Rangitaiki River Stopbanks Assessment

Otakiri Road to Kokohinau

Left Bank 12300 to 16100m

Prepared for

Environment Bay of Plenty

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ICE GEO & CIVIL

A division of ICE CONSTRUCTION LTD

Contents

Appendices

1 Introduction

Severe erosion of the left bank of the Rangitaiki River occurred at four bends upstream of Edgecumbe during the flood of July 2004 and some emergency repair work was carried out immediately after the flood. Ice Geo & Civil has been requested by Environment Bay of Plenty (EBOP) to assess the stability of the stopbank at these bends, which are referred to as follows:

- Otakiri Road LB 12300 – 12700
- Black's Bend LB 13000 – 13250
- Campbell's Bend LB 14100 - 14400
- Kokohinau Bend LB 15400 – 16100

Initially slope stability analyses, based on limited subsurface information, were carried out on cross sections at the bends so that appropriate rock berms could be built to protect the stopbank from further erosion.

The stopbank along the study length is typically 2.0 to 3.5m high. The ground surface falls away from the river by up to 2.0% due to the river levee which developed before the stopbanks were built. Following the 1987 Edgecumbe earthquake slumping and cracking of the stopbank was observed at the bends. The earthquake damage could indicate favourable subsurface conditions for flow under the stopbank, which combined with the fall away from the river, may result in seepage related problems at the stopbank or further inland.

The river berm on the inside of the stopbank along the study length was used as a source of fill during the construction of the stopbank; it is therefore typically 2m lower than the ground on the landward side of the stopbank. If there are coarse grained soils under the stopbank the lowering of the river berm could allow significant seepage under the stopbanks.

Some sub-surface investigations and seepage analyses have been carried out to assess whether work in addition to the rock berms is required to improve the stopbank integrity.

Two further sections of stopbank were investigated where old river channels on the landward side of the stopbanks were identified between the bends. These sections are referred to as follows:

- Campbell's Straight LB 13250 – 13500
- Campbell's Dip LB 14500 – 14600

This report presents the results of the investigations and analyses of the sections of stopbank described above. The investigations and analyses were carried out at the same time as the physical work on the stopbanks. There was therefore some interaction between the physical work, which provided good exposures, and the investigations and analyses. The report is presented more of less in the chronological order of the work carried out and includes the following;

- slope stability analyses results,
- the results of the in situ investigations,
- laboratory grading test results,
- the results of seepage analyses for the estimated 100 year return period flood and
- 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 lengths of stopbank along the Rangitaiki River left bank listed above. The conclusions of this report are based on the interpretation of limited ground exposures, in situ investigations carried out at isolated points, some laboratory and in situ testing and two dimensional analyses. Due to the complex geology in the area, there could be ground conditions more detrimental to the integrity of the stopbank than those that have been identified.

2 Slope Stability Assessment

Initial slope stability assessments were carried out on cross sections through the stopbank at Black's Bend and Campbell's Bend in August 2009 so that work on the river berms could begin. The subsurface soil profile and strengths assumed were based on deep boreholes carried out previously at Sullivan's Breach, on the opposite river bank, and at Kokohinau upstream. A failure in the river bank at Campbell's Bend was back analysed using the soil parameters and a factor of safety of 0.95 was found with a low water level in the river. It is therefore considered that the soil parameters used are reasonable (Table 1).

The stability analyses were carried out for high river, low river and rapid draw down conditions. The minimum factors of safety against slope failure considered acceptable are 1.5, for normal river conditions, and 1.2 for rapid drawdown conditions.

It was found that a rock berm was required at each bend to provide adequate stopbank stability in low river and rapid drawdown conditions. A rock berm had already been built at the Kokohinau Bend.

Table 1: Assumed Soil Parameters

soil	density (kN/m^3)	effective cohesion (kPa)	friction angle (degrees)
stopbank fill	16	2	26
silt	15.5	2	24
silty fine sand	15	1	26
medium to coarse sand	14	0	35
clayey silt	15	5	24
pumice lapilli and sand	14	0	35

The stability analyses were checked in 2010 following the subsurface investigations and the berm requirements were found to be unchanged.

The recommendations for the berm geometry are given in Table 2.

Table 2: Stability berm requirements

location	berm level	minimum width	batter
Otakiri Bend	RL4.0	3m	2H:1V
Black's Bend	RL4.0	3m	2H:1V
Campbell's Bend	RL4.0	4m	2H:1V

3 Stopbank Construction Assessment

Most of the stopbanks along the Rangitaiki River are constructed of silty fine to medium grained sands. It was discovered early in the subsurface investigations at the Otakiri Road Bend that there were coarse sands within the stopbank which could be readily eroded by stock and washed out if exposed to river flows. Rabbits also like burrowing into these sand layers as they are well drained and easy to dig.

The coarse sand layers allow significant seepage through the stopbank, which in the worst case could lead to piping problems at the inland toe. It was therefore decided to investigate the extent of these layers by excavating shallow test pits along the face of the stopbank while the rock berm work was being carried out. Aerial photographs marked up with the depth of the coarse sand below the stopbank crest are included in Appendix A.

At Otakiri Road the coarse sand layer was found to be up to 2.7m thick (the stopbank at this point is about 3.5m high). It is thought that the coarse layer was placed soon after the Edgecumbe Earthquake to reinstate the stopbank levels after this area settled by about 2.05m. At Black's Bend the coarse sand was typically 2.5m thick and upstream it varied from about 1m to 1.8m thick. At the downstream end of Campbell's Bend the thickness of coarse sand increased again to 2.4m, whereas there was no coarse sand at the upstream end. It is possible that due to the lack of river berm, a section of stopbank collapsed into the river during the earthquake and had to be topped up.

In the summer the coarse sand layer could be picked up by the more rapid drying of the grass compared to the rest of the stopbank.

It was decided that rather than removing and replacing the sand layer, a low permeability overlay should be placed on the upstream side of the stopbank in conjunction with the rock berm work. This layer is typically 1m thick.

During the investigations it was found that the crest of the stopbank was too low in places to provide 300mm freeboard in the 1 in 100 year flood with an allowance for climate change (see Section 5.2). The low permeability overlay was extended over the crest in these areas to achieve the required levels.

4 Subsurface Investigations

4.1 Hand Augers and Bore Holes

The only sub surface information available within the study sections was a deep borehole carried out at the Kokohinau Bend in 2007 (Cross Section 3). A hand auger investigation programme was therefore carried out along each length of stopbank. Table 3 gives the number of hand augers in each section. The augers were carried out to 4m depth or until the hole collapsed as sand washed in. They were arranged in cross sections at right angles to the stopbank, as shown in Appendices B to G. Two constant head tests were carried out in hand auger holes in the stopbank at the Otakiri Bend.

A sand layer found towards the base of the many of the hand auger investigations. Preliminary seepage analyses carried out showed that the continuity and thickness of this layer was critical in determining whether there could be problems with heave of the soils at a distance from the stopbank when the river is in flood. A deep borehole was therefore carried out at each of Otakiri, Campbell's and Black's bends to gain more information on the sand layer. Some falling head tests were carried out in the boreholes to gain estimates of the permeability of the critical sand layers.

The deep drilling was carried out by Perry Drilling Ltd of Tauranga.

The hand auger and borehole logs are included in Appendices B to G.

Table 3: In situ test programme

location	number of hand augers
Otakiri Road	14
Black's Bend	9
Campbell's Straight	8
Campbell's Bend	12
Campbell's Dip	8
Kokohinau Bend	11

4.2 Site Description and Sub-surface Soil Profiles

4.2.1 Otakiri Road

The layout of the hand augers carried out at the Otakiri Road Bend and the cross sections interpolated from the subsurface investigations are given in Appendix B. The cross sections show that the levee nearest the stopbank consists predominantly of silty sands and silts, whereas the low lying area consists of silts, clays and peat. In some of the hand augers (Cross Section 4) the black Tarawera Ash layer (coarse sand) was quite distinctive in the surface silts. Elsewhere this ash had been mixed in by ploughing. A medium to coarse pumice sand layer up to about 200mm thick was found above fibrous peat in the investigations below RL1.0. Fine pumice lapilli were found at most locations below RL0. The thickness of this layer was considered critical in the stopbank seepage analysis.

The three augers carried out in the river berm showed silty fine sands overlying coarser sands and lapilli. It is possible that the clayey silts and peat originally found at a similar level on the landward side of the stopbank have been eroded out during floods and replaced by more recent sediment. One of the silty fine sand layers exposed on the river side of the stopbank is particularly light and is favoured by rabbits for their burrows.

4.2.2 Black's Bend

The layout of the in situ investigations at Black's Bend is shown in Appendix C. The borehole was drilled close to Hand Auger 3. The soils found are similar to those at the Otakiri Road Section except more silty fine sands were found due to the river levee here being broader and less steep than at Otakiri Road. This can be seen in the LIDAR plot included in Appendix C. Similarly less organic material was found within the depth of the hand investigations. Where the peat and overlying coarse sand layers were found, they are at about the same RL as further downstream.

There was no natural river berm at Cross Section 2 and it was less than 10m wide at Cross Sections 1 and 3 (There is now a rock berm.). The natural berm was found to consist of similar silty fine sands and silts to those on the inland side of the stopbank, with little evidence of recent deposition of sediment.

4.2.3 Campbell's Straight

The Campbell's Straight section is a relatively straight length of stopbank that cuts across a bend in the old river channel. A shallow dip in the ground level can be seen behind the stopbank and is evident on the Black's Bend LIDAR plot (Appendix C). Extensive rabbit holes could be seen in the river side face of the stopbank and within the dip and there were depressions around two power poles in the upstream end of the dip. Although the stopbank is only about 2.5m high it was considered that some investigations should be carried

out along the dip in case there were coarse soils in the old river bed extending under the stopbank.

Eight hand augers were carried out in five cross sections across the dip and a 15m deep borehole was drilled through the stopbank at Cross Section 3. A plan of the test locations and Cross Sections 3 and 4 are included in Appendix D.

Coarse sand was found at between 1.7 and 2.5m depth in the old river bed. This is underlain by pumice lapilli at between 2.8 and 3.7m depth. The coarse sand is overlain by the very light fine sand and silty fine sand that the rabbits were burrowing into. Little correlation in soil layers was found between augers on the inside and the outside of the stopbank. The river berm consists predominantly of silty fine sand. Extensive layers of coarse sand and lapilli were found below RL 0 in the borehole. These layers were interleaved with layers of pumiceous silt and below RL-5 some organic rich clay.

4.2.4 Campbell's Bend

At Campbell's Bend the river bank was covered in vegetation which was hiding the lack of a river berm and the failures within the river bank. Appendix E includes five cross sections through the stopbank that show about 150m of very steep river bank from Cross Sections 2 to 4. Eleven hand augers were carried out along these five cross sections as shown on the plan. A deep borehole was carried out through the stopbank at Cross Section 3, which was considered to have the most critical subsurface soil profile.

This section of stopbank was just over 2m high and was found to be too low to provide freeboard in the 100 year return period flood. It was therefore topped up with clayey soil when the clay overlay was placed across the riverside face to prevent excessive water flow through the coarse sand found in the stopbank.

Reasonable consistency can be seen in the soil layers from one side of the stopbank to the other in the cross sections. The upper soils appear to be finer and have lower permeability than those found further downstream. With the exception of at Cross Section 3, more than 2m of silt and clay was found to overly any higher permeability sand or lapilli layers. This cross section extended beyond the edge of the river levee into the lower lying land (see LIDAR plot). At the edge of the levee (HA6) the coarse sand was just on 2m below ground level but in the low lying land the layer of coarse sand / fine lapilli overlying the peat (as found at the Otakiri and Black's bends) was 1.6m below ground level (RL1.8). A sand layer was found at a similar RL in the borehole. Fewer high permeability layers were found at depth in this borehole than those further downstream.

At Cross Section 1 the hand augers suggested that a coarse sand would be found at the river bank at about RL 3.0. When the rock berm was formed this layer was exposed and was found to be up to 1.5m thick and as high as RL 3.5 at Cross Section 2. The layer appeared to dip down towards Cross Section 3. These surface exposures were incorporated into the seepage analysis models.

Hand augers 3 and 5 encountered rock beneath the stopbank, suggesting an old road.

Mr Campbell commented on the occurrence of vibrations when trucks travelled along a section of stopbank just upstream of his house and along the road outside his house. Auger C1 was carried out near the stopbank, where he considered the vibrations originated, to find if there was a change in soil conditions. It was found that the soils here were silty sands similar to those found along Campbell's Straight and not like those found around Campbell's Bend. There is therefore a change between the HAC1 and Campbell's Bend from predominantly sandy soils to predominantly silty, clayey soils. The LIDAR plot possibly indicates some sort of levee structure at right angles to the river in this location. There is no recorded fault trace here.

4.2.5 Campbell's Dip

Just upstream from Campbell's Bend there is another dip in the ground surface behind the stopbank suggesting an old river channel. This dip is up to 1.5m deep, which means the stopbank at this location is 3.2m high. The river berm is a further 1m lower than the ground on the inland side of the stopbank. Eight hand augers were carried out in three cross sections across the stopbank at the dip to assess if there could be any localised problems. The location of these augers and the central cross section are shown in Appendix F.

Peat was found at between RL 1.3 and 1.8 in five of the augers on both sides of the stopbank. This is overlain by sand as found at the three downstream bends. There was little other correlation between the inland and river sides of the stopbank.

A thick layer of clayey silt was found in HA5 at the low point within the bend, whereas predominantly silty sands were found in the other augers inside the stopbank. Various layers of sand were found within the bend with a layer of coarse sand / fine lapilli found at RL1.0 in HA7 at the downstream end of the bend.

The stopbank was found to consist mainly of silty fine to medium sand with only 200mm of gravelly medium to coarse sand (HA4) 1m below the surface.

Just upstream of benchmark R38, towards the apex of the bend between Campbell's Bend and Kokohinau Bend, the top of the stopbank has been damaged, probably by cattle. This needs to be repaired in case the stopbank is overtopped. There is also a row of stumps at the inland toe of the stopbank near benchmark R39. These should be dug out, if no coarse sand layers are found the holes should be back filled with a low permeability soil. If there is a coarse layer, some form of filter may be required.

4.2.6 Kokohinau Bend

The stopbank around the Kokohinau Bend was compromised during the flood of July 2004 and a rock berm was quickly built around the bend to protect it. The stopbank is 2 to 2.5m high and the land slopes gently away from the stopbank. At the upstream end of this section (Cross Section 1) there is a slightly steeper drop between 50 and 70m from the stopbank.

Eleven hand augers were carried out around this bend to provide subsurface information for six cross sections. Due to the rock berm no augers could be carried out on the river side of the stopbank. The borehole was in the stopbank at Cross Section 3.

Hand augers 1 and 10 were carried out through the stopbank. These augers and the borehole showed that the whole stopbank appears to be constructed of silty fine sand.

The hand augers inland from the stopbank show consistent soil layers. In the river levee near the stopbank there are silty fine sand and sand layers beneath the surface brown silt. Further away the soils consist of more silts, clayey silts and organic clays. As in the other sections downstream, at the base of many of the augers a medium to coarse grained sand was found overlying peat. The peat almost directly overlies the pumiceous gravelly silt which is found slightly deeper further downstream. There is typically more than 2m of soil overlying the upper most sand layer.

4.3 In Situ Testing

Two constant head permeability tests were carried out in hand augered holes in the stopbank at the Otakiri Road bend. The estimated average permeability over the depth of the holes ranged from 7×10^{-5}m/s to 2.8×10^{-4}m/s. It was assumed that the horizontal layering within the stopbank would result in higher horizontal permeabilities than vertical. Therefore the following stopbank permeabilities were assumed in the analyses.

$$k_h = 3.0 \times 10^{-4} \text{m/s}$$
$$k_v = 1.5 \times 10^{-4} \text{m/s}$$

Table 4: Falling Head Test Results

Borehole	depth (m)	RL (m)	soil	k_h (m/s)
Otakiri	7.5 to 9.0	-0.2 to -1.7	0.8m pumice lapilli to 10mm 0.7m silt	lapilli 1×10^{-4}
Black's	7.5 to 9.0	0.5 to -1.0	0.7m sand, 0.4m silty sand, 0.4m peat	sand 8×10^{-6}
Black's	9.0 to 10.5	-1.0 to -2.5	0.3m sand, 0.3m lapilli, 0.9m silt	average 4×10^{-5}
Campbell's	6.0 to 7.5	1.6 to 0.1	0.5m lapilli, 0.5m sand, 0.3m silty sand, 0.2m peat	average 2.0×10^{-5}
Campbell's	7.5 to 10.5	1.6 to -1.4	2.1m silt, 0.9m fine sand	4×10^{-5}

In an effort to gain better estimates of the in situ permeabilities of the sandy and gravelly layers, five falling head permeability tests were carried out at various depths in the boreholes. It was assumed in the analyses that the horizontal permeability is equal to the vertical permeability in the layers being tested. Table 4 summarises the results of the tests.

4.4 Laboratory Testing

Hydrometer particle grading tests were carried out on three samples of subsurface soils taken from the hand augers to enable estimation of soil permeability using the Hazen formula:

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

The grading test results are summarised in Table 5.

Table 5: Particle Grading Results

Sample	Description	D_{10} (mm)	D_{60} (mm)	permeability (m/s)
Black's HA3 1.5m	medium to coarse SAND	0.07	0.9	4.9×10^{-5}
HA8 1.3m	silty fine SAND	0.015	0.11	2.3×10^{-6}
Campbell's HA1 2.9m	well graded SAND	0.065	0.7	4.2×10^{-5}

The results of the laboratory tests are included in Appendix H.

5 Analyses

5.1 Discussion

The in situ investigations carried out provide subsoil profiles in isolated locations only and show considerable variation in the soil layers throughout the study area. Although an effort has been made to build a degree of conservatism into the analysis of the stopbank cross sections, 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 assumed.

The computer programmes used to analyse the seepage problems and slope stability problems, Geo-Slope Seep/W and Slope/W (2004), are two dimensional programmes. Therefore, three dimensional effects such as seepage along old river channels can not be accurately modelled. For a linear problem like a stopbank, the lack of a third dimension should not have

much influence on the slope stability issues but the seepage analyses must be considered indicative only.

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

- excessive flows through or 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.

Due to the presence of thick layers of coarse sands within the stopbank it was decided early on in the investigations to place about a 1m thick layer of clayey, low permeability soil over the river side of the stopbank. Therefore there should be only a small volume of seepage through the stopbank in a flood and flows under the stopbank are more of a concern.

The maximum acceptable hydraulic exit gradient for the light pumice soils in the area is considered to be 0.4. Exit gradients higher than this may lead to a loss of fines and piping failure. A check was made in the seepage analyses to see that this gradient was not exceeded in the soil models.

Seepage of only small volumes of water from the ground surface can significantly reduce the uplift pressures below the surface. Seepage from the ground surface has therefore been allowed for in the computer models except for across the sealed road.

5.2 Flood Hydrograph

EBoP has provided 100 year return period flood flow hydrographs for the Rangitaiki River at four river meterages within the study length. The flow model used was the 2010 model which allows for climate change. Figure 1 shows the hydrographs.

As can be seen from Figure 1 there is little attenuation of the peak part of the hydrograph between the upstream and downstream ends of the study length of stopbank. The water level in the river is above that of the ground at the inland toe of the stopbank for about three days and above the level of the low ground further inland for about six days.

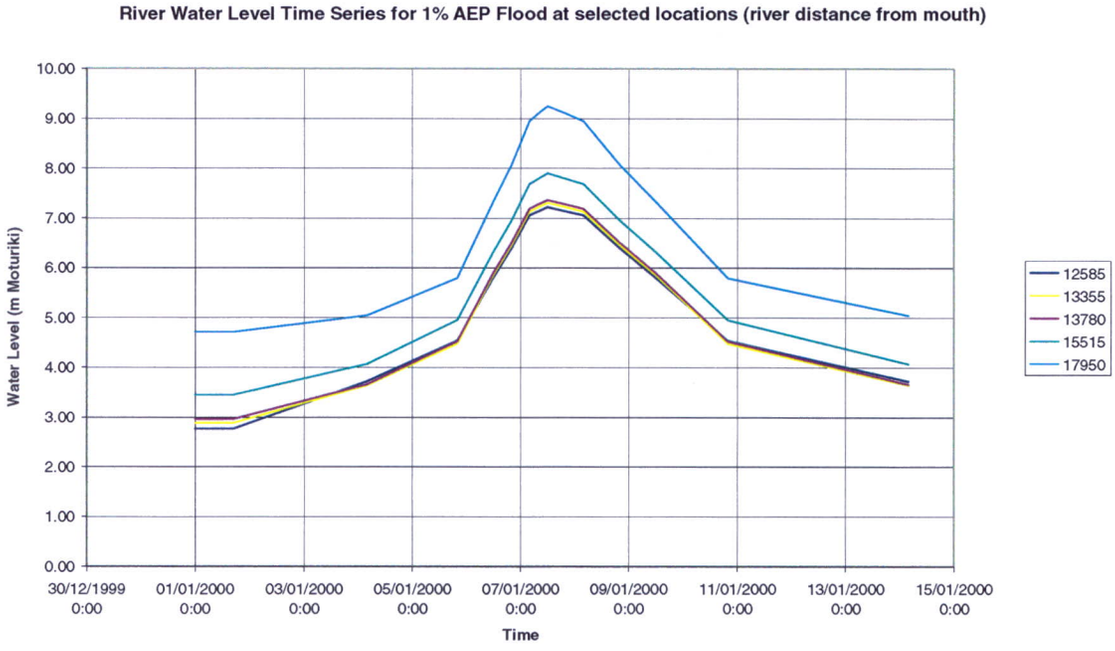

Figure 1: 100 year return period flood flow hyrographs

5.3 Soil Model - Seepage

The soil layers found in the in situ investigations were simplified in the models used for the seepage analyses on the basis of permeability. The subsurface profiles were divided into layers of silt, silty fine sand, medium to coarse sand, clayey silt and peat, coarse sand and lapilli. It was assumed in the analyses that the clayey overlay had been placed on the river side of the stopbank from the top of the rock berm to the top of the stopbank.

The permeabilities assumed were conservatively based on the grading, falling head and constant head test results for this site. Grading and permeability test results for similar soils elsewhere along the river were considered as well. Table 6 shows the assumed permeabilities.

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.

When assessing the heave potential of upper layers the weight of the soil was assumed to be 15 kN/m^3.

The stopbank cross sections were generally modelled to 150 to 200m from the river. Infinite elements were then used to model flow outside the model in both the initial steady state analysis and the transient flood analysis. During the initial analysis a head was specified at the infinite elements and another in the river. The river head was set at an average level and the inland head a little higher to generate flow towards the river. The depth of the river bed was taken as that at the nearest EBOP benchmark. The transient analysis of the 100 year return period flood was carried out with a two hour time step.

Table 6: Assumed Soil Permeabilities

soil	k_h (m/s)	k_v (m/s)
stopbank fill	3×10^{-4}	1.5×10^{-4}
silt and stopbank overlay	4×10^{-7}	4×10^{-7}
silty fine sand	4×10^{-6}	2×10^{-6}
fine sand	5×10^{-5}	5×10^{-5}
medium to coarse sand	1×10^{-4}	1×10^{-4}
fine pumice lapilli	1×10^{-4}	1×10^{-4}
clayey silt, silt and peat layers	5×10^{-7}	5×10^{-8}
deep sand, silt, clay and organic layers	5×10^{-5}	5×10^{-7}

5.4 Otakiri Road

Due to the similarities in the subsurface soil profiles between the cross sections, seepage analyses were only carried out at Cross Sections 1 and 4. It was assumed that there was an 800mm thick layer of high permeability lapilli at around RL0 extending across the soil model to the river. In reality the placement of the rotten rock berm along the river bank will have partially blocked the flow path from the river through the lapilli layer.

At Cross Section 1 the model showed about a 1.5% reduction in water pressure in the lapilli layer with distance from the river. It was found that the uplift pressures below the deepest parts of the water tables at the edge of the road are marginally below the weight of the soil. However the soil in these water tables is likely to be heavier than 15kN/m^3 and there will be some three dimensional effects as friction causes the uplift pressures to be spread to the sides of the water tables. It is therefore considered that there should be no heave problems at this cross section. The model showed that the phreatic surface should not reach the ground surface during the flood.

The analysis of Cross Section 4 showed that the phreatic surface does not reach the ground surface until about 150m from the inland toe of the stopbank. Therefore no problems with high hydraulic exit gradients are expected. A fine sand layer was modelled under the stopbank but as this is blocked by the clayey overlay no heave problems appear at this cross section.

5.5 Black's Bend

At Cross Section 1 (upstream end of section) the silty fine sand layer extending under the stopbank allows the ground water level to rise to the ground level at the inland toe of the stopbank during the period of the flood. The assumption was made in the seepage analysis model that the rotten rock stability berm did not seal across this layer but that the face of the stopbank was sealed with clayey fill. The model indicated that there should be no problems with high hydraulic exit gradients or with heave further inland.

At Cross Section 2 the uplift pressure below the deepest part of the water tables are marginally below the weight of the soil. However, as for the Otakiri Road section, no uplift problems are expected here. Due to the cross section geometry and the clayey stopbank overlay it appears that the ground water level should only reach the ground surface about 100m away from the inland stopbank toe. Cross Section 3 is similar to Cross Section 2 and no piping or heave problems are expected.

