

Rangitaiki River Stopbanks Assessment

Miro Place

Right Bank 11200 to 11850m

Prepared for

Environment Bay of Plenty

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1 Introduction

During the flood of 11 to 14 July 1998, seepage was observed from the base of the section of stopbank on the right bank of the Rangitaiki River between the ends of Nikau Place and Miro Place. Clean rock was placed along the toe to form a berm about 4m wide during the flood. Following the flood Opus International Consultants carried out some investigations in this area and recommended that a pressure relief trench be installed along the inland toe of the stopbank (Reference 1). This work was not carried out.

The Transpower substation, just upstream from Miro Place, requires flood protection for events with up to a 300 year return period, in contrast to the 100 year return period design standard for the stopbanks along the river. It was therefore decided to re-assess the competence of the stopbank from State Highway 2 upstream to Hydro Road (RB 11200 – 11850). This report presents the results of the assessment. The section of stopbank between 11850m and the substation has recently been assessed for a 100 year return period flood and will be re-assessed for the higher level of protection.

This report includes the following information:

- the results of insitu investigations,
- laboratory grading test results,
- the results of seepage analyses for bank full conditions,
- the results of stability analyses 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 right bank from 11200m to 11850m.

2 Site Description

Along this section the stopbank varies in height between about 1.6m and 2.6m above the ground level on the inland side. The top of the stopbank is 3 to 4m wide. The river berm is typically 2m or more lower than the natural ground surface. Over time the river berm, which is up to 100m wide just upstream of the rail bridge, has been used as a borrow area for stopbank construction and a dump site (Figure 1). At the upstream end of the study section (11850m) there is no river berm.

The ground falls away from the stopbank at most of the eight cross sections assessed (Figure 1). The greatest fall is at Cross Section 6 where there is 900mm fall within 35m of the stopbank. The ground in the resulting low area was very wet but it is considered that this was due to a leak in a Whakatane District Council water valve. The valve has recently been repaired and the ground has dried out.

There is one building at the end of Nikau Place quite close to the stopbank. This area has the appearance of an old contractor's yard and it is understood that debris from the Edgumbe Dairy factory was buried here after the 1986 earthquake. At the upstream end of the study sections there are several houses and garages close to the toe of the stopbank.

A 33kV cable crosses from the river side of the stopbank to the inland toe of the stopbank opposite the end of Nikau Place. The cable remains at the inland toe of the stopbank for the remainder of the study length and its presence limits the available remedial options for the stopbank.

3 Subsurface Investigations

The subsurface investigations originally consisted of 19 hand augers carried out in eight cross sections at 60 to 70m intervals along the study length (Figure 1). Two deeper boreholes carried out by Opus in 2000 were used to provide additional subsurface information at Cross Section 3. The hand augers were normally continued until the holes collapsed below ground water level, the holes squeezed in or over 4.0m depth was achieved. The logs of all the subsurface investigations are included in Appendix A and Figures 3 to 10 show the estimated subsurface soil profiles.

It was found impossible to get below 0.8m depth in the HA5 location due to the presence of rock and coal. HA5A was augered through the top of the stopbank at this cross section to try to determine what lies beneath the stopbank. After passing through some coarse sand it was abandoned at 1.4m depth due the presence of more rock. Further coal and rubbish was found in HA6 at the river side toe of the stopbank. This was underlain by natural sand and silt sequences.

Rock was also found below coarse sand in the stopbank in HA2 and HA4 on each side of the rail bridge. HA2A at the toe of the stopbank showed there was a layer of fine coal below the grass.

Due to the discovery of high permeability coarse sand within the stopbank in several locations and the difficulties in finding what lies below the stopbank around Cross Section 2, it was decided to use an excavator to dig some test pits. Care had to be taken to avoid the 33 kV cable in this area. The protection board above the cable was found to be about 1.6m below the top of the stopbank. A total of seven test pits were excavated from the top of the stopbank and one at the river side toe of the stopbank. Four further hand augers (HA20 to 23) were carried out through the top of the stopbank to confirm the extent of the coarse sand layer found in all the test pits.

Figure 2 shows a long section through the stopbank developed from the test pits. Distinct layers of flyash and fine coal were found in several of the test pits and layers of mixed material in others. The high permeability coal extended to almost 4.5m below the top of the stopbank and the layers of coal and flyash may extend for over 120m along the stopbank. Figure 4 shows the subsurface profile found at Cross Section 2. It can be seen that the coal

would have formed a flow path under the stopbank in the flood of 1998. The extent of this layer corresponds well with the rock toe loading placed during the flood.

The coarse sand layer in the top of the stopbank was found right along the study length and to extend to up to 1.6m depth. Its presence may be due to the need to rapidly lift the stopbanks after the 1986 earthquake.

The natural surface soil away from the yard at the end of Nikau place is typically a 200 to 300mm thick layer of silt. This is underlain by silty fine to medium sands and coarse sands and fine lapilli. Some clayey silts were found at cross sections 5 to 8 away from the bend in the river. Some thin lenses of peat were also found. There does not appear to be any particular trend in layers sloping towards or away from the river.

A constant head permeability test was carried out at the HA13 location in order to gain a reasonable estimate of the in situ permeability of the light silty fine to medium sand that is present across most of the site. The result of this test is a permeability of 2 to 2.5×10^{-6} m/s.

4 Laboratory Test Results

Hydrometer particle grading tests were carried out on six samples of subsurface soils to enable estimation of permeability using the Hazen formula:

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

The grading test results are summarised in Table 1.

Table 1: Particle Grading Results

Sample	Description	D ₁₀ (mm)	D ₆₀ (mm)	permeability
HA2 1.2m	yellow brown grey well graded sand	0.005	0.12	2.5×10^{-7} m/s
HA2A 1.2m	brown grey silty fine sand	0.0075	0.10	5.6×10^{-7} m/s
HA6 3.0m	brown grey medium-coarse sand	0.01	0.45	1.0×10^{-6} m/s
HA9 1.5m	brown grey silty fine-medium sand	0.018	0.19	3.2×10^{-6} m/s
HA12 0.8m	brown grey silty fine sand	0.0105	0.09	1.1×10^{-6} m/s
HA18 1.2m	brown grey silty fine-medium sand	0.016	0.16	2.6×10^{-6} m/s

The estimated permeabilities of the HA12 and HA18 samples are close to that estimated from the constant head test in the same sand at HA13.

The results of all the laboratory tests are included in Appendix B.

A sample of the flyash was tested to see if it could be a significant source of ground water contamination. It was concluded that if the flyash was undisturbed it did not form a significant risk but that if it was exposed and excavated a controlled disposal area would be required.

5 Analyses

5.1 Discussion

The in situ investigations carried out provide subsoil profiles in isolated locations only. The 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 test pits identified an area where rubbish, coal and flyash were buried below the stopbank but there may be other undetected pipes, rubbish pits or rotten tree stumps below the stopbank.

The computer programme used to analyse the seepage problems, Geo-Slope Seep/W (2004), is a two dimensional programme. Therefore three dimensional effects, such as lateral changes in the soil profile or the presence of an impermeable surface of given width, can not be accurately modelled. The seepage analyses carried out must therefore be considered indicative only.

Four possible problems could arise due to a flood in the river:

- excessive flows under the stopbank
- piping of soils leading to collapse of the stopbank
- heave of upper soil layers resulting in rapid piping and stopbank collapse
- failure of either face of the stopbank due to high water level or draw down conditions.

The most common remedial measures for heave problems are the addition of an overlay on the ground surface or the construction of a pressure relief trench or wells. Pressure relief trenches are usually formed at the inland toe of the stopbank but at this site there is a 33kV cable in this location. In many places a trench can not be moved inland because of the presence of structures. Therefore pressure relief trenches are not considered to be a viable option for this section of stopbank.

The aim of the remedial measures is to achieve a minimum factor of safety against heave of 1.1 to 1.2. In reality, due to the conservative assumptions made in the permeability of the soil layers and the weight of the upper soils, the factor of safety should be higher than that estimated.

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 area susceptible

to piping to allow seepage without the removal of soil particles. The maximum hydraulic gradient considered acceptable with the light soils in this area is 0.4.

Seepage of only small volumes of water from the ground surface can significantly reduce the uplift pressures acting on a surface layer with a lower permeability than those soils underlying it. Seepage from the ground surface inside the stopbank has been modelled right along the study length except at the adjacent road. Most of the houses in the area are built on short timber piles which will allow ground seepage under them. The driveways and paths are relatively narrow.

5.2 Flood Hydrograph

As the design level for this section of stopbank is a 300 year return period flood, steady state bank full conditions have been assumed. This is a conservative approach as it can take many days for high water pressures to develop inland of a stopbank and it is considered unlikely that water levels will remain at or close to the top of the stopbank for more than say four days. The peak of the 100 year return period flood flow hydrograph for the Rangitaiki River is less than two days long.

5.3 Soil Model

The soil layers found in the in situ investigations were simplified in the models used for the seepage analyses (Figures 3 to 10). The grading test results were compared to the field descriptions of the soils to confirm the soil categories. Below the surface layer of brown silt the layers were divided into silty fine to medium sand, fine to medium sand, clayey silt and coarse sands and fine lapilli. The peat lenses were modelled as clayey silt due to their low permeability.

The stopbank was modelled as layers of coarse sand, and silty fine sand. The flyash was modelled as a silty fine sand and the coal as a coarse sand.

The horizontal permeability of the silty fine sand stopbank fill was considered to be twice the vertical permeability due to it being compacted in layers. All the other soils were considered to have equal horizontal and vertical permeability.

The permeabilities assumed were conservatively based on the grading test results for this site, the constant head test and laboratory permeability tests on samples from other sites along the river. In terms of the assessment of the heave potential of the upper silt layer it is conservative to assume a permeability on the low side of that found from the tests on the upper silts and on the high side for the more permeable sand layers acting as aquifers.

Table 2 summarises the saturated soil permeabilities assumed. Some sensitivity analyses were carried out to check how sensitive the developed water pressures were to the assumed permeabilities. It was conservatively

assumed that there is a thick layer of coarse sand and lapilli below the depth of investigations as this was found at the base of many of the augers in the river berm, in the two deep Opus bore holes and in the investigations at near by sites along the river.

The Geo-Slope Seep/W (2004) 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

soil	k_h (m/s)
stopbank fill silty fine sand	2×10^{-6} $k_v=1 \times 10^{-6}$
stopbank fill coarse sand	1×10^{-4}
flyash	4×10^{-6}
coal	1×10^{-4}
brown silt	8×10^{-7}
silty fine sand	4×10^{-6}
fine to medium sand	1×10^{-5}
clayey silt/peat	5×10^{-8}
coarse sand and fine lapilli	1×10^{-4}

The weight of the upper soils was assumed to be between 14 and 15.5 kN/m³, depending on the particle size and pumice content.

Each stopbank cross section was modelled to at least 40m away from the inland side of the stopbank to take into account the fall of the land away from the stopbank and to minimise the influence of the boundary conditions on the results. Infinite elements were used to model flow towards the river from a great distance. Steady state analyses were carried out with the water level equal to the level of the top of the stopbank.

5.4 Cross Section 1

Cross Section 1 lies beside the railway bridge and butts into the railway embankment (Figure 3). It includes about a 50m wide hummocky river berm. There were reports of seepage from the railway embankment near Hydro Road in one flood. It is possible that water passed through the coarse sand at the top of the stopbank and tracked through the railway ballast.

The seepage analysis was carried out with an assumed ground level on the inside of the stopbank to represent the section between the rail and road bridges.

Stopbank fill materials were found to extend to 4m below the top of the stopbank in TP2. Clayey silts were found below this. The two hand augers in the river berm showed silt and silty fine sand overlying a medium sand and peat. It was assumed that the medium sand layer extends under the stopbank.

The steady state analysis indicated an acceptable factor of safety against heave and an acceptable hydraulic exit gradient at the toe. The flow through the coarse sand at the top of the stopbank was estimated at $0.5\text{m}^3/\text{day}/\text{m}$ length of stopbank.

It is therefore considered that the only work that is required along this length of stopbank is to remove the coarse sand and to replace it with a soil of lower permeability.

5.5 Cross Section 2

Figure 4 shows Cross Section 2 with coal extending right under the stopbank and a 2m head difference between the top of the stopbank and the inland ground level. Seepage through the coal layer and the overlying flyash could result in inland contamination. The investigations showed silts, silty fine sand and medium sand underlie the coal. Coarse sand and lapilli were found at between RL1.6 and 1.0 in HA6 and HA7. The presence of the high permeability rock berm was ignored in the seepage analysis.

Under steady state conditions the flow through the coarse sand in the stopbank and that through the coal under the stopbank is an estimated $1.8\text{m}^3/\text{day}/\text{m}$ length of stopbank. There are low hydraulic exit gradients due to the presence of these high permeability layers.

To avoid the need to excavate and relocate the flyash it is considered a 0.5m thick clay overlay on the river side of the stopbank is the best remedial option. This would greatly reduce the water flowing through the coarse sand and coal. In order to seal off the coal layer the overlay would have to extend at least 30m from the toe of the stopbank. The precise extent of the coal across the river berm would have to be checked by digging test pits during construction. The permeability of any proposed overlay material should be tested to ensure it is below the $5 \times 10^{-8} \text{ m/s}$ assumed. If the permeability is higher a greater thickness of overlay will be required.

A check was made to see if there was any risk of heave of a competent surface silt layer behind the stopbank with this option. Factors of safety in excess of 1.2 were found.

