

Rangitaiki River Stopbanks Assessment

Section 1

Left Bank 10300 to 10400m

Prepared for

Environment Bay of Plenty

February 2006



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1 Introduction

A breach occurred in the Rangitaiki River stopbank adjacent to Hydro Road in the storm of July 2004. Some other areas of seepage and potential problems were observed by Environment Bay of Plenty (EBoP) staff and locals during the storm. EBoP commissioned Ice Geo and Civil to carry out an assessment of potential problem areas within the stopbanks in 2005. The results of this assessment were presented in a report in September 2005. Twelve potential problem areas were identified. The length of stopbank considered most critical was along College Road in Edgecumbe (left bank 10300 to 10400m). Ice Geo and Civil has been commissioned by EBoP to investigate the risk and possible remedial measures for this length of stopbank.

This report presents the following information:

- the results of insitu investigations,
- laboratory tests results,
- 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 left bank of the Rangitaiki River from 10300 to 10400m.

2 Site Description

During the flood of July 2004 the residents of 35 College Road described the lawn as being like jelly to walk on. This suggests high water pressures under the upper soil layers. The water level was up to the top of the stopbank during the flood and the occupants were evacuated. The property was covered in water to about ankle deep. As the house is in a slight depression it is not clear whether the water was due to surface ponding or due to seepage from under the stopbank. Some erosion occurred under a concrete slab at the back of the property between the house and the stopbank. This formed a hole about 300mm deep. Repairs had been carried out before the site was visited. It is possible that the erosion was caused by seepage flow under the stopbank being concentrated at a point of low resistance at the edge of the slab.

This is the first property downstream from a section of stopbank which, due to a lack of space between the river and College Road, has a concrete flood wall at the top and toe wall on the land side. The top of the stopbank at this property is at RL6.9, about 2m above the adjacent ground level. The river berm was eroded away during the July 2004 flood and rock rip rap has been placed to prevent further erosion. The river berm in this area slumped in the 1987 earthquake. The house is on short timber piles and some movement has been noticed after the 2004 flood.

Now that the river berm has been eroded away the seepage path to the back of the property is only 15m long (Figure 2). The fact that there appears to have been high water pressure under the front lawn as well as the back suggests that there is a highly permeable layer extending under the house.

In the flood in 1998 there was seepage under the concrete wall just upstream from the property. Investigations carried out by Opus International Consultants Ltd showed layers of sandy fill, silt and peat with coarse sand at 7.0m depth. The short seepage path through the sandy layers appeared to have caused the seepage problem and a toe drain was recommended and has been constructed.

Early aerial photographs suggest a depression or old river channel at the College Road site. The residents recall a river channel along what are now Kowhai St and Rata Road. The presence of an old river channel is another reason for suspecting a high permeability cohesionless layer below ground level.

3 Subsurface Investigations

The insitu investigations consisted of six hand augers and two machine boreholes. The hand augers continued to a layer of sandy fine pumice lapilli which caused collapse of the holes at 3.4 to 4.6m depth. The fully cored boreholes extended to 12m depth. There was some loss of sample in the boreholes due to the loose cohesionless nature of many of the soil layers. Figure 1 shows the location of the holes and the logs are included in Appendix A. BH1 was beside HA3 and BH4 beside HA4. The boreholes were carried out after the initial seepage analyses to provide information on the thickness of the lapilli rich layer as this has a significant influence on possible remedial measures.

Figures 2 to 4 show the assumed soil profiles of three sections through the stopbank. The sections were surveyed by EBoP staff. Figure 5 shows an approximate long section along hand augers 1, 3 and 5. The surface soil layer was found to be a grey/brown silt, 0.6 to 1.1m thick, underlain by a higher permeability silty fine sand. Within the upper silt layer is a layer of gritty Tarawera Ash. In hand augers 1 and 2 at 35 College Road the silt layer was 0.8 and 0.7m thick respectively. The thinnest silt layer was found in the neighbouring property (HA3). Below the silty fine sand is typically another silt layer about 0.3m thick.

There was found to be considerable variation in the soil layers below the second silt layer in the hand auger holes. A fine pumice sand was found in HA1, HA2, HA5 and HA6. In HA4 there appeared to be a hole in the ground at about the depth that the sand layer would be expected. There was considerable core loss at this depth in the machine borehole but it is considered that the layer consists of loose sand and lapilli. Below the fine sand are layers of sandy silts, silty sands and silts (some containing organic material).

A layer of sandy pumice lapilli was found in all the holes at between 3.0 and 3.95m depth. HA5 was different to the remaining five hand augers in that there are no low permeability layers between the top of the fine sand at 1.4m depth and the pumice lapilli layer at 3.8m depth. Fortunately at this location the upper silt layer is 1.1m thick. The fine sand layer was also very thick in

HA6, between HA5 and the stopbank. In this hand auger there was about 400mm of organic silt between the fine sand and the lapilli.

The machine boreholes showed that the lapilli layer extends to 6.5 to 6.9m depth in 37 College Road. There are some pockets of organic material within the layer. The lapilli are underlain by a pumiceous silt containing organic material, peat and clayey silt. A coarse sand was found at over 11m depth.

The ground water level was at 3.8 to 4.0m depth when the hand augers were carried out in November.

4 Laboratory Test Results

Hydrometer particle grading tests were carried out on four samples from the hand augers (Appendix B). These were to provide information on the permeability of the soil layers. The results and assumed permeabilities based on Hazen's formula are summarised in Table 1.

Table 1: Particle Grading Results

Sample	Description	D ₁₀ (mm)	D ₆₀ (mm)	permeability
HA1 0.9m	light grey sandy silt	0.011	0.075	1.2×10^{-6} m/s
HA1 1.2m	light grey silt	0.0048	0.031	2.3×10^{-7} m/s
HA2 3.3m	light grey silty gravelly sand	0.011	0.8	1.2×10^{-6} m/s
HA5 2.0m	light grey silty sand	0.015	0.09	2.25×10^{-6} m/s

A solid particle density test was also carried out on the fine sand from HA5 to provide data for assessing the piping potential of cohesionless soils. The solid particle density was found to be only 2.44 t/m^3 . This low density is a result of the pumiceous origin of many of the soils.

5 Analyses

5.1 Flood Hydrograph

EBoP has provided a 100 year return period flood flow hydrograph for the Rangitaiki River at their benchmark number 25, which is at the site (Figure 6). This is an eight day hydrograph which rises to a peak of RL6.35 on the third day of the flood. This would allow about 0.55m of freeboard at the site. During the July 2004 the residents say the water was lapping at the top of the stopbank. In the 100 year flood the water level stays close to the peak level for two days before beginning to drop.

5.2 Soil Model

The soil layers found in the hand augers were simplified in the models used in the seepage and stability analyses (Figure 7). The thin layers of silts, silty sands and sandy silts were modelled as one layer with a representative

horizontal permeability but a lower vertical permeability. Table 2 summarises the saturated soil parameters assumed. Some sensitivity analyses were carried out varying the permeabilities and vertical to horizontal permeability ratios.

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.

Table 2: Assumed Soil Permeabilities

layer	soil	k_h (m/s)	k_v (m/s)	k_v/k_h
1	stopbank fill	2×10^{-6}	1×10^{-6}	0.5
2	brown silt	5×10^{-7}	5×10^{-7}	1.0
3	layered sandy silt/silt/silty sand	1×10^{-5}	5×10^{-6}	0.5
4	fine sand	5×10^{-5}	5×10^{-5}	1.0
5	silty fine sand	2.5×10^{-6}	2.5×10^{-6}	1.0
6	silt with organics	2.5×10^{-7}	2.5×10^{-7}	1.0
7	sandy lapilli	1×10^{-4}	1×10^{-4}	1.0
8	pumiceous silt	5×10^{-7}	5×10^{-7}	1.0
9	peat	2.5×10^{-7}	2.5×10^{-7}	1.0
10	coarse sand	1×10^{-4}	1×10^{-4}	1.0

5.3 Cross Section 1

Seepage

Cross Section 1 is through 35 College Road. An initial static seepage analysis was carried out assuming the ground water level and river water level were at RL2.2 as at the start of the 100 year flood hydrograph. 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.

