

# **Rangitaiki River Stopbanks Assessment**

## **Section 3**

**Left Bank 11500 to 12200m**

Prepared for

**Environment Bay of Plenty**

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## 1 Introduction

A study of the information available on the stopbanks along the Rangitaiki River carried out by Ice Geo & Civil in 2005 identified some areas where there may be potential problems in major floods. The areas were mainly identified on the basis of reports from locals, the extent of damage in the Edgumbe Earthquake, the height of the stopbank, the fall of the land away from the stopbank, the lack of a river berm and the removal of berm material for fill.

This report addresses the area considered to be the third most critical at the time of the 2005 study, the left bank from 11,500m to 12,200m.

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 Rangitaiki River left bank from 11,500m to 12,200m.

## 2 Site Description

Along the length of the study section the stopbank varies in height from 1.7m to 2.8m. There is up to 0.8m of fall away from the stopbank within 60m. The river berm is typically 30m in width but ranges from 60m at about 11,900m to 5m downstream at 12,200m. The river berm is about 1-2m lower than the land inside the stopbank due to excavation for fill material (Figures 1 and 2).

At the upstream end of the study length is the Ballance Fertiliser depot. Adjacent to this are the remains of an abandoned timber mill. Within the mill site are various concrete slabs, structures and pockets of decomposing organic material (probably bark and sawdust). Industrial buildings of various sizes occupy the lots around Ngaio Place. There is a reasonable clearance between most of these buildings and the inland toe of the stopbank. A self storage complex has just been built in the most downstream lot off Ngaio Place. This is closer to the toe of the stopbank than the other buildings. There are three residential properties at the downstream extent of the study area.

During the flood of July 1998 sand boils springs and areas of soft ground were observed some distance from the stopbank around Ngaio Place. A hole formed in the turning circle at the end of Ngaio Place, possibly due to heave of the seal. In July 2004 seepage was again observed near the road.

### 3 Subsurface Investigations

Opus International Consultants carried out some subsurface investigations in the Ngaio Place area after the 1998 floods (Reference 2). These consisted of one borehole to 5.2m depth in the Environment Bay of Plenty depot in Ngaio Place and two ground penetrating radar surveys upstream from the borehole. One radar run was along the top of the stopbank and one on the river side base of the stopbank. The borehole showed silty sand and sandy silt layers to 2m depth with loose coarse sands to 5m and dense medium grained sand below.

The insitu investigations consisted of 29 hand augers along the study length. These were arranged in 11 cross sections which extended inland up to 130m from the stopbank. 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 3.9m. Figure 1 shows the location of the hand auger holes and the logs are included in Appendix A.

Hand auger 3 in the Balance Fertiliser Depot was found to be in an old rubbish pile and had to be abandoned after several attempts. The remainder of the augers showed a large variation in soil types and layer thickness. The soils range from clayey silts to clean pumice lapilli up to about 3mm in size. The surface silt layer ranges from 0.5m to over 2m in thickness. On the inland side of the stopbank the depth to the first layer with medium to high permeability ranges from 0.8 to 2.9m. Coarse sand and lapilli were found to be as shallow as 1.8m below the ground surface just inside the stopbank at the end of Ngaio Place (HA14). There is a trend of thicker layers of lower permeability soils upstream and downstream of Ngaio Place compared to the soils in the central Ngaio Place area.

Old pavement materials were found in some of the hand augers close to the river side toe of the stopbank. Sandy pumice lapilli were found exposed in the river side toe of the stopbank in HA9. A large rabbit burrow was observed in the stopbank close to HA9.

The ground water level was found to be between about 1.1 and 3.2m depth on the inland side of the stopbank in January.

### 4 Laboratory Test Results

Hydrometer particle grading tests were carried out on seven 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
HA7 1.2m	blue grey silt	0.0015	0.0195	$2.25 \times 10^{-8}$ m/s
HA10 2.0m	grey silty sand	0.0085	0.082	$7.2 \times 10^{-7}$ m/s
HA10 2.4m	grey med sand	0.08	0.32	$6.4 \times 10^{-5}$ m/s
HA12 2.0m	brown-grey med – coarse sand	0.212	0.85	$4.5 \times 10^{-4}$ m/s
HA13 1.5m	brown-grey silty fine sand	0.0045	0.077	$2.0 \times 10^{-7}$ m/s
HA14 1.2m	grey med-coarse sand	0.035	0.48	$1.2 \times 10^{-5}$ m/s
HA20 0.7m	lt grey-brown silty fine sand	0.008	0.92	$6.4 \times 10^{-7}$ m/s

In addition to the grading tests a constant head permeability test was carried out on a reconstituted sample from 2.0m depth in HA10. This showed a permeability about five times greater than indicated by the Hazen formula ( $3.6$  to  $4.1 \times 10^{-6}$  m/s for a head 20 – 40 kPa).

## 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. The seepage analyses carried out must therefore be considered indicative only.

The problems identified on site could be initiated either by heave or 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.

In most of the study area the use of a surcharge is impractical due to the number of buildings and services. The exception to this is the area of the old timber mill where an overlay could be placed following demolition of the remaining structures. The use of a pressure relief trench between buildings and the toe of the stopbank has therefore been the main remedial measure investigated.

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. Surface seepage inside the stopbank has been allowed for over most of the cross sections analysed. Where there are large areas of concrete or seal an area of no surface seepage has 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 a floor or road can lead to high concentrations of

flow around the edge of the structure. These concentrations can be sufficient to cause localised piping problems which is possibly the cause of the holes in and around the sealed road in Ngaio Place. 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 the presence of a floor slab of given width, can not be accurately modelled.

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

## 5.2 Flood Hydrograph

EBoP has provided a 100 year return period flood flow hydrograph for the Rangitaiki River at their benchmark number 30 (Figure 3). This is an eight day hydrograph which rises to a peak of RL6.9 on the third day of the flood. This would allow about 0.5m of freeboard at the site of the benchmark. In the 100 year flood the water level stays close to the peak level for two days before beginning to drop. During the July 2004 the residents say the water was close to the top of the stopbank however the level was high for less than a day with a rapid drop due to the breach upstream of Edgecumbe.

## 5.3 Soil Model

The soil layers found in the hand augers were simplified in the models used for the seepage and stability analyses (Figure 4). 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 and coarse sand and lapilli. The permeabilities assumed were conservatively 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. It was conservatively assumed that there is a thick layer of pumice lapilli below the depth of investigations.

**Table 2: Assumed Soil Permeabilities**

layer	soil	$k_h$ (m/s)
1	stopbank fill	$2 \times 10^{-6}$
2	brown silt	$5 \times 10^{-7}$
3	fine sand	$5 \times 10^{-5}$
4	silty fine sand	$4 \times 10^{-6}$
5	fine to medium sand	$1 \times 10^{-4}$
6	coarse sand and lapilli	$5.0 \times 10^{-4}$

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 the layers therefore the horizontal and vertical permeabilities were assumed to be the same for all the soils except the stopbank. The vertical permeability of the stopbank was assumed to be half the horizontal.

#### **5.4 Cross Section 1**

Cross Section 1 runs across the corner of the fertiliser depot into the abandoned timber mill site. As discussed above an old rubbish pile was found in HA3. In HA4 a 300mm thick layer of fine sand was found at 0.8m depth between two layers of silt. Clayey silt was found at 2.8m depth. In the river berm sand was found at 2.0m depth and coarse sand and lapilli at 2.4m depth.

An initial static seepage analysis was carried out assuming a ground water level of RL3.0 on the inland side of the model and a river level of RL2.7. 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.

It was found that the ground water level did not rise to the ground surface on the inside of the stopbank at any time during the flood and no piping or heave problems were predicted.

#### **5.5 Cross Section 2**

Cross section 2 lies through Hand augers 5, 6 and 7 in the abandoned timber mill site. HA7 is 90m from the inland toe of the stopbank and 0.2m below it in elevation. The surface silt layer was found to be 0.8m thick in HA6 and 2.3m thick in HA7. It is underlain by silty fine sand, fine sand and fine to medium sand. In HA5, within the broad river berm, coarse sand and lapilli were found at 1.9m depth but are underlain by a thin layer of peat and some medium grain sized sand. It was assumed that the coarse sand layer almost extended inland to HA6.

The seepage analysis indicated that there would be a factor of safety (FOS) of about 1.0 against heave of the thin part of the surface silt layer in the 100 year flood. The application of a 0.5m thick overlay to 30m out from the inland toe of the stopbank improved the factor of safety to 1.2. There did not appear to be a problem with piping at the stopbank toe. The installation of a pressure relief trench down to the coarse layer at the inland toe of the stopbank, as an alternative to placing the overlay, produced a factor of safety of about 1.4. There is room for either remediation option at this cross section.

### 5.6 Cross Section 3

Coarse sand and lapilli were found exposed in the riverside toe of the stopbank at cross section 3. Some rabbit holes were also found in this area. A medium sand layer was found under the coarse sand and then another coarse sand layer. A medium sand layer was also found in HA10. It was assumed from the hand auger results that the soil layers dip inland away from the river, which is typical of the formation of river plains. The coarse sands and lapilli were therefore assumed to be close to the ground surface at the inland side of the stopbank.

The stopbank is 2.2m high at this location but there is a further fall of 0.8m to HA10 60m away. The seepage analysis showed high uplift pressures on the inland side of the stopbank. These were reduced with the application of a 1m thick overlay over the coarse sand layer on the river berm but not sufficiently to prevent heave of a silt layer of typical thickness. Widening the overlay to cover the whole river berm did not make a significant difference to the uplift pressures. The installation of a pressure relief trench on the inland side of the stopbank in addition to the river berm overlay reduced the uplift pressures to an acceptable level. If the river berm overlay is removed there are high volumes of seepage from the pressure relief trench. The flow from the toe trench over the eight day period is estimated at roughly  $40\text{m}^3/\text{m}$  with the river berm overlay. It is therefore considered that both the river berm overlay and the pressure relief trench should be installed.

### 5.7 Cross Section 4

Cross section 4 passes through the industrial area at the end of Ngaio Place. Just inside the stopbank the surface silt layer was found to be only 0.5m thick with coarse sands found at only 1.5m depth (HA14). An auger carried out through the stopbank showed an old road at natural ground level below the stopbank. It is not clear whether the coarse sand layer found inside the stopbank is the same as the layer found 1.5m below the river berm as the river berm is over 1m lower than the land inside the stopbank. The cross section has been conservatively modelled as having one continuous coarse layer.

As for cross section 3 there is potential for heave of the silt layer due to the coarse sand layer being close to the ground surface. The introduction of a pressure relief trench down to the coarse layer reduces the uplift pressures below the silt to acceptable levels. The estimated volume of seepage from the trench is about  $30\text{m}^3/\text{m}$  over the eight day period. Care will be needed on site to determine the lateral extent of the exposure of the coarse layer at the toe of the stopbank and consequently the river berm overlay.

### 5.7 Cross Section 5

Cross section 5 passes through some industrial properties and across Ngaio Place. The stopbank is 2.2m high but the road is 0.9m lower than the toe of the stopbank. A hand auger close to the road showed 0.5m of silt with coarse



sand at 2.4m depth. The level of the coarse sand is only 0.2 to 0.4m higher than where it was found below the river berm. It has therefore been assumed to be the same layer in the analysis and that it is very thick. The road was modelled as a 20m wide strip with an impermeable surface.

Analysis of the 100 year flood showed that any areas of the surface silt layer less than 0.8m thick would have a high risk of heave. The uplift pressures under the road were 30% higher than adjacent to the road and the hydraulic exit gradient at the edge of the road also 30% higher than the adjacent ground. It was found that a pressure relief trench at the toe of the stopbank and a well under the road would be needed to bring the factor of safety up to an acceptable level. This amount of pressure relief reduces the uplift pressure under the road by 35%.

A sensitivity analysis was carried out assuming the coarse sand layer was 3m thick, as found in Opus BH8. This analysis showed that two pressure relief locations would still be advisable.

The flow from the well under the road would only be a small proportion of that which would come from the trench. The trench flow has been estimated at about 25m<sup>3</sup>/m over the eight day flood period modelled.

## **5.8 Cross Section 6**

The road was also modelled in cross section 6. The coarse sand was found at 3.4m depth 20m from the inland toe of the stopbank; but if the hand auger adjacent to Ngaio Place is included in the model a single pressure relief trench at the stopbank toe does not produce an adequate factor of safety against uplift. Another pressure relief well under the road is therefore recommended.

The estimated flow from the pressure relief trench is about 20m<sup>3</sup>/m over the eight day flood. The flow from the trench/well under the road over the eight day period would be about 36m<sup>3</sup>/m.

## **5.9 Cross Section 7**

Cross section 7 is close to the EBoP depot. The soil profile used in the analysis was based on hand augers 22 and 23 and Opus' BH8 with coarse sands at 2m depth. It was found that one pressure relief trench at the toe would sufficiently reduce uplift pressures under a 0.5m thick layer of silt to provide a factor of safety of 1.2.

## **5.10 Cross Section 8**

The soil profile found in hand augers 24 and 25 is similar to that found in hand augers 22 and 23 and one pressure relief trench is required.

### 5.11 Cross Section 9

Cross section 9 passes through a property where some self storage units have just been built. The stopbank is 2.8m high and there is a narrow river berm. At the inland toe of the stopbank (HA27) silt was found at 1.8m depth below the surface silt and a silty fine sand layer. Clayey silt was found at 2.6m depth and the auger was stopped at 2.8m due to the hole squeezing in. The clayey silt was assumed to have a permeability of  $1 \times 10^{-7}$  m/s.