5.6 Cross Section 3

The subsurface soil profile at Cross Section 3, shown in Figure 5, was derived from HA8, test pits 6 and 7, and Opus boreholes 4 and 5. There is not such

an extent of coal and flyash as at Cross Section 2 but the underlying soils are similar with coarse sand and lapilli found at between RL1.1 and 2.4.

The combined flow through the coal and the coarse sand in the stopbank was found in the steady state analysis to be $0.9\text{m}^3/\text{day}/\text{m}$. An unacceptable high hydraulic exit gradient was found at the toe of the stopbank beneath the rock fill. The factor of safety against heave of the upper silt layer was also found to be marginal.

A 30m wide, 0.5m thick clay overlay on the river berm and up the face of the stopbank is recommended as a remedial option as for Cross Section 2. This recommendation is made on the assumption that the underlying clean coarse sands are less than 4m thick, as found in all the deep boreholes in the area.

A sensitivity analysis was carried out varying the permeability of the surface silt to confirm an adequate factor of safety against heave.

High hydraulic exit gradients will remain at the toe of the stopbank even with the clay overlay. It is therefore recommended that the rock berm be removed, a geotextile filtration layer be laid and the rock berm replaced.

It will be necessary during construction to confirm that the clay overlay extends at least 5m laterally beyond where the medium sand layer is close to the surface of the river berm.

5.7 Cross Section 4

There is still a rock berm at Cross Section 4 but no coal or flyash were discovered in the test pits. The soils are predominantly silty fine sands with a silt layer containing some clay found at 0.6m depth in HA9 at the inland side of the stopbank. The under-lying coarse sand layer appears to dip away from the river and is at RL1.3 on the inside of the stopbank (Figure 6).

The ground level on the inside of the stopbank is low compared to the previous three cross sections. Within 10m of the stopbank it is at RL4.6, giving a 2.6m head difference between the top of the stopbank and the ground level.

As for Cross Section 3, under steady state conditions the analysis showed high hydraulic exit gradients below the rock berm. There is also a risk of heave of the surface soil layers. To reduce the flow through the stopbank and the risk of heave it is proposed to place a 25m wide, 0.5m thick clay overlay over the river berm and up the stopbank face, and to bring the ground level within 15m of the inside toe of the stopbank up to at least RL4.8. As this area is in a gravel yard it is recommended that gravel be used for this purpose.

As a precaution against piping at the toe of the stopbank it is recommended that the entire extent of the rock berm be removed and geotextile be laid under it before it is replaced. This will also enable the rock berm to be covered in soil to make it more usable for the adjacent land owners.

5.8 Cross Section 5

At Cross Section 5 the river berm is much narrower than at the previous four cross sections and there is a 200mm deep dip at the inland toe of the stopbank (Figure 7). The soils under the stopbank are similar to those at Cross Section 4 with coarse sands found at RL 1.9m. Clayey silt was found at RL2.2 in HA12.

The steady state analysis showed potential problems with high hydraulic exit gradients and heave at the toe of the stopbank. As a river berm overlay will not seal the soil layers causing the high uplift pressures an internal overlay is recommended. It is considered that this overlay should be 600mm thick at the toe of the stopbank and taper down to 300mm thick 30m from the toe. It should be formed of a relatively high permeability material. The coarse sand that should be removed from the top of the stopbank could be used as an overlay with a topsoil cover.

5.9 Cross Section 6

At Cross Section 6 the river berm has reduced to about 15m width. The ground falls as low as RL4.4 between the stopbank and Hydro Road. This gives an effective head difference of 2.8m between the top of the stopbank and the ground level. Clayey silt layers were found in all three of the hand augers along this cross section and no coarse sands or lapilli were found within the depths of the hand augers. The steady state analysis was carried out assuming these high permeability layers below the depth of the investigations (RL 1.0). As these soils were found just upstream and downstream of this cross section their presence is considered a reasonable assumption.

The seepage analysis showed potential heave problems in the low area near the road. A sensitivity analysis was carried out varying the depth to the high permeability layers to see if a deep borehole would be justified to confirm the soil layers. It was found that even if the high permeability soil was below RL-4.0 the minimum factor of safety against heave still did not rise above 1.1. The use of an over-lay in this area by the road is considered impractical. An analysis was therefore carried out assuming a pressure relief well was installed in the road verge. This pressure relief should improve the factor of safety against heave to an acceptable level.

In reality a series of wells along the road verge would be required. It is suggested that these be placed at 12 to 15m spacings. Great care will be required in their installation as there is an 11kV cable in the verge, a water main and other services. Under bank full conditions the estimated flow from these wells would be in the order of 1.7m³/day/m.

The coarse sand within the stopbank should be removed and replaced with a fill with lower permeability.

5.10 Cross Section 7

At Cross Section 7 extensive layers of silt and clayey silt were found beneath the stopbank (Figure 9). An old road was found to extend inland from under the stopbank. The gravely silty sand forming the road could not be penetrated under the stopbank. As for Cross Section 6 no coarse sand was found within the depth of the investigations.

Under steady state bank full conditions there should not be any problems with high hydraulic exit gradients at this cross section. However if a coarse sand is assumed below the depth of investigations the factor of safety against heave could be marginal. A pressure relief well close to the road should reduce the uplift pressures to an acceptable level.

As for Cross Section 6 a sensitivity analysis was carried out varying the depth to a high permeability layer. It was found that if this layer was below RL-3.3 there is an adequate factor of safety against heave; however as coarse sands have been found above this level in all the deep investigations and as pressure relief wells are required at the two adjacent cross sections, it is considered that pressure relief wells should be installed here.

The coarse sand within the stopbank should be removed.

5.11 Cross Section 8

At Cross Section 8 there is no river berm and there is a 2.6m head difference between the top of the stopbank and the adjacent land. A fine to medium sand layer was found to run below the stopbank. No coarse sands were found within the depth of the investigations but they were found at the adjacent cross section previously reported on in Section 6 of the Rangitaiki investigations (Reference 2). Coarse sands were therefore included at the base of the soil model.

It was found in the steady state bank full analysis that the fine to medium sand layer gives rise to high uplift pressures below the inland silt layers and a high hydraulic exit gradient. There is also a marginal factor of safety against heave of all the upper soil layers due to the coarse sand below.

It was found in the steady state analysis that the factors of safety against heave still did not reach above 1.1 when the river side of the sand layer was sealed with clay and a pressure relief well was installed near the road. The steady state analysis is however conservative as it assumes the river level is at the top of the stopbank for an indefinite time. A 10 day transient analysis was carried out and it was found that acceptable factors of safety against heave should be maintained with the river level high for at least 4 days. The factors of safety then slowly drop with time. It is therefore considered that the clay seal and pressure relief well as shown in Figure 10 should provide an adequate factor of safety in a 300 year return period flood.

As there is no river berm at this cross section a stability analysis was carried out. The assumed soil strength parameters are given in Table 3.

Table 3: Assumed Soil Parameters

soil	density (kN/m³)	effective cohesion (kPa)	friction angle (degrees)
stopbank coarse sand fill	14	0	35
stopbank silty sand fill	16	2	33
silt	15.5	5	27
silty fine sand	15	2	33
fine to medium sand	14	0	35
coarse sand	14	0	35
clayey silt	15.5	5	24
rock fill	18	0	45

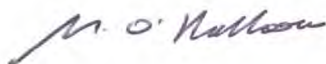
It was found that the factor of safety against a slope failure which could reach to the crest of the stopbank under normal river flow condition is only about 1.1. Under bank full conditions the factor of safety increases to 1.3 as the river water helps to support the face. Under rapid drawdown conditions the factor of safety drops below 1.0. It is therefore considered that a rock berm is required along the river bank.

If a 5m wide rock berm is placed against the river bank up to RL3.0, under normal river flow conditions the factor of safety against slope failure should increase to 1.5. Under rapid drawdown from bank full conditions the factor of safety drops to about 1.2. This is considered acceptable in these extreme conditions. The clay seal across the fine sand layer can be placed at the same time as the rock berm.

6 Conclusions

The design of the remedial measures required to improve the integrity of the stopbank has had to allow for the need to leave the flyash, coal and 33 kV cable undisturbed and the locations of various structures. Figure 11 shows the approximate locations of the various remedial measures discussed below.

1. The coarse sand in the top of the stopbank should be removed and replaced by a lower permeability fill over the entire study length except where there is a clay overlay on the river side of the stopbank.
2. The existing rock berm on the inside of the stopbank should be uplifted, a layer of geotextile placed and then the rock berm replaced and shaped for ease of maintenance.
3. A 0.5m thick clay overlay up the river side face of the stopbank and across 25m to 30m of the berm is required where there is coal and other debris beneath the stopbank. The permeability of the proposed overlay needs to be confirmed by testing and the extent of coal and high permeability sand across the river berm established.
4. A gravel overlay should be placed within the area of the bus park to bring the ground level up to RL4.8 within 15m of the toe of the stopbank.
5. A 30m wide high permeability overlay is required in the horse paddock. It should be 600mm thick at the toe of the stopbank and taper to 300mm. It could be made of the coarse sand removed from the stopbank.
6. Pressure relief wells should be installed at 12m to 15m intervals in the grass verge along Hydro Road.
7. At the upstream end of the study section a 5m wide rock berm reaching to RL3.0 is required along the river bank. The exposed fine sand layer in the river bank should be sealed with clay.



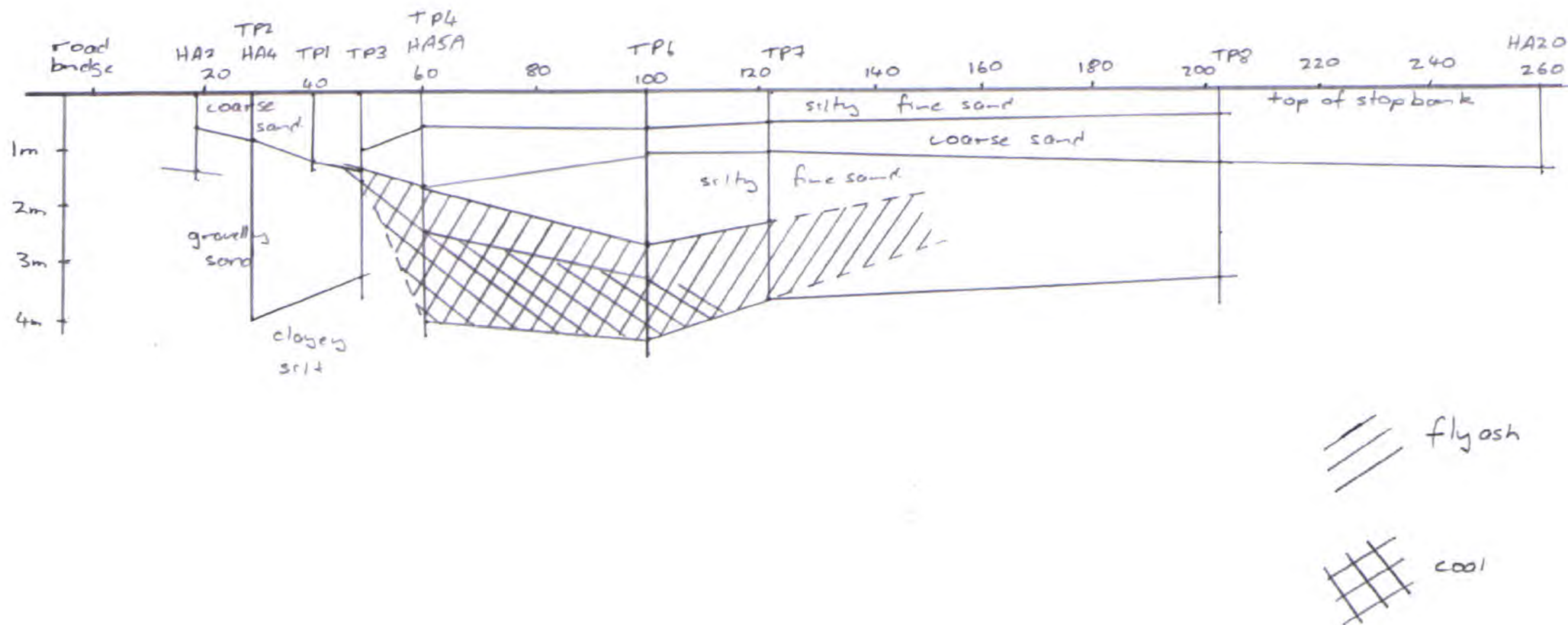
M. O'Halloran
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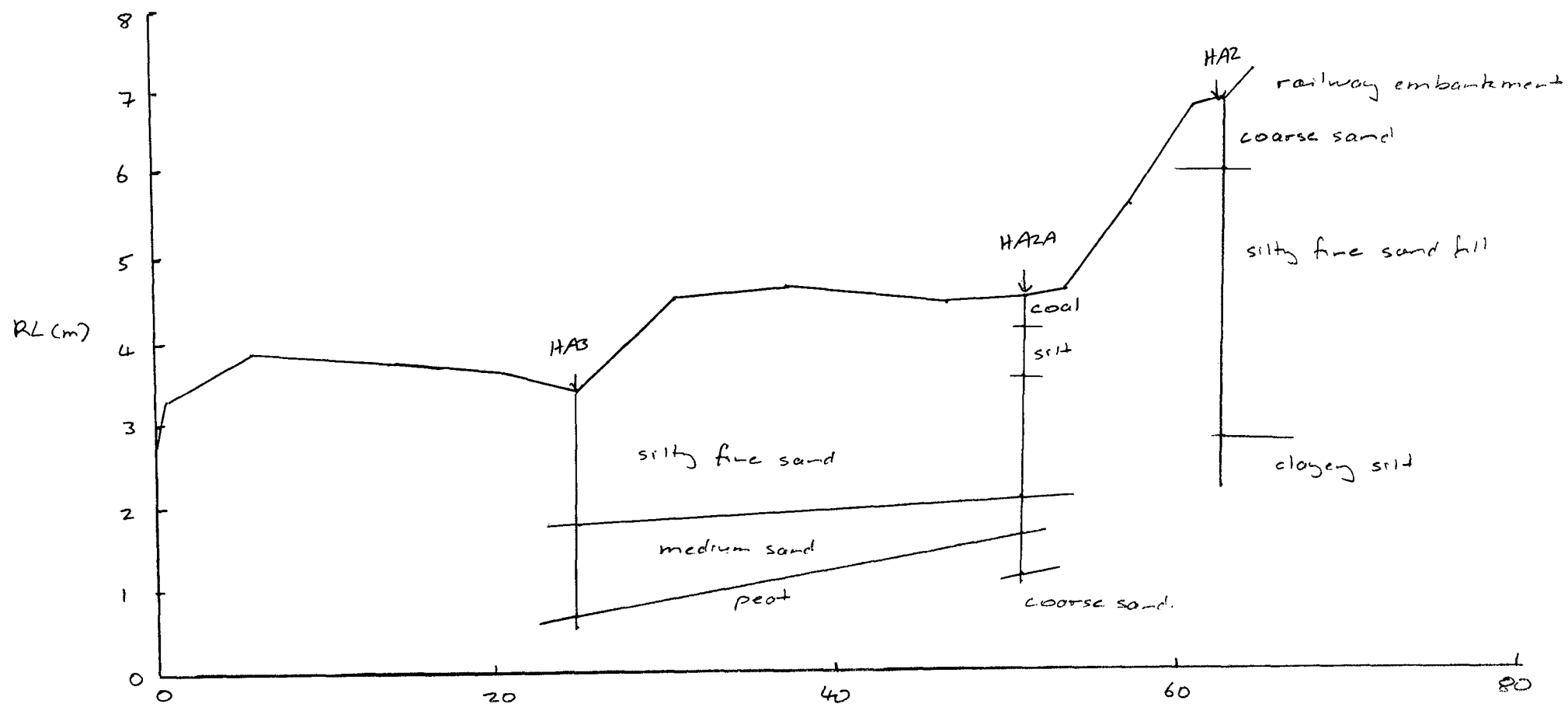
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- 2 Ice Geo & Civil (May 2006) Rangitaiki River stopbanks assessment, Section 6, Right bank 11850 to 12300m.



