

# **Rangitaiki River Stopbanks Assessment**

**63A College Road, Edgecumbe**

Prepared for

**Environment Bay of Plenty**

**Rev A  
July 2006**



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## 1 Introduction

A small subdivision is proposed at 63A College Road, Edgecumbe. The site is beside the Rangitaiki River and is presently a paddock. As a study of the integrity of the stopbanks along the river is presently being carried out it was decided to assess the stopbank along the 63A College Road property before the subdivision is developed.

This report presents the following information:

- the results of insitu investigations,
- the results of laboratory tests,
- the results of seepage analyses for the 100 year return period flood and
- possible remedial measures.

This report is the property of our client, Environment Bay of Plenty and Ice Geo and Civil. The comments within relate only to the length of stopbank along the paddock forming 63A College Road.

## 2 Site Description

The stopbank is typically 1.7m high adjacent to 63A College Road. The river berm is 20 to 30m wide and about 2m lower than the paddock. The paddock generally falls away from the stopbank at a grade of about 600mm over 50m distance.

The only structure within the site is a small re-locatable building.

## 3 Subsurface Investigations

The initial insitu investigations consisted of 12 hand augers arranged in four cross sections as shown in Figure 1. Typically a hand auger was carried out in the river berm, inland from the toe of the stopbank and 40 to 50m further inland. One hand auger was carried out in the access way 85m from the stopbank.

After some initial analyses two more hand augers were carried out to confirm the soil layers. The hand auger logs are included in Appendix A.

The hand augers were continued until the hole collapsed in sandy soils below the ground water level or the holes squeezed in. The maximum depth was 4.2m. The ground water level was found in the inland augers to be between 2.5 and 2.8m below ground level (June).

The surface soil was found to be a brown silt layer, usually underlain by a grey silt or silty fine sand. The upper silt layers varied in thickness from 0.6m to 1.5m. 700mm of cinders were found in HA5. According to the present owner,

a previous owner spread cinders from the dairy factory over low areas of the paddock.

Below the upper silt layers there is complex layering of silts, silty sands, well graded sands, coarse sand and pumice lapilli and some peat. The layering appears to run in strands roughly parallel to the river rather than being consistent across a cross section. The upper layers are missing from the river berms as these soils were used for stopbank construction.

Well graded and ungraded coarse sands were found about 3m below the ground level. A peat layer at least 0.3m thick was found at a similar level in HA3 and 0.6m thick in HA11. Traces of peat were also found within the coarse sands in other augers but there does not seem to be a consistent peat layer below the whole site or below a particular cross section. The peat found within the coarse sands is considered to be in thin lenses which will not have a significant influence on the horizontal permeability of the layer.

#### 4 Laboratory Test Results

Hydrometer particle grading tests were carried out on six samples from the hand augers to provide information on the permeability of the soil layers (Appendix B). The grading test results are summarised in Table 1. The permeabilities given are estimates based on the Hazen formula:

$$k=0.01d_{10}^2$$

**Table 1: Particle Grading Results**

Sample	Description	D <sub>10</sub> (mm)	D <sub>60</sub> (mm)	permeability
HA2 0.8	brown fine sandy silt	0.0022	0.037	$4.8 \times 10^{-8}$ m/s
HA2 2.5m	brown silty fine sand	0.012	0.089	$1.4 \times 10^{-6}$ m/s
HA4 2.3m	light grey silty fine-med sand	0.03	0.16	$9.0 \times 10^{-6}$ m/s
HA8 2.6m	brown grey silty pum sand	0.085	0.47	$7.2 \times 10^{-5}$ m/s
HA10 0.4m	grey brown silty fine – med sand	0.01	0.105	$1.0 \times 10^{-6}$ m/s
HA10 1.0m	grey brown fine-med sandy silt	0.0038	0.053	$1.4 \times 10^{-7}$ m/s

These test results have been used in conjunction with the results from other soil tests from along the river to estimate the permeability characteristics of each soil type.

## 5 Analyses

### 5.1 Discussion

The hand augers carried out provide subsoil profiles in isolated locations only. The hand auger logs show considerable variation in the soil layers and it is possible that in terms of the seepage response to a flood in the river there are worse combinations of soil layers than those identified. In the stopbank stability analysis some sensitivity analyses have been carried out varying the soil layers between and below the hand augers to try to take account of possible soil profiles.

The computer programme used to analyse the seepage problems, Geo-Slope Seep/W (Version 5), is a two dimensional programme. Therefore three dimensional effects, such as lateral changes in the soil profile or the presence of an impermeable surface of given width, can not be accurately modelled. The seepage analyses carried out must therefore be considered indicative only.

The two problems being investigated are heave and piping. The most common remedial measures for heave are the addition of a surcharge on the ground surface or the construction of a pressure relief trench (or wells). The risk of piping can be reduced by increasing the length of the seepage path by the addition of overlays or by installing a drain in the susceptible area to allow seepage without the removal of soil particles.

As 63A College Road is a green field site the use of a surcharge is a practical option. Simple solutions such as overlays are preferred.

Seepage of only small volumes of water from the ground surface can significantly reduce the uplift pressures on a surface layer with a lower permeability than those underlying it. Seepage from the ground surface inside the stopbank has been allowed in the cross sections analysed. When the site has been developed there will be some impermeable roads and driveways and possibly some house foundations poured on grade. As the locations of these surfaces are unknown they have not been modelled.

The increase in uplift pressures below impermeable surfaces compared to the adjacent permeable ground surface is significant. The build up in water pressure below an impermeable surface can lead to high concentrations of flow around the edge of the structure. It is therefore considered that any impermeable surfaces wider than say 10m should have subsoil drains installed along the edge to allow seepage without the loss of soil particles (Figure 8).

### 5.2 Flood Hydrograph

EBoP has provided a 100 year return period flood flow hydrograph for the Rangitaiki River at their benchmark number 24 (Figure 2). This is an eight day hydrograph which rises to a peak of RL6.1 on the third day of the flood.

The top of the stopbank ranges from RL6.4 to 6.6. In the 100 year flood the water level stays close to the peak level for two days before beginning to drop.

### 5.3 Soil Model

The soil layers found in the hand augers were simplified in the models used for the seepage and stability analyses (Figures 3 to 6). The surface layers of silt and sandy silt were modelled with the same low permeability. Below this the layers were divided into silty fine sand, fine sand, fine to medium sand, silt, peat, well graded sand and coarse sand and lapilli. A layer of coarse sand was found at the base of many of the investigations. This layer was assumed to be at least 4m thick below the base of the investigations.

The permeabilities assumed were based on the grading test results for this site and near-by sites previously investigated. The grading test results were compared to the field descriptions of the soils to confirm the soil category. Table 2 summarises the saturated soil parameters assumed.

**Table 2: Assumed Soil Permeabilities**

soil	$k_h$ (m/s)
stopbank fill	$2 \times 10^{-6}$
brown silt	$2 \times 10^{-7}$
silty fine sand	$4 \times 10^{-6}$
fine sand	$5 \times 10^{-5}$
fine to medium sand	$1 \times 10^{-4}$
peat	$1 \times 10^{-7}$
well graded sand	$1 \times 10^{-4}$
coarse sand and lapilli	$1 \times 10^{-4}$

The Geo-Slope Seep/W (Version 5) computer package used for the seepage analyses contains a library of soil grading curves with corresponding hydraulic conductivity and water content versus water pressure relationships. The particle gradings observed on site were compared to those in the Seep library and the closest fit chosen as the soil model to be used in the seepage analysis.

There was no apparent evidence of significant banding within most of the layers therefore the horizontal and vertical permeabilities were assumed to be the same. Some peat lenses were found within the well graded sand and it was assumed the stopbank would be layered due to the method of construction. Therefore the vertical permeability of these two layers was assumed to be half the horizontal.

In assessing the uplift potential of the upper silt layer a bulk density of  $14\text{kN/m}^3$  was assumed.

The soil models analysed for each cross section are included in Appendix C.

## 5.4 Cross Section 1

Cross Section 1 is at the upstream end of the property. The upper silt layer was found to be 1.3 to 1.5m thick. High permeability layers are 2.3 to 3.0m deep.

An initial static seepage analysis was carried out assuming a ground water level of RL2.5 on the inland side of the model and a river level of RL2.2. A transient seepage analysis was then carried out modelling the full eight days of the 100 year flood. A two hour time step was used.

An allowance was made in the soil model for seepage from the ground surface inland from the stopbank. Coarse sand was assumed below the depth of the investigations.

The transient flood analysis showed that the factor of safety against uplift would be in the order of 0.9 to 1.0. The high uplift pressures occur over about a 20 hour period during the flood. The maximum hydraulic exit gradient found during the flood was 0.4. The maximum hydraulic gradient considered acceptable in terms of piping potential is 0.4 and this does not allow for any binding effects of surface vegetation. It is therefore considered that there should be no piping problems at this cross section.

An analysis including a 400mm thick overlay inside the stopbank toe produced factors of safety against uplift of 1.15 to 1.2. This overlay needs to be about 40m wide and basically fills in a small depression on the site as shown in Figure 3. The maximum hydraulic exit gradient is reduced to about 0.25.

## 5.5 Cross Section 2

At cross section 2 the upper silt layer is thinner than at cross section 1. A hollow in the area of HA5 has been filled with cinders which were modelled as a fine sand. Coarse sand was found only in HA3 in the river berm above a layer of peat. Coarse sand was assumed to lie below the depth of all the hand augers.