At about 3.5 days it was found that the water pressure below the upper low permeability silt layer at the inland toe of the stopbank was 11.5kPa. At the location of the scour hole that appeared in July 2004 (approximately 10m from the toe of the stopbank) the predicted pressure was 11kPa. The silt layer probably has a density of 15.5 to 16kN/m³. At this cross section the layer was found to be 0.7 to 0.8m thick, therefore the factor of safety against heave of the silt layer is less than 1.0. This confirms the jelly-like description of the soil given by the residents in the July 2004 flood.

The analysis model allows some seepage from the ground surface which reduces the pressure build up below the low permeability silt layer. Where there is an impermeable concrete slab at the ground surface water pressure could become higher. This build up in pressure could be the reason for the observed flow and loss of soil from the edge of the concrete slab in July 2004.

A sensitivity analysis was carried out to estimate the river level at which the factor of safety against heave would become less than 1.0. It was found that if the river remains at RL5.8 or higher for more than one day there could be heave problems.

At the toe of the stopbank the maximum hydraulic gradient was found to be 0.7. This is close to the critical gradient for pumice sands and silts with a specific gravity of 2.44 which is 0.75.

Sensitivity analyses were carried out reducing the permeability of the fine sand to 1×10^{-5} m/s and reducing the vertical permeability in the layered soil to 1/10 the horizontal permeability. Both these analyses showed that heave would still be a problem.

Remedial Measures

The easiest remedial measure for heave problems is the addition of weight to the ground surface, however at this site there is a house and garage.

A pressure relief trench extending to the fine sand was modelled. This produced only a marginal reduction in uplift pressure out from the toe of the stopbank.

An alternative to a pressure relief trench is a low permeability cut off trench below the stopbank to virtually prevent flow from the river to the upper soil layers. It was found that a cut off down to RL1.5, 3.5m below natural ground level, would reduce the pressure head below the upper silt to an acceptable level. The problem with a cut off system is that in normal winter conditions it will prevent drainage of the upper soil layers towards the river and could cause surface flooding behind the stopbank.

From the discussion above it appears that a soil overlay across 35 College Road remains the best option for improving the safety of the stopbank. A factor of safety against heave of 1.2 should be obtained with a 500mm overlay over 700mm of insitu silt. If the silt layer is 600mm thick the factor of safety should still be over 1.1. The maximum hydraulic exit gradient appears to be reduced to about 0.3 by the overlay. The overlay would have to extend to 25m from the inland toe of the stopbank. This would encroach on the house. The house is on short timber piles and could be lifted but the garage, driveway etc. would have to be demolished.

The overlay should extend laterally at least to the boundary with 37 College Road. Due to all the structures and trees at the back of 37 College Road there is little scope for further tests between 35 College Road and HA3. The overlay could be extended between the back boundary of 37 College Road and the toe of the stopbank until approximately level with HA3.

To prevent ponding on 35 College Rd the overlay should be tapered to the road boundary. An effort should be made to reduce the run-off along the boundary onto 37 College Rd.

Stability

Stability analyses have been carried out on the river side of the stopbank assuming the soil parameters given in Table 3:

Table 3: Assumed Soil Parameters

layer	soil	density (kN/m ³)	effective cohesion (kPa)	friction angle (degrees)
1	stopbank fill	16	2	33
2	brown silt	15.5	5	27
3	layered sandy silt/silt/silty sand	15.5	2	30
4	fine sand	14	0	35
5	silty fine sand	15.5	2	30
6	silt with organics	15.5	5	27
7	sandy lapilli	15	0	35

Table 4 summarises the analyses carried out and the lowest factors of safety obtained for failures which reach the crest of the stopbank.

Table 4: Assumed Soil Parameters

analysis	time	river level	FOS
peak flood	92 hrs	6.3m	1.9
draw down	120 hrs	5.0m	1.7
end of flood	192 hrs	4.6m	1.3

It can be seen from Table 4 that the lowest factor of safety occurs at the end of the flood when water is flowing out of the stopbank towards the river. A factor of safety of 1.3 is considered acceptable for this situation especially as the soil model used does not take into account the rip rap that has been placed on the river bank.

5.4 Cross Section 2

A seepage analysis has been carried out for Cross Section 2 through 37 College Road. The main difference between this cross section at that at 35 College Road is the absence of the fine sand layer at about 2.5m depth. Figure 8 shows the ground water level in Cross Section 2 at the same time step as that at Cross Section 1 in Figure 7. It can be seen that the absence of the sand layer has reduced the rise in the water level. The maximum pressure found below the upper silt layer was 5kPa. Therefore no problems are expected at this location and none were reported by the occupants of the house.

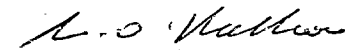
5.5 Cross Section 3

Figure 9 shows the seepage response of a cross section through 39 College Road at 90 hours. The maximum pressure head below the upper silt layer was found to be 11.5kPa. As the silt layer here was found to be at least 900mm thick the factor of safety against heave is above 1.2.

The maximum exit hydraulic gradient at the toe of the stopbank is about 0.4. It is therefore considered that no work needs to be carried out at this location.

6 Conclusions

1. The investigations and analyses carried out confirm that there is a potential problem with the stopbank at 35 College Road. It appears possible that had the stopbank not failed at Sullivan's Breach in the July 2004 flood it could have failed in College Road. The unfavourable seepage conditions in this area were probably exacerbated by the erosion of the river bank during the July flood. This has left the stopbank in a more vulnerable state than it was.
2. The seepage analyses suggest that heave problems could be experienced at 35 College Road if the river remains at or above RL5.8 for more than one day.
3. It appears from the analyses that the most viable way to improve the safety of the stopbank is to place a minimum 25m wide, 500mm thick overlay across 35 College Road and a narrower overlay between the back boundary of 37 College Road and the toe of the stopbank. This will involve some demolition work and raising of the house at 35 College Road.