5.6 Campbell's Straight

The only cross section analysed at Campbell's Straight was Cross Section 3 as this was where the coarse sand and lapilli were shallowest in the old river bed. The borehole was drilled at this cross section for this reason. Due to coarse sand being found within the stopbank and the rabbit holes, a clay overlay was placed over the riverside face of the stopbank and this was included in the analyses.

A seepage analysis was carried out using the soil permeabilities given in Table 6 and assuming a 1m thick layer of pumice lapilli from RL 1.0 under the stopbank, rising to RL1.4 at HA46. No piping or uplift problems were identified with this soil model. A sensitivity analysis was carried out varying the initial static ground water level but this had minimal effect on the water pressures developed. A further sensitivity analysis was carried out increasing the permeability of the lapilli layer to 2×10^{-4}m/s. There was a small increase in the water pressures but not sufficient to cause problems.

As the coarse sand and lapilli layers were found to be deeper at the other four cross sections investigated, it is considered that there should be no problems in this old river channel.

5.7 Campbell's Bend

A seepage analysis was carried out on Cross Section 1 using the permeabilities given in Table 6 and a subsurface soil profile based on the hand augers, the borehole and the exposures along the river berm. It was assumed that the sand layer under the stopbank was not sealed by the rotten rock berm placed against it. Although the phreatic surface rises to the ground surface during the 100 return period flood, the hydraulic exit gradients are considered not to be high enough to cause piping. Similarly due to the thickness of the surface silty layers on the inland side of the stopbank, the uplift pressures are not considered to be high enough to cause heave problems.

At Cross Section 2 the uplift pressures under the surface layers are higher than those at Cross Section 1 due to the sand layer being higher in the river bank. Although the weight of the soil at the water table at the toe of the stopbank is only marginally above the predicted pressures it is considered that heave will not be a problem.

At Cross sections 3, 4 and 5 the sand layers are deeper than at Cross Sections 1 and 2 and no problems are expected.

5.8 Campbell's Dip

The subsurface soil profile at the central cross section was modified by the addition of a 0.5m thick medium grained sand layer 2m below the inland toe of the stopbank and a 1m thick coarse sand / lapilli layer 3.2m below the toe. These layers were found in hand augers to each side of the central section. The seepage analysis carried out with this hybrid cross section showed the phreatic surface just reaching the ground surface at the inland toe of the stopbank. The model indicated that the uplift pressures under the surface layers are not high enough to cause heave and the hydraulic exit gradients are low. It is therefore considered that there should be no seepage problems at this section of stopbank.

5.9 Kokohinau Bend

A seepage analysis was carried out on Cross Section 2 as there is a slightly steeper fall away from the stopbank here than elsewhere and the sand overlying the peat layer was found to be just 2m below the ground surface 130m from the stopbank. At Cross Section 3 there was about 1.2m of core loss in the borehole below RL1.0. It was assumed in the analysis that the lost core was a lower lapilli layer. It was found in the analysis that the phreatic surface did not reach the ground surface and there should not be any uplift problems.

A second seepage analysis was carried out on Cross Section 6 as a fine sand layer was found below the stopbank only about 1.6m below ground level at the inland toe. No seepage problems were identified at this cross section.

6 Conclusions

1. Rock stability berms are required at the Otakiri Road, Black's and Campbell's Bends.

2. Due to the presence of coarse sands in the stopbank and the exposure of light, readily burrowed sands in the river bank, a clayey overlay is needed right along the river side face of the stopbank from Otakiri Road to Campbell's Bend.

3. The depressions around the power poles at the upstream end of the Campbell's Straight section need to be filled in.

4. Repairs are needed to the stopbank between Campbell's Bend and Kokohinau Bend.

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

Appendix A

Thickness of coarse sand in stopbank

Otakiri Rd Section

Environment Bay of Plenty
REGIONAL COUNCIL

Rangitaiki River
Geotechnical Remedial Works

Blacks Farm Area

100 50 0 100
M

Scale

Environment Bay of Plenty
REGIONAL COUNCIL

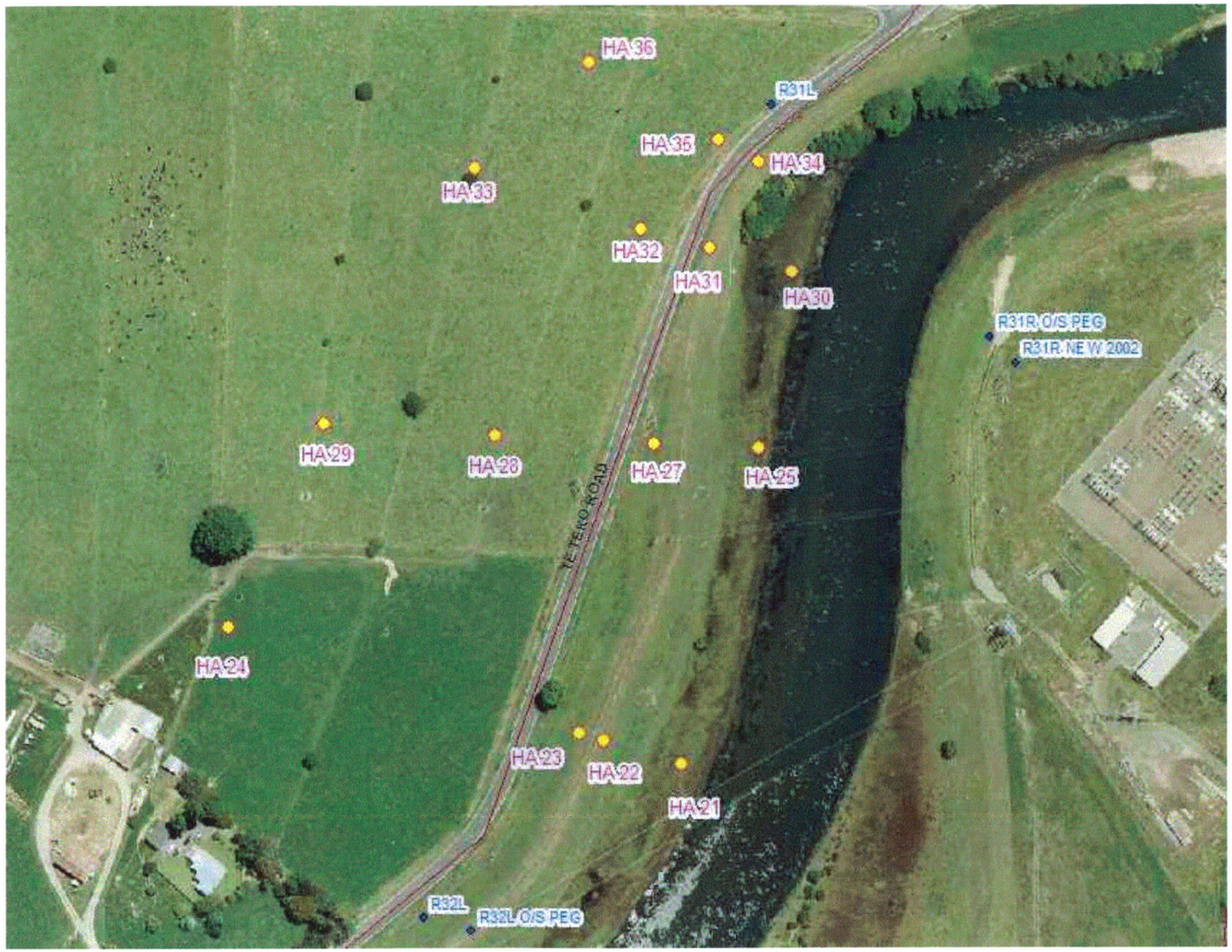
Rangitaiki River
Geotechnical Remedial Works

Campbells Corner

100 50 0 100
Metres
Scale = 1:

Appendix B

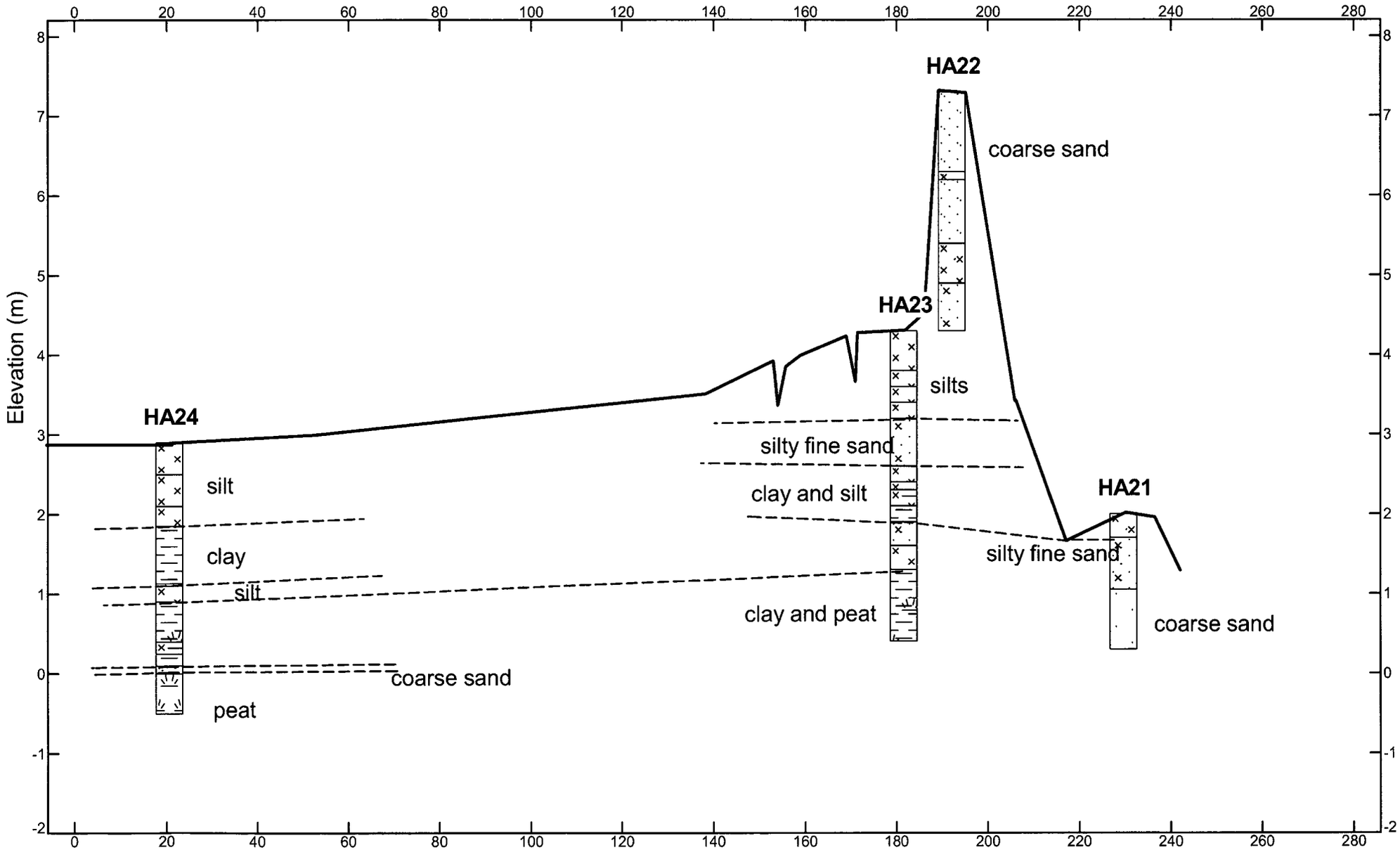
Otakiri Road



Otakiri Road Hand Augers

Project: Rangitaiki River
Client: EBOP
Location: Otakiri Left Bank
Number:

Subsurface Cross Section 1

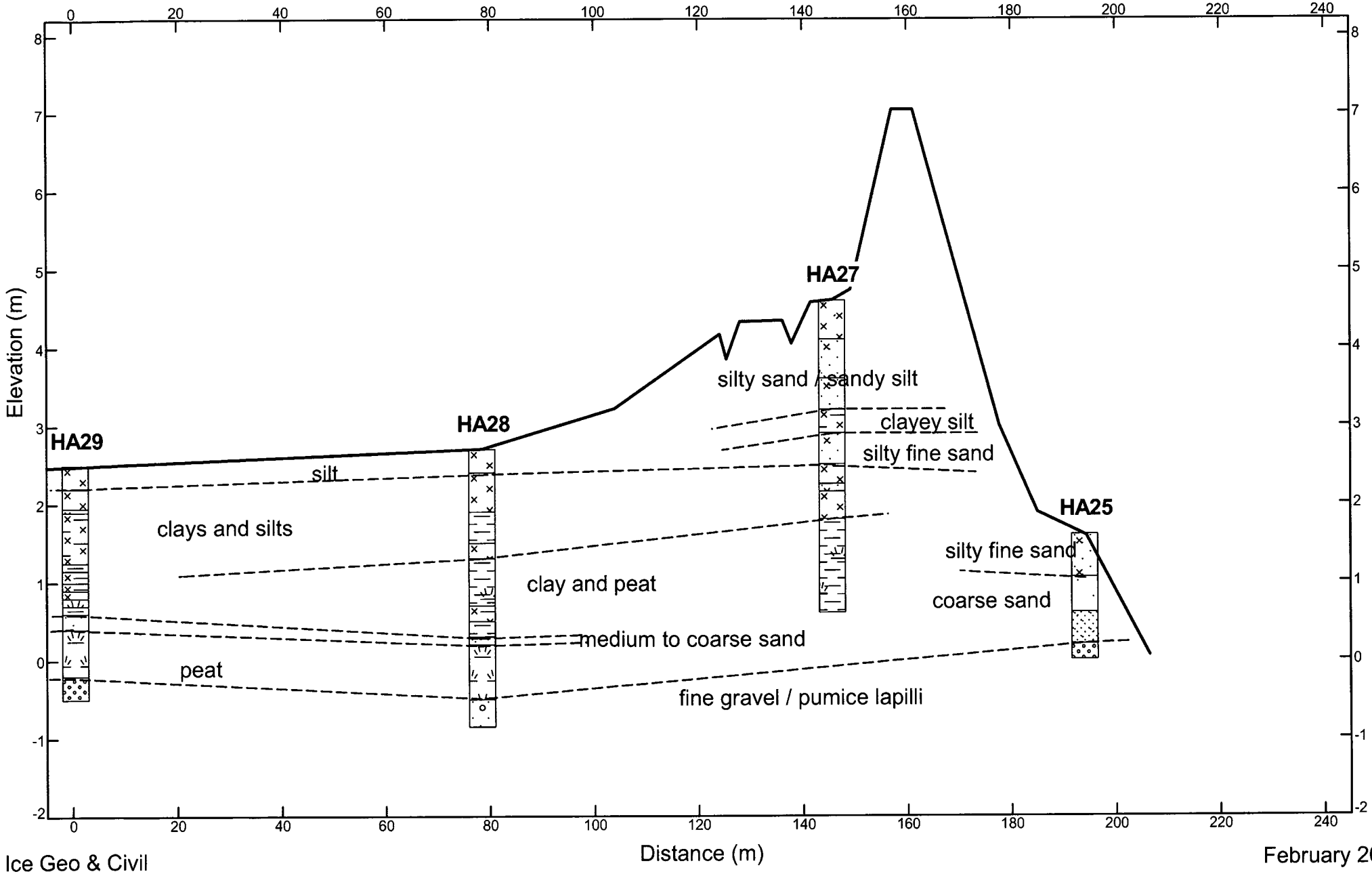


Ice Geo & Civil

December 2009

Project: Rangitaiki River
Client: EBOP
Location: Otakiri Left Bank
Number:

Subsurface Cross Section 2

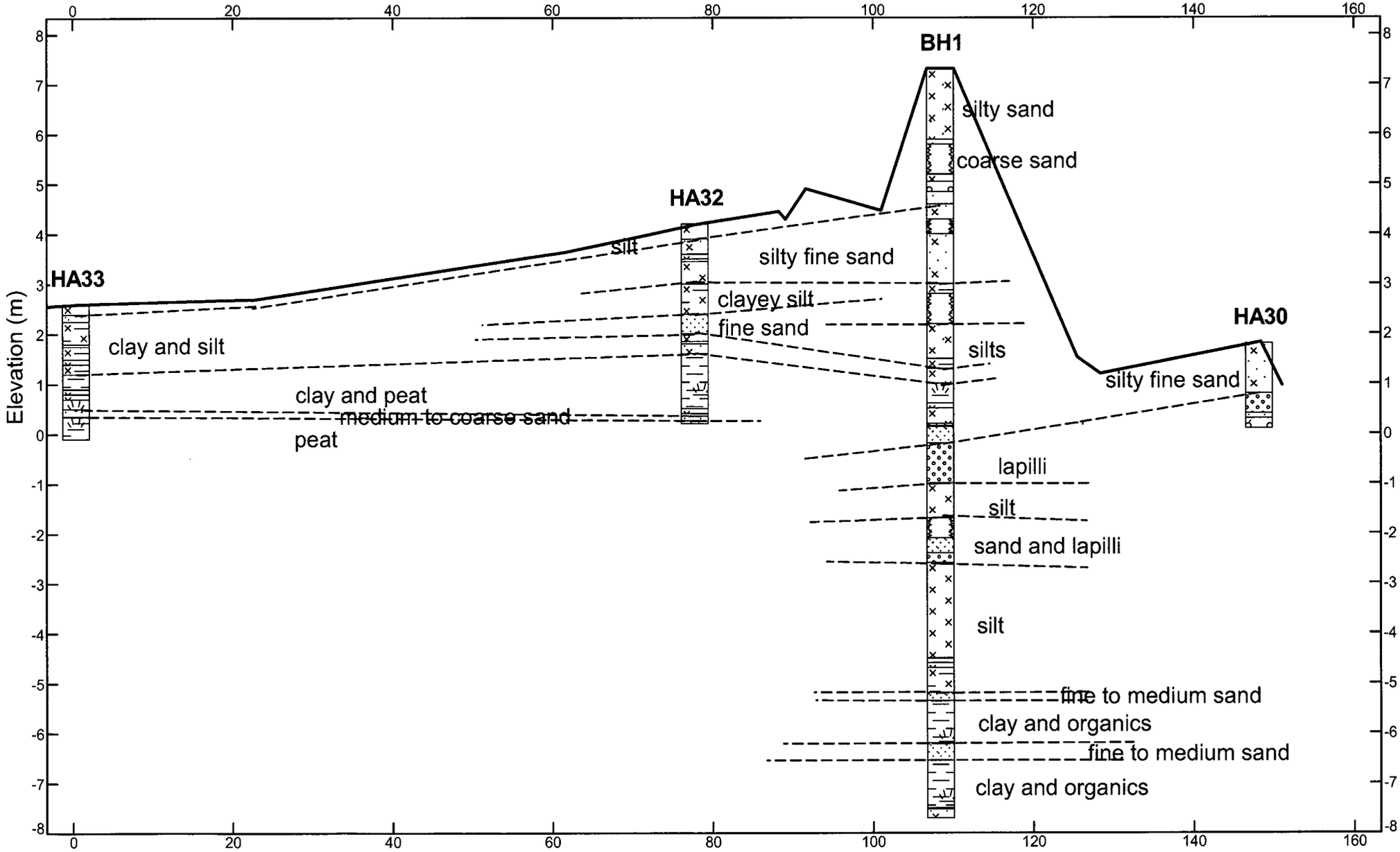


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBOP
Location: Otakiri Left Bank
Number:

Subsurface Cross Section 3

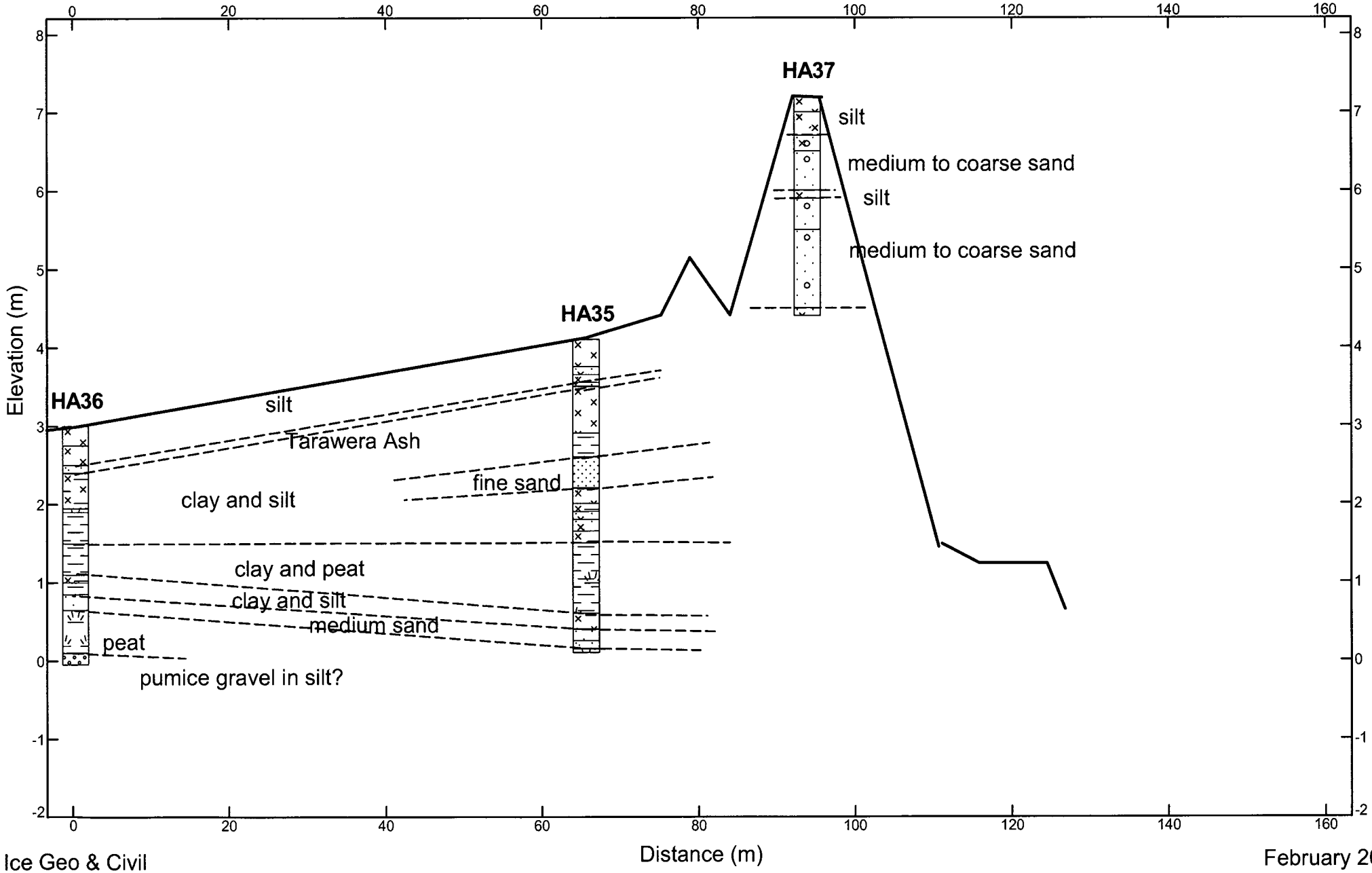


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBOP
Location: Otakiri Left Bank
Number:

Subsurface Cross Section 4



Ice Geo & Civil

February 2010

ICE GEO & CIVIL
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Bore Hole Log

Borehole: BH1

Project: **Rangitaiki Stopbank**
Client: **EBoP**

Location: **Otakiri Road**
Co-ordinates: East
Elevation: 7.3

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
0.00					**sandy SILT**, banded some fine gravel to 4mm, brown grey					
0.50										
1.00					1.0 piece timber to 10mm					
	5.90									
1.50	5.80				coarse **SAND**, grey					
		100			sand washed out					
2.00										
	5.20				gritty **SILT**, rare hard angular gravel to 15mm, dark grey					
	5.05				gritty **silty SAND**, dense and **charcoal**, grey / black					
	4.85	10			coarse **SAND**, some fine lapilli, some silt, brown					
2.50										
	4.60				**silty fine SAND**, dense, brown					
3.00	4.30									
	4.00				**silty fine SAND**, dense, brown					
3.50										
		100								
4.00										
	3.00				**clayey SILT**, plastic, medium strength, grey with orange staining, moist					
4.50	2.80									
5.00										
	2.20				pumiceous fine **sandy SiLT**, light brown, very sensitive					
5.50		100								
	1.50				**clayey SILT**, plastic, medium strength, grey brown					
6.00	1.30									

Observations:
falling head test 7.5 to 9.0m, 96mm hole

Vane no.
Core Dia. 69mm

Rig: Marooka
Contractor: Perry Drilling Tim

Date started: 02/03/2010
Date finished: 02/03/2010
Logged by: M O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
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Project: **Rangitaiki Stopbank**
Client: **EBoP**

