# APPENDIX I TOPOGRAPHICAL AND GEOTECHNICAL SURVEY

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## I.1 Pipe Route and Geotechnical Investigation Survey

# 1. INTRODUCTION

This geotechnical investigation was commissioned by Tokyo Engineering Consultants Co. Ltd, who are the design engineers for the extension to the Port Moresby Sewerage system, National Capital District (Figure 1). The developer for this project is Eda Ranu. The project is funded by the Government of Japan under Japanese International Co-operation Agency (JICA).

The Port Moresby Sewerage Project is an extension to the existing sewerage system and is planned to serve all the Motuan Villages along the Coastline of Port Moresby from Pari to Tatana. The study will include an estimated 20 kilometres of sewerage pipeline, six new pumping stations, one new treatment plant at Kilakila and extension of the existing treatment plant at Paga Point.

Three existing pumping stations are located along the proposed system and will be upgraded if required. No geotechnical investigations were carried out for these stations.

# 2 SCOPE OF WORK

The scope of geotechnical work is as follows:

- Desk study involving the review of project concept maps, a review of previous reports and publications that outline the known site conditions, and the impact of geological hazards on the project.
- Field investigations at the site, comprised surface geological mapping, subsurface soil investigations, involving drilling and test pits.
- Analysis of field data, to provide appropriate design parameters for earthworks, excavation conditions.
- Design criteria for the construction works.

# 3. INVESTIGATION METHOD

## 3.1 Introduction

The tasks for the field work for the investigation of the Sewerage Project consist of drilling boreholes, excavating trial pits, making visual assessment of the route and a topographical survey of the proposed route and treatment plant. The topographical survey and production of plans was subcontracted to Arman Larmer Survey Pty Ltd.

## 3.2 Desktop Study

The initial study involved a review of existing topographic and geological maps and reports. In addition aerial photos of the site were viewed at the geological survey. Previous reports prepared by Engineering Geology (PNG) for similar terrain were also reviewed. The following data were reviewed:

Port Moresby 1:2,000 topographic sheets
Port Moresby 1:100,000 geological sheet
Port Moresby-Kalo-Aroa 1:250,000 geological sheet and explanatory notes

### 3.3 Drilling

A total of 9 No. boreholes were drilled out the 10 No. proposed for the project. The driller could not get access to the 10th borehole planned at the Paga Treatment Plant, because the gate was too narrow for the rig.

The client requires the maximum depth to be 10m however where bedrock was encountered before 10m, the client agreed to terminate the drilling 3 metres into bedrock. The boreholes were drilled using a Longyear LY 38 rotary FMC track-mounted rig, using washboring technique for gravelly clay aided by water and bentonite flush. On encountering rock, drill holes were advanced using a PQ (75mm dia) core barrel. The drill holes range from 6.4 metres to 10 metres. Variform Contractors were engaged to provide water for the drilling program.

The drilling program coincided with the Christmas and New Years period. As Port Moresby is renowned for its criminal activities, the field staff planned to do one borehole in a day (i.e. mobilise, set up, drill and demobilise by the end of the same day) and keep the rig parked in a safe place. Originally, it was planned to do SPT at 1.0m interval however after the first trial; it was considered sufficient to cut the SPT down to 5.0m intervals to speed up the drilling.

The results of the drilling, with the various strata encountered and the results of the SPT tests, are given on the Geotechnical Logs of Boreholes in Appendix 1 and core photographs in Appendix 5

### 3.4 Field Traverses

A walkover traverse was made for the proposed route from Tatana to Paga Point, Pari Village to Kilakila Treatment Plant, Vabukori to Kilakila and Badili Pumping Station to Sabama Pumping Station.

Using the Port Moresby 1: 100, 000 geological sheet the aim of the traverse was to confirm the pertinent features such as slope, drainage, major soil groupings and developmental features. The traverse also enabled an assessment of excavation difficulties and selection of trial pit sites to be made.

The excavation conditions are classified into four types as follows: -

Type A — material that includes all forms of "solid rock in places", occurring in masses, ledges and seams that in our opinion is not practical to excavate without drilling and blasting.

Type B — includes all forms of material firmly cemented, such that they cannot be removed by pushed blade action only, but only with tractor unit of weight 16 tonnes and a flywheel horsepower rating of 180 HP of metric equivalent. The material cannot be removed without first loosening them by means of ripping equipment, or some means other than drilling or blast-

ing.

Type C material such as sand, silt and clay that can be easily dug with an excava-
tor without much effort and does not require loosening.

Type D. Very soft, peaty material that is considered not suitable for construction
and equipment can easily get bogged.

### 3.5 Trial Pits and Dynamic Cone Penetrometer (DCP) Tests

Trial pit sites were selected where it is understood to give a representation of profiles expected during the excavation of the pipeline trench. The depths of the pit ranges from 0.3m to 1.5m. The pits were dug using a backhoe with $0.5m^3$ bucket. A total of twelve (12) sites were selected, however three sites (TP 10, TP 11 & TP 12) were not dug because the local villagers would not allow field staff to excavate. Furthermore the local villagers interrupted two other trial pit excavations (TP 1 and TP 2), so the pits were terminated prematurely. Dynamic Cone Penetrometer (DCP) tests were carried out at base most of the trial pits.

The pits were logged and photographed during excavation by our geotechnical engineer, and the results are presented in Appendix 2 and photographs of the trial pits and are presented in Appendix 5. Bulk samples were collected and selected samples sent to the laboratory for testing.

### 3.6 Laboratory testing

Selected soil samples recovered from the test pits and boreholes were tested to assess the material texture, plasticity, unit weight, shearing resistance and moisture contents. The samples were tested by Bowler Soil Technics Laboratory here in Port Moresby.

Due to time constraints laboratory testing in Port Moresby takes at least three weeks and with the Christmas new period it took longer than anticipated.

The tests comprised:

- Natural moisture content and bulk density
- Atterberg limits and linear shrinkage
- Particle size distribution by both sieve and hydrometer analysis

The results of the laboratory results are presented in Appendix 3 of this report.

## 4. SITE DESCRIPTION

### 4.1 Regional Description

The 1: 250,000 scale Geological Survey of Papua New Guinea Sheet; Port Moresby - Kalo - Aroa indicates that the proposed route for the sewerage pipelines and the treatment plants is underlain by a succession of alluvial and beach deposits overlying the Port Moresby Beds and Burns Peak Formation.

The Recent alluvial deposits and beach deposits comprise clay, silt, sand and gravel with some cobbles and occasional boulders. Most of the proposed pipeline route follows the

shoreline, which comprises deposits of predominantly silt, sand and gravel in places with occasional cobbles and rare boulders. Boulders are predominant at the base of filled ground especially at the Hubert Murray Stadium area and Tatana causeway. Clay occurs in areas where there is an absence of beach deposits. Cobbles occur in places throughout the route. A peaty clay and peaty silt material occurs in mangrove swamp deposits along sheltered bays of the shoreline.

The Late to Middle Eocene Port Moresby Beds are widespread through the proposed route for the sewerage pipeline. Port Moresby Beds are separated into Paga Beds, Baruni Limestone and Nebiri Limestone. Paga Beds and Baruni Limestone are common along the proposed pipeline route. They comprise siliceous argillite, chert, calcarenites, calcilutite, calcirudite and mudstone. They are steeply dipping, very thinly bedded or laminated to medium bedded or massive. Some occur within the bedding nodules. The rock mass varies in strength, and has very closely to widely spaced fractures.

The Paleocene age Burns Peak Formation out crops along the shoreline at Pari Village and Burns Peak Area. This rock comprises calcareous mudstone, and red-cream micritic limestone. They are steeply dipping, thin to medium bedded, vary in strength and have very closely to widely spaced fractures.

### 4.2 Site Description

Photographs of the site, including selections of the pipeline route and treatment plant site are presented in Appendix 5.

For discussion purposes the sewerage scheme will be divided into 2 schemes:

- The Paga Scheme consists of the pipeline from Tatana, along Baruni Road to Hanuabada Village and along the Hubert Murray Highway to Revenue Haus up Musgrave Street to the Paga Treatment Plant.

- The Kilakila Scheme comprises three pipelines. The first pipeline which goes from Pari Village to Kilakila through Sabama Pumping Station. The second pipeline begins at Badili Pumping Station to Kilakila through Sabama Pumping Station and the third one begins from Taikone to Kilakila through Vabukori Village.

## 5. ANALYSIS OF FIELD AND LABORATORY DATA

### 5.1 General

The ground condition encountered on site are described in details in the drill log, trial pits and summary of the field traverse in the Appendices. A summary below categorises the pipeline into sections based partly on locations and geology.

Selected samples were sent to the laboratory to get a representative of the soil characteristics of the project. The samples were from Pari, Sabama Idubada and Tatana. The samples indicate the soil is of very high plasticity.

## 5.2 Paga Scheme

### A) Tatana to Idubada

(Fieldwork - TP 1, TP 2, TP 3, Field Traverse)

The proposed pipeline traverses southeast of Tatana Island along the causeway. The material for

the causeway comprises gravel, sand and silt overlying cobbles and boulders up to 1.5m in diameter.

At the end of the causeway the route generally traverses southeast along the coastline and road formation to Hanuabada. The ground condition is basically the road formation and appears to be well-compacted gravelly sand of low to medium plasticity underlain by cobbles and boulders. Sections of the road have proper retaining walls constructed while others have boulders placed along the shorefront to protect the road. Mangrove swamp deposit is common between the shoreline and road formation. The trial pits along this section were terminated prematurely by local villagers. No dynamic cone penetrometer (DCP) tests were carried out at these trial pit sites.

On the opposite side of the shoreline is the Baruni Limestone dipping steeply into the shoreline. Trial pit (TP) 3 was dug at the foot of the slope. The formation is moderate to highly weathered bedrock.

No groundwater was encountered during trial pit excavations because of their shallow depths. The excavation condition along this section is classified as Type BC.

### B) Idubada Pumping Station

Field work - BH 6 Field Traverse

Borehole (BH) 6 was drilled to 10.45m depth at the proposed Idubada Pumping Station Site. The ground condition there is soft to stiff sandy clay, whitish to bluish medium to high plasticity. The site appears to on filled ground. Two SPT tests were carried out at 5m and 10m below ground level, and recorded N' values of 34 and 56 of respectively. These values correlate to undrained shear strength ranging from 40 to 75 kPa ( ref no. 8). Corresponding allowable pressure are 50 -100kPa.

At the BH 6 water was measured at 1m below ground level after the drilling and may be a residue of the water that was used for drilling . The BH site is 10 m from this shore line and it is anticipated that the water level will be dictated by the tide. The excavation condition is classified as Type C.

### C) Idubada (BH 6) to Gabi

(Fieldwork - Field Traverse)

This section has an estimated length of 200 m stretching along the shoreline in front of a steep rock face (Baruni Formation- siliceous and calcareous mudstone). The rock face is

moderate to highly weathered and has close to widely spaced folds. Evidence presented during the walkover is that this section is dry only when the tide is low and submerged during high tides.

Constructing a trench along this section will require some form of blasting. There are some anchor blocks along this section which suggest that an overland pipeline has been previously built along here. The presence of rock at the surface also indicates that an underground trench is uneconomical along this section. Excavation condition is classified as Type A

**D) Gabi through Hanuabada Village to Hubert Murray Stadium**
(Fieldwork - BH 7, BH 8, TP 4 Field Traverse)

The ground formation along this section comprises beach deposits along the shoreline (lower pipeline) and hillslope deposit along the upper line. The material is gravelly clay and silty sand, light yellowish brown moist and some subangular to rounded gravel (chert, shell fragments).

The DCP test at TP 4 recorded readings ranging from 7 to 13 blows per 100mm from the base of the pits. The values correlate to an allowable bearing pressure ranging from 180 - 260 kPa.

The underlying bedrock is Baruni Formation (siliceous and calcareous mudstone) and is estimated to be about 2m to 3 m below ground level. The excavation condition is classified Type C.

**E) Gabi Pumping Station**
Fieldwork - BH 7

The ground condition is silty sand loose to medium dense, with low plasticity and some gravels from ground level to 6.0m below ground level. Between 6.0m to 10.0m the ground conditions change to a silty sand and clay, moist, medium dense to dense and high plasticity.

Two SPT tests were done at 5m and 10m below ground level and the reading recorded values that were 11 and 24 respectively. These correlate to loose to medium dense material with an allowable bearing pressure ranges from 90 - 180 kPa.

**F) Hanuabada Pumping Station**
Fieldwork - BH 7

The ground conditions comprises silty sand, loose to medium dense, with low plasticity and some gravels from ground level to the top of bedrock at 6.5m below ground level.

Between 6.5 to 8m the bedrock is of calcareous sediments of the Baruni Mudstone. Moderate weathered with siliceous veins and weak veins up to 50mm wide.

One SPT test was done at 5m below ground level and the reading after 10 blows the split sampler rebound correlated to SPT refusal. Allowable bearing pressures are estimated to be greater than 1MPa.

Excavation condition to 6.5m below ground level is classified type C, and below 6.5m is type B. No groundwater is expected at this site.

**G) Hanuabada through Hubert Murray Stadium to Revenue Haus Pumping Station**

Fieldwork - Field Traverse, TP 5

The pipeline traverses south through well-compacted fill material (silty sand and gravel overlying cobbles and boulders) at Sir Hubert Murray Stadium. At the corner of the stadium, the road traverses south-southeast on well-compacted road base materials [fill; consisting of silty sand and gravel, overlying cobbles and boulders, overlying Paga Beds] to a pump station at Revenue Haus, Port Moresby.

The pipeline will traverse southeast from Hanuabada along the road to Sir Hubert Murray Stadium. This section of the route comprises well-compacted road base materials (silty sand and gravel overlying cobbles and boulders (fill) overlying Paga Beds).

The depth of the road and filled ground is estimated to range from 2m to 5m. There are several underground services along this section and before any excavation, the relevant authorities must be consulted to confirm their location.

Almost 80 % of this route is along the Champion. The proposed route is about 1.0m off the kerb and almost parallel to the freeway. There is a concrete footpath along this stretch. Excavation cost estimates along this section should include ripping up the footpath and restoring after the pipes are laid.

A trial pit (TP 5) was dug closer to the pumping station on a slope. The bedrock was 0.4m below ground level. The material was moderately weathered Paga Beds (calcareous mudstone). Estimated Allowable bearing pressure is estimated to be 1.5MPa.

Excavation conditions for this section is classified type C. Groundwater is expected 2m below ground level.

**H) Musgrave Street to Ela Beach**

Fieldwork - Field traverse

The route traverses south-southeast along the Musgrave Street over road base material (silty sand and gravel) overlies Paga Beds to Ela Beach. The route traverses southwest from Ela Beach to Paga Point treatment plant.

The materials in this section of the route comprise well-compacted road construction materials and sand, silt, gravel, cobbles and boulders overlying Paga Beds. Estimated depths would range from 0.5m to 1.0m.

The excavation condition for this section is classified as type BC. No groundwater is expected here.

**I) Paga Treatment Plant**

Fieldwork - BH 9

Only one borehole was drilled out of the two proposed. The second site could not be reached because the rig was too wide for the gates to the existing treatment plant and the proposed site.

The borehole was drilled to 10m below ground level. The logs indicated that top 2.5m was loose gravelly sand and cobbles with some clay. From 2.5m to 10m the borehole was cored. The rockmass was highly to moderately weathered and there weak zone up to 200mm wide and closely spaced. This formation is part of the Paga Beds.

A drilling program was carried for the nearby Oceanarium back in the 1988. The logs produced gave similar characteristics to that found at BH 9. Point Load test done on the sample taken from his investigation ranged from 3 - 10 MPa.

The excavation condition is classified as type BC.

## 5.3 Kilakila Scheme

**A) Pari Pumping Station**

Fieldwork - BH 1

The pumping is about 10 m from the shoreline. The ground condition comprises silty sand of medium density and moist. Four SPT tests were done at 2m intervals in this borehole; the N' values of 7, 11, 10 and 17 were recorded at 2, 6, 8 and 10m respectively. At the bottom of the pit the material is medium dense as indicated by the SPT N' value. Correlated allowable bearing pressures ranges from 80 to 200 kPa.

The groundwater level is dictated by the tidal fluctuation. When measured about 24 hrs after the hole was bored the water level was recorded at 1.5m below ground level. The excavation condition is classified as type C.

**B) Pari Road**

Field work - Field Traverse

The proposed pipeline for the Kilakila Scheme strikes northwest along the shoreline from Pari village to the edge of Sabama and ends at Kilakila treatment plant. The materials within this route comprise peaty soil (clay and silt) silt, sand, occasional clay and cobbles (mangrove swamp deposits, beach deposits and valley floor deposits) in places overlying Burns Peak Formation

Three trial pits (TP 10, TP 11 and TP 12) were proposed this route but the local villagers did not allow field staff to excavate the pits.

A visual inspection of the route was made. It is apparent that the overburden material is well-compacted road construction material. The material comprises gravely sand and silt, underlain by alluvial cobbles and sand and silt. Closer to the village the underlying formation will change to calcareous mudstone. Estimated depths along this section will range from 1.5m to 3.0m.

The excavation condition is classified as type C. Groundwater may be encountered at 1m below ground level where the pipeline is at lower elevations adjacent to sea level.