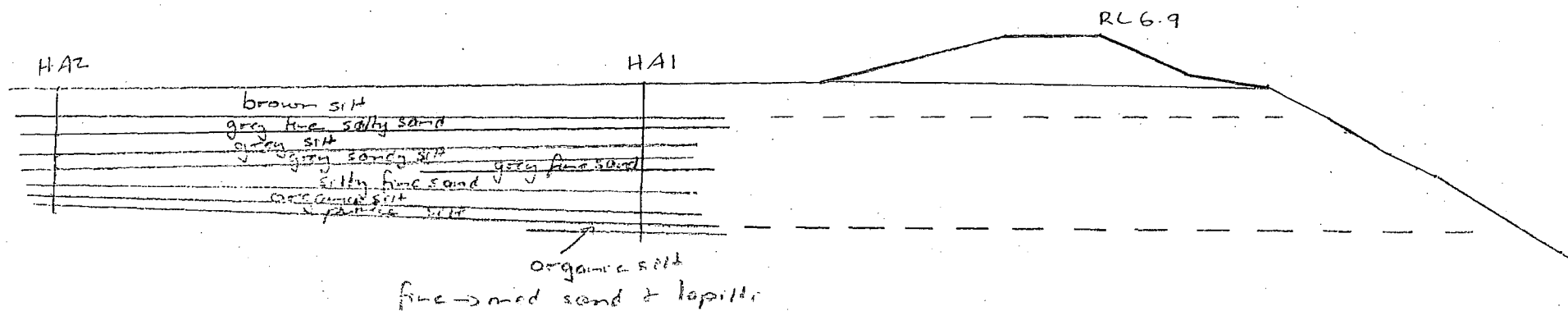
M. O'Halloran

BE, PhD, Dip BA, MIPENZ (Geotechnical), CPEng IntPE

February 2006



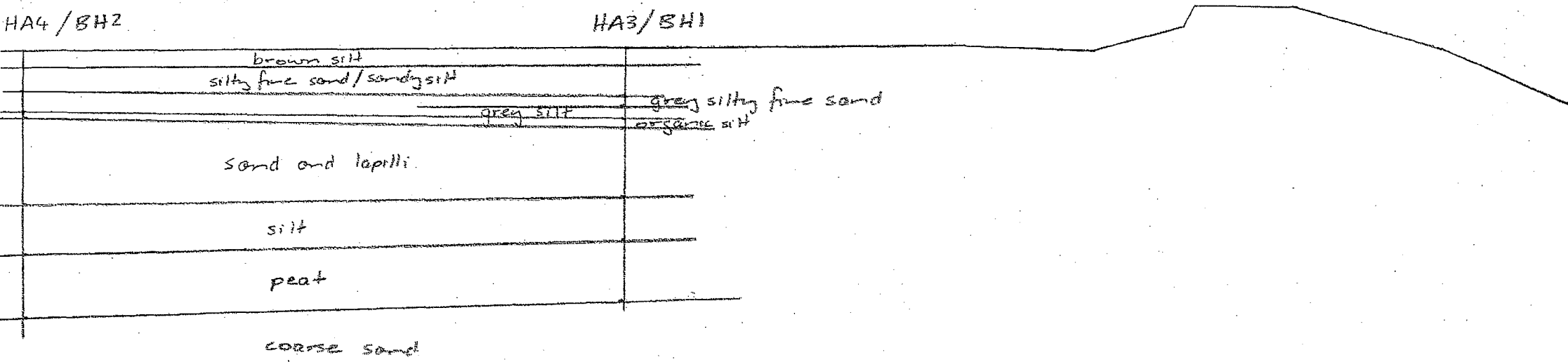
Plan showing hand auger locations



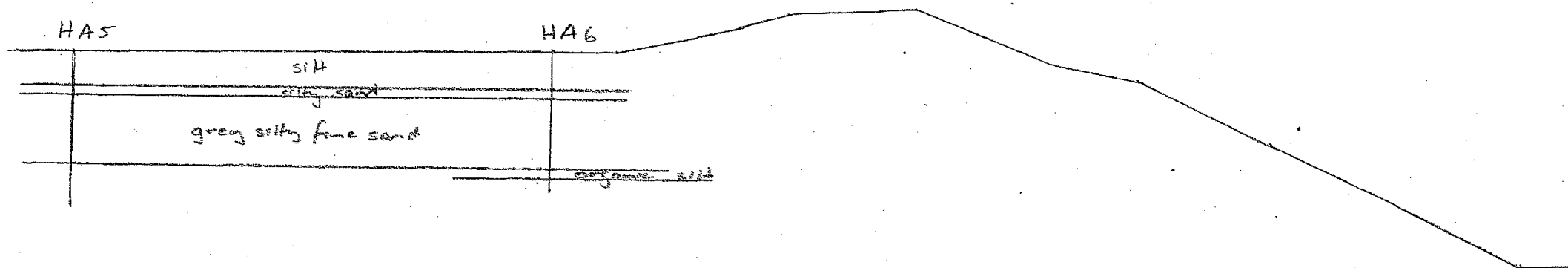
Cross Section 1
Scale 1:200

Rangitaiki River Stopbank
Section 1 LB 10300-10400m

Figure 2



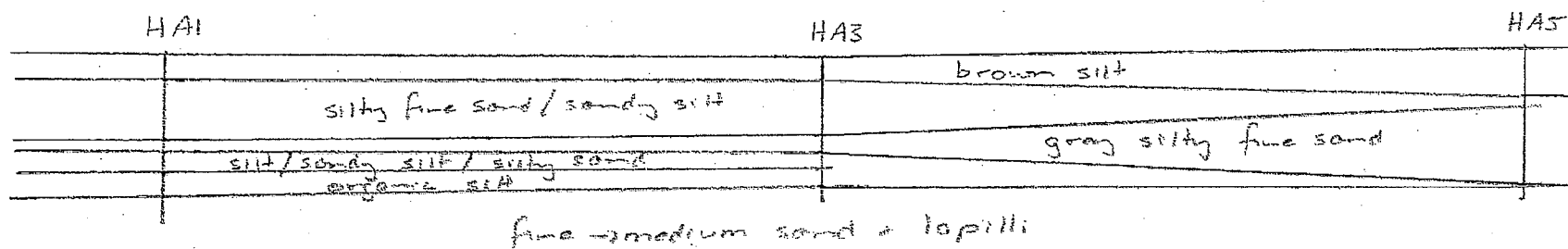
Cross Section 2
Scale 1:250



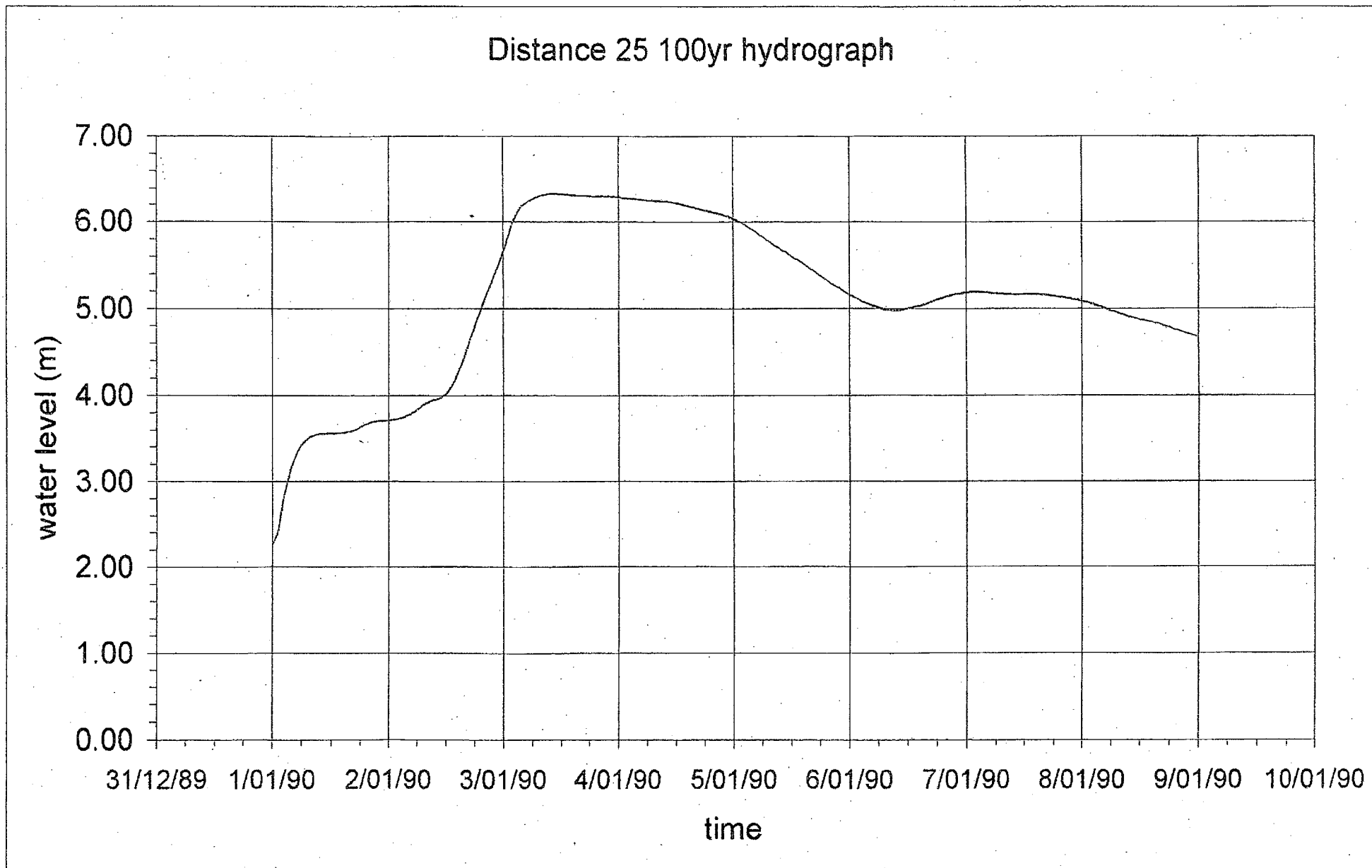
Cross Section 3
Scale 1:250

Rangitaiki River Stopbank
Section 1: LB 10300-10400m

Figure 4



Long Section
Scale H1:400
V1:200



Distance 25 - 100 year flood flow hydrograph
Figure 6

Title: Rangitaiki Stopbanks Section 1
 Comments: Cross Section 1 100 yr flood
 Name: cs1 extended 100 yr.gsz
 Date: 03/03/2006 Time: 1:55:07 p.m.