Location: **Otakiri Road**
Co-ordinates: East
Elevation: 7.3

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
6.00					**SILT**, grey, sensitive					
	1.00				clayey and fibrous **PEAT**, roots and timber to 20mm, soft, dark brown					
6.50										
	0.60				pumiceous **clayey SILT**, light grey brown					
	0.50	100			pumiceous **SILT**, light grey brown					
7.00										
	0.20				fine to medium **SAND**, grey					
	0.16				**PEAT**, black					
	0.13				well graded pumice **SAND** and pumice to 60mm, grey					
7.50	-0.20				fine **lapilli** to 10mm, typically 2mm, some banding, rare charcoal	7.7	dis			
8.00										
	-1.00	100			**SILT**, grey, varved, dense, stiff, liquefiable					
8.50										
9.00	-1.70				falling head test					
	-2.10				well graded pumice **SAND** and fine lapilli to 1.5mm, grey					
9.50										
	-2.40				pumice **lapilli** to 5mm					
	-2.60				**SILT**, some angular **pumice** to 20mm, varved, stiff, grey	10	dis			
10.00		100								
10.50					10.5 to 11.0 silt washed away from around pumice					
11.00										
		100								
11.50										
	-4.50									
	-4.51				**organic CLAY**, brown					
12.00	-4.60									

Observations:
falling head test 7.5 to 9.0m, 96mm hole

Vane no. Core Dia. 69mm	Rig: Marooka Contractor: Perry Drilling Tim	Date started: 02/03/2010 Date finished: 02/03/2010 Logged by: M O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
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Project: **Rangitaiki Stopbank**
Client: **EBoP**

Location: **Otakiri Road**
Co-ordinates: East
Elevation: 7.3

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
12.00	-4.70				**CLAY**, some fine organic material, estuarine, plastic, soft, green grey					
					SILT, firm, green grey					
12.50	-5.20				bands **CLAY**, some fine organic material, estuarine, plastic,					
	-5.35	100			soft, green grey and **SILT**, firm, green grey					
					fine to medium **SAND**, green grey					
13.00					bands **CLAY** with fine organic material and small timber fragments and fine to medium **SAND**, bands 100 to 200mm thick					
13.50	-6.20				fine to medium **SAND**, grey					
	-6.55				13.8 10mm black organic material					
14.00		100			banded **CLAY** and fibrous **organic** material and rotten timber to 60mm, bands brown,black and green					
14.50										
	-7.50									
	-7.52				coarse pumiceous **SAND and lapilli** to 10mm, grey					
15.00	-7.70				finely banded **silty fine SAND** and **SILT**, green grey					
					EOB					
15.50										
16.00										
16.50										
17.00										
17.50										
18.00										

Observations:
falling head test 7.5 to 9.0m, 96mm hole

Vane no.
Core Dia. 69mm

Rig: Marooka
Contractor: Perry Drilling Tim

Date started: 02/03/2010
Date finished: 02/03/2010
Logged by: M O'Halloran

Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA21**

Elevation: 2
Date: 15/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown fine **sandy SILT**, dry	
	1.7			
0.5			grey with orange staining **silty fine SAND**, damp	
1.0	1.05		speckled black and white **coarse SAND**, wet	dis.
1.5				
	0.3		EOB washing in	
2.0				
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA22**

Elevation: 7.3
Date: 12/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **medium to coarse SAND**, minor silt, dry	
1.0	6.3			
	6.2		brown fine **sandy SILT**, damp	
			brown **medium to coarse SAND**, minor silt, damp	
2.0	5.4		dark brown fine **sandy SILT**, damp	
	4.9		brown **silty fine SAND**, damp	
3.0	4.3		EOB	

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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA23**

Elevation: 4.3
Date: 12/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, firm, dry	
0.5	3.8		grey with orange staining **SILT**, dry, firm	
	3.6		dark brown **SILT**, some clay, damp	
	3.4		grey with Mn/Fe staining fine **sandy SILT**, some clay, damp	
1.0	3.2		grey with Mn/Fe staining **silty fine SAND**, dry	
1.5				
	2.6		grey with some orange staining **fine sandy SILT**, moist	
	2.4		grey with some orange staining **SILT**, moist	
2.0	2.3		grey with orange and some brown staining **clayey SILT**, moist	
	2.1		brown / grey **CLAY**, with some fine organic material, moist	
▼	1.9		grey **silty fine SAND**, wet	
2.5				
	1.6		grey **SILT**, wet	
3.0	1.3		interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
3.5				
	0.4		EOB squeezing	
4.0				
4.5				

HAND AUGER HAND AUGERBH.GPJ HAND AUGER BASIC.GDT 3/5/10

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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA24**

Elevation: 2.9
Date: 08/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, firm, dry, 0.15 some grit	
	2.5		0.3 becoming damp	
0.5			grey with orange staining **SILT**, some clay, firm, damp becoming **clayey SILT**	
	2.1		grey with orange mottles **SILT**, damp, firm	
1.0	1.85		grey with orange mottles **CLAY**, some organic content, firm, damp	
1.5			1.4 moist	
	1.13		brown fibrous material **PEAT**	
	1.1		green grey **SILT**, moist, medium strength	
2.0	0.9		interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
2.5	0.4		light brown **clayey SILT**, medium strength, moist	
	0.25		brown **organic CLAY** and fibrous organic material, soft	
	0.1		grey medium to coarse **pumice SAND**, some silt, wet	
	0		black fibrous **PEAT**, wet	
3.0				
	-0.5		EOB, UTP log/dense pumice sand?	
3.5				
4.0				
4.5				

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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA25**

Elevation: 1.6
Date: 15/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			grey with orange mottles, **silty fine SAND**, moist	
0.5	1.05		speckled black and white **coarse SAND**, wet	
1.0	0.6		grey well graded **SAND**	
1.5	0.2		light grey pumice **lapilli** to 2mm	
	0		EOB washing in	
2.0				
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA27**

Elevation: 4.6
Date: 15/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown fine **sandy SILT**, dry, firm 0.3 some grit (Tarawera Ash)	
0.5	4.1		brown **silty fine SAND / sandy SILT**, dry	
1.0	3.6		grey with orange staining **silty fine SAND / sandy SILT**, damp	
1.5	3.2		grey with orange mottles **clayey SILT**, plastic, damp	
	2.9		grey with orange staining **silty fine SAND**, damp	
2.0	2.5		grey with orange staining **SILT**, moist	
	2.25		grey with orange staining **silty fine SAND**, moist	
2.5	2.15		grey with orange staining **SILT**, moist	
	1.8		interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
▼3.0				
3.5				
4.0	0.6		EOB	
4.5				

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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA28**

Elevation: 2.7
Date: 08/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, dry, firm	
	2.4			
0.5			grey with orange mottles **SILT**, some clay, firm, damp	
	1.9			
1.0			grey with orange mottles and some orange staining **CLAY**, firm, damp	
	1.5			
			light brown with orange staining, **SILT**, medium strength, damp	
	1.3			
1.5			interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
2.0	0.7		light brown **clayey SILT**, medium strength, moist	
	0.5			
			brown **organic rich CLAY**, soft, moist	
	0.3			
2.5	0.2		grey medium to coarse **pumice SAND**, some silt, wet	
			black fibrous **PEAT**	
3.0				
	-0.5			
			grey **gravelly fine to coarse pumice SAND**, with minor silt, gravel to 4mm, rare pumice to 20mm, dense, wet	
3.5	-0.85			
			EOB, washing in	
4.0				
4.5				

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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA29**

Elevation: 2.5
Date: 12/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, dry, firm	
			0.2 some grit	
	2.2			
0.5			grey with orange mottles **SILT**, dry	
	1.95			
	1.9		brown **organic clayey SILT**, damp	
			grey with orange mottles **clayey SILT**, damp, becoming moist	
1.0				
	1.25			
	1.15		brown **organic CLAY**, moist	
			dark grey with orange mottles **clayey SILT**, some organic material,	
1.5	1		moist	
	0.9		light brown pumice **clayey SILT**, moist, dilatant	
	0.8			
	0.7		light brown pumice **SILT**, moist	
	0.6		black fibrous **PEAT**, medium strength, moist	
2.0			black organic **CLAY**, soft, moist	dis.
	0.4		grey medium pumice **SAND**, wet	
			black fibrous **PEAT**, firm, moist	
2.5				
	-0.2			
			grey fine pumice **GRAVEL**, with some silt, dense, wet (silt matrix??)	
3.0	-0.5			
			EOB losing sample	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA30**

Elevation: 1.8
Date: 15/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			grey with orange staining **silty fine SAND**, moist	
1.0	0.8		light grey pumice **lapilli** to 2mm, some rotten timber, wet	dis.
1.5	0.4		grey **silty fine SAND**	
	0.3		black and white **coarse SAND** and **fine GRAVEL** to 4mm, pumice lapilli and hard grey gravel	
	0.1		EOB washing in	
2.0				
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA32**

Elevation: 4.2
Date: 08/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, dry	
	3.9		brown **silty fine SAND**, dry	
0.5	3.6		grey with orange mottles **SILT**, dry	
	3.5		black medium to coarse basalt **SAND**, Tarawera Ash, dry	
	3.45		grey with orange mottles **SILT**, firm, dry	
1.0				
	3		grey with orange mottles **clayey SILT**, some organic staining	
1.5				
	2.4		grey/brown **fine SAND**, some silt, moist	dis.
2.0				
	2		grey **SILT**, moist	
▼	1.85		green grey **clayey SILT**, with organics, moist	
2.5	1.8		grey **silty fine SAND / sandy SILT**, moist	
	1.6		interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
3.0				
3.5				
	0.5		light brown **clayey SILT**, medium strength, moist	
	0.4		brown **organic CLAY and fibrous material**	
	0.35		grey medium to coarse **pumice SAND**, some silt, wet	
4.0	0.25		black fibrous **PEAT**, wet	
	0.2		EOB	
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA33**

Elevation: 2.6
Date: 12/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	2.4		brown **SILT**, firm, dry	
	2.25		black medium to coarse basalt **SAND**, Tarawera Ash, dry	
0.5			grey with orange staining **clayey SILT**, damp	
	1.8			
	1.75		black **organic CLAY**, damp	
1.0			grey with orange staining **clayey SILT**, damp	
	1.5			
	1.4		grey with orange mottles **SILT**, damp	
			grey with orange staining **clayey SILT**, damp	
	1.2			
1.5			interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
	0.9			
	0.8		light brown pumice **clayey SILT**, moist	
	0.7		light brown pumice **SILT**, moist	
2.0			black fibrous **PEAT**, moist	
▼	0.5			dis.
	0.35		grey medium pumice **SAND**, minor silt, wet	
			black fibrous **clayey PEAT**	
2.5				
	-0.1			
			EOB sand washing in	
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA35**

Elevation: 4.1
Date: 08/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, dry, firm	
	3.75			
0.5	3.65		brown **silty fine SAND**, dry	
	3.55		brown with orange mottles grey fine **sandy SILT**	
	3.5		black medium to coarse basalt **SAND**, Tarawera Ash, dry	
			grey with orange staining **SILT**, damp	
1.0				
	2.9		grey with orange staining **CLAY**, some organic staining, damp	
1.5	2.6		grey/brown **fine SAND**, some silt, moist	dis.
	2.2			
2.0			grey fine **sandy SILT**, damp	
	2			
	1.9		grey with organic staining **clayey SILT**, moist	
	1.8		grey with black staining **silty fine to medium SAND**, wet	
▼			grey with orange staining **silty fine SAND**, wet	
2.5	1.65		grey **SILT**, wet	
	1.5		interbedded green grey **CLAY** and black fibrous **PEAT**, medium strength, moist	
3.0				
3.5	0.6		light brown pumice **SILT**, wet	
	0.39		brown **organic material** and **silty fine to medium pumice SAND**	
	0.25		grey medium to coarse pumice **SAND**	
4.0	0.14		black fibrous **PEAT**	
	0		EOB	
4.5				

HAND AUGER HAND AUGER2.GPJ HAND AUGER BASIC.GDT 26/7/10

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA36**

Elevation: 3
Date: 12/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, dry, firm	
	2.75		grey with orange staining **SILT**, dry	
0.5	2.5			
	2.4		black medium to coarse basalt **SAND**, Tarawera Ash, dry	
			grey with orange staining **clayey SILT**, damp	
1.0	1.95			
	1.9		brown fibrous **PEAT**, moist	
			brown and grey with orange staining **CLAY**, some organic content, soft moist	
1.5	1.5		interbedded green grey **CLAY** and black fibrous **PEAT**, soft, moist	
	1.1			
2.0	1		light brown pumice **clayey SILT**, moist	
▼			brown **organic rich CLAY**, soft, moist	
	0.85		grey medium pumice **SAND**, minor silt, wet	dis.
	0.65		black fibrous **PEAT**, wet	
2.5				
	0.1			
3.0			grey fine pumice **GRAVEL**, with some silt, dense, wet (silt matrix??)	
	-0.1		EOB	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBOP
Location: Otakiri Left Bank
Number:

Test: **HA37**

Elevation: 7.2
Date: 04/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0	7		brown **organic SILT**, dry	
			brown fine **sandy SILT**, some fine gravel to 2mm, dry	
0.5	6.7		brown fine **gravelly silty fine SAND**, damp	
	6.5		brown **gravelly medium to coarse SAND**, rounded hard gravel to 5mm, dense	
1.0				
	6			
	5.9		dark grey **SILT**, trace fine sand, dense, damp	
			brown **gravelly medium to coarse SAND**, rounded hard gravel to 5mm, dense, 1.4m some silt	
1.5	5.5			
			brown fine **gravelly fine to coarse SAND**, dense, damp	
2.0				
2.5				
	4.5			
	4.4		brown **silty fine SAND**	
			UTP gravel railway / road	
3.0				
3.5				
4.0				
4.5				

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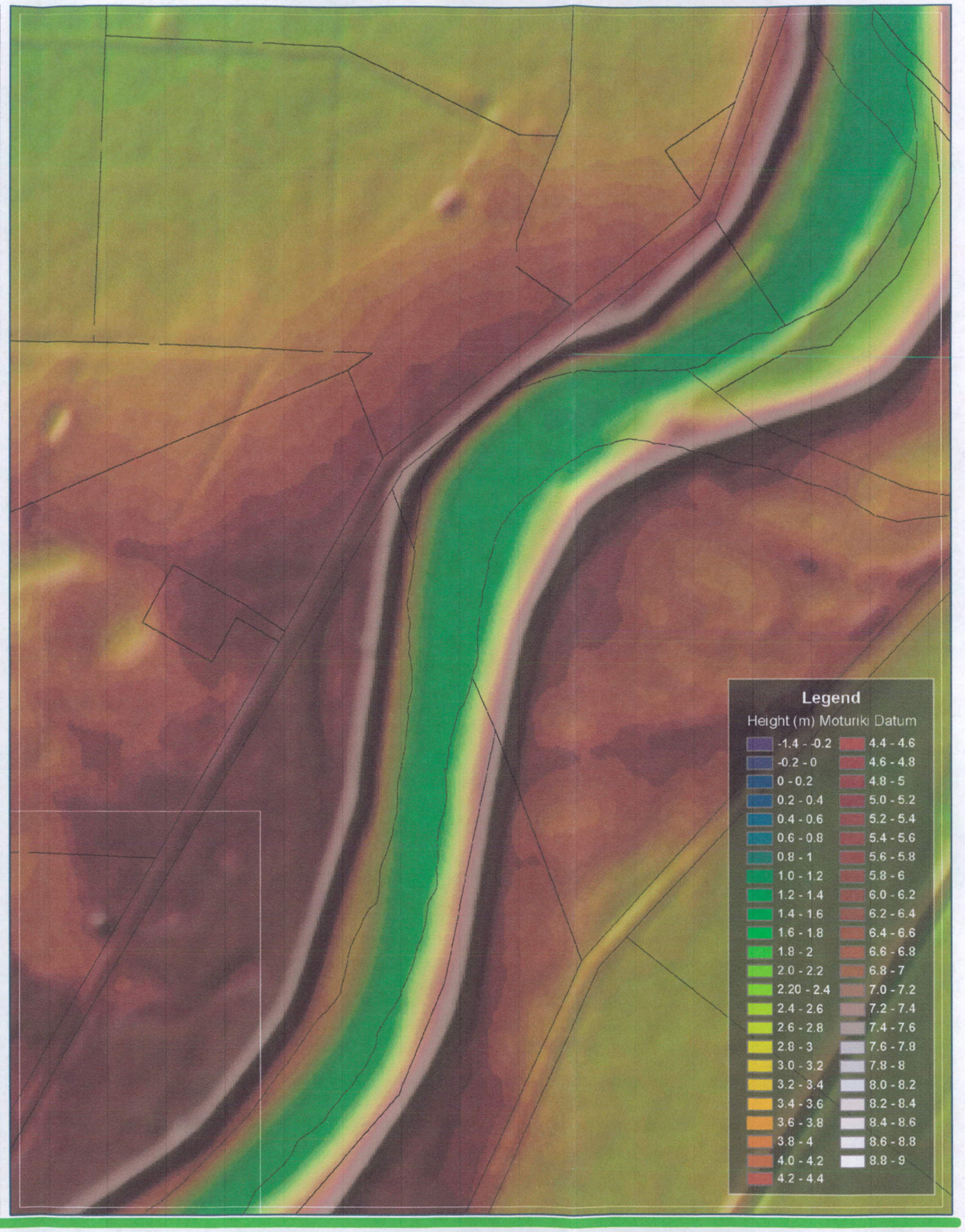
Appendix C

Black's Bend



Environment Bay of Plenty
REGIONAL COUNCIL

Rangitaiki River
Geotechnical Remedial Works

Blacks Farm Area

100 50 0 100 200 300 400
Meters

Scale = 1:4,000

Note: The DEM dataset is generated from LIDAR data captured in 2006.
The original LIDAR dataset has a verticle accuracy of 0.15m.
The DEM shown has a 2m cell size which as a consequence of some generalisation reduces the verticle accuracy to approximately 0.3m.

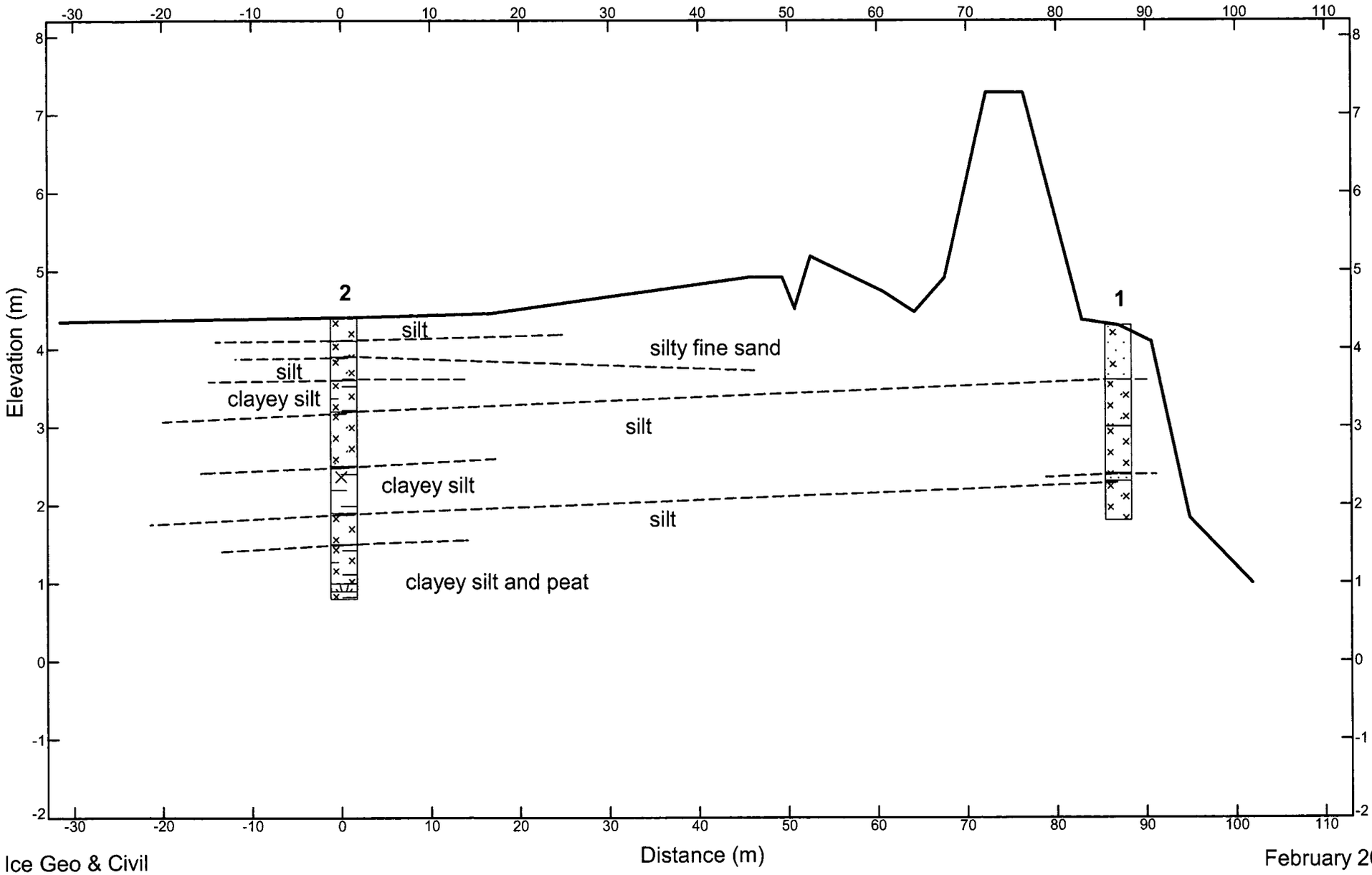
N

Map 4
c2367_Rangitaiki
July 09

Black's Bend Hand Augers

Project: Rangitaiki River Stopbanks
Client: EBoP
Location: Black's Bend
Number: 49

Subsurface Cross Section 1

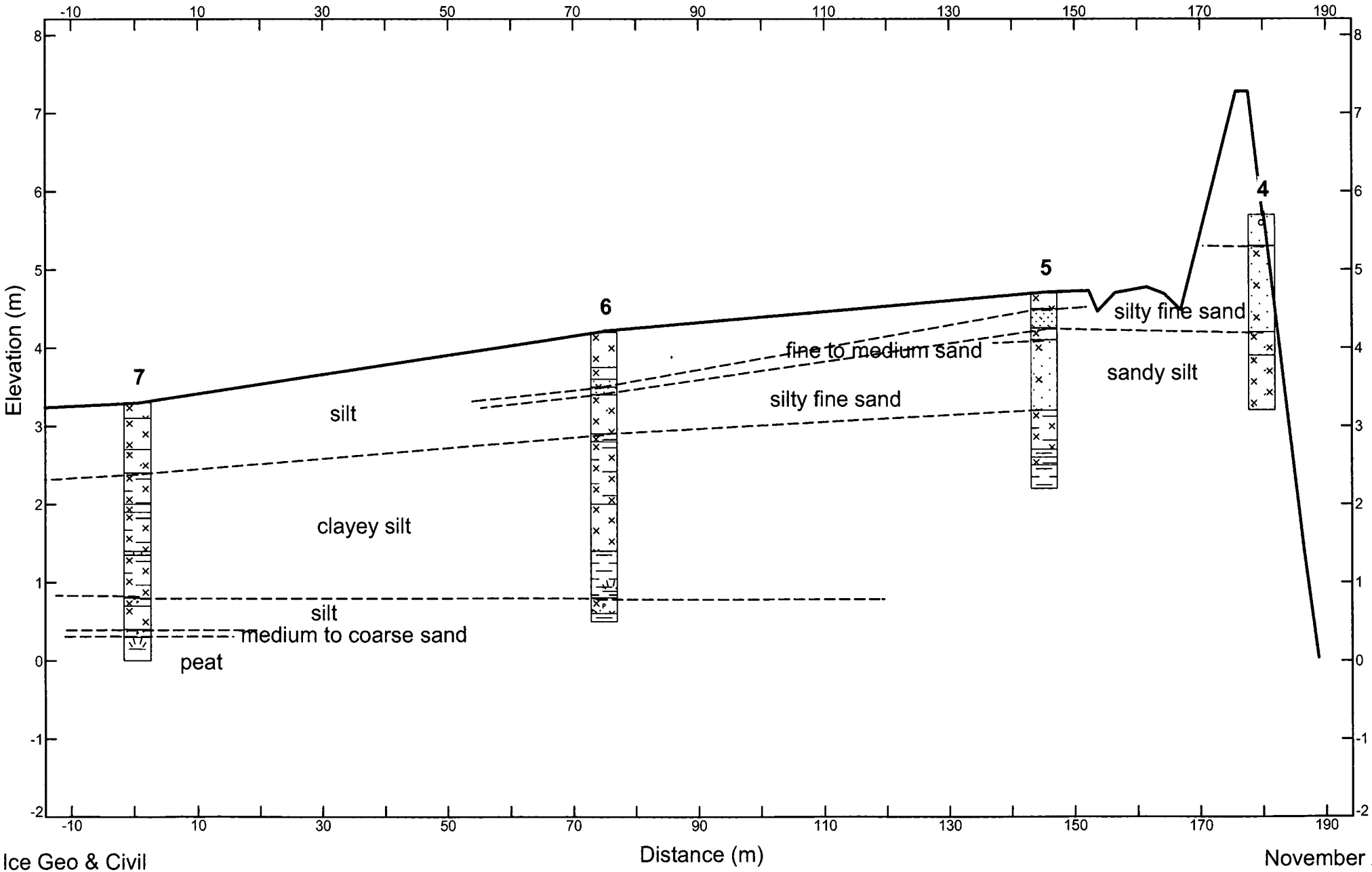


Ice Geo & Civil

February 2010

Project: Rangitaiki River Stopbanks
Client: EBoP
Location: Black's Bend
Number: 49

