LINTIN GEOTECHNICAL PTY LTD

GEOTECHNICAL SITE INVESTIGATION REPORT

PROPOSED AQUACULTURE PROJECT
SUNTAY AQUACULTURE PTY LTD
BYNOE HARBOUR, NT

LINTIN Geotechnical Pty Ltd
1/10 Butler Place
Berrimah, NT 0828

Telephone. 08 89324022

October 2002

TABLE OF CONTENTS

LIST OF TABLES

FIGURES

APPENDICES

GEOTECHNICAL SITE INVESTIGATION REPORT
PROPOSED AQUACULTURE SCHEME
SUNTAY AQUACULTURE PTY LTD
BYNOE HARBOUR, NT.

1.0 INTRODUCTION

This report presents the findings of a geotechnical site investigation conducted for a proposed Aquaculture Project consisting of an aquaculture pond and a fresh water storage dam. These structures are to be constructed using the materials available on site and are to be lined with an impermeable geomembrane. The geotechnical properties of the aquaculture pond and two alternative dam sites were investigated (Dams A and B). The investigation was conducted at the request of Mr Michael McElwee, Resident Director, Suntay Aquaculture Pty Ltd as per LINTIN's proposal of 21 September 2002. The site is located approximately 5km south of Point Ceylon, Bynoe Harbour, Northern Territory (See Figure 1).

2.0 PURPOSE AND SCOPE

The primary objective of this investigation is to determine the geotechnical properties of two dam sites and the aquaculture pond. This to include recommendations for construction of the dam wall and storage reservoir for the two dam sites and excavation and construction of the aquaculture pond. The findings of the investigation are reported separately for Dam site A, Dam site B and the Aquaculture pond.

In order to accomplish the above the following scope of work was conducted:

1. A desk study was conducted using aerial photographs and a geological Report and map of the area (NT, Geological Survey, BYNOE 5072).

2. The locations of 15 test pits were located in the field using a portable Global Positioning System (GPS) receiver.

3. Subsurface conditions were explored by drilling, sampling and logging a total of fifteen (15) test pits to depths ranging from 1.3m to 5m.

4. Representative soil samples were taken for laboratory testing.

5. The ground at the boreholes was reinstated as close as possible to its original condition.

6. Engineering analysis of the acquired field data has been carried out. A report outlining our findings, conclusions and recommendations has been completed.

3.0 FIELD EXPLORATION AND LABORATORY WORK

The field investigation was conducted from September 27 to 29, 2002. All available surface exposure was examined by walking or driving along all roads, footpaths and dry riverbeds. The subsurface investigation was conducted by visually describing and estimating the engineering properties of fifteen (15) test pits which were excavated using a Ferminco 760 excavator with a 600mm wide bucket. A member of our field staff who assisted in positioning the test pits and described the geological conditions in each test pit supervised the field investigation. Soil profiles were recorded at the sites shown on Figure 2 and the logs are presented graphically in Appendix A. The soils have been classified in accordance with the Unified Soil Classification System. Representative bulk soil samples were tested for grain size distribution and Atterberg Limit testing (8 samples), California Bearing Ratio (CBR) testing (3 samples), compaction testing (3 samples) and dispersion testing (2 samples). The results are of the laboratory testing are attached as Appendix B and the results are presented in the following sections.

All holes were backfilled following completion of the field work.

4.0 REGIONAL GEOLOGY

The Welltree Metamorphics, Finnis River Group that consists of a range of rock types including shale, siltstone and phillite, underlies the site. Local intrusions of Two Sisters Granite, consisting of granite, granodiorite and pegmatite also underlie the area. The soil types encountered during the investigation are described separately below.

5.0 AQUACULTURE POND

5.1 Surface Conditions

The site is bordered by the gravel access road to the East and the floodplain of Wheatly Creek to the West. The site is currently disused and is covered with woodland vegetation. The topography forms an elongate ridge ranging in height from 5 to 22m above sea level. A number of old forest ‘cut lines’ transect the site in an east-west direction. The ground surface is covered with gravel and sand and hardpan ferricrete was occasionally observed to outcrop at surface.