In the seepage analysis a coarse sand layer was conservatively assumed below the depth of HA27 as coarse sand was found below the river berm. If seepage is allowed at the ground surface there appears to be an adequate factor of safety against heave, however if the concrete slab of the self storage units is modelled higher uplift pressures develop. These pressures are not considered to be high enough to cause uplift problems but concentrations of flow around the edges of the slab could be created. It is therefore recommended that subsoil drainage be installed around the edge of the slab to allow water to escape without the loss of soil particles.

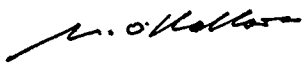
### 5.12 Cross Section 10

Cross section 10 is just at the downstream edge of the houses on Te Teko Road. Hand augers 28 and 29 on each side of the stopbank showed that there are predominantly silts at this end of the study area. Both hand augers had to be stopped due to soft silts squeezing into the holes. The stopbank is 2.6m high, with a further 0.4m fall to the edge of the road. The river berm is only about 5m wide.

In the seepage analysis it was assumed that there was a 4m thick layer of coarse sands below the depth of the hand augers. The road was modelled as an impermeable surface. It was found that there is a factor of safety of about 1.2 against uplift of the silt layer without any remedial measures. The maximum hydraulic exit gradient at the toe of the stopbank was found to be 0.4 which is the maximum considered acceptable in these soils.

## 7 Conclusions

1. The investigations and analyses carried out confirm the type of response to high river water levels that have been observed on site during major floods.
2. Remedial measures are required within a major portion of the study length as shown marked up on Figure 6.
3. A pressure relief trench extending down to a high permeability sand layer is required along the inland toe of the stopbank as shown on Figure 6.
4. In addition to the pressure relief trench there is an area where a 1m thick overlay is required on the river berm over an exposure of high permeability sands. The lateral extent of this overlay will need to be confirmed by further tests on site.
5. Three pressure relief wells are recommended under the pavement at the end of Ngaio Place.
6. It is recommended that a subsoil drain be installed around the edge of the concrete slab close to the stopbank in the self storage complex.
7. The rabbit burrow near HA9 should be investigated.



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29 April 2006

## References

- 1 Ice Geo & Civil (Sept. 2006) Rangitaiki River stopbanks, review of stability.
- 2 Opus International Consultants Ltd (2000) Stopbank assessment Rangitaiki River, Edgecumbe. Geotechnical Report No. 2069.



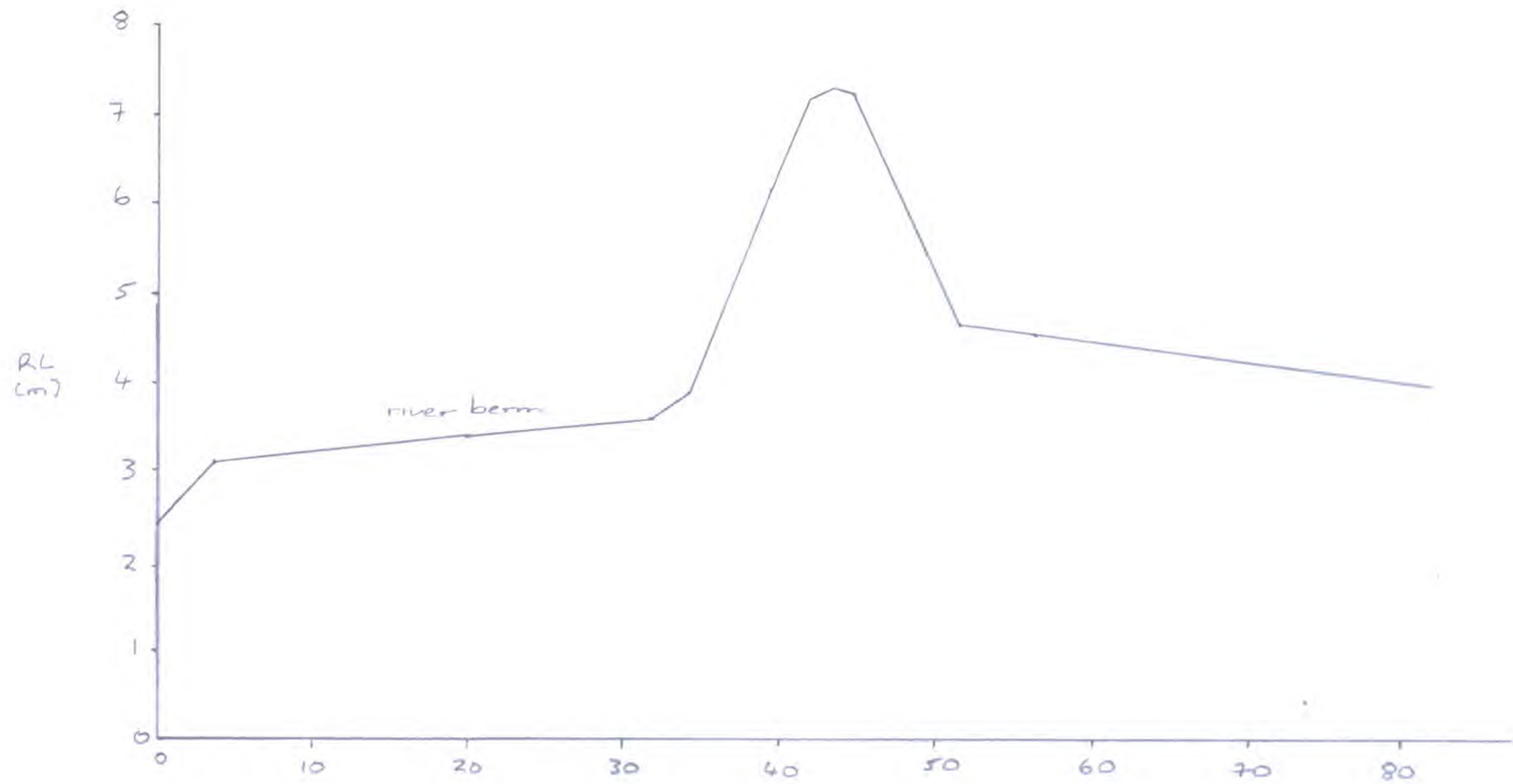
Site plan



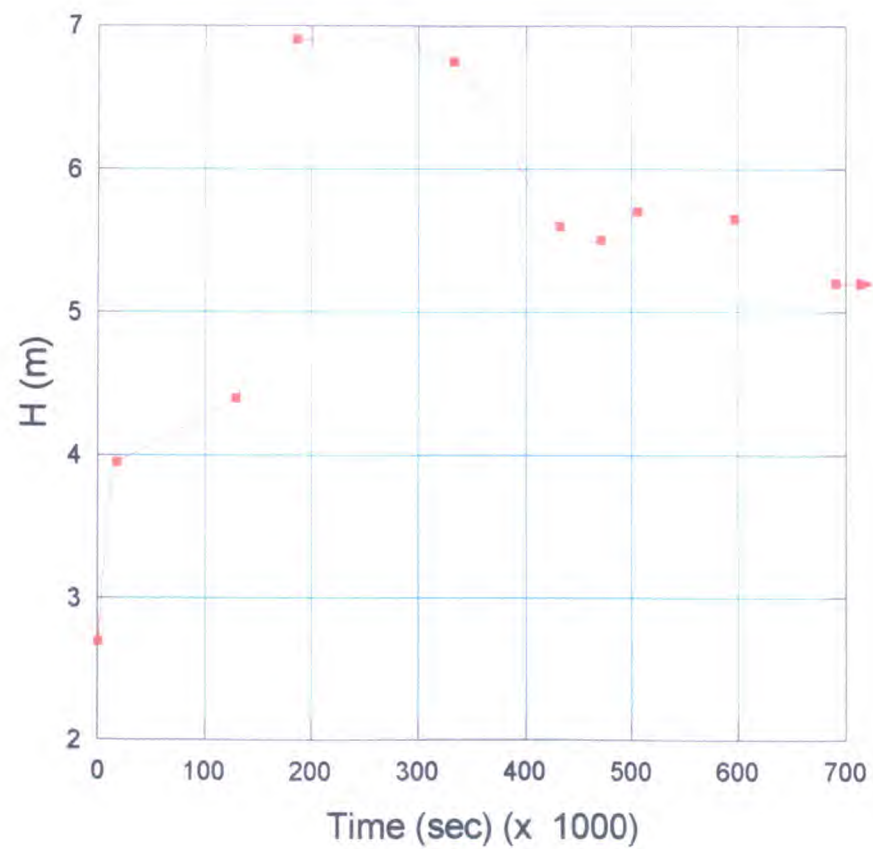
### Site plan







Cross section 7



100 year flood flow hydrograph



**Appendix A**

**Hand auger logs**

# Hand Auger Log

Test Number: *HA1*

Job Name: *Rangitahiri Stopbanks  
Section 3*

Date: *2/02/06*

Tested by: *D.O.H*

Blows/50mm		soil description	
m	Cu (kPa)		
0.2		X X	<i>brown silty fine SAND</i>
0.4		X X	<i>0.1 dark brown organic SILT, topsoil, damp</i>
0.6		X X	<i>0.4 brown silty fine SAND, damp</i>
0.8		X X	<i>0.6 grey silty fine SAND, damp</i>
1.0		X	
1.2		X	
1.4		X	<i>- 1.4 moist, timber, logs</i>
1.6			<i>1.5 EOB - LTP</i>
1.8			<i>2. attempts</i>
2.0			
2.2			
2.4			
2.6			
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

Cu (kPa)

# Hand Auger Log

Test Number: HAZ

Job Name: Rangitaihi Stopbank  
Section 3

Date: 2/02/06

Tested by: M.O.H

Blows/50mm													C <sub>u</sub> (kPa)	soil description
m	0	2	4	6	8	10	12							
													X	0.1 brown fine sandy SILT
0.2													X	grey silty fine SAND, damp
0.4													X	
0.6													X	
0.8													X	
1.0													X	
1.2													X	
1.4													X	1.4 moist
1.6													X	
1.8													X	
2.0												19	DX	1.9 wet
2.2													X	2.0 grey fine → medium SAND, some silt
2.4													X	2.4 grey coarse SAND & fine lapilli → 1mm
2.6													X	2.5 EOB collapse.
2.8														
3.0														
3.2														
3.4														
3.6														
3.8														
4.0														

020406080100120

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

# Hand Auger Log

Test Number: HA3

Job Name: Rangitiki stopbanks  
Section 3

Date: 2/02/06

Tested by: M.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									0.1 dark brown sandy silt, topsoil
0.4									0.2 brown grey sandy silt & gravel fill
0.6									0.3 brown grey silty med. sand & some gravel, fill
0.8									0.4 EOP, LTP
1.0									rubber pit
1.2									3 attempts
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									

# Hand Auger Log

Test Number: HA4

Job Name: Rangitahiri Stopbanks  
Section 3

Date: 2/02/06

Tested by: N.O.H

Blows/50mm													soil description
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)					
0.2													dark brown sandy SILT, some gravel, topsoil
0.4													0.4 grey gritty sandy SILT
0.6													
0.8													0.8 light grey fine pum. SAND
1.0													
1.2													1.1 grey SILT
1.4													1.2 light grey fine sandy SILT
1.6													1.5 light grey silty fine SAND
1.8													1.7 light grey fine sandy SILT, wet
2.0													1.9 light grey SILT
2.2													
2.4													
2.6													
2.8													2.8 brown clayey SILT, some fine organics
3.0													3.0 EOB, squeezing
3.2													
3.4													
3.6													no high permeability layers
3.8													
4.0													