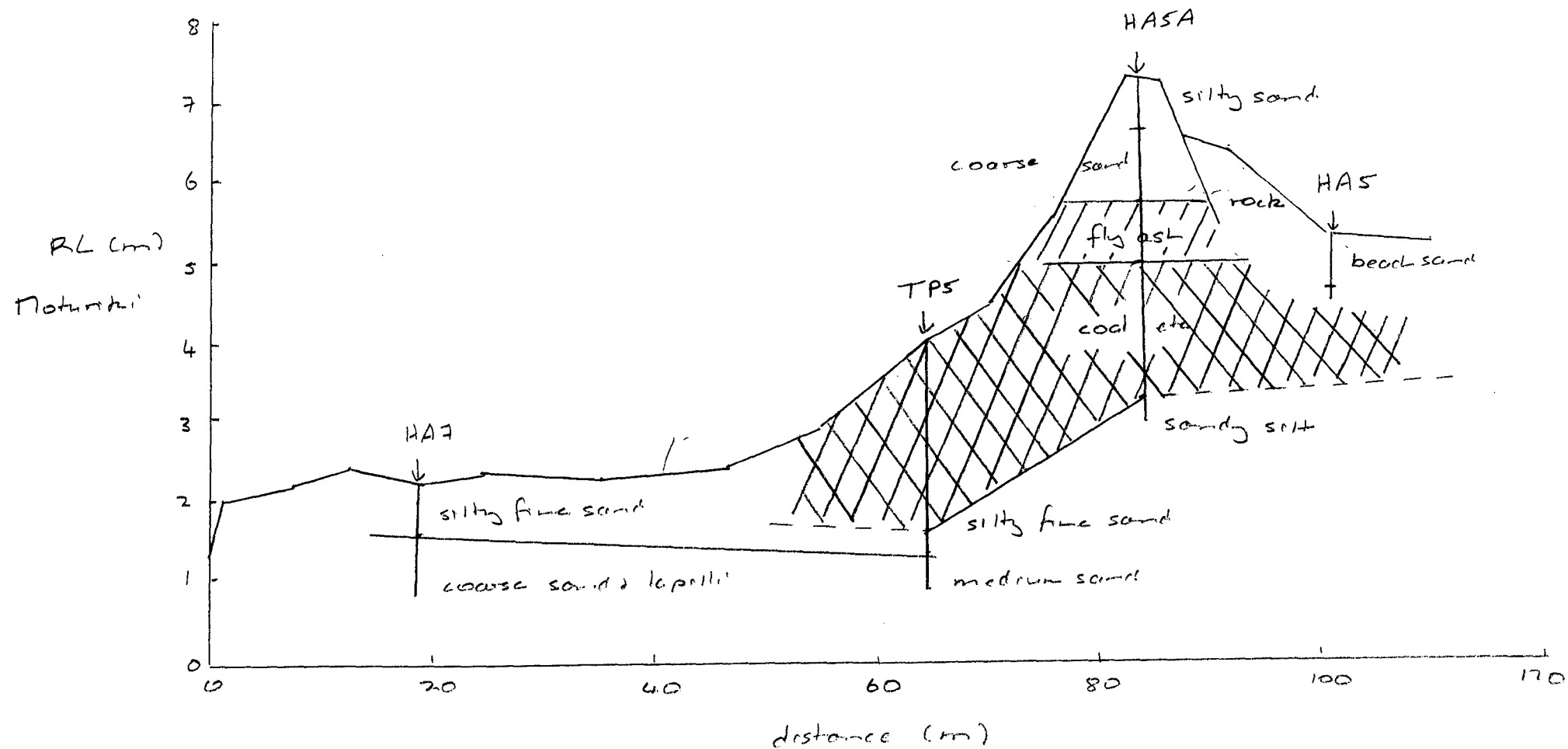


Long Section

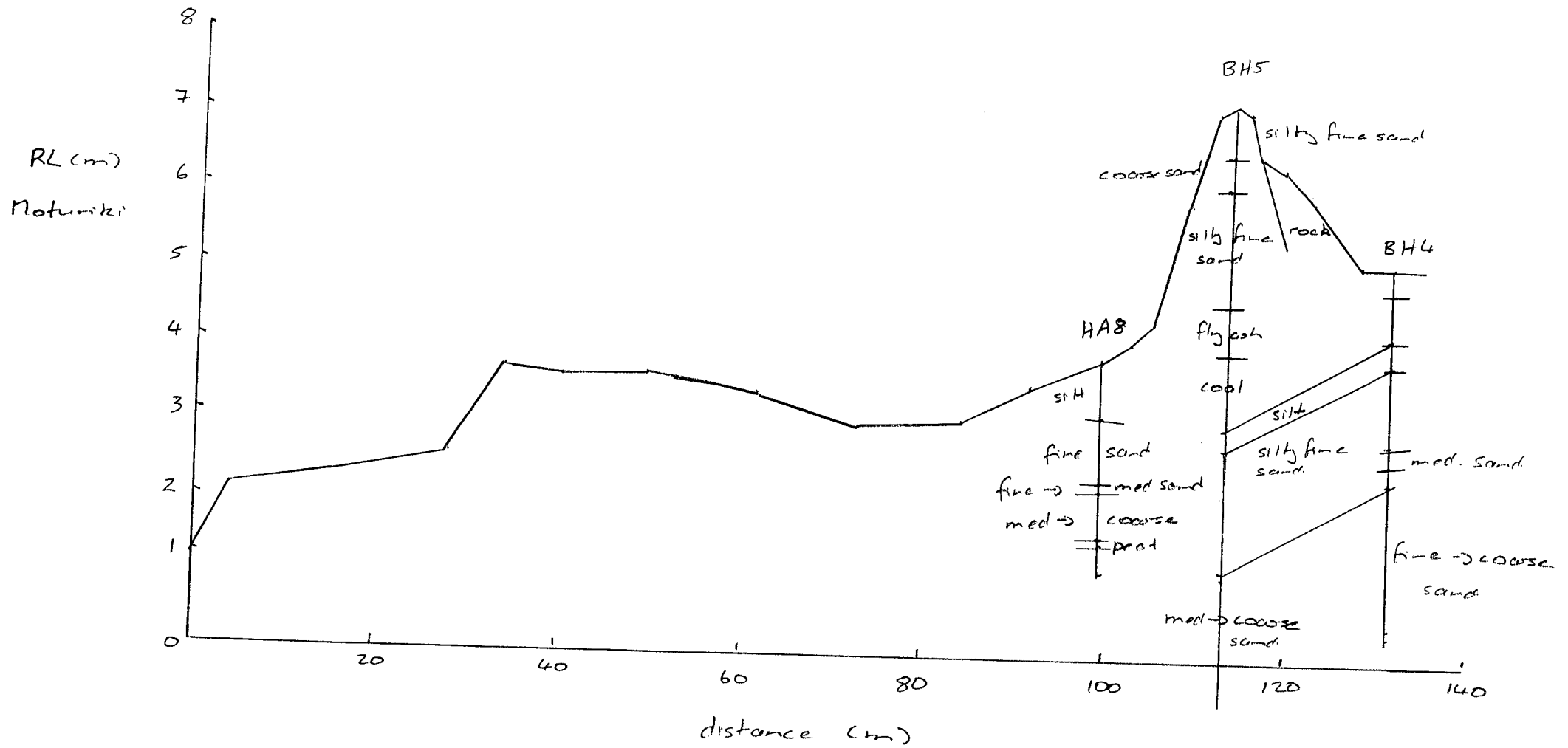


Cross section 1

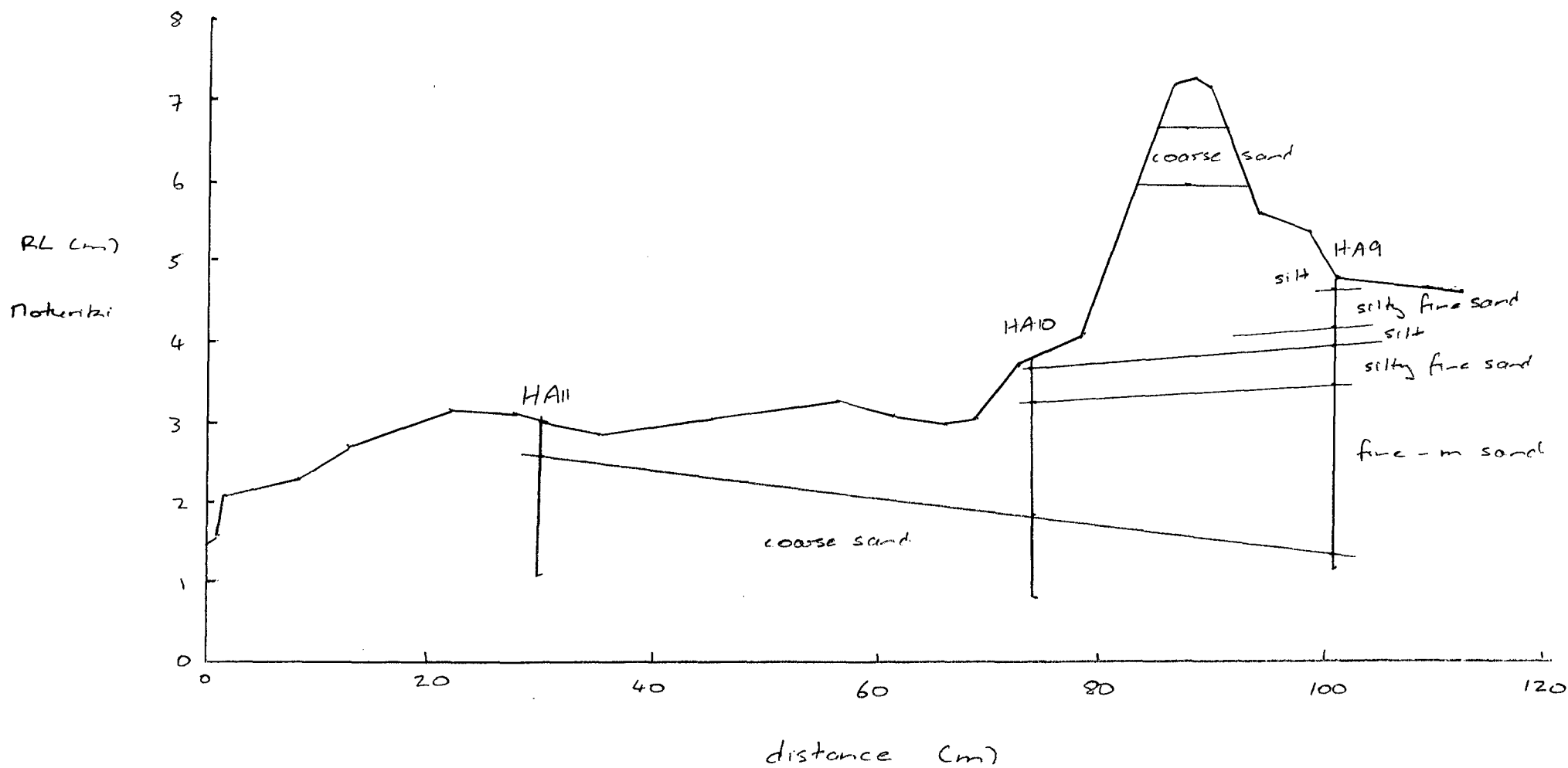
Figure 3



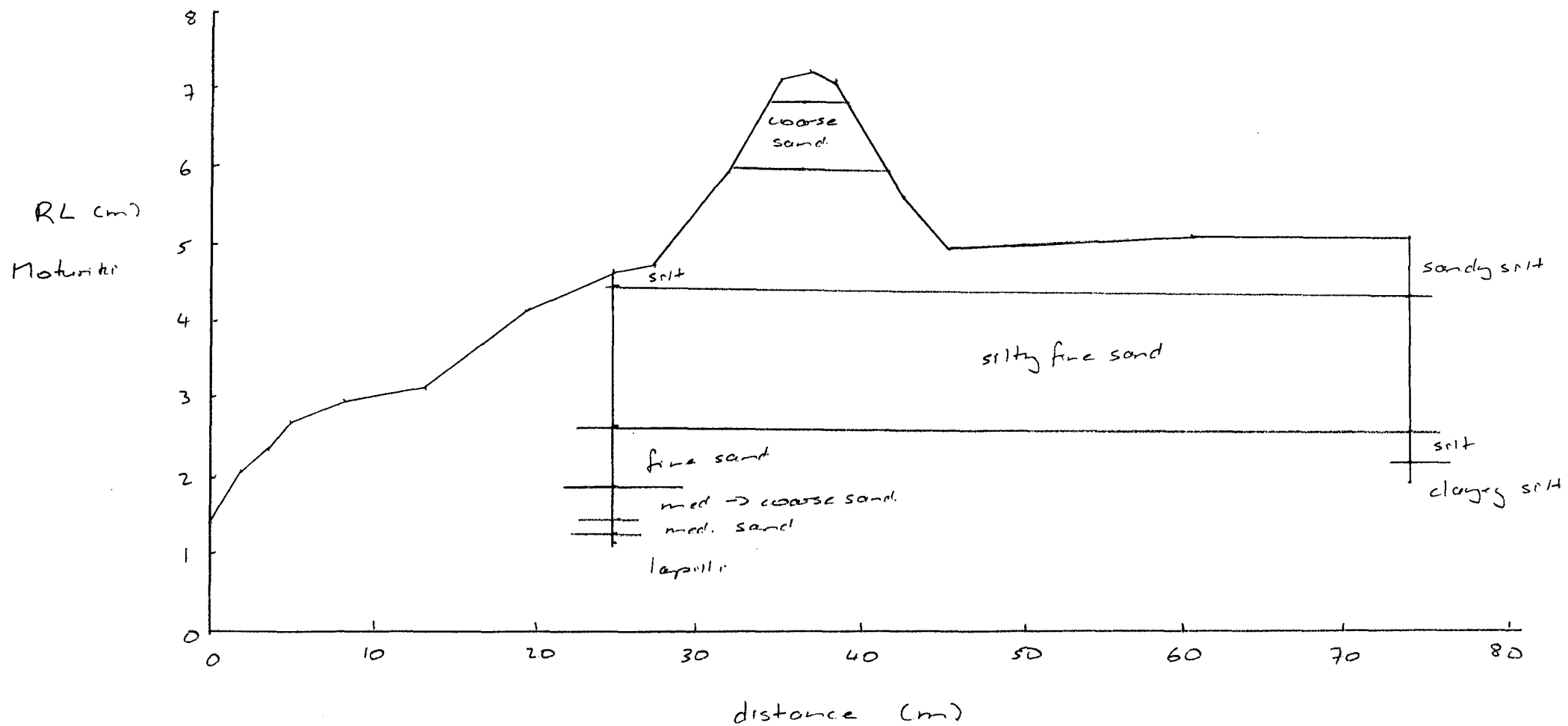
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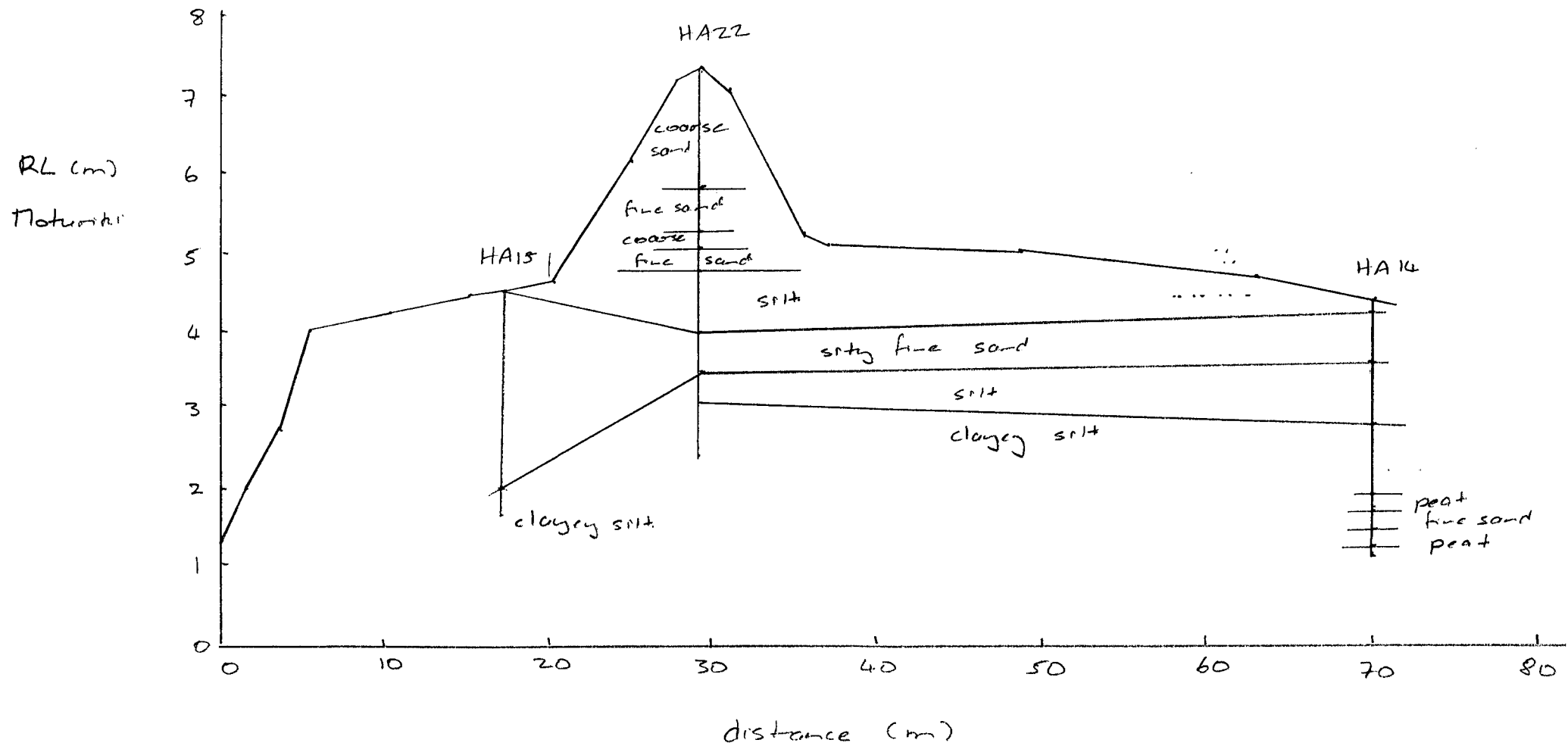
