N
C 22+00, 1+50 N
C 22+00, 1+75 N
C 22+00, 2+00 N
C 22+00, 2+50 N
C 22+00, 3+00 N
C 22+00, 3+50 N


CROSS-SECTION
C 24+00
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
5+00N
6+00N
7+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
C 24+00,0+00
C 24+00,0+50 N
C 24+00,3+00 N
C 24+00,3+50 N
C 24+00,4+00 N
C 24+00,4+50 N
C 24+00,5+00 N
C 24+00,6+00 N


CROSS-SECTION
C 26+00
1+00N
2+00N
3+00N
4+00N
5+00N
6+00N
7+00N
8+00N
9+00N
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
C 26+00,5+25 N
C 26+00,6+00 N
C 26+00,7+00 N
C 26+00,7+50 N
C 26+00,8+00 N


2+00N
3+00N
4+00N
5+00N
6+00N
7+00N
8+00N
9+00N
10+00N
CROSS-SECTION
C 28+00
ELEVATION IN METRES
ELEVATION IN FEET
50
40
30
20
10
170
160
140
120
100
80
60
40
20
C 28+00, 5+00 N
C 28+00, 5+50 N
C 28+00, 6+00 N
C 28+00, 6+50 N
C 28+00, 7+00 N
C 28+00, 7+80 N
C 28+00, 8+50 N
C 28+00, 9+00 N



LEGEND

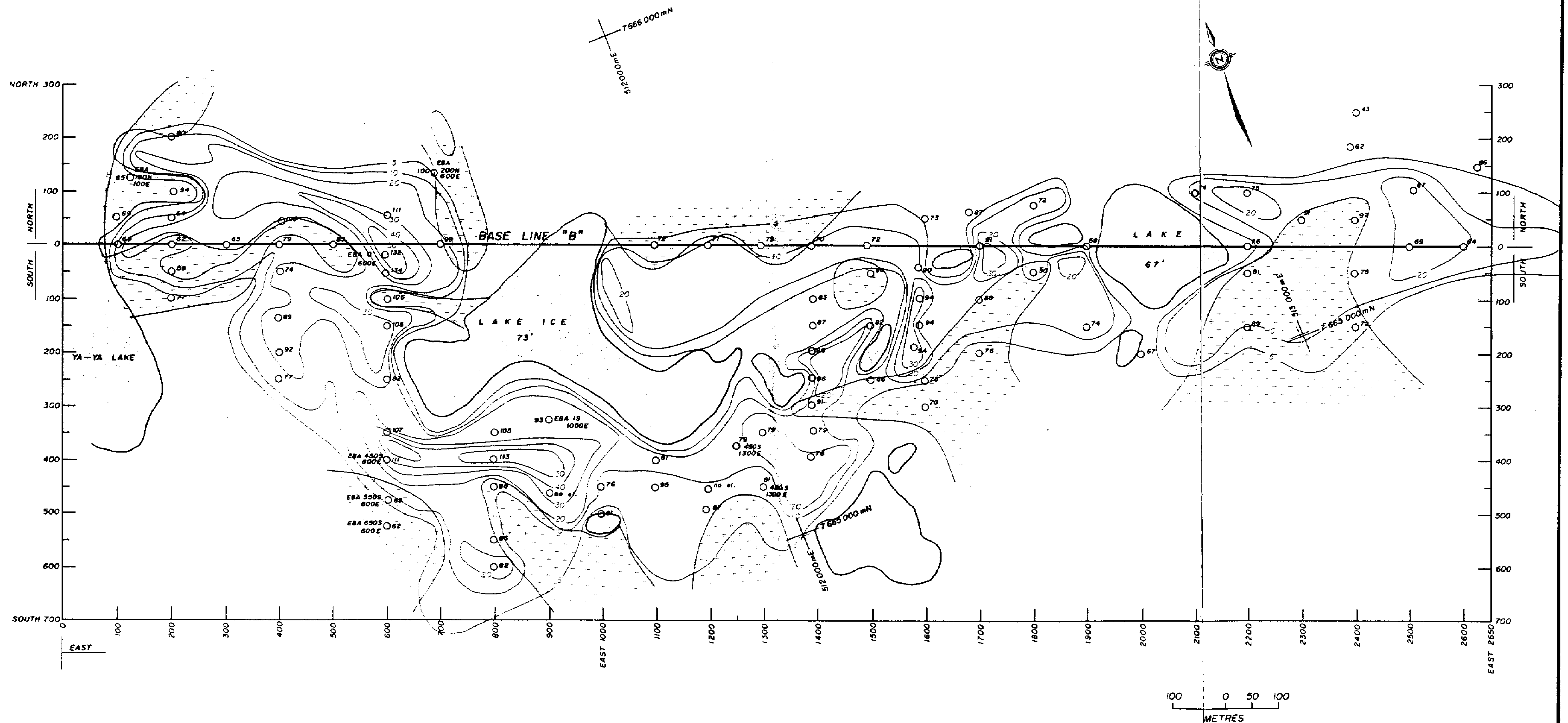
THICKNESS OF BORROW (feet)
AREA OF HIGH ICE CONTENT
TESTHOLE WITH ELEVATION (feet)