C <sub>u</sub> (kPa)	0	20	40	60	80	100	120
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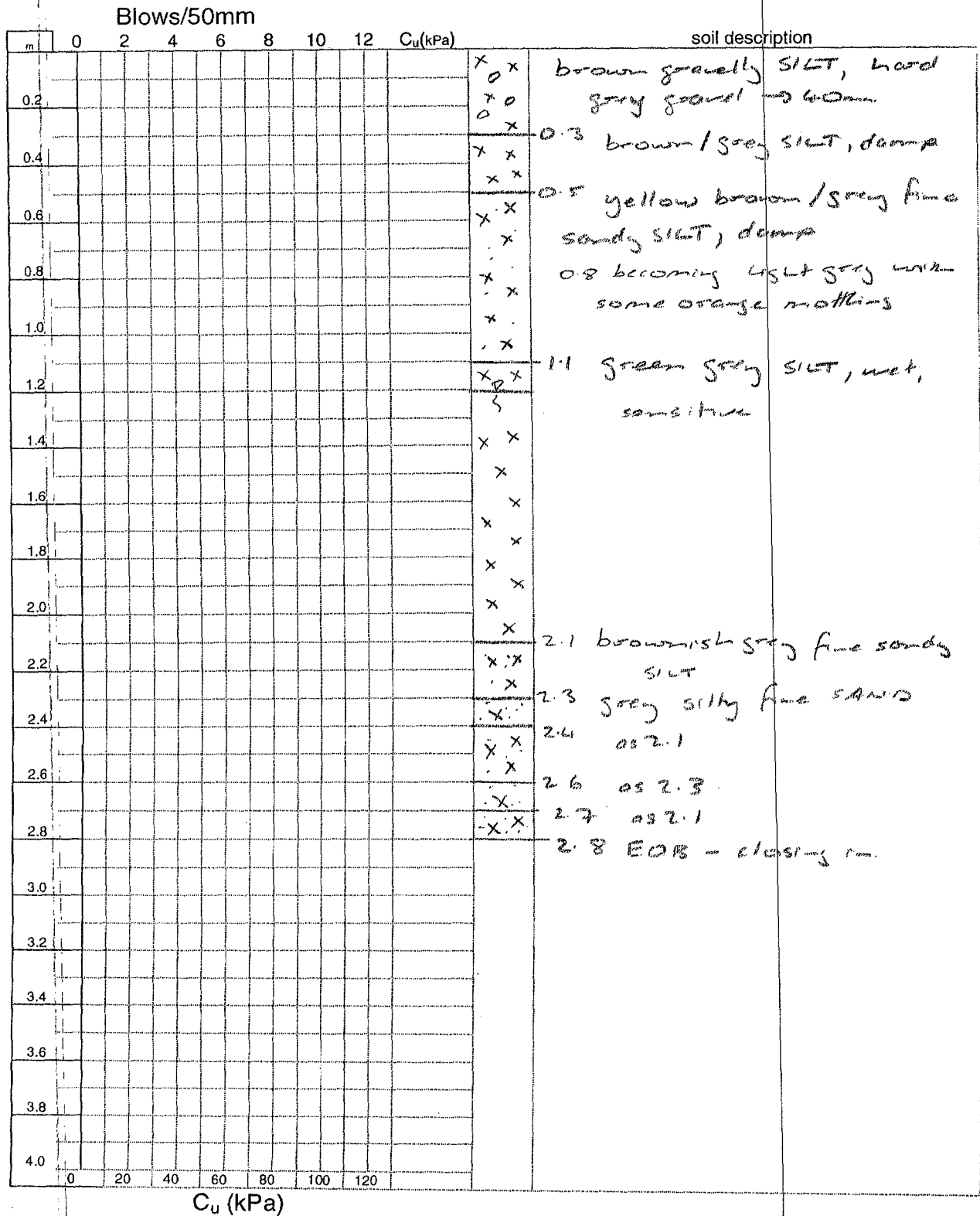
# Hand Auger Log

Test Number: HA7

Job Name: Rangitahi Stopbanks  
Section 3

Date: 15 Feb 06

Tested by: M.O.H





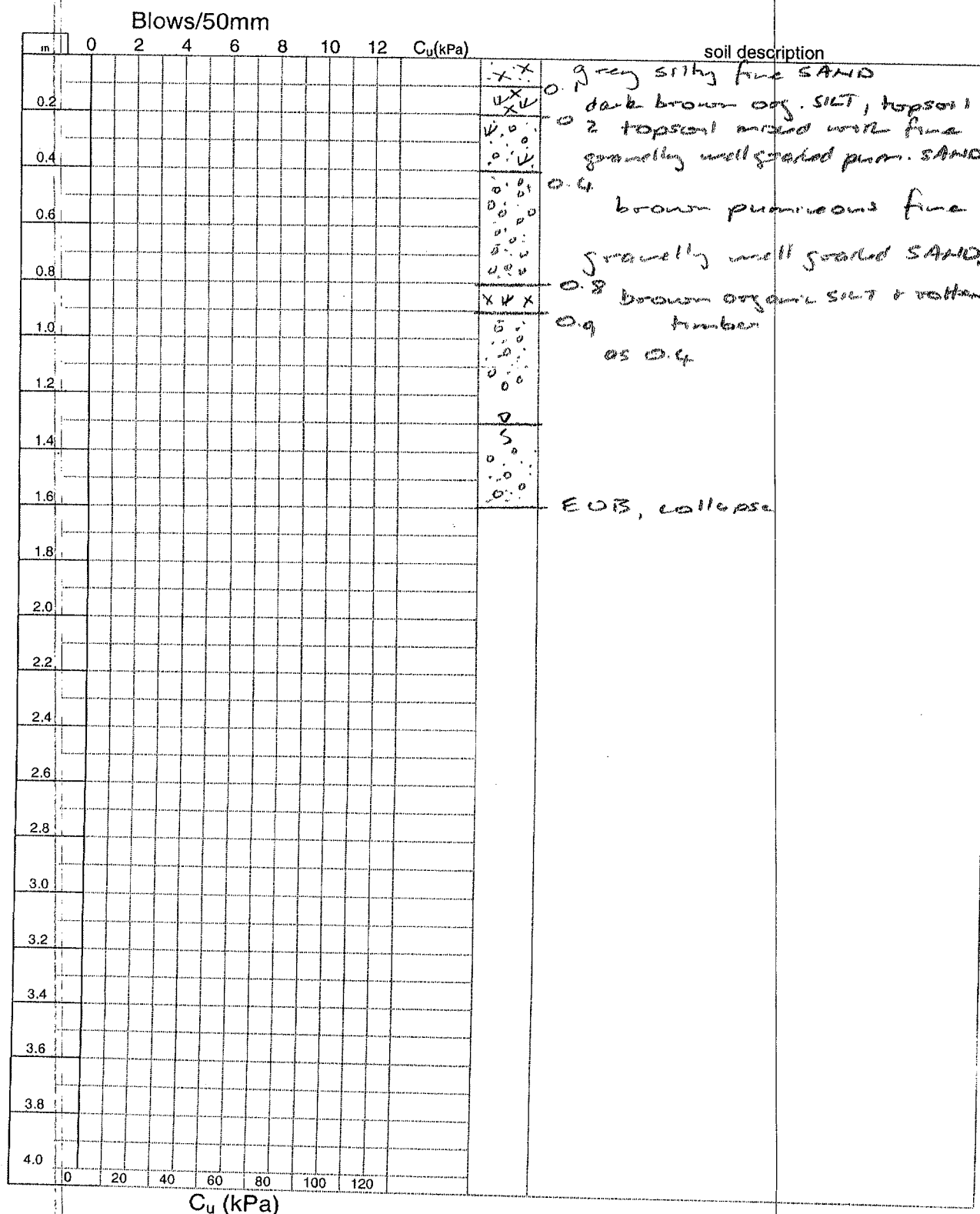
# Hand Auger Log

Test Number: HA8

Job Name: Rangitikei Stopbanks  
Section 3

Date: 15/02/06

Tested by: N.O.H



# Hand Auger Log

Test Number: HA9

Job Name: Rangitikei Stopbanks  
Section 3

Date: 15/02/06

Tested by: M.O.H

m	Blows/50mm													C <sub>u</sub> (kPa)	soil description
	0	2	4	6	8	10	12								
0.2														0.0	brown pumiceous fine gravelly well graded SAND, dry
0.4														0.0	
0.6														0.0	
0.8														0.0	
1.0														0.0	
1.2														0.0	
1.4														0.0	1.2 grey med. SAND
1.6														0.0	1.8 wet
1.8														0.0	
2.0														0.0	1.9 grey pumiceous fine gravelly well graded SAND
2.2														0.0	2.3 EOB, collapse.
2.4														0.0	
2.6															
2.8															
3.0															
3.2															
3.4															
3.6															
3.8															
4.0															

old pavement in stopbank

# Hand Auger Log

Test Number: HA 10

Job Name: Rangitaihi Stopbanks  
Section 3

Date: 3/02/06

Tested by: n.o'h

Blows/50mm										soil description	
m	0	2	4	6	8	10	12	Cu(kPa)			
0.2										✓	black organic material, bark etc.
0.4										✓	
0.6										✓	0.4 black organic material with gravel
0.8										✓	
1.0										✓	0.9 grey silty fine SAND
1.2										X	1.1 grey SILT
1.4										X	
1.6										X	1.5 grey fine sandy SILT, damp
1.8										X	1.8 grey silty fine SAND
2.0										X	2.0 *
2.2										X	
2.4										X	2.3 grey medium pum. SAND
2.6										X	2.4 *
2.8										X	2.5 moist
3.0										X	2.6 grey coarse pum SAND w fine lapilli
3.2										X	2.9 wet
3.4										X	3.3 EOB collapse
3.6										X	
3.8										X	
4.0										X	



# Hand Auger Log

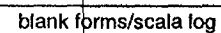
Test Number: HA 12

Job Name: Rangitikei Stopbanks  
Section 3

Date: 16/02/06

Tested by: N.O.H.

Blows/50mm		Cu(kPa)												soil description	
m	0	2	4	6	8	10	12	Cu(kPa)							
0.2									X	X				dark brown org. silt, topsoil, damp	
0.4									X	X				0.2 mixed topsoil & grey silty med. SAND, some gravel	
0.6									X	X				0.5 orange stained grey fine sandy silt	
0.8									X	X				0.8 orange stained grey silty fine SAND	
1.0									X	X				1.3 grey fine → med SAND some silt & lapilli → 3mm	
1.2									X	X				1.5 well graded SAND & fine lapilli → 3mm	
1.4									X	X				1.6 coarse SAND & fine lapilli & fine rounded grey & brown gravel → 4mm, wet	
1.6									X	X				2.0 x	
1.8									X	X				2.2 EOB collapse	
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	X					
	0	20	40	60	80	100	120								



# Hand Auger Log

Test Number: HAK

Job Name: Rangitikei Stopbanks  
Section 3

Date: 17/02/06

Tested by: N.O.H

m	Blows/50mm													C <sub>u</sub> (kPa)	soil description	
	0	2	4	6	8	10	12									
0.2														X	X	brown SILT
0.4														X	X	0.2 gravelly brown SILT
0.6														X	X	0.5 brown silty fine SAND
0.8														X	X	
1.0														X	X	
1.2														X	X	1.1 brown & grey fine →
1.4																coarse pumice SAND 12 *
1.6																1.5 well graded SAND & lapilli → 3mm
1.8														X	X	1.7 orange stained grey silty fine SAND
2.0																1.8 well graded SAND & lapilli → 3mm
2.2																
2.4																
2.6																
2.8														X	X	2.7 grey fine SAND, some silt, moist
3.0														X	X	2.9 grey med. SAND, loose silt
3.2																3.2 grey coarse SAND, wet
3.4																3.3 EOB
3.6																
3.8																
4.0																

# Hand Auger Log

Test Number: HA 15

Job Name: Rangitaiti Stopbank  
Section 3

Date: 3/02/06

Tested by: M.O.H

Blows/50mm												soil description
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)				
0.2										11 X	dark brown organic SILT + gravel, topsoil	
0.4										11 X		
0.6										11 X	0.6 brown SILT, damp	
0.8										11 X		
1.0										11 X		
1.2										11 X	1.1 light brown fine pum. SAND some SILT	
1.4										11 X	1.2 light brown silty fine pum. SAND	
1.6										11 X		
1.8										11 X		
2.0										11 X		
2.2										11 X	2.2 moist	
2.4										11 X	2.3 light grey coarse SAND + fine lapilli	
2.6										11 X	2.5 light grey medium → coarse SAND + fine lapilli	
2.8										11 X	2.9 wet	
3.0										11 X		
3.2										11 X		
3.4										11 X	3.4 EOB collapse	
3.6										11 X		
3.8										11 X		
4.0										11 X		



# Hand Auger Log

Test Number: HA16

Job Name: Rangitikei Stopbanks  
Section 3

Date: 16/02/06

Tested by: M.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									0.05 brown silty fine SAND brown organic SLT, topsoil
0.4									0.25 brown fine to med SAND, some silt
0.6									0.6 orange stained grey silty fine SAND
0.8									
1.0									
1.2									
1.4									1.4 grey fine SAND
1.6									1.45 grey fine to med SAND, wet
1.8									1.8 coarse SAND + fine lapilli
2.0									1.9 EOB collapse
2.2									
2.4									
2.6									
2.8									
3.0									
3.2									
3.4									
3.6									
3.8									
4.0									

# Hand Auger Log

Test Number: HA17

Job Name: Rangitachi Stopbanks  
Section 3

Date: 16/02/06

Tested by: N.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	Cu(kPa)						
0.2									X	X			dark brown org. SILT, topsoil	
0.4									X	X			0.25 brown silty fine SAND	
0.6									X	X			0.6 orange mottled grey silty f. SAND, damp	
0.8									X	X			0.8 orange mottled grey fine → med SAND	
1.0									X	X			1.1 grey SILT, moist	
1.2									X	X			1.2 orange stained grey f. SAND	
1.4									X	X			1.3 grey SILT	
1.6									X	X			1.35 grey silty fine SAND	
1.8									X	X			1.5 *	
2.0									X	X			1.9 grey fine → med. SAND	
2.2									X	X			2.1 coarse SAND & fine lapilli	
2.4									X	X			2.5 EOB collapse	
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	X				
	0	20	40	60	80	100	120	Cu (kPa)						

