FROM Opus. Report 2001
commissioned by 3 developers
of Business Park

APPENDIX F

Geotechnical Assessment

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Ref: T - 5943
25 January, 2002

Opus International Consultants Ltd
PO Box 646
Tauranga

Attention: Janine Fellwell

Dear Madam

Re: Geotechnical Investigation and Assessment
Proposed Zone Change Application - Rural to Industrial
Te Puna Station Road, Bay of Plenty

This report provides the results of our geotechnical assessment of three properties located off Te Puna Station Road, Te Puna. The purpose of the assessment was to determine the suitability of properties owned by Messrs Overton, Daniels and Bax, to accommodate activities associated with a zone change to industrial land use. The work was commissioned by Opus International Consultants, on behalf of the three property owners.

The properties are located adjacent to Te Puna Station Road, being situated over a low-lying floodplain area located to the west of the Wairoa River mouth where it discharges to the Tauranga Harbour. A plan showing the location of the properties is presented on the attached Drawing No. 5943-01.

The report that follows outlines the difficulties that will be encountered in developing the properties to provide building sites and road access for industrial purposes. Therefore prior to the commencement of any industrial development of the properties, this report should be consulted.

However, in spite of the difficulties as listed below, it is considered that the properties could be utilised for industrial purposes provided the appropriate engineering works, such as site preloading, were carried out beforehand.

The properties are presently zoned Rural H and are predominantly utilised for the grazing of livestock.

1. Field Investigations

The subsurface soil conditions below the properties were investigated by drilling a series of truck-mounted machine auger test borings, together with continuous Scala Penetrometer test probes. The locations of the various bore holes and probings are presented on the attached Site Plan, Drawing No. 5943-02.

Bore Hole Nos. 1 to 3 were drilled in March 1999 as part of an earlier investigation of a portion of Mr Overton's property for a specific development proposal. The logs of those borings are presented on Figs. A-1 to A-3.

Four additional borings, denoted Bore Hole Nos. 10 to 13, were drilled more recently within other parts of the subject sites with their respective boring logs presented on Figs. B-1 to B-4.

2. Soil Conditions and Site Geology

The soil conditions encountered across the majority of the investigated site area were found to be relatively consistent and are summarised as follows:

Within the upper 1.0 to 2.0 metres of the soil profile, the near-surface disturbed Topsoil and subsoil layers associated with past farming activities are underlain by firm to stiff, grey and brown-coloured SILTS and sandy SILTS. These soils are described as reworked tephra deposits, having originated from surrounding elevated ground areas.

Underlying deposits, extending to varying depths of between 5 metres to in excess of 12 metres, consist of very soft bluish grey-coloured SILTS. These materials are described as marine estuarine deposits forming an infill deposit of previous incised valleys, which themselves were formed during times of significantly lower sea levels.

The estuarine deposits typically contain organic SILT lenses, which occur randomly in both lateral and vertical directions. The organic deposits are also very soft and represent wetland deposits associated with a terrestrial (non-marine) environment. Their random distribution suggests fluctuating sea levels during deposition of these and the estuarine soils.

At Bore Hole No. 13 location, very loose silty SANDS were encountered from a depth of 1.7 metres. These soils represent reworked alluvial deposits also formed at times of temporarily lowered sea levels. It is likely that similar sand lenses will be intermixed with estuarine sediments elsewhere across the investigation site.

3. Groundwater Conditions

The investigation site is low-lying containing a year-round groundwater table elevation at between 0.0 and 0.5 metres below the present ground surface. Extensive drainage works have been carried out within the investigated properties with flowing water levels elevated slightly above sea level or around 1.0 to 1.5 metres below present ground levels.

Towards the northern part of the investigated site area (Bore Hole Nos. 1, 2 and 10), the water levels within the bore holes following removal of the Scala probe was noted to rise to ground level and flow across the ground surface.