In the transient analysis the factor of safety against uplift was found to be between about 1.0 and 1.1 over a strip 5 to 25m from the inland toe of the stopbank. A 400mm thick overlay placed in this area should increase the factor of safety to 1.2 (Figure 4). The maximum high hydraulic exit gradient was found to be 0.18.

## 5.6 Cross Section 3

The thickness of the silt layer along this cross section varied from 600mm to 1.5m. Coarse sand was found at 2.4 to 3.1m depth. The auger carried out 90m away from the stopbank shows low permeability soils within the depth of the auger.

The transient analysis produced a factor of safety against uplift below 1.0 within about 40m of the inland toe of the stopbank. If the assumed deep coarse sand layer is only 4m thick the factor of safety is still unacceptable. The maximum hydraulic exit gradient was found to be 0.6. A 40m wide, 400mm thick overlay which tapers to meet the natural ground surface 60m from the stopbank toe will increase the factor of safety to 1.2 and reduce the hydraulic exit gradient to an acceptable level (Figure 5).

## 5.7 Cross Section 4

The ground at cross section 4 is slightly higher than elsewhere in the paddock which reduces the hydraulic gradient across the stopbank. The upper silt layer was found to be 1.0 to 1.3m thick. A peat layer at least 600mm thick was found in HA11 and no high permeability layers were found within the depth of the augers.

The factor of safety against uplift of the upper silt layer was found to be close to 1.0 from the toe of the stopbank to about 15m away. To achieve a factor of safety against uplift of about 1.2 an overlay should be 400mm thick 15m from the stopbank toe, tapering to 200mm thick at the stopbank toe and tapering to the natural ground surface 40m from the stopbank toe (Figure 6).

## 6 Conclusions

- The analyses indicate that the factor of safety against heave of the upper soil layer at this site would be less than 1.0 in some areas in the design 100 year flood.
- An overlay is recommended to increase to 1.2 the factor of safety against heave of the upper silt layer. The extent of this layer is shown on Figure 7
- There should be no excavation at the site for the construction of buildings or access-ways. Where it is necessary to remove surface organic material the volume of the soil removed should be replaced with something of equal or greater weight.
- Impermeable surfaces greater than 10m in width should be bounded by subsoil drains to allow seepage without the removal of fines from the soil Figure 8.