**C) Between Pari road and Sabama Pumping Station**
Fieldwork - TP 9, Field Traverse

A trial pit was excavated close to the shoreline. The ground conditions indicate the material is silty sand, very loose to loose fine to medium beach sand deposits with organic matter and clay. (Mangrove Swamp Deposit).

The pit was excavated to 1.5m below ground level and at 0.9m below ground level ground water was seeping into the pit.

The field staff did not carry out any DCP tests. The excavation condition along this section is classified as type D.

**D) Sabama Pumping Station**
Fieldwork - BH 2, Filed Traverse

The proposed pumping station is located about 6m from an open unlined drain. At the time of the investigation the drain was filled with sewer water up to about 0.3m below ground level. The ground condition comprises very soft peaty clay, with low plasticity below ground level. From 5m to 10 m the condition changes to very soft white clay with high plasticity.

Three SPT tests were carried out at 2m, 5m and 10 m below ground level; and the corresponding N' values recorded were 7, 12 and 19 which correlates to bearing pressures ranging from 80 to 200 kPa. The excavation condition at this site is classified as type D.

**E) Sabama Pumping Station to Kilakila Treatment Plant**
Fieldwork - Field Traverse

The ground conditions along this section is partly mangrove swamp deposit with similar conditions to that at BH 3. The other part is hillslope deposits with estimated depths ranging from 1.0 to 2m overlying siliceous argillite bedrock.

The excavation condition along this section is classified as type D and type BC, as it approaches the Kilakila Treatment Plant.

**F) Kilakila Treatment Plant**
Fieldwork - BH 3, BH 4, field traverse

Two boreholes were drilled at the proposed treatment plant. The overburden material is soft to firm gravelly sand and silt with medium plasticity. The estimated overburden thickness is from 0.1 to 4.5m below ground level. Below 4.5m depth the rock is extremely to moderately weathered siliceous argillite with weak seams up to 150mm wide and widely spaced calcite veins. Hard chert layers to 0.5m thickness were also encountered.

No SPT tests were carried out in this borehole. Estimated allowable bearing pressure ranges from 1 - 3.5 MPa. The excavation condition here is classified as type B and possibly type A.

**G) Badili Pumping Station to Sabama Pumping Station**
Fieldwork - TP 6, TP 7, TP 8, Field Traverse

The proposed pipeline for sector C traverses southeast along the road from Badili to Kilakila treatment plant through Sabama. The materials within this route comprise road base material (silt, sand and gravel), fill (sand, gravel, cobbles), footslopes deposits (clayey silt, sand and gravel, occasional cobbles) and valley floor deposits (clay and silt, occasional sand and gravel) overlying Port Moresby Beds.

Three trial pits were dug along this section to 1.2m below ground level. From ground level to 1.2 m below ground level the ground condition is predominantly colluvial silty sand; loose to dense yellowish brown clay and sand.

A fair portion of this section is along Scratchley Road and it is expected that road base, concrete kerbs and footpath will be excavated before the pipeline is laid. This should included in the cost estimates.

DCP's carried out on the base of the trial pits range from 1.3 - 8 blows per 100mm, indicating relative density is very loose to loose. Based on the data the allowable bearing pressure is estimated to range from 50 - 180 kPa. The excavation condition is classified as type C and B.

**H) Taikone Pumping Station**
Fieldwork - BH 5, Field Traverse

This borehole about 50m away from the shoreline and some 10m above sea level. Ground condition at the proposed pumping station comprise silty sand; loose to medium dense dark grey to pink silty sand with minor organic matter from ground level to 10m below ground level.

Two SPT tests were carried out in this borehole at 5m and 10m below ground level. The N' values recorded were 30, and refusal after 10 blows respectively. The second SPT was done on top of bedrock. These values indicate the relative density is dense to very dense and allowable bearing range 320kPa for the dense sand and 1 Mpa for the bedrock.

The excavation condition is classified as type C. In addition groundwater may be expected at this site.

**I) Vabukori to Kilakila**

Fieldwork - Field Traverse

The Vabukori to Kilakila sector traverses southeast along the coastline from Taikone to Vabukori and around Taina Nadeara then traverses northeast to Kilakila treatment plant. The materials within this route comprise peaty materials (silt and clay of mangrove swamp deposits) sand, occasional clay and cobbles (beach deposits) in places overlying Port Moresby Beds.

The ground conditions along most of this section consist of soft to firm sandy gravelly and silt, with medium plasticity similar to Kilakila pumping station site, with medium plasticity. The depths of the overburden are estimated to range from ground level to 2 m depth. The underlying bedrock is siliceous argillite.

This rock level falls steeply to the sea and forms a rocky coastline. The rock mass is moderate to highly weathered and the pipeline trench would require drilling and blasting. A pipeline placed at the surface would be exposed to impact of waves breaking onto the rock platform, pertaining at high tides. Unless the pipe is well anchored and/or covered it may become unserviceable.

## 6. DESIGN CRITERIA

### 6.1 Excavation Condition

The majority of the materials assessed during the walkover survey fall into type C and BC. The BC infers some of effort will be required to loosen the rocks before excavating.

The traverse was made to assess the materials for excavation difficulties and to select trial pit sites where changes in subsurface conditions are expected and to obtain a variety of subsurface conditions. Details of the excavation condition and assessment are given in Appendix 4.

**A) Pipeline Trench**

Table I.1, presented in Appendix 4, indicates in detailed the expected excavation conditions along the route.

In general, nearly 90% of the proposed pipeline trenches will be along roads and highways. It is expected that the top 1.0 - 1.5m below ground level will be well-compacted road construction fill material (silty sand and gravel overlying cobbles and boulders).

At the surface, bitumen and some concrete kerbs and footpaths will be encountered. The cost of refurbishment should included when costing the project (excavating and restoring).

Bedrock encountered along the proposed route may not be any real problem. It is extremely to very highly weathered should be can be rippable using tynes of a bulldozer or reasonably sized rock breaker, depending on the size of the trench.

There are two sections that will require some drilling and blasting; the section mentioned in parts 5.2. (C) (Idudaba to Gabi) and 5.3 (G) (Vabukori to Kilakila). An overland pipeline will suit these sections but must comply with environment regulations. Total estimated distance would be about 500m.

During the trial pit investigations, the pits were dug to a maximum of 1.5m and the side walls were stable during the logging of the holes. It should be noted here that the duration of the operation is between 20 to 45 minutes.

Despite the apparent stability it is recommended that for any trenches deeper than 1.2m, the walls of the trenches must be supported where personnel will be working in them.

The section between Pari Road and Sabama Pumping Station is the only place where groundwater was noticed and will cause some problems during construction.

It is essential that dewatering methods and durability of the pipe type be considered for these sections of the pipeline.

**B) Pumping Stations**

It is understood that the pumping stations will be 8 - 10m below ground level.

Five of the six boreholes were drilled to 10m depth except for borehole BH 8, which encountered bedrock at 6.5m and was terminated at 8m. Excavation conditions at these sites are expected to be free digging (i.e. excavation type C).

At BH 8 the rock mass is highly weathered and has weak seams up or 150m thick and closely spaced. This indicates the rock can be easily broken up using a rock breaker followed by removal using mechanical means.

Groundwater was encountered at Pari, Sabama, Idubada and Gabi Pumping Stations. The levels ranged from drill hole collar (Sabama) to 1.5m (Idubada) below ground level. Apart from Sabama it is assumed that the water level in the above mentioned stations were dictated by the tidal levels. There is however a possibility that the water levels relate to residual drilling water in the borehole.

**Table I.1 – Summary of Ground Condition and Water Level**

| Pump Station | Soil Type | Water Level Below GI (M) | Rock Depth (M) | Excavation Condition |
|---|---|---|---|---|
| Pari | Silty SAND | 1.5 | N.A | TYPE C |
| Sabama | Peat and clay | 0.1 | N.A | TYPE C |
| Taikone (Vabukori) | Silty SAND | N.A | 10m | TYPE C |
| Idubada | Silty CLAY | 2.5 | N.A | TYPE C |
| Gabi (H/Bada) | Silty SAND | 2.5 | N.A | TYPE C |
| Hanuabada | Silty SAND | N.A | 6.5 | TYPE C and B |

N.A - not applicable Excavation Condition refer to section 3.4

Regardless of the above, when designing any subsurface structures, all of them should be treated as underwater structures because they are located less than 20m from the shoreline. It is recommended that all excavation for these structures must be fully supported.

## C) Treatment Plants

### Kilakila Treatment Plant

This site is located at the foot of the slopes of Kilakila Range (Figure 3), the estimated gradient of the hill slopes is about 20 degrees steepening to 40-50 degrees on the upper slopes. A narrow gently sloping coastal plain extends about 20-30m inland. The edge is marked by an eroded terrace of fine sandy sediments. The shoreline at the site is at the transition between mangrove swamp deposits on the northeast side and a coastal rock platform on the southwest side. In order to prepare the site for the treatment plant it is apparent that substantial cut and fill operations will be undertaken to level the site.

The underlying rock mass at this plant is moderate to extremely weathered siliceous argillite at less than 0.5m depth at the toe of the slope to 4.5m depth below mangrove deposits. If excavation extends more than 0.5m into the bedrock we anticipate a need to drill and blast, based on the occurrence of siliceous/chert layers within the bedrock. However we recommend that the configuration for the treatment plant layout be designed to limit the amount of excavation in rock.

Filling over the coastal mangrove swamp deposits will involve up to about 5m of compressible materials overlying rock. The compressible materials are organic, soft silty clays which will consolidate under loading. It is recommended that the filling does not exceed 3m in order to limit overall settlement to 60mm. Preloading of sites is recommended in places where filling is to exceed 3m over the mangrove deposits Settlement should be monitored by survey on gauge poles embedded in the fill. In order to limit the long term settlement to 10mm for structures built on the fill allowable bearing pressures should not exceed 150kPa.

The investigation was bounded by the terms of reference to two boreholes and several SPT tests in the boreholes. Furthermore it is understood that the limits of the proposed site is only preliminary and the actual size of the treatment plant is not finalised (refer to Figure 2 for locations of the boreholes). If the site development, including cutting and filling exceeds about 4m in height then specific geotechnical advice should be sought in order to optimise the design.

### Paga Treatment Plant

The Paga Treatment Plant Site is adjacent to the coastal cliffs at Paga Point. It occupies the rock platform overlain by variable thicknesses of saturated sand with coral fragments and frimging coral reef. The silty gravelly sand deposits are up to 1.5m thick, loose to medium dense, and grey in colour, with about 10% gravel to boulder sized rock and coral fragments. The coral is about 2m deep, adjacent to the existing Pump Station and is expected to thicken to 3m to 4m on the edge of the reef. It comprises white, high to very

high strength masses, with a sugary texture and cavities to 0.3m. The bedrock is moderately to slightly weathered siliceous and calcareous mudstone and chert with high strength.

Drilling data from the Oceanarium study in 1979 and from this study concentrated on the area adjacent to the existing pump station. The bedrock profile underlying the sand and coral units, is expected to be similar along the rock platform and reef to the west of the pump station. Depth to bedrock ranges from 1.5m to 3m. The assessment of foundation conditions is expected be consistent over the full extent of the site.

Filling over the deposits will involve up to about 2m of compressible materials overlying rock or coral. The compressible materials loose to medium dense silty gravelly sand which will consolidate rapidly under loading. It is unlikely that filling will exceed 3m at which overall settlement is expected to be 10mm. Preloading of site is not necessary. In order to limit the long term settlement to 10mm for structures built on the fill allowable bearing pressures should not exceed 200kPa.

The ground water is estimated to be 1.0m below the ground level at low tide and at the surface during high tide.

## 6.2 Assessment of Foundation Conditions for all sites

The treatment plant sites are located on coastal rock platforms with fringing reefs. The foundations will comprise a combination of weathered sedimentary rock, a variable layer of unconsolidated beach deposits and coral.

Foundation conditions in the unconsolidated sediments are assessed from the SPT data and engineering judgement of the materials encountered. For soils of very fine or silty sand texture under saturated conditions, the equation is $N_c = 15 + 0.5(N_m - 15)$ (Ref 4). It is assumed that the foundation for all pumping stations will be below groundwater, as nearly all of them are near the coastline.

The table below summarises the materials and tests carried out for the different sites investigated for the project. The values of the allowable bearing pressure assumes 2m wide footings.

**Table I.2- Summary of STP and Correlated Allowable Bearing Pressure**

| BH | Location | Soil Type | Depth of Test (m) | N' Value | Nc Corrected | Allowable Bearing Pressure (kPa) | Comments |
|---|---|---|---|---|---|---|---|
| 1 | Pari | Clay SAND | 5 | 11 | 11 | 80 | water level at 2.5m |
| 1 | Pari | Clay SAND | 10 | 17 | 16 | 150 | |
| 2 | Sabama | Clay SILT | 5 | 12 | 12 | 80 | Water level 0.1m |
| 2 | Sabama | Clay SILT | 10 | 19 | 17 | 150 | |
| 3 | K/Kila # 1 | | NT | NT | | 1-3MPa | Bedrock at 4.5m |
| 4 | K/Kila # 2 | | NT | NT | | 1-3MPa | Bedrock at 4.5m |
| 5 | Taikone | Silt SAND | 5 | 19 | 17 | 150 | |
| 5 | Taikone | Silt SAND | 10 | 15 ref | 10 | 1 - 3 Mpa | Tested on bedrock |
| 6 | Idubada | Clay SILT | 5 | 48 | 31.5 | 280 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | Idubada | Clay SILT | 10 | 56 | 35.5 | 350 | |
| 7 | Gabi | Silt SAND | 5 | 24 | 19.5 | 180 | |
| 8 | H/bada | Silt SAND | 8 | 10 ref | 10 | 1 – 3MPA | Tested on bedrock |
| 9 | Paga | | NT | | | 3- 10 Mpa ** | Bedrock at 2.5m |

NT - No SPT test undertaken
1MPa=1,000KN/m² (kPa)
ref = refusal of SPT tests when N> 50 over 150mm or the hammer bounces hard rock or boulders
** estimates from Ref 6

### 6.3 Slope Stability

There were no apparent slope stability problem observed during the site investigation, apart from the Kilakila Treatment Plant Site which may require some geotechnical input. Any cutting into the slopes should be designed as follows:-

- cuttings in soil: batter at 2H : 1V for maximum height of 3m. Any cuts greater than 3m should have 2m wide benches between the batters.

- cuttings in rock face: batter at 0.5H : 1V for a maximum height of 3m. Any cuts greater than 3m should have 2m wide benches between batters.

For the sewer pipelines we recommend that any trench depths greater than 1.2m below ground level must be fully supported.

The pump stations will require excavation of up to 8m and 10m at sites which are commonly confined between existing structures and roads. In order to avoid cutting back to a stable batter angle it is recommended that the excavations in soil be fully supported prior to placement of the pumping well. Excavations in rock are expected to stand unsupported for short periods. For safety reasons, personnel should not enter any of the excavations, whether in rock or soil unless they are fully supported.

## 7. CONSTRUCTION MONITORING

SMEC - Engineering Geology have suitably qualified personnel based in Port Moresby, that can be consulted during the earthworks phase of the project. It is anticipated that geotechnical engineers will be required at the pumping stations and the Kilakila Treatment plant to assess the exposed bedrock for stability of the slopes and foundation preparation. If filled embankment are to be constructed to more than 4m in height special design considerations are required for compaction and settlement analysis.

## 8. SUMMARY AND CONCLUSION

- The excavation conditions of the pipeline route is generally type C (readily excavated by mechanical means), with some type B (combination of difficult mechanical excavation, ripping, rock breaker and possibly blasting) and may be type A (drilling and blasting over a total of 500m), depending upon alternative routes.

- The foundation conditions presented above suggests minimum bearing pressure of 80 kPa to be founded on silty sand and clay and 1MPa for foundations in bedrock.

- The treatment plant sites are underlain by siliceous to calcareous mudstone at depths of up to 4.5m, underlying coastal sediments and/or coral reef. At the Kilakila site it is expected that earthworks could involve cutting to 3m and filling to 3m to 4m. Depending upon the size of the plant the site the works may be more extensive. Filling over the unconsolidated sediments should include a period of preloading and monitoring to assess rates of consolidation prior to placement of any structures. The Paga site is on competent rock and coral at shallow depths and no such filling requirements would be necessary.

- The pumping station sites were all within silty sand to silty clay soild, with the exception of the Sabama site in peaty clay and the Hanuabada site, which encountered rock at 6.5m. Excavation conditions in soil should be dug by mechanical means. If the Hanuabada site is to excavated below 6.5m blasting will be required.

- All pumping stations investigated are close to the shoreline and it is recommended all substructures be treated as submerged.

- All trenches deeper than 1.2m below ground level must be fully supported.

## 9. REFERENCES


1. *Port Moresby Urban Geology*, Geological Survey of Papua New Guinea Memoir 1

2. *SAA Site Investigation Code* (1981) AS 1726. Standards Association of Australia.

3. Stockwell, M. J., (1977). *Determination of allowable bearing pressure under small structures*. New Zealand Engineering (32,6) pp 132 - 135.