That observation suggests the presence of artesian groundwater pressures at depth, which are characteristic of confined subsurface sand lenses.

4. Site Setting

The three properties forming the basis of this investigation are located to the north (Overton Property) and south (Daniels and Bax Properties) of Te Puna Station Road, being predominantly restricted to the low-lying floodplain.

The floodplain extends to the west of the Wairoa River mouth with the northern (Overton) property being bounded to the north and west by more elevated ground topography.

The East Coast Main Trunk (ECMT) railway line passes by the northern boundary of the Overton Property, being situated largely over the toe of the elevated ground topography. However, towards the western part of the Overton block, the railway passes over the low-lying floodplain, being situated over a fill embankment elevated some 6 to 8 metres above the floodplain level.

To the south, the Te Puna ignimbrite also forms more elevated sloping ground topography with the southern boundary of the Daniel's Property lying adjacent to a small stream channel that separates the higher ground areas to the south from the low-lying subject site.

The south-western corner of the Bax Property is situated over elevated ground topography and is occupied by a recently constructed residential dwelling and implement shed. The Overton Property contains a recently constructed coolstore/packhouse facility together with a dwelling located towards the western boundary. The Daniel's Property also contains a dwelling together with associated shed facilities.

Within the eastern part of the Daniel's Property, ground levels have been raised in the order of 2 metres above the surrounding floodplain level with the placement of unsupervised earth and rubble fill.

Drainage of the low-lying properties is maintained through a network of drains and culverts that discharge to the Te Puna Station Road water table drains and onto the Wairoa River.

5. Geotechnical Considerations Related to Potential Industrial Development

5.1 Soil Bearing Capacity

The subsurface soils from ground surface level and extending to variable depths of between 5 and greater than 12 metres are dominated by the presence of low-strength estuarine and organic SILTS. The geological history of these sediments dictates that they are normally consolidated (having never been loaded above their present stress level). This is indicative of a highly compressible material deposit.

Also, the compressibility of the estuarine deposits is accentuated by the sodium and chloride ions that remain from the marine depositional environment, which generally promote a high void ratio within the soil structure. The effect of loading of these soils by filling over, is for the voids tending to collapse and thereby accentuate ground settlements.

Based on these characteristics, the site soils are classified as compressible and therefore not suitable for the support of industrial buildings and/or access formations in their present state.

5.2 Groundwater Elevations

Artesian (above ground) groundwater elevations were noted within parts of the site with all remaining areas containing groundwater elevations at or near the present ground surface.

High groundwater tables provide numerous difficulties for industrial development and include a reduction of induced ground settlement rates, restrictions to the disposal of human effluent in un-sewered areas, such as this, together with more complex access construction and culvert construction requirements.

5.3 Liquefaction Potential

Very loose, saturated SANDS were also encountered within parts of the investigation site, which are considered susceptible to the effects of liquefaction under earthquake loading conditions.

Liquefaction occurs when vibrations induced by earthquake shaking causes a sudden consolidation of the particle structure with the excess water from within the former voids creating an "excess pore water pressure". This excess pore water pressure may result in the formation of "mini-volcanoes" of fine-grained soils being thrust up to ground surface.

The effect of soil liquefaction may be a sudden settlement of the ground surface, that could result in a distortion or tilting of a structure constructed above the point of soil liquefaction.

However for an industrial site that contains only single-storey buildings with extensive yard areas, some liquefaction of site soils could be accommodated as any damage is likely to be of only minor extent.

5.4 Inundation

The subject sites are low-lying, being estimated to contain an average level at around RL 2.0 to 2.6 metres, Moturiki Datum. Industrial development regulations stipulated by the Western Bay of Plenty District Council require minimum floor levels at RL 2.8 metres Moturiki Datum on account of the potential for inundation created by flooding and storm surge effects.

To facilitate industrial development of any part of the floodplain area will therefore require ground levels to be raised by controlled earth filling.