5.2 Subsurface Conditions

General

Reference is made to the appended test pit logs (test pits TH30 to TH35) for details of the fieldwork including soil description, inferred stratigraphy and location of laboratory testing samples. The materials encountered on site are described below.

Sand

A layer of slightly gravelly sand containing abundant roots covers the site. This material was observed to be grey in color, loosely consolidated and to range in thickness from 0.2 to 1.1m.

The following table summarises the results of grain size testing carried out on this material.

TABLE 1: GRAIN SIZE ANALYSIS, SAND

TEST PIT	DEPTH(m)	% Clay and Silt.	%Sand	%Gravel
TH35	0.5-1.0	5	75	20

This material is non-plastic and is expected to have the following engineering characteristics:

- fair workability as a construction material.
- semipervious when compacted.
- low compressibility when compacted.

The result of an Emerson dispersion test indicates that this material is non-dispersive (Emerson Class 6).

Gravel

A layer of soil consisting of sandy gravel with variable amounts of cobbles was observed in TH30, TH31, TH33, TH34 and TH35. This material was observed to occur from 0.2 to 1.1m below ground level (bgl) and ranges in thickness from 0.2 to 1.0m.

Sandy Silt

A layer of soil ranging in grain size from sandy clayey silt to silty sand with variable amounts of gravel and trace cobbles was observed to occur from 0.2 to 1.4m bgl. This material was observed be dense and to range in thickness from 0.5 to 1.3m.

The following tables summarise the results of grain size and Atterberg Limits testing conducted on this material.

TABLE 2: GRAIN SIZE ANALYSIS, SILTY SAND

TEST PIT	DEPTH(m)	% Clay and Silt.	%Sand	%Gravel
TH30	1-1.5	33	35	32
TH32	0.5-1.5	16	41	43

TABLE 3: ATTERBERG LIMITS ANALYSIS, SILTY SAND

TEST PIT	DEPTH(m)	Liquid Limit %	Plastic Limit %	Plast. Index %	Linear Shrink %
TH30	1-1.5	46	26	18	8
TH32	0.5-1.5	39	21	20	6.5

This material is expected to have the following engineering characteristics:

- fair to good workability as a construction material.
- impervious when compacted.
- low compressibility when compacted.

California Bearing tests conducted on this material yielded CBR values of 35 and 90.

Laboratory testing of two samples indicated Maximum Dry Density (MDD) values of 2.0 and 2.06t/m^3 at Optimum Moisture contents of 9.7 and 11.0%.

Silt

A layer of stiff grey or beige, occasionally streaked reddish brown, sandy clayey silt was observed to underlie the above materials. This material was observed to occur from 1.2 to 2.3m bgl ranging in thickness from 0.2 to greater than 1.6m.

The following tables summarise the results of grain size and Atterberg Limit testing conducted on this material.

TABLE 4: GRAIN SIZE ANALYSIS, SILT

TEST PIT	DEPTH(m)	% Clay and Silt.	%Sand	%Gravel
TH33	1.2-1.5	50	25	25

TABLE 5: ATTERBERG LIMITS ANAYSIS, SILT

TEST PIT	DEPTH(m)	Liquid Limit %	Plastic Limit %	Plastic Index %	Linear Shrink %
TH33	1.2-1.5	60	31	29	9

This material is expected to have the following engineering characteristics:

- poor to fair workability as a construction material.
- impervious when compacted.
- low compressibility when compacted.

Bedrock

The bedrock conditions encountered on site are summarised in the following table.

TABLE 6: BEDROCK DESCRIPTION

TEST PIT	DEPTH (m)	DESCRIPTION
TH30	2.6	Grey distinctly weathered fine grained low strength SILTSTONE.
TH31	2.0	Grey distinctly weathered fine to medium grained silty SANDSTONE.
TH32	3.0	Very soft SILTSTONE/SANDSTONE.
TH33	>2.8	Rock not encountered.
TH34	>2.8	Rock not encountered.
TH35	2.0	Grey distinctly weathered very fine grained SILTSTONE.