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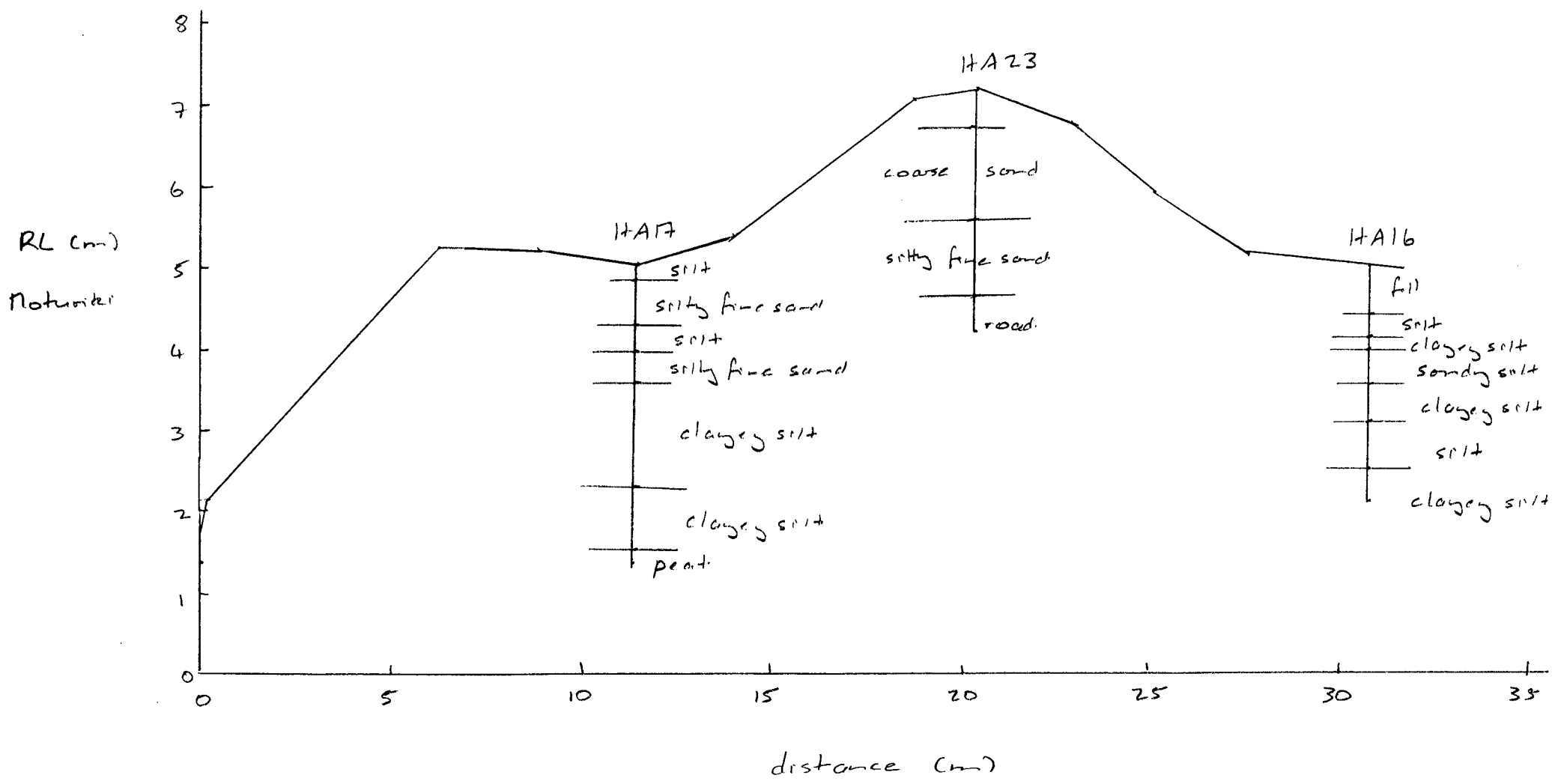
Cross section 4



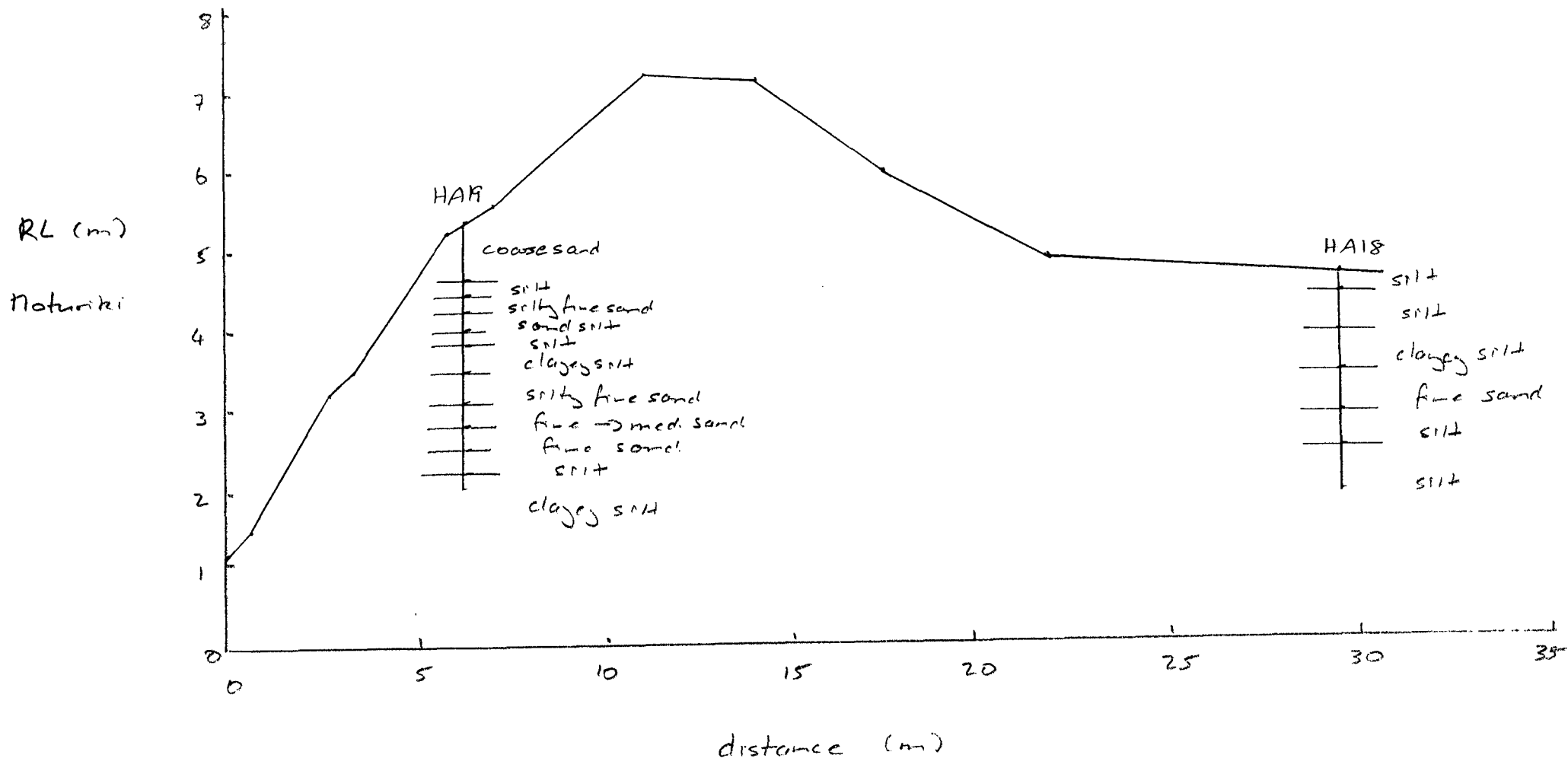
Cross section 5



Cross section 6



Cross section 7



Cross section 8



- clay overlay
- re-lay rock berm
- granular overlay
- rock berm
- pressure relief well