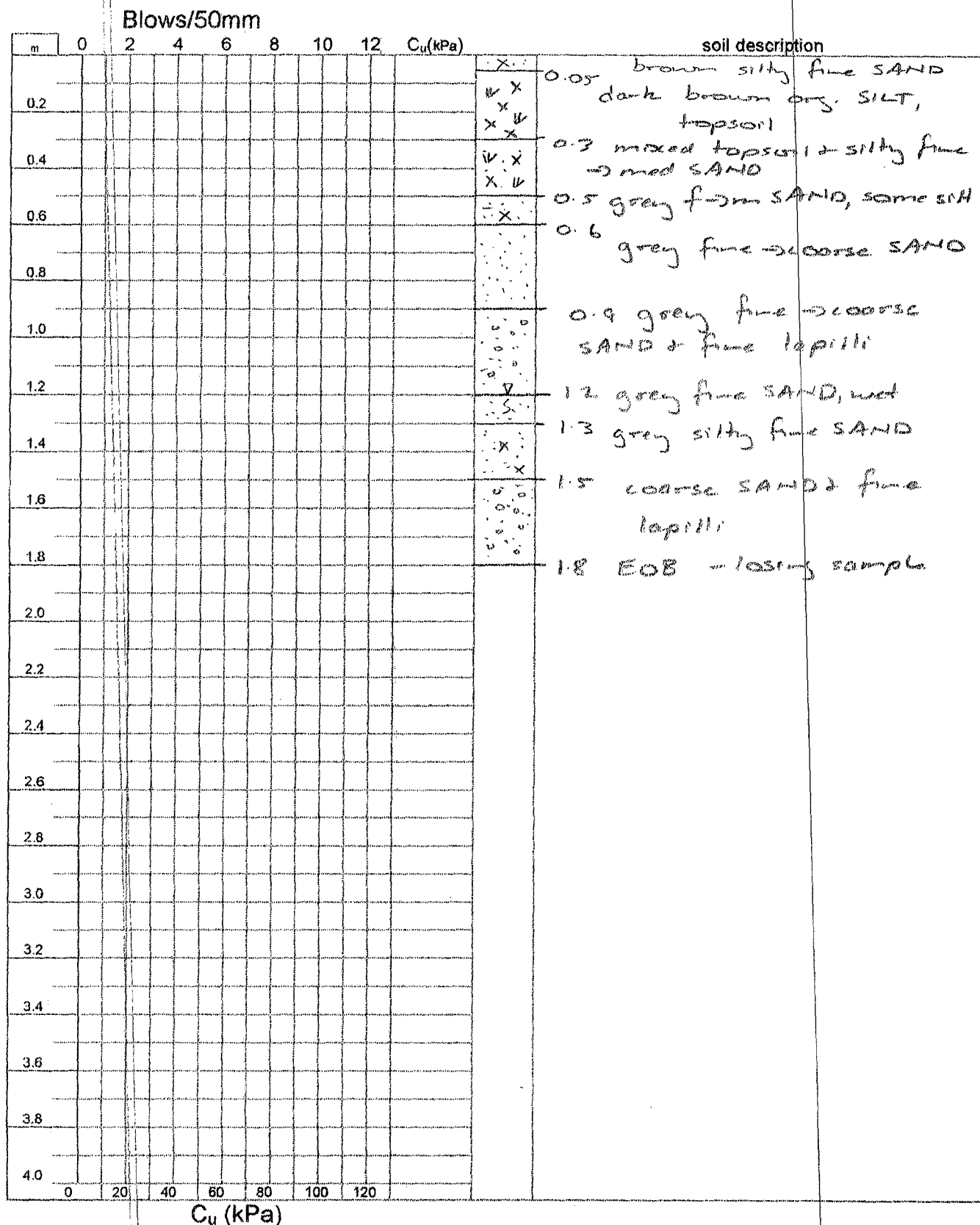
# Hand Auger Log

Test Number: HA18

Job Name: Rangitahi Stopbanks  
Section 3

Date: 16/02/06

Tested by: M.O'H



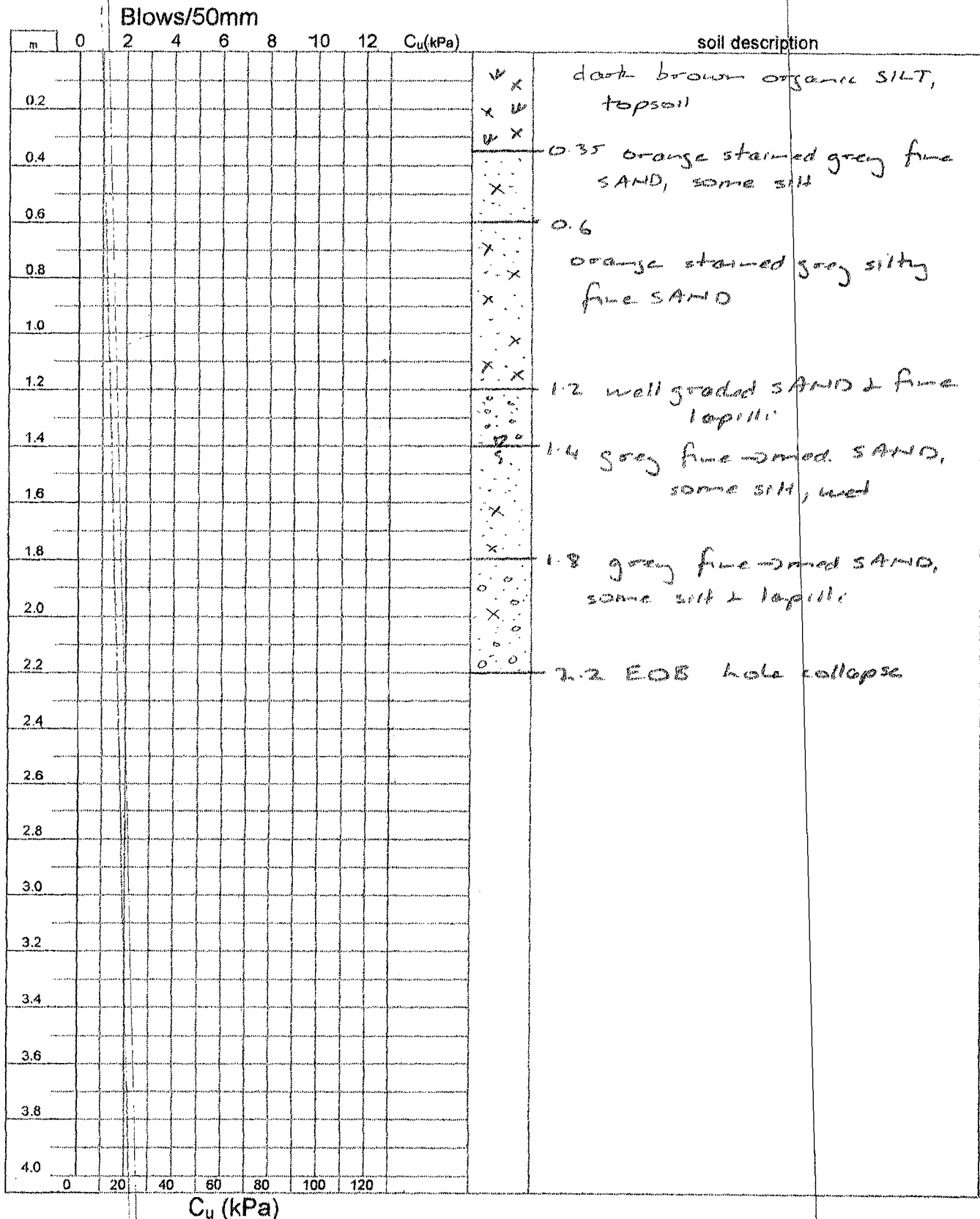
# Hand Auger Log

Test Number: HA19

Job Name: Rangitiki Stopbanks  
Section 3

Date: 16/02/06

Tested by: M.OH



# Hand Auger Log

Test Number: HAZO

Job Name: Rangitiki Stopbanks  
Section 3

Date: 17/02/06

Tested by: M.O.H

		Blows/50mm												soil description	
m	0	2	4	6	8	10	12	Cu (kPa)							
0.2														0.1	dk brown org. SILT, topsoil
															brown SILT
0.4															
														0.5	yellow brown silty
0.6															fine sand, light
0.8															
1.0															
1.2															
1.4															
1.6															
1.8															
2.0															
2.2															
2.4															
2.6															
2.8															
3.0															
3.2															
3.4														3.4	grey & dk brown med →
3.6															COARSE SAND, some silt
3.8														3.5	EOB hole collapse
4.0															

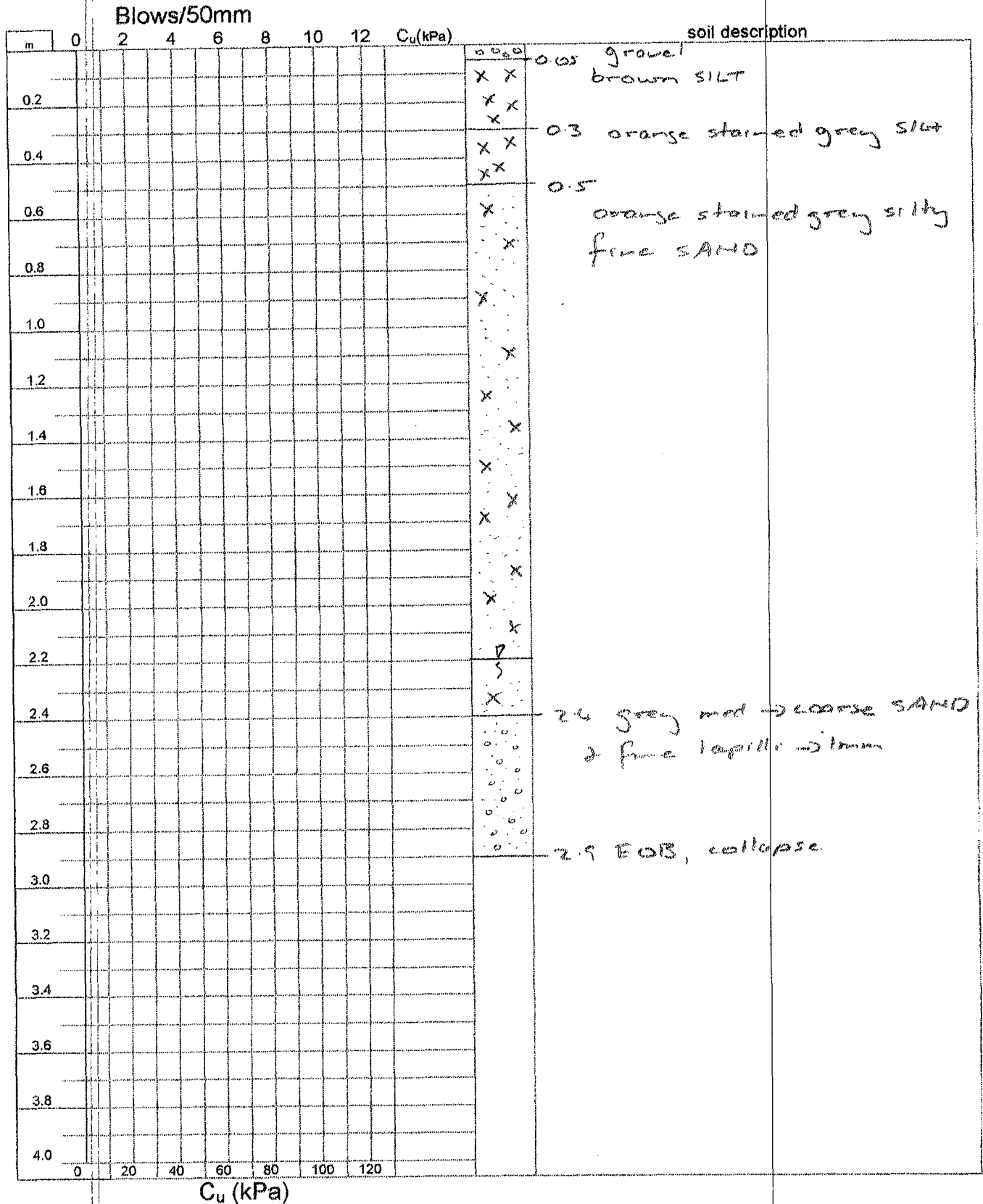
# Hand Auger Log

Test Number: HAZ1

Job Name: Rangitiki Stopbanks  
Section 3

Date: 17/02/06

Tested by: M.O'H



# Hand Auger Log

Test Number: HAZZ

Job Name: Rangitiki Stopbanks  
Section 3

Date: 22/02/06

Tested by: M.O.H

		Blows/50mm														soil description
m		0	2	4	6	8	10	12	$C_u$ (kPa)							
														X X		brown silty SAND
0.2														↓ X		0.05 dk brown org. sandy SILT, topsoil
														X ↓		
0.4														X		0.3 orange stained grey fine sandy SILT, damp
														X		
0.6														X		0.6 black med → coarse SAND, Taranaki Ash
														X		
0.8														X		0.7 orange stained grey silty fine SAND, moist
														X		
1.0														X		
														X		
1.2														X		1.2 grey fine SAND, some silt
														X		1.3 grey fine → med. SAND
1.4																
1.6																
1.8																1.7 grey med. → coarse SAND
2.0																
2.2																2.1 med → coarse SAND & fine lapilli → 1mm
2.4																2.3 fine lapilli 1 → 3 mm
2.6																2.5 EOB. collapse
2.8																
3.0																
3.2																
3.4																
3.6																
3.8																
4.0																

# Hand Auger Log

Test Number: HAZ3

Job Name: Rangitikei Stopbanks  
Section 3

Date: 22/02/06

Tested by: P.O.H

Blows/50mm										soil description	
m	0	2	4	6	8	10	12	$C_u$ (kPa)			
0.2										X	dk brown fine sandy SILT, some gravel → 30mm
0.4										X	
0.6										X	0.5 orange stained grey fine sandy SILT / silty SAND
0.8										X	0.7 grey fine → med. SAND
1.0										X	
1.2										X	
1.4										X	
1.6										X	
1.8										X	1.7 brown / grey fine sandy SILT / silty fine SAND, banded some lapilli → 3mm moist
2.0										X	
2.2										X	2.2 grey fine → med. SAND
2.4										X	
2.6										X	2.5 grey silty fine SAND
2.8										X	2.8 grey fine → med. SAND
3.0										X	2.9 EOB collapse
3.2											
3.4											
3.6											
3.8											
4.0											
$C_u$ (kPa)											