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21 July 2006

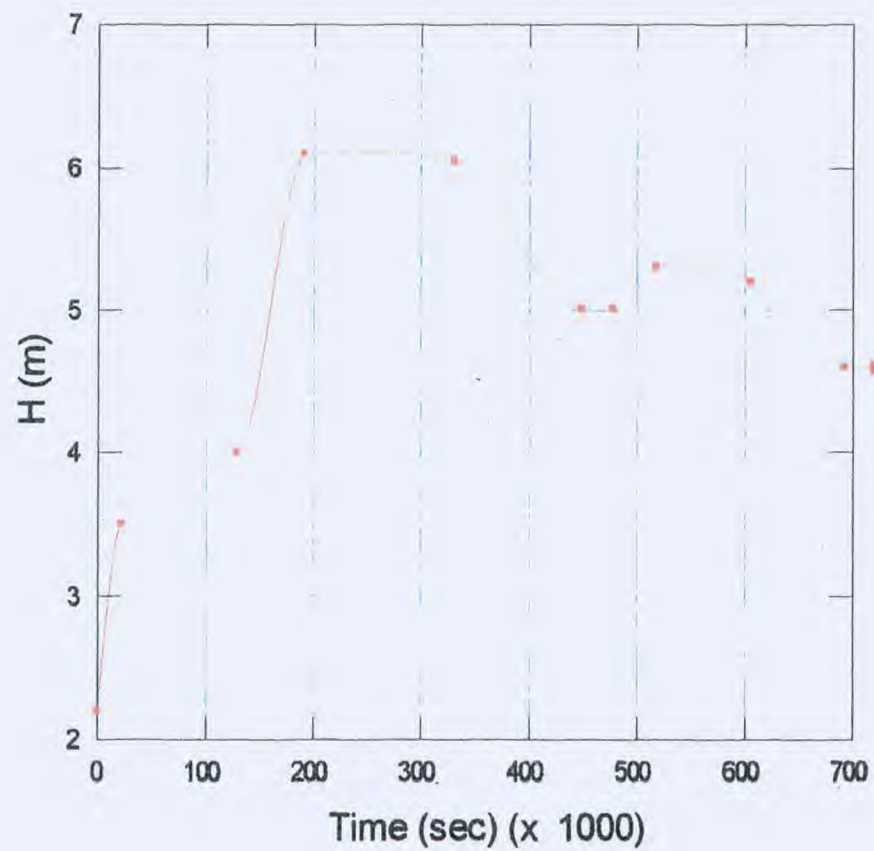




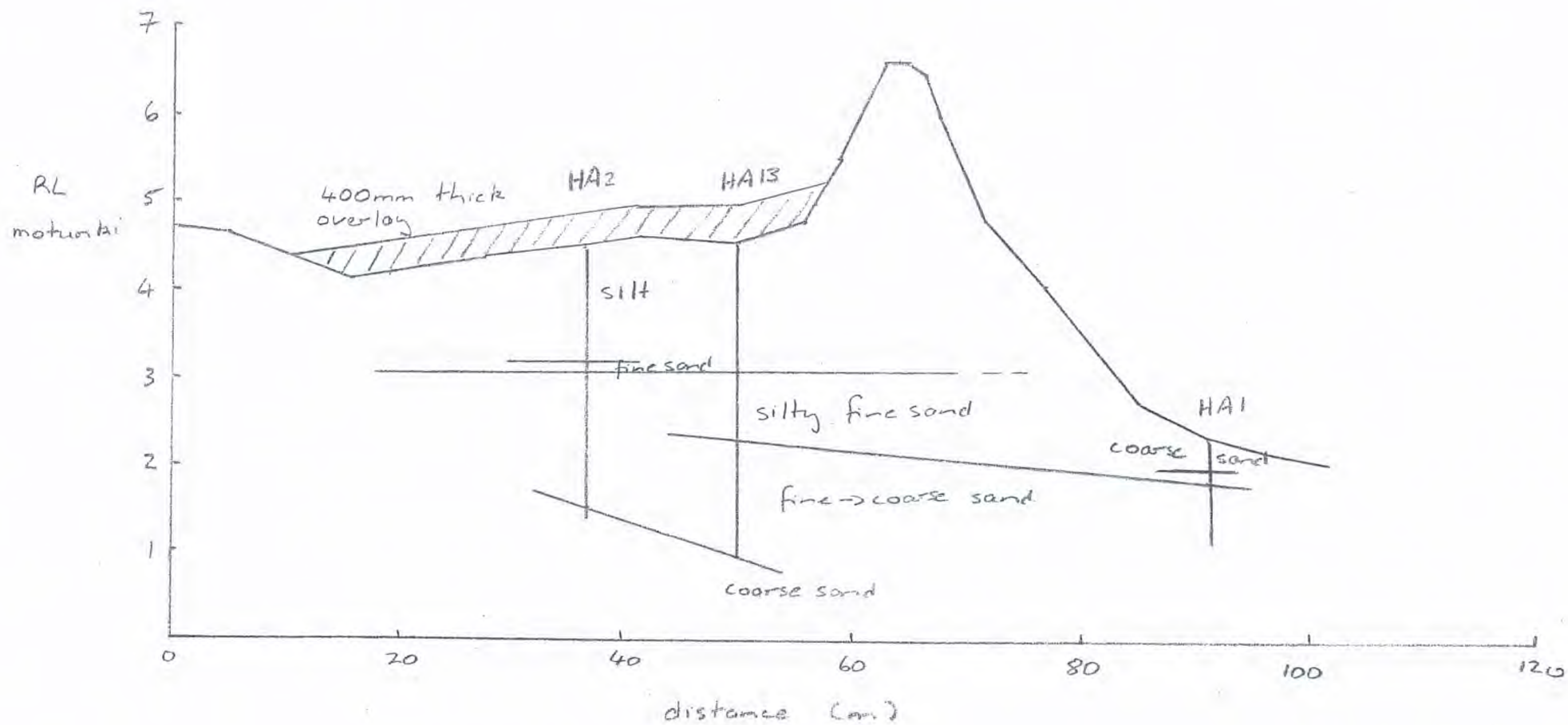
Plan

Figure 1

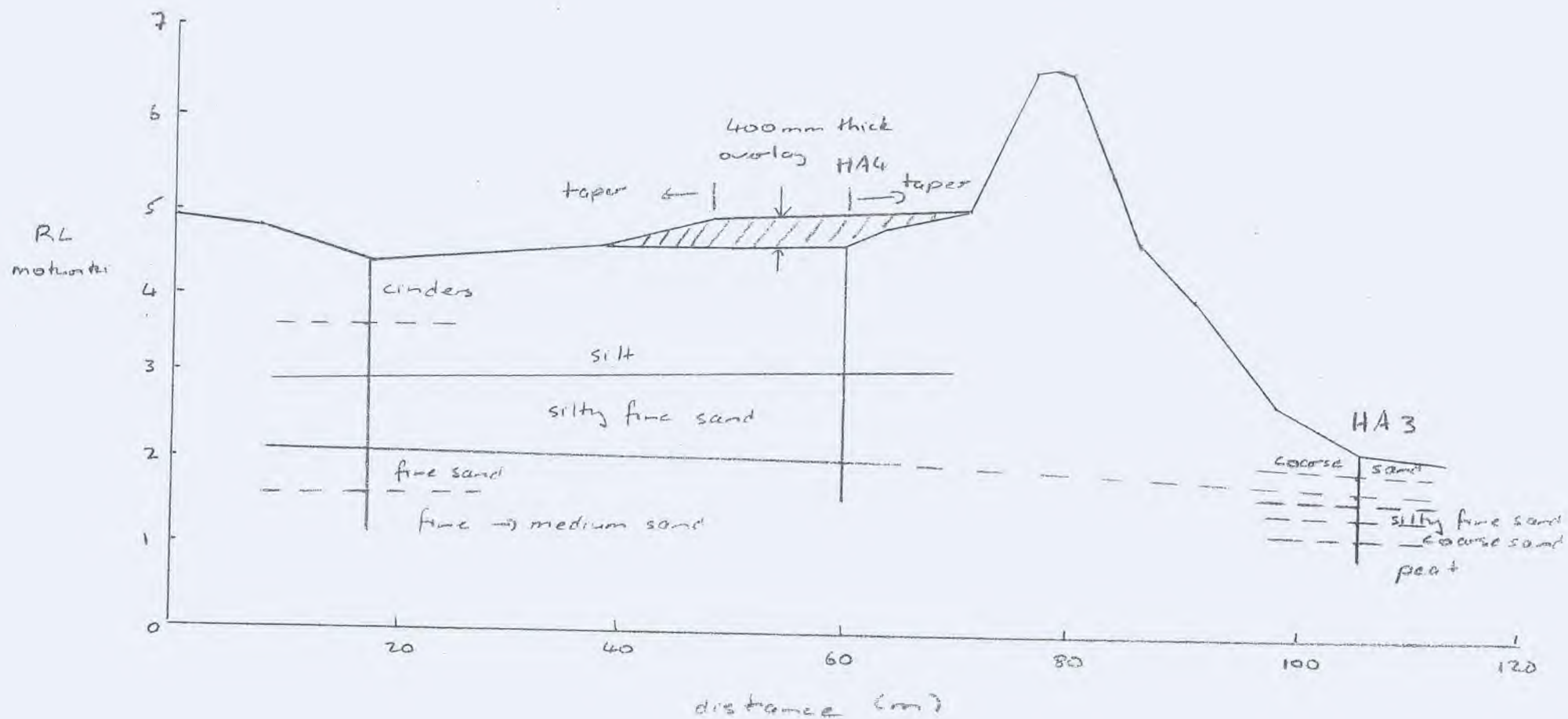




100 year flood flow hydrograph

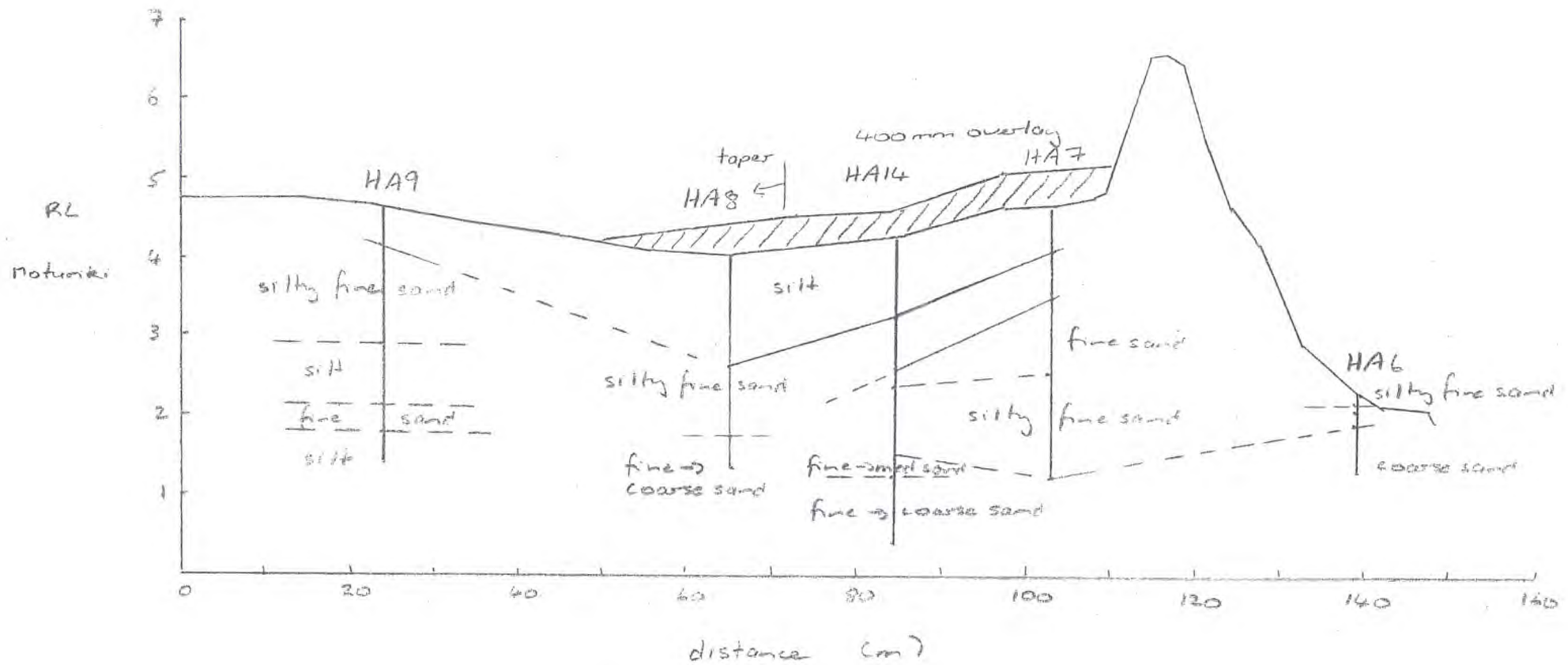


Cross Section 1



Cross Section 2

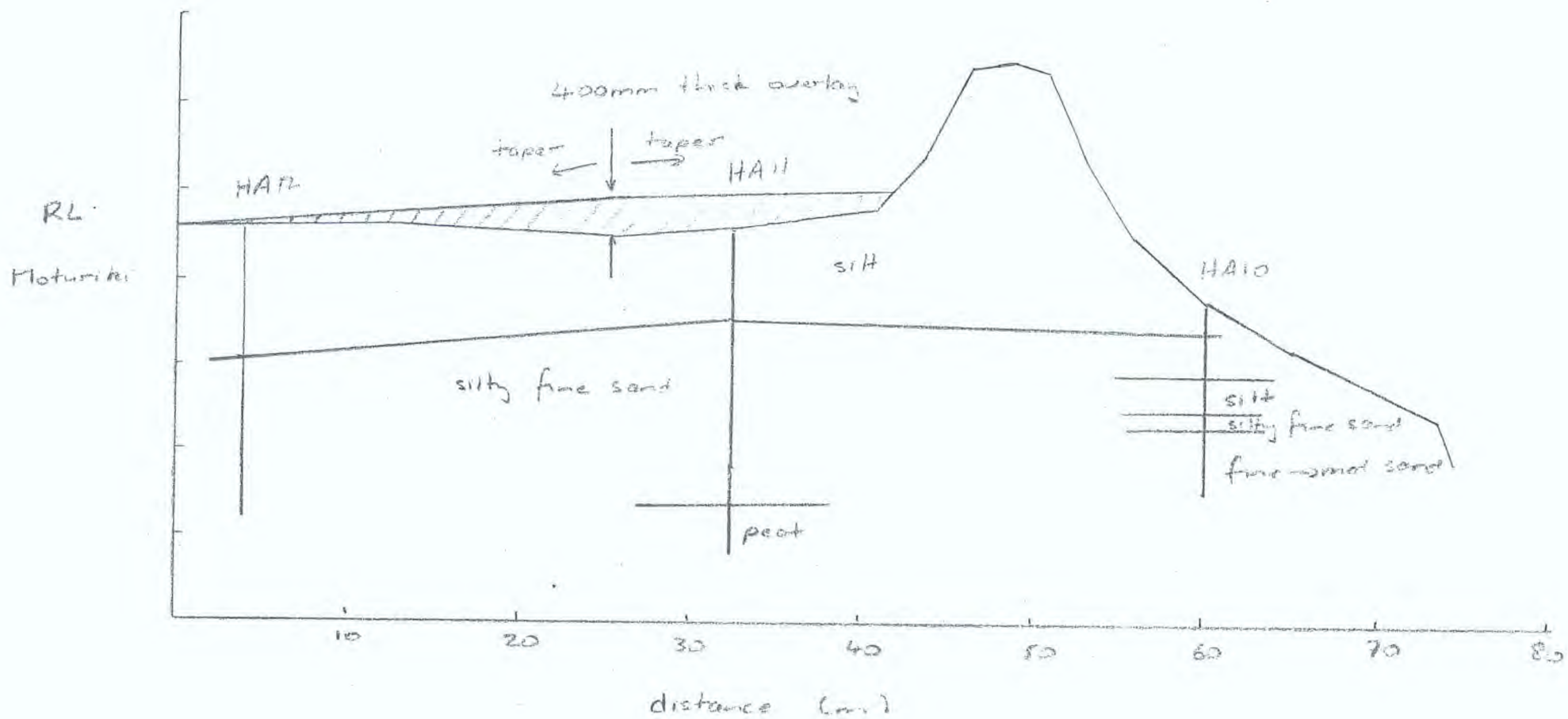
Figure 4



Cross Section 3

Figure 5





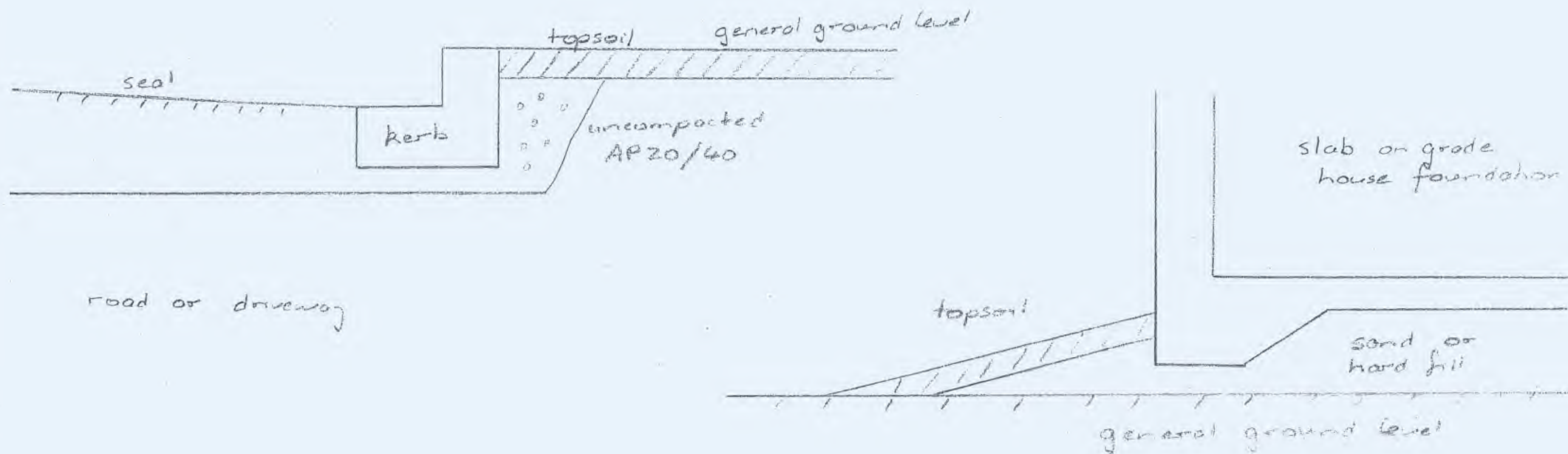
Cross Section 4





Extent of overlay







## **Appendix A**

### **Hand auger logs**

# Hand Auger Log

Test Number: **HAI**

Job Name: **Rangitikei Stopbanks  
63A College Rd**

Date: **31/5/06**

Tested by: **N.O.H**

Blows/50mm		soil description	
m	C <sub>u</sub> (kPa)		
0.2		0.0	grey LOOSE SAND & fine lapilli → 2mm
0.4		0.4	grey silty fine SAND
0.6		0.5	grey fine → med SAND some silt
0.8		X	
1.0			
1.2		X	
1.4			1.3 EOB - closing
1.6			
1.8			
2.0			
2.2			
2.4			
2.6			
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

C<sub>u</sub> (kPa)

# Hand Auger Log

Test Number: HAZ

Job Name: Rangitikei Stopbanks  
63A College Rd

Date: 31/5/06

Tested by: M.O.H

Blows/50mm										C <sub>u</sub> (kPa)	soil description
m	0	2	4	6	8	10	12				
										X X	black SILT
0.2										X X	0.2 grey silty SILT
										X X	0.25 grey SILT
0.4										X	
										X X	
0.6										X X	
										X	
0.8										X X	0.7 orange stained grey
										X X	fine sandy SILT
1.0										X X	
										X X	1.0 orange stained
1.2										X	grey SILT
										X X	
1.4											1.3 grey fine SAND
											1.4 grey silty fine SAND
1.6										X X	
										X X	
1.8										X	
										X X	
2.0										X X	
										X X	
2.2										X X	2.2 moist
										X X	
2.4										X X	
										X X	
2.6										X X	
										X X	
2.8										X X	
										X X	
3.0										X X	3.0 coarse SAND +
										X X	fine lapilli
3.2										X X	
										X X	
3.4										X X	3.4 FOB collapsing
										X X	
3.6										X X	
										X X	
3.8										X X	
										X X	
4.0										X X	

# Hand Auger Log

Test Number: **HAB**

Job Name: **Rangitikei Stopbanks**  
**63 A College Rd**

Date: **31/05/06**

Tested by: **M.O.H**

Blows/50mm											C <sub>u</sub> (kPa)	soil description
m	0	2	4	6	8	10	12					
0.2												coarse SAND & lapilli → 2mm
0.4												0.3 orange stained grey silty fine SAND
0.6												0.5 orange stained grey fine to medium SAND, some silt
0.8												0.6 orange stained grey silty fine SAND
1.0												0.8 coarse SAND & lapilli
1.2												1.0 black fine fibrous PEAT rare charcoal
1.4												1.3 EOB squatters
1.6												
1.8												
2.0												
2.2												
2.4												
2.6												
2.8												
3.0												
3.2												
3.4												
3.6												
3.8												
4.0												
	0	20	40	60	80	100	120					

C<sub>u</sub> (kPa)

# Hand Auger Log

Test Number: HA 4

Job Name: Rangitikei Stopbanks  
63A College Rd

Date: 31/05/06

Tested by: M.O.H

Blows/50mm				soil description					
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)	
0.2									X
									X
0.4									X
									X
0.6									X
									X
0.8									X
									X
1.0									X
									X
1.2									X
									X
1.4									X