Appendix A

Hand Auger and Bore Hole Logs

Hand Auger Log

Test Number: HAZ

Job Name: Rangitaihi Stopbanks
Miro Place

Date: 13/9/07

Tested by: M.O'H

p/s side railway bridge
top of stopbank

m	Blows/50mm													C _u (kPa)	soil description
	0	2	4	6	8	10	12								
0.0															topsoil
0.2															0.05 light brown coarse pumice SAND
0.4															0.4 x
0.6															0.55 gravelly SAND, some clay clasts, rounded hard gravel → 20mm
0.8															0.7 orange-yellow / grey silty f SAND with clay, some blue rock → 10mm
1.0															1.0 orange-yellow / grey silty fine-med. SAND
1.2															12 x
1.4															
1.6															1.5 EOB rocks
1.8															
2.0															
2.2															
2.4															
2.6															
2.8															
3.0															
3.2															
3.4															
3.6															
3.8															
4.0															

C_u (kPa)

Hand Auger Log

Test Number: HAZA

Job Name: Rangitikei Stopbanks
Miro Place

Date: 13/9/07

Tested by: N.O.H

D/S side of railway bridge
toe of stopbank

		Blows/50mm										Cu(kPa)	soil description
m		0	2	4	6	8	10	12					
0.2												✓	black charcoal
0.4												✓	0.4 brown/grey clayey SILT, damp
0.6												✓	0.5 dk brown grit → 1mm, Tawhara ASL
0.8												✓	0.55 orange stained grey SILT, some clay, damp
1.0												✓	0.9 orange stained grey SILT, damp
1.2												✓	1.0 orange stained grey silty fine SAND, damp
1.4												✓	
1.6												✓	
1.8												✓	
2.0												✓	
2.2												✓	
2.4												✓	2.4 grey med. pum SAND as HAZ
2.6												✓	
2.8												✓	2.8 dk brown fibrous PEAT
3.0												✓	
3.2												✓	3.2 grey coarse pum. SAND & fine lapilli → 15mm
3.4												✓	3.4 EOB
3.6													
3.8													
4.0													

Hand Auger Log

Test Number: **HAB**

Job Name: **Rangitikei Shoplands
Pine Place**

Date: **13/9/07**

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

Blows/50mm												soil description	
m	0	2	4	6	8	10	12	C _u (kPa)					
0.2												↓ X	mixed topsoil & silty fine SAND
0.4												X ↓	
0.6												X	
0.8												↓ X	
1.0												X	0.5 light grey brown silty fine SAND, damp
1.2												X	
1.4												X	
1.6												X	
1.8												X	1.6 orange stained grey fine SAND some silt moist
2.0												X	
2.2												↓	2.0 grey fine → med. pum. SAND, wet
2.4												S	
2.6												X	2.2 grey silty fine SAND
2.8												X	
3.0												↓ ↓	2.7 dark brown fibrous PEAT 2.8 EOB collapse.
3.2													
3.4													
3.6													
3.8													
4.0													

C _u (kPa)											
0	20	40	60	80	100	120					

Hand Auger Log

Test Number: *HAS*

Job Name: *Rangitauhi Stopbanks
Nino Place*

Date: *11/9/07*

Tested by: *N.O.H*

Blows/50mm		C _u (kPa)		soil description					
m	0	2	4	6	8	10	12	C _u (kPa)	
0.2									<i>black coal & rounded</i>
0.4									<i>grey waste gravel → 15mm</i>
0.6									<i>0.5 grey SILT</i>
0.8									<i>0.8 rock</i>
1.0									
1.2									
1.4									
1.6									
1.8									
2.0									<i>black coal</i>
2.2									<i>grey fine beach SAND</i>
2.4									
2.6									<i>0.6 black sandy coal</i>
2.8									<i>0.8 rock</i>
3.0									
3.2									
3.4									
3.6									
3.8									
4.0									

C_u (kPa)

Hand Auger Log

Test Number: *HASA*

Job Name: *Rangitahiri Stopbanks
Miro Place*

Date: *13/9/07*

Tested by: *M.O'H*

top of stopbank

Blows/50mm												soil description
m	0	2	4	6	8	10	12	C _u (kPa)				
0.2												black charcoal & SAND
0.4												0.2 brown /grey silty fine SAND
0.6												0.6 brown/grey coarse SAND & fine gravel
0.8												1.1 brown gravelly coarse SAND, some silt
1.0												1.4 combined with TP4
1.2												1.6 FCB rock
1.4												1.6 grey compacted silty SAND/sandy SILT & some rock, fly ash?
1.6												2.3 black fine coal, some plastic & rubbish
1.8												3.2 some rounded gravel → 20mm
2.0												3.5 rocks & concrete → 300mm
2.2												4.0 grey fine sandy SILT, some vesicles, moist
2.4												4.3 EOP.
2.6												
2.8												
3.0												
3.2												
3.4												
3.6												
3.8												
4.0												
	0	20	40	60	80	100	120					
	C _u (kPa)											
Ice Geo & Civil												blank forms/scale log

Hand Auger Log

Test Number: HA6

Job Name: Rangitikei Stopbanks
Mira Place

Date: 13/9/07

Tested by: N.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	Cu(kPa)						
0.2									V				black mixed SAND/GRAVEL/ rubbish / silty SAND/coal	
									X					
0.4									o					
									o					
0.6									X				1.0 orange stained grey silty fine pum. SAND	
									o					
0.8									X					
									o					
1.0									X				1.8 orange stained grey fine - med. pum SAND, some silt	
									o					
1.2									X					
									o					
1.4									X				2.1 grey silty fine SAND, moist	
									o					
1.6									X					
									o					
1.8									X				2.7 black fibrous PEAT	
									o					
2.0									X					
									o					
2.2									X				2.9 grey coarse pum. SAND + fine lapilli -> 1.5mm 3.0 - 3.2 EUB, collapse	
									o					
2.4									X					
									o					
2.6									X				3.2 EUB, collapse	
									o					
2.8									X					
									o					
3.0									X				3.2 EUB, collapse	
									o					
3.2									X					
									o					
3.4									X				3.2 EUB, collapse	
									o					
3.6									X					
									o					
3.8									X				3.2 EUB, collapse	
									o					
4.0									X					
									o					

Hand Auger Log

Test Number: **HA7**

Job Name: **Rangitauhi Stopbanks
Miro Place**

Date: **13/9/07**

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

Blows/50mm		soil description	
m	Cu(kPa)		
0.2		X	brown silty fine SAND
		X	
0.4		X	
		X	
0.6		X	0.6 grey coarse SAND & fine lapilli becoming coarser with depth
0.8			
1.0			
1.2			
1.4			1.35 EOB collapse
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			

Cu (kPa)

Hand Auger Log

Test Number: H48

Job Name: Rangitiki Stopbanks
Mimo Place

Date: 13/9/07

Tested by: M.O.H

Blows/50mm												C _u (kPa)	soil description	
m	0	2	4	6	8	10	12							
										X X	0.05	brown SILT		
0.2										X				
										- X		orange stained grey SILT,		
0.4										X X		some clay		
										- X				
0.6										X X	0.6	orange stained grey SILT		
										X X	0.7	orange stained grey fine		
0.8												pum. SAND		
1.0											0.95	pumice gravelly grey fine		
												SAND, gravel → 20mm		
1.2											1.2	grey fine pum. SAND		
1.4														
1.6											1.6	grey fine → med. pum. SAND		
											1.7	grey med. → coarse pum.		
1.8												SAND with pum. gravel		
2.0												→ 10mm		
2.2														
												becoming coarser SAND with		
2.4												pumice lapilli → 3mm		
											2.4	50mm PEAT (arse 2.5)		
2.6														
2.8											2.8	FOB		
3.0														
3.2														
3.4														
3.6												cf. Opus BH4, BH5		
3.8														
4.0														
	0	20	40	60	80	100	120							
	C _u (kPa)													

Hand Auger Log

Test Number: HA 9

Job Name: Rangitikei Stopbanks
New Place

Date: 11/9/07

Tested by: N.O.H

inside stopbank

Blows/50mm												soil description	
m	0	2	4	6	8	10	12	Cu(kPa)					
0.0												X X	0.1 brown fine sandy SILT
0.2												X X	light brown silty fine SAND
0.4												X X	cf. HA 12
0.6												X X	0.6 dark brown / grey SILT,
0.8												X X	some clay, damp
1.0												X X	0.85 brown silty fine SAND, damp
1.2												X X	
1.4												X X	1.35
1.6												X X	light yellow brown fine → 1.5 X
1.8												X X	medium purple SAND, some
2.0												X X	silt
2.2												X X	becoming grey fine purple
2.4												X X	SAND, some silt, cf HA 12
2.6												X X	
2.8												X X	
3.0												X X	3.0 moist
3.2												X X	
3.4												X X	
3.6												X X	3.5 grey fine → med. pur. SAND 3.5 X
3.8												X X	with some silt
4.0												X X	3.6 EOB collapse
													c.f. Opus BH4

Hand Auger Log

Test Number: HA10

Job Name: Rangitaiti Stopbanks
Miro Place

Date: 17/9/07

Tested by: N.O.H

outside toe

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	Cu(kPa)						
0.0													X X	0.1 brown fine sandy SILT
0.2													X	brown / grey silty fine SAND
0.4													X	
0.6													X	0.5 brown / grey fine →
0.8														coarse pum. SAND, some
1.0														silt, some lapilli &
1.2														gravel → 10mm
1.4														
1.6														
1.8														
2.0														2.0 brown / grey coarse
2.2														pum. SAND / fine
2.4														lapilli → 2mm
2.6														
2.8														
3.0														2.9 EOB, collapse
3.2														
3.4														
3.6														
3.8														
4.0														
	0	20	40	60	80	100	120	Cu (kPa)						

Hand Auger Log

Test Number: HA11

Job Name: Rangitauhi Stopbanks
Miro Place

Date: 17/9/07

Tested by: N.O.H

river berm

Blows/50mm		soil description	
m	Cu(kPa)		
0.0	0	X	brown silty fine SAND
0.2	0	X	0.2 brown med. → coarse SAND
0.4	0	0.4	brown coarse SAND + 0.5 → fine lapilli → 3mm
0.6	0		
0.8	0		
1.0	0		
1.2	0		
1.4	0		
1.6	0		
1.8	0		
2.0	0	1.9 EOB collapse	
2.2	0		
2.4	0		
2.6	0		
2.8	0		
3.0	0		
3.2	0		
3.4	0		
3.6	0		
3.8	0		
4.0	0		

Cu (kPa)

Hand Auger Log

Job Name: Rangitiki Stopbanks
Miro Place

Tested by: M.O.H

Test Number: HAR

Date: 11/9/07
paddock

Blows/50mm												soil description	
m	0	2	4	6	8	10	12	Cu(kPa)					
0.2												X X	dark brown fine sandy SILT
0.4												X X	
0.6												X X	
0.8												X	0.65 light yellow brown
1.0												X	0.8 silty fine SAND, damp
1.2												X	
1.4												X	1.3 becoming moist
1.6												X	
1.8												X	
2.0												X	
2.2												X	
2.4												X	
2.6												X	2.5 light brown SILT, some clay
2.8												X	2.8 light brown clayey SILT
3.0												X	with organic material
3.2												X	3.1 EOB squeezing
3.4													
3.6													
3.8													
4.0													old stream / drainage channel