# Hand Auger Log

Test Number: HA25

Job Name: Rangitaiti Stopbanks  
Section 3

Date: 22/02/06

Tested by: M.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	Cu(kPa)						
0.2									X				dark brown organic SILT, topsoil	
0.4									X				0.3 orange stained grey fine sandy SILT	
0.6									X					
0.8									X				0.8 orange stained grey silty fine SAND, damp	
1.0									X					
1.2									X					
1.4									X					
1.6									X					
1.8									X					
2.0									X					
2.2									X				2.2 grey fine to med SAND	
2.4									X					
2.6									X				2.5 med. to coarse SAND & fine lapilli to 1mm	
2.8									X				2.65 EOB collapse	
3.0														
3.2														
3.4														
3.6														
3.8														
4.0														

# Hand Auger Log

Test Number: HAZ 6

Job Name: Rangitaihi Stopbanks  
Section 3

Date: 22/02/06

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				dark brown organic SILT, topsoil	
0.4									X ✓				0.3 brown silty fine SAND / sandy SILT	
0.6									X				0.45 orange stained grey silty fine SAND	
0.8									X					
1.0									X					
1.2									X					
1.4									X					
1.6									X					
1.8									X				1.8 grey fine med SAND	
2.0									X				1.9 grey fine SAND, some silt	
2.2									o o				2.1 grey med. - loose SAND + fine lapilli → 1mm	
2.4									o o				2.4 EOB collapse	
2.6														
2.8														
3.0														
3.2														
3.4														
3.6														
3.8														
4.0														

# Hand Auger Log

Test Number: HA27

Job Name: Rongitaki Stopbanks  
Section 3

Date: 17/02/06

Tested by: M.O'H

		Blows/50mm												soil description	
m		0	2	4	6	8	10	12	C <sub>u</sub> (kPa)						
														✓ x	dark brown organic SILT, topsoil
0.2														x ✓	
														x	0.2 brown fine sandy SILT
0.4														x	
														x	
0.6														x	0.5 orange mottled grey
														x	silty fine SAND, light
0.8														x	
														x	
1.0														x	
														x	
1.2														x	
														x	
1.4														x	
														x	
1.6														x	
														x	
1.8														x	1.8 thin band purple lapilli
														x	orange stained grey SILT
2.0														x	
														x	
2.2														x	
														x	
2.4														x	2.4 green grey SILT
														x	
2.6														x	2.6 green grey clayey SILT
														x	with organic fibres
2.8														x	2.8 EOB squeezing
														x	
3.0															
3.2															
3.4															
3.6															
3.8															
4.0															

# Hand Auger Log

Test Number: HA28

Job Name: Rangitahi Stopbanks  
Section 3

Date: 22/02/06

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		brown SILT	
														X			
														X			
0.4														X		0.3 orange stained grey fine	
														X		sandy SILT / silty SAND	
														X			
0.6														X		0.5 orange stained grey silty	
														X		fine SAND	
														X			
0.8														X		0.7	
														X		orange stained grey SILT	
														X			
1.0														X			
														X			
														X			
1.2														X			
														X			
1.4														X		1.3 orange stained grey silty	
														X		fine SAND	
														X			
1.6														X		1.6	
														X		grey SILT some organics	
														X			
1.8														X			
														X			
														X			
2.0														X			
														X			
														X			
2.2														X			
														X			
														X			
2.4														X			
														X			
														X			
2.6														X		2.5 EOB, squeezing	
														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			
														X			

# Hand Auger Log

Test Number: HA29

Job Name: Rangitikei Stopbanks  
section 3

Date: 22 / 02 / 06

Tested by: M.O'H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C <sub>u</sub> (kPa)						
									✓ x				brown organic SILT, topsoil	
0.2									x ✓					
									x					
0.4									x x				0.3 orange stained grey fine sandy SILT	
									x x					
0.6									x x					
									x					
0.8									x				0.7 orange stained grey silty fine SAND	
									x					
1.0									x				1.0 moist	
									x					
1.2									x					
									x					
1.4									x x				1.4 orange stained grey fine sandy SILT	
									x x					
1.6									x x					
									x x					
1.8									x x				1.7 grey silty fine SAND	
									x					
2.0									x					
									x					
2.2									x				2.1 grey SILT, some organics	
									x x					
2.4									x x					
									x x					
2.6									x x					
									x x					
2.8									x x				2.7 grey fine sandy SILT	
									x x				2.8 grey SILT	
3.0									x x				2.9 EOB, squeezers.	
3.2														
3.4														
3.6														
3.8														
4.0														
	0	20	40	60	80	100	120	C <sub>u</sub> (kPa)						

**Appendix B**

**Laboratory Tests**

# CONSTANT HEAD PERMEABILITY TEST REPORT

Project: Rangitaiki Stopbanks  
 Location: Rangitaiki  
 Client: Ice Geo & and Civil Ltd  
 Source: Section 3  
 Sampled by: Client Date: Unknown  
 Sampling Method: Recompacted Sample



## Comments:

Project No: 2-68229.82  
 Lab Ref No: 06/229/002  
 Client No:

## SOIL PROPERTIES

Sample ID:	HA 10							
Position:	2.0m							
Sample description	Grey fine SAND							
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Specimen length (mm)	108.60	108.60						
Specimen diameter (mm)	70.65	70.50						
Specimen mass (g)	601.22	648.65						
As rec'd Water Content (%)	44.2	-						
Water content (%)	44.2	55.6						
Wet density (t/m <sup>3</sup> )	1.41	1.53						
Dry density (t/m <sup>3</sup> )	0.98	0.98						
Saturat <sup>n</sup> by calculation (%)	69	87						
Saturation calculations uses the ASSUMED Solid Density (t/m <sup>3</sup> )=	2.65							
	Head (kPa)	Permeability (m/s)	Head (kPa)	Permeability (m/s)	Head (kPa)	Permeability (m/s)	Head (kPa)	Permeability (m/s)
	20	4.1E-06						
	30	3.8E-06						
	40	3.6E-06						
	81							

Saturation by pore pressure response (B value) (%) =

Notes: 1. 1kPa Head = 0.10m H<sub>2</sub>O  
 2. (m/s) = metres per second  
 3. X.YE-0Z = X.Y x 10<sup>-0Z</sup> m/s

## Sample Test Conditions

Cell Pressure (kPa)= 600  
 Saturation Backpressure (kPa)= 500  
 Effective Confining Pressure (kPa)= 100  
 Permeant Liquid Used for Test : Deaired Tap Water  
 Temperature during Test (°C): 20.0

Test Methods	Notes
Permeability Test : ASTM D5084-00:Method A-Constant Head Method	1.The sample was tested using the ELE test apparatus to enable back pressure saturation.
Water Content : NZS 4402 : 1986 Test 2.1	

Date tested : 1/03/06

Testing is covered by IANZ Accreditation

Date reported : 6/03/06

IANZ Approved Signatory

Designation: Senior Civil Engineering Technician

Date: 6/03/06



All tests reported herein have been performed in accordance with the laboratory's scope of accreditation



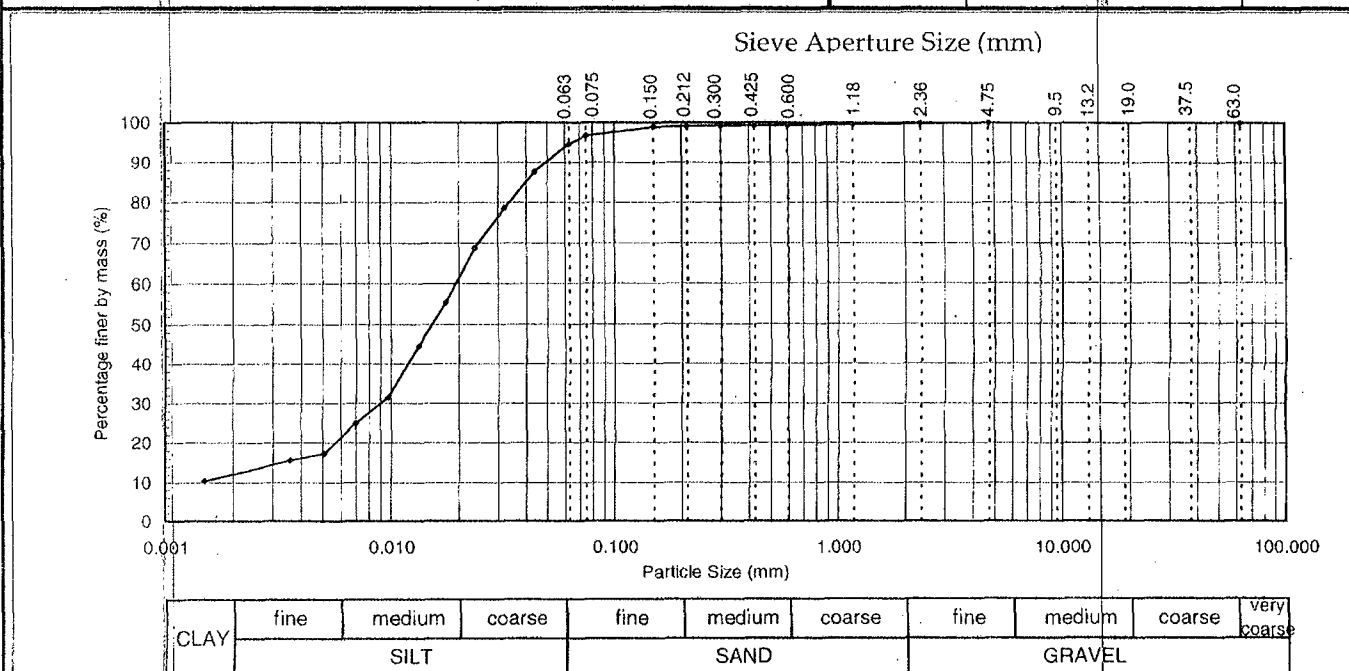
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)  
TEST REPORT**

Project : Rangitaiki Stopbanks  
 Location : Rangitaiki  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref : Section 3  
 Contractor : -  
 Auger no : HA7 Depth: 1.20 metres  
 Sampled by : Client  
 Date received : 27/02/06  
 Sampling method : Hand Auger  
 Sample condition : As received  
 Sample description : Bluish grey SILT  
 Solid Particle Density (t/m<sup>3</sup>): 2.65 Assumed  
 Water Content (as received): 49.6 %



Project No: 2-68229.82  
 Lab Ref No: 06/229/002  
 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	0.0437	88	0.0070	25
37.5	--	2.36	100	0.212	99	0.0321	79	0.0051	17
19.0	--	1.18	100	0.150	99	0.0236	69	0.0036	16
13.2	--	0.600	99	0.075	97	0.0175	55	0.0015	10
9.5	--	0.425	99	0.063	95	0.0132	44	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0097	32		



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: 28/02/06

Sampling is not covered by IANZ Accreditation  
 This report may only be reproduced in full

Date Reported: 3/03/06

IANZ Approved Signatory

Designation: Senior Civil Engineering Technician  
 Date: 3/03/06



All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

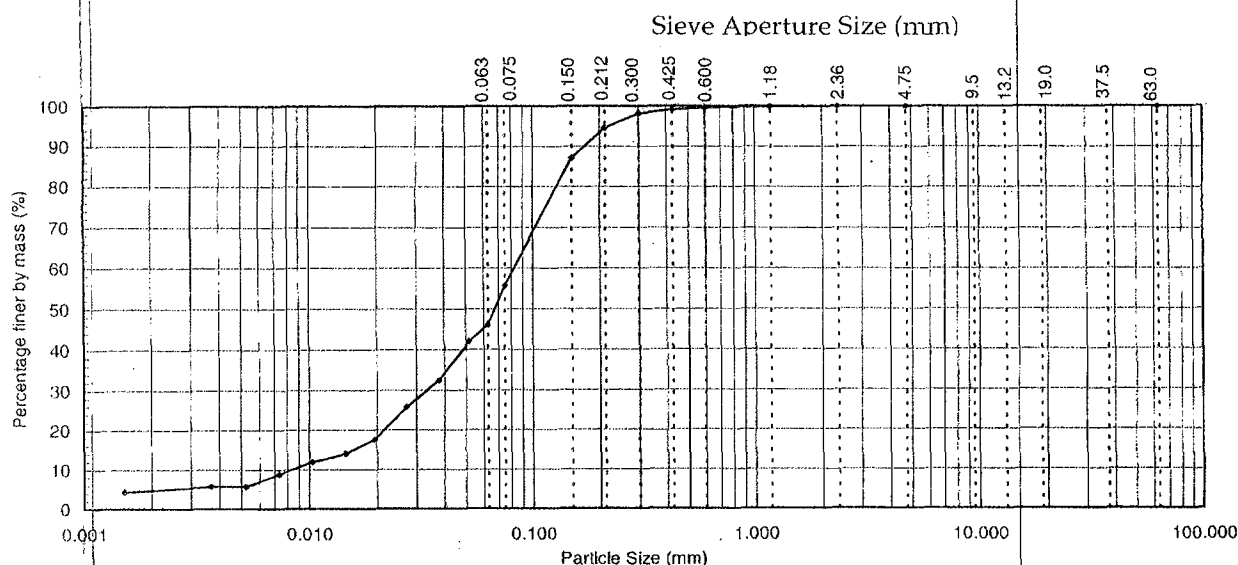
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)  
TEST REPORT**