100 year flood at 90 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: 0.5	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: 1	Direction of Kx: 0
Material #: 8	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0

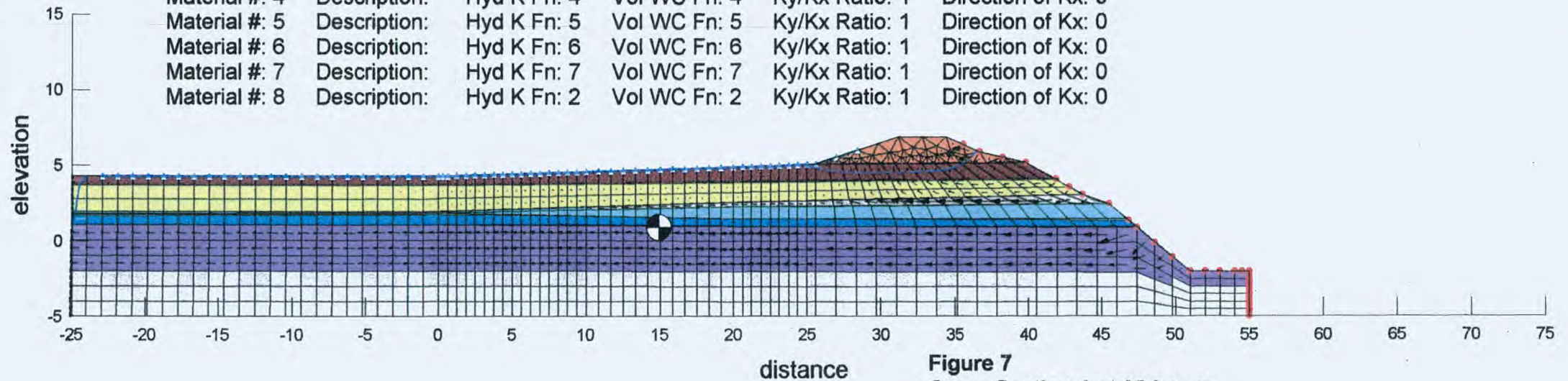
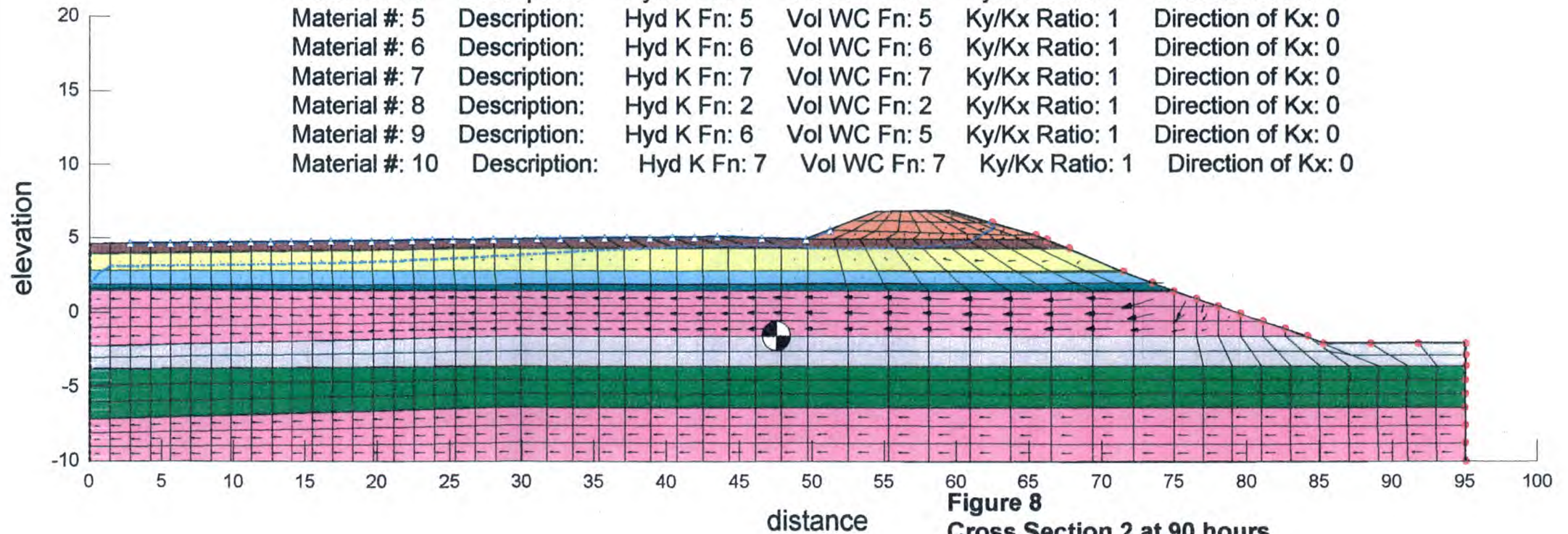


Figure 7
 Cross Section 1 at 90 hours

Title: Rangitaiki Stopbank Section 1
 Comments: Cross Section 2 100 yr flood
 Name: cs2 100 yr.gsz
 Date: 03/03/2006 Time: 1:27:18 p.m.

100 year flood at 90 hours

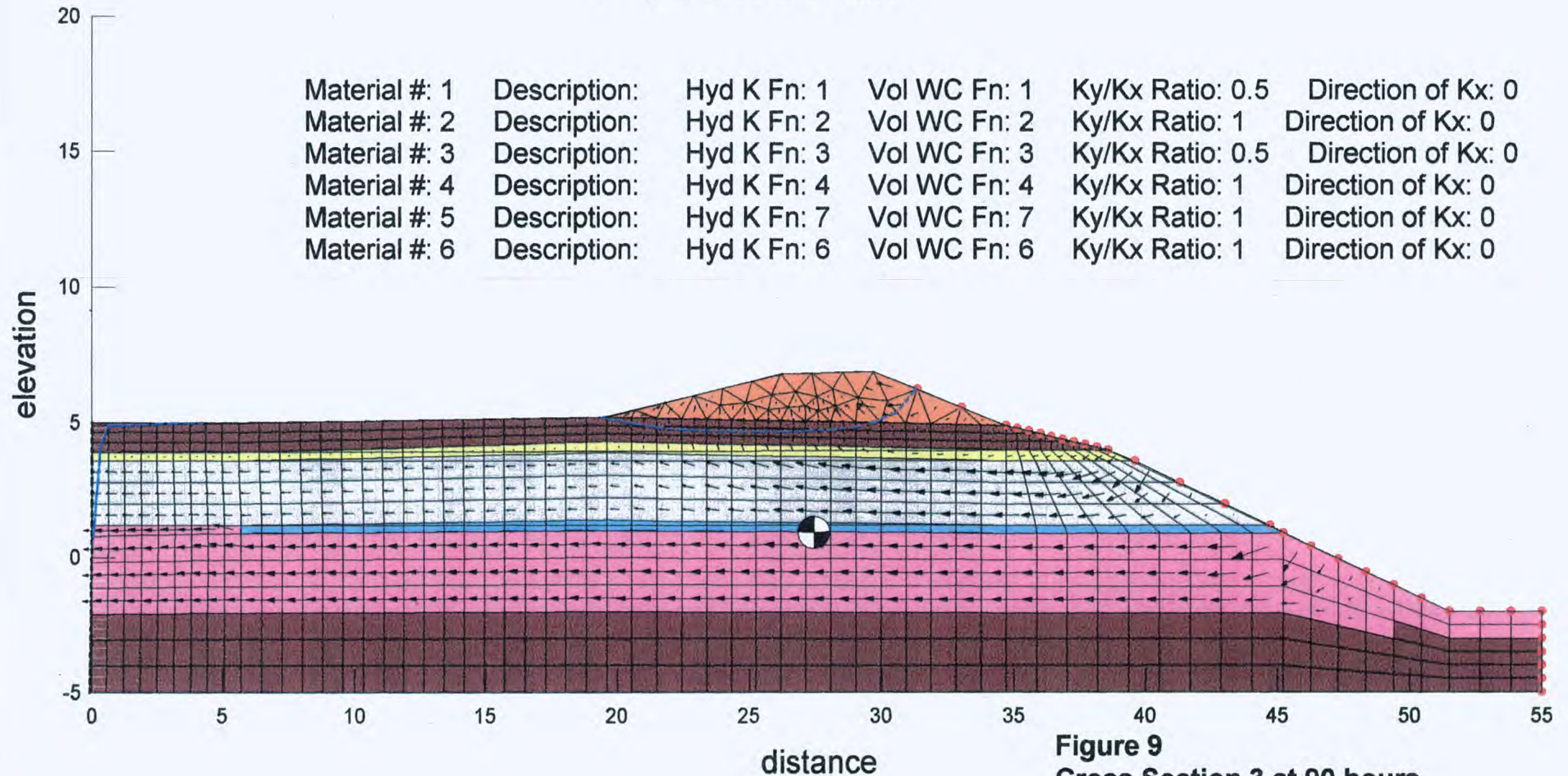
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Material #: 2	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #: 0	Description:	Hyd K Fn: 0	Vol WC Fn: 0	Ky/Kx Ratio: 1	Direction 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: 1	Direction of Kx: 0
Material #: 8	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 9	Description:	Hyd K Fn: 6	Vol WC Fn: 5	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #: 10	Description:	Hyd K Fn: 7	Vol WC Fn: 7	Ky/Kx Ratio: 1	Direction of Kx: 0