However because of the compressibility of the site soils, together with the extensive depth of these soils, it can be expected that over-filling by about 30% of the height difference between present ground level and the required finished level fill depth will be required. That is, to achieve a final ground level of 1.0 metres above present ground level, some 1.3 metres depth of filling would be required.

The time for this settlement to take place could take in excess of a year. However the time period could be reduced to a several-month period where preloading of the building site areas, accompanied with sand drains, is carried out.

6. Review of Development Requirements

6.1 Building Construction

Where suitable engineering design and construction techniques are utilised, the compressible estuarine and organic SILT soils can be prepared such that a floating raft foundation may be adopted for relatively light-weight and/or flexible construction.

Preparation works will require the placement of a compacted earthfill pad constructed of a sufficient thickness to raise ground levels above the minimum floor level requirement. Compression of the underlying natural sediments during this process will require specific design of the pad thickness such that its surface remains above the minimum floor elevation following ground settlement.

Once the foundation pad is constructed to the required grade, the underlying natural sediments would then be pre-loaded with the placement of additional (loose) filling to a designated elevation, to be predetermined by specific geotechnical investigations.

Settlement of the compacted pad surface induced by the pre-load filling will then be required to be monitored by a geotechnical engineer to ensure adequate compression of the underlying sediments has occurred prior to pre-load fill removal and subsequent building construction.

On account of the saturated nature of the site soils, the consolidation process will be significantly enhanced with the construction of specific drainage measures, such as wick drains or subsoil drains together with the utilisation of geotextile separation layers.

However, where loose SAND soils are found by specific geotechnical investigations to predominate any particular development area, the adoption of a piled foundation may be required on account of liquefaction potential. In order to provide for the dissipation of excess pore water pressures created by soil liquefaction, stone column piles would need to be adopted in that situation.

6.2 Roading and Access Formation Construction

The creation of a stable access formation will also be required for any development proposal, considering that the passage of heavily loaded trucks is commonly associated with industrial premises.

Such formations will need to be constructed to a suitable design so as to prevent the occurrence of bearing capacity or thrust failures along the margins of the access alignment. This may be achieved in a similar manner to that described for the building site preparation, but to a lesser extent.

The use of geogrid soil reinforcement in combination with geotextiles within and/or below the access formation embankment has been proven to significantly reduce fill thickness requirements and settlement rates.

6.3 Domestic Effluent Discharges

The presence of an elevated groundwater table (near ground surface) will require the adoption of mounded effluent disposal systems to cater for domestic wastewater generation associated with industrial premises.

The Environment Bay of Plenty Operative On-Site Effluent Treatment Regional Plan requires that any proposed effluent disposal system that does not consist of a conventional absorption trench will require a resource consent from that authority. Resource consent will therefore be required to discharge treated domestic effluent from any industrial site within the investigated properties.

6.4 Effect of Pre Load induced Ground Settlements

Pre-loading of potential building sites has the effect of compressing the underlying soft sediments causing ground settlement both below and adjacent to the pre-load area. The extent to which the pre-load induced ground settlements are felt is dependent on the depth of compressible sediments below a particular site.

The depth of these sediments has found to vary considerably throughout the investigated properties. However, with the incorporation of a safety factor, it is suggested that no pre-load fill activities should be carried out within a distance of 30 metres from any existing facilities, which includes, but not limited to existing residences, buildings, railway line embankment or other structures intolerant of ground settlement.

6.5 Existing Fill Area

An existing earth and rubble fill area is present within the eastern part of the Daniel's Property. An inspection of the fill shows that it has been placed to a height of around 2 metres above the surrounding ground levels and contains appreciable amounts of concrete.

The fill will be having the effect of compressing the underlying sediments to a degree but not to the full extent required for building construction. Additionally, the nature of the filling (containing large blocks of concrete) suggests that voids will be present with the potential for settlement of the fill itself following building construction. The variable nature of the fill determines that it can not be evenly or adequately compressed by pre-loading activities.