Project : **Rangitaiki Stopbanks**  
 Location : **Rangitaiki**  
 Client : **Ice Geo & Civil Ltd**  
 Client/Sample Ref : **Section 3**  
 Contractor : **-**  
 Auger no : **HA10**      Depth: **2.00 metres**  
 Sampled by : **Client**  
 Date received : **27/02/06**  
 Sampling method : **Hand Auger**  
 Sample condition : **As received**  
 Sample description : **Grey silty SAND**  
 Solid Particle Density ( $t/m^3$ ): **2.65**      Assumed:  
 Water Content (as received): **43.7** %



Project No: **2-68229.82**  
 Lab Ref No: **06/229/002**  
 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	98	0.0517	42	0.0073	9
37.5	--	2.36	100	0.212	95	0.0376	32	0.0052	6
19.0	--	1.18	100	0.150	87	0.0271	26	0.0037	6
13.2	--	0.600	100	0.075	56	0.0196	18	0.0015	4
9.5	--	0.425	99	0.063	46	0.0144	14	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0103	12		



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

**Test Methods**

Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)

**Notes**

pH of suspension : 8.0      Whatmans Full Range pH indicator paper

Date Tested: **28/02/06**

**Sampling is not covered by IANZ Accreditation  
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Date Reported: **3/03/06**

**IANZ Approved Signatory**

Designation: **Senior Civil Engineering Technician**  
 Date: **3/03/06**



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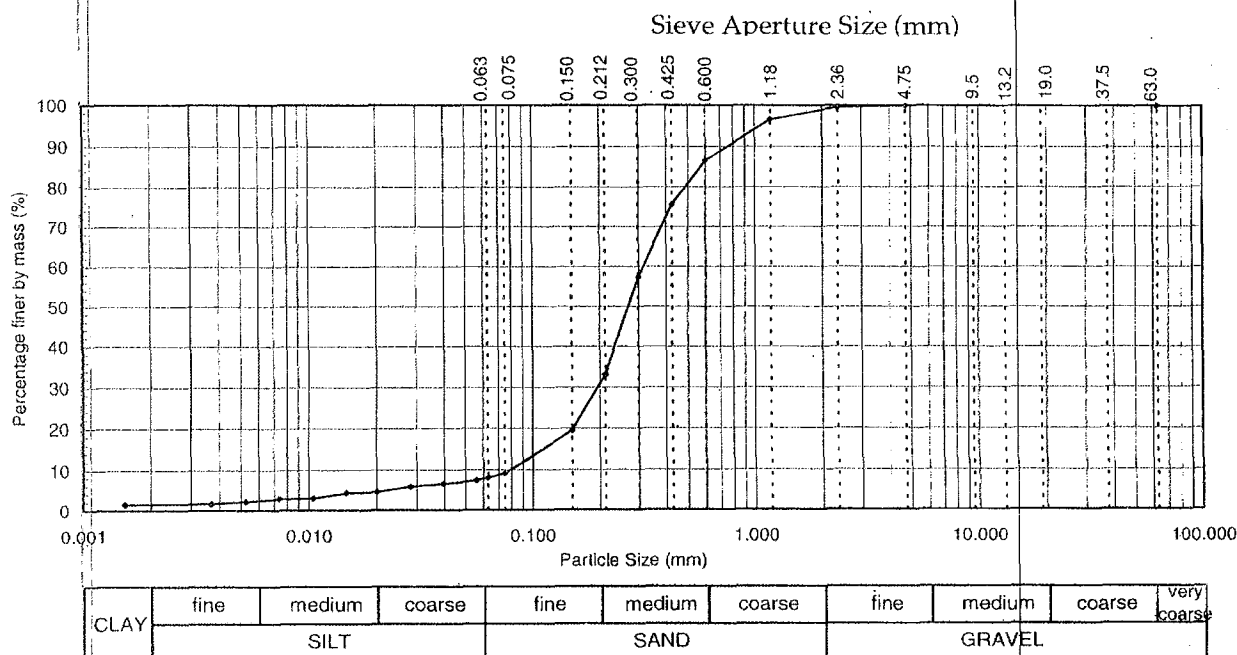
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)**  
**TEST REPORT**

Project : **Rangitaiki Stopbanks**  
 Location : **Rangitaiki**  
 Client : **Ice Geo & Civil Ltd**  
 Client/Sample Ref : **Section 3**  
 Contractor : **-**  
 Auger no : **HA10**      Depth: **2.40 metres**  
 Sampled by : **Client**  
 Date received : **27/02/06**  
 Sampling method : **Hand Auger**  
 Sample condition : **As received**  
 Sample description : **Grey medium SAND**  
 Solid Particle Density (t/m<sup>3</sup>): **2.65**      Assumed  
 Water Content (as received): **27.8** %



Project No: **2-68229.82**  
 Lab Ref No: **06/229/002**  
 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	57	0.0558	7	0.0074	3
37.5	--	2.36	100	0.212	33	0.0396	6	0.0052	2
19.0	--	1.18	97	0.150	19	0.0281	6	0.0037	2
13.2	--	0.600	86	0.075	9	0.0200	5	0.0015	2
9.5	--	0.425	75	0.063	8	0.0146	4	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0104	3		



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: **28/02/06**

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Date Reported: **3/03/06**

**IANZ Approved Signatory**

Designation: **Senior Civil Engineering Technician**  
 Date: **3/03/06**



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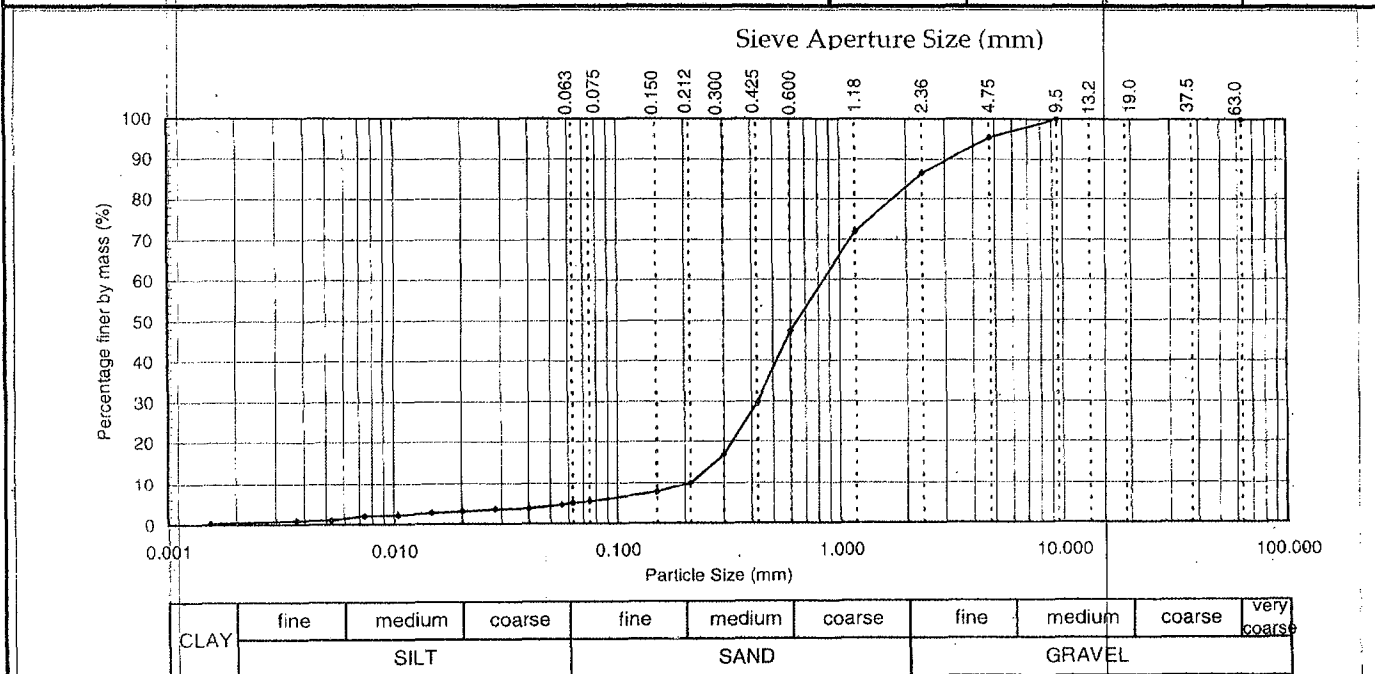
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)**  
**TEST REPORT**

Project : **Rangitaiki Stopbanks**  
 Location : **Rangitaiki**  
 Client : **Ice Geo & Civil Ltd**  
 Client/Sample Ref : **Section 3**  
 Contractor : **-**  
 Auger no : **HA12**      Depth: **2.00 metres**  
 Sampled by : **Client**  
 Date received : **27/02/06**  
 Sampling method : **Hand Auger**  
 Sample condition : **As received**  
 Sample description : **Brownish grey medium - coarse SAND**  
 Solid Particle Density (t/m<sup>3</sup>): **2.65**      Assumed  
 Water Content (as received): **31.7**      %



Project No: **2-68229.82**  
 Lab. Ref No: **06/229/002**  
 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	95	0.300	17	0.0561	5	0.0074	2
37.5	--	2.36	86	0.212	10	0.0399	4	0.0052	1
19.0	--	1.18	72	0.150	8	0.0283	4	0.0037	1
13.2	--	0.600	47	0.075	5	0.0200	3	0.0015	0
9.5	100	0.425	30	0.063	5	0.0147	3	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0104	2		



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: **28/02/06**

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IANZ Approved Signatory

Designation: **Senior Civil Engineering Technician**  
 Date: **3/03/06**



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# PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

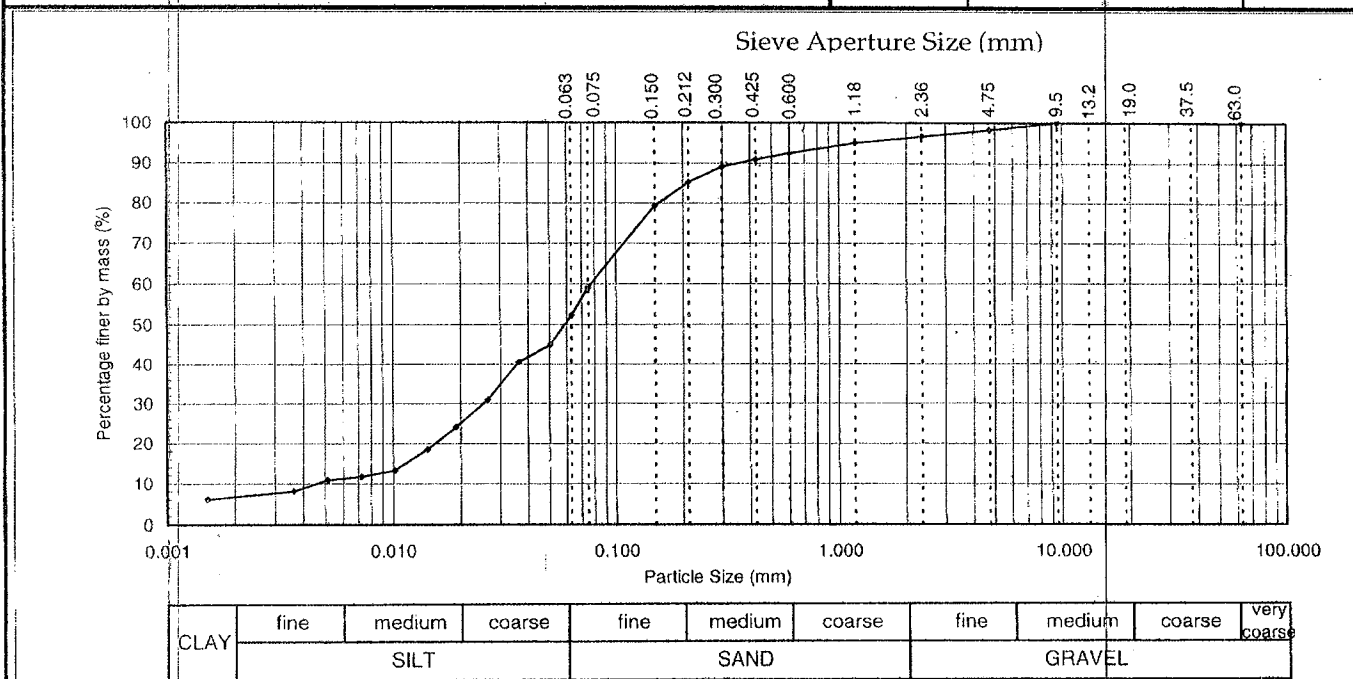
## TEST REPORT

Project : Rangitaiki Stopbanks  
 Location : Rangitaiki  
 Client : Ice Geo & Civil Ltd  
 Client/Sample Ref : Section 3  
 Contractor : -  
 Auger no : HA13      Depth: 1.50 metres  
 Sampled by : Client  
 Date received : 27/02/06  
 Sampling method : Hand Auger  
 Sample condition : As received  
 Sample description : Brownish grey silty fine SAND  
 Solid Particle Density ( $t/m^3$ ): 2.65      Assumed  
 Water Content (as received): 27.9      %