									X
1.6									X
									X
1.8									X
									X
2.0									X
									X
2.2									X
									X
2.4									X
									X
2.6									X
									X
2.8									X
									X
3.0									X
									X
3.2									X
									X
3.4									X
									X
3.6									X
									X
3.8									X
									X
4.0									X

soil description

brown / grey SILT

1.4 grey silty fine → medium SAND

2.3 \*

2.5 grey fine → med. SAND

3.2 EOB collapse.

# Hand Auger Log

Test Number: *HAS*

Job Name: *Rangitikei Stopbanks  
63 A College Rd.*

Date: *31/05/06*

Tested by: *noh*

Blows/50mm		C <sub>u</sub> (kPa)		soil description					
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)	
0.2									✓
0.4									✓
0.6									✓
0.8									0.7
1.0									grey silt
1.2									
1.4									1.3 grey silty fine SAND / sandy silt
1.6									1.45 grey silty fine SAND
1.8									
2.0									
2.2									2.2 grey fine SAND, moist
2.4									
2.6									
2.8									2.8 grey fine to med SAND
3.0									some silt & fine lapilli
3.2									3.2 FOB, collapse. PEAT?
3.4									
3.6									
3.8									
4.0									

# Hand Auger Log

Test Number: **HA6**

Job Name: **Rangitahia Stopbanks**  
**62A College Rd**

Date: **31/05/06**

Tested by: **M.O.H**

Blows/50mm		soil description	
m	C <sub>u</sub> (kPa)		
		X	brown silty fine SAND
0.2		X	0.2 dark grey med → coarse SAND
			wet
0.4		X	0.3 grey silty fine SAND, moist
		X	
0.6		S	0.5
			coarse SAND & fine
0.8			lapill. → 2mm
1.0			
1.2			1.1 EOB - collapsing
1.4			
1.6			
1.8			
2.0			
2.2			
2.4			
2.6			
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

C<sub>u</sub> (kPa)

# Hand Auger Log

Test Number: **H47**

Job Name: **Rangitiki Stopbanks  
63A College Rd**

Date: **31/05/06**

Tested by: **M.O.H**

Blows/50mm										soil description
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)		
0.2									X X	brown SILT
0.4									X X	
0.6									X X	0.5 brown fine sandy SILT 0.6
0.8									X X	
1.0									X X	grey silty fine SAND 1.0
1.2									X X	
1.4									X X	grey fine SAND
1.6									X X	
1.8									X X	2.1 grey silty fine SAND
2.0									X X	
2.2									X X	2.5 moist
2.4									X X	
2.6									X X	3.4 orange stained fine grained SAND 3.5 EOB collapse
2.8									X X	
3.0									X X	
3.2									X X	
3.4									X X	
3.6									X X	
3.8									X X	
4.0									X X	
	0	20	40	60	80	100	120	C <sub>u</sub> (kPa)		



# Hand Auger Log

Test Number: **HAB**

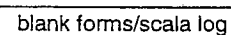
Job Name: **Rangitikei Stopbanks  
63A College Rd**

Date: **31/05/06**

Tested by: **M.O.H**

Blows/50mm											soil description	
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)				
											X X	0.15 brown SILT
0.2											X X	0.2 dark grey silt, Torowā Ash
0.4											X	orange stained grey silt
0.6											X X	
0.8											X X	
1.0											X X	1.0 more
1.2											X X	
1.4											X X	
1.6											X	1.5 orange stained grey
1.8											X	silty fine SAND
2.0											X	
2.2											X	2.2 wet
2.4											X	2.4 orange & grey
2.6											X	fine → coarse SAND
2.8											X	some silt
3.0												2.8 EOB collapse
3.2												
3.4												
3.6												
3.8												
4.0												
	0	20	40	60	80	100	120					