For the present fill area, it will therefore be required that the fill soils are removed from directly below any proposed building site and spread elsewhere on the property. The building area should then be backfilled with engineer-certified filling and the building pad then pre-loaded and monitored as described under 6.1 above.

The pre-load period is however likely to be significantly shorter for building sites located over the present fill area on account of soil compression that has already occurred.

7. Conclusions

The subject sites have been assessed in terms of their suitability to support activities associated with potential industrial development. A number of geotechnical restrictions to development of the properties exist as follows:

- Potential inundation of building sites due to the low-lying nature of the properties.
- Presence of a high groundwater table, which at some locations has been found to contain artesian (above ground) pressures.
- Ground settlement problems as a result of significant depths of compressible Silt soils.
- Liquefaction potential within certain areas where significant depths of loose Sand soils occur.
- Difficulties with disposing of treated domestic wastewater volumes.

However, provided detailed geotechnical design and construction works are carried out for each phase of the industrial development, it is considered that the site restrictions could be overcome and industrial development of the properties could proceed.

Yours faithfully

Mark T Mitchell Ltd

David Morton
Engineering Geologist

Mark T Mitchell
Consulting Geotechnical Engineer

SOIL DESCRIPTION

BORE HOLE LOG No. 2

FIELD TEST DATA

Depth in metres | W.L. | Vane Shear Strength (kPa) | Scala Penetrometer (blows per 100mm drop)

0 2 4 6 8 10

FILLING. Mixture of clayey SILTS and TOPSOIL.

TOPSOIL

Very soft, light blueish grey, wet, clayey SILT.
Containing roots and occasional organic SILT lenses.

Medium dense to dense, light yellowish brown and pale whitish grey, silty fine - medium Pumice SAND.

Bottom of Bore Hole completed 22/03/99

0 2 4 6 8 10 12

NOTE: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

BORE HOLE LOG No. 2

GEOCON SOIL TESTING LTD
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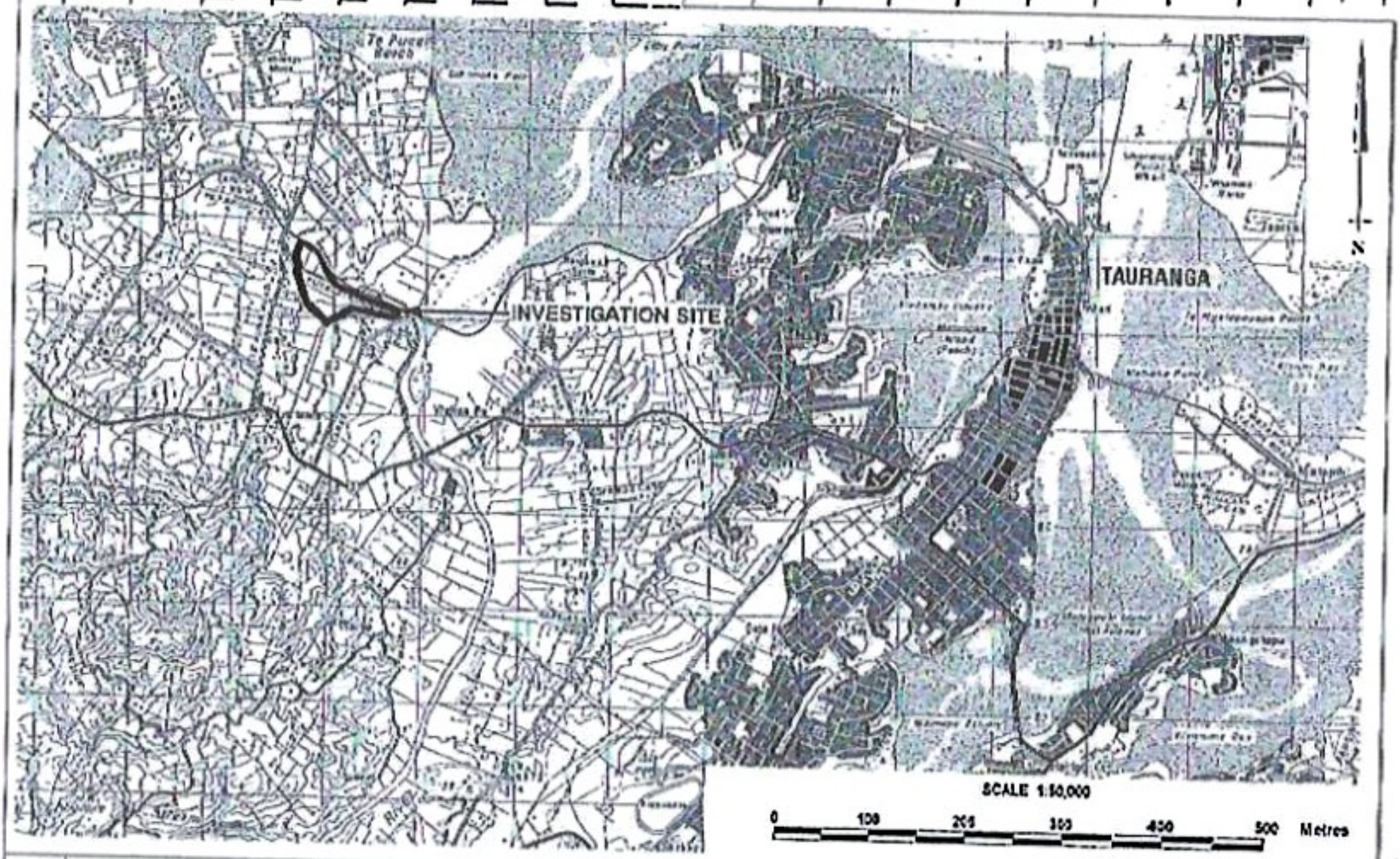
1202 Victoria St, P.O. Box 9123, Hamilton