4. Carter, M., (1983). *Geotechnical Engineering Handbook*. Pentech Press, London pp 81 - 110

5. Simons, N.E., and Menzies, B. K, (1977). *Foundation Engineering*. Butterworth Scientific, London. pp 49 - 58

6. Goldsmith, R.C., et al (1979). *Port Moresby Oceanarium Geological Investigation*. Geological Survey of Papua New Guinea, Report No 79/24.

7. Pells, P. J N, et al, (1978). *Design Loadings for Foundation in Shale and Sandstone in the Sydney Region*. Australia Geomechnics Journal. pp31 - 39

# Appendix 1

## Geotechnical Logs of Boreholes

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1 | **BOREHOLE NO: 1**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE | DRILL METHOD WASH BORING | DATE COMMENCED:16-12-97 | JOB NO: J096 |
| CLIENT : TOKYO ENGINEERING | DRILL MODEL: FMC | DATE COMPLETED:16-12-97 | LOGGED: KT |
| LOCATION : PARI VILLAGE | HOLE SIZE: 75cm / CASING SIZE 75cm | CO-ORDINATES: | CHECKED: KT |
| | DEPTH: 10m / DEPTH.10m | | APPROVED: KT |
| CONTRACTOR: PNG DRILLERS | | ELEVATION: DATUM: | |

| Laboratory test results: % fines -75um | Atterberg limits: LL (%) | Atterberg limits: PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil, components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | water level 1997/12/19 | 1 D(1) 2 | | SM | SILTY SAND: Very soft to soft, loose, orange to white, moist silty fine to coarse sand and approximately 15-20%, subangular to rounded, fine to coarse, white and brown gravel (chert, mudstone, limestone and shell fragments) |
| | | | | | SPT 3/3/4 N=7 | D(2) 3 D(3) 6.4 4 | | SM | SILTY SAND: Soft to firm and dense, orange to white, moist silty, fine to coarse sand with approximately 10-20%, fine to coarse, subangular to rounded white and brown gravel (chert, limestone, mudstone and shell fragments) |
| | | | | | | D(4) 5 D(5) | | SC | SANDY CLAY: Stiff, brownish orange moist clayey fine to coarse sand, medium plasticity fines with approximately 10% fine angular gravel (chert and shell fragments) |
| | | | | | SPT 2/5/6 N=11 | 6 7 8 | | CH | CLAY: Very stiff brown moist clay of high plasticity with trace of fine sand |
| | | | | | SPT 6/4/9 N=13 | 9 10 | | SC | SANDY CLAY: Very stiff orange moist fine to coarse sandy silty clay of very high plasticity. |
| | | | | | SPT 8/9/10 N=19 | | | SC | CLAYEY SAND: Stiff, dense, orange brown, clayey fine to sand with approximately 15% fine angular mudstone gravel. HOLE TERMINATED AT 10.45m |

**sampling**
- B bulk sample
- D disturbed sample (sample number in brackets)
- T tube sample (sample number in brackets)
- T* no recovery

**field tests**
- permeability
- cons=constant head
- fall=falling head
- rise=rising head test

SPT N VALUE (blows per three lengths of 150 mm in brackets)
R=sample recovery

= Water level in borehole, and date.

**notes**
1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results

# SMEC Engineering Geology — BOREHOLE LOG

Sheet 1 of 1 | **BOREHOLE NO: 2**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE | DRILL METHOD:WASH BORING | DATE COMMENCED: 17-12-97 | JOB NO: J096 |
| CLIENT : TOKYO ENGINEERING | DRILL MODEL: FMC | DATE COMPLETED: 17-12-97 | LOGGED: KT |
| LOCATION : PUMP STATION 2 | HOLE SIZE: 75cm / CASING SIZE:75cm | CO-ORDINATES: | CHECKED: KT |
| SABAMA SETTLEMENT | DEPTH: 10m / DEPTH:10m | | APPROVED: KT |
| CONTRACTOR: PNG DRILLERS | | ELEVATION: DATUM: | |

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil, components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | water level 1997/12/19 | 0 0 | | Pt | PEATY SILT: Very soft black organic clay of low plasticity, wet MANGROVE SWAMP DEPOSITS. |
| | | | | | SPT 3/3/4 N=7 | D(6) 1 2 3 | | Pt | PEATY CLAY: Very soft, blackish grey, very high plasticity peaty clay. MANGROVE SWAMP DEPOSITS |
| | | | | | SPT 4/5/7 N=12 | 4 5 D(7) 6 7 8 9 | | OL | CLAYEY SILT: Very soft and white, very high plasticity clayey silt . Possible limestone origin |
| | | | | | SPT 6/8/11 N=19 | 10 | | OL | CLAYEY SILT: Stiff yellowish white low plasticityclayey silt with approximately 15-20% fine to coarse white sand HOLE TERMINATED AT 10.45m |

**sampling**
- B bulk sample
- D disturbed sample (sample number in brackets)
- T tube sample (sample number in brackets)
- T* no recovery

**field tests**
- permeability
- cons=constant head
- fall=falling head
- rise=rising head test

SPT N VALUE (blows per three lengths of 150 mm in brackets)
R=sample recovery

⇩ = Water level in borehole, and date

**notes**
1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.

# SMEC ENGINEERING GEOLOGY — BOREHOLE LOG

Sheet 1 of 1 | **BOREHOLE NO: 3**

PROJECT: PORT MORESBY SEWERAGE
CLIENT : TOKYO ENGINEERING
LOCATION : KILAKILA TREATMENT PLANT
SABAMA SETTLEMENT
CONTRACTOR: PNG DRILLERS

DRILL METHOD:WASH BORING
DRILL MODEL: FMC
HOLE SIZE: 750m CASING SIZE:750m
DEPTH: 8.5m DEPTH:8.5m

DATE COMMENCED: 18-12-97
DATE COMPLETED: 18-12-97
CO-ORDINATES:
ELEVATION: DATUM:

JOB NO: J096
LOGGED:KT
CHECKED: KT
APPROVED: KT

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil. components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | drilling method: washbore to 4.5m | 0 0 | | OL | SILTY CLAY: Soft white moist low plasticity silty clay with approximately 10-20% fine to coarse brown sand. |
| | | | | | | 1 D(6) | | | |
| | | | | | | 2 | | | |
| | | | | | | 5 | | | |
| | | | | | | 3 | | | |
| | | | | | | 4 | | | |
| | | | | Core data | | | | | |
| | | | | CRR= 25 RQD= 0 | drilling method: PQ coring | 5 D(7) | | | Gravelly clayey silt, light grey-brown, low plasticity, sub-rounded to angular gravel frags to 30mm |
| | | | | CRR= 85 RQD= 45 | | 6 | | | SILICEOUS ARGILLITE: Greyish white, orange along joints, fractures and bedding planes (due to oxidation). very closely spaced healed structures, brecciated in places, highly to moderately weathered mainly along joints and bedding planes, moderately strong. |
| | | | | CRR= 80 RQD= 25 | | 7 | | | Includes weak zones of angular gravelly silty sand, up to 200mm wide, dipping at 20 deg, spaced 500mm apart. Below 7.5m competent highly weathered Calcareous argillite; intact rock with minor stained caly infilled joints dipping at about 10 deg. |
| | | | | | | 8 | | | BOREHOLE TERMINATED AT 8.0m |
| | | | | | | 9 | | | |
| | | | | | | 10 | | | |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)
T tube sample (sample number in brackets)
T' no recovery

**field tests**
permeability
cons=constant head
fall=falling head
rise=rising head test
SPT N VALUE (blows per three lengths of 150 mm in brackets)
R=sample recovery
—— = Water level in borehole, and date.

**notes**
1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.
4) CRR is the Core Recovery Ratio, the percentage of core or core fragments recovered over the length of the interval drilled.
5) RQD is the Rock Quality Designation, the total length of intact core pieces as a percentage of the total core run drilled.

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1 | **BOREHOLE NO: 4**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE | DRILL METHOD: WASH BORING | DATE COMMENCED: 17-12-97 | JOB NO: J096 |
| CLIENT : TOKYO ENGINEERING | DRILL MODEL: FMC | DATE COMPLETED: 17-12-97 | LOGGEDKT: |
| LOCATION : KILAKILA TREATMENT PLANT on the shoreline | HOLE SIZE: 75cm / CASING SIZE:75cm | CO-ORDINATES: | CHECKED: KT |
| | DEPTH: 6m / DEPTH:6m | | APPROVED: KT |
| CONTRACTOR: PNG DRILLERS | | ELEVATION: DATUM. | |

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure. Secondary soil. components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | | MH | SANDY CLAYEY SILT: Very soft black, clayey silt of low plasticity with some organic matter (Derived from Mangrove Deposits) |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | |
| | | | | | | 3 | | | |
| | | | | | | 4 | | | |
| | | | | Core data | | | | | |
| | | | | CRR= 25<br>RQD= 0 | Drilling Method: PQ Coring | 5 | | | SILICEOUS ARGILLITE: Greyish green, mild brown mottles and bands, iron oxide stained fractures and bedding planes. Extremely to highly weathered alongjoints, becoming less weathered with depth. Steeply dipping foliation, joints at 10 to 60 deg. sections of the core totally fragmented. |
| | | | | | | 6 | | | BOREHOLE TERMINATED AT 6.0m (due to security and safety reasons) |
| | | | | | | 7 | | | |
| | | | | | | 8 | | | |
| | | | | | | 9 | | | |
| | | | | | | 10 | | | HOLE TERMINATED AT 10.45m |

**sampling**
- B bulk sample
- D disturbed sample (sample number in brackets)
- T tube sample (sample number in brackets)
- T* no recovery

**field tests**
- permeability
- cons=constant head
- fall=falling head
- rise=rising head test
- SPT N VALUE (blows per three lengths of 150 mm in brackets)
- R=sample recovery
- —— = Water level in borehole, and date.

**notes**
1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.
4) CRR is the Core Recovery Ratio, the percentage of core or core fragments recovered over the length of the interval drilled.
5) RQD is the Rock Quality Designation, the total length of intact core pieces as a percentage of the total core run drilled.

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1

**BOREHOLE NO: 5**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE<br>CLIENT : TOKYO ENGINEERING<br>LOCATION : TAIKONE, VABUKORI<br>SABAMA SETTLEMENT<br>CONTRACTOR: PNG DRILLERS | DRILL METHOD:WASH BORING<br>DRILL MODEL: FMC<br>HOLE SIZE: 75cm<br>DEPTH: 10.45m<br>CASING SIZE:75cm<br>DEPTH:10.45m | DATE COMMENCED: 17-12-97<br>DATE COMPLETED: 17-12-97<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: J096<br>LOGGED:KT:<br>CHECKED: KT<br>APPROVED:KT |

| Laboratory test results: % fines -75um | Atterberg limits: LL (%) | Atterberg limits: PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil, components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 0 | | SM | SILTY SAND: Loose, becomining dense and very dense, dark greyish to pinkish, fine to medium calcareous sand with approximately 10-15% fine to coarse, angular to subrounded calcareous gravel and trace of organics |
| | | | | | | 1 | | | |
| | | | | | | D(6) | | | |
| | | | | | | 2 | | | |
| | | | | | SPT 7/12/18 N=30 | 5.45 | | | |
| | | | | | | 3 | | | |
| | | | | | | 6.4 | | | |
| | | | | | | 4 | | | |
| | | | | | | 5 | | | |
| | | | | | SPT 15/13/2 bounce N>30 | D(7) | | | |
| | | | | | | 6 | | | |
| | | | | | | 7 | | | |
| | | | | | | 8 | | | |
| | | | | | | 9 | | | |
| | | | | | | 10 | | | LIMESTONE: Fine grained, moderately strong white and off-white at places, massive.<br>HOLE TERMINATED AT 10.45m |

**sampling**

B bulk sample
D disturbed sample (sample number in brackets)
T tube sample (sample number in brackets)
T* no recovery

**field tests**

permeability
cons=constant head
fall=falling head
rise=rising head test
—·— = Water level in borehole, and date.

SPT N VALUE
(blows per three lengths of 150 mm in brackets)
R=sample recovery

**notes**

1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1 | **BOREHOLE NO: 6**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE | DRILL METHOD:WASH BORING | DATE COMMENCED: 17-12-97 | JOB NO: J096 |
| CLIENT : TOKYO ENGINEERING | DRILL MODEL: FMC | DATE COMPLETED: 17-12-97 | LOGGEDKT: |
| LOCATION : PUMP STATION 6 | HOLE SIZE: 75cm / CASING SIZE:75cm | CO-ORDINATES: | CHECKED: KT |
| IDUBADA | DEPTH: 10m / DEPTH:10m | | APPROVED: KT |
| CONTRACTOR: PNG DRILLERS | | ELEVATION: DATUM: | |

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil. components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | | CH | CLAYEY SILT: Very soft and white, very high plasiticity clayey silt |
| | | | | | | 2 | | | FILL |
| | | | | | | 4 | | | |
| | | | | SPT 11/16/27 N=43 | | 6 | | CH | CLAYEY SILTY: Very stiff, white, very high plasiticity clayey silt , possibly LMST origin |
| | | | | | | 6.4 | | | FILL |
| | | | | | | 8 | | | |
| | | | | | | 10 | | SM | CLAYEY SILTY: Very stiff yellowish white, low plasticity clayey silt with approximately 15-20% fine to coarse sand. |
| | | | | | | | | | HOLE TERMINATED AT 10.45m |

**sampling**

B bulk sample
D disturbed sample (sample number in brackets)
T tube sample (sample number in brackets)
T* no recovery

| field tests | SPT N VALUE |
|---|---|
| permeability | (blows per three |
| cons=constant head | lengths of 150 mm |
| fall=falling head | in brackets) |
| rise=rising head test | R=sample recovery |

—— = Water level in borehole, and date.

**notes**

1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1

**BOREHOLE NO: 7**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE<br>CLIENT : TOKYO ENGINEERING<br>LOCATION : GABI<br>HANUABADA<br>CONTRACTOR: PNG DRILLERS | DRILL METHOD:WASH BORING<br>DRILL MODEL: FMC<br>HOLE SIZE: 75cm CASING SIZE:75cm<br>DEPTH: 10m DEPTH:10m | DATE COMMENCED: 6-1-98<br>DATE COMPLETED: 6-1-98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: J096<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED: KT |

| Laboratory test results | | | | | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure. Secondary soil. components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | 1<br>2 | | SM | Silty SAND: soft to firm dense, orange to white fine to coarse sand approximately 15 - 20% .<br>subangular to rounded , fine to coarse and and brown gravel (chert, mudstone , limestone and shell fragments) |
| | | | | ΣΠΤ 10 βλοωσ & ρεφυσαλ<br>N value > 30 | | 3<br>4<br>5 | | CH | SANDY CLAY : Very stiff fine to coarse sandy silty clay of very high plasticity |
| | | | | | | 6<br>7<br>8<br>9<br>10 | | | Light brown moderately weathered calcereous MUDSTONE sheared and brecciated veined by calcite<br>BOREHOLE TERMINATED AT 10.0m |

**sampling**

B bulk sample
D disturbed sample (sample number in brackets)
T tube sample (sample number in brackets)
T* no recovery

**field tests**

permeability
cons=constant head
fall=falling head
rise=rising head test

SPT N VALUE
(blows per three lengths of 150 mm in brackets)
R=sample recovery

—— = Water level in borehole, and date.

**notes**

1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1 | **BOREHOLE NO: 8**

| | | | |
|---|---|---|---|
| PROJECT: PORT MORESBY SEWERAGE | DRILL METHOD:WASH BORING | DATE COMMENCED: 17-12-97 | JOB NO: J096 |
| CLIENT : TOKYO ENGINEERING | DRILL MODEL: FMC | DATE COMPLETED: 17-12-97 | LOGGED:KT |
| LOCATION : PUMP STATION 2 | HOLE SIZE: 75cm / CASING SIZE:75cm | CO-ORDINATES: | CHECKED: KT |
| SABAMA SETTLEMENT | DEPTH: 10m / DEPTH:10m | | APPROVED:KT |
| CONTRACTOR: PNG DRILLERS | | ELEVATION: DATUM: | |

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1, 2, 3, 4 | | SM | Silty Sand, light grey brown, low plasticity, fine to coarse, some gravel to 10mm. |
| | | | | Drill Core | | 5 | | | |
| | | | | CRR= 55 RQD=0 | Drilling method: PQ Coring | 6 | | | Silty-sandy gravel; pale brown to cream, with dark patches and bands, loose to medium dense, very low plasticity, moist, sub-angular to angular gravel. Gravel composed of calcareous argillite. |
| | | | | CRR=80 RQD=10 | | 7, 8 | | | Fine calcareous siltstone, (pale yellow grey, iron and manganese oxide staines on joints, some joints soil-filled to 30mm width. Very closely spaced fractures in place. |

**sampling**
- B bulk sample
- D disturbed sample (sample number in brackets)
- T tube sample (sample number in brackets)
- T* no recovery

**field tests**
- permeability
- cons=constant head
- fall=falling head
- rise=rising head test

SPT N VALUE (blows per three lengths of 150 mm in brackets)
R=sample recovery

— = Water level in borehole, and date.

**notes**
1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.
4) CRR is the Core Recovery Ratio, the percentage of core or core fragments recovered over the length of the interval drilled.
5) RQD is the Rock Quality Designation, the total length of intact core pieces as a percentage of the total core run drilled.