C<sub>u</sub> (kPa)





# Hand Auger Log

Test Number: *HA11*

Job Name: *Rangitaiti Stopbanks  
63 A College Rd*

Date: *01/06/06*

Tested by: *M.O.H*

Blows/50mm											soil description	
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)				
											X X	brown SILT
0.2											X X	
											X X	0.25 50mm dark grey grt + Taranaki Ash
0.4											X	
											X X	
0.6											X	0.6 orange stained grey
											X X	fine sandy SILT
0.8											X	
											X	
1.0											X	1.0
											X	orange stained grey
1.2											X	silty fine SAND
											X	
1.4											X	
											X	
1.6											X	
											X	
1.8											X	
											X	
2.0											X	
											X	
2.2											X	
											X	
2.4											X	
											X	
2.6											X	2.6 wet
											X	
2.8											X	
											X	
3.0											X	3.1 dark brown fibrous PEAT
											X	
3.2											X	3.15 grey fine SAND
											X	
3.4											X	3.2
											X	as 3.1
3.6											X	
											X	3.65 50mm blue grey fine
3.8											X	pvm SAND
											X	3.8 EOB, squeezing
4.0											X	
	0	20	40	60	80	100	120					

# Hand Auger Log

Test Number: **HAR**

Job Name: **Rangitahi Stopbanks**  
**63A College Rd**

Date: **01/06/06**

Tested by: **N.O.H**

Blows/50mm		C <sub>u</sub> (kPa)		soil description					
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)	
0.2									X
0.4									X
0.6									X
0.8									X
1.0									X
1.2									X
1.4									X
1.6									X
1.8									X
2.0									X
2.2									X
2.4									X
2.6									X
2.8									X
3.0									X
3.2									X
3.4									X
3.6									X
3.8									X
4.0									X

**0.6**  
brown SILT

**1.3**  
brown fine sandy SILT

**1.3**  
orange stained grey  
silty fine SAND

**2.0** moist

**2.4** wet

**3.5** EOB collapse

**C<sub>u</sub> (kPa)**

# Hand Auger Log

Test Number: *HAT3*

Job Name: *Rangitahiri Stopbanks  
63A College Rd*

Date: *1/7/06*

Tested by: *N.O.H*

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)						
0.2									x	x			brown SILT	
0.4									x	x			0.3 50 mm grit, Tasmans Ash	
0.6									x	x			0.5 orange stained grey SILT	
0.8									x	x				
1.0									x	x				
1.2									x	x				
1.4									x	x				
1.6									x	x			1.5 grey silty fine SAND	
1.8									x	x				
2.0									x	x				
2.2									x	x				
2.4									x	x			2.3 grey fine → coarse SAND	
2.6									x	x			some pumice → 20mm	
2.8									x	x			2.6 50mm peat	
3.0									x	x				
3.2									x	x			3.2 grey medium → coarse SAND, some peat	peat lenses
3.4									x	x				
3.6									x	x				
3.8									x	x			3.7 coarse SAND	
4.0									x	x			3.9 PEAT	
									x	x			4.0 coarse SAND	
									x	x			4.2 EOB - collapse	

# Hand Auger Log

Test Number: HA 14

Job Name: Rangitahi Stopbanks  
63A College Rd

Date: 1/7/06

Tested by: M.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)						
0.2													X X	brown silt
0.4													X X	0.3 50mm grt, Tasman Ash
0.6													X X	0.45 orange stained grey silt
0.8													X X	
1.0													X X	
1.2													X X	1.1 grey silty fine SAND
1.4													X X	
1.6													X X	1.6 grey fine sandy silt, moist
1.8													X X	
2.0													X X	2.0 grey fine silty SAND, moist
2.2													X X	
2.4													X X	
2.6													X X	
2.8													X X	2.8 grey fine to med SAND wet
3.0													X X	
3.2													X X	3.1 grey fine to coarse SAND & lapilli, wet
3.4													X X	
3.6													X X	3.6 grey coarse SAND
3.8													X X	
4.0													X X	4.0 FOB - collapse

## **Appendix B**

### **Laboratory Tests**



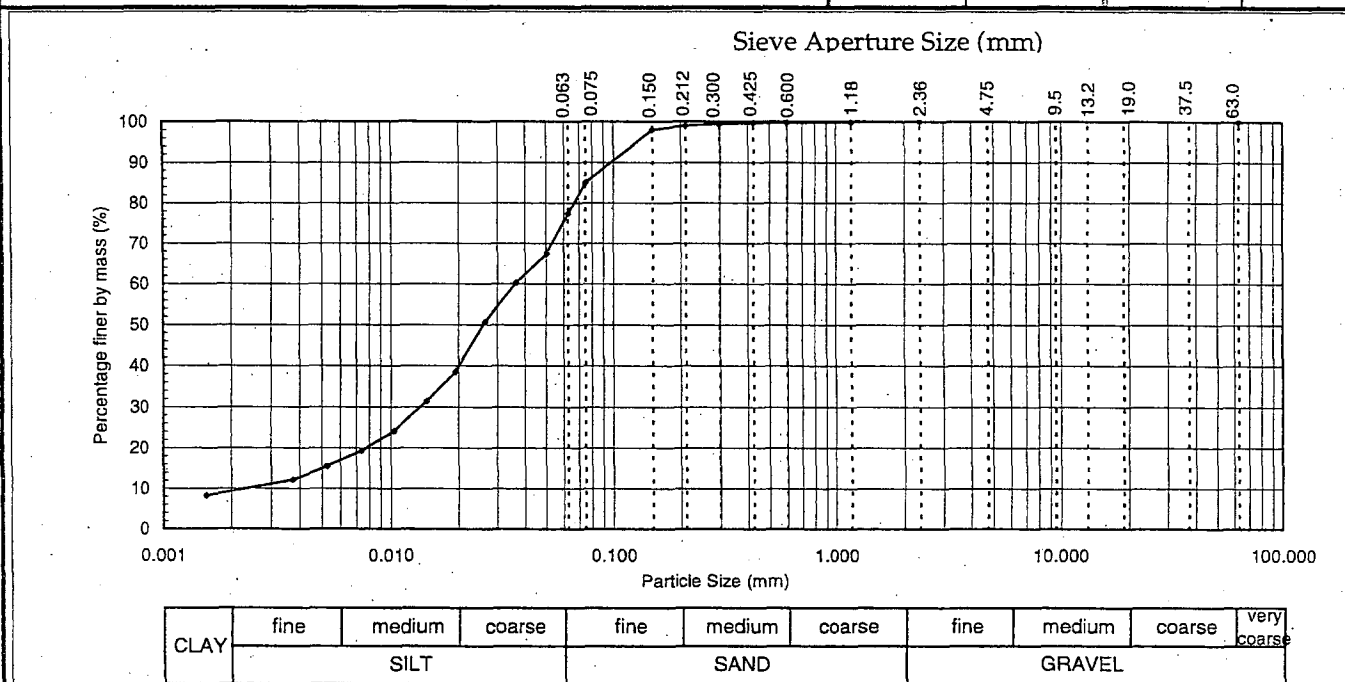
# PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



Project : 63 College Road  
 Location : Tauranga  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref :  
 Contractor :  
 Sample ID: HA 2 Depth: 0.80 metres  
 Sampled by : M. O'Halloran  
 Date received : 6/06/06  
 Sampling method : Small sample bag  
 Sample condition : As received  
 Sample description : Brown fine sandy SILT.  
 Solid Particle Density ( $t/m^3$ ): 2.65 Assumed  
 Water Content (as received): 48.9 %

Project No: 2-68229.82  
 Lab Ref No: 06/229/005  
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	99	0.0505	67	0.0074	19
37.5	--	2.36	100	0.212	99	0.0365	60	0.0053	15
19.0	--	1.18	100	0.150	98	0.0265	51	0.0037	12
13.2	--	0.600	100	0.075	85	0.0194	39	0.0016	8
9.5	--	0.425	100	0.063	77	0.0144	31	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0104	24		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 8/06/06

Sampling is not covered by IANZ Accreditation  
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Date Reported: 9/06/06

IANZ Approved Signatory   
 Designation : Senior Civil Engineering Technician  
 Date : 9/06/06



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 have been performed in  
 accordance with the  
 laboratory's scope of  
 accreditation