LAKE
BASE LINE

YA-YA GRANULAR RESOURCES STUDY - 1975

BORROW THICKNESS BASE LINE "A"

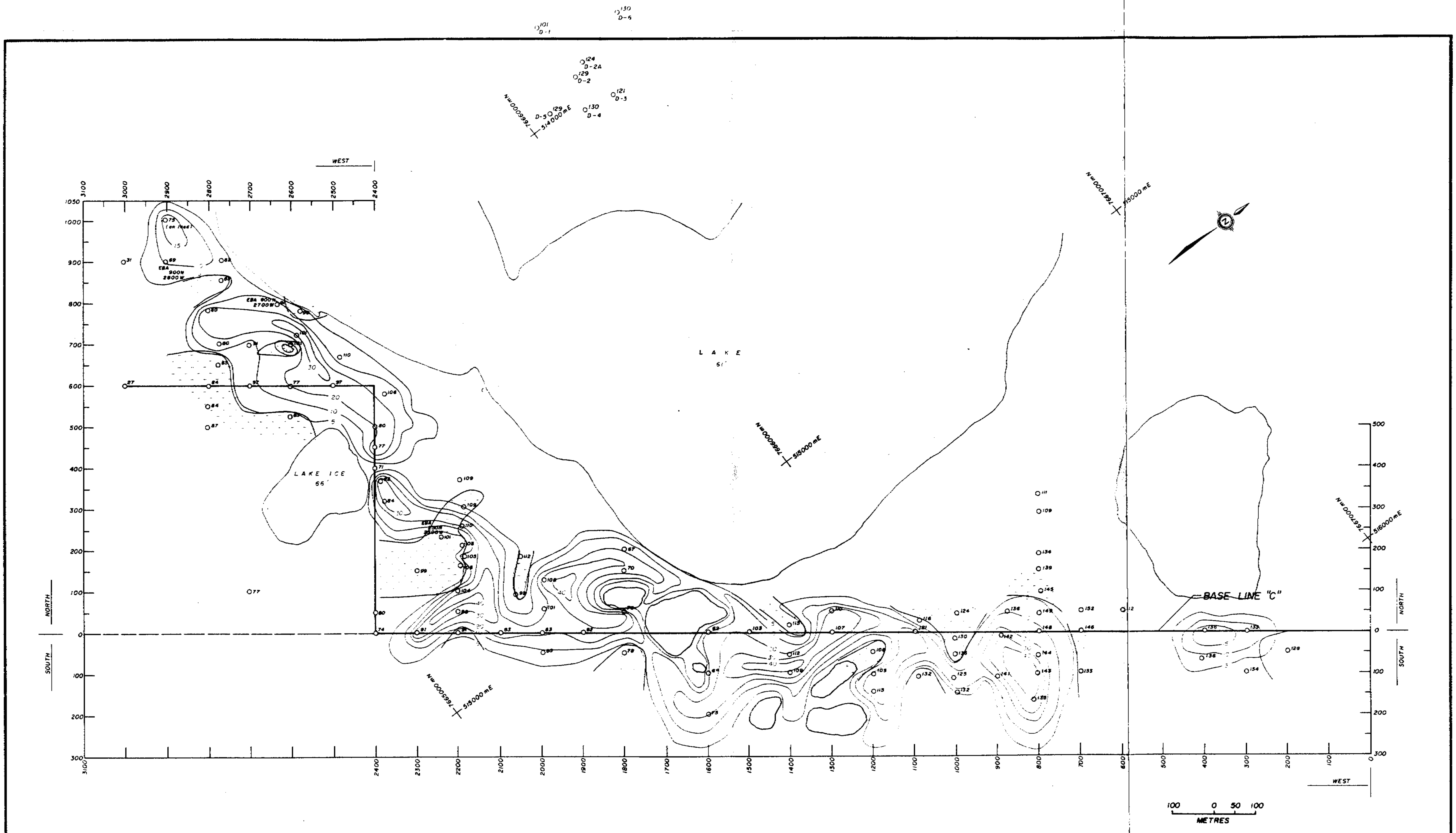
DWG Nº	B-3
DATE	15/08/75
SCALE	AS SHOWN
JOB Nº	1-965 3