# SMEC ENGINEERING GEOLOGY BOREHOLE LOG

Sheet 1 of 1

**BOREHOLE NO: 9**

PROJECT: PORT MORESBY SEWERAGE
CLIENT : TOKYO ENGINEERING
LOCATION : PUMP STATION 2
SABAMA SETTLEMENT
CONTRACTOR: PNG DRILLERS

DRILL METHOD:WASH BORING
DRILL MODEL: FMC
HOLE SIZE: 75cm CASING SIZE:75cm
DEPTH: 10m DEPTH:10m

DATE COMMENCED: 17-12-97
DATE COMPLETED: 17-12-97
CO-ORDINATES:
ELEVATION: DATUM:

JOB NO: J096
LOGGED:KT
CHECKED: KT
APPROVED:KT

| Laboratory test results: % fines -75um | Atterberg limits: LL (%) | Atterberg limits: PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure. Secondary soil, components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Drill method rock roller | | | GP | Sandy gravel, angular gragments of chert, argillite Loose to dense. FILL |
| | | | | Drill core | | 1 | | | |
| | | | | CRR=55 RQD=0 | Drill method: PQ Coring | 2 | | GP | Cobbles and gravel of highly siliceous, very high strength Chert. Recovered core fragment 200mm inj length, plus broken fragments to 60mm size. FILL |
| | | | | CRR=.55 RQD=0 | | 3 4 | | | Silty sandy gravel, angular to sub-rounded fragments to 50mm size, mid brown, light coloured motties and zones FILL |
| | | | | CRR=55 RQD=0 | | 5 | | | FILL as above |
| | | | | | | | | | Top of rock 5.5m |
| | | | | | | 6 | | | Argillite: highy to extremely weathered, plae gray brown, Low to very low strength, very closely staced fractures, with soil seams to 200mm, dip at 10 deg. |
| | | | | CRR=40 RQD=0 | | 7 8 | | | Base of hole completey fragmented core. |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)
T tube sample (sample number in brackets)
T* no recovery

**field tests**
permeability
cons=constant head
fall=falling head
rise=rising head test
SPT N VALUE (blows per three lengths of 150 mm in brackets)
R=sample recovery
—— = Water level in borehole, and date

**notes**
1) Undisturbed samples advanced using SPT hammer.
2) USC = Unified soil classification
3) Material strengths assessment based on visual inspection and SPT results.
4) CRR is the Core Recovery Ratio, the percentage of core or core fragments recovered over the length of the interval drilled.
5) RQD is the Rock Quality Designation, the total length of intact core pieces as a percentage of the total core run drilled.

# Appendix 2

## Geotechnical logs of Trial Pits

# SMEC ENGINEERING GEOLOGY — TEST PIT LOG

Sheet 1 of 1 | **TEST PIT NO: 1**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT : Tokyo Engineering Consultants<br>LOCATION : Tatana | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.8m x 3m<br>DEPTH: 0.9m | DATE COMMENCED: 06/01/98<br>DATE COMPLETED: 06/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED: RG |

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION: consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | GM | Gravely SAND; loose greyish, wet, medium to low plasticity, medium to coarse sand, with coral fragments and organics. Some cobbles minor boulders.<br><br>[MANGROVE SWAMP DEPOSIT] |
| | | | | | | 0.5 | | | |
| | | | | | | | | | EOH @ 0.9M |
| | | | | | | 1 | | | |
| | | | | | | 1.5 | | | |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)

**DCP TEST**
Not done

**Remarks:**

* Test pit excavation stopped to 0.9m due to pressure and threaths from local villagers
* Bedrock slightly deeper, approxmately 5m deeper based on visual estimates from beach (tonth rock level
* No water encountered to 0.9m. However sea water appear to have seeped through this soil layer.

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1

**TEST PIT NO: 2**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT : Tokyo Engineering Consultants<br>LOCATION : Kanudi | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.8m x 3m<br>DEPTH: 0.6m | DATE COMMENCED: 06/01/98<br>DATE COMPLETED: 06/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED:<br>APPROVED: |

| Laboratory test results | | | | | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | | | GM | Silty GRAVEL; Loose, dark greyish brown, wet, low to medium plasticity, coarse angular gravel with slome clay and cobbles, minor organics trace of boulder.<br>( SLOPE WASH / BEACH DEPOSIT) |
| | | | | | | 0.5 | | | |
| | | | | | | | | | EOH @ 0.6m |
| | | | | | | 1 | | | |
| | | | | | | 1.5 | | | |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

**sampling**

B bulk sample

D disturbed sample (sample number in brackets)

**DCP TEST**

Not done

**Remarks:**

* Test pit excavation stopped to 0.6m due to pressure and threaths from landowners.
* Bedrock slightly deeper, approxmately 4 to 5m deeper from beach fronth edge levels.

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1 | **TEST PIT NO: 3**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT : Tokyo Engineering Consultants<br>LOCATION : Idubada | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.8m x 3m<br>DEPTH: 0.7m | DATE COMMENCED: 06/01/98<br>DATE COMPLETED: 06/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED:RG |

| Laboratory test results | | | | | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | | | MS | Sandy SILT; Loose to dense, greyish brown, dry, low to medium plasticity silt with some angular gravel fragments and roots, minor cobbles trace of clay.<br>[TOP SOIL] |
| | | | | | | 0.5 | | GM | Silty GRAVEL; Dense, light yellowish brown, dry, angular gravel with some sand and cobbles.<br>[COLLUVIUM]<br>Bed rock exposed in base of pit. |
| | | | | | | | | | EOH @ 0.7m |
| | | | | | | 1 | | | |
| | | | | | | 1.5 | | | |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)

**DCP TEST**
Not done due to the granular nature of the soil type.

**Remarks:**
Exposure of bed rock at base of pit (EOH).

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1

**TEST PIT NO: 4**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage | Contractor: Variform | DATE COMMENCED: 06/01/98 | JOB NO: JO96 |
| CLIENT: Tokyo Engineering Consultants | Excavation type: JCB excavator | DATE COMPLETED: 06/01/98 | LOGGED: SO |
| LOCATION: Hunuabada | PIT SIZE: 0.8m x 3m / DEPTH: 1.4m | CO-ORDINATES: | CHECKED: RG |
| | | ELEVATION: DATUM: | APPROVED:RG |

| Laboratory test results | Field test Results | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|
| | | | | CG | Gravely CLAY; Firm, dark greyish black, dry , low to medium plasticity, slightly organic clay with some silt and roots trace of cobbles. [TOP SOIL] |
| | | 0.5 | | GM | Silty GRAVEL; Dense, light yellowish brown, dry, angular gravel with some sand. [COLLUVIUM / HILLSLOPE DEPOSIT] |
| | | 1 | | | |
| | | 1.5 | | | EOH @ 1.4m |
| | | 2 | | | |
| | | 2.5 | | | |

sampling
B bulk sample
D disturbed sample (sample number in brackets)

DCP TEST (blows per 100mm)
at EOH = 7,6,9,12,13,12

Remarks:

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1

**TEST PIT NO: 5**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT : Tokyo Engineering Consultants<br>LOCATION : Paga Point | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.8m x 3m<br>DEPTH: 0.4m | DATE COMMENCED: 05/01/98<br>DATE COMPLETED: 05/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED:RG |

| Laboratory test results | | | | | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | | | MG | Gravely SILT; loose, greyish brown, dry, silt, with angular slope wash rock fragments with roots and some organics.<br><br>[SLOPE DEBRIS] |
| | | | | | | 0.5 | | | EOH on bed rock at 0.4m. |
| | | | | | | 1 | | | |
| | | | | | | 1.5 | | | |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)

**DCP TEST**
Not done as unsuitable for this site.

**Remarks:**
This was dug purposely to determine the colluvium thickness that forms the base of the slopes around this site.

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1

**TEST PIT NO: 6**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT: Tokyo Engineering Consultants<br>LOCATION: Badili | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.6m x 3m<br>DEPTH: 1.2m | DATE COMMENCED: 05/01/98<br>DATE COMPLETED: 05/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED: RG |

| Laboratory test results | | | | | Field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture, plasticity, structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | | | MG<br>CG | Gravely silty CLAY; Loose to dense, light greyish brown, dry, low to medium plasticity, slightly organic clay with some cobbles and roots.<br>[TOP SOIL] |
| | | | | | | 0.5 | | SM | Silty SAND; Loose to dense, yellowish brown, dry, coarse sand with some gravel.<br>[COLLUVIUM] |
| | | | | | | 1 | | MG<br>CG | Silty gravelly CLAY; Firm, light greyish brown, dry, low to medium plasticity clay with some angular gravel fragments minor cobbles trace of boulder (<1m).<br>[COLLUVIUM / HILLSLOPE DEPOSIT] |
| | | | | | | 1.5 | | | |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

sampling
B bulk sample
D disturbed sample (sample number in brackets)

**DCP TEST (blows per 100mm @ EOH)**
10, 12, 11, 12, 10

Remarks:

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1 | TEST PIT NO: 7

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT : Tokyo Engineering Consultants<br>LOCATION : Vabukori turn off | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.8m x 3m<br>DEPTH: 1.2m | DATE COMMENCED: 05/01/98<br>DATE COMPLETED: 05/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED RG |

| Laboratory test results | | | | | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | | | GM | Gravely SILT; loose to dense, light greyish brown, dry, low plasticity Silt with some clay, minor roots, trace of cobbles.<br>[ TOP SOIL] |
| | | | | | | 0.5 | | | SILICEOUS MUDSTONE; Strong, dark yellow, moderately weathered fragmented and interbedded with chert.<br>[PAGA BED ROCK] |
| | | | | | | 1 | | | |
| | | | | | | | | | EOH @ 1.2m<br>Terminated in rock |
| | | | | | | 1.5 | | | |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)

**DCP TEST**
Not done

Remarks:

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1 | **TEST PIT NO: 8**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage | Contractor: Variform | DATE COMMENCED: 05/01/98 | JOB NO: JO96 |
| CLIENT : Tokyo Engineering Consultants | Excavation type: JCB excavator | DATE COMPLETED: 05/01/98 | LOGGED: SO |
| LOCATION : KilaKila High School. | PIT SIZE: 0.8m x 3m / DEPTH: 1.2m | CO-ORDINATES: | CHECKED: RG |
| | | | APPROVED:RG |
| CONTRACTOR: | | ELEVATION: DATUM: | |

| Laboratory test results: % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture,plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.5 | | GM | Silty GRAVEL; Loose to dense, compacted, dry, angular to sub-rounded gravel with some angular cobbles with sand, minor organics trace of metal fragments.<br><br>[FILL ?] |
| | | | | | | 1 | | MC | Silty CLAY; Stiff to firm, dark greyish black, low to medium plasticity slightly organic clay with some sand.<br><br>[COLLUVIUM / VALLEY FLOOR DEPOSIT] |
| | | | | | | 1.5<br>2<br>2.5 | | | EOH @ 1.2m |

**sampling**
B bulk sample
D disturbed sample (sample number in brackets)

**DCP TEST (blows per 100mm at EOH)**
3,4,3,3,2,4,4,7,6,7

**Remarks:**
Compacted fill directly overlying existing soil appears to be stable.

# SMEC ENGINEERING GEOLOGY TEST PIT LOG

Sheet 1 of 1

**TEST PIT NO: 9**

| | | | |
|---|---|---|---|
| PROJECT: Port Moresby Sewerage<br>CLIENT : Tokyo Engineering Consultants<br>LOCATION : Sabama beach fronth. | Contractor: Variform<br>Excavation type: JCB excavator<br>PIT SIZE: 0.8m x 3m<br>DEPTH: 1.5m | DATE COMMENCED: 05/01/98<br>DATE COMPLETED: 05/01/98<br>CO-ORDINATES:<br>ELEVATION: DATUM: | JOB NO: JO96<br>LOGGED: SO<br>CHECKED: RG<br>APPROVED: RG |

| Laboratory test results | | | | | field tests water levels | depth (m), sampling | log | USC | SOIL DESCRIPTION consistency, color, moisture plasticity,structure/particle shape. Secondary soil components and minor soil components |
|---|---|---|---|---|---|---|---|---|---|
| % fines -75um | Atterberg limits LL (%) | Atterberg limits PI(%) | moisture (%) | other test results | | | | | |
| | | | | | | 0.5 | | SM | Silty SAND; loose to very loose, greyish brown, wet, fine to medium beach sand with organics and clay, Odour. Some gravel cobbles, trace of logs.<br><br>[MANGROVE SWAMP DEPOSIT] |
| | | | | | ▽ | 1 | | | |
| | | | | | | 1.5 | | | EOH @ 1.5m<br>Bluish fine beach sand encounted at this depth. |
| | | | | | | 2 | | | |
| | | | | | | 2.5 | | | |

**sampling**

B bulk sample

D disturbed sample (sample number in brackets)

**DCP TEST**

**Remarks:**

Test pit dug at this site to purposely locate the bed rock beneath the mangrove swamp and hence determine the soil consistency for these conditions.

Backhoe could not go in deeper do to mobility problem on this site and also presence of landowners threaths.

Water seeping at approximately 1 litres per second from sea level corner.

# Appendix 3

## Walkover Survey

Table I.3 Geotechnical Description of Sewer Pipeline Route

| SECTOR | ESTIMATED DISTANCE (m) | GENERAL DESCRIPTION OF SECTIONS INCLUDING GEOLOGY AND SOILS | PRESENCE OF FILL OR OTHER BURIED STRUCTURE | DEPTH OF SOIL/FILL OVER BEDROCK (m) | DRAINAGE / EVIDENCE OF GROUND WATER | EXCAVATION CONDITION |
|---|---|---|---|---|---|---|
| A/1 | PARI pumping station | Sandy SILT: loose yellowish white moist with traces of clay | No underground services apparent | | groundwater encountered at 3.5m | C |
| A/1-2 | 200 | Route follows existing sealed road underlain by sandy silt (beach deposit with some clay of low plasticity. | Road Base 0.5-1.0m<br>No underground services apparent<br>Telecom cables | 5 - 10m | Excellent | C |
| A/ 2 - 3 | 200 | Road base underlain by partly calcareous and siliceous argillite. | Road Base 0.5 - 1.0m<br>No underground services apparent<br>Telecom cables | 0.5 - 1.0m | Excellent | C |
| A/3 - 4 | 500 | Road base material underlain by gravelly sand, silt and some clay from the nearby mangrove swamp. | Road construction material. No underground services apparent. | 5 - 10m | Poor<br>May find ground water 1 - 2m<br>Below ground level | C |
| A/ 4 - 5 | 1500 | Almost parallel to high tide line along the beach. (mangrove swamp). | No underground services apparent | 5 - 10m | Poor<br>Will encounter ground water during high tide. | C |
| A/ 5 - 6 | 400 | Eava Street. Partly through residential areas . Will have problems relating to compensation of coconut trees etc. Ground condition is : Sandy SILT and some clay from mangrove swamp. | No underground services apparent | 5 - 10m | Poor drainage.<br>Will find ground water at 0.5-1m | C |
| A/ 6 - 7 | 360 | Along Eava Street. . Road construction material underlain by clay of medium plasticity.<br>Open unlined sewer drains on right hand side of the road. | Water pipes for domestic purposes. | 5 - 10m | Fair. | C |
| A/ 7 - 8 | 120 | Through residential areas. Will have problems relating to some form of compensation.<br>Ground condition is silty clay, dense and medium plasticity. | Water pipes for domestic purposes. | 5 - 10m | Poor. | C |
| A/ 8 | Sabama Pumping Station | Soft peaty clay of low to medium plasticity. Water table about 0.2 - 0.5m below ground level.<br>Open Unlined Sewer Drain about 5m from the drill hole. | No services within vicinity. Water pipes for domestic purposes. About 10 - 15m away. | 10m | Very Poor. | D |

NOTES: SECTOR A - ROUTE FROM PARI VILLAGE THROUGH SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR B - ROUTE FROM TAIKONE THROUGH VABUKORI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR C - ROUTE FROM BADILI TO SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR D - ROUTE FROM TATANA THROUGH HANUABADA (POREPORENA) VILLAGE TO PAGA TREATMENT PLANT

Table I.4 Geotechnical Description of Sewer Pipeline Route

| SECTOR | ESTIMATED DISTANCE (m) | GENERAL DESCRIPTION OF SECTIONS INCLUDING GEOLOGY AND SOILS | PRESENCE OF FILL OR OTHER BURIED STRUCTURE | DEPTH OF SOIL/FILL OVER BEDROCK (m) | DRAINAGE / EVIDENCE OF GROUND WATER | EXCAVATION CONDITION |
|---|---|---|---|---|---|---|
| A/ 8-9 | 240 | Along Hoge Street. Road base would be no more than 1.0m . below ground level underlain by peaty clay of low medium plasticity, black to Greyish blue. Water table 0.5m below top of road. | Water supply line for domestic purposes on the left hand side. | | | C |
| A/ 9 -10 | 500 | Part of Onno Street to Kilakila Treatment Plant. Road base material at 0.5 -1.0m below ground level. Underlain by partly calcareous and siliceous argillite. | No underground services apparent in this almost virgin track. | 1 - 2m- | Good | C |
| A/ 10 | Proposed Kilakila Treatment Plant site | Gully with extremely to moderately weathered calcareous argillite underlying clayey silt soft white low plasticity. | No underground services apparent. | 2 - 4m | Good | B/C |