Groundwater

All test pits were observed to be dry at the time of drilling. Due to the presence of permeable materials, particularly the sandy gravelly horizons, groundwater flow may occur following extended heavy rainfall.

5.3 Recommendations

Our recommendations are based upon the information presented above. The recommendations are governed by the physical properties of the soil and rock that was encountered on site.

Site Preparation and Earthworks

It is necessary to remove all topsoil containing organics including tree stumps as this material will decompose and form voids and could form sharp points beneath the liner membrane. Excavation can be carried out using light earth moving equipment to an average depth of 2.5m. Excavations near TH31 and TH35 will require a dozer with a ripper tooth below 2m. The geomembrane can be placed directly on the compacted insitu materials treated with 30 passes of a sheep's foot roller and trimmed with a grader. The walls of the pond can be constructed using fill from the excavation compacted in 150mm thick layers compacted to 95%MDD (within 2% of optimum moisture content). All cobbles greater than 100mm diameter should be removed. In order to increase workability it is suggested that the fine grained material encountered at an average depth of 1.8m below ground level be blended with the upper sandy and gravelly materials. Compaction should be carried out using a sheeps foot roller. Excess material should be stockpiled for use in construction of the dam wall.

6.0 DAM SITE A

6.1 Surface Conditions

The proposed dam wall crosses the Wheatley Creek at the location shown on Figure 2. The banks of the river are covered with Woodland vegetation and a variety of grasses and shrubs occur in the river flood plain. At the dam wall location the Wheatly Creek consists of two channels. The main channel is approximately 15m wide and the minor channel approximately 6m wide. The banks of the channel are mostly gently sloping with the exception of the east bank of the main channel, which forms an approximately 3m high terraced bank. The creeks were not flowing at the time of the investigation, however standing water was observed in two shallow pools in the larger channel.

6.2 Subsurface Conditions

General

Reference is made to the appended test pit logs for details of the fieldwork including soil description, inferred stratigraphy and laboratory testing data. The information for this investigation was obtained from the test pits TH36, TH37, TH38, TH41, TH42 and TH43. A representative geological section though the proposed Dam A site is shown on Figure 3.

The materials encountered on site are described below.

Sand

A layer of grey sand was observed to occur at surface in all test pits. This material was observed to range in thickness from 0.2 to 1.2m. The grain size was observed to range from silty sand to gravelly sand. Numerous cobbles were observed in TH36 and TH38. The consistency was observed to range from loose to dense.

Sandy Silt

A layer of soil (absent in TH36) ranging in grain size from silty sand to clayey sandy silt with variable amounts of gravel was observed in to occur from 0.6 to 1.5m bgl. The thickness of this layer was observed to range from 1 to 1.4m. This soil was observed to be ferruginised and the consistency was observed to range from dense to very dense.

The following tables summarise the results of grain size distribution and Atterberg Limits testing conducted on this soil.

TABLE 7: GRAIN SIZE ANALYSIS, SANDY SILT

TEST PIT	DEPTH(m)	% Clay and Silt.	%Sand	%Gravel
TH37	0.9-1.1	34	41	25
TH41	1.0	25	33	42
TH42	2.3	43	45	12

TABLE 8: ATTERBERG LIMITS ANAYSIS, SANDY SILT

TEST PIT	DEPTH(m)	Liquid Limit %	Plastic Limit %	Plast. Index %	Linear Shrink %
TH37	0.9-1.1	47	28	19	7.5
TH41	1.0	42	21	21	8.0
TH42	2.3	35	15	20	7.0

This material is expected to have the following engineering characteristics:

- fair to good workability as a construction material.
- impervious when compacted.
- low compressibility when compacted.

The results of a California Bearing Ratio test indicate this material has a CBR of 45.
A laboratory test conducted on this material indicated that the Maximum Dry Density (MDD) of this material is 1.92t/m3 at an Optimum Moisture content of 12.8%.

The result of an Emerson dispersion test indicates that this material is non-dispersive (Emerson Class 6).