ANGRO EXPORTS LIMITED
Site Investigation for Proposed Packhouse Coolstore
Te Puna Station Road, Te Puna
March 1999

W.4944

Fig A-7



Mark T Mitchell Ltd
Consulting Geotechnical Engineer

MESSRS OVERTON, DANIELS & BAX

Geotechnical Assessment - Proposed Zone Change
Te Puna Station Road, Te Puna

LOCATION PLAN

DRAWING No. 5343-01
DATE January 2002
ISSUE One

SOIL DESCRIPTION

BORE HOLE LOG No. 1

FIELD TEST DATA

Depth in metres		Vane Shear Strength (kPa)	Scala Penetrometer (blows per 100mm drop) 0 2 4 6 8 10
0	TOPSOIL.		
	Soft, light grey (slightly iron stained), moist, clayey SILT.		
	Very soft, light brownish grey, moist, clayey SILT.	W.L.	110
2	Very soft, light grey and light bluish grey, wet, clayey SILT. Containing roots and occasional organic SILT lenses.		
4			
	Very soft, light bluish grey, wet, clayey SILT.		
6	Bottom of Bore Hole completed 22/03/99		
8			
10			
12			

NOTE. The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

BORE HOLE LOG No. 1

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Fig A-1

SOIL DESCRIPTION

BORE HOLE LOG No. 3

FIELD TEST DATA

Depth in metres

Vane Shear Strength (kPa)

Scala Penetrometer (blows per 100mm drop)

0 2 4 6 8 1

0

FILLING. Mixture of sandy and clayey SILTS and TOPSOIL.

FILLING. Dark grey clayey SILT.

FILLING. Pale whitish grey, silty very fine SAND.

W.L.

72
92
120
120
14
18

2

Very soft, light grey and light bluish grey, wet, clayey SILT.
Containing roots and occassional organic SILT lenses.