LEGEND

- THICKNESS OF BORROW, (feet)
- AREA OF HIGH ICE CONTENT
- o126 TESTHOLE WITH ELEVATION (feet)
- LAKE
- BASE LINE

eba	YA-YA GRANULAR RESOURCES STUDY - 1975	DWG. Nº B-4
		DATE 13/08/75
	BORROW THICKNESS BASE LINE "B"	SCALE AS SHOWN
		JOB Nº 1-965·3



LEGEND

THICKNESS OF BORROW (feet)

AREA OF HIGH ICE CONTENT

TESTHOLE WITH ELEVATION (feet)

LAKE

BASE LINE

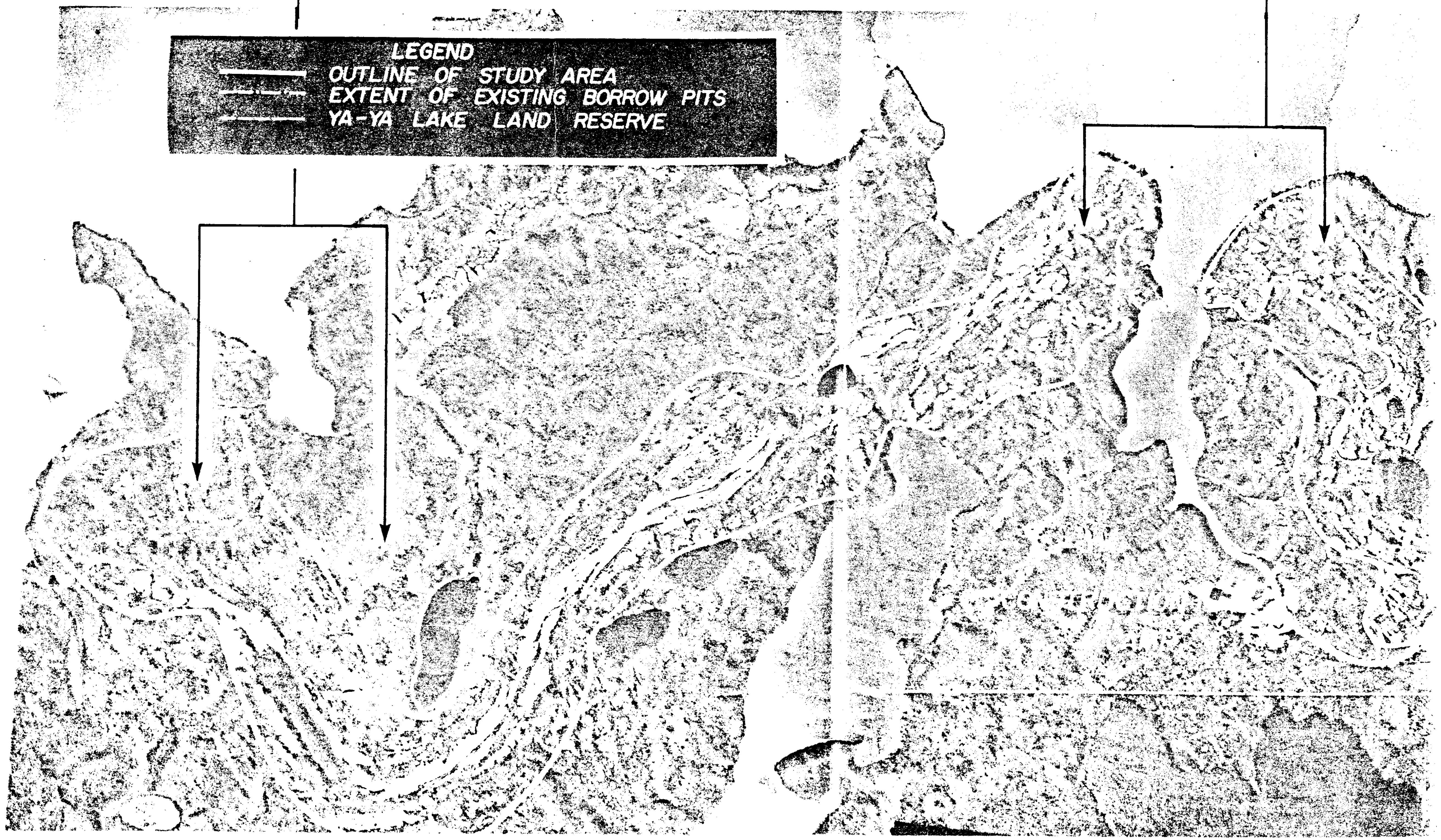
YA-YA GRANULAR RESOURCES STUDY - 1975

BORROW THICKNESS BASE LINE "C"