NOTES: SECTOR A - ROUTE FROM PARI VILLAGE THROUGH SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR B - ROUTE FROM TAIKONE THROUGH VABUKORI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR C - ROUTE FROM BADILI TO SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR D - ROUTE FROM TATANA THROUGH HANUABADA (POREPORENA) VILLAGE TO PAGA TREATMENT PLANT

Table I.5 Geotechnical Description of Sewer Pipeline Route

| SECTOR | ESTIMATED DISTANCE (m) | GENERAL DESCRIPTION OF SECTIONS INCLUDING GEOLOGY AND SOILS | PRESENCE OF FILL OR OTHER BURIED STRUCTURE | DEPTH OF SOIL/FILL OVER BEDROCK (m) | DRAINAGE / EVIDENCE OF GROUND WATER | EXCAVATION CONDITION |
|---|---|---|---|---|---|---|
| B1 | Taikone Pumping Station | Beach Sand: Silty dark , dark Greyish to pinkish fine. Underlain by Extremely to moderate partly calcareous and siliceous argillite. | No underground services apparent. | 10m | No ground water Level depend-ent on tide. | C |
| B/1-2 | 400m | Road base from 0.5-1.0m below ground level. Beach Sand : Silty, dark, Greyish to pinkish fine | No underground services apparent. | 2-5m | ground water. at 2-3m | C |
| B/2-3 | 200m | Road base material from 0.5-1.0m below ground level. Extreme to moderately siliceous argillite. | No underground services apparent. | | | C |
| B/3-4 | 400m | Road base, from 0.5 - 1.0m below ground level. Extreme to moderately weathered siliceous argillite. | Along foreshore. Extremely to moderately weathered calcareous argillite. | 10m | | C |
| B/3- A/10 | 1500 | Along coastline. Extremely to moderately weathered calcareous argillite. There would be possible problems of getting earth moving equipment to this section. Possible alternative such as above ground should be considered. | No underground services. | 0.5 -1m | | B/A |

NOTES: SECTOR A - ROUTE FROM PARI VILLAGE THROUGH SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR B - ROUTE FROM TAIKONE THROUGH VABUKORI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR C - ROUTE FROM BADILI TO SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR D - ROUTE FROM TATANA THROUGH HANUABADA (POREPORENA) VILLAGE TO PAGA TREATMENT PLANT

Table I.6 Geotechnical Description of Sewer Pipeline Route

| SECTOR | ESTIMATED DISTANCE (m) | GENERAL DESCRIPTION OF SECTIONS INCLUDING GEOLOGY AND SOILS | PRESENCE OF FILL OR OTHER BURIED STRUCTURE | DEPTH OF SOIL/FILL OVER BEDROCK (m) | DRAINAGE / EVIDENCE OF GROUND WATER | EXCAVATION CONDITION |
|---|---|---|---|---|---|---|
| C/1 | Badili Pumping Station | Existing Pump Station. | | | | |
| C/1-2 | 1700m | Along Hides Road, Pascal and 800m on Scratchley road from Pascal Junction. Sealed Road, 0.5 - 1.0m of road base. Underlain by extremely to moderately weathered deep gravel, sand silt beach deposits. | Likely to find Electrical, Telikom, Stormwater, sewerage and water supply Lines. | 10m | Excellent | C |
| C/2 - 3 | 1840 | Part of Scratchley Road and Sea bed Road. Road base underlain: clayey sand and silt, white to yellow and medium to low plasticity. Stiff to very stiff. | Likely to find Electrical, Telikom, Storm-water, Sewerage and Water Supply Lines. | 2 -10m | Excellent. | B/C |
| C/3-A8 | 150 | Part of Seabed Road to Eava Street. Road base underlain by soft peaty clay | Likely to find Telikom Lines and Water Pipes. | 10m | Poor. | C |

NOTES:
SECTOR A - ROUTE FROM PARI VILLAGE THROUGH SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR B - ROUTE FROM TAIKONE THROUGH VABUKORI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR C - ROUTE FROM BADILI TO SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR D - ROUTE FROM TATANA THROUGH HANUABADA (POREPORENA) VILLAGE TO PAGA TREATMENT PLANT

Table I.7 Geotechnical Description of Sewer Pipeline Route

| SECTOR | ESTIMATED DISTANCE (m) | GENERAL DESCRIPTION OF SECTIONS INCLUDING GEOLOGY AND SOILS | PRESENCE OF FILL OR OTHER BURIED STRUCTURE | DEPTH OF SOIL/FILL OVER BEDROCK (m) | DRAINAGE / EVIDENCE OF GROUND WATER | EXCAVATION CONDITION |
|---|---|---|---|---|---|---|
| D/1 - 2 | 300 | Through Tatana Village : Clayey silt, soft to stiff, white to orange moist, medium | | 0.5-1.0m | Good. | B/C |
| | | to low plasticity with some white sand. | | | | |
| D/2 - 3 | 800m | Causeway:FILL: Gravelly sand: apparently well compacted white to orange, | Boulders up to 2.0m maybe encountered | 0.2 - 1.0m | Excellent. | B/C |
| | | low plasticicty some clay. Underlain by boulders, car wrecks up to 2.0m. | | | | |
| | | Tatana Junction to Idubada Pump station. | | 0.2 - 1.0m | Excellent. | |
| D/3-4 | 2000 | Beach Front: FILL; along the Baruni road | Likely to cross fuel, water, sewer, Telikom | 2- 10m | | C |
| | | Sealed Road: Top 0.5 - 1.0m Road base. Granular fill gravelly sand. | and maybe electrical lines | | | |
| | | Apparently well compacted, orange,yellowish white. Some boulders up to 1.5m | | | Poor. | |
| | | in diameter. There magrove swamps along the coastline and possibility of | | | | |
| | | encountering swamp deposits at .5m at places. | | | | |
| D4 | Idubada | Fill: apparently well compacted , gravelly sand with boulders | fuel line is obviously close by. | 10 | N/A | C |
| | Pump Station | | | | | |
| D/4-5 | 200 | Along shoreline. Remnants (anchor blocks) of an existing line evident. | | | | C |
| | | Exposed siliceous argillite extremely to moderately weathered. | | | | |
| | | Defined structure, bedding in rock dipping away from the shore line | | 0 | N/A | |
| D/5-6 | | Lower Hanuabada route; traverses through Poreporena Village | Likely to cross water and Telikom lines | 1-10m | good | |
| | | SANDY silt: dense to very dense, yellowish white with some clay | | | | |
| D/5-6 | | Upper Hanuabada: traverse along the Baruni Road. | Likely to cross water and Telikom lines. | 1- 10m | good | C |
| | | Road base: apparently well compacted gravelly sand, yellowish white, | | | | |
| | | low to medium plasticity. With some clay Underlain by Siliceous Argillite. | | | | |
| D/6-7 | | Hanuabada Village to Paga Pumping station. | Very high possibility of crossing fuel, | 1-10m | good | C |
| | | Road Base: Apparently well compacted gravelly sand, yellowish white. | water, electrical, Telikom and sewer line. | | | |
| | | low to medium plasticity with some clay. Underlain by Siliceous Argillite. | | | | |

CLASSIFICATION OF MATERIAL TYPE

TYPE A- REQUIRE DRILLING AND BLASTING
TYPE B - REQUIRE RIPPING WITH A TRACTOR UNIT WEIGHT OF 16 TONNES AND A FLYWHEEL HORSEPOWER OF 180 HPOR METRIC EQUIVALENT
TYPE C - FREE DIG

NOTES:
SECTOR A - ROUTE FROM PARI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR B - ROUTE FROM TAIKONE THROUGH VABUKORI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR C - ROUTE FROM BADILI TO SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR D - ROUTE FROM TATANA THROUGH HANUABADA (POREPORENA) VILLAGE TO PAGA TREATMENT PLANT

CLASSIFICATION OF MATERIAL TYPE

Table I.8 Geotechnical Description of Sewer Pipeline Route

| SECTOR | ESTIMATED DISTANCE (m) | GENERAL DESCRIPTION OF SECTIONS INCLUDING GEOLOGY AND SOILS | PRESENCE OF FILL OR OTHER BURIED STRUCTURE | DEPTH OF SOIL/FILL OVER BEDROCK (m) | DRAINAGE / EVIDENCE OF GROUND WATER | EXCAVATION CONDITION |
|---|---|---|---|---|---|---|
| B/1 | Taikone | Beach Sand Silty, dark, Greyish to pinkish fine. Underlain by most at 10m. | No underground services apparent. | 10m | No ground water | |
| | Pumping | | | | Level dependent | |
| | Station | | | | on tide. | |
| | | | | | | |
| B/1-2 | 400m | Road base from 0.5-1.0m below ground level. Beach Sand : Silty, dark, Greyish | No underground services apparent. | | Maybe a | |
| | | to pinkish fine | | | possibility of | |
| | | | | | ground water. | |
| B/2-3 | 200m | Road base material from 0.5-1.0m below ground level. Extreme to moderately | No underground services apparent. | | | |
| | | siliceous argillite. | | | | |
| | | | | | | |
| B/3-4 | 400m | Road base, from 0.5 - 1.0m below ground level. Extreme to | Along foreshore. Extremely to moderately weathered calcareous argillite. | No underground services apparent. | | |
| | | moderately weathered siliceous argillite. | | | | |
| B/3- A/10 | | Along foreshore. Extremely to moderately weathered calcareous argillite. | No underground services apparent. | | | |

NOTES: SECTOR A - ROUTE FROM PARI VILLAGE THROUGH SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR B - ROUTE FROM TAIKONE THROUGH VABUKORI VILLAGE TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR C - ROUTE FROM BADILI TO SABAMA TO PROPOSED KILAKILA TREATMENT PLANT
SECTOR D - ROUTE FROM TATANA THROUGH HANUABADA (POREPORENA) VILLAGE TO PAGA TREATMENT PLANT

## I.2 Ocean Outfall Pipe Survey

## 1. EXECUTIVE SUMMARY

This report summarizes the combines results of in-shore and marine survey work, plus the limited soil investigations that have been carried out to determine a route for the proposed Vabukori sewerage outfall pipeline.

Further analysis of the results obtained is necessary to determine the most suitable route to traverse the steep hillside shoreline area and the fringing coral reef. From 1,000m to 3,000m from shore the increasing water depth and 2 to 3m sediment thickness should assist with placement of the pipeline, however the final route will be dependent upon the pipeline flexibility.

## 2. INTRODUCTION

C&D received an invitation to submit a quotation for the sewerage outfall survey and ground investigation portions of the project on 08 October 1997, followed by further clarification of specific project details on 14 October 1997.

The extent of survey work indicated in the Specification included with the invitation was for a 40m wide corridor of the following anticipated lengths:

| SECTION | ELEVATION(m) | DISTANCE(m) |
|---|---|---|
| Land + Seashore | +2 to 0 | 200 |
| Coral Reef | 0 to -5 | 1,000 |
| Reef Edge to Ocean Bed | -5 to -30 | 100 |
| Ocean Bed | below -30 | 2,000 |

A submission was forwarded 20 October 1997 based on the above scope of work.

Following receipt of the order to proceed and subsequent inspection of the site, the investigation work was carried out in two distinct portions, namely;

- that which could be carried out using normal land based methods and equipment, and
- the work that required specialised marine survey methods.

This report covers the general results of both of the above operations, which are presented using the same survey control datum so that the data can be directly compared.

## 3. LAND AND IN-SHORE SURVEY

Survey work was carried out during the last week in December 1997 and early January 1998.

Permanent survey marks, consisting of a length of galvanised steel pipe securely concreted into the ground, were installed at each of the control points shown on the drawings between the proposed treatment plant site and Station 7, from where the pipeline deviates seaward. The survey marks were linked to nearby permanent trig stations so that they could be available in the future for use during further investigations

and construction. Coordinate data for these points is contained in the Digital Terrain Model computer file included with this report.

Land based work was carried out by a surveyor plus two chainmen using Total Station survey and data recording equipment. Inshore work, where a series of sightings were taken to points parallel with the shoreline, involved an additional two man boat crew.

A 900m long corridor was actually surveyed around the steep shale rock face that exists from the proposed treatment plant site to Station 7. Due to the steepness of the terrain, this resulted in levels along this section actually ranging from +30 to –2m.

Spot levels were taken along the seaward outfall line corridor for a distance of approximately 750m south, or seaward, of Station 7. This allowed a good overlap with the marine survey investigations for checking the correlation of results.

The resulting DTM survey plot is shown on Steros Pty Ltd Drawing Nos. 7057A and 7057B, and the included electronic file.

## 4. MARINE SURVEY

The marine portion of the outfall is proposed to be within a 40m wide straight-line route from Station 7 on the shore to the nominated end point.

A specialist marine survey firm was engaged for this work, Mapping and Hydrographic Surveys Pty Ltd from Brisbane, Australia (MHS). Following mobilization the site work was carried out during the period 15 to 23 December 1997.

Due to the prevailing tides, boat draft and submerged reef levels, the hydrographic survey equipment was unable to approach to a distance of less than 400m from shore, however it is considered that this still provided an adequate overlap with the land based in-shore survey.

The hydrographic survey extended to an ocean floor depth of –36m at a distance of 3,000m from shore.

Upon completion of the marine survey, the equipment was demobilized and the data was relayed to the M&HS Brisbane office for interpretation. A marker bouy was also firmly anchored to the sea bed at the end of the surveyed section.

The resulting MHS report, drawings and electronic data files are included with this report.

## 5. SOIL INVESTIGATIONS

A barge was not available in Port Moresby for geotechnical driling/sampling at the time of the investigations, nor was it possible to arrange hire of drilling equipment in the limited time available.

Alternatively two (2) soil samples were taken in-shore, plus a total of twelve (12) seabed grab samples along the marine section.

A. IN-SHORE

As shown by the survey drawings and the site photographs, the shoreline from the proposed treatment plant to in-shore Station 7 in bounded by a steep hillside face, with shale rock outcrops. A Cat 219 excavator was used to dig test pits and take soil samples at the base of the hillside along the shoreline.

Sample No.1 was taken 20m south of Station 7. The trial pit was excavated to a depth of 1m where a hard coral base was encountered. The soil sample obtained has been classified as fine to coarse SAND.

Sample No.2 was taken at a point along the shore approximately midway between the proposed treatment plant site and Station 7. In this case a hard rock/coral base was encountered at a depth of 1.5m. The soil sample obtained has been classified as silty sandy GRAVEL.

A copy of the laboratory material type classification and description for both samples is included on the next page.

B. MARINE

During the hydrographic survey a series of seabed grab samples were taken within the route corridor. The locations of these samples is marked on the marine survey drawings. The approximate locations where samples were taken is as listed below.

| Grab Point | Approx. Distance from In-Shore Station 7 (m) |
|---|---|
| 1 | 2,755 |
| 2 | 2,615 |
| 3 | 2,495 |
| 4 | 2,325 |
| 5 | 2,195 |
| 6 | 1,995 |
| 7 | 1,885 |
| 8 | 1,715 |
| 9 | 1,575 |
| 10 | 1,435 |
| 11 | 1,155 |
| 12 | 985 |

5. continued

In all cases the material recovered was light grey silty sand, with varying amounts of coral and shell material, correlating with the geological interpretation of sea floor reflector results in the MHS report. The interpreted seismic results suggest that this material is 2 to 3m thick.