Subsurface Cross Section 2

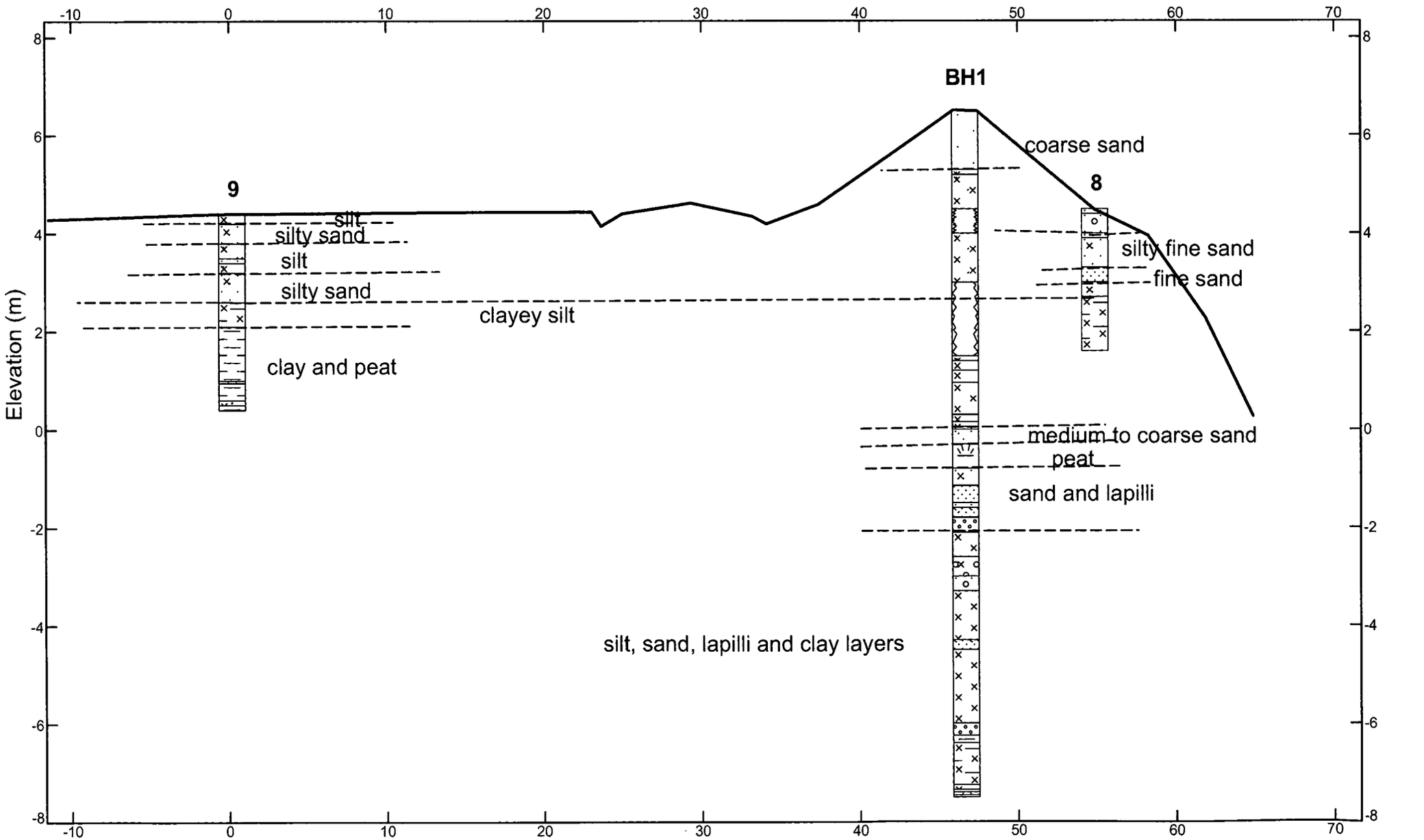


Ice Geo & Civil

November 2009

Project: Rangitaiki River Stopbanks
Client: EBoP
Location: Black's Bend
Number: 49

Subsurface Cross Section 3



Ice Geo & Civil

February 2010

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: **EBoP**

Location: **Black's Bend**
Co-ordinates: East
Elevation: 8.0

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
0.00					**clayey SILT**, stiff, fill, orange brown					
0.50		100								
1.00	7.00				**coarse SAND** and fine gravel to 3mm, grey					
1.50										
2.00										
	5.80	100			fine **sandy SILT**, fill, hard, brown					
2.50	5.70				fine **sandy SILT**, fill, hard, blue grey					
3.00	5.00									
3.50	4.50				fine **sandy SILT**, fill, hard, blue grey					
4.00		100								
4.50	3.50									
5.00										
5.50										
6.00	2.00									

Observations:
Falling Head test 7.5 to 9.0m

Vane no.
Core Dia. 69mm

Rig: Marooka
Contractor: Perry, Tim

Date started: 02/03/2010
Date finished: 02/03/2010
Logged by: M O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: **EBoP**

Location: **Black's Bend**
Co-ordinates: East
Elevation: 8.0

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
6.00	1.90				fine **sandy SILT**, fill, hard, blue grey					
	1.70				**SILT**, sensitive, soft, grey with orange staining					
6.50	1.45				**SILT**, some clay and organics, grey					
		100			**SILT**, rare timber, spongy, dilatant, brown					
7.00										
	0.80				**SILT**, some timber, stiff, grey					
	0.65				pumiceous **SILT**, firm, light brown grey					
	0.55				**silty fine to medium SAND**, grey					
7.50	0.50				pumiceous **SAND** medium to coarse, grey	7.6	dis			
	0.20				**PEAT**, fibrous homogeneous (like particle board) stiff, black					
8.00										
		100								
	-0.30				pumiceous **silty** fine to medium **SAND**, brown grey					
8.50										
	-0.65				fine pumiceous **SAND**, some lapilli to 3mm, grey					
9.00	-1.00									
	-1.10				**organic** rich silty fine to medium **SAND**					
	-1.30				well graded **SAND** and lapilli to 5mm, grey					
					pumice **LAPILLI** 1 to 12mm					
9.50	-1.60									
		90			**SILT** and **sandy SILT** with pumice lapilli rich bands grey					
10.00	-2.10									
					LAPILLI in SILT matrix, approx. 70% lapilli, 30% silt, lapilli to 20mm					
10.50	-2.50									
					layers fine **SAND**, grey and **LAPILLI** to 5mm, layers approx. 50mm thick					
	-2.80									
					varved **SILT**, some lapilli rich layers, liquefiable, grey					
11.00		100								
11.50										
	-3.80									
12.00	-4.00				fine to medium **SAND**, some bands rich in fine lapilli and					

Observations:
Falling Head test 7.5 to 9.0m

Vane no. Core Dia. 69mm	Rig: Marooka Contractor: Perry, Tim	Date started: 02/03/2010 Date finished: 02/03/2010 Logged by: M O'Halloran

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Bore Hole Log

Borehole: BH1

Project: **Rangitaiki River**
Client: **EBoP**

Location: **Black's Bend**
Co-ordinates: East
Elevation: 8.0

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
12.00					charcoal, grey					
					varved **SILT**, some lapilli rich layers, liquefiable, grey					
12.50		100								
13.00										
13.50	-5.50				lapilli and fine **GRAVEL** to 2mm, some silt, some fibrous organic material					
	-5.75				organic rich **CLAY**, fibres, roots to 20mm, plastic, soft, green grey, 13.8m 2mm band white extremely sensitive SILT					
	-5.90				organic rich **CLAY**, fibres, roots to 20mm, plastic, firm, dark brown green grey					
14.00		100								
14.50										
	-6.75				**clayey SILT**, firm, brown grey					
	-6.85				varved pumiceous **SILT**, stiff, light greenish grey and brown					
	-6.90				**timber**					
15.00	-6.96				pumice **LAPILLI** to 8mm, some silt, brownish grey					
	-7.00				EOB					
15.50										
16.00										
16.50										
17.00										
17.50										
18.00										

Observations:
Falling Head test 7.5 to 9.0m

Vane no. Core Dia. 69mm	Rig: Marooka Contractor: Perry, Tim	Date started: 02/03/2010 Date finished: 02/03/2010 Logged by: M O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: **EBoP**

Location: **Black's Bend**
Co-ordinates: East
Elevation: 8.0

North
Datum: Moturiki

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
0.00					**clayey SILT**, stiff, fill, orange brown					
0.50		100								
1.00	7.00				**coarse SAND** and fine gravel to 3mm, grey					
1.50										
2.00										
	5.80	100								
	5.70				fine **sandy SILT**, fill, hard, brown					
2.50					fine **sandy SILT**, fill, hard, blue grey					
3.00	5.00									
3.50	4.50				fine **sandy SILT**, fill, hard, blue grey					
4.00		100								
4.50	3.50									
5.00										
5.50										
6.00	2.00									

Observations:
Falling Head test 7.5 to 9.0m

Vane no.
Core Dia. 69mm

Rig: Marooka
Contractor: Perry, Tim

Date started: 02/03/2010
Date finished: 02/03/2010
Logged by: M O'Halloran

Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **1**

Elevation: 4.3
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **silty fine SAND**, damp	
	3.6		orange stained grey **fine sandy SILT**, damp	
1.0				
	3		orange stained grey **SILT**, dilatant, sensitive, moist to wet	
1.5				
	2.4			
2.0	2.3		grey **fine SAND**, wet	
			grey fine **sandy SILT**, sensitive, dilatant	
2.5	1.8		EOB hole squeezing in	
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **2**

Elevation: 4.4
Date: 04/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, firm, damp	
	4.1			
0.5	3.9		orange stained grey **silty fine SAND / sandy SILT**	
			grey fine **sandy SILT**, some fine roots, moist	
	3.6			
1.0			orange stained dark grey **clayey SILT**, moist, soft	
▼	3.2			
			orange stained grey fine **sandy SILT**	
1.5				
	2.5			
2.0			layers orange and black stained grey **clayey SILT** and orange stained grey **SILT**, layers approx 100mm, soft	
2.5	1.9			
			grey **SILT**, sensitive, dilatant	
	1.5			
3.0			dark grey **clayey SILT** and brown **clayey SILT** with organic content	
	1			
3.5	0.9		dark brown fibrous **PEAT**	
	0.8		dark grey **clayey SILT** and brown **clayey SILT** with organic content	
			EOB squeezing	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **3**

Elevation: 7.5
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0	7.35		brown **organic SILT**, trace fine sand, dry	
			brown **gravelly medium to coarse SAND**, minor silt, trace clay, hard rounded gravel to 5mm, dry	
0.5				dis.
1.0				dis.
1.5				dis.
2.0	5.3			
	5.2		dark brown **silty fine SAND**, damp	
	5.15		grey medium to coarse SAND	
2.5	5.05		grey **silty fine SAND**, dense, damp	
3.0				
3.5			EOB	
4.0				
4.5				

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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **4**

Elevation: 5.7
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **gravelly medium to coarse SAND**, dry	
	5.3			
0.5			brown **silty fine SAND**, damp, dense	
1.0				
1.5	4.2		dark brown **silty fine SAND / sandy SILT**, damp, dense	
	3.9			
2.0			dark grey fine **sandy SILT**, oxidises black, damp, firm	
2.5	3.2		EOB UTP gravel	
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **5**

Elevation: 4.7
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	4.5		brown **organic SILT**, trace fine sand, dense	
			brown **fine to medium SAND**, some silt	
0.5	4.25			
	4.1		brown **silty fine SAND / sandy SILT**, damp	
			orange and black stained **silty fine SAND**, moist	
1.0				
			▼	
1.5	3.2		orange stained grey **clayey SILT**	
2.0	2.7			
	2.6		orange stained grey **CLAY**	
	2.5		blue grey **clayey SILT**	
			blue grey **CLAY**	
2.5	2.2			
			EOB squeezing	
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **6**

Elevation: 4.2
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, dense	
			0.4m 50mm Tarawera Ash rich layer	
0.5	3.75		orange stained grey **SILT**, damp, dense	
	3.6			
	3.5		orange stained grey **silty fine SAND**, moist	
	3.4		orange stained grey **fine SAND**, moist	
1.0			orange stained grey fine **sandy SILT**, moist	
	2.9			
	2.8		brown **clayey SILT** with fibrous organic material	
1.5			orange stained grey **clayey SILT**	
2.0				
	2			
			grey **SILT**, sensitive, dilatant	
2.5			2.5m 50mm organic rich layer	
	1.4			
			brown **CLAY** with organic fibres	
3.0				
	0.8			
3.5			light brown pumice **SILT**	
	0.6			
	0.5		light brown organic fibrous rich **CLAY**, some timber	
			EOB squeezing	
4.0				
4.5				

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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **7**

Elevation: 3.3
Date: 04/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **SILT**, firm, damp	
	3.1		0.1 gritty Tarawera Ash	
0.5			orange stained grey **SILT**, damp, firm 0.5m moist	
	2.7		grey fine **sandy SILT**, moist	
▼	2.4			
1.0			orange stained grey and brown **clayey SILT**, some organic material, soft	
	2			
	1.9		grey **SILT**	
1.5			orange and black stained **clayey SILT**, some organic fibrous material	
	1.4			
2.0	1.35		black fibrous **PEAT**	
			orange and black stained **clayey SILT**, some organic fibrous material	
2.5	0.8			
	0.7		white pumiceous **SILT**	
			dark brown **organic clayey SILT**, fibres	
	0.4			
3.0	0.3		light grey pumiceous **medium to coarse SAND**, fine lapilli	
			dark brown fibrous **PEAT**	
	0			
			EOB sand washing in	
3.5				
4.0				
4.5				

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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **8**

Elevation: 4.5
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0	4.4		brown **silty fine to coarse gravelly SAND**	
			brown medium to coarse **gravelly SAND**, some silt, hard rounded gravel to 5mm	
0.5	4			
	3.9		grey **silty fine SAND**	
			brown **silty fine SAND**	
1.0				
	3.3		grey fine SAND, wet	dis.
1.5	3		grey with black and orange staining **silty fine SAND**, wet	
			▼	
	2.7		orange stained grey **clayey SILT**, some black staining and fine organic material	
2.0				
2.5				
	1.6			
3.0			EOB squeezing in	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River Stopbanks**
Client: EBoP
Location: Black's Bend
Number: 49

Test: **9**

Elevation: 4.4
Date: 06/11/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	4.2		brown **organic SILT**, dense , firm	
0.5			brown **silty fine to medium SAND**, minor coarse sand and Tarawera Ash	
	3.8		orange stained grey fine **sandy SILT**, damp	
	3.5			
1.0	3.4		orange stained grey **silty fine SAND**, moist	
			orange stained grey fine **sandy SILT**, wet	
	3.2		orange stained grey **silty fine SAND**, wet	
1.5				
	2.6		orange stained grey **clayey SILT**	
2.0				
	2.1		blue grey **CLAY**, some fibrous organic material, soft	
2.5				
3.0				
	1			
3.5	0.95		fibrous **PEAT**	
			blue grey **CLAY**, some fibrous organic material, soft	
0.600000000000001				
	0.5		light brown pumiceous **SILT**	
4.0	0.4		brown fibrous organic rich **CLAY**	
			EOB	
4.5				

ICE GEO & CIVIL
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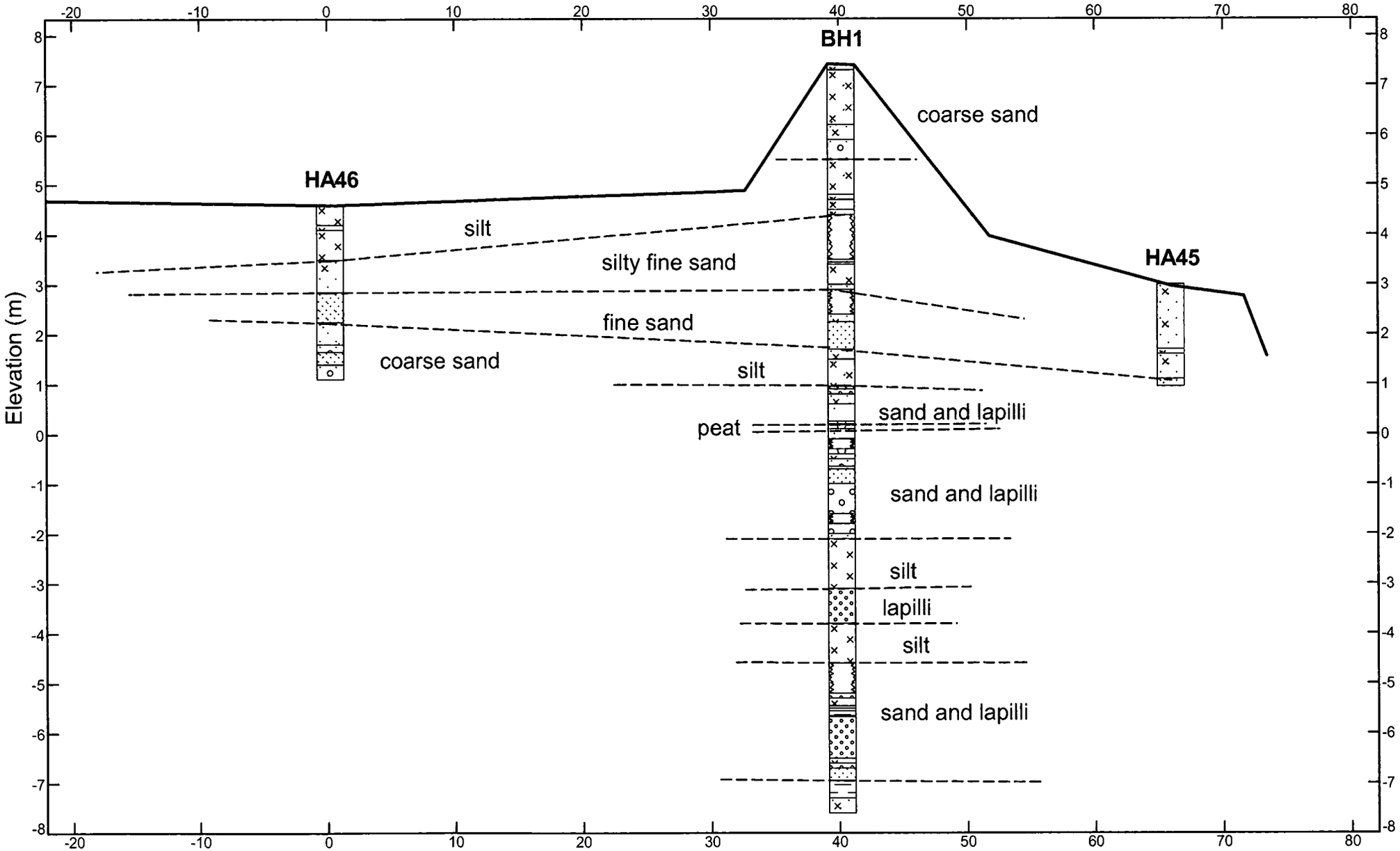
Appendix D

Campbell's Straight

Campbell's Straight Hand Augers

Project: Rangitaiki River Stopbank Assessment
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Subsurface Cross Section 3

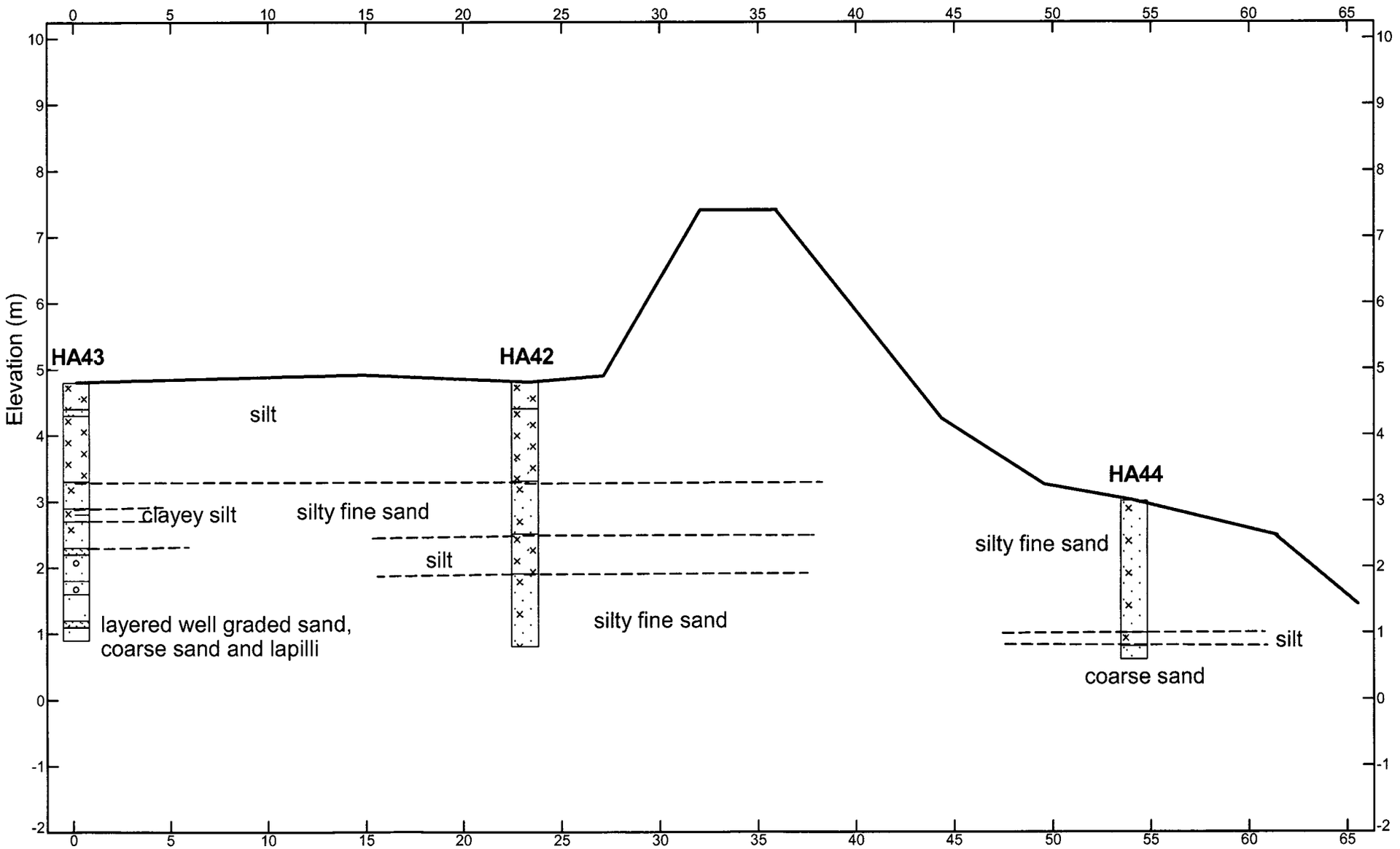


Ice Geo & Civil

February 2010

Project: Rangitaiki River Stopbank Assessment
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Subsurface Cross Section 4



Ice Geo & Civil

February 2010

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project:
Client: **Environment Bay of Plenty**

Location: **Campbells Straight**
Co-ordinates: East 40 North 0
Elevation: 7.4 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
0.00	7.30				**sandy SILT**, brown, topsoil					
					coarse **sandy SILT** and **silty SAND** layers, dense, brown					
0.50										
1.00										
	6.20				**silty fine to medium SAND**, dense, grey					
1.50	5.90				coarse **SAND** and hard rounded **GRAVEL** to 8mm					
	5.50				fine **sandy SILT**, firm, grey					
2.00										
2.50										
	4.80									
	4.70				fine **sandy SILT**, some clay, firm, grey					
	4.50				fine **sandy SILT**, firm, grey					
3.00	4.40				fine **sandy SILT**, firm, brown grey					
3.50										
	3.50									
4.00	3.45				**clayey SILT**, grey with orange staining					
	3.44				coarse **SAND**, black, Tarawera Ash					
	3.40				**silty fine SAND**, grey with brown staining					
	3.00				**SILT**, some clay, firm, grey with brown staining					
4.50	2.90				**silty fine SAND**, firm, grey with orange staining					
5.00	2.40				**silty fine SAND**, firm, grey with orange staining					
	2.25				**fine pumiceous SAND**, moderately loose, light, fluffy, light grey					
5.50										
	1.70				**silty fine SAND**, some fine bands fine sand, dense, grey with orange staining					
	1.50									
6.00										

Observations:

Vane no. Core Dia.	Rig: Contractor:	Date started: Date finished: Logged by: M. O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project:
Client: **Environment Bay of Plenty**