Title: Rangitaiki Stopbanks Section 1
 Comments: Cross Section 3 100 yr flood
 Name: cs3 100 yr.gsz
 Date: 03/03/2006 Time: 5:07:24 p.m.

100 year flood at 90 hours

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Material #: 3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 0.5	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: 7	Vol WC Fn: 7	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



Appendix A

Hand auger logs

Hand Auger Log

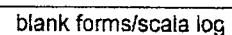
Test Number: HAI

Job Name: Rangitikei Section 1

Date: 10/11/05

Tested by: M.O.H

Blows/50mm												Cu(kPa)	soil description
m	0	2	4	6	8	10	12						
0.2												X X	brown fine sandy SILT
0.4												X X	0.3 grey brown SILT,
0.6												X X	some grit (Taranaki Ash?)
0.8												X X	damp, firm
1.0												X X	0.8 light grey with orange
1.2												X X	staining fine sandy SILT
1.4												X X	damp
1.6												X X	1.2 light grey with orange
1.8												X X	staining, SILT, some fine sand
2.0												X X	moist
2.2												X X	1.6 as 0.8m
2.4												X X	1.7 as 1.2m
2.6												X X	1.8 as 0.8m moist
2.8												X X	2.3 light grey fine SAND, wet
3.0												X X	2.6 light grey silt, moist
3.2												X X	2.7 grey silty formed SAND, wet
3.4												X X	2.9 grey silty fine SAND, wet
3.6												X X	3.3 brown/grey SILT, some organic, wet
3.8												X X	3.6 grey firm SILT with some
4.0												X X	fine particles
												X X	3.8 some green grey clayey SILT, org.
												X X	smaller green grey clayey fine
												X X	sandy SILT
												X X	3.9 grey formed firm SAND & fine
												X X	lumps
												X X	4.2 brown organic clayey SILT
												X X	blank forms/scale log
												X X	4.3 grey med. firm SAND
												X X	4.4 firm



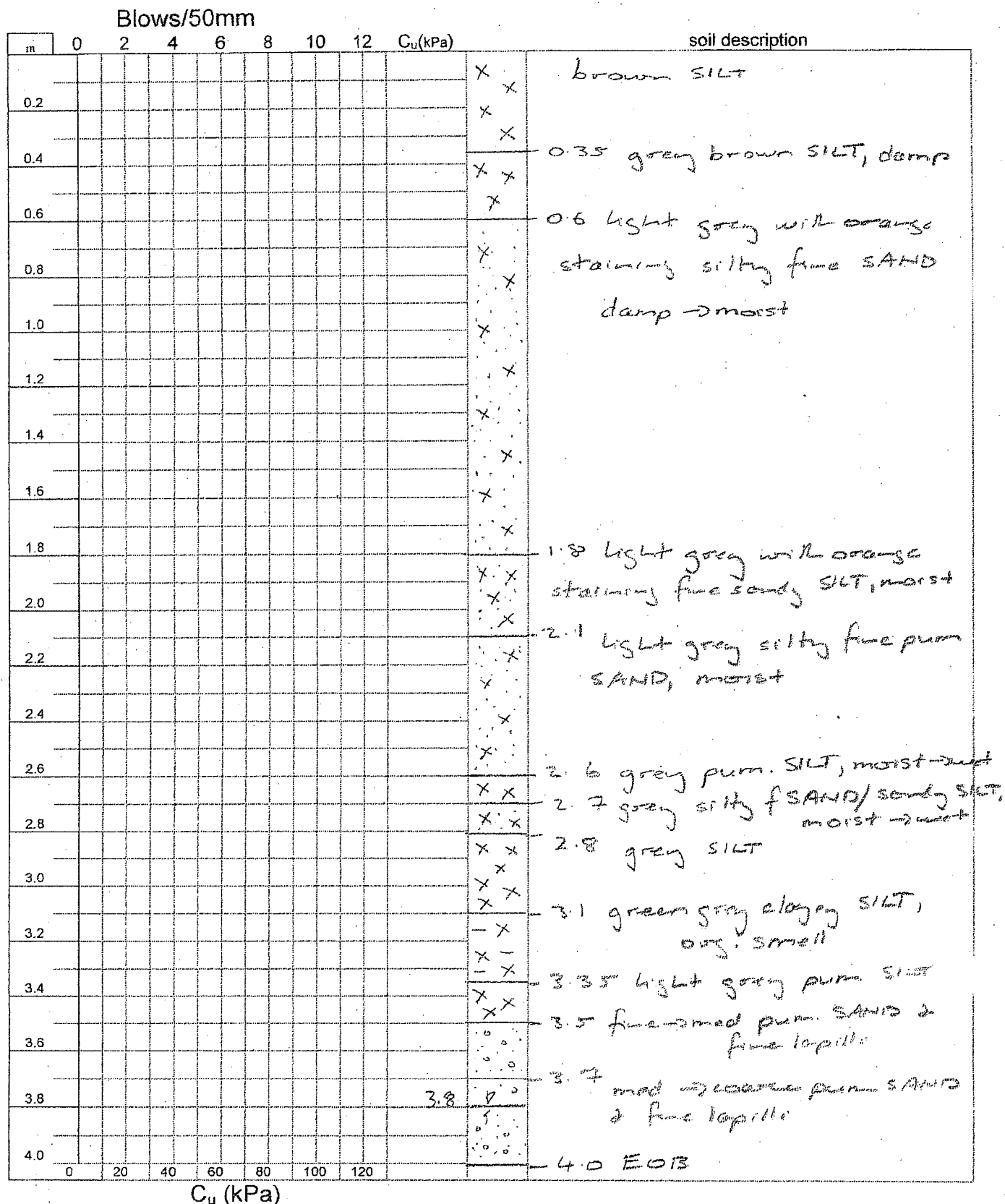
Hand Auger Log

Test Number: HA3

Job Name: Rangitiki Section 1

Date: 10/11/05

Tested by: M.O.H



Hand Auger Log

Test Number: HA 4

Job Name: Rangitikei Section 1

Date: 10/11/05

Tested by: M.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C _u (kPa)						
													X X	brown SILT
0.2													X	0.2 brown fine silty SAND
													X	0.3 brown silty SILT, Tararua Ash
0.4													X X	0.4 grey / brown SILT, damp
													X X	
0.6													X	
													X Y	0.7 orange stained grey
0.8													X X	fine sandy SILT
													X	
1.0													X	
													X	1.1 orange stained grey
1.2													X X	SILT, damp
													X	
1.4													X	1.45 orange stained grey f sandy SILT
													X X	1.55 orange stained grey silty
1.6													X	fine SAND
													X	1.8 light grey SILT,
1.8													X X	hole 1.9 → 2.1 ?
2.0													X X	v. loose ?
													X	tree root hole ?
2.2													X	some organic staining.
													X	
2.4													X	
													X	2.7 green grey clayey SILT, soft
2.6													X	2.9 light grey pum. SILT
													X	3.0 med. pum. SAND + fine
2.8													X	lapilli, wet
													X X	3.2 coarse pum. SAND +
3.0													X X	fine lapilli, wet
													X	3.4 EOB
3.2													X	
													X	
3.4													X	
													X	
3.6													X	
													X	
3.8													X	
													X	
4.0													X	