Bottom of Bore Hole completed 22/03/99

4

6

8

10

12

NOTE: The stratification lines represent the approximate boundary between soil types and the transition may be gradual

BORE HOLE LOG No. 3

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March 1999

W.4944

Fig A-3

SOIL DESCRIPTION

BORE HOLE LOG No. 10

FIELD TEST DATA

Depth in metres	Geological Formation	As Drilled W.L	Scala Penetrometer (blows per 100mm drop) 0 2 4 6 8 10
0	Reworked Tephra		
			TOPSOIL.
			Soft to stiff, light grey brown, moist to wet, SILT containing occasional plant material.
2	Wetland Deposits		Very soft, dark brownish black, moist, fine sandy organic SILT.
			Very soft, dark brownish black, moist, organic SILT, containing occasional plant material.
			Very soft, light grey brown, moist to wet, SILT containing occasional plant material.
			Very soft, dark brownish black, wet, organic SILT.
4	Estuarine Silts		
6			Very soft, clayey SILTS containing organic silt lenses (inferred).
8			
10			
12			Bottom of Bore Hole completed 18/1/02

NOTE: The stratification lines represent the approximate boundary between soil types and the transition may be gradual

BORE HOLE LOG No. 10

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January 2002.

W. 5943

Fig B-1

SOIL DESCRIPTION

BORE HOLE LOG No. 11

FIELD TEST DATA

Depth in metres	Geological Formation	W.L.	Scala Penetrometer (blows per 100mm drop) 0 2 4 6 8 10
0	Reworked Tephra	As Drilled	
TOPSOIL.			
Firm to still, brown and greyish brown, moist to wet, SILT.			
Very soft, dark brownish black, brown and greyish brown, moist, SAND and organic SILT.			
2			
Very soft, brown and greyish brown, moist to wet, SILT.			
Very soft, light bluish grey, wet, SILT.			
4			
6	Estuarine Silts		
Very soft, light bluish grey, wet, SILT (inferred below 3.0m).			
8			
10			
12			
Bottom of Bore Hole completed 18/1/02			

NOTE: The stratication lines represent the approximate boundary between soil types and the transition may be gradual.

BORE HOLE LOG No. 11

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W. 5943

Fig B-2

SOIL DESCRIPTION

BORE HOLE LOG No. 12

FIELD TEST DATA

Depth in metres | Geological Formation | Scala Penetrometer (Blows per 100mm drop) 0 2 4 6 8 10

TOPSOIL

FILLING: Mixture of pale greyish brown, SAND and SILT.

Fill

Firm to stiff, brown and pale greyish brown, moist, slightly fine sandy SILT.

Kaawaka Tephra

Stiff becoming very soft, light bluish grey, wet, SILT.

Very soft, light bluish grey, wet, SILT containing organic SILT lenses (inferred below 3.0 metres).

Estuarine Silts

0 2 4 6 8 10 12

W.T. As Drilled

Bottom of Bore Hole completed 15/1/02

NOTE: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

BORE HOLE LOG No. 12

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January 2002.

W. 5943
Fig B-3

SOIL DESCRIPTION

BORE HOLE LOG No. 13

FIELD TEST DATA

Depth in metres	Geological Formation	Scala Penetrometer (blows per 100mm drop) 0 2 4 6 8 10
0	Kaweka Tephra	
	Walton Deposits	
2	Recent Alluvial	
4		
6		
8		
10		
12		

W.T. At Drilling

TOPSOIL.

Soft, pale grey, grey brown and orangy brown, moist, clayey SILT.

Soft, dark blackish brown, wet, organic SILT containing occasional plant material.

Soft becoming very soft, light grey brown, wet, SILT and organic SILT.

Very loose, brown and greyish brown, wet, silty fine – coarse SAND.

Bottom of Bore Hole completed 18/1/02

NOTE: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

BORE HOLE LOG No. 13

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Civil Engineering Laboratory
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January 2002.

W. 5943

Fig B-4