Location: **Campbells Straight**
Co-ordinates: East 40 North 0
Elevation: 7.4 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
6.00					**sandy SILT**, stiff, grey with orange staining					
	0.95									
6.50	0.90				fine to medium pumiceous **SAND**, some silt, grey					
	0.80				pumice **LAPILLI** to 2mm orange					
	0.60				banded **silty fine SAND**, some lapilli to 5mm, grey					
7.00					**coarse SAND**, some silt, grey speckled					
	0.25									
	0.20				timber					
	0.18									
	0.10				fine **sandy SILT**, green grey					
7.50	-0.10				**PEAT**, homogeneous, black					
	-0.30				medium to coarse pumiceous **SAND** and fine lapilli to 3mm					
	-0.40				falling head test					
	-0.50				**PEAT**, amorphous, soft, black					
8.00	-0.65				**organic rich fine sandy SILT**, soft, brown					
	-0.70				coarse pumice **SAND and LAPILLI** to 10mm, some silt, brown grey					
	-1.00				**silty fine SAND**, brown					
8.50					banded **fine SAND**, some pumice lapilli rich bands, lapilli to 5mm, grey					
9.00	-1.60				pumice **LAPILLI** to 60mm, typically 10mm, fine charcoal fragments to 2mm					
	-1.80				pumice **LAPILLI** to 60mm, typically 10mm, fine charcoal fragments to 2mm					
	-2.00				pumiceous **silty fine SAND**, grey					
9.50	-2.10				pumiceous **SILT in bands, pumice lapilli to 10mm**, charcoal to 20mm, extremely sensitive, grey					
10.00										
10.50	-3.10				pumice **LAPILLI**, 0.5 to 5mm, grey					
11.00										
	-3.80				pumiceous **SILT**, stiff, sensitive, grey					
11.50					11.7 some varving 11.9 20mm lapilli rich layer					
12.00	-4.60									

Observations:

Vane no. Core Dia.	Rig: Contractor:	Date started: Date finished: Logged by: M. O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project:
Client: **Environment Bay of Plenty**

Location: **Campbells Straight**
Co-ordinates: East 40 North 0
Elevation: 7.4 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
12.00					washed out					
12.50	-5.20									
	-5.30				pumice **LAPILLI**, 2 to 3mm, grey					
	-5.45				varved **SILT**, extremely sensitive, brown and grey					
	-5.50									
13.00	-5.55				pumice **LAPILLI** to 1mm, grey					
	-5.66				**SILT**, extremely sensitive, white					
	-5.67				**CLAY**, some fine lapilli to 1mm and organic fragments, trace fine sand, very plastic					
13.50					pumiceous **SILT** and charcoal, white					
					pumice **LAPILLI**, 1 to 2mm, some sandy layers					
	-6.50									
14.00	-6.60				pumiceous **SILT**, some fine fibres, extremely sensitive, grey					
	-6.70				pumice **LAPILLI**, 1 to 2mm, some sandy layers					
					fine SAND, some rotten timber, some fine lapilli rich bands, green grey					
	-6.95									
14.50					**organic rich CLAY**, some rotten timber, very plastic, firm, brown					
	-7.30									
					silty fine SAND, rare organic fibres, slighty sensitive, dense, stiff, green grey					
15.00	-7.60				EOB					
15.50										
16.00										
16.50										
17.00										
17.50										
18.00										

Observations:

Vane no. Core Dia.	Rig: Contractor:	Date started: Date finished: Logged by: M. O'Halloran

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA41**

Elevation: 5.0
Date: 26/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown fine **sandy SILT**, damp	
	4.7			
0.5	4.5		grey brown **silty fine gravelly fine SAND**, pumice gravel to 5mm, dry, loose	
			light brown **silty fine SAND**, dry, loose, very light, fluffy	
1.0				
			2.0 damp	
1.5				
2.0				
	2.6			
2.5			grey with orange staining **fine sandy SILT**, moist	
	2.4			
			grey with orange staining **silty fine SAND**, moist, loose, very light, fluffy	
3.0				
3.5 ▼			3.6 wet	
4.0	0.95			
			EOB	
4.5				

HAND AUGER HAND AUGERS.GPJ HAND AUGER BASIC.GDT 2/7/10

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA42**

Elevation: 4.8
Date: 26/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown fine **sandy SILT**, damp	
	4.4			
0.5			light brown **fine sandy SILT / silty SAND**, dry, loose, light	
1.0				
1.5	3.3		grey with orange staining **silty fine SAND**, dry, light, fluffy	
2.0				
	2.5			
2.5			grey with orange staining **fine sandy SILT**, moist	
	1.9			
3.0			grey with orange staining **silty fine SAND**, wet, light	
▼3.5				
4.0	0.8			
			EOB	
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA43**

Elevation: 4.8
Date: 26/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **silty fine SAND**, damp	
	4.4			
0.5	4.3		light brown **silty fine SAND**, light, dry	
			light brown **SILT**, dry, light	
1.0				
1.5	3.3		grey with orange staining **silty fine SAND**, light, fluffy, dry	
	2.9			
2.0			grey with orange staining **clayey SILT**, moist	
	2.7		grey with orange staining **silty fine SAND**, light, fluffy, moist	
			2.4m 30mm pumice lapilli rich layer, lapilli to 3mm	
2.5	2.3			
	2.2		orange clean **fine to medium SAND**	
			grey **well graded gravelly SAND**, pumice gravel to 4mm	
3.0	1.8		orange **gravelly medium to coarse SAND**, dry	
	1.6		orange **coarse SAND / fine lapilli**	
▼ 3.5				
	1.2			
	1.1		grey well graded **SAND**	
			orange **coarse SAND / fine lapilli**	
	0.9			
4.0			EOB washing in	
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA44**

Elevation: 3.0
Date: 26/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			light brown **silty fine SAND**, light, fluffy, dry	
0.5			1.6 wet	
1.0				
1.5				
2.0	1		brown grey **fine sandy SILT**, some clay and organic content	
	0.8		grey **medium to coarse SAND**, wet	
	0.6		EOB washing in	
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA45**

Elevation: 3.0
Date: 26/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			light brown **silty fine SAND**, light, fluffy, dry	
0.5			1.6 wet	
1.0				
	1.7			
	1.6		brown grey **fine sandy SILT**, some clay and organic content	
1.5			grey **silty fine SAND**, wet	
	1.1			
2.0			grey **medium to coarse SAND**	
	0.95		EOB washing in	
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA46**

Elevation: 4.6
Date: 28/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
			brown **SILT**, some fine sand, damp	
	4.2			
0.5	4.1		brown grey **SILT**, damp	
			light brown **SILT**, minor sand, damp	
1.0				
	3.5		grey with orange staining **silty fine SAND**, damp, very light	
1.5			1.7 pumice lapilli rich layer, pumice to 2mm	
	2.85		grey **fine to medium pumice SAND**, light	dis.
2.0				
	2.25		grey pumiceous **medium to coarse SAND**, light, layered	dis.
2.5				
	1.8		grey pumiceous **gravelly coarse SAND**, fine lapilli to 3mm	dis.
3.0	1.65		grey well graded pumiceous **SAND**, moist	
▼	1.4		banded grey pumiceous **gravelly coarse SAND** and grey well graded pumiceous **SAND**, fine lapilli to 3mm	
3.5	1.1		EOB washing in	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA47**

Elevation: 4.9
Date: 28/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown fine **sandy SILT**, dry	
	4.5		0.3 gritty Tarawera Ash	
0.5			brown grey **SILT**, dry	
	4			
1.0			light brown **silty fine SAND**, dry, very light	
1.5				
2.0				
	2.6			
	2.5		grey fine **sandy SILT**, moist	
2.5			banded clean **LAPILLI** to 3mm, orange **medium SAND**, **coarse gravelly pumiceous SAND**, pumice gravel to 4mm, some 20mm bands **fine sandy SILT**	
	2			
3.0	1.9		grey pumice **LAPILLI** to 3mm, dry	
			EOB	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River Stopbank Assessment**
Client: Environment Bay of Plenty
Location: Campbells Straight
Number:

Test: **HA48**

Elevation: 5.1
Date: 28/01/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
			brown fine **sandy SILT**, dry	
	4.7			
0.5			brown grey **sandy SILT**, dry, loose	
	4.5			
			light brown **silty fine pumiceous SAND**, very light, dry	
1.0				
1.5				
	3.4			
			light brown well graded pumiceous **SAND and fine LAPILLI**, minor silt, dry	
2.0				
	2.7			
2.5			grey with orange staining **silty fine SAND**, damp	
3.0	2.1			
			grey fine to medium **SAND**	
	1.9			
			light orange grey medium to coarse **SAND**	
3.5				
	1.35			
	1.3		grey pumice **LAPILLI** to 3mm, wet	
			EOB	
4.0				
4.5				

ICE GEO & CIVIL
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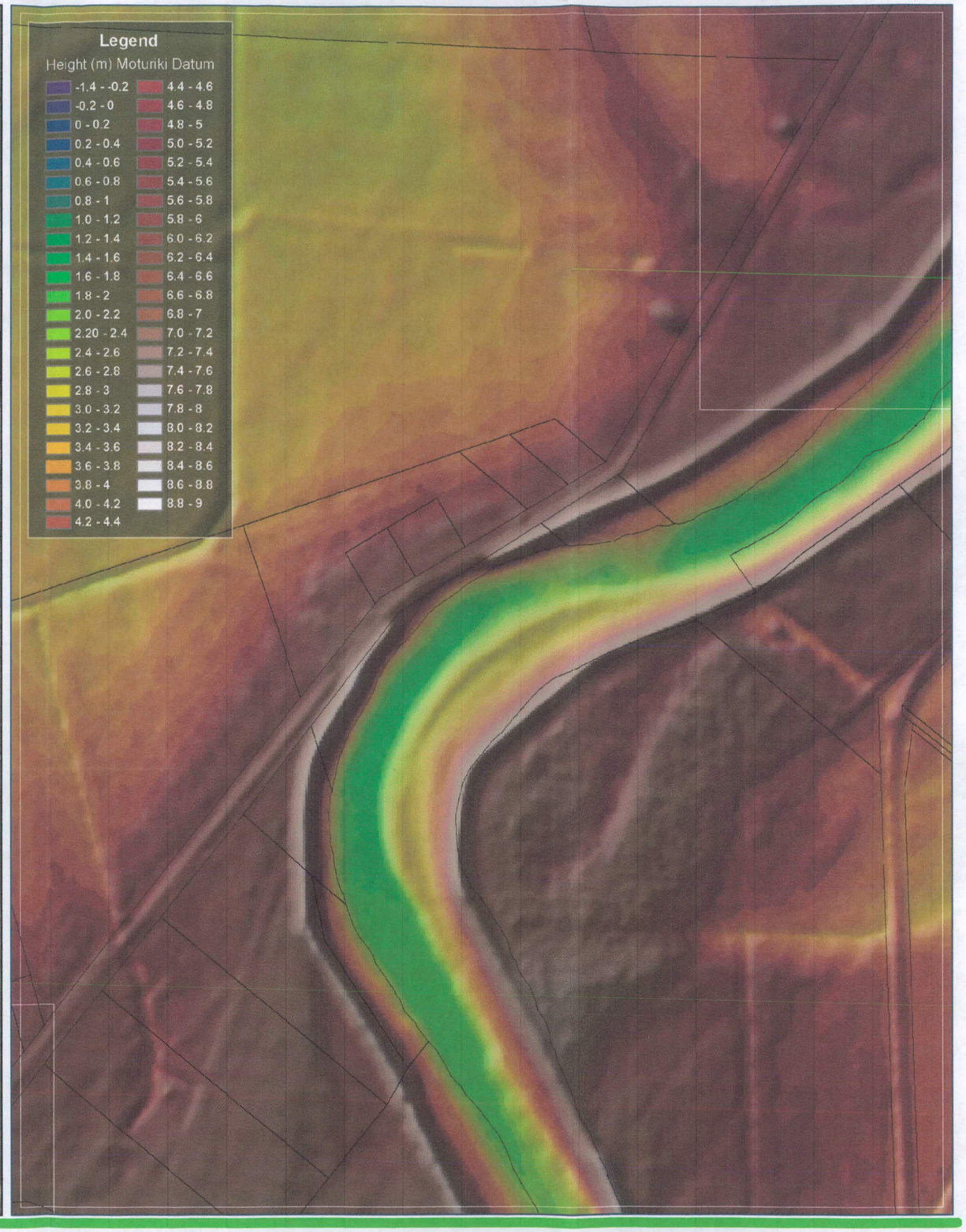
Appendix E

Campbell's Bend



Environment Bay of Plenty
REGIONAL COUNCIL

Rangitaiki River
Geotechnical Remedial Works

Campbells Corner

100 50 0 100 200 300 400
Meters
Scale = 1:4,000

Note: The DEM dataset is generated from LIDAR data captured in 2006.
The original LIDAR dataset has a verticle accuracy of 0.15m.
The DEM shown has a 2m cell size which as a consequence of some generalisation reduces the verticle accuracy to approximately 0.3m.

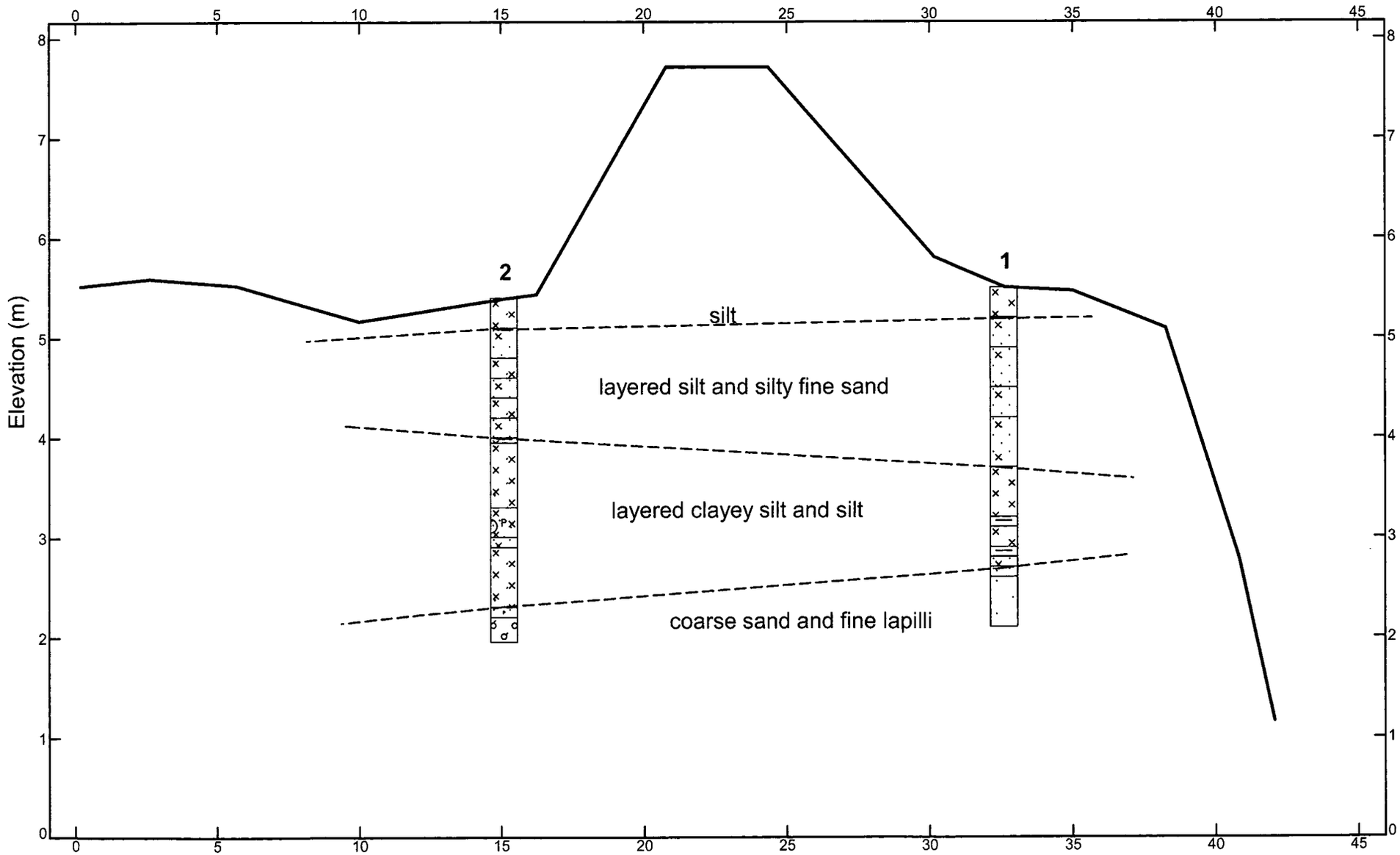
N

Map 3
c2367_Rangitaiki
July 09

Campbell's Bend

Project: Rangitiaki River Stopbanks
Client: EBoP
Location: Campbell's Bend
Number: 49A

Subsurface Cross Section 1 (400m)

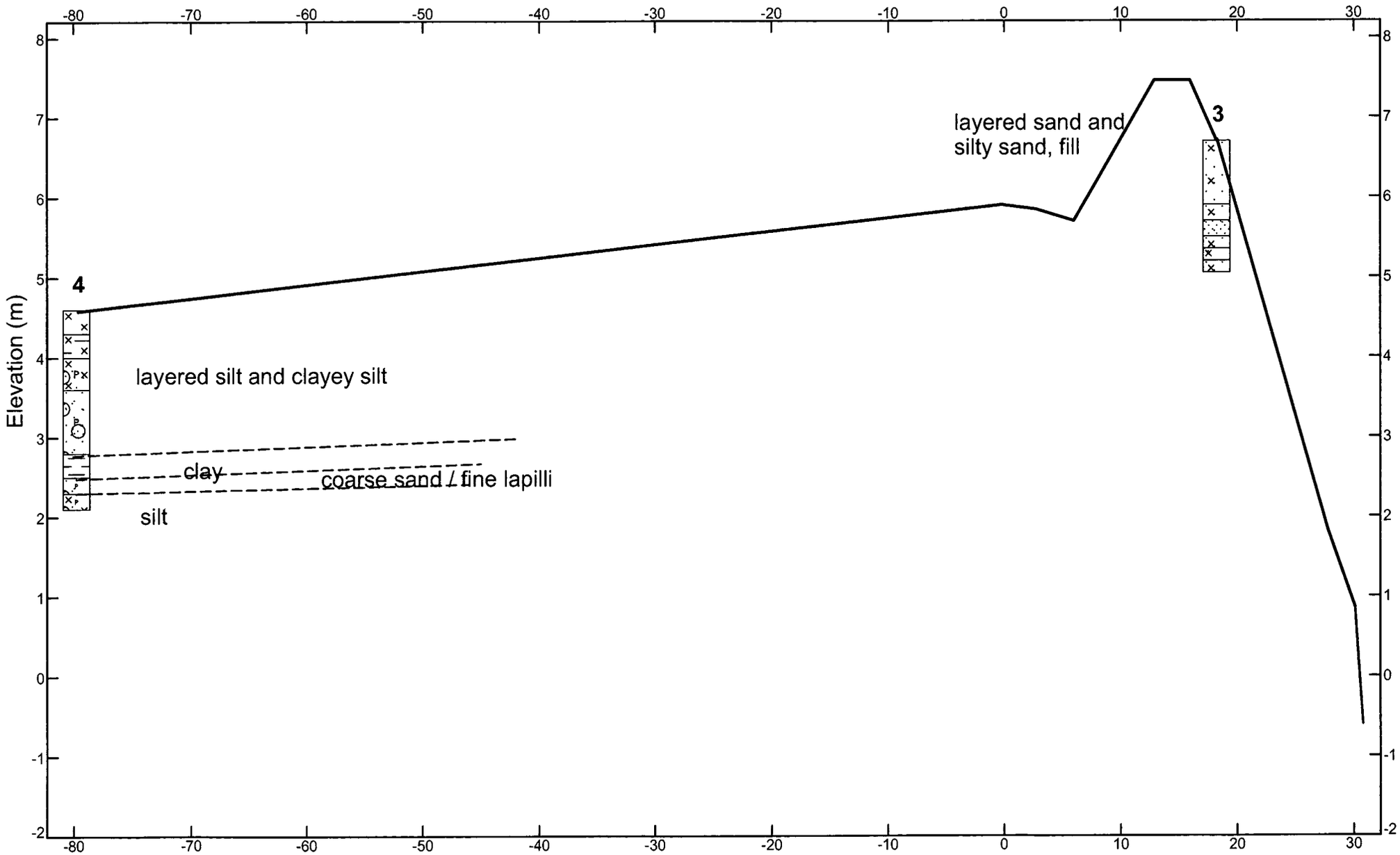


Ice Geo & Civil

October 2009

Project: Rangitiaki River Stopbanks
Client: EBoP
Location: Campbell's Bend
Number: 49A

Subsurface Cross Section 2 (300m)

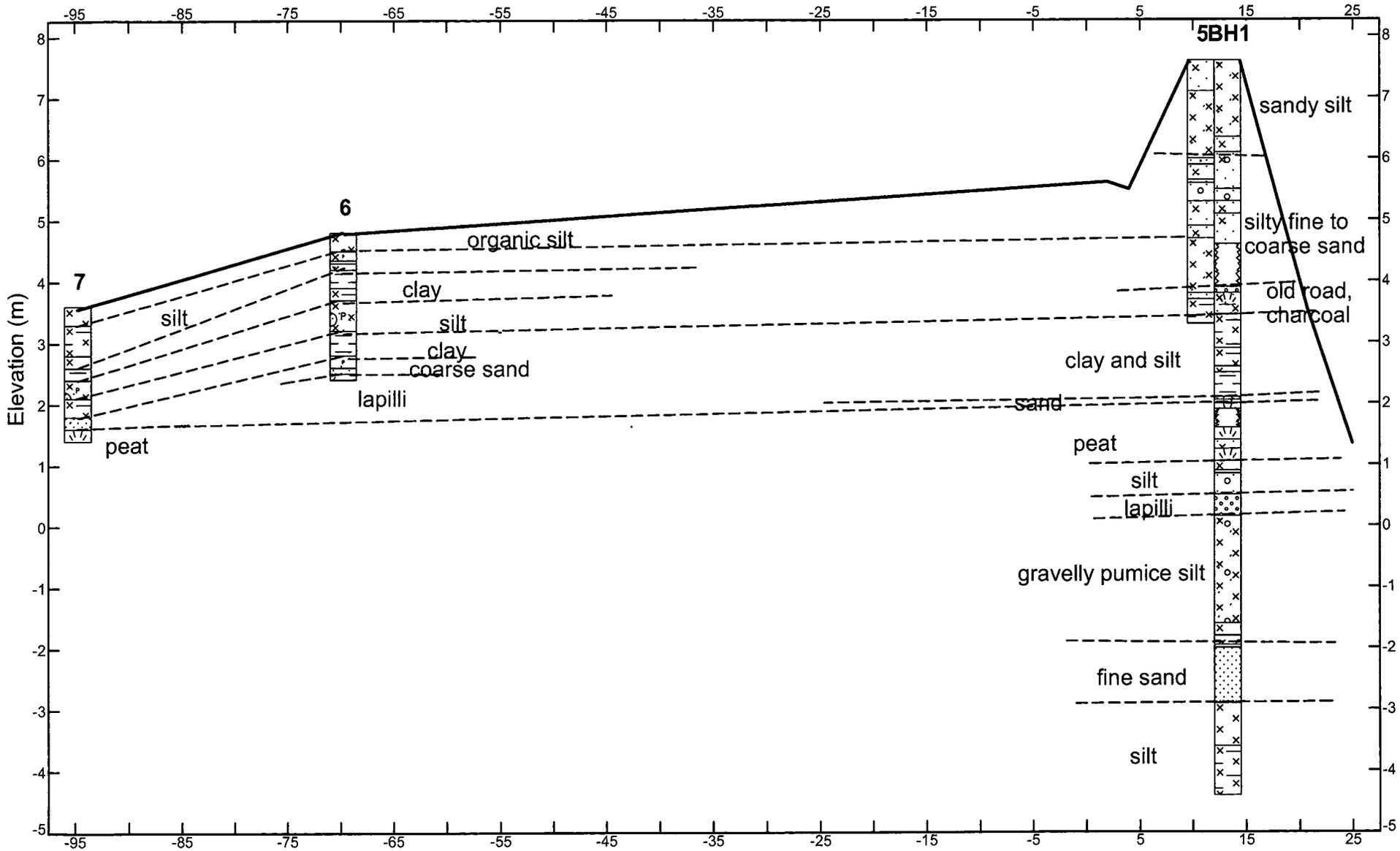


Ice Geo & Civil

October 2009

Project: Rangitiaki River Stopbanks
Client: EBoP
Location: Campbell's Bend
Number: 49A

Subsurface Cross Section 3 (250m)