Hand Auger Log

Test Number: 1413

Job Name: Rangitahi Stopbanks
New Place

Date: 17/9/07

Tested by: P.O.H

outside toe

Blows/50mm												soil description	
m	0	2	4	6	8	10	12	Cu(kPa)					
0.2												XX	0.1 brown SILT
0.4												X	brown silty fine SAND
0.6												X	
0.8												X	
1.0												X	
1.2												X	
1.4												X	
1.6												X	
1.8												X	1.8 grey fine SAND
2.0													
2.2													
2.4													
2.6													
2.8													2.7 grey med. → coarse pum. SAND & fine lapilli → 2mm
3.0													
3.2													3.1 grey med. SAND
3.4													3.3 pumice lapilli, hard EORS
3.6													
3.8													
4.0													
	0	20	40	60	80	100	120	Cu (kPa)					

Hand Auger Log

Test Number: 17A14

Job Name: Rangitikei Stopbanks
New Place

Date: 11/9/07

Tested by: M.O.H

wet depression

Blows/50mm				C _u (kPa)		soil description	
m	0	2	4	6	8	10	12
0.2							
0.4							
0.6							
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							
3.6							
3.8							
4.0							

0 20 40 60 80 100 120

C_u (kPa)

soil description

0.1 brown organic SILT
orange stained grey
clayey SILT, damp

0.8 orange stained grey
pum. SILT, wet

1.55 orange stained grey
clayey SILT

PEAT

PEAT

2.9 grey fine pum. SAND

3.05 black homogeneous fibrous
PEAT

3.3 EOB

Hand Auger Log

Test Number: HA15

Job Name: Rangitikei Stopbanks
Nino Place

Date: 17/9/07

Tested by: MCH

Blows/50mm		soil description	
m	C _u (kPa)		
0.2		X	0.05 brown SILT
0.4		X	light brown silty fine SAND
0.6		X	
0.8		X	
1.0		X	
1.2		X	
1.4		X	
1.6		X	
1.8		X	
2.0		X	
2.2		X	
2.4		X	
2.6		X	2.5 dark grey clayey SILT with organic material
2.8		X	2.8 EOB losing sample
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

C_u (kPa)

Hand Auger Log

Test Number: HA16

Job Name: Rangitikei Stopbanks
Nino Place

Date: 11/9/07

Tested by: N.O.H

inland toe

Blows/50mm													C _u (kPa)	soil description
m	0	2	4	6	8	10	12							
0.2														0.02 brown sandy organic SILT, topsoil
														0.05 cream coarse SAND + pum
0.4														grey brown gravelly lapilli → 4mm fill
														slity SAND, rounded GW gravel → 30mm
0.6														0.3 as 0.02
														0.5 grey brown Fe stained SILT
0.8														with fine sand, damp
														0.6 black coarse SAND, Tarawera Ash
1.0														0.63 grey Fe stained clayey SILT,
														damp
1.2														1.0 brown stained grey fine
														sandy SILT, moist
1.4														1.3 Fe stained grey clayey
														SILT, plastic, moist
1.6														
1.8														
2.0														1.9 orange stained grey
														pum. SILT
2.2														
2.4														
2.6														2.5 dark grey clayey SILT
														with some organics
2.8														
3.0														3.0 EOB, squeezing
3.2														
3.4														
3.6														
3.8														
4.0														

020406080100120

C_u (kPa)



Hand Auger Log

Test Number: HA18

Job Name: Rangitahi Stopbanks
Pine Place

Date: 11/9/07

Tested by: N.O.H

inland toe

Blows/50mm												soil description
m	0	2	4	6	8	10	12	C _u (kPa)				
0.2												dark brown organic SILT, some fine sand, damp
0.4												brown stained grey SILT, some clay, damp → moist with depth
0.6												0.7 brown stained grey clayey SILT, moist
0.8												1.15 grey fine pum. SAND some silt
1.0												1.45 grey pumice SILT, wet
1.2												2.1 dark blue grey SILT with some Fe staining & some fine sand, some fine organic material, organic smell
1.4												2.8 EOB losing sample.
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: HA19

Job Name: Rangitikei Stopbanks
Pine Place

Date: 17/9/07

Tested by: N.O.H

outside toe

Blows/50mm												C _u (kPa)	soil description
m	0	2	4	6	8	10	12						
												X X	0.05 brown fine sandy SILT
0.2												X X	brown coarse SAND & gravel → 6mm
0.4												X X	
0.6												X X	0.65 brown fine sandy SILT, rare
0.8												X X	light grey gravel → 30mm
												X X	0.75 brown fine silty SAND
1.0												X X	0.9 brown fine sandy SILT
1.2												X X	
												X X	1.3 brown SILT, some clay.
1.4												X X	1.4 brown stained grey clayey SILT
1.6												X X	
												X X	1.8 grey silty fine SAND
1.8												X X	
2.0												X X	2.25 grey/brown fine → med. pum. SAND, some silt.
2.2												X X	2.5 grey fine SAND, some silt, wet
												X X	
2.4												X X	2.9 blue/grey SILT
2.6												X X	3.1 blue/grey SILT with clay.
2.8												X X	3.3 EOB losing sample
3.0												X X	
3.2												X X	
3.4												X X	
3.6												X X	
3.8												X X	
4.0												X X	
	0	20	40	60	80	100	120						
	C _u (kPa)												

Hand Auger Log

Job Name: Rangitikei Stopbanks
Nimble Place

Tested by: N.O.H

Test Number: HA20

Date: 27/9/07

Top of stopbank
centre of house paddock

Blows/50mm		soil description	
m	C _u (kPa)		
0.2			LOOSE SAND
0.4			0.4 → 1.2 m → rock
0.6			
0.8			
1.0			
1.2			
1.4			
1.6			
1.8			HA21
2.0			top of stopbank
2.2			between HA18, HA19
2.4			LOOSE SAND
2.6			0.3 → 1.4 m.
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

C_u (kPa)

Hand Auger Log

Test Number: HA22

between 14 & 15

Job Name: Rangitahi Stopbanks
Piro Place

Date: 26/10/07

Tested by: M.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C _u (kPa)						
0.2									X X				0.05 brown silty fine SAND	
0.4									X X				brown fine gravel/loose SAND	
0.6									X X					
0.8									X X					
1.0									X X					
1.2									X X					
1.4									X X				1.35 brown fine sandy SILT	
1.6									X X				1.45 brown/grey silty fine SAND	
1.8									X X					
2.0									X X				1.95 grey med-coarse pumice SAND	
2.2									X X					
2.4									X X				2.25 grey silty fine SAND	
2.6									X X				some fine pum. gravel	
2.8									X X				2.5 brown fine sandy silt	
3.0									X X					
3.2									X X					
3.4									X X				3.2 orange stained grey silty fine SAND	
3.6									X X					
3.8									X X				3.6 orange stained grey fine sandy SILT	
4.0									X X					
									X X					
									X X				4.1 grey silt, some clay	
									X X				blank forms/scale log	
									X X				4.25 EOB	

Hand Auger Log

Test Number: HAZ3

bore 16217

Job Name: Rangitahi Stopbanks
Niro Place

Date: 26/10/07

Tested by: N.O.H

Blows/50mm										soil description
m	0	2	4	6	8	10	12	C _u (kPa)		
0.2									X	brown silty fine SAND
									X	
0.4									X	0.4 brown silty LOOSE SAND
									X	
0.6									X	
									X	
0.8									X	
									X	
1.0									X	
									X	
1.2									X	
									X	
1.4									X	
									X	
1.6									X	1.55 brown silty fine SAND
									X	
1.8									X	1.7 orange stained grey silty fine SAND
									X	
2.0									X	
									X	
2.2									X	
									X	
2.4									X	2.45 dark brown gravelly silty fine SAND
									X	
2.6									X	
									X	
2.8									X	2.9 EOB too hard
									X	
3.0										
3.2										
3.4										
3.6										
3.8										
4.0										
	0	20	40	60	80	100	120	C _u (kPa)		

Hand Auger Log

Test Number: TP1

Job Name: Rangitikei Stopbanks
New Place

Date: 27/9/07

Tested by: P.O.H

top of stopbank over 11 kV cable

Blows/50mm		soil description	
m	C _u (kPa)		
0.2			brown coarse SAND
0.4			
0.6			
0.8			
1.0			
1.2			1.20 silt & gravel
1.4		X O	
1.6		O X	
1.8		X O	
2.0			board over cable
2.2			≈ 400 below original
2.4			ground surface
2.6			
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

C_u (kPa)

Hand Auger Log

Test Number: TP3

Job Name: Rangitahiri Stopbanks
Tiro Place

Date: 27/9/07

Tested by: N.O.H

top of stopbank
7m D/s from gate

Blows/50mm		soil description	
m	Cu(kPa)		
0.2			brown coarse SAND
0.4			
0.6			
0.8			
1.0			
1.2		x	1.0 brown silty fine SAND
1.4		x	containing concrete rubble,
1.6		x	steel, rocks
1.8		x	1.3 blue grey sandy SILT, stiff
2.0		x	fly ash?
2.2			1.5
2.4			brown coarse pumice
2.6			SAND & fine lapilli
2.8			
3.0			
3.2			
3.4		-x	3.2 orange stained grey
3.6		x	clayey SILT
3.8		x	
4.0			3.5 FOP

Cu (kPa)

Hand Auger Log

Job Name: Rangitikei Stopbanks
New Place

Tested by: N.O.H

Test Number: TP5

Date: 27/9/07

toe of stopbank
D/S HA6

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

soil description

mixed soil, coal, rubbish

permeable.

2.3 grey silty fine pum. SAND

2.6 grey med. pum. SAND, v. light

3.0 FOP

C_u (kPa)

Hand Auger Log

Job Name: Rangitaiti Stopbanks
Noro Place

Tested by: N.O.H

Test Number: TP6

Date: 27/9/07

opposite pool - top of stop bank

Blows/50mm											soil description	
m	0	2	4	6	8	10	12	Cu(kPa)				
0.0											✓✓	brown organic silt, topsoil
0.2											X	0.15 brown silty fine SAND
0.4											X	
0.6											X	0.6 brown coarse SAND
0.8												
1.0											X	1.0 brown silty fine SAND
1.2											X	
1.4											X	
1.6											X	
1.8											X	
2.0											X	2.0 brown silty f → c SAND
2.2											X	& fine lapilli, rose timber
2.4											X	
2.6											X	2.6 grey sandy SILT,
2.8											X	fly ash?
3.0											X	coarsely, stiff
3.2											X	3.2 black fine coal, rose
3.4											e	steel.
3.6											e	
3.8											e	
4.0											e	4.0 mixed coal & fly ash
											X	
											X	4.2 blank forms/scale log
											X	orange stained grey SILT
											X	4.5 EOP

Hand Auger Log

Job Name: Rangitahiri Stopbanks
New Place

Tested by: M.O.H

Test Number: TP7

Date: 27/9/07

opposite end of building - s.
top of stopbank

Blows/50mm										soil description	
m	0	2	4	6	8	10	12	C_u (kPa)			
0.2										X X	0.1 brown organic SILT, topsoil
0.4										X X	0.1 brown fine sandy SILT, silty fine SAND, some timber
0.6										X X	0.5 brown coarse SAND
0.8										X X	
1.0										X X	1.0 brown/grey compacted silty fine to med. SAND, rare rounded gravel - 20mm
1.2										X X	
1.4										X X	
1.6										X X	
1.8										X X	
2.0										X X	
2.2										X X	2.2 coal in thin layers with grey sandy SILT, fly ash
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	3.5 orange stained grey sandy SILT
3.8											3.6 EOP
4.0											
C_u (kPa)											

Hand Auger Log

Job Name: Rangitaiki Stopbanks
Niro Place

Tested by: N.O.H

Test Number: TP8

Date: 27/9/07

4m D/S property boundary
top of stopbank

Blows/50mm											soil description	
m	0	2	4	6	8	10	12	C _u (kPa)				
0.0											✓	brown organic SILT, top soil
0.2											X	0.1 brown silty fine SAND
0.4											X	0.4 brown coarse SAND
0.6											X	
0.8											X	
1.0											X	
1.2											X	1.2 brown & grey layers
1.4											X	compacted silty fine SAND/
1.6											X	sandy SILT
1.8											X	
2.0											X	
2.2											X	
2.4											X	
2.6											X	
2.8											X	
3.0											X	
3.2											X	3.2 brown fine sandy SILT
3.4											X	
3.6											X	3.5 grey fine SAND, some silt
3.8											X	3.7 EOB
4.0												
	0	20	40	60	80	100	120	C _u (kPa)				

BORE HOLE LOG

BORE HOLE NO:

BH 4

PROJECT: RANGITAIKI STOPBANK INVESTIGATION LOCATION: Base of Stopbank
 RL GROUND(m): CO - ORDINATES :
 DATUM (m):

PROJECT NO: 2-89030.01
 LAB REF NO: 000TC

CORE DESCRIPTION <i>Rock or Soil Type, Colour, Strength, Structure, Particle Size, Weathering Lithological Features, (bedding, foliation, texture, mineralogy, etc)</i>	Depth (m)	Graphic Log	ROCK DEFECTS / COMMENTS <i>Joints, bedding, seams, shear and crush Zones</i>	Water Level (Date)	Shear Strength (kPa)	SPT Values
Topsoil	0.30	0.0				
Greyish brown silty fine SAND, pumiceous, medium dense, moist, current bedded	0.80	-0.5				
Greyish brown SILT, firm, moist, non plastic, current bedded	1.20	-1.0				
Greyish brown silty fine SAND, pumiceous, medium dense, moist to wet, current bedded	2.20	-1.5				
Greyish brown medium SAND, medium dense, wet, current bedded	2.40	-2.0				
Greyish brown silty fine SAND, medium dense, wet, current bedded	2.70	-2.5				
		-3.0				
Light grey silty fine to medium SAND, pumiceous, loose, saturated, current bedded, some pumice gravel up to 20mm diameter	4.70	-4.5				
Light grey silty fine SAND, pumiceous, very dense, wet	4.80	-4.5				
EOB - (Losing Core)		-5.0				
		-5.5				
		-6.0				
		-6.5				
		-7.0				
		-7.5				
		-8.0				
		-8.5				
		-9.0				
		-9.5				
		-10.0				
		-10.5				
		-11.0				
		-11.5				
		-12.0				
		-12.5				
		-13.0				
		-13.5				
		-14.0				
		-14.5				
		-15.0				