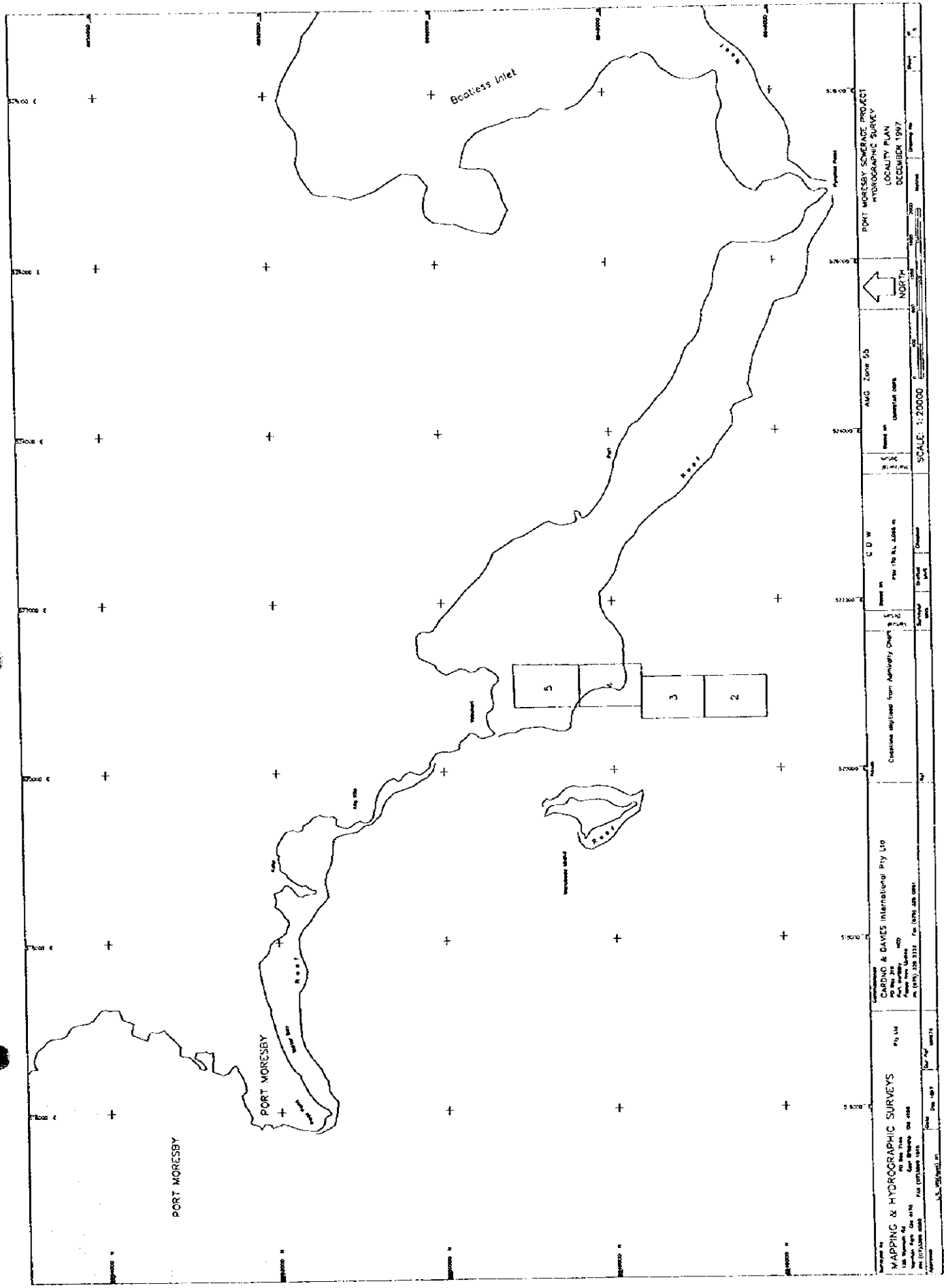
Section 6.0 of the MHS report also includes a recommendation for further marine seismic refraction profiling and drilling to obtain sub-bottom information below the fine grained sediments, should this be considered necessary.

6. ROUTE INVESTIGATION FINDINGS

From the proposed treatment plant location to Station 7 the terrain is steep and rocky, and the soil investigation test pits indicate that hard rock and coral is present close to the surface along the shoreline.
In order to locate the pipeline so as to minimize exposure to the elements and to possible vandalism, it may be necessary to further investigate the most suitable and cost-effective route over this 900m length.

The longitudinal profile plot on the next page combines the results of the in-shore and marine survey results along the straight line from Station 7 to the end point. Soil investigation results suggest that the thickness of sediment for a distance of 1,000m from Station 7 would be in the order of 1m, and that from 1,000m to 3,000m the sediment thickness would be 2 to 3m

Further detailed examination of the survey data obtained is necessary to determine the most suitable pipeline alignment.