Alluvium

Alluvium was encountered from surface in test pit TH36 positioned in the main tributary of Wheatley Creek. This soils encountered are described on the table below:

TABLE 9: ALLUVIAL SOIL PROPERTIES

DEPTH (m)	DESCRIPTION
0 - 1.0	Gravelly SAND with numerous cobbles.
1 – 15	Numerous cobbles in a matrix of silty CLAY with sand lenses.
1.5 – 3.0	Trace sand silty CLAY and ferruginised SAND.
3.0 – 4.0	Cobbles in matrix of clayey SAND
3 - >5	Sandy SILT. Residual GNEISS

Bedrock

Bedrock was encountered at 2m bgl in TH37 (very soft Sandstone) and TH38 (very soft Siltstone) at 2.5m bgl.

Groundwater

The soils sampled during the investigation were observed to be dry to moist, no groundwater was encountered. Due to the presence of permeability materials, particularly the alluvium encountered in test pit TH36, groundwater flow will likely occur following extended heavy rainfall.

6.3 Recommendations

Our recommendations are based upon the information presented above. The recommendations are governed by the physical properties of the soil and rock that was encountered on site.

Site Preparation

It is necessary to remove all topsoil containing organics including tree stumps as this material will decompose and form voids and could form sharp points beneath the liner membrane.

Dam Construction

Dam Wall

The dam wall is to be covered with a impermeable geomembrane, which will cover the upstream and downstream walls of the dam. Construction of the dam wall can be carried out using fill material stockpiled from the excavation of the storage ponds or by sourcing material from the reservoir or the banks of Wheatley Creek. The dam wall should be constructed in 150mm thick layers compacted to 95%MDD (within 2% of optimum moisture) using a sheep's foot roller. All cobbles greater than 100mm diameter should be removed. Due to the presence of the deep compressible and permeable materials encountered in test pit TH36 it is recommended that the alluvium be excavated to a depth of 4m beneath the dam footprint (See Figure 4) and the soil inspected by a geotechnical engineer. The soil at base of the excavation should be densified using 30 passes of a sheep's foot roller. This should be carried out for the width of the soft alluvium layer, estimated to be 15m. These measures are necessary to ensure that the dam wall does not settle over time and that the contact between the dam and the founding materials does not form a plane of low shear strength which could allow the dam to slide.

It is recommended that the dam abutments be founded on the dense silty sand that occurs at approximately 1.5m bgl. This material should be densified with 30 passes of a sheep's foot roller.

In order to facilitate equipment access and placement of the impermeable geomembrane it is suggested that the upstream and downstream slopes of the dam be constructed at an angle of 2.5:1 (H:V, See Figure 4).

In is strongly recommended that additional investigation be carried out in order to determine the hydrogeological characteristics of the Wheatly Creek alluvium when the Dam A design is finalised.

Reservoir

The dam reservoir is to be lined with an impermeable membrane. The geomembrane can be placed directly onto the insitu materials compacted with a sheeps foot roller and trimmed with a grader. The edges of the membrane should be placed in a 1.5m deep trench (or low permeability soils/rock) so that water cannot flow into permeable strata and cause uplift pressures beneath the geomembrane.

Due to the presence of "deep" alluvium and soft weathered rock encountered to a depth of 5m in the main channel of Wheatly Creek consideration should be given to deepening and widening the existing streambed to increase the dams storage volume (See Figure 3).

7.0 DAM SITE B

7.1 Surface Conditions

The proposed dam wall at site B dams the catchment of a valley between two quartzite covered ridges which occurs to the east of the access road as shown on Figure 1. The valley is covered with Woodland vegetation and grasses. Shallow ponds in a dry streambed occur at the proposed wall position.

7.2 Subsurface Conditions

General

Reference is made to the appended test pit logs for details of the fieldwork including soil description, inferred stratigraphy and laboratory testing data. The information for this investigation was obtained from the test pits TH46, TH47 and TH48.

The materials encountered on site are described below.

Clay

A 200mm thick layer of silty clay was recorded at surface in test pit TH48.

Sand

A layer of sand with variable amounts of silt was observed from surface in test pits TH46 and TH47 and at 0.2 bgl in test pit TH48. The thickness of this layer ranges from 0.4 to 0.6m.