Water Table 2.7m 25/11/98

Driller: Perry Drilling
 Operator: G Wright
 Started: 25/11/98
 Finished: 25/11/98



Tauranga Office
 13 McLean Street
 PO Box 646
 Tauranga, New Zealand
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 Fax: +64 7 578 2086

Drilling Method: Hollow Stem Auger (100mm ID)
 Sampling Method: Continuous Wire Line Split Spoon Sampling (750mm long x 75mm diameter)

	Checked	Date
Logged by: M Burt	MB	25/11/98
Drawn by: M Burt	MB	30/11/98

BORE HOLE LOG

BORE HOLE NO: BH 5

PROJECT: RANGITAIKI STOPBANK INVESTIGATION LOCATION: Top of Stopbank
 RL GROUND(m): CO - ORDINATES:
 DATUM (m):

PROJECT NO: 2-89030.01
 LAB REF NO: 000TC

CORE DESCRIPTION <i>Rock or Soil Type . Colour, Strength, Structure, Particle Size, Weathering Lithological Features, (bedding, foliation, texture, mineralogy, etc)</i>	Depth (m)	Graphic Log	ROCK DEFECTS / COMMENTS <i>Joints, bedding, seams, shear and crush Zones</i>	Water Level (Date)	Shear Strength (kPa)	SPT Values
Topsoil	0.10	0.0				
Light brown sandy SILT, firm, moist, some organics [FILL]	0.90	-0.5				
Light brown silty medium SAND, pumiceous, loose, moist [FILL]	1.30	-1.0				
Light brown silty fine SAND, pumiceous, medium dense, moist, [FILL]	3.10	-1.5				
Light brown silty fine SAND, pumiceous, medium dense, moist, some organics and coal gravel [Old Topsoil Layer?]	3.30	-2.0				
Greyish brown silty fine SAND, medium dense, moist, current bedded	3.90	-2.5				
Greyish brown fine sandy SILT, firm, moist, current bedded	4.00	-3.0				
Greyish brown silty fine SAND, pumiceous, medium dense, moist, current bedded, some iron staining Becoming more medium grained and loose with depth	5.60	-3.5				
Black fibrous PEAT, firm, moist	5.80	-4.0				
Grey fine SAND, loose to medium dense, wet	5.90	-4.5				
Greyish brown medium to coarse SAND, loose, saturated, current bedded	9.30	-5.0				
EOB - (Nil Core Recovery in Running Sands)		-5.5				
		-6.0				
		-6.5				
		-7.0				
		-7.5				
		-8.0				
		-8.5				
		-9.0				
		-9.5				
		-10.0				
		-10.5				
		-11.0				
		-11.5				
		-12.0				
		-12.5				
		-13.0				
		-13.5				
		-14.0				
		-14.5				
		-15.0				

Water Table 6.0m 26/11/98

Driller : Perry Drilling
 Operator : G Wright
 Started : 26/11/98
 Finished : 26/11/98



Tauranga Office
 13 McLean Street
 PO Box 646
 Tauranga, New Zealand
 Ph: +64 7 578 2089
 Fax: +64 7 578 2086

Drilling Method: Hollow Stem Auger (100mm ID)
 Sampling Method: Continuous Wire Line Split Spoon Sampling
 (750mm long x 75mm diameter)

	Checked	Date
Logged by : M Burt	MB	26/11/98
Drawn by : M Burt	MB	30/11/98

Appendix B

Laboratory Tests

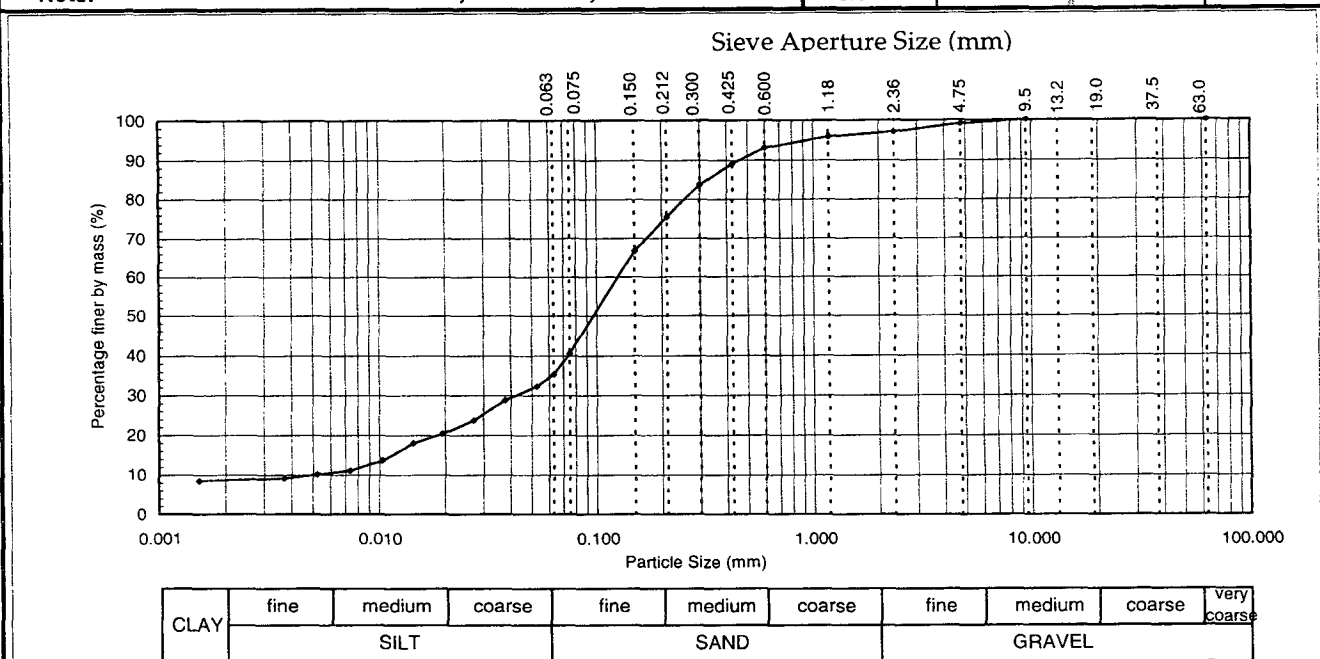
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT**

Project : **Rangitaiki Stopbanks**
 Location : **Miro Place Testing**
 Client : **Ice Geo & Civil Ltd, Papamoa**
 Client/Sample Ref : -
 Contractor : -
 Sample ID: **HA 2** Depth: **1.20 metres**
 Sampled by : **M. O'Halloran**
 Date received : **8/10/07**
 Sampling method : **Small sample bag**
 Sample condition : **As received**
 Sample description : **Yellowish brownish grey silty fine-med-coarse SAND**
 Solid Particle Density (t/m³): **2.65** Assumed
 Water Content (as received): **22.5** %



Project No: **2-68229.82**
 Lab Ref No: **07/229/007**
 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	99	0.300	84	0.0526	32	0.0073	11
37.5	--	2.36	97	0.212	76	0.0377	29	0.0052	10
19.0	--	1.18	96	0.150	67	0.0272	24	0.0037	9
13.2	--	0.600	93	0.075	40	0.0194	20	0.0015	8
9.5	100	0.425	89	0.063	35	0.0143	18	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0103	14		



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: 10/10/07

Sampling is not covered by IANZ Accreditation

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Designation : Senior Civil Engineering Technician

Date : 12/10/07



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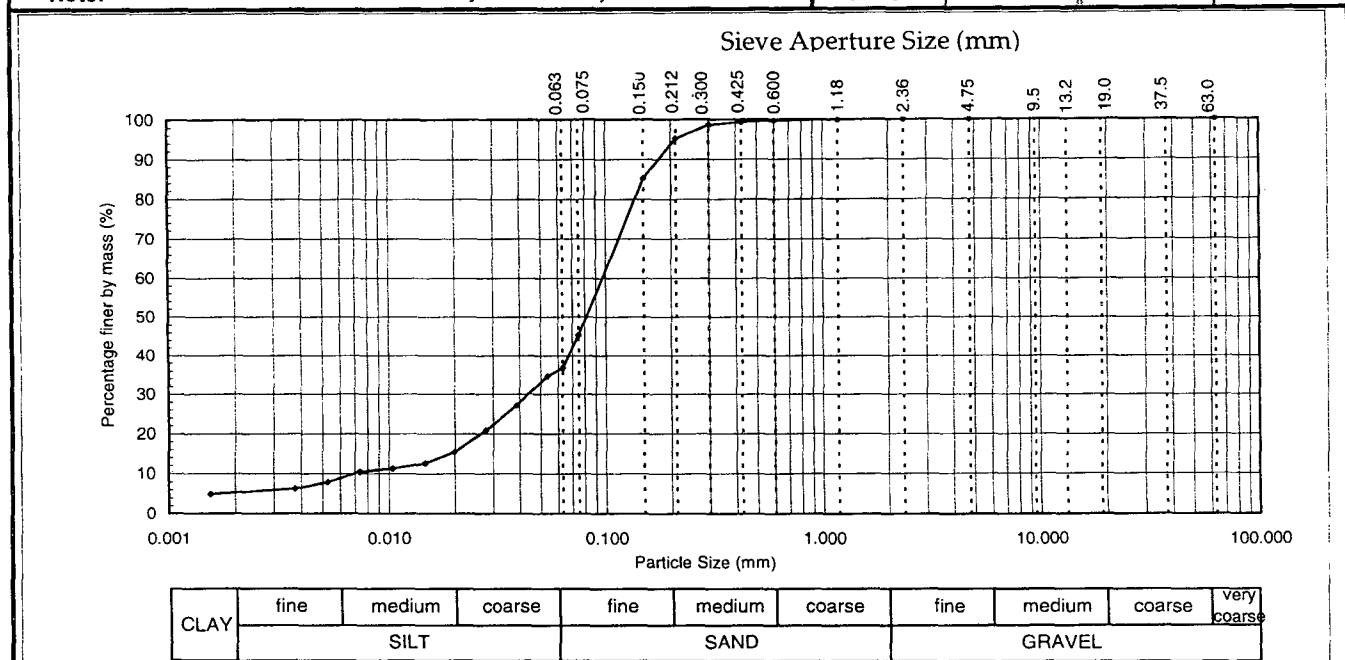
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT**

Project : **Rangitaiki Stopbanks**
 Location : **Miro Place Testing**
 Client : **Ice Geo & Civil Ltd, Papamoa**
 Client/Sample Ref : -
 Contractor : -
 Sample ID: **HA 2A** Depth: **1.20 metres**
 Sampled by : **M. O'Halloran**
 Date received : **8/10/07**
 Sampling method : **Small sample bag**
 Sample condition : **As received**
 Sample description : **Dk brownish grey silty fine-med SAND.**
 Solid Particle Density (t/m^3): **2.65** Assumed
 Water Content (as received): **26.0** %



Project No: **2-68229.82**
 Lab Ref No: **07/229/007**
 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	0.0535	35	0.0074	10
37.5	--	2.36	100	0.212	95	0.0387	27	0.0053	8
19.0	--	1.18	100	0.150	85	0.0278	21	0.0038	6
13.2	--	0.600	100	0.075	45	0.0200	15	0.0015	5
9.5	--	0.425	99	0.063	37	0.0147	13	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0104	11		



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: 10/10/07

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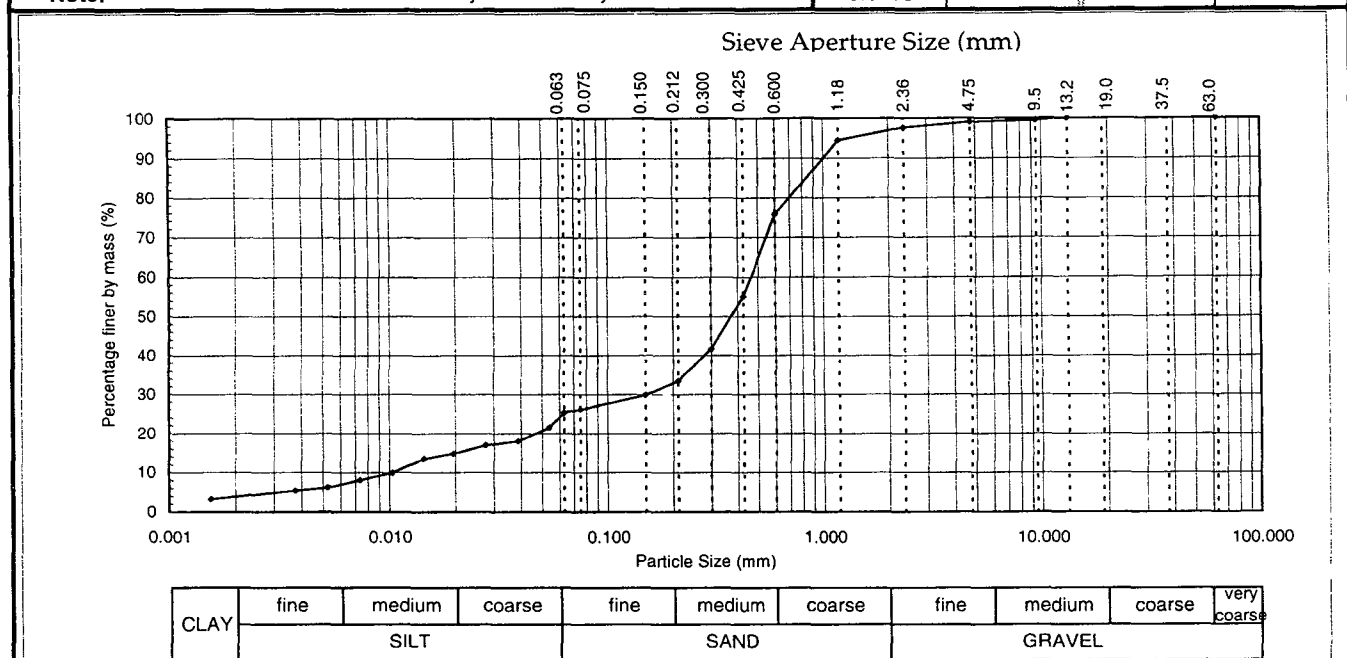
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT**