Boatless Inlet
PORT MORESBY
PORT MORESBY
PORT MORESBY SEWERAGE PROJECT
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LOCALITY PLAN
DECEMBER 1997
NORTH
AMG Zone 55
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C D W
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CARDNO & DAVIES International Pty Ltd
MAPPING & HYDROGRAPHIC SURVEYS
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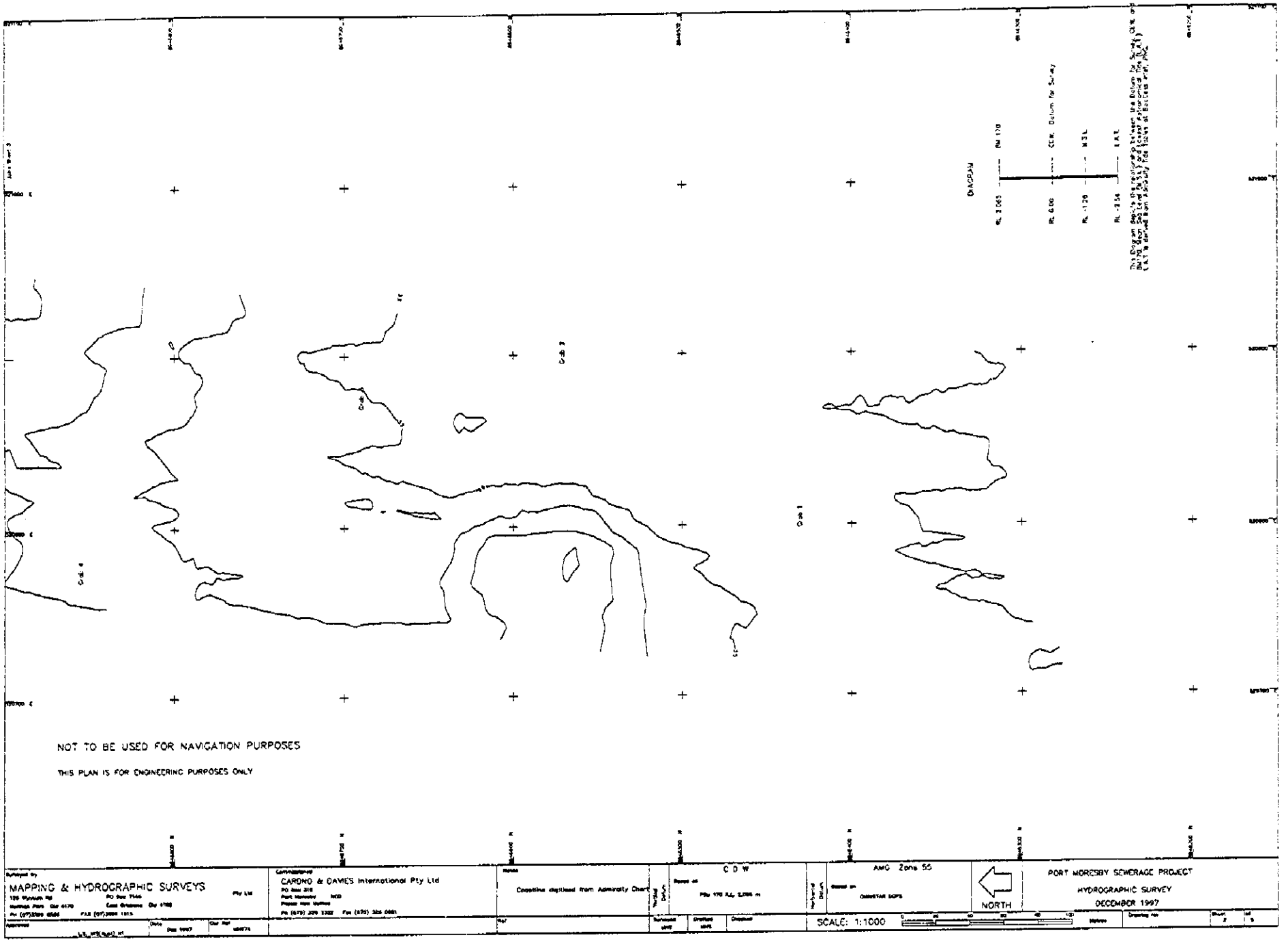
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NOT TO BE USED FOR NAVIGATION PURPOSES
THIS PLAN IS FOR ENGINEERING PURPOSES ONLY
MAPPING & HYDROGRAPHIC SURVEYS
CARONO & DAVIES International Pty Ltd
Coastline digitised from Admiralty Chart
C D W
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NORTH
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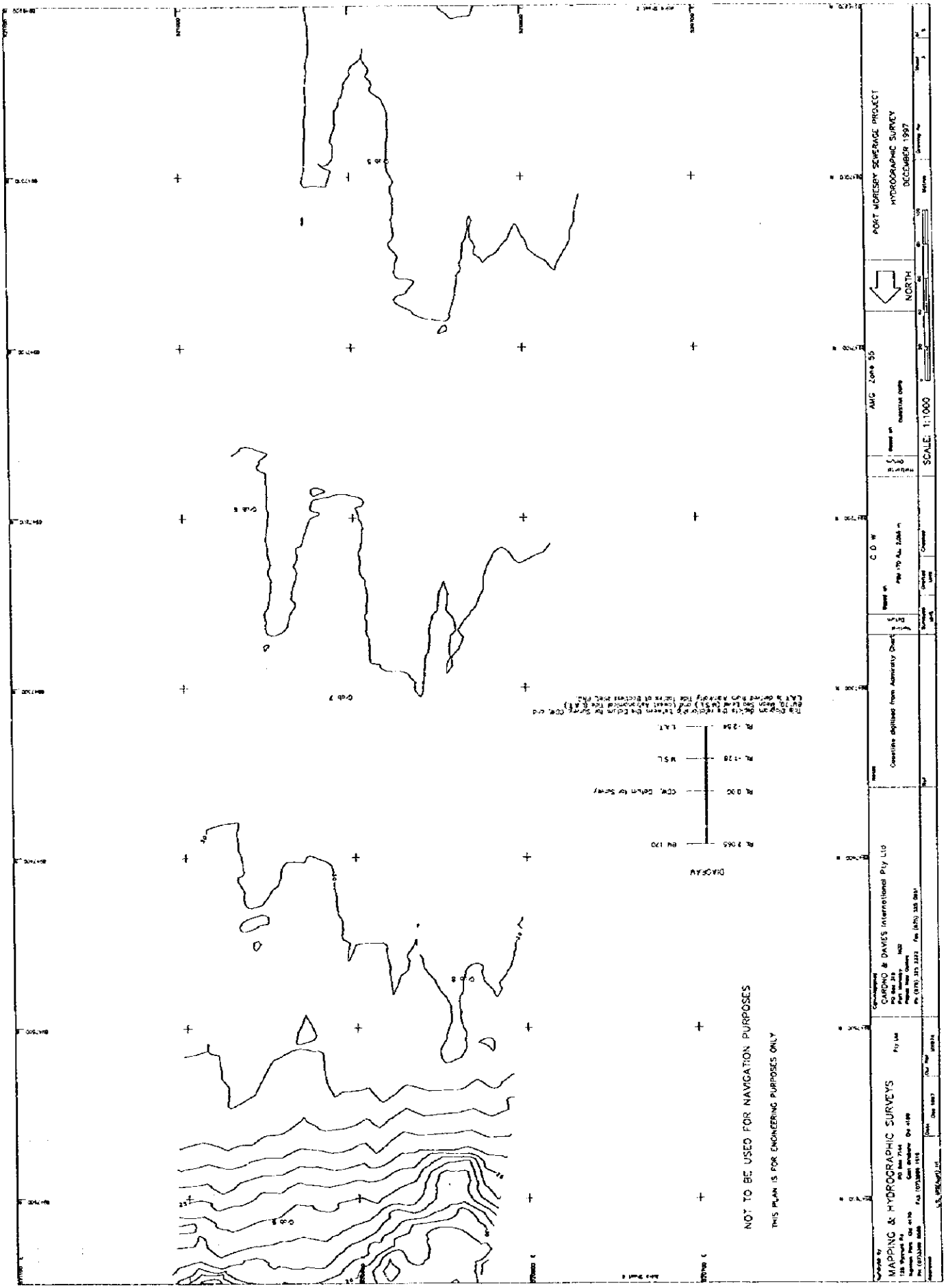
PORT MORESBY SEWERAGE PROJECT
HYDROGRAPHIC SURVEY
DECEMBER 1997
NORTH
AMG Zone 55
SCALE 1:1000
C O W
Coastline digitised from Admiralty Chart
CARONO & DAVIES International Pty Ltd
MAPPING & HYDROGRAPHIC SURVEYS
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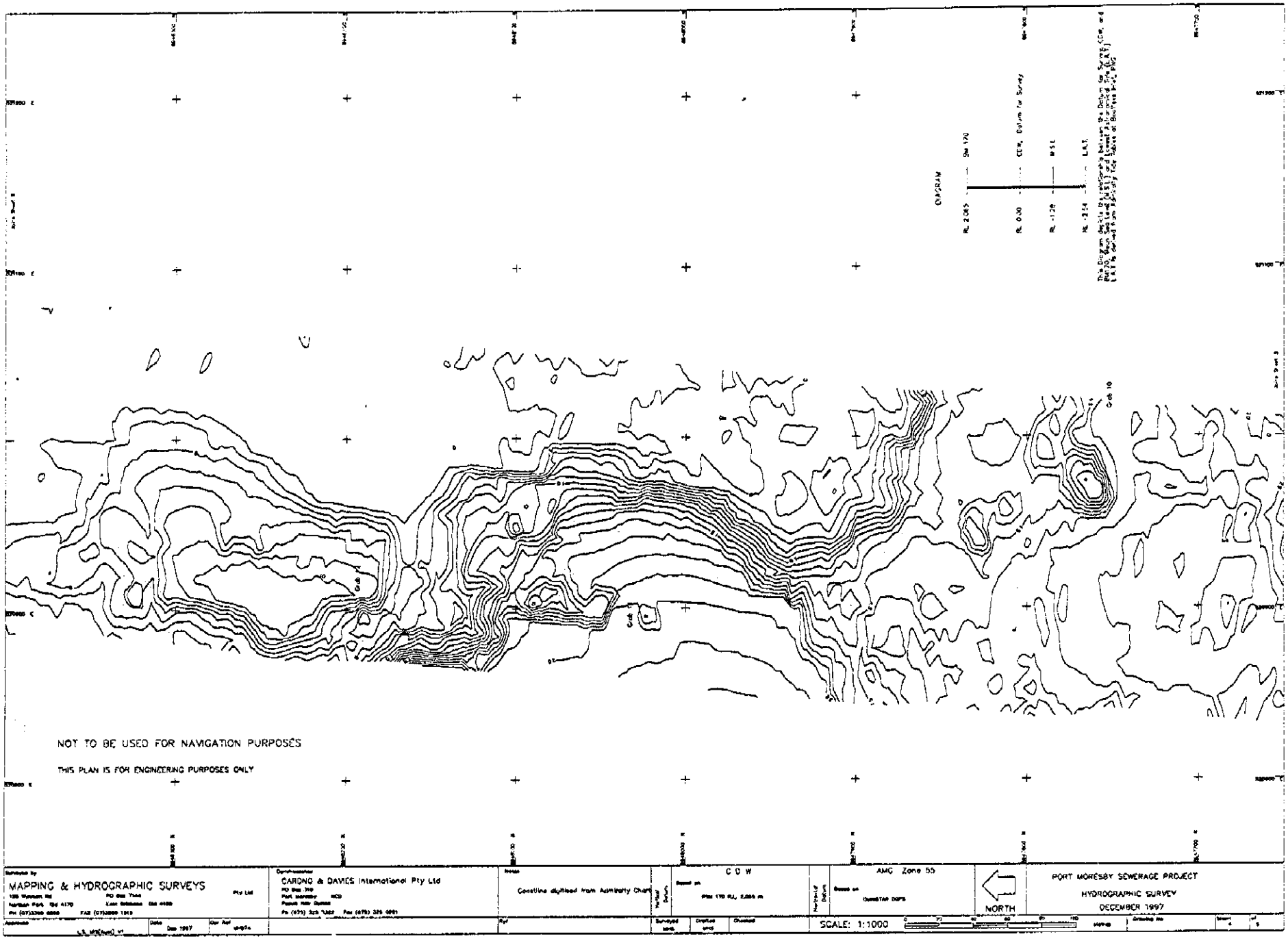
NOT TO BE USED FOR NAVIGATION PURPOSES
THIS PLAN IS FOR ENGINEERING PURPOSES ONLY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THIS PLAN IS FOR ENGINEERING PURPOSES ONLY
MAPPING & HYDROGRAPHIC SURVEYS
CARDNO & DAVIES International Pty Ltd
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C D W
AMG Zone 55
NORTH
PORT MORESBY SEWERAGE PROJECT
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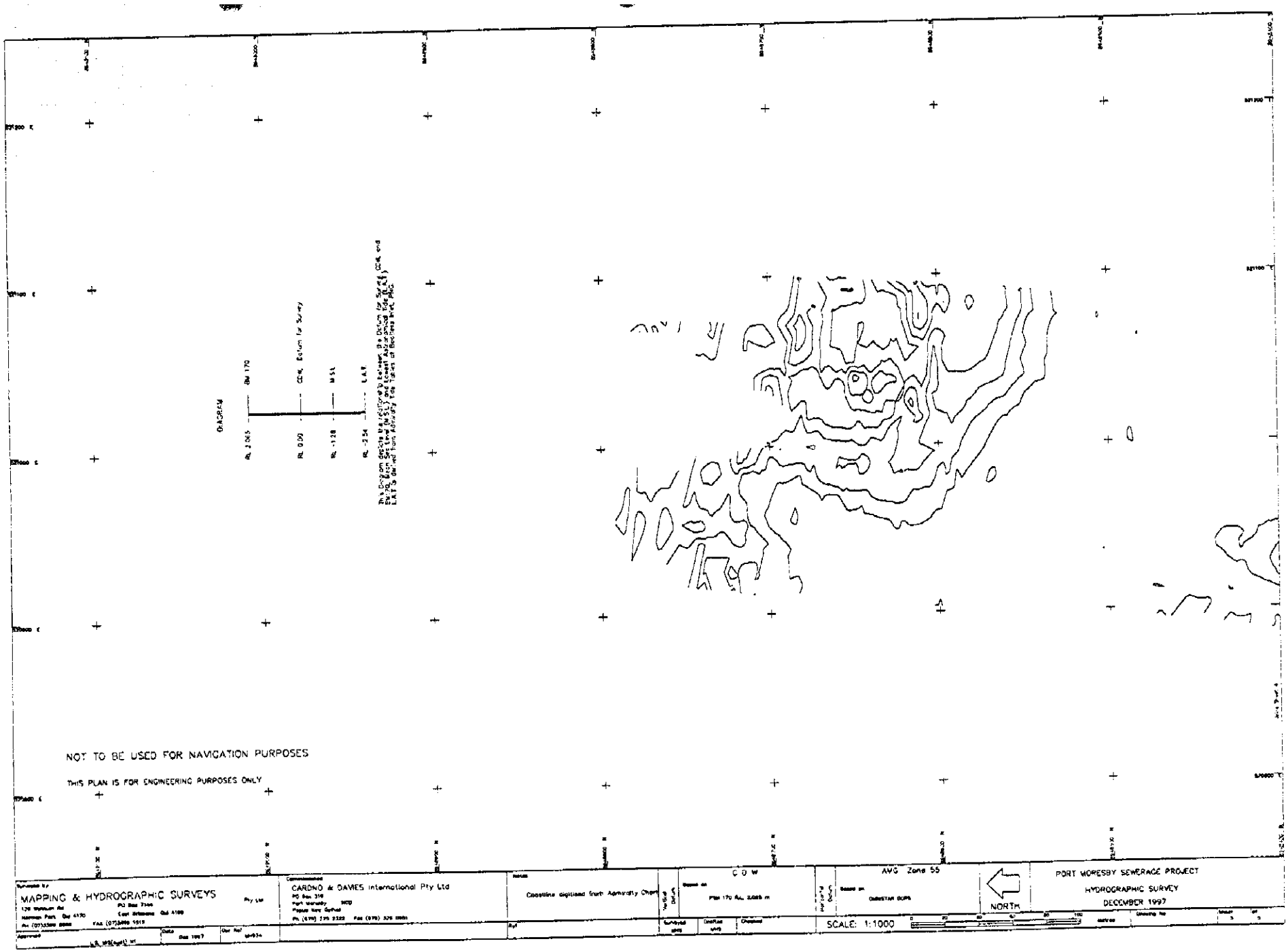
DAUGRUM
BM 170
CDK. Datum for Survey
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This Diagram depicts the relationship between the Datum for Survey (CDK and Datum Set Level (M.S.L.) and Lowest Astronomical Tide (L.A.T.) as derived from Admiralty Tide Tables for Port Moresby.
NOT TO BE USED FOR NAVIGATION PURPOSES
THIS PLAN IS FOR ENGINEERING PURPOSES ONLY
MAPPING & HYDROGRAPHIC SURVEYS
CARDNO & DAVIES International Pty Ltd