C_u (kPa)

Hand Auger Log

Test Number: HAS

Job Name: Rangitiki Section 1

Date: 10/11/05

Tested by: M.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C _u (kPa)						
													X	brown silt
0.2													X	0.2 some Toromiro Ash
													X	
0.4													X	
													X	
0.6													X	0.6 light brown/grey silt;
													X	some fine lapilli; damp
0.8													X	0.7 no lapilli
													X	
1.0													X	
													X	
1.2													X	1.1 orange stained light
													X	grey silty f SAND/sandy
1.4													X	silt, damp
													X	
1.6													X	1.4 grey silty fine SAND
													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	3.0 moist
													X	
3.2													X	
													X	
3.4													X	
													X	
3.6													X	3.5 fine purple lapilli; wet
													X	
3.8													X	
													X	
4.0													X	
													X	4.1 EOL

Record of Borehole					Sheet 1 of 2		BH 1			
Job Name: Rangitikei Stopbanks Section 1				Location: 37 College Rd by HA3						
Client: EBoP				Coordinates:		Datum				
Elevation:										
depth (m)	logged	symbol	% recovery	Strata	sample		field tests			lab test
				description	depth (m)	type	SPT	vane	other	
10	✓ x		100	dark brown org. SILT, topsoil	0.9	*				
	x ✓	0.3 brown/grey SILT								
	x x	0.8 orange stained grey fine sandy SILT								
	x x	1.4 orange stained grey silty fine SAND, sensitive								
20	x x		100	2.1 grey SILT, sensitive	2.2	*				
	x x	2.5 30mm fine lapilli rich layers								
	x x	2.7 brown SILT, with some organic & clay								
	x x	2.9 orange staining some green grey SILT, some clay, sensitive								
30	x x		100	3.1 grey SILT, sensitive						
	x x	3.3 orange stained light grey SILT								
	x x	3.33 orange stained well graded SAND & fine lapilli → 1mm								
	x x	3.6 → 5.1 lost								
40	x x		100	Loose sand & purple lapilli → 8mm						
	x x	5.1 organic fibres in loose sand & lapilli								
	x x	5.2 timber								
	x x	5.3 brown & grey SILT								
50	x x		100	5.5 bonded grey fine SAND & loose lapilli → 15mm, bands 20 → 50mm	5.8	*				
	x x	50/50 sand/lapilli, some charcoal fragments								
	x x	6.0 - 6.4 lost								
	x x									
60	x x		100							
	x x									
	x x									
	x x									

Observations	Samples * small disturbed b large bag tube sample	Field Tests SPT blows/150mm, N blows/300mm C direct shear vane reading Cr remoulded shear vane Cc corrected shear vane
Pilon Vane		
Date started: 17/2/06	core dia: 68mm	Rig: Kibota
Date finished: 17/2/06	logged by: M.O.H.	Contractor: Perry

Ice Geo & Civil Ltd

Record of Borehole					Sheet 1 of 2		BH 2			
Job Name: Rongitakei Stopbanks Section 1				Location: 37 College Rd by HA4						
Client: ERBP				Coordinates:						
				Elevation: Datum						
depth (m)	logged	symbol	% recovery	Strata	sample		field tests			lab test
				description	depth (m)	type	SPT	vane	other	
10	X X		100	orange brown fine sandy silt						
	X X			0.25 Tarawera Ash						
	X X			0.3 orange mottled grey silt						
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
20	X X		75	1.2 orange mottled grey fine sandy silt						
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
30	X X		80	1.9 light grey with orange staining silt, sensitive						
	X X			2.4 becoming brown/grey						
	X X			2.7 green grey clayey silt						
	X X			2.95 pinkish light grey firm silt						
	X X			3.0 pumice lapilli → 8mm?						
	X X									
	X X									
	X X									
	X X									
	X X									
40	X X		85	4.45 brown organic silt						
	X X			4.5 pumice → 50mm in pum.						
	X X			silt matrix, pumice dominant, hard.						
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
50	X X		85							
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
60	X X		85							
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									
	X X									

Observations	Samples * small disturbed b large bag tube sample	Field Tests SPT blows/150mm, N blows/300mm C direct shear vane reading Cr remoulded shear vane Cc corrected shear vane
Pilon Vane		
Date started: 17/02/06	core dia: 68mm	Rig: Kubota
Date finished: 17/02/06	logged by: T.O.H	Contractor: Perry

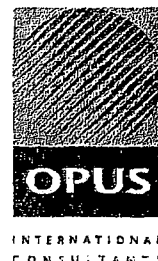
Record of Borehole				Sheet 2 of 2		BH 2				
Job Name: Rangitahua Stopbanks Section 1				Location: 37 College Rd						
Client: E B O P				Coordinates:						
				Elevation: Datum						
depth (m)	logged	symbol	% recovery	Strata	sample		field tests			lab test
				description	depth (m)	type	SPT	vane	other	
6.7	X		100	large charcoal - 100mm x leaves						
6.9	X		100	grey pum. SILT, rare fine lapilli bands, hard						
7.4	X			increasing pumice lapilli content, grey pumice gravelly SILT						
8.4	X		100	very finely banded grey pum. SILT, rare leaves & flux fibres, sensitive						
9.0	X		80	brown organic clay, PEAT, timber, leaves etc.						
9.9	X			green grey clayey SILT/silty CLAY, plastic, soft, some fibres etc.						
10.15	X			timber						
10.5	X			black fibrous PEAT						
11.1	X		85	dark brown organic clayey SILT, soft						
11.4	X			grey green CLAY, soft, plastic						
11.6	X			grey green silty CLAY/clayey SILT, organic matrix						
11.8	X			grey med - coarse SAND						
12.0	X			EOB						

Observations	Samples * small disturbed b large bag tube sample	Field Tests SPT blows/150mm, N blows/300mm C direct shear vane reading Cr remoulded shear vane Cc corrected shear vane
Pilon Vane		
Date started: 17/02/06	core dia: 68mm	Rig: Kubota
Date finished: 17/02/06	logged by: MOW	Contractor: Perry