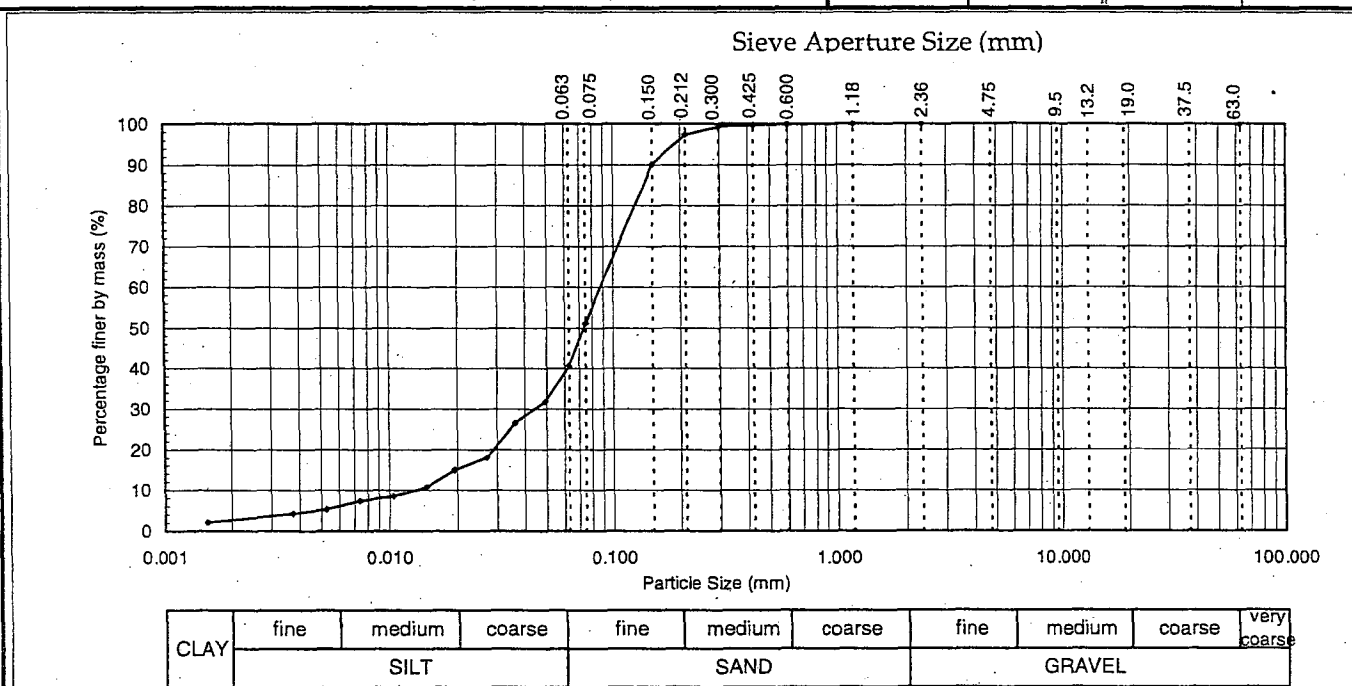
# PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT

Project : 63 College Road  
 Location : Tauranga  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref :  
 Contractor :  
 Sample ID: HA 2      Depth: 2.50 metres  
 Sampled by : M. O'Halloran  
 Date received : 6/06/06  
 Sampling method : Small sample bag  
 Sample condition : As received  
 Sample description : Brown silty fine SAND  
 Solid Particle Density ( $t/m^3$ ): 2.65      Assumed  
 Water Content (as received): 46.8 %



Project No: 2-68229.82  
 Lab Ref No: 06/229/005  
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	99	0.0494	32	0.0074	7
37.5	--	2.36	100	0.212	97	0.0362	26	0.0053	5
19.0	--	1.18	100	0.150	90	0.0271	18	0.0037	4
13.2	--	0.600	100	0.075	51	0.0195	15	0.0016	2
9.5	--	0.425	100	0.063	41	0.0146	11	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0104	8		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	pH of suspension : 8.0      Whatmans Full Range pH indicator paper

Date Tested: 8/06/06

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Date Reported: 9/06/06

IANZ Approved Signatory

Designation : Senior Civil Engineering Technician  
 Date : 9/06/06



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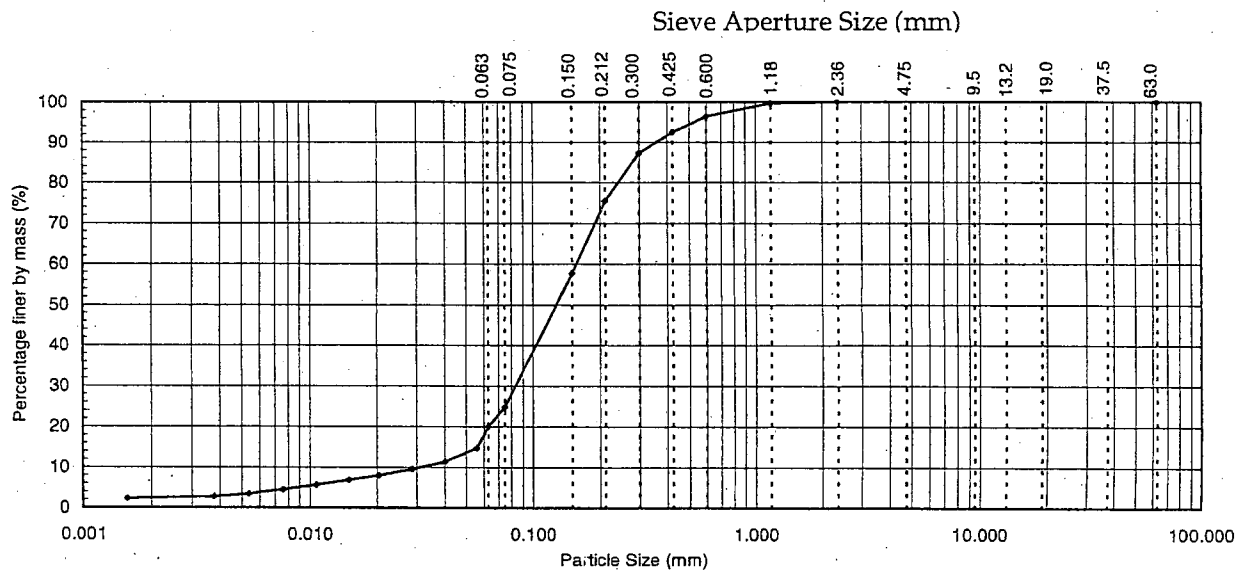
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)**  
**TEST REPORT**

Project : 63 College Road  
 Location : Tauranga  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref :  
 Contractor :  
 Sample ID: HA 4 Depth: 2.30 metres  
 Sampled by : M. O'Halloran  
 Date received : 6/06/06  
 Sampling method : Small sample bag  
 Sample condition : As received  
 Sample description : Lt grey silty fine-med SAND  
 Solid Particle Density (t/m<sup>3</sup>): 2.65 Assumed  
 Water Content (as received): 45.6 %

Project No: 2-68229.82  
 Lab Ref No: 06/229/005  
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	87	0.0559	15	0.0076	5
37.5	--	2.36	100	0.212	75	0.0402	11	0.0054	3
19.0	--	1.18	100	0.150	58	0.0287	10	0.0038	3
13.2	--	0.600	96	0.075	25	0.0205	8	0.0016	2
9.5	--	0.425	92	0.063	20	0.0150	7	--	--
						0.0107	6		

Note: "--" denotes sieve not used and/or hydrometer analysis not tested



CLAY	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	very coarse
	SILT			SAND			GRAVEL			

Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	pH of suspension : 8.0      Whatmans Full Range pH indicator paper

Date Tested: 8/06/06

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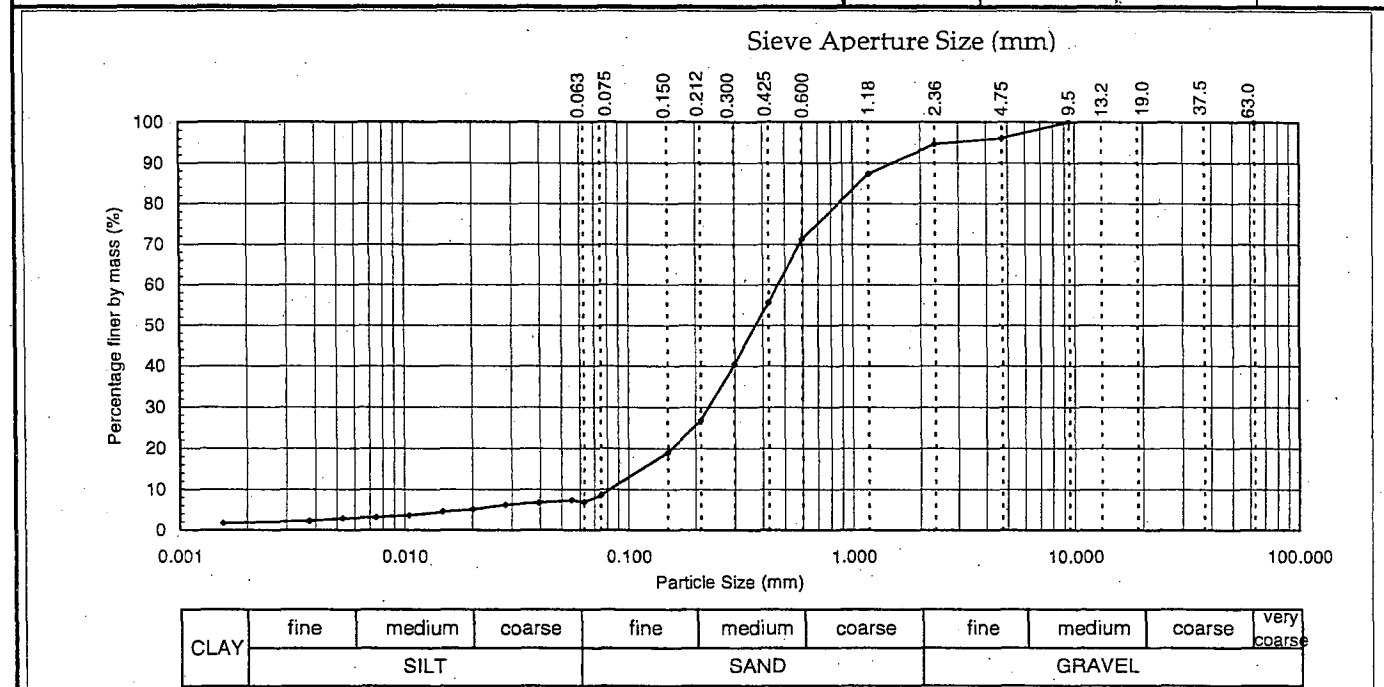
# PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