Coastline digitised from Admiralty Chart
AMG Zone 55
NORTH
PORT MORESBY SEWERAGE PROJECT
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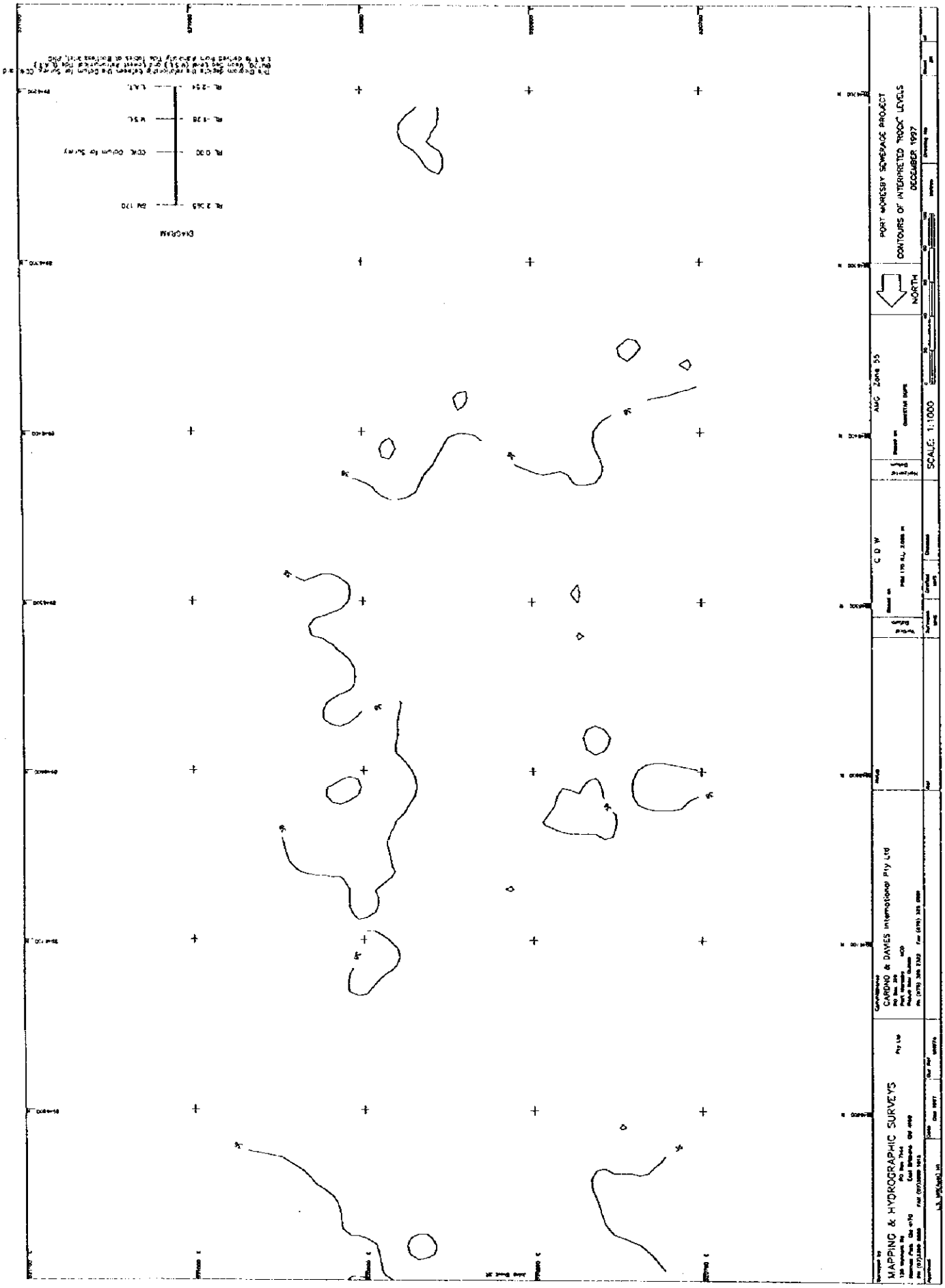
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CONTOURS OF INTERPRETED 'ROCK' LEVELS
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SCALE: 1:1000
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CARDNO & DAVIES International Pty Ltd
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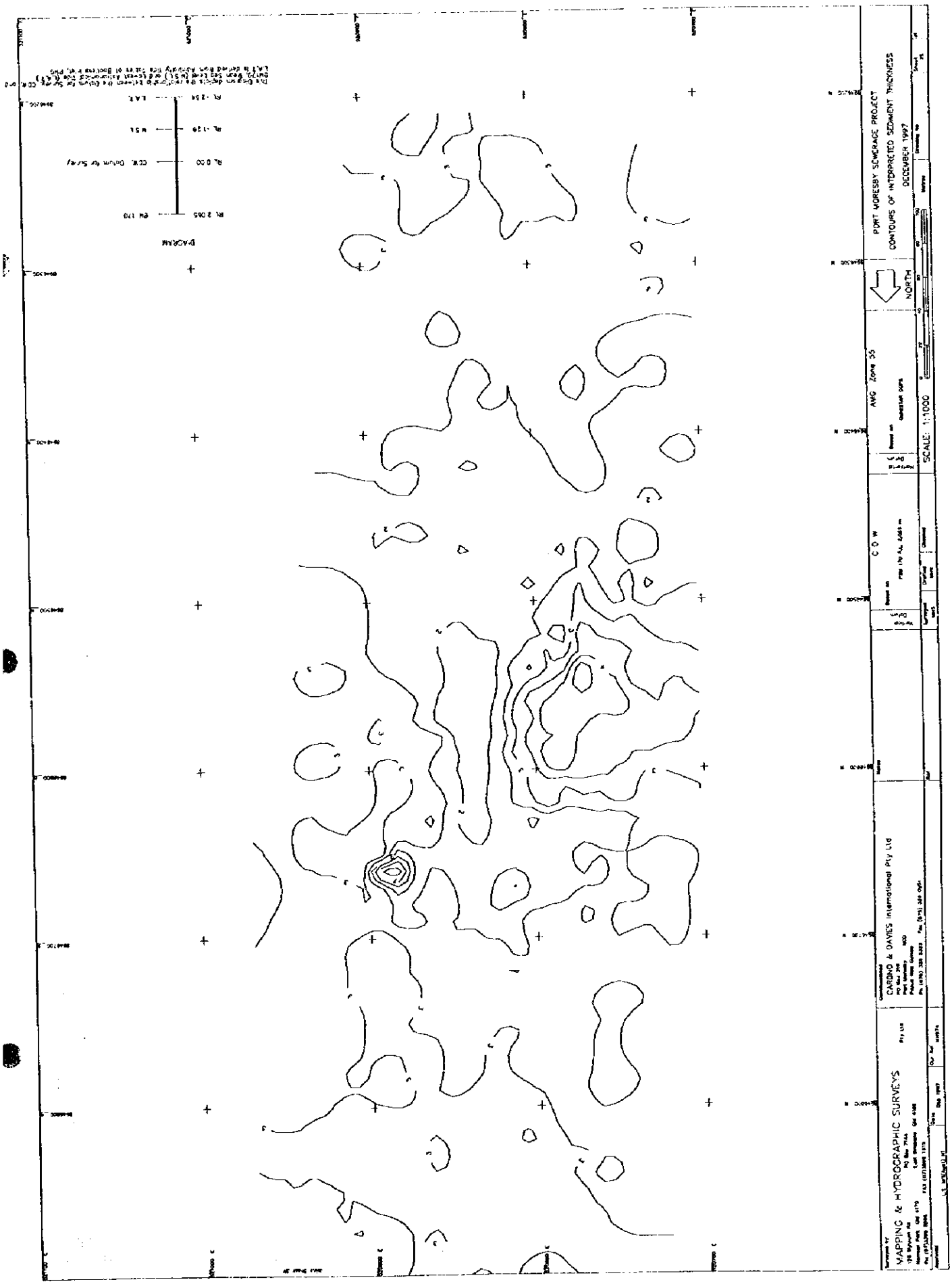
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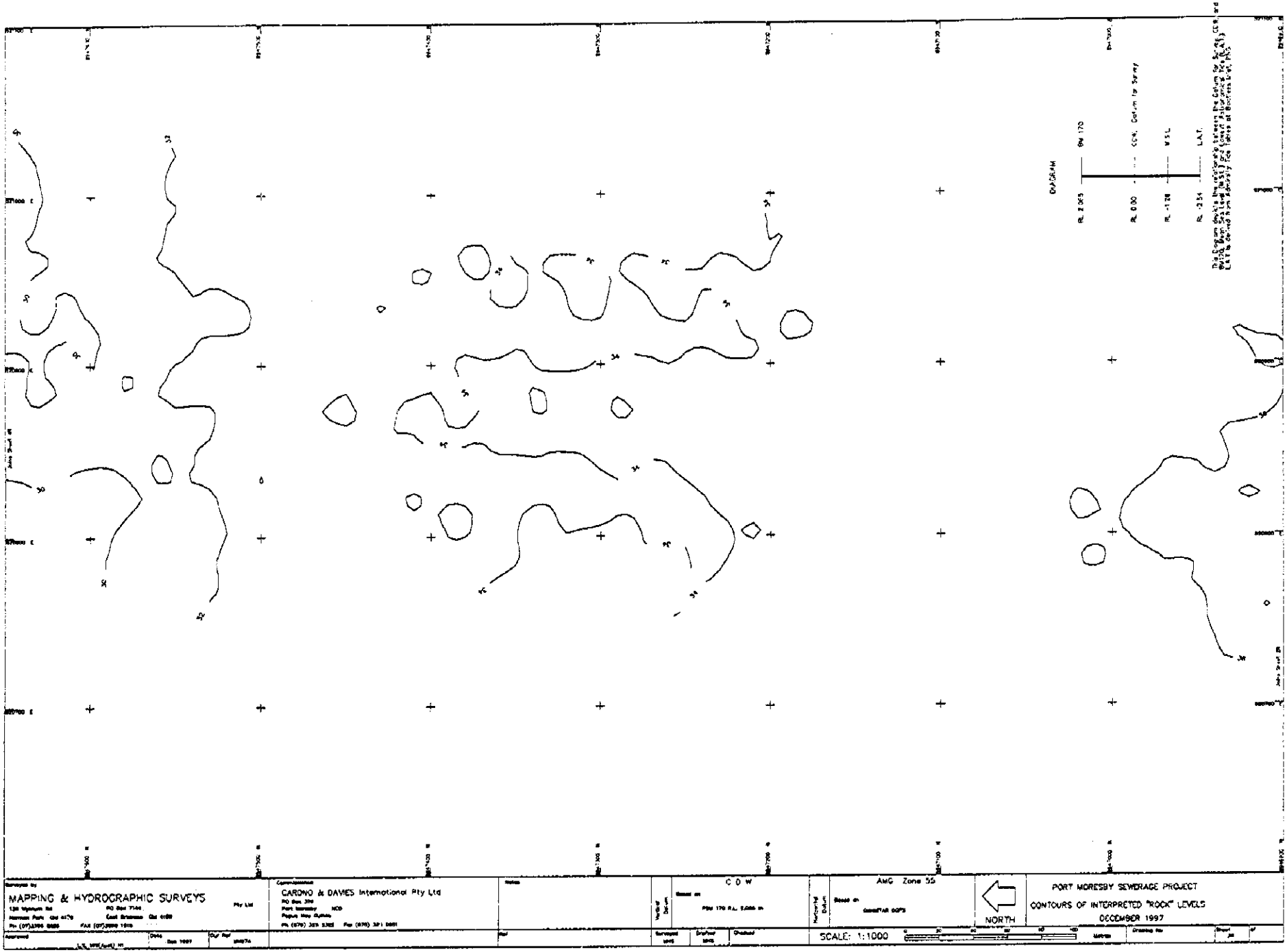
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AMG Zone 55
NORTH
PORT MORESBY SEWERAGE PROJECT
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DECEMBER 1997
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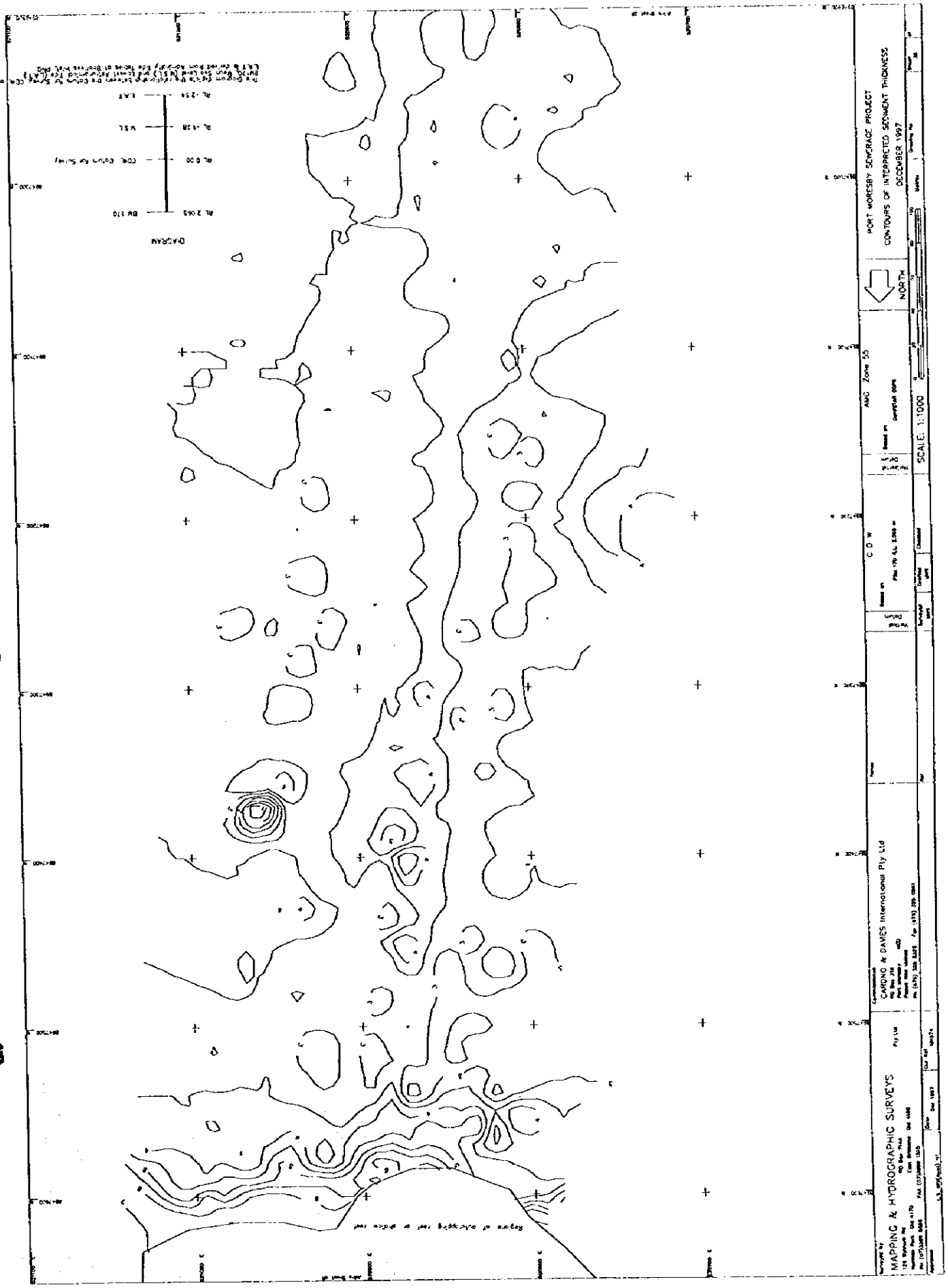
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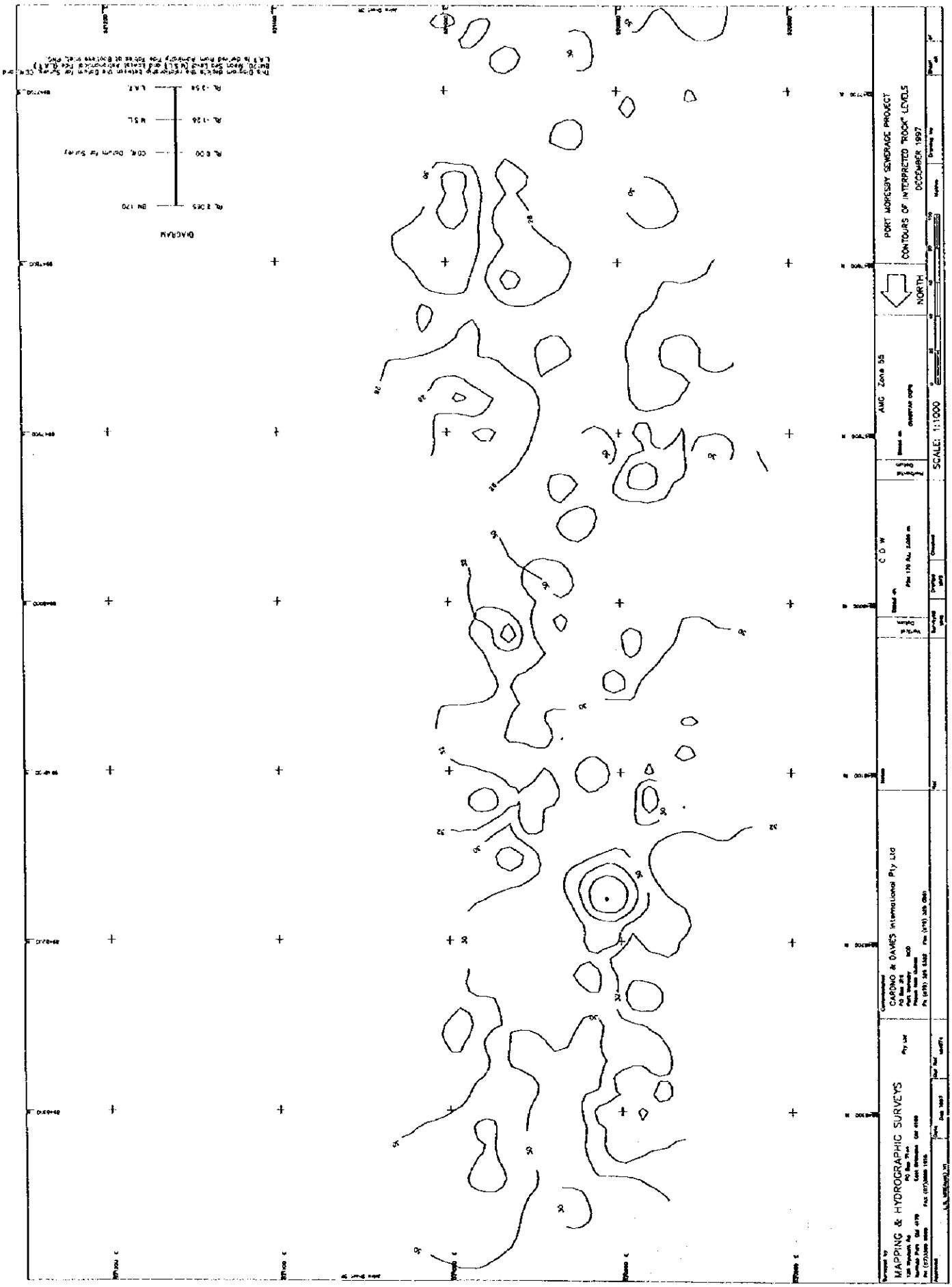
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CONTOURS OF INTERPRETED "ROCK" LEVELS
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MAPPING & HYDROGRAPHIC SURVEYS
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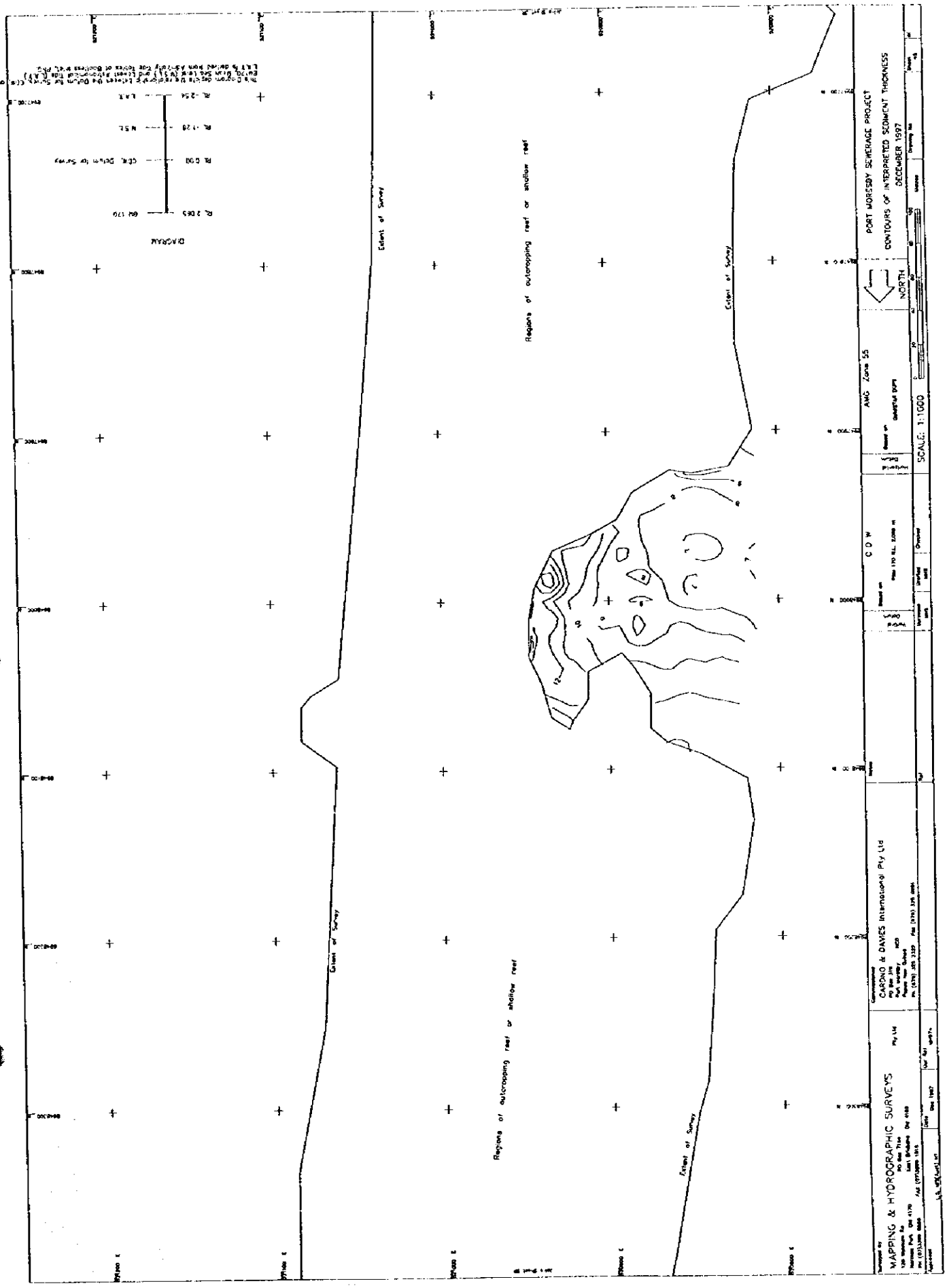
Extent of Survey
Regions of outcropping reef or shallow reef
Extent of Survey
Regions of outcropping reef or shallow reef
Extent of Survey
Extent of Survey
DIAGRAM
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CONTOURS OF INTERPRETED SEDIMENT THICKNESS
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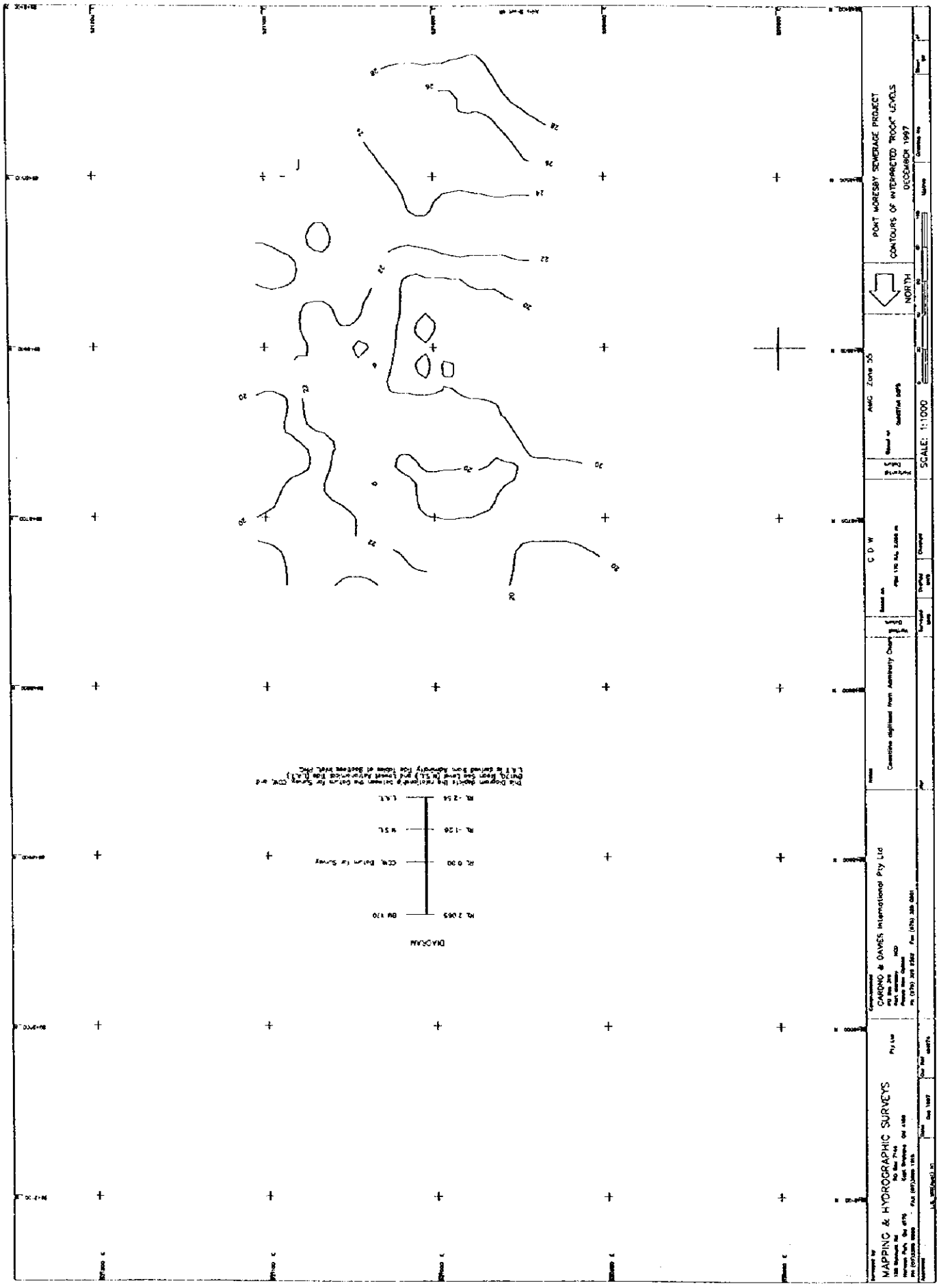
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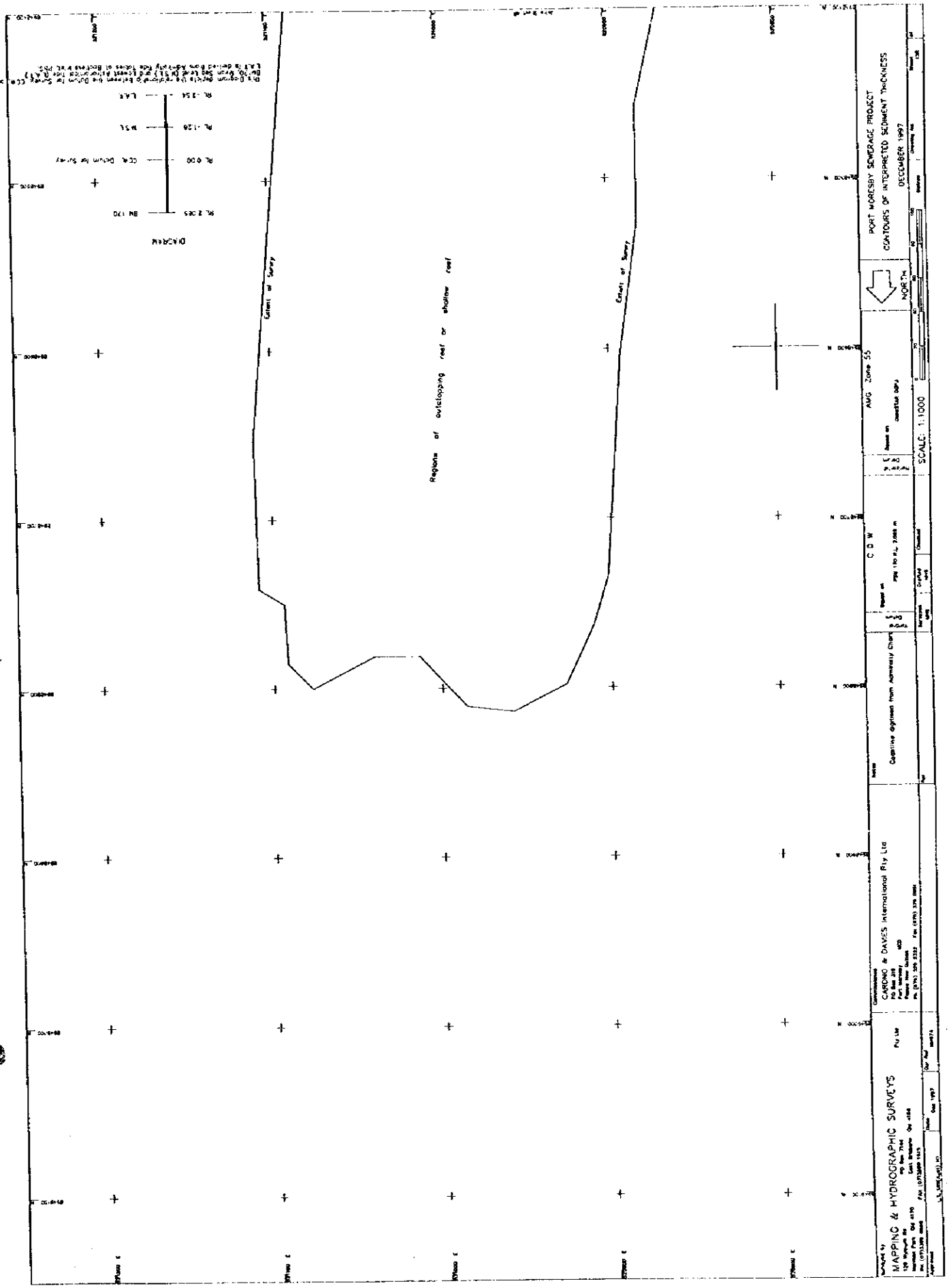
Extent of Survey
Regions of overlapping reef or shallow reef
Extent of Survey
DIAGRAM
PORT MORESBY SEWERAGE PROJECT
CONTOURS OF INTERPRETED SEDIMENT THICKNESS
DECEMBER 1997
NORTH
AMG Zone 55
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Digitised from Admiralty Chart
CARONO & DAVIES International Pty Ltd
MAPPING & HYDROGRAPHIC SURVEYS

JICA