Appendix B

Laboratory Tests

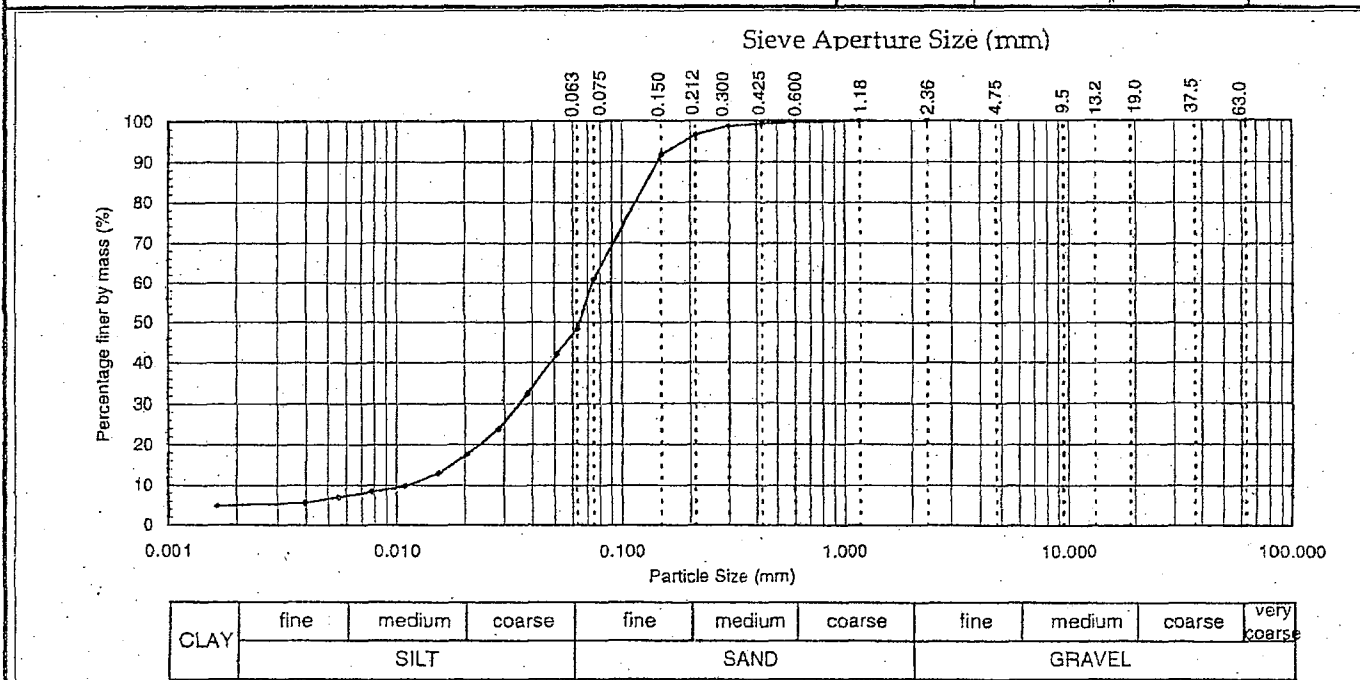
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



Project : Rangitaiki Stopbanks
 Location :
 Client : Ice, Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA1 Depth: 0.90 metres
 Sampled by : M. O'Halloran
 Date received : 18/11/05
 Sampling method : Small bags
 Sample condition : As received
 Sample description : Lt grey sandy SILT
 Solid Particle Density (t/m^3): 2.44 Assumed
 Water Content (as received): 38.2 %

Project No: 2-68229.82
 Lab Ref No: 05/229/003
 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	0.0513	42	0.0078	8
37.5	--	2.36	100	0.212	97	0.0383	32	0.0056	7
19.0	--	1.18	100	0.150	92	0.0283	24	0.0040	6
13.2	--	0.600	100	0.075	61	0.0206	17	0.0016	5
9.5	--	0.425	99	0.063	48	0.0153	13	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0110	10		



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

Date Tested: 21/11/05

Sampling is not covered by IANZ Accreditation

Date Reported: 22/11/05

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IANZ Approved Signatory

Designation : Senior Civil Engineering Technician
 Date : 22/11/05



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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



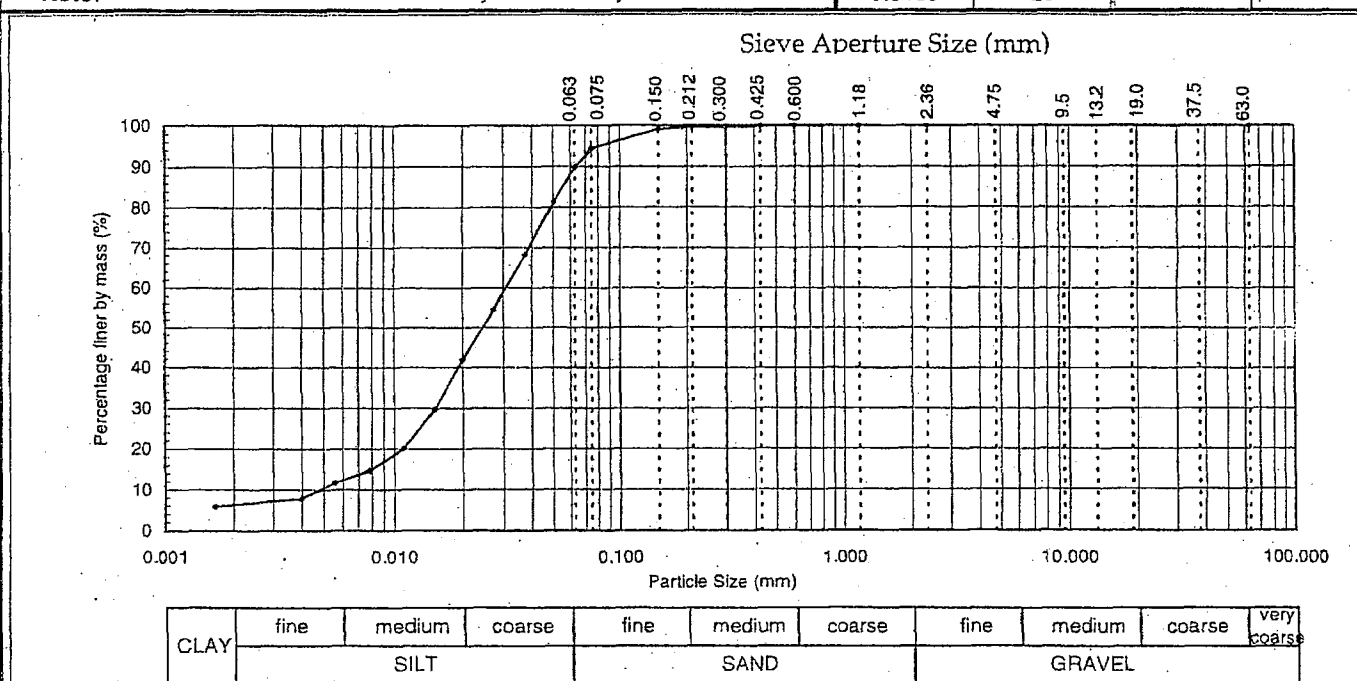
INTERNATIONAL
CONSULTANTS

Project : Rangitaiki Stopbanks
 Location :
 Client : Ice, Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA1 Depth: 1.20 metres
 Sampled by : M. O'Halloran
 Date received : 18/11/05
 Sampling method : Small bags
 Sample condition : As received
 Sample description : Lt grey SILT
 Solid Particle Density (t/m^3): 2.44 Assumed
 Water Content (as received): 46.5 %

Project No: 2-68229:82
 Lab Ref No: 05/229/003
 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	100	0.0504	81	0.0078	15
37.5	--	2.36	100	0.212	100	0.0372	68	0.0056	12
19.0	--	1.18	100	0.150	99	0.0274	54	0.0040	8
13.2	--	0.600	100	0.075	94	0.0200	42	0.0017	6
9.5	--	0.425	100	0.063	90	0.0151	30	--	--
						0.0109	20		

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



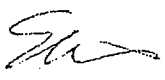
Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 21/11/05