Project : 63 College Road  
 Location : Tauranga  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref :  
 Contractor :  
 Sample ID: HA 8 Depth: 2.60 metres  
 Sampled by : M. O'Halloran  
 Date received : 6/06/06  
 Sampling method : Small sample bag  
 Sample condition : As received  
 Sample description : Brownish grey silty pumiceous SAND  
 Solid Particle Density ( $t/m^3$ ): 2.65 Assumed  
 Water Content (as received): 44.2 %

Project No: 2-68229.82  
 Lab Ref No: 06/229/005  
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	96	0.300	40	0.0556	7	0.0075	3
37.5	--	2.36	95	0.212	27	0.0395	7	0.0053	3
19.0	--	1.18	87	0.150	19	0.0281	6	0.0038	2
13.2	--	0.600	71	0.075	8	0.0201	5	0.0016	2
9.5	100	0.425	56	0.063	7	0.0148	4	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0105	4		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	pH of suspension : 8.0    Whatmans Full Range pH indicator paper

Date Tested: 8/06/06

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# PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

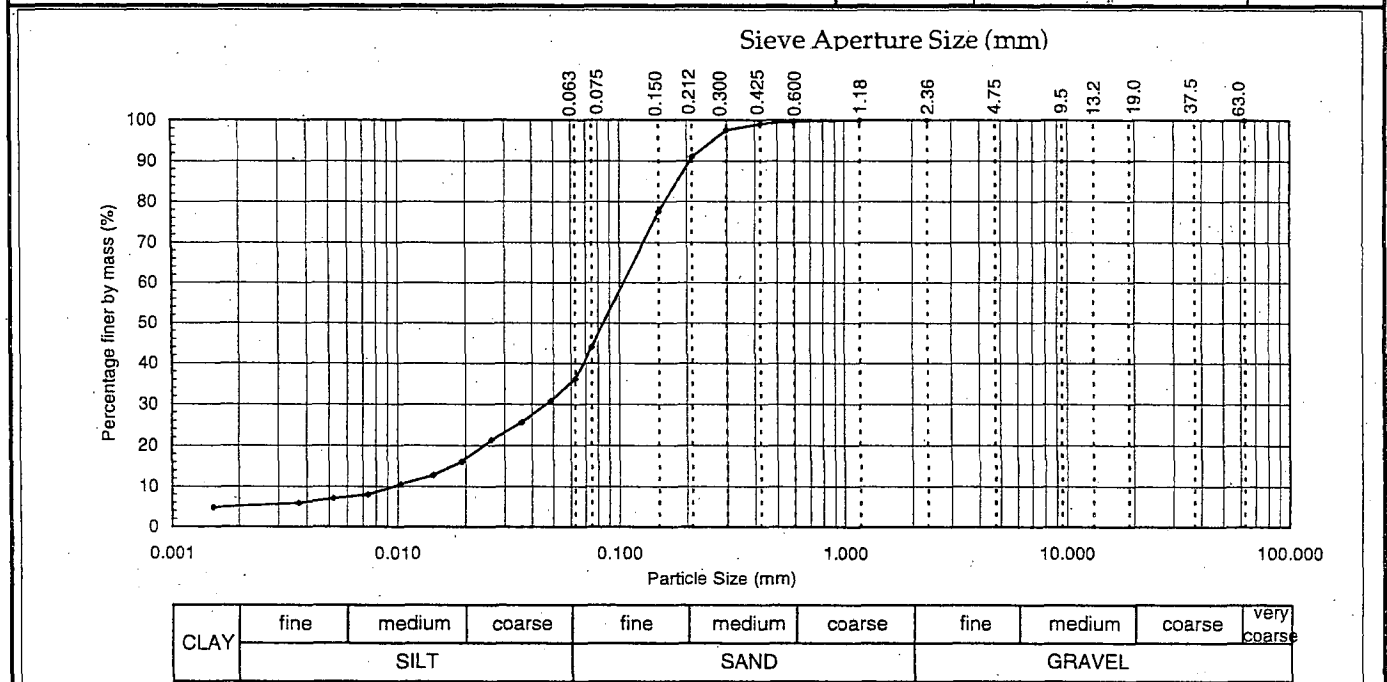
## TEST REPORT

Project : 63 College Road  
 Location : Tauranga  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref :  
 Contractor :  
 Sample ID: HA 10      Depth: 0.40 metres  
 Sampled by : M. O'Halloran  
 Date received : 6/06/06  
 Sampling method : Small sample bag  
 Sample condition : As received  
 Sample description : Greyish brown silty fine-med SAND  
 Solid Particle Density ( $t/m^3$ ): 2.65      Assumed  
 Water Content (as received): 30.2 %



Project No: 2-68229.82  
 Lab Ref No: 06/229/005  
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	98	0.0488	31	0.0074	8
37.5	--	2.36	100	0.212	91	0.0360	26	0.0052	7
19.0	--	1.18	100	0.150	78	0.0263	21	0.0037	6
13.2	--	0.600	100	0.075	44	0.0193	16	0.0015	5
9.5	--	0.425	99	0.063	36	0.0144	13	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0103	10		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	pH of suspension : 8.0      Whatmans Full Range pH indicator paper

Date Tested: 8/06/06

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 Designation : Senior Civil Engineering Technician  
 Date : 9/06/06



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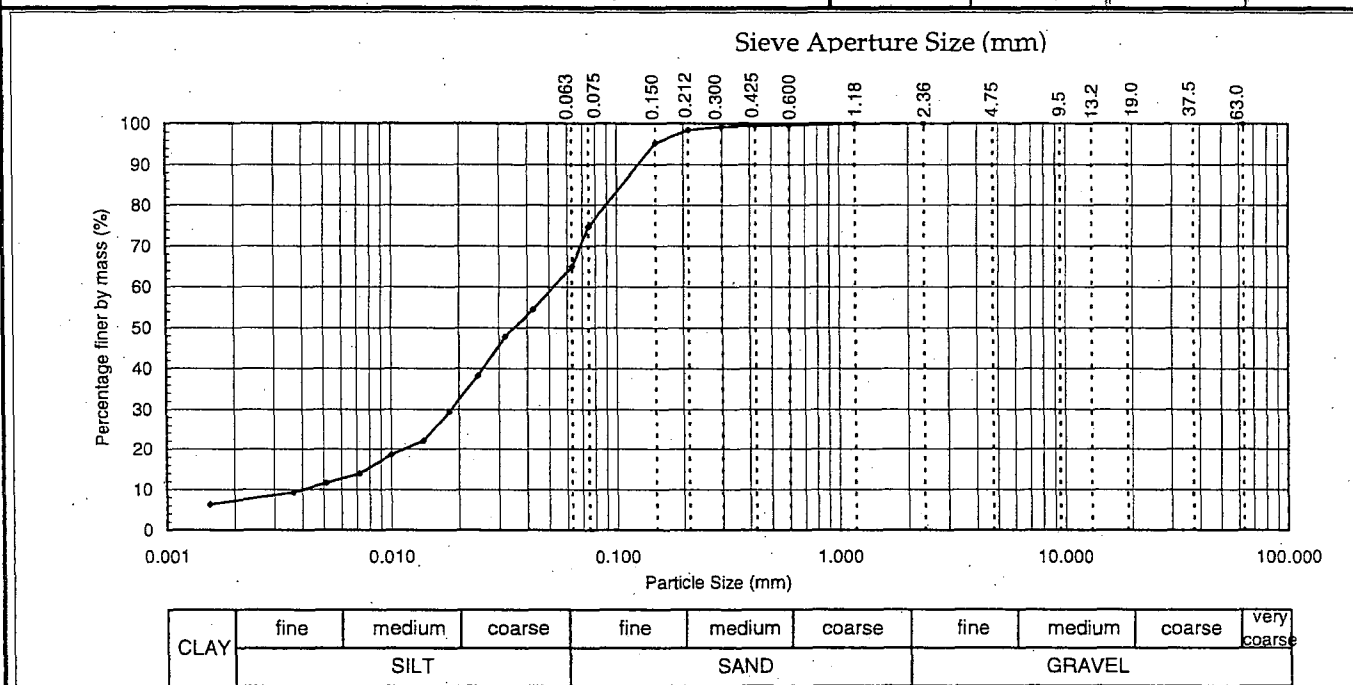
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)**  
**TEST REPORT**



Project : 63 College Road  
 Location : Tauranga  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref :  
 Contractor :  
 Sample ID: HA 10 Depth: 1.00 metres  
 Sampled by : M. O'Halloran  
 Date received : 6/06/06  
 Sampling method : Small sample bag  
 Sample condition : As received  
 Sample description : Greyish brown fine-med sandy SILT  
 Solid Particle Density (t/m<sup>3</sup>): 2.65 Assumed  
 Water Content (as received): 53.1 %