Project : **Rangitaiki Stopbanks**
 Location : **Miro Place Testing**
 Client : **Ice Geo & Civil Ltd, Papamoa**
 Client/Sample Ref : -
 Contractor : -
 Sample ID: **HA 6** Depth: **3.00 metres**
 Sampled by : **M. O'Halloran**
 Date received : **8/10/07**
 Sampling method : **Small sample bag**
 Sample condition : **As received**
 Sample description : **Brownish grey silty med-coarse SAND.**
 Solid Particle Density (t/m^3): **2.65** Assumed
 Water Content (as received): **30.2** %



Project No: **2-68229.82**
 Lab Ref No: **07/229/007**
 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	99	0.300	42	0.0537	21	0.0073	8
37.5	--	2.36	98	0.212	34	0.0386	18	0.0052	6
19.0	--	1.18	94	0.150	30	0.0274	17	0.0037	5
13.2	100	0.600	76	0.075	26	0.0196	15	0.0015	3
9.5	99	0.425	55	0.063	25	0.0144	13	--	--
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0103	10		



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

Date Tested: 10/10/07

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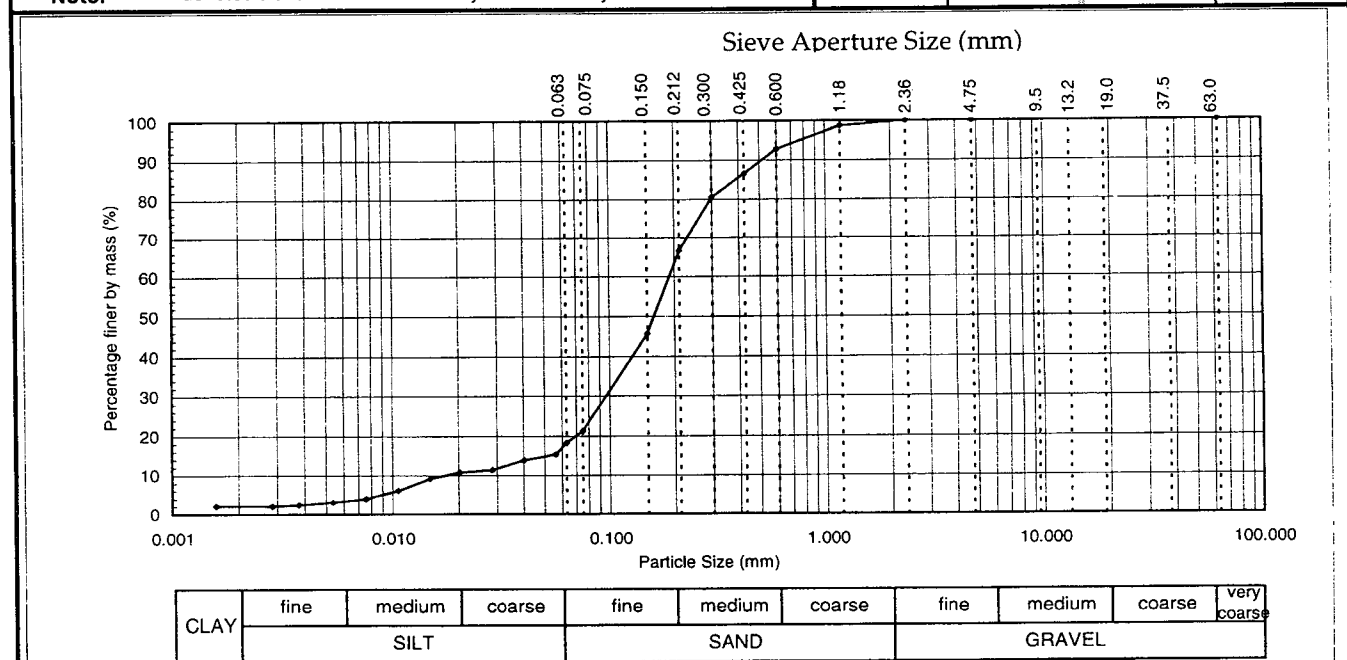
**PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT**

Project : **Rangitaiki Stopbanks**
 Location : **Miro Place Testing**
 Client : **Ice Geo & Civil Ltd, Papamoa**
 Client/Sample Ref : -
 Contractor : -
 Sample ID: **HA 9** Depth: **1.50 metres**
 Sampled by : **M. O'Halloran**
 Date received : **8/10/07**
 Sampling method : **Small sample bag**
 Sample condition : **As received**
 Sample description : **Brownish grey silty fine-med SAND.**
 Solid Particle Density (t/m^3): **2.65** Assumed
 Water Content (as received): **16.8** %



Project No: **2-68229.82**
 Lab Ref No: **07/229/007**
 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	81	0.0563	15	0.0076	4
37.5	--	2.36	100	0.212	67	0.0400	14	0.0054	3
19.0	--	1.18	99	0.150	46	0.0286	11	0.0038	2
13.2	--	0.600	93	0.075	21	0.0202	11	0.0029	2
9.5	--	0.425	87	0.063	18	0.0149	9	0.0016	2
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0106	6		



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: 11/10/07

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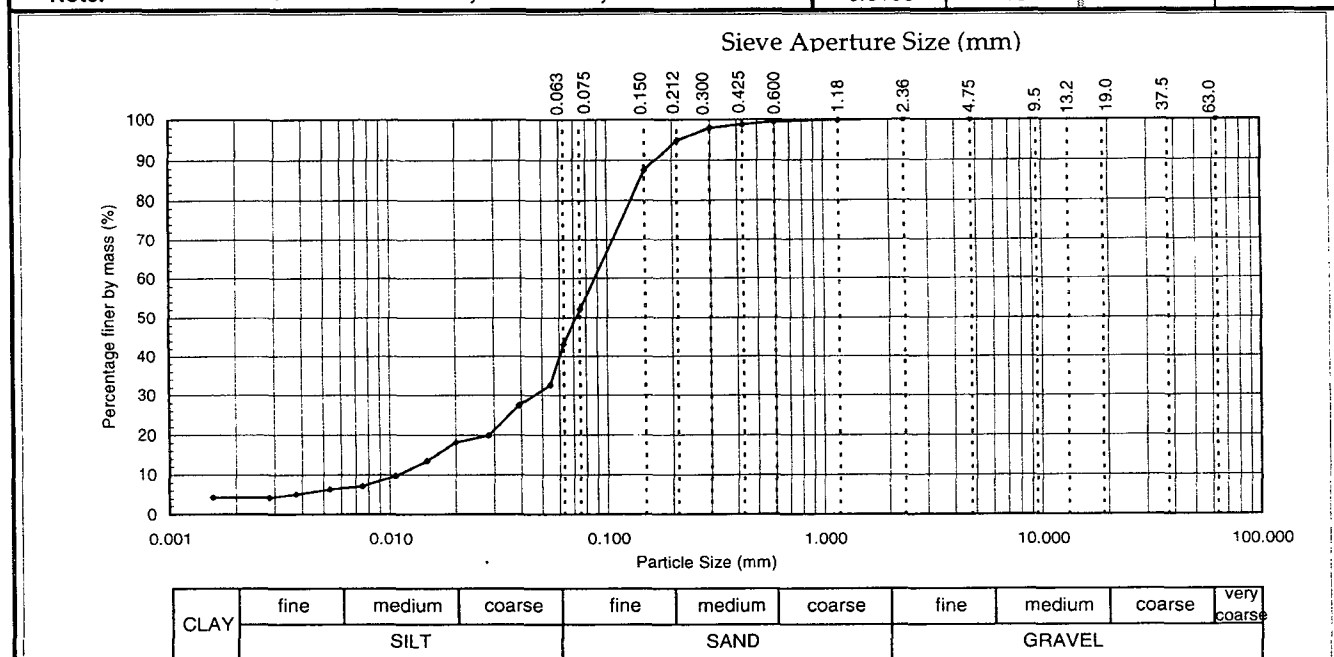
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT

Project : **Rangitaiki Stopbanks**
 Location : **Miro Place Testing**
 Client : **Ice Geo & Civil Ltd, Papamoa**
 Client/Sample Ref : **-**
 Contractor : **-**
 Sample ID: **HA 12** Depth: **0.80 metres**
 Sampled by : **M. O'Halloran**
 Date received : **8/10/07**
 Sampling method : **Small sample bag**
 Sample condition : **As received**
 Sample description : **Dk brownish grey silty fine-med SAND.**
 Solid Particle Density (t/m^3): **2.65** Assumed
 Water Content (as received): **27.6** %



Project No: **2-68229.82**
 Lab Ref No: **07/229/007**
 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	0.0545	33	0.0075	7
37.5	--	2.36	100	0.212	95	0.0391	27	0.0053	6
19.0	--	1.18	100	0.150	88	0.0282	20	0.0038	5
13.2	--	0.600	99	0.075	52	0.0201	18	0.0028	4
9.5	--	0.425	99	0.063	43	0.0148	14	0.0016	4
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0106	10		



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

Date Tested: 11/10/07

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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT

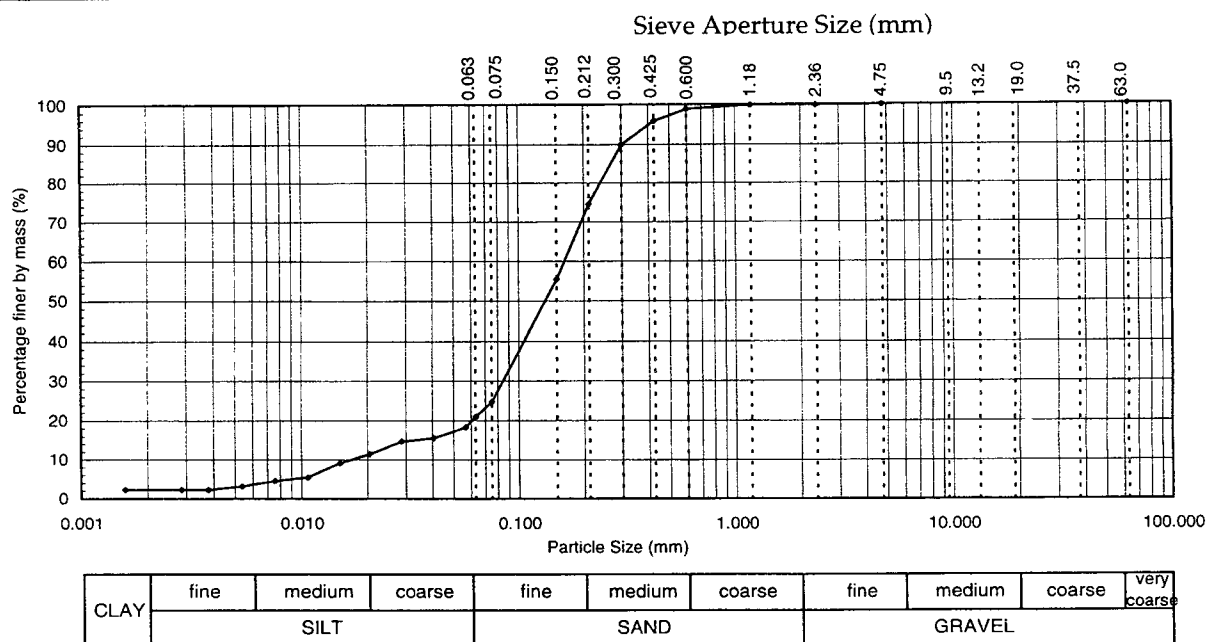
Project : **Rangitaiki Stopbanks**
 Location : **Miro Place Testing**
 Client : **Ice Geo & Civil Ltd, Papamoa**
 Client/Sample Ref : **-**
 Contractor : **-**
 Sample ID : **HA 18** Depth: **1.20 metres**
 Sampled by : **M. O'Halloran**
 Date received : **8/10/07**
 Sampling method : **Small sample bag**
 Sample condition : **As received**
 Sample description : **Dk brownish grey silty fine-med SAND.**
 Solid Particle Density (t/m^3): **2.65** Assumed
 Water Content (as received): **61.6** %



Project No: **2-68229.82**
 Lab Ref No: **07/229/007**
 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	90	0.0569	18	0.0076	5
37.5	--	2.36	100	0.212	75	0.0405	16	0.0054	3
19.0	--	1.18	100	0.150	55	0.0287	15	0.0038	2
13.2	--	0.600	99	0.075	25	0.0205	11	0.0029	2
9.5	--	0.425	96	0.063	21	0.0150	9	0.0016	2
						0.0107	5		

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)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 11/10/07

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