DWG Nº	B-5
DATE	13/08/75
SCALE	AS SHOWN
JOB Nº	1-965-3

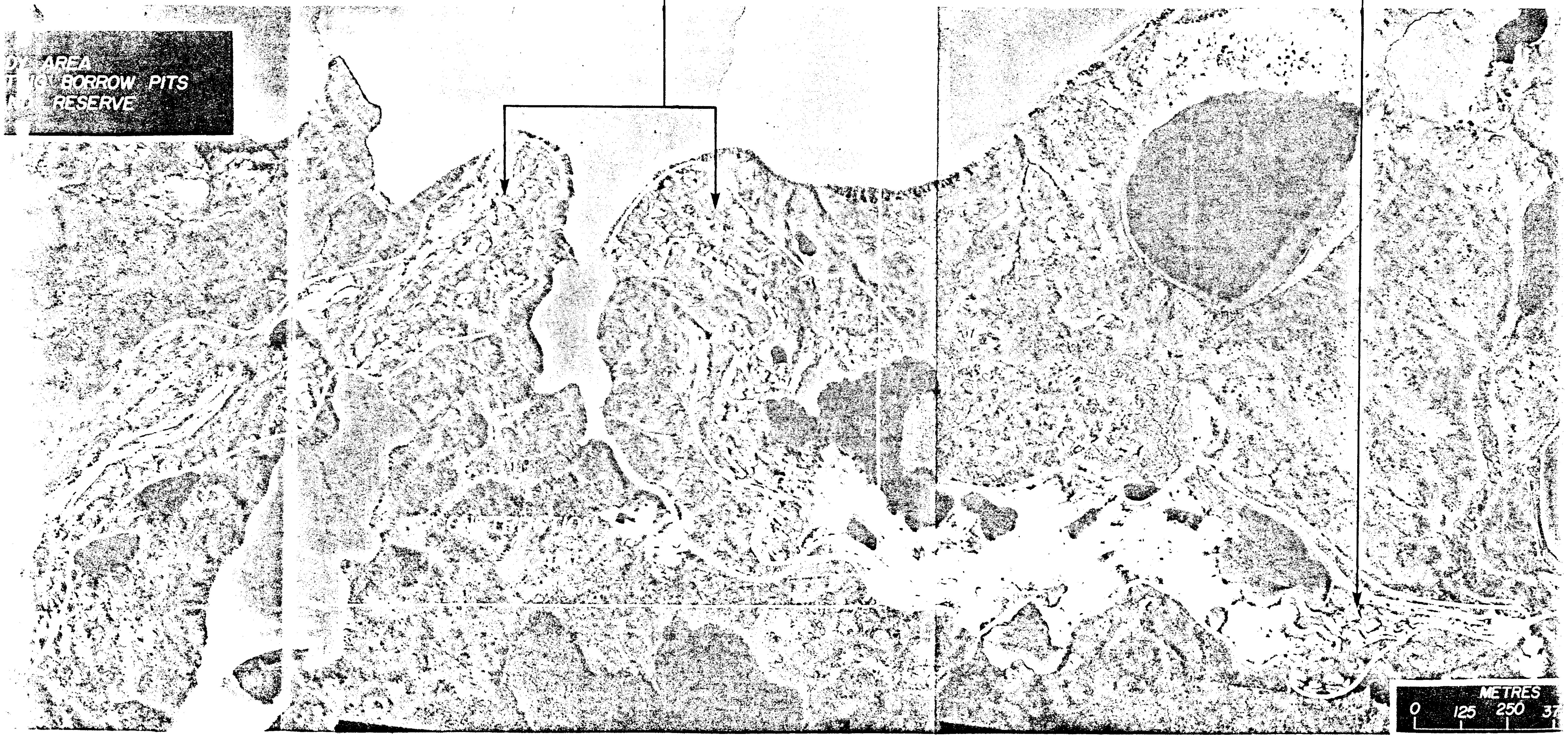
NOTE 2.1.3 (a)
Glacial - lacustrine modified beach terrace.