Silt Sand

A layer of silty sand, occasionally sandy silt was observed in test pits TH46 and TH47. This layer was observed to occur at 0.6m bgl and the thickness ranges from 0.7 to 1.1m.

Clayey Sand

A layer of greyish green firm clayey sand was observed at 0.8m bgl in test pit TH48. This material is approximately 1.5m thick.

TABLE 10: GRAIN SIZE ANALYSIS, CLAYEY SAND

TEST PIT	DEPTH(m)	% Clay and Silt	%Sand	%Gravel
TH48	1.5	32	50	2

TABLE 11: ATTERBERG LIMITS ANAYSIS, CLAYEY SAND

TEST PIT	DEPTH(m)	Liquid Limit %	Plastic Limit %	Plast. Index %	Linear Shrink %
TH48	1.5	44	27	17	6.0

This material is expected to have the following engineering characteristics:

- good workability as a construction material.
- impervious when compacted.
- low compressibility when compacted.

Bedrock

The bedrock conditions encountered on site are summarised below.

TABLE 12: BEDROCK DESCRIPTION

TEST PIT	DEPTH m	DECRIPTION
TH46	1.3	Light brown distinctly weathered SANDSTONE
TH47	1.7	Very soft rock SANDSTONE
TH48	2.3 1	Soft SCHIST Hard SANDSTONE

Groundwater

All test pits were observed to be dry at the time of drilling. Due to the presence of permeable soil groundwater will likely occur in the granular materials following extended periods of heavy rainfall.

7.3 Recommendations

Our recommendations are based upon the information presented above. The recommendations are governed by the physical properties of the soil and rock that was encountered on site.

Site Preparation

It is necessary to remove all topsoil containing organics including tree stumps as this material will decompose and form voids and could form sharp objects beneath the liner membrane.

Dam Construction

Dam Wall

The dam wall is to be covered with an impermeable geomembrane which will cover the upstream and downstream walls.

It is recommended that the dam be founded on the weathered bedrock encountered at approximately 1.5m bgl. Construction of the dam wall can carried out using fill material from excavation of the storage ponds or material excavated from the reservoir. These materials should be placed in 150mm thick layers compacted to 95%MDD (within 2% of optimum moisture) using a sheep's foot roller (See Figure 4). All cobbles greater than 100mm diameter should be removed. It is suggested that the upstream and downstream slopes of the dam be constructed at an angle of 2.5:1 (H:V).

Reservoir

The reservoir is to be lined with an impermeable geomembrane, which can be placed directly onto the existing soil. The founding soil should be densified by compacting with 30 passes of a sheep's foot rollera and trimming with a grader. The upstream edge of the geomembrane should be firmly placed below the permeable soil layers (See Figure 4).

8.0 CONCLUSIONS

The recommendation provided above should be considered as preliminary guidelines. Detailed recommendations for the dam design can be carried out when the height and position of the dam wall are finalised.

If the Dam A site is selected it is strongly recommended that additional investigation be carried out in order to determine the hydrogeological characteristics of the Wheatly Creek alluvium and bedrock.

Consideration should be given for the potential of silt or dispersive particle accumulation in the dam reservoir. Silt accumulation decreases the reservoir storage capacity and dispersive suspended particles or solutions (eg Calcium/ Magnesium Sulphate) will influence the chemistry of the water. The results of two tests indicated that the materials sampled in test pits TH35 and TH37 are non-dispersive (Emerson Class 6), however additional testing is recommended.

It is important to note that the geomembrane that is utilised should be of adequate shear strength, tensile puncture strength and be UV resistant. Consideration should be given to covering the geomembrane with a layer of soil (approximately 400mm in thickness) and covered with grasses in order to protect the geomembrane from motorbikes, animal hooves and equipment used to remove silt from the reservoir. In addition the surface of the dam wall should be protected to allow vehicle access.

It is strongly recommended that the construction be carried out in the dry season.

We trust that the foregoing information meets with your present requirements. Please do not hesitate to contact the undersigned should you have any queries or if you require additional information.

Sincerely yours,

P C LOUBSER, B.Sc. (Engineering)
Geotechnical Engineer