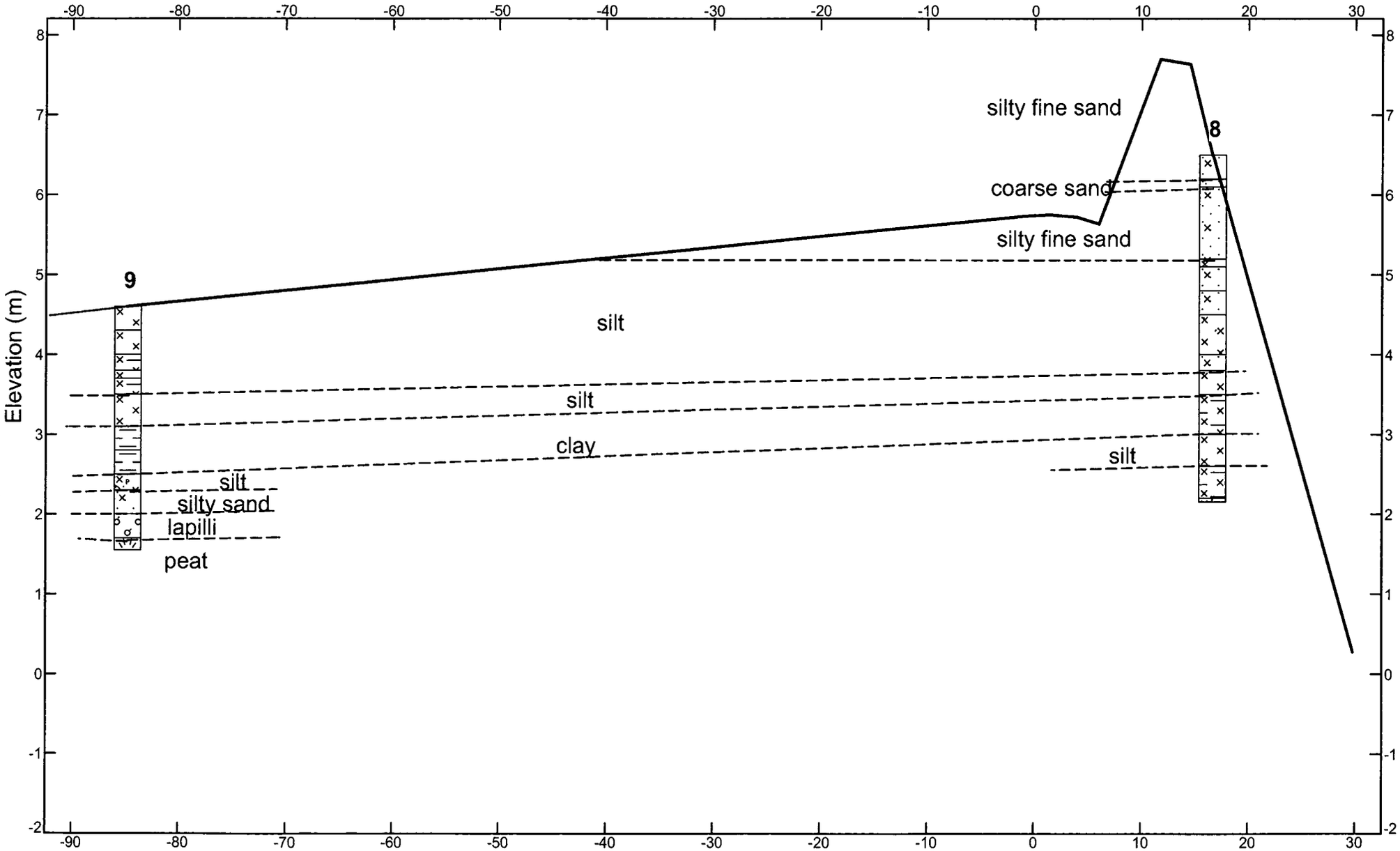


Ice Geo & Civil

February 2010

Project: Rangitiaki River Stopbanks
Client: EBoP
Location: Campbell's Bend
Number: 49A

Subsurface Cross Section 4 (200m)

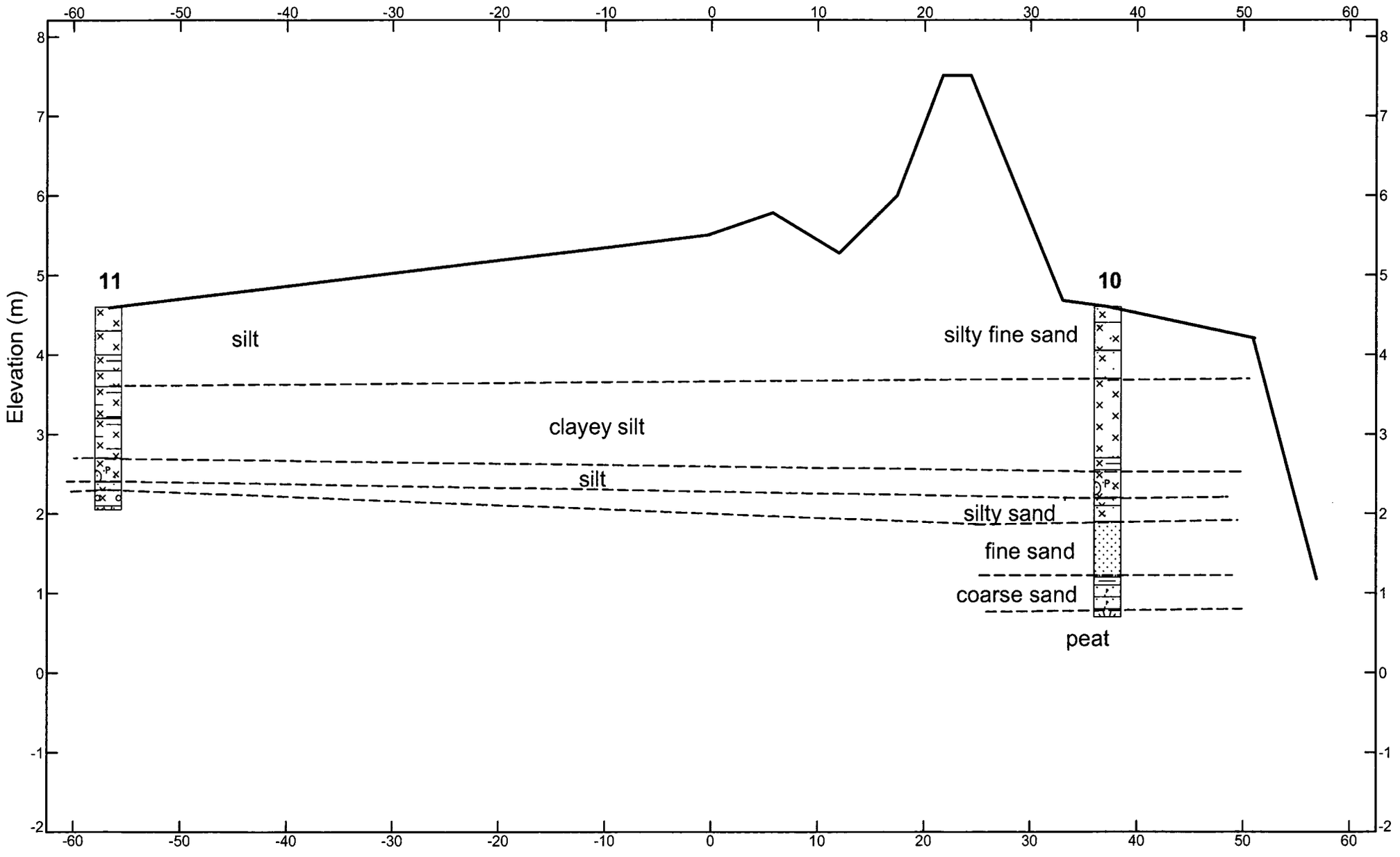


Ice Geo & Civil

October 2009

Project: Rangitiaki River Stopbanks
Client: EBoP
Location: Campbell's Bend
Number: 49A

Subsurface Cross Section 5 (100m)



Ice Geo & Civil

October 2009

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project:
Client: **EBoP**

Location: **Campbell's Bend**
Co-ordinates: East 13 North 0
Elevation: 7.6 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
0.00					fine **sandy SILT**, brown and grey, fill					
0.50										
1.00										
	6.35				**silty fine SAND**, brown / grey, dense, stiff					
1.50	6.10				**silty fine to coarse SAND** and fine gravel, brown / grey					
2.00										
	5.50				**gravelly** fine to coarse **SAND**, fine gravel, brown grey, loose					
	5.30				**silty fine SAND**, brown / grey					
2.50	5.10				**silty fine SAND**, brown / grey					
3.00	4.60				hard					
3.50										
	3.90				fine **GRAVEL**, washed out, old road?					
	3.80				fine **sandy SILT** with charcoal, black and brown					
4.00	3.45				**clayey SILT** with fine organic fibres, grey with orange staining, firm					
4.50										
	2.90				**clayey SILT** with organic fibres and rotten timber, brown and green grey					
5.00	2.60				pumiceous **SILT**, light grey brown, sensitive					
	2.50				**CLAY**, very plastic, green grey, firm 5.2m 20mm lapilli rich layer some charcoal fragments					
5.50	2.10				fine to medium **SAND**					
	2.05				fibrous **PEAT** (like particle board), black					
	2.00				timber					
	1.90				timber pushed through					
6.00	1.60				fibrous **PEAT** (like particle board), black, soft					
	1.40				**silty fine SAND**, grey, dense					
	1.25									
6.50										

Observations:

Vane no. Core Dia.	Rig: Contractor:	Date started: Date finished: Logged by: M. O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
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Project:
Client: **EBoP**

Location: **Campbell's Bend**
Co-ordinates: East 13 North 0
Elevation: 7.6 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
6.50	1.05				fibrous **PEAT** (like particle board), black					
	0.90				some pockets silty fine sand					
	0.85				pumiceous **SILT** with some pumice to 60mm, grey					
7.00					pumice **LAPILLI** to 2mm					
	0.50				fine **gravelly pumice SAND and lapilli** to 3mm, rare to 10mm, some charcoal fragments, grey					
	0.15				pumice **LAPILLI**, 1 to 10mm, some silt and charcoal					
7.50					pumiceous **gravelly sandy SILT**, pumice to 40mm, stiff					
8.00					hard drilling					
					charcoal to 30mm					
8.50					say 50% lapilli / 50% fines					
9.00										
	-1.60				pumiceous **SILT**, extremely sensitive, grey					
	-1.80				**silty fine LAPILLI** to 2mm, some charcoal, grey					
9.50	-1.95				**SILT**, extremely sensitive, white					
	-2.08				fine **SAND**, some silt, green grey					
10.00										
10.50	-2.90				**SILT** green grey, firm					
11.00										
	-3.60				**clayey SILT**, green grey, firm					
11.50										
12.00	-4.40				EOB					
12.50										
13.00										

Observations:

Vane no. Core Dia.	Rig: Contractor:	Date started: Date finished: Logged by: M. O'Halloran

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **1**

Elevation: 5.5
Date: 20/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **organic SILT**	
	5.2		brown **silty fine to medium SAND**, damp	
0.5	4.9		brown **silty fine SAND**, dense, damp	
1.0	4.5		brown **silty fine SAND / sandy SILT**, dense, damp	
	4.2		light brown / grey **silty fine pumiceous SAND**, damp	
1.5	3.7		orange stained grey **SILT**, moist	
2.0	3.2			
	3.1		orange stained grey **CLAY**, plastic, moist	
2.5			orange stained grey **SILT**, moist	
	2.9			
▼	2.8		orange stained light grey **CLAY**, plastic, moist	
	2.7		light grey **silty fine pumiceous SAND**, moist	
	2.6		grey medium to coarse **SAND**, wet	dis.
3.0			grey coarse SAND / fine lapilli to 1.5mm	dis.
	2.1			
3.5			EOB washing in	
4.0				
4.5				

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ICE GEO & CIVIL
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Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **2**

Elevation: 5.4
Date: 20/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown fine **sandy SILT**	
	5.1		brown **silty fine SAND**	
0.5	4.8		brown **fine sandy SILT**, damp	
	4.6		light brown **silty fine SAND**, damp	
1.0	4.4		brown **fine sandy SILT**, damp	
	4.2		orange stained grey **silty fine SAND**, moist	
	4			
1.5	3.95		orange stained grey **clayey SILT**, moist	
			orange stained grey **fine sandy SILT**, moist	
2.0				
	3.3		pinkish light grey with orange staining **pumiceous SILT**, damp, firm	
	3			
2.5	2.9		light grey **silty fine pumiceous SAND**	
			light grey fine sandy SILT, dilatant, wet	
3.0				
▼	2.3			
	2.2		grey clean **medium to coarse pumiceous SAND**	
			grey clean **pumice lapilli** 1 to 3mm	
3.5	1.95		EOB , washing in	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **3**

Elevation: 6.7
Date: 20/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **silty fine SAND**, some fine lapilli to 2mm, dense, damp	
			0.6m some rounded hard gravel to 5mm	
0.5				
	5.9		brown **silty well graded SAND** and some fine gravel, damp	
1.0	5.7		brown **fine to medium SAND**, some silt, damp	
	5.5		grey **silty fine SAND / sandy SILT**, dense, damp	
	5.35		grey **fine sandy SILT**, dense, damp	
1.5	5.2		brown **silty fine SAND**, dense, damp	
	5.05		EOB rock	
2.0				
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **4**

Elevation: 4.6
Date: 20/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	4.3		brown **organic SILT**, damp, firm	
0.5	4		grey **clayey SILT**, moist, plastic, firm	
			grey **pumiceous SILT**, some clay, moist, soft	
1.0	3.6		orange stained grey **pumiceous SILT**, wet	
1.5				
	2.8		greenish grey **CLAY** with organic content, soft	
2.0	2.5		light grey coarse **SAND**, fine lapilli to 1.5mm	
	2.3		grey pumiceous **SILT**	
2.5	2.1		EOB sand washing in	
3.0				
3.5				
4.0				
4.5				

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ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **5**

Elevation: 7.6
Date: 16/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **silty fine SAND**, dense, damp	
	7.1		brown grey **silty fine SAND / sandy SILT**, dense, damp	
1.0				
1.5				
	6			
	5.9		brown grey medium to coarse **pumiceous SAND**	
			brown **silty fine SAND**, dense, damp	
	5.65			
2.0	5.6		brown **silty gravelly medium to coarse SAND**, rounded hard gravel to 6mm dense, damp	
	5.3		brown **gravelly medium to coarse SAND**, rounded hard gravel to 6mm dense, damp	
2.5			brown **silty fine to medium SAND**, dense, damp	
	4.9		brown **silty fine SAND / fine sandy SILT**, dense, damp	
	4.7		brown **fine sandy SILT**, dense, damp	
3.0			3.5m moist	
3.5				
	3.8			
	3.7		orange stained grey **silty fine SAND**, moist, dense	
4.0			orange stained grey **clayey SILT**, moist	
	3.3		EOB	
4.5				

ICE GEO & CIVIL
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Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **6**

Elevation: 4.8
Date: 20/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **organic SILT**, damp, firm	
	4.5		0.2 gritty Tarawera Ash	
	4.35		orange stained grey **pumiceous SILT**, damp, firm	
0.5	4.3		grey **clayey SILT**, moist	
	4.2		grey fine **sandy SILT**, moist	
			brown grey **CLAY** with organic content, soft, plastic, damp	
	3.9		orange stained grey **clayey SILT**, moist	
1.0	3.7		orange stained grey **pumiceous SILT**, wet	
1.5	3.2		greenish grey **CLAY** with organic content, wet, soft	
2.0	2.8		light grey coarse **SAND**, fine lapilli to 1.5mm	
	2.6		grey **silty fine SAND**	
	2.5		pumice **LAPILLI** to 4mm	
	2.4		EOB sand washing in	
2.5				
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **7**

Elevation: 3.6
Date: 28/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	3.3		brown **organic SILT**, some clay, damp	
0.5			orange stained grey **clayey SILT**, damp	
	2.8		orange stained grey **SILT**	
1.0	2.6		orange stained grey **CLAY**, some organic material, plastic	
	2.4		light grey brown **pumiceous SILT**	
1.5	2.1		green grey **clayey SILT**, some organic material, plastic	
	1.8		grey speckled **fine to coarse SAND** and fine lapilli	
2.0	1.6		dark brown clayey organic material **PEAT**	
	1.4		EOB washing in losing sample	
2.5				
3.0				
3.5				
4.0				
4.5				

HAND AUGER HAND AUGERS.GPJ HAND AUGER BASIC.GDT 27/7/10

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **8**

Elevation: 6.5
Date: 16/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **silty fine SAND**, dense, damp	
	6.2			
	6.1		grey brown **medium to coarse SAND**, some fine sand and silt	
0.5			layers grey brown **silty fine SAND** and grey brown **medium to coarse SAND**, some fine sand and silt, dense, damp, bands approx 100mm thick	
1.0			0.9m rare rounded hard gravel to 6mm	
	5.2			
	5.1		brown fine **sandy SILT**, firm , moist	
1.5			brown **silty fine SAND**, rare hard angular gravel to 30mm, firm, moist	
	4.8		orange stained grey **silty fine SAND**, damp, dense	
2.0	4.5		dark brown fine **sandy SILT**, damp, dense	
2.5	4		brown **silty fine SAND / sandy SILT**, damp, dense	
	3.8		orange stained grey **SILT**, some clay, damp, dense	
3.0	3.5		orange stained grey **clayey SILT**, firm, plastic, damp	
3.5	3		orange stained grey **SILT**, moist	
	2.6			
4.0			orange stained grey **clayey SILT**, some fine roots, firm, plastic, moist	
	2.2			
	2.15		orange stained light pinkish grey **pum SILT**, sensitive, dilatant, firm	
4.5			EOB	

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **9**

Elevation: 4.6
Date: 28/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
			brown **organic SILT**, some clay, damp	
			0.25 gritty Tarawera Ash	
	4.3			
0.5			orange stained grey **SILT**, damp	
	4			
			orange stained grey **clayey SILT**, some organics, damp	
	3.8			
	3.7		orange stained grey **SILT**, damp	
1.0			orange stained grey **clayey SILT**, some organics, damp	
	3.5			
			orange stained grey **SILT**, damp	
1.5	3.1			
			orange stained grey **CLAY with organic material,** soft	
	2.8			
2.0			green grey **CLAY with organic material**, soft	
	2.5			
			light grey brown **pumiceous SILT**	
	2.3			
2.5			grey brown **silty fine to coarse SAND** and fine lapilli	
	2			
			fine **lapilli** ?	
	1.7			
3.0			dark brown fibrous **PEAT**	
	1.55			
			EOB losing sample	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **10**

Elevation: 4.6
Date: 16/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0	4.4		brown **silty fine SAND**, dry	
			brown fine **sandy SILT / silty fine SAND**, damp	
0.5	4.05		0.3 minor rounded hard gravel to 5mm	
			orange stained grey **silty fine SAND**, damp, dense	
	3.7			
1.0			orange stained grey **SILT**, some clay, damp, dense	
			1.1 moist	
1.5				
	2.7			
2.0	2.55		orange stained grey **clayey SILT**, plastic, firm, moist	
		P	orange stained light pinkish grey **pumiceous SILT**, sensitive, dilatant, firm	
	2.2		becoming grey	
2.5	2.1		grey **silty fine SAND**, wet	
	1.9		orange grey **silty medium to coarse SAND** and fine lapilli to 1mm, dense	
3.0			grey fine **SAND**, dense	
	1.2			
3.5	1.1		brown **organic CLAY**, soft, plastic	
	0.95	P	light grey medium **pumiceous SAND**	
	0.8	P	light grey coarse **pumiceous SAND**	
	0.7		**PEAT**, organic clay, some fibrous plant material, roots and timber	
4.0			EOB washing in	
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **11**

Elevation: 4.6
Date: 28/10/2009
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			brown **organic SILT**, some clay, thick Tarawera Ash at base, all ploughed up	
	4.3		orange stained grey **SILT**, trace fine sand, damp	
0.5	4		brown **clayey SILT**, damp, plastic	
	3.8		grey **SILT**	
1.0	3.6		orange stained grey **CLAY**, soft	
	3.2		orange stained grey **clayey SILT**	
1.5				
	2.7		light brown grey **pumiceous SILT**	
2.0	2.4			
	2.3		grey **silty fine SAND**	
			fine lapilli in silt matrix??	
2.5	2.1			
	2.05		grey **silty fine SAND/ sandy SILT** with organic material	
			EOB washing in	
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitiaki River Stopbanks**
Client: EBoP
Location: Campbell's Bend
Number: 49A

Test: **C1 10m from SB toe 60m U/S Campbell Hous**

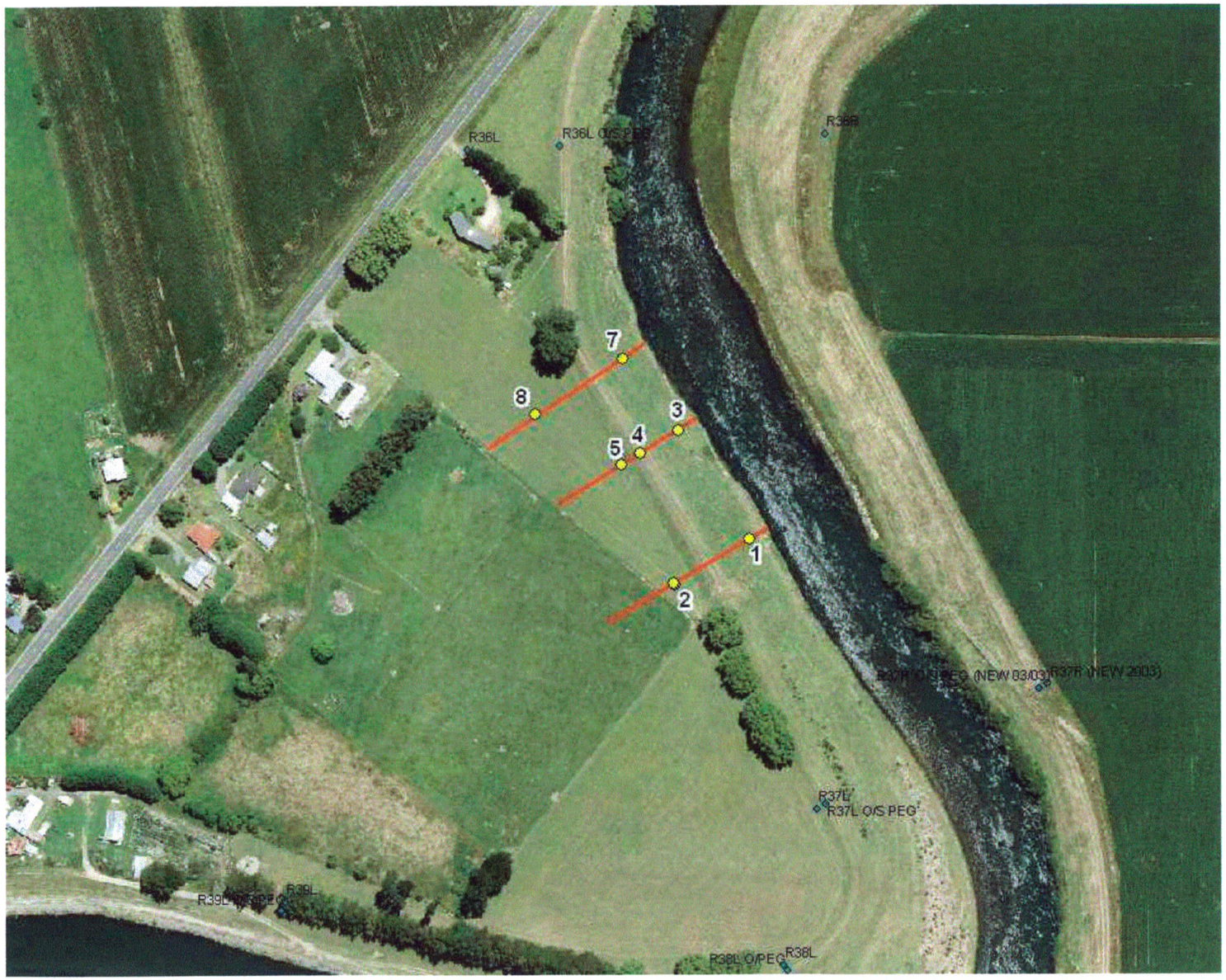
Elevation: 5.4
Date: 18/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, trace fine sand, dry, brown	
			0.15 some coarse balck sand, Tararwera Ash	
	5			
0.5			**silty fine SAND**, light fluffy, light brown/grey	
1.0				
	4.3			
			SILT, grey with orange mottles, damp	
1.5				
	3.7			
			silty fine SAND, grey	
2.0				
2.5				
3.0	2.4		**silty fine to medium SAND**, dense, moist, grey	
3.5	1.9		medium **SAND**, grey with orange staining	
4.0	1.4		fine to coarse **SAND / fine LAPILLI**, grey, some bands fine lapilli to 1mm, wet	
4.5	0.9		EOB washing in, black PEAT?	