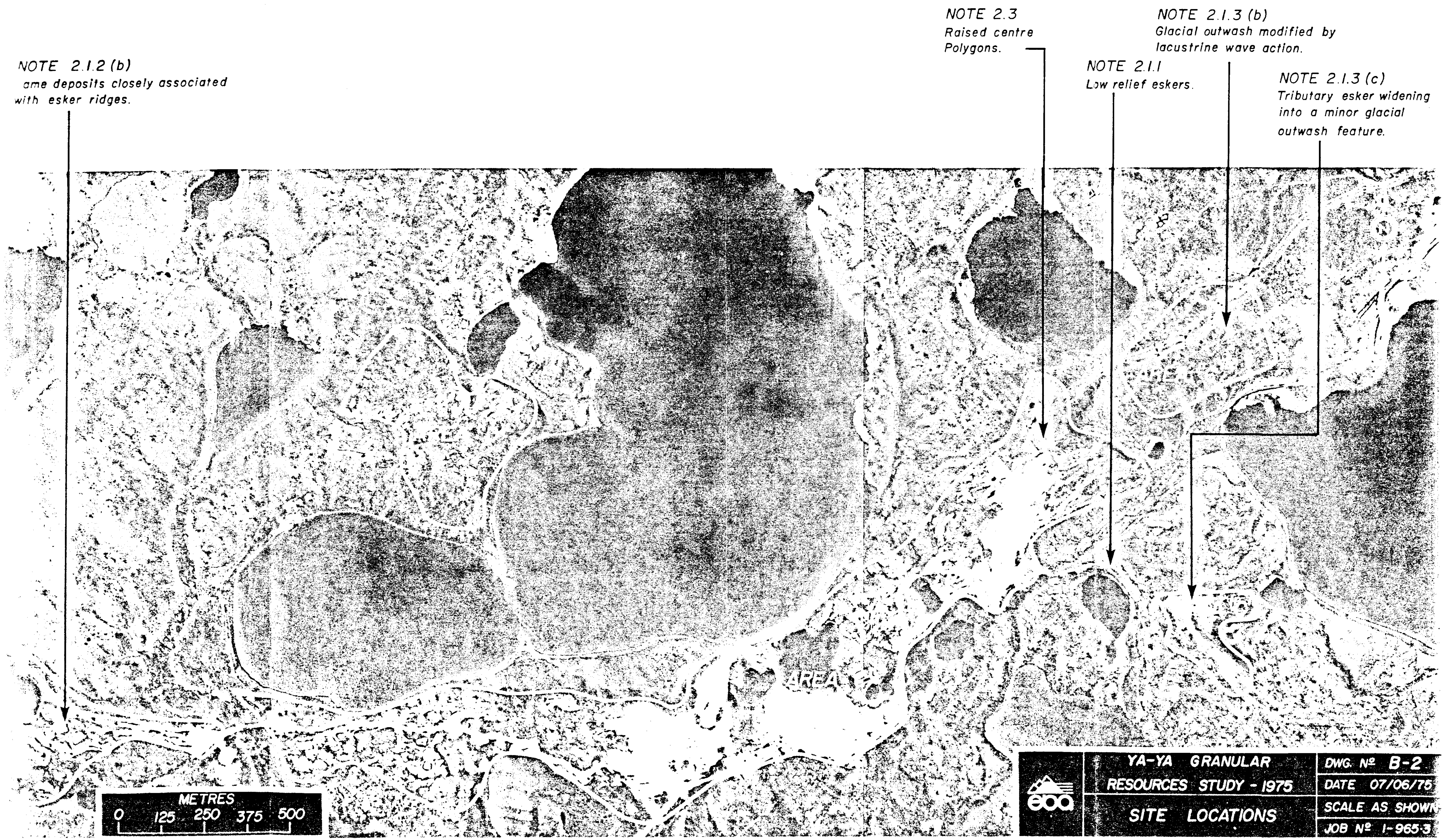
NOTE 2.1.2 (a)
Kame deposits closely associa
with esker ridge.



NOTE 2.1.2 (a)
Kame deposits closely associated with esker ridge.

NOTE 2.1.2 (b)
Kame deposits closely associated with esker ridges.





NOTE 2.1.2 (b)
ame deposits closely associated
with esker ridges.
NOTE 2.3
Raised centre
Polygons.
NOTE 2.1.1
Low relief eskers.
NOTE 2.1.3 (b)
Glacial outwash modified by
lacustrine wave action.
NOTE 2.1.3 (c)
Tributary esker widening
into a minor glacial
outwash feature.
AREA
METRES
0 125 250 375 500
YA-YA GRANULAR
RESOURCES STUDY - 1975
SITE LOCATIONS
DWG. Nº B-2
DATE 07/06/75
SCALE AS SHOWN
JOB Nº 1-965-3