Project No: 2-68229.82  
 Lab Ref No: 06/229/005  
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	99	0.0428	54	0.0073	14
37.5	--	2.36	100	0.212	98	0.0320	48	0.0052	12
19.0	--	1.18	100	0.150	95	0.0243	38	0.0037	9
13.2	--	0.600	100	0.075	75	0.0182	29	0.0015	6
9.5	--	0.425	99	0.063	65	0.0139	22	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0100	19		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 8/06/06

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Date Reported: 9/06/06

IANZ Approved Signatory

Designation : Senior Civil Engineering Technician  
 Date : 9/06/06



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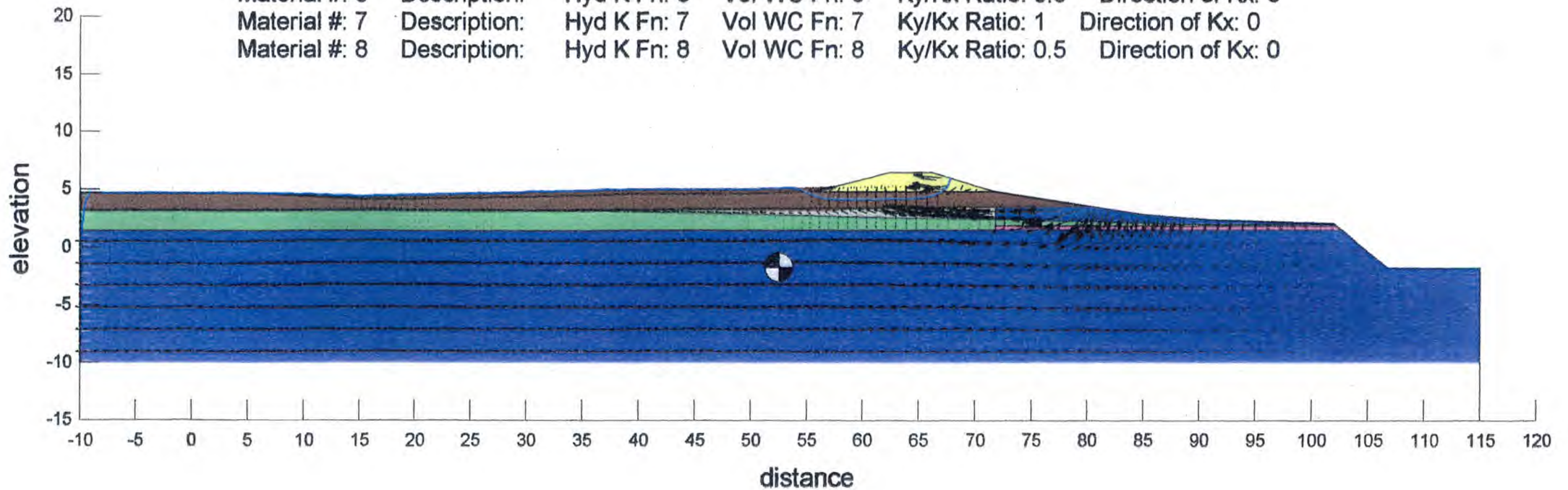
## **Appendix C**

### **Seepage Models**

Name: cross section 1 overlay 100 yr.gsz  
 Title: Rangitaiki Stopbanks 63A College Rd  
 Comments: Transient  
 Date: 19/07/2006 Time: 1:00:45 p.m.

time step 42 - 84 hours

Material #: 1	Description:	Hyd K Fn: 1	Vol WC Fn: 1	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 2	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 4	Description:	Hyd K Fn: 4	Vol WC Fn: 4	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 5	Description:	Hyd K Fn: 5	Vol WC Fn: 5	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 6	Description:	Hyd K Fn: 6	Vol WC Fn: 6	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 7	Description:	Hyd K Fn: 7	Vol WC Fn: 7	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 8	Description:	Hyd K Fn: 8	Vol WC Fn: 8	Ky/Kx Ratio: 0.5	Direction of Kx: 0

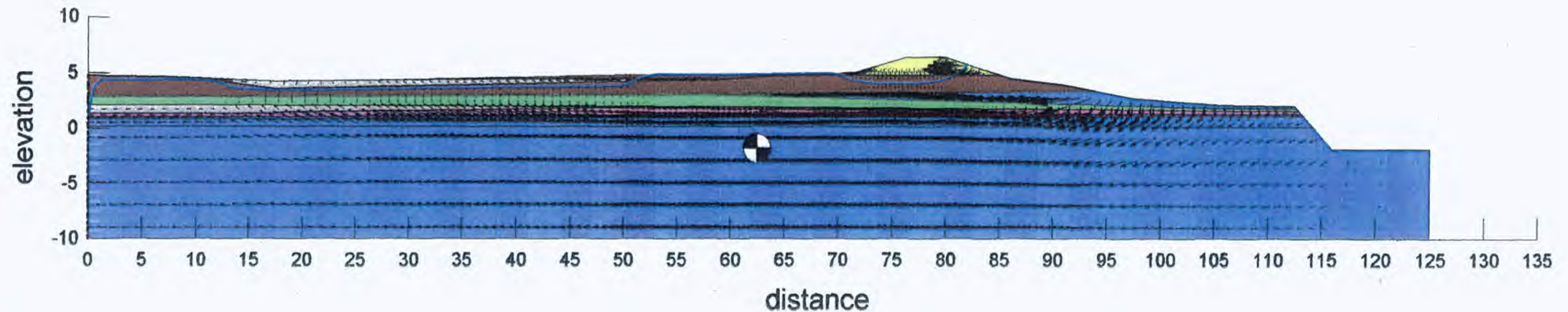




Name: cross section 2 overlay 100 yr.gsz  
 Title: Rangitaiki Stopbanks 63A College Rd  
 Comments: Cross Section 2 100 yr flood  
 Time: 2:24:14 p.m. Date: 19/07/2006

time step 48 - 96 hours

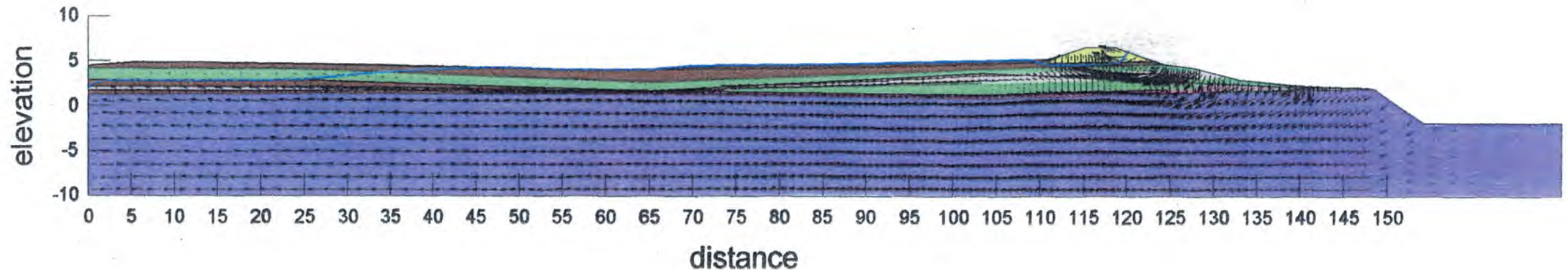
Material #: 1	Description:	Hyd K Fn: 1	Vol WC Fn: 1	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 2	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 4	Description:	Hyd K Fn: 4	Vol WC Fn: 4	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 5	Description:	Hyd K Fn: 5	Vol WC Fn: 5	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 6	Description:	Hyd K Fn: 6	Vol WC Fn: 6	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 7	Description:	Hyd K Fn: 7	Vol WC Fn: 7	Ky/Kx Ratio: 1	Direction of Kx: 0



Name: cross section 3 overlay 100yr.gsz  
 Title: Rangitaiki stopbanks 63A College Road  
 Comments: Cross Section 3 overlay 100yr  
 Date: 18/07/2006 Time: 4:26:25 p.m.

time step 42 - 84 hours

Material #: 1	Description:	Hyd K Fn: 1	Vol WC Fn: 1	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 2	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 4	Description:	Hyd K Fn: 4	Vol WC Fn: 4	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 5	Description:	Hyd K Fn: 5	Vol WC Fn: 5	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 6	Description:	Hyd K Fn: 6	Vol WC Fn: 6	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 7	Description:	Hyd K Fn: 7	Vol WC Fn: 7	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 8	Description:	Hyd K Fn: 8	Vol WC Fn: 8	Ky/Kx Ratio: 1	Direction of Kx: 0





Name: cross section 4 overlay 100yr.gsz  
 Title: Rangitaiki Stopbanks 63 A College Road  
 Comments: Cross section 4 100 yr flood  
 Date: 20/07/2006 Title: Rangitaiki Stopbanks 63 A College Road

time step 42 - 84 hours

Material #: 1	Description:	Hyd K Fn: 1	Vol WC Fn: 1	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 2	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 4	Description:	Hyd K Fn: 4	Vol WC Fn: 4	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 5	Description:	Hyd K Fn: 5	Vol WC Fn: 5	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 6	Description:	Hyd K Fn: 6	Vol WC Fn: 6	Ky/Kx Ratio: 1	Direction of Kx: 0