Sampling is not covered by IANZ Accreditation

Date Reported: 22/11/05

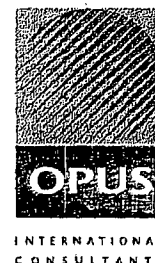
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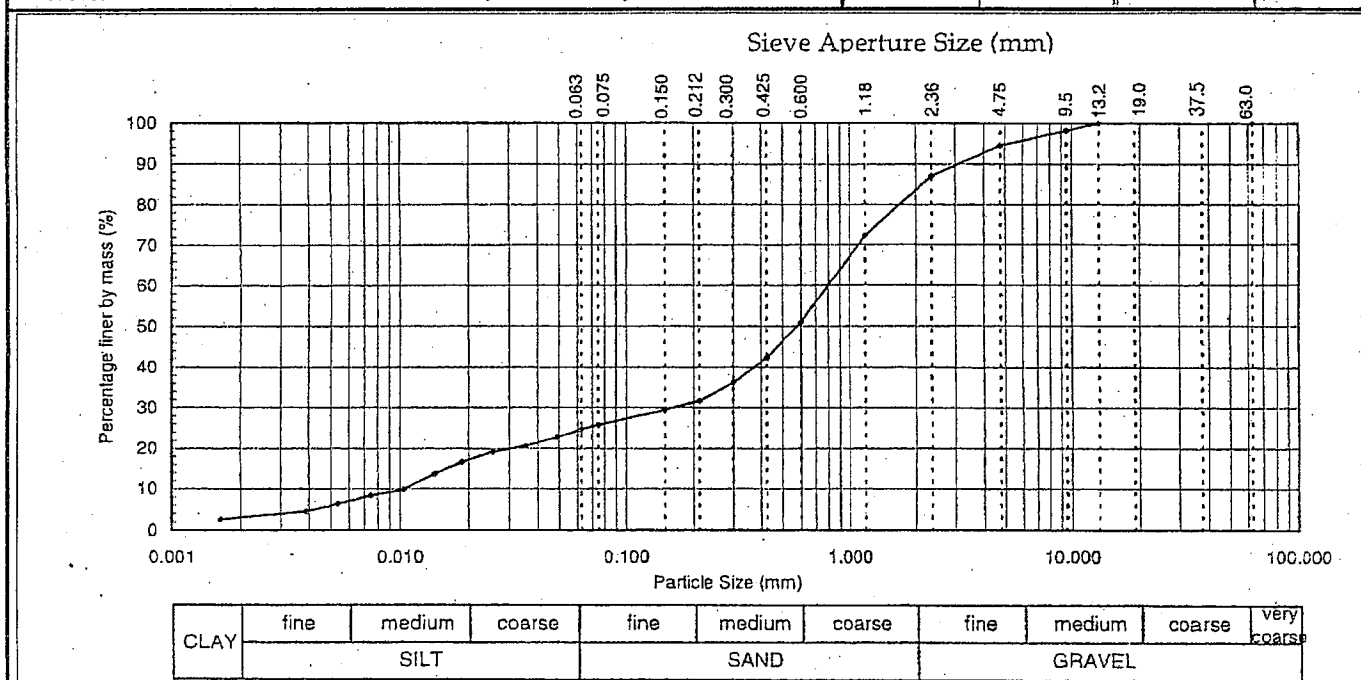
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



Project : Rangitaiki Stopbanks
 Location :
 Client : Ice, Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA2 Depth: 3.30 metres
 Sampled by : M. O'Halloran
 Date received : 18/11/05
 Sampling method : Small bags
 Sample condition : As received
 Sample description : Lt grey Silty SAND
 Solid Particle Density (t/m^3): 2.44 Assumed
 Water Content (as received): 35.4 %

Project No: 2-68229.82
 Lab Ref No: 05/229/003
 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	94	0.300	36	0.0489	23	0.0075	6
37.5	--	2.36	87	0.212	32	0.0356	21	0.0054	6
19.0	--	1.18	72	0.150	29	0.0257	19	0.0039	5
13.2	100	0.600	51	0.075	26	0.0187	17	0.0016	3
9.5	98	0.425	42	0.063	25	0.0142	14	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0104	10		



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

Date Tested: 21/11/05

Sampling is not covered by IANZ Accreditation

Date Reported: 22/11/05

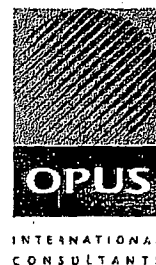
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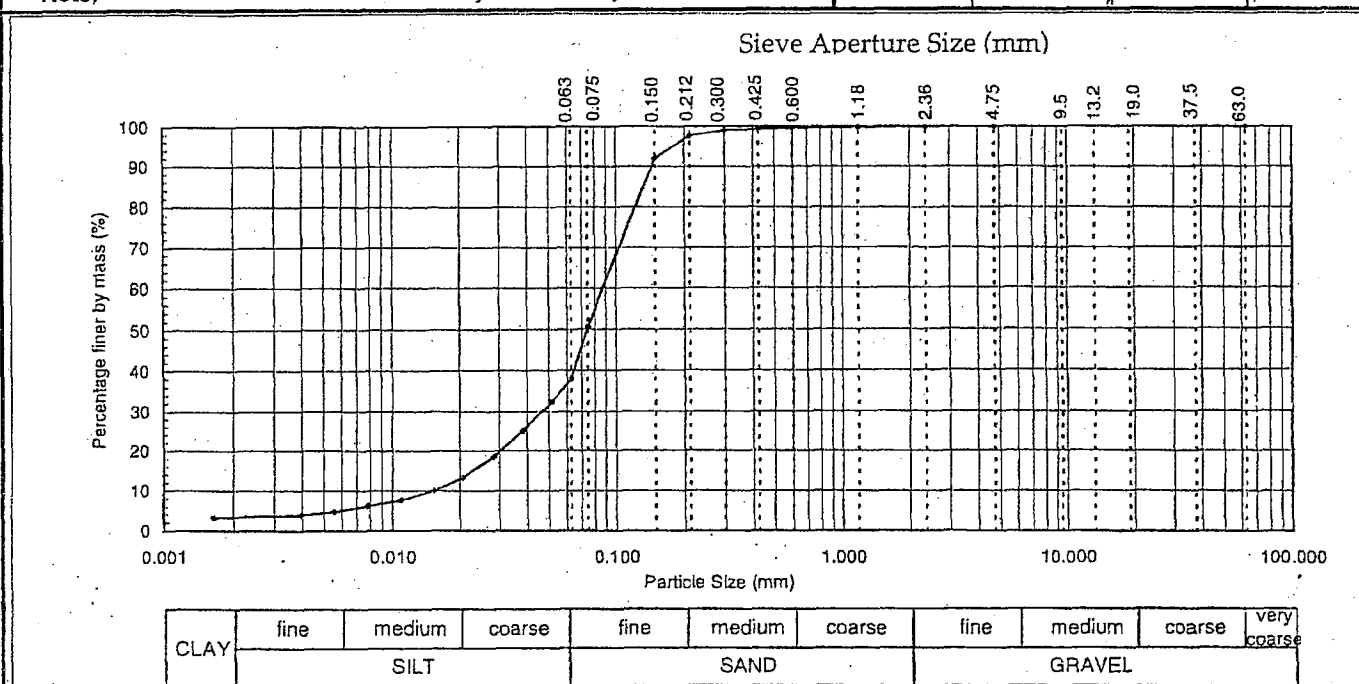
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT



Project : Rangitaiki Stopbanks
 Location :
 Client : Ice, Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA5 Depth: 2.00 metres
 Sampled by : M. O'Halloran
 Date received : 18/11/05
 Sampling method : Small bags
 Sample condition : As received
 Sample description : Lt grey Silty SAND
 Solid Particle Density (t/m³): 2.44 Tested
 Water Content (as received): 27.9 %

Project No: 2-68229.82
 Lab Ref No: 05/229/003
 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	100	0.300	99	0.0516	32	0.0078	6
37.5	--	2.36	100	0.212	98	0.0384	25	0.0056	5
19.0	--	1.18	100	0.150	92	0.0283	18	0.0040	4
13.2	--	0.600	100	0.075	51	0.0206	13	0.0016	3
9.5	--	0.425	99	0.063	38	0.0153	10	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0110	8		



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

Date Tested: 21/11/05

Sampling is not covered by IANZ Accreditation

Date Reported: 22/11/05

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 Designation : Senior Civil Engineering Technician
 Date : 22/11/05



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**SOLID PARTICLE DENSITY
TEST REPORT**

Project : Rangitaiki Stopbanks
Location :
Client : Ice, Geo & Civil Ltd, Papamoa
Contractor :
Sampled by : M. O'Halloran
Date sampled : 18/11/05
Sampling method : Small bag
Sample description : Lt grey fine silty Sand.
Sample condition : As received



Project No : 2-68229.82
Lab Ref No : 05/229/003
Client Ref No :

Test Results

Hole No: HA5
Depth (m): 2.0m
Solid Particle Density (t/m^3): 2.44

Test Method:	Notes:
Solid Particle Density: NZS 4402 : 1986 Test 2.7.2	1) whole soil tested

Date tested : 21/11/05
Date reported : 23/11/05

IANZ Approved Signatory

A handwritten signature in black ink, likely belonging to the Senior Civil Engineering Technician.

Designation : Senior Civil Engineering Technician
Date : 23/11/05

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