Project No: 2-68229.82  
 Lab Ref No: 06/229/002  
 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	98	0.300	89	0.0505	45	0.0072	12
37.5	--	2.36	97	0.212	85	0.0362	41	0.0051	11
19.0	--	1.18	95	0.150	79	0.0264	31	0.0036	8
13.2	--	0.600	93	0.075	59	0.0191	24	0.0015	6
9.5	100	0.425	91	0.063	52	0.0142	18	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0102	13		



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: 28/02/06

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Date Reported: 3/03/06

IANZ Approved Signatory

Designation: Senior Civil Engineering Technician

Date: 3/03/06



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 laboratory's scope of  
 accreditation

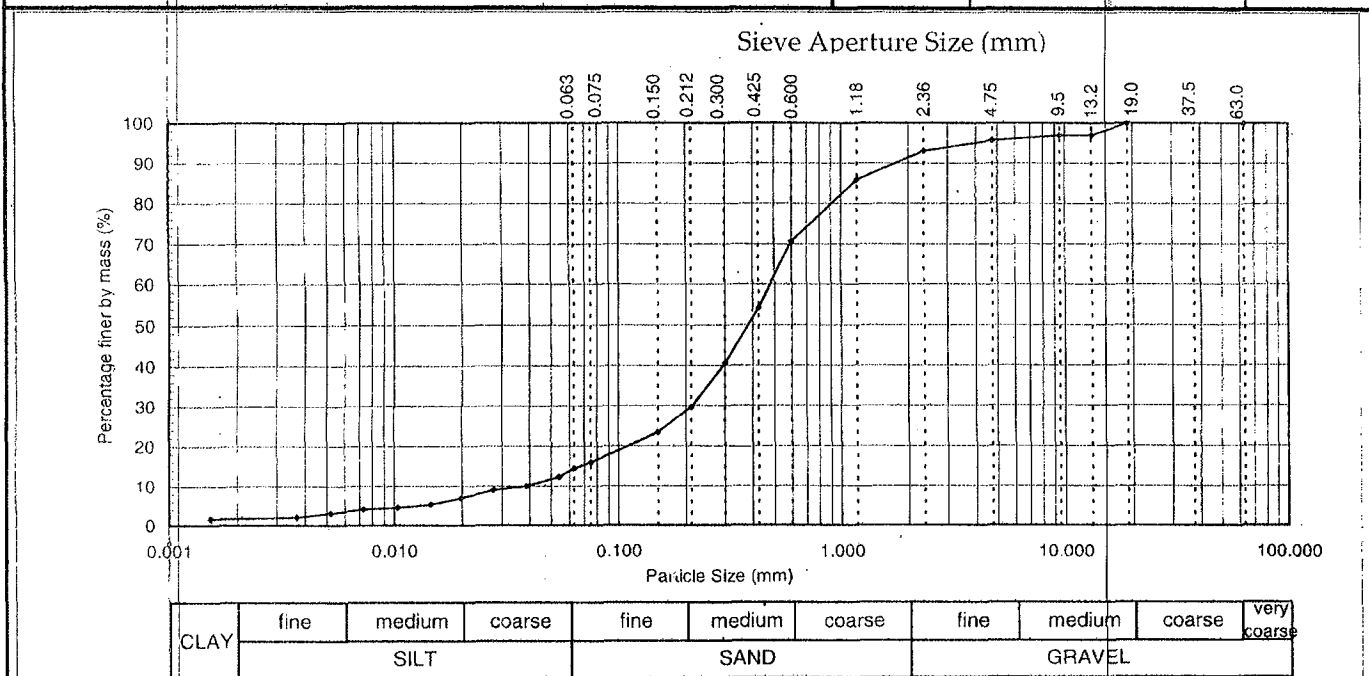
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)**  
**TEST REPORT**

Project : **Rangitaiki Stopbanks**  
 Location : **Rangitaiki**  
 Client : **Ice Geo & Civil Ltd**  
 Client/Sample Ref : **Section 3**  
 Contractor : **-**  
 Auger no : **HA14**      Depth: **1.20 metres**  
 Sampled by : **Client**  
 Date received : **27/02/06**  
 Sampling method : **Hand Auger**  
 Sample condition : **As received**  
 Sample description : **Grey medium - coarse SAND**  
 Solid Particle Density ( $t/m^3$ ): **2.65**      Assumed  
 Water Content (as received): **24.7** %



Project No: **2-68229.82**  
 Lab Ref No: **06/229/002**  
 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	41	0.0540	12	0.0073	4
37.5	--	2.36	93	0.212	30	0.0387	10	0.0052	3
19.0	100	1.18	86	0.150	23	0.0275	9	0.0037	2
13.2	97	0.600	71	0.075	16	0.0197	7	0.0015	2
9.5	97	0.425	54	0.063	14	0.0145	5	--	--
<b>Note:</b> "--" denotes sieve not used and/or hydrometer analysis not tested						0.0103	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: **28/02/06**

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Date Reported: **3/03/06**

**IANZ Approved Signatory**

Designation: **Senior Civil Engineering Technician**  
 Date: **3/03/06**



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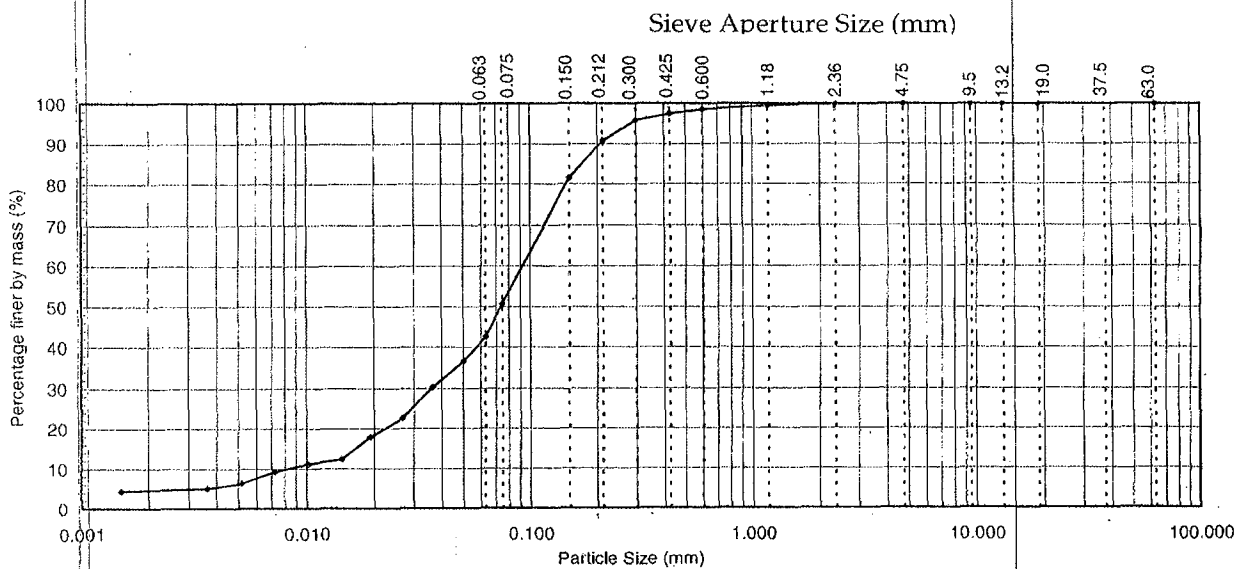
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)  
TEST REPORT**

Project : **Rangitaiki Stopbanks**  
 Location : **Rangitaiki**  
 Client : **Ice Geo & Civil Ltd**  
 Client/Sample Ref : **Section 3**  
 Contractor : **-**  
 Auger no : **HA20** Depth: **0.70 metres**  
 Sampled by : **Client**  
 Date received : **27/02/06**  
 Sampling method : **Hand Auger**  
 Sample condition : **As received**  
 Sample description : **Lt greyish brown silty fine SAND**  
 Solid Particle Density (t/m<sup>3</sup>): **2.65 Assumed**  
 Water Content (as received): **29.9 %**



Project No: **2-68229.82**  
 Lab Ref No: **06/229/002**  
 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	96	0.0502	37	0.0072	9
37.5	--	2.36	100	0.212	91	0.0365	30	0.0052	6
19.0	100	1.18	99	0.150	82	0.0266	23	0.0036	5
13.2	100	0.600	98	0.075	51	0.0192	18	0.0015	4
9.5	100	0.425	97	0.063	42	0.0143	12	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0102	11		



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

**Test Methods**

Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)

**Notes**

pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 28/02/06

Date Reported: 3/03/06

IANZ Approved Signatory

Designation: *Senior Civil Engineering Technician*  
 Date: 3/03/06

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**Appendix C**

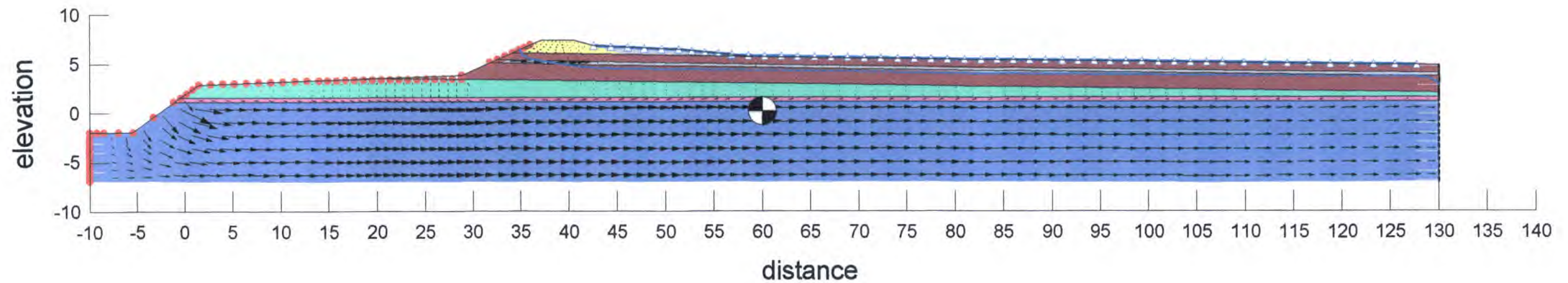
**Seepage Models**



Name: cross section 1 100yr.gsz  
Title: Rangitaiki Stopbanks Section3  
Comments: Cross Section 1 100 yr flood  
Date: 29/03/2006 Time: 11:52:36 a.m.

Time step 50

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

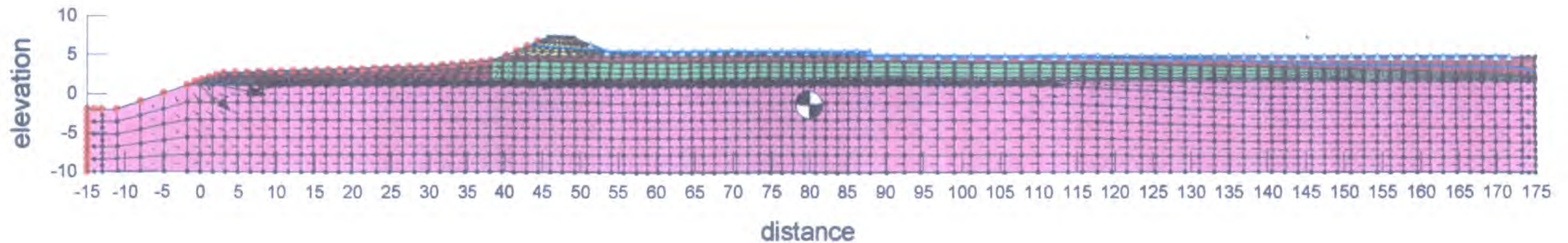


Name: cross section 2 overlay 100yr.gsz  
 Title: Rangitaiki Stopbanks Section 3  
 Comments: Cross Section 2 overlay 100 yr  
 Date: 30/03/2006 Time: 3:45:08 p.m.

Time step 50 - 100 hours

30m wide, 0.5m thick overlay

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



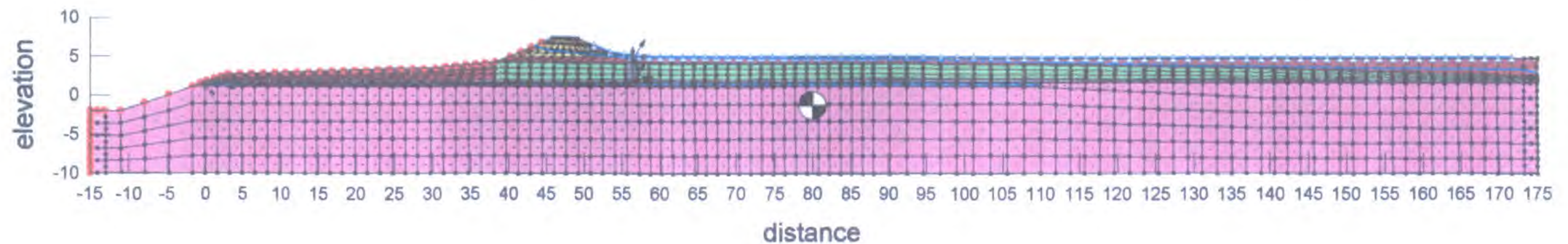


Name: cross section 2 100yr.gsz  
Title: Rangitaiki Stopbanks Section 3  
Comments: Cross Section 2 100 yr flood  
Date: 06/05/2006 Time: 2:28:01 p.m.

pressure relief trench at toe

time step 50 - 100 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: 1	Direction of Kx: 0



Name: cross section 3 overlay 100yr well.gsz

Title: Rangitaiki Stopbanks Section 3

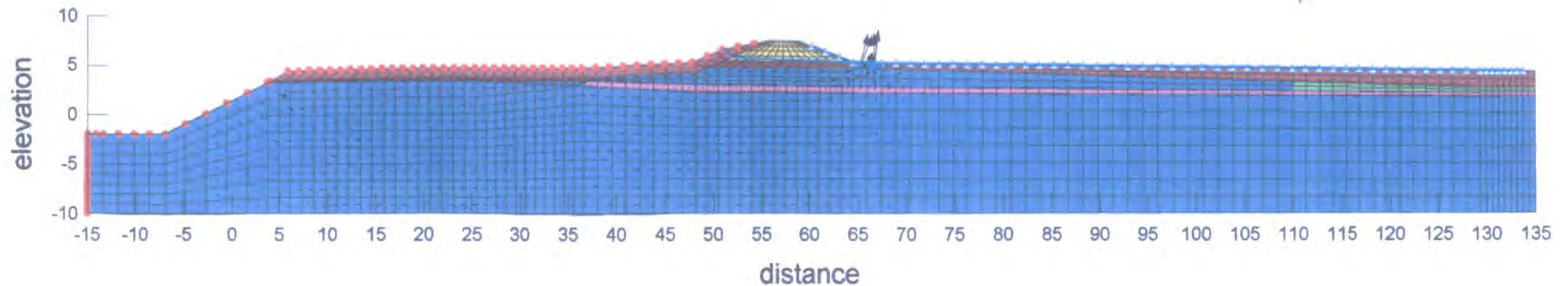
Comments: Cross Section 3 100 yr overlay

Date: 30/03/2006 Time: 10:12:09 p.m.

overlay on river berm and pressure relief trench at toe

time step 50 - 100 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



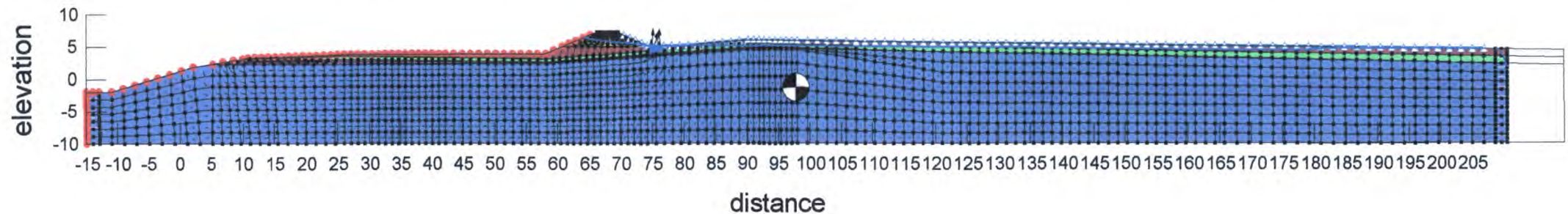


Name: cross section 4 100 yr.gsz  
 Title: Rangitaiki Stopbanks Section 3  
 Comments: Cross Section 4 100 yr  
 Date: 26/09/2006 Time: 12:27:53 p.m.

pressure relief well

time step 50 - 100 hrs

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

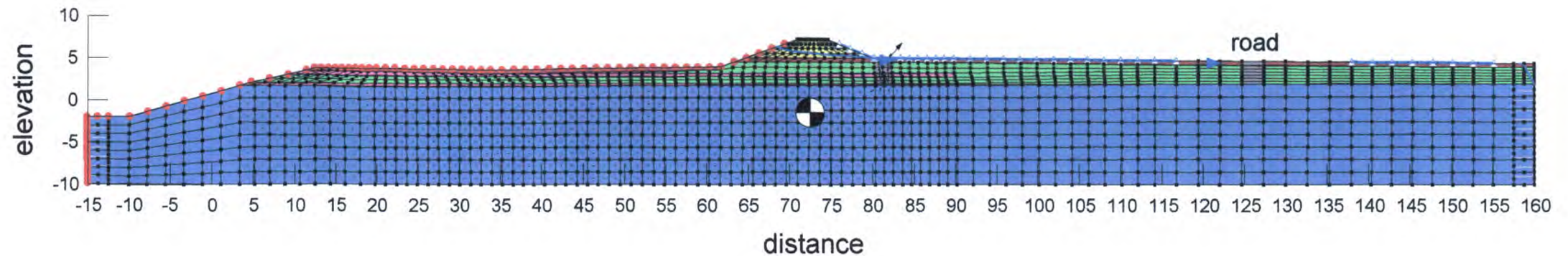


Name: cross section 5 100 yr.gsz  
Title: Rangitaiki Stopbanks Section 3  
Comments: Cross Section 5 100 yr  
Date: 26/09/2006 Time: 12:53:42 p.m.

pressure relief trench at toe and well under road

time step 50 - 100 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



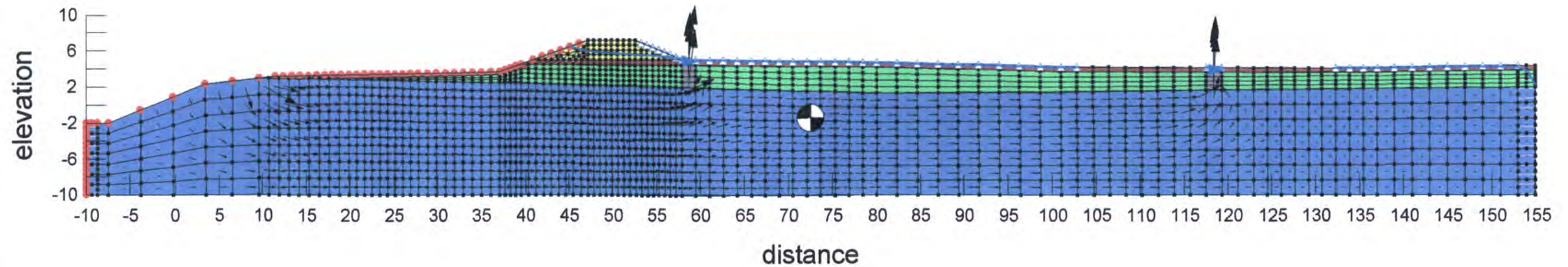


Name: cross section 6 100 yr.gsz  
Title: Rangitaiki Stopbanks Section 3  
Comments: Cross section 6 100 yr  
Date: 26/09/2006 Time: 1:27:49 p.m.

Time step 50 - 100 hours

two pressure relief trenches

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: 4	Vol WC Fn: 4	Ky/Kx Ratio: 1	Direction of Kx: 0

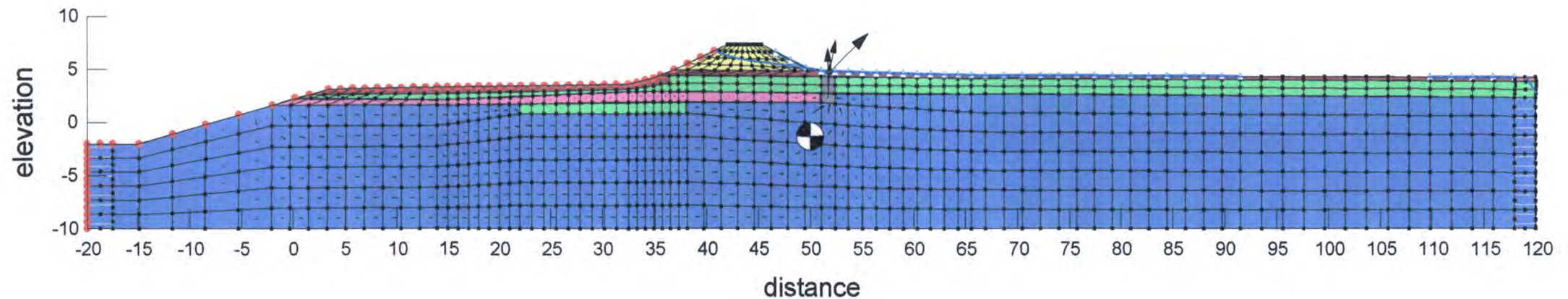


Name: cross section 7 100yr.gsz  
Title: Rangitaiki Stopbanks Section 3  
Comments: Cross Section 7 100 yr  
Date: 26/09/2006 Time: 1:40:48 p.m.

One pressure relief trench at toe

time step 40

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: 5	Ky/Kx Ratio: 1	Direction of Kx: 0



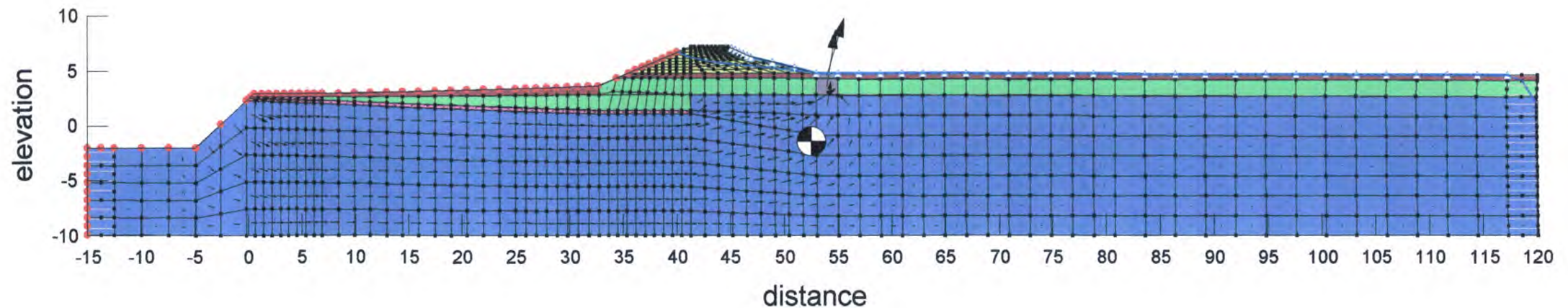


Name: cross section 8 100 yr.gsz  
Title: Rangitaiki Stopbanks Section 3  
Comments: Cross Section 8 100 yr flood  
Date: 26/09/2006 Time: 4:29:45 p.m.

One pressure relief trench

time step 40

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: 5	Ky/Kx Ratio: 1	Direction of Kx: 0



Name: cross section 9 100 yr flood mod silt.gsz

Title: Rangitaiki Stopbanks Section 3

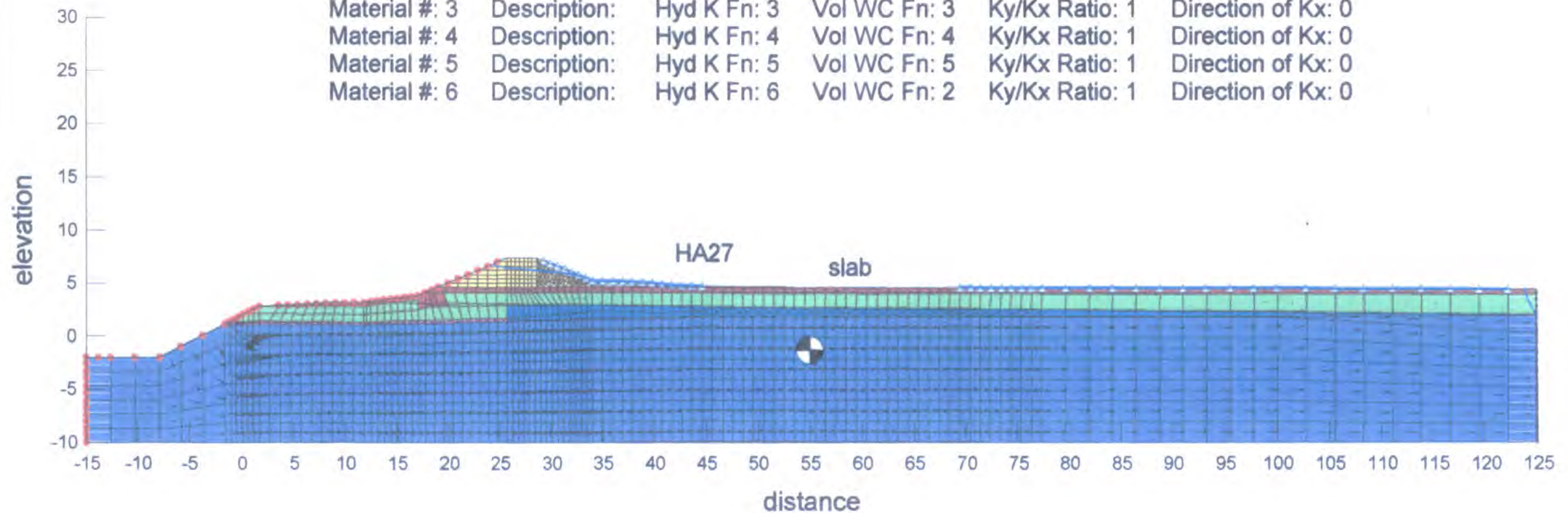
Comments: Cross section 9 100 yr flood

Date: 20/04/2006 Time: 10:45:24 a.m.

no remediation work - concrete slab

time step 40 - 80 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: 2	Ky/Kx Ratio: 1	Direction of Kx: 0





Name: cross section 10 100 yr flood mod.gsz  
Title: Rangitaiki Stopbanks Section 3  
Comments: Cross Section 10 - 100 yr flood  
Date: 07/05/2006 Time: 11:03:05 a.m.

time step 40 - 80 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