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Appendix F

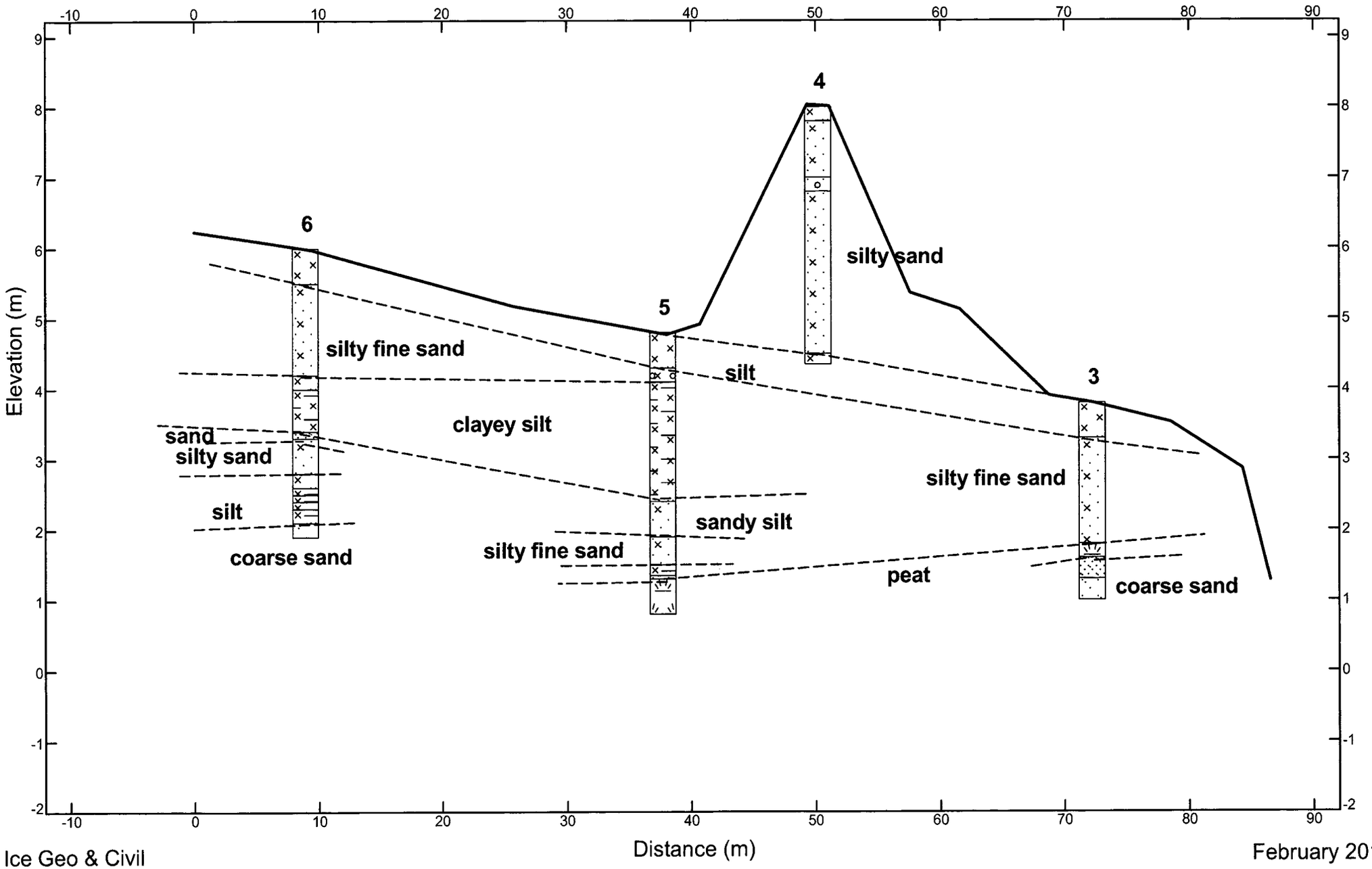
Campbell's Dip



Campbell's Dip Hand Augers

Project: Rangitaiki River
Client: EBoP
Location: Campbell's Dip
Number:

Subsurface Cross Section 2



Ice Geo & Civil

February 2010

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **1**

Elevation: 4.1
Date: 19/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**silty fine SAND**, brown, dry	
	3.8			
	3.7		**fine sandy SILT**, brown, dry	
0.5			**silty fine SAND**, grey with orange staining, damp, dense	
	3.5		**fine sandy SILT**, grey with orange staining,damp	
1.0				
	2.9		**silty fine SAND**, grey with orange staining, damp	
1.5				
	2.5		fibrous homogeneous **PEAT**, dark brown, moist	
2.0				
	1.9		fine to medium **SAND**, grey with orange staining	
2.5	1.6		medium **SAND**, grey speckled, moist	
	1.4		fibrous homogeneous **PEAT**, dark brown, moist	
3.0				
	0.85			
	0.8		**pumiceous SILT** with angular pumice gravel, grey, stiff	
3.5			EOB	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **2**

Elevation: 5.1
Date: 19/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry 0.3 some Tarawera Ash 0.7 rare hard rounded gravel to 10mm	
	4.3		fine **sandy SILT**, grey with orange staining	
	4		fine **silty SAND** , grey with orange staining, damp, light, fluffy	
	2.7		fine **sandy clayey SILT**, brown, moist	
	2.6		**silty fine SAND**, grey, moist	
	1.8		fine to medium **SAND**, some silt, grey speckled, wet	
	1.6		fibrous homogeneous **PEAT**, dark brown, moist	
	1.15		**pumiceous SILT** with angular pumice gravel, grey, stiff	
	1		EOB	

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

▼ 3.6

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **3**

Elevation: 3.8
Date: 19/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry	
0.5	3.3		**silty fine SAND**, brown, dry	
1.0				
1.5				
2.0	1.8		fibrous homogeneous **PEAT**, dark brown, moist	
	1.6		fine to medium **SAND**, grey, moist	
2.5	1.3		medium to coarse **SAND**, grey speckled, wet	
	1		EOB washing in	
3.0				
3.5				
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **4**

Elevation: 8.0
Date: 19/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	7.8		**SILT**, brown	
			silty fine to medium SAND, brown	
0.5				
1.0	7			
			fine **gravelly medium to coarse SAND**, brown	
	6.8			
			silty fine to medium SAND, brown	
1.5				
2.0				
2.5				
3.0				
3.5	4.5			
			SILT, brown, damp	
	4.35			
			EOB	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **5**

Elevation: 4.8
Date: 19/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry	
0.5	4.3		silty fine **GRAVEL / coarse SAND**, black, Tarawera Ash	
	4.1		fine **clayey SILT**, grey with orange staining, moist	
1.0				
1.5				
2.0				
	2.4			
2.5			fine **sandy SILT**, grey with orange staining, moist	
	1.9			
3.0			**silty fine SAND**, grey, moist	
	1.5			
			clayey SILT, some organic material, brown	
	1.35			
3.5	1.3		**silty fine SAND**, grey, moist	
			fibrous homogeneous **PEAT**, dark brown	
4.0	0.8			
			EOB	
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **6**

Elevation: 6
Date: 18/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry	
0.5	5.5		**silty fine SAND**, light brown, dry	
1.0				
1.5				
	4.2		**SILT**, light grey with brown staining	
2.0	4		**clayey SILT**, light grey with brown staining, plastic, moist	
2.5				
	3.4			
	3.3		fine to medium **SAND**, light grey	
			silty fine to medium SAND, light grey, moist	
3.0				
	2.8		**SILT**, some organic content, grey	
	2.6			
3.5	2.5		**clayey SILT**, green grey	
	2.4		pumiceous **clayey SILT**, light creamy grey, moist	
	2.3		pumiceous **SILT**, light creamy grey, moist	
			clayey SILT, green grey, plastic, moist	
▼	2.1			
4.0			coarse **SAND**, grey speckled, wet	
	1.9			
			EOB, washing in	
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **7**

Elevation: 4
Date: 22/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dense, dry	
0.5	3.5		**SILT**, grey with iron staining, dense, dry	
1.0	3.1		**silty fine SAND**, grey with orange staining, damp	
1.5	2.8		fine **sandy SILT**, brown, damp	
2.0	2.2		**silty fine SAND**, grey, moist	
2.5	1.2		**clayey SILT**, some organic material, brown, moist	
3.0	1		coarse **SAND** and fine **LAPILLI** to 1mm, some silt and timber, grey speckled, wet	
3.5	0.65		EOB washing in	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project: **Rangitaiki River**
Client: EBoP
Location: Campbell's Dip
Number:

Test: **8**

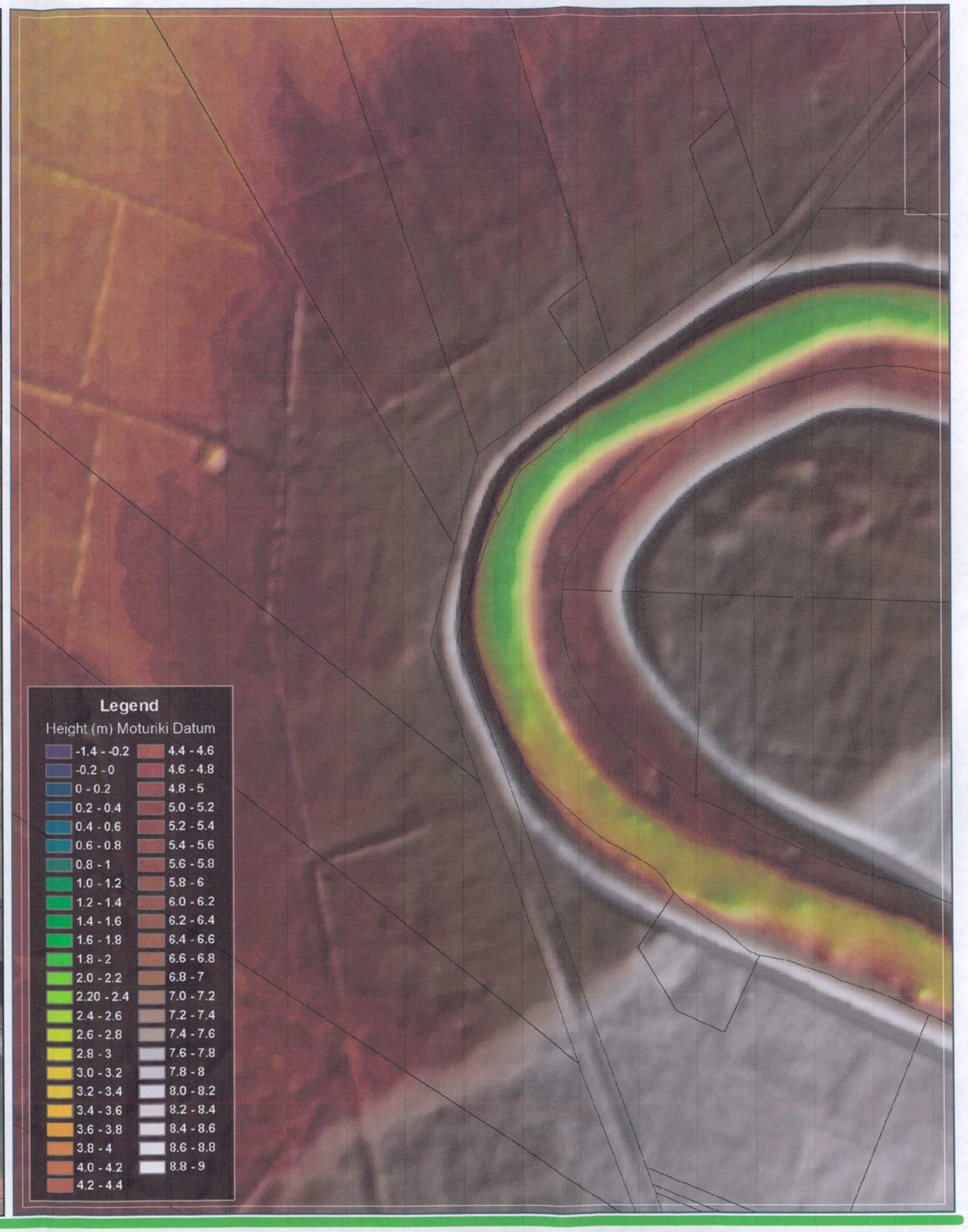
Elevation: 5.7
Date: 18/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, some Tarawera Ash grit, dry	
0.5	5.2		**silty fine SAND**, light brown, dry	
1.0				
1.5	4.2		fine **sandy SILT**, grey with orange staining, damp	
2.0	3.7		**clayey SILT**, grey with iron staining, damp, plastic	
	3.5		fine to medium **SAND**, some silt, light grey	
2.5	3.1		**silty** fine to medium **SAND**, light grey, moist	
	2.9		**clayey SILT**, some organic content, grey, plastic, organic smell, moist	
3.0	2.7		pumiceous **clayey SILT**, light creamy grey	
	2.6		**SILT**, some clay, blue grey, moist	
▼	2.4		coarse **SAND**, grey speckled, wet	
3.5	2.1		EOB, washing in	
4.0				
4.5				

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Appendix G

Kokohinau Bend



Environment Bay of Plenty
REGIONAL COUNCIL

Rangitaiki River
Geotechnical Remedial Works

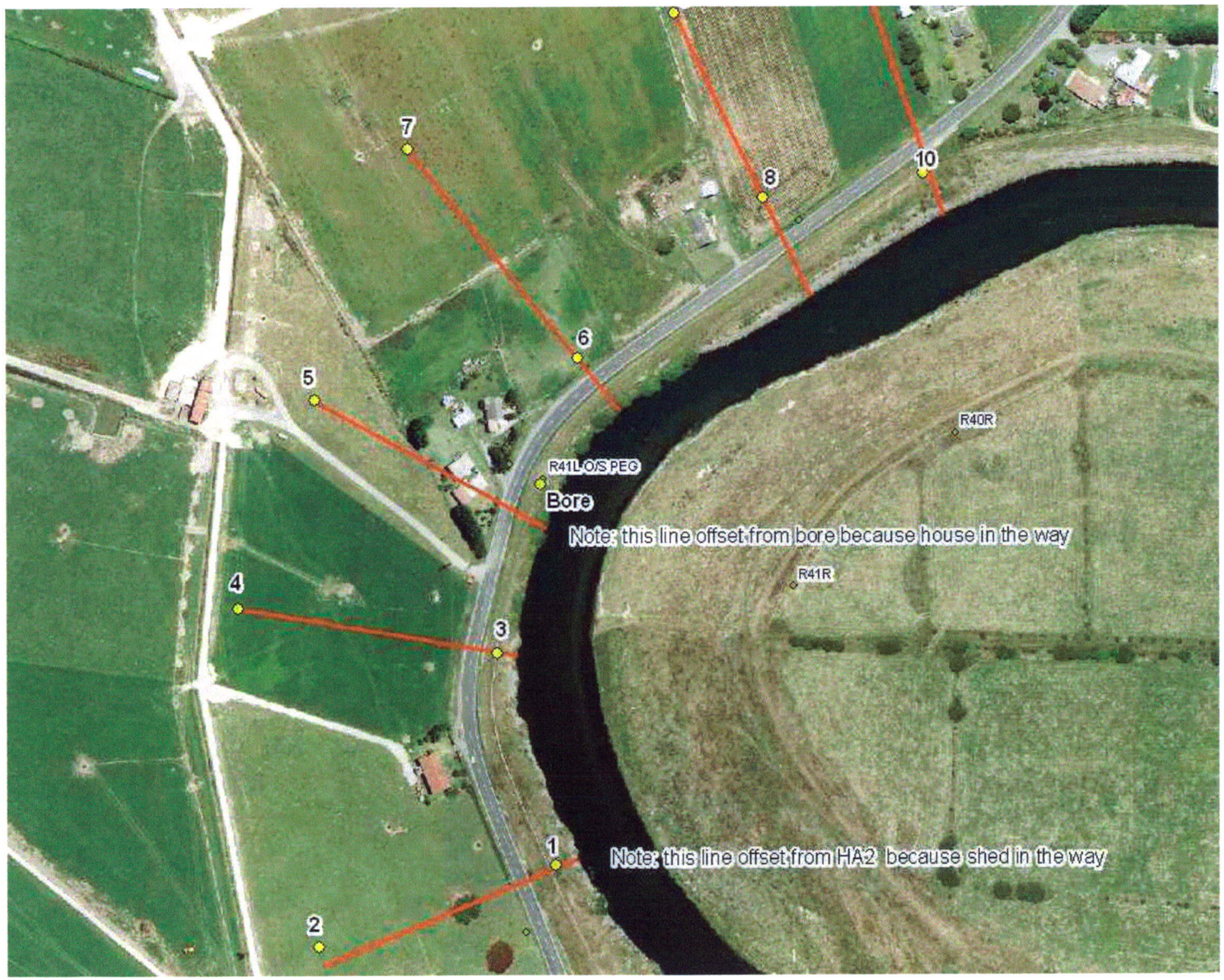
Kokohinau

100 50 0 100 200 300 400
Meters
Scale = 1:4,000

Note: The DEM dataset is generated from LIDAR data captured in 2006.
The original LIDAR dataset has a vertical accuracy of 0.15m.
The DEM shown has a 2m cell size which as a consequence of some generalisation reduces the vertical accuracy to approximately 0.3m.

N

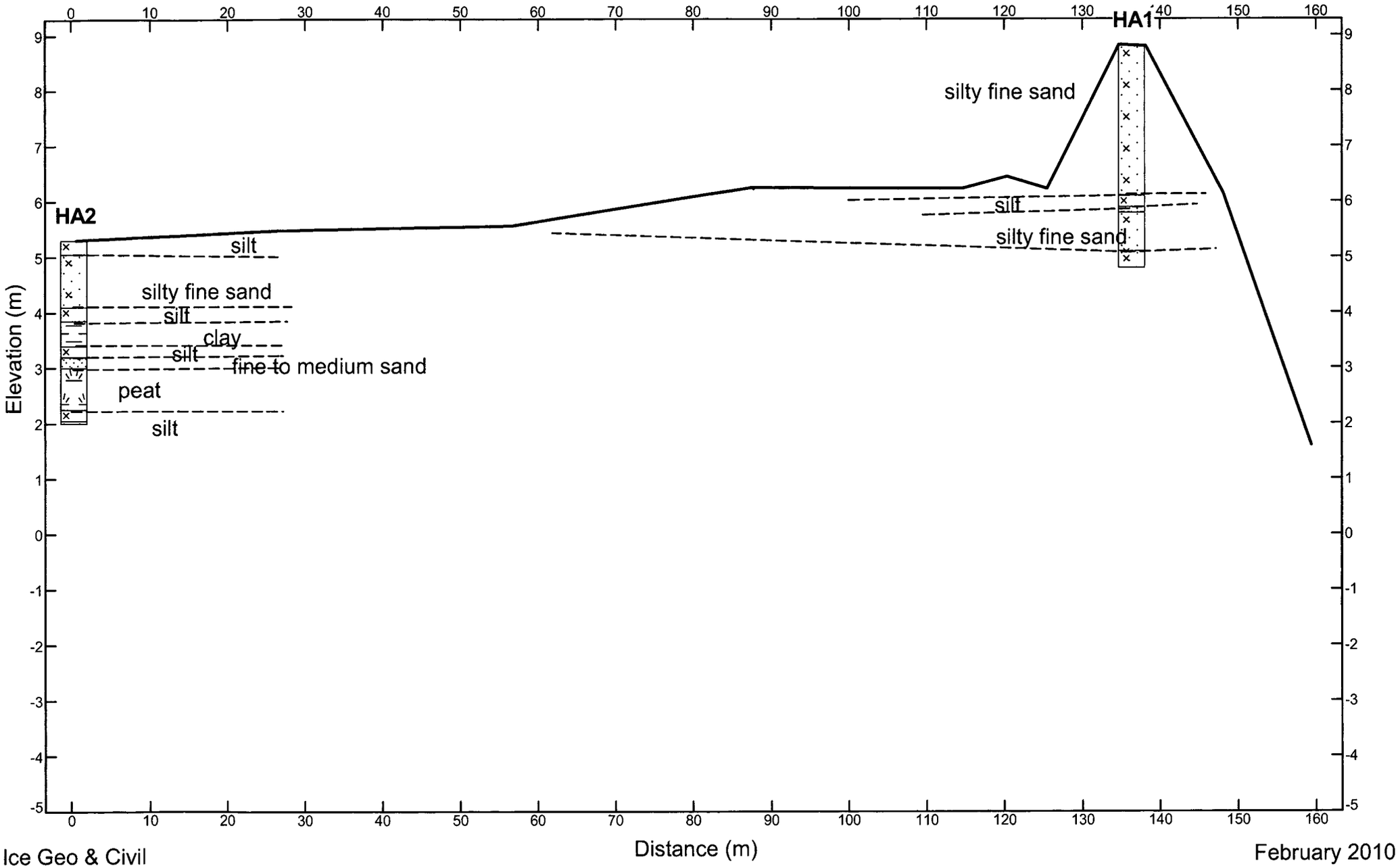
Map 2
c2367_Rangitaiki
July 09



Kokohinau Bend Hand Augers

Project: Rangitaiki River
Client: EBoP
Location: Kokohinau
Number:

Subsurface Cross Section 1

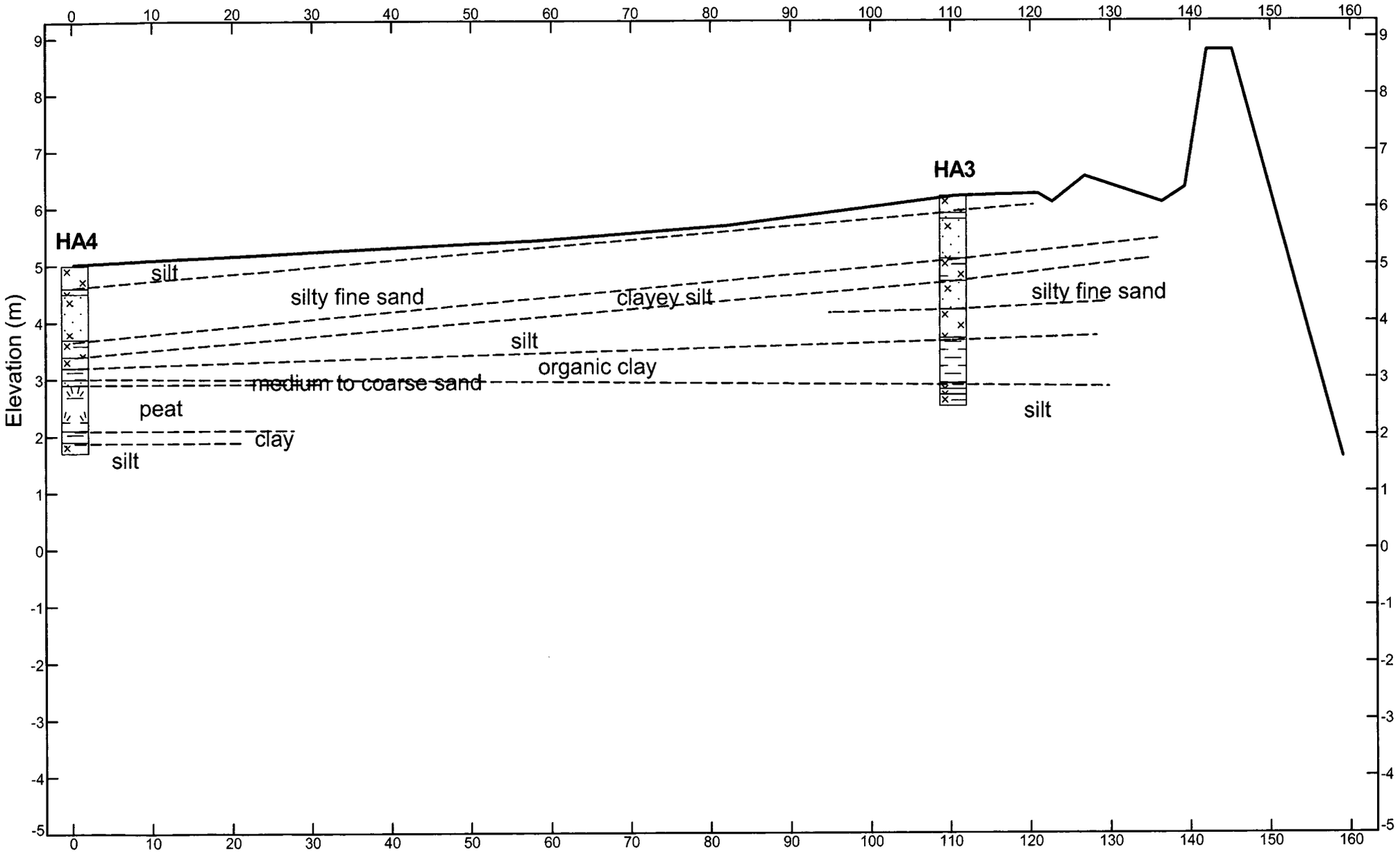


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBoP
Location: Kokohinau
Number:

Subsurface Cross Section 2

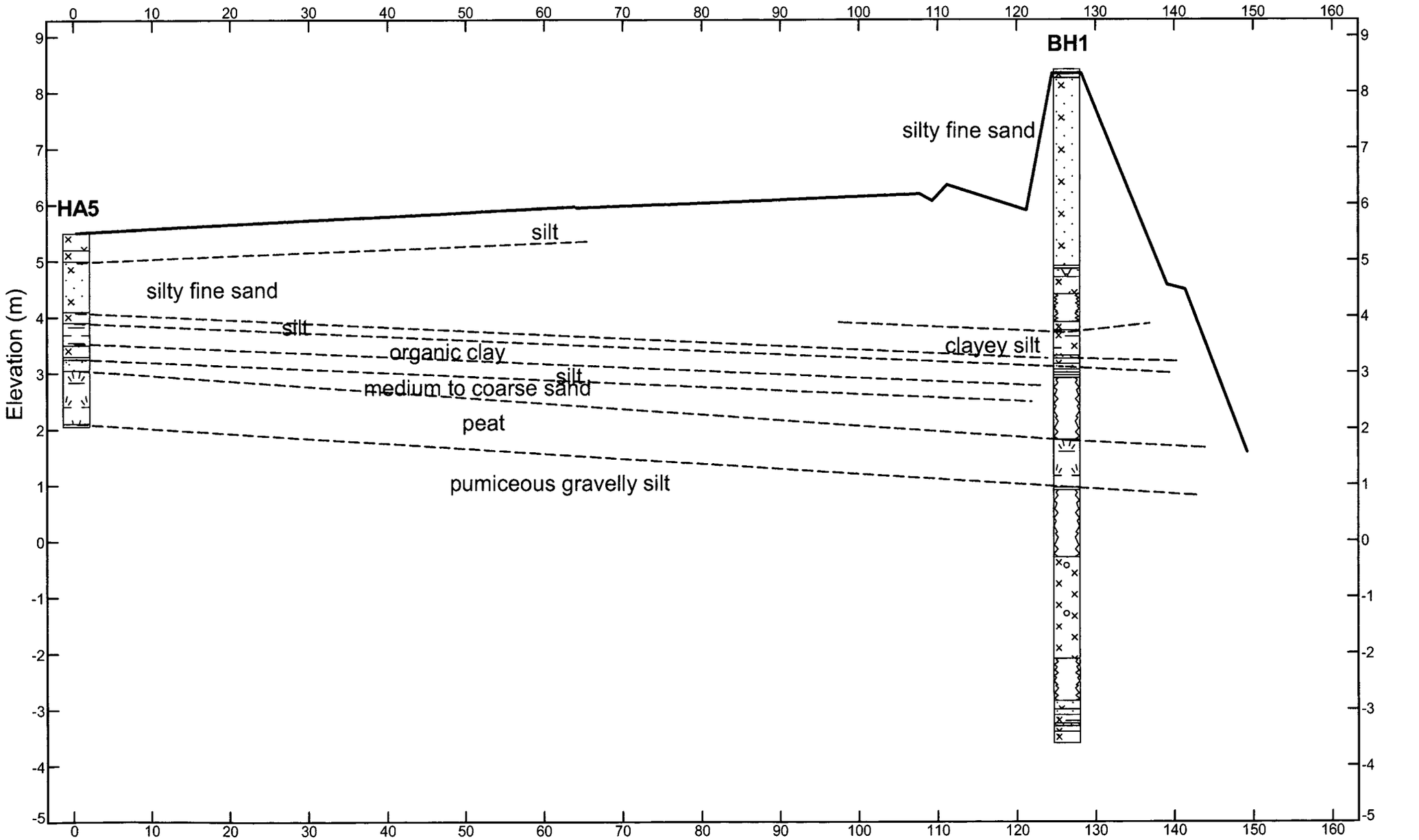


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBoP
Location: Kokohinau
Number:

Subsurface Cross Section 3

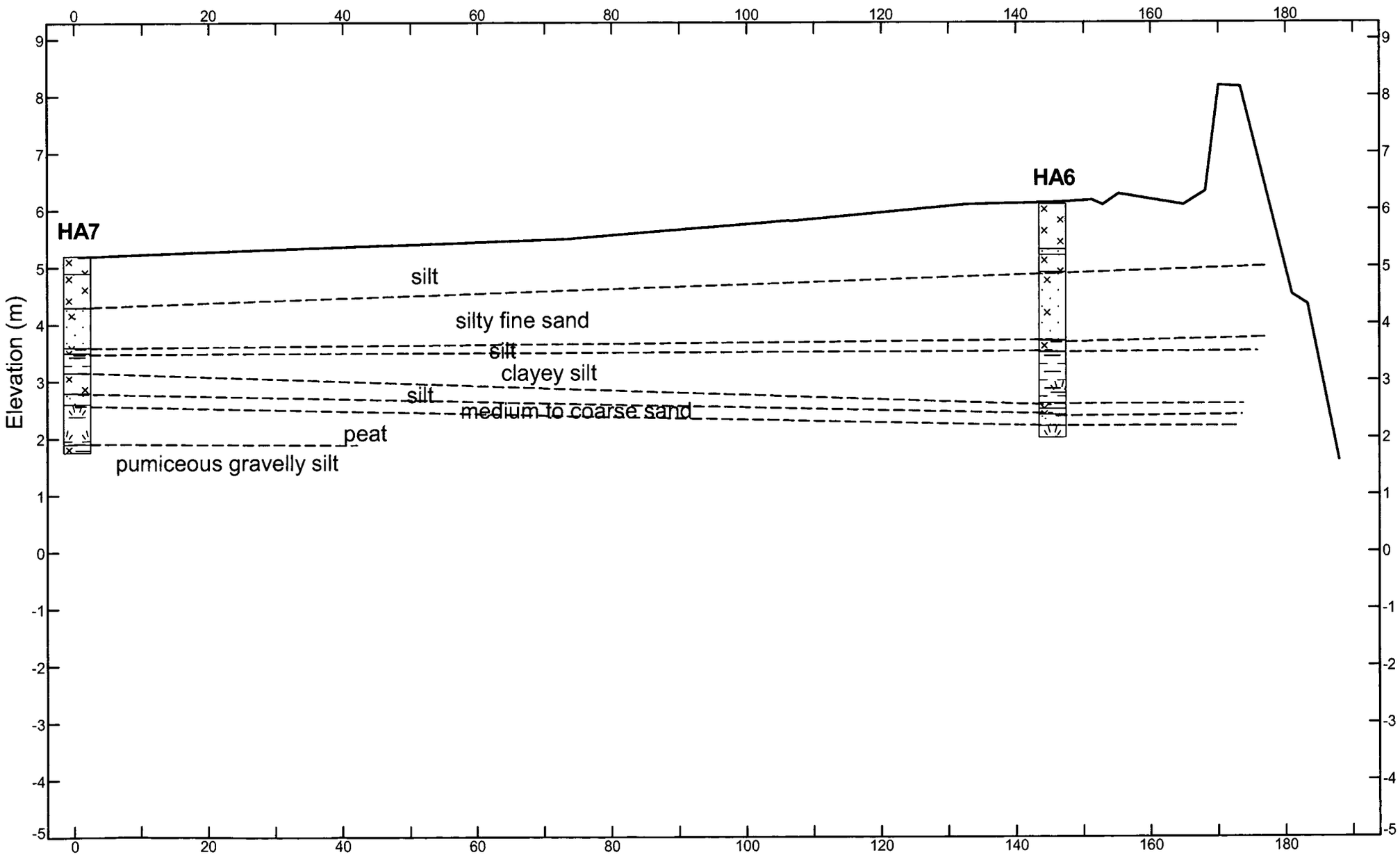


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBoP
Location: Kokohinau
Number:

Subsurface Cross Section 4

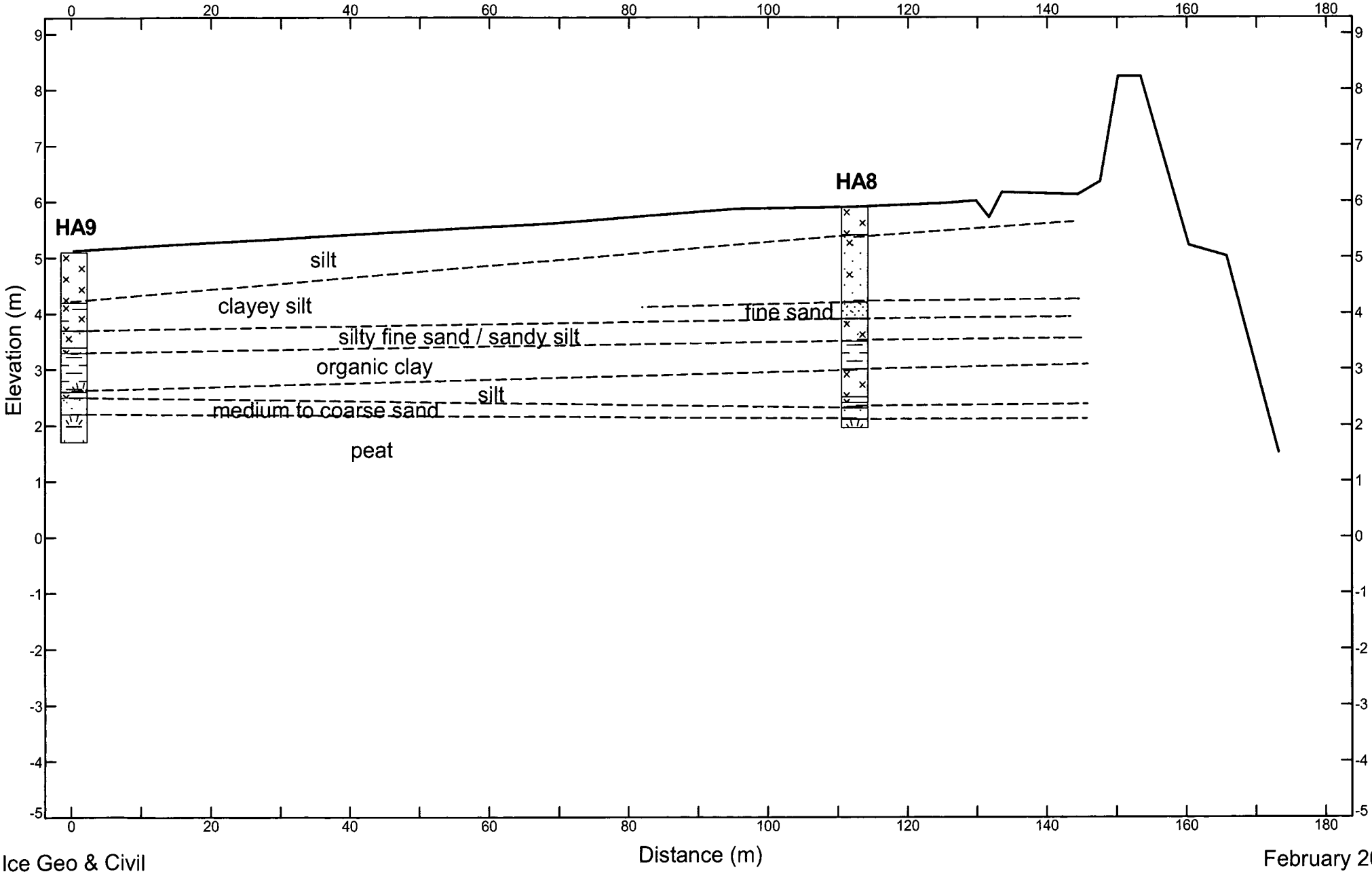


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBoP
Location: Kokohinau
Number:

Subsurface Cross Section 5

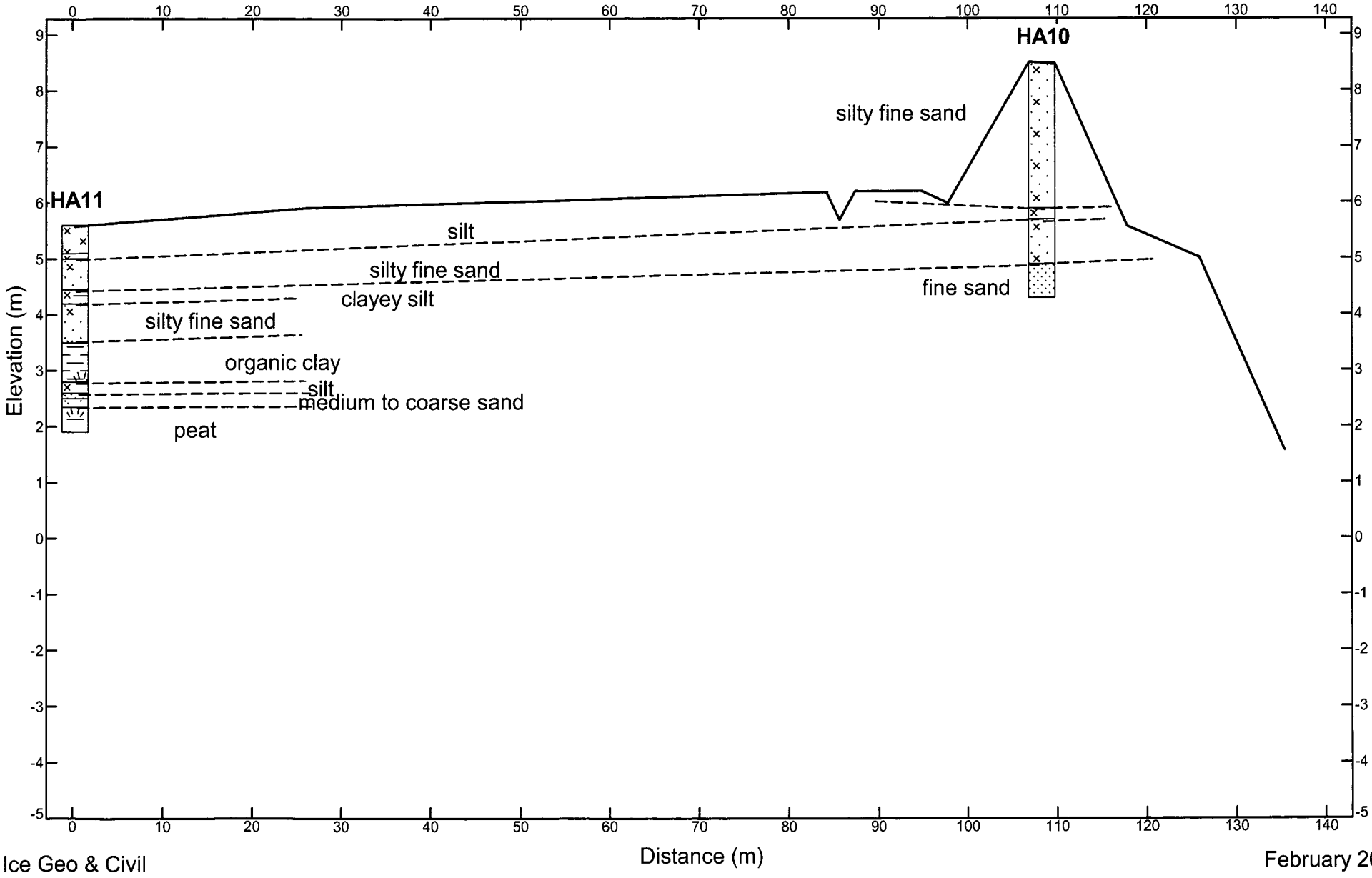


Ice Geo & Civil

February 2010

Project: Rangitaiki River
Client: EBoP
Location: Kokohinau
Number:

Subsurface Cross Section 6



Ice Geo & Civil

February 2010

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project:
Client: **EBoP**

Location: **Kokohinau**
Co-ordinates: East 126 North 0
Elevation: 8.4 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
0.00	8.25				fine **sandy SILT**, brown, topsoil					
					silty fine SAND, some hard rounded gravel to 3mm and lapilli to 3mm, brown / grey, firm to stiff, fill					
0.50					0.4m 100mm piece pumice	0.75				
1.00										
1.50					1.8m 50mm piece charcoal					
2.00					2.5m 200mm black staining, oil					
						2.25				
2.50										
3.00										
3.50	4.90									
	4.86				fine **sandy SILT**, black					
	4.70				rhyolite **rock**					
4.00	4.40				fine **sandy SILT**, light grey and brown marbled, mdeium to firm, liquefiable					
4.50	3.90									
	3.75				fine **sandy SILT**, light grey and brown marbled, mdeium to firm, liquefiable					
5.00					**clayey SILT**, some rotten timber and organic material, grey, soft					
	3.30									
	3.25				fine to medium pumice **SAND**, some silt, orange stained					
	3.15									
	3.05				**clayey SILT**, some rotten timber and organic material, grey, soft					
5.50	3.00									
	2.95				pumiceous **silty fine SAND / sandy SILT**, light greenish grey, firm					
	2.90									
6.00					rotten **timber** with insect droppings, black					
					pumiceous **SILT**, creamy light grey, stiff, sensitive					
					organic CLAY, brown					
6.50					fine to medium pumice **SAND**, grey ??					

Observations:

Vane no.
Core Dia.

Rig:
Contractor:

Date started:
Date finished:
Logged by: M. O'Halloran

Bore Hole Log

Borehole: BH1

ICE GEO & CIVIL
A division of ICE CONSTRUCTION LTD

Project:
Client: **EBoP**

Location: **Kokohinau**
Co-ordinates: East 126 North 0
Elevation: 8.4 Datum:

depth (m)	elevation (m)	recovery (m)	graphic log	Classification	description	samp depth (m)	sample type	SPT result	Vane result (kPa)	other
6.50	1.80				fibrous **PEAT**, (like rotten particle board), some roots, black, medium strength					
7.00										
7.50	0.95 0.90				pumiceous **gravelly SILT**, hard angular pumice to 15mm, grey, firm to stiff					
8.00										
8.50	-0.30				pumiceous **gravelly SILT**, hard angular pumice to 15mm, grey, firm to stiff 8.8m 150mm piece rotten timber					
9.00										
9.50					9.8m some silt bands, some brown stained bands, very senstive					
10.00										
10.50	-2.10				10.3m pumice rich layer					
11.00										
	-2.85				**silty fine SAND**, grey					
	-3.00				**silty fine SAND**, some fine roots, green grey					
11.50	-3.10				fine **sandy clayey SILT**, some roots, green grey					
	-3.25				fine to medium **pumiceous SAND**, some silt, green grey					
	-3.30				**clayey SILT**, green grey, firm					
	-3.40				fine **sandy SILT**, some clay, green grey, firm					
12.00	-3.60				EOB					
12.50										
13.00										

Observations:

Vane no. Core Dia.	Rig: Contractor:	Date started: Date finished: Logged by: M. O'Halloran

Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA1**

Elevation: 8.8
Date: 26/04/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**silty fine SAND**, some fine lapilli and gravel, dense, brown, dry	
1.5			1.5m some coarse sand	
	6.1		**SILT**, damp, brown	
3.0	5.9 5.8		**silty fine SAND**, damp, grey **silty fine SAND**, black (topsoil) with charcoal, loose	
	5.1		**silty fine SAND**, pumiceous, light, grey with orange staining, damp	
4.0	4.8		EOB	
4.5				

HAND AUGER HAND AUGERS.GPJ HAND AUGER BASIC.GDT 27/7/10

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA10**

Elevation: 8.5
Date: 26/04/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**silty fine SAND**, some fine pumice lapilli to 1.5mm, rare hard gravel to 20mm, dry, dense	
2.5	5.9		fine **sandy SILT**, dark brown, damp	
	5.7		**silty fine SAND**, some fine charcoal, brown and grey, damp	
3.5	4.9		fine **SAND**, some silt, pumiceous, light grey with orange staining, light, damp	
	4.3		EOB	

0.5 1.0 1.5 2.0 3.0 4.0 4.5

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA11**

Elevation: 5.6
Date: 22/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dense, dry	
	5.1			
0.5	5		**organic SILT**, dark brown, damp	
			silty fine SAND, grey with orange staining, light, fluffy, dry	
1.0				
	4.45		**clayey SILT**, grey with Fe staining, damp	
	4.2			
1.5			**silty fine SAND**, rare pumice lapilli to 1mm, grey with Fe staining, light, fluffy, dry	
			1.8m moist	
2.0				
	3.5		**CLAY** with some fine timber/roots, grey, plastic, soft, moist	
2.5			2.25 clay becoming brown with fibrous peat material	
	2.8		**SILT**, pumiceous, light creamy grey, moist	
3.0	2.6			
	2.5		fine to medium **SAND**, some silt, grey, wet	
			medium to coarse **SAND**, grey, wet	
	2.35		**PEAT**, fibrous, dark brown	
3.5				
	1.9		EOB timber	
4.0				
4.5				

HAND AUGER HAND AUGERS.GPJ HAND AUGER BASIC.GDT 27/7/10

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA2**

Elevation: 5.3
Date: 22/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry 0.05 some Tarawera Ash grit	
	5.05		**silty fine SAND**, some clay, grey with orange staining, damp	
0.5				
1.0				
	4.1		**SILT**, grey with orange staining, damp	
1.5	3.85		**CLAY**, some organic material, grey	
	3.4		**SILT**, pumiceous, creamy brown grey, moist	
2.0	3.2		fine to medium **SAND**, some silt, grey, wet	
	3		**PEAT**, fibrous, dark brown, dense	
2.5				
3.0				
	2.25		**SILT**, pumiceous, some timber, rare pumice to 10mm, grey, firm	
	2.05		**silty fine SAND**, grey, dense	
	2		EOB	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA3**

Elevation: 6.2
Date: 22/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry	
	5.9			
	5.8		coarse **SAND**, grey, dry	
0.5			**silty fine SAND**, slight fluffy, light brown, dry	
1.0				
	5.1		**clayey SILT**, brown, plastic, moist	
1.5	4.7		**silty fine SAND**, light, fluffy, light brown	
2.0	4.2		**SILT**, grey, moist	
2.5	3.7		**CLAY** with organic fibres, brown and grey, very soft, moist	
3.0				
	2.9			
	2.8		**SILT**, grey, moist	
3.5	2.7		**SILT**, pumiceous, light creamy brown grey, moist	
			clayey SILT and timber, brown and grey, moist	
	2.5		UTP timber	
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA4**

Elevation: 5.0
Date: 22/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry	
	4.6			
0.5	4.5		**clayey SILT**, grey with orange staining, damp	
			silty fine SAND, light, fluffy, grey, dry	
1.0				
	3.7		**clayey SILT**, brown and grey	
1.5				
	3.4		**SILT**, pumiceous, light creamy grey brown	
	3.2		**organic CLAY**, some fine organic fibres, brown and grey, plastic, moist, soft	
2.0	3		medium to coarse **SAND**, pumiceous, grey	
	2.9		**PEAT** fibrous and clayey, dark brown	
2.5				
	2.1			
3.0			**CLAY**, greenish grey, soft	
	1.9		**SILT**, pumiceous and fine lapilli to 1mm, bands fine sand, grey, dense	
	1.7		EOB	
3.5				
4.0				
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA5**

Elevation: 5.5
Date: 29/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, dry	
	5.2		**SILT** grey, dry	
0.5	5		**silty fine SAND**, grey, light, fluffy, dry	
1.0				
	4.1		**SILT**, grey, moist	
1.5	3.9		**organic CLAY**, some organic fibres, brown, plastic, soft, moist	
2.0	3.5		**SILT**, pumiceous, creamy brown, moist	
	3.3		**clayey SILT** with organic fibres, grey and brown, moist	
	3.25		medium to coarse **SAND**, pumiceous, grey, moist	
2.5	3.05		fibrous **PEAT**, timber, dark brown, moist	
3.0				
	2.1			
3.5	2.05		**SILT** with pumice pieces to 10mm, grey	
			EOB	
4.0				
4.5				

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Sheet 1 of 1

HAND AUGER HAND AUGERS.GPJ HAND AUGER BASIC.GDT 27/7/10

Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA6**

Elevation: 6.1
Date: 29/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, some grit, brown, dry	
	5.3			
	5.2		**silty fine SAND**, orange stained grey , dry	
1.0			**SILT** with angular pumice to 20mm, brown, moist	
	4.9		**silty fine SAND**, orange stained grey , moist	
2.5	3.7		**SILT**, brown, moist	
	3.5		**organic CLAY**, some fibrous material, brown, plastic, moist, soft	
3.5	2.6			
	2.5		**SILT**, pumiceous, creamy brown, moist	
	2.4		**clayey SILT**, brown, moist	
			medium to coarse **SAND**, pumiceous, grey, wet	
4.0	2.2		**PEAT**, fibrous, dark brown	
	2		EOB	
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA7**

Elevation: 5.2
Date: 29/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0				
	4.9		**SILT**, brown, dry	
0.5			**SILT**, orange stained grey, dry	
	4.3			
1.0			**silty fine SAND**, light grey, dry	
1.5				
	3.6			
	3.5		**SILT**, grey, moist	
2.0			**CLAY and fibrous organic material**, brown and grey, plastic, soft, moist	
	3.15		**SILT**, pumiceous,	
2.5	2.8		medium to coarse **SAND**, some silt, pumiceous, grey, wet	
	2.6		**PEAT**, fibrous, dark brown, moist	
3.0				
	1.9		**clayey SILT** with pumice to 10mm, grey, wet	
3.5	1.75		EOB	
4.0				
4.5				

HAND AUGER HAND AUGERS.GPJ HAND AUGER BASIC.GDT 27/7/10

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA8**

Elevation: 5.9
Date: 29/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT,** brown, damp	
0.5	5.4		**silty fine SAND**, brown, damp	
1.0				
1.5				
	4.2		fine **SAND**, some silt, grey with Fe staining, damp	
2.0	3.9		fine **sandy SILT**, grey, moist	
	3.5		**organic CLAY**, some fibrous organic material and roots, brown and some grey, moist	
2.5				
	3		**SILT**, grey, moist	
3.0				
	2.5		**SILT**, pumiceous, creamy grey brown, moist	
3.5	2.4		**organic CLAY**, some fibrous organic material and roots, brown and some grey, moist	
	2.3		medium **SAND**, grey, wet	
	2.1		**PEAT** fibrous, dark brown	
4.0	1.95		EOB washing in, grey silt?	
4.5				

ICE GEO & CIVIL
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Project: **Rangitaiki River**
Client: EBoP
Location: Kokohinau
Number:

Test: **HA9**

Elevation: 5.1
Date: 29/03/2010
Logged by: M. O'Halloran

Depth (m)	Elev(m)	Graphic Log	Description	Sample
0.0			**SILT**, brown, damp	
0.5				
1.0	4.2		**clayey SILT**, grey with Fe staining, damp to moist	
1.5	3.7		**silty fine SAND**, grey with FE staining, damp, light, fluffy	
	3.4			
	3.3		fine **sandy SILT**, grey, moist	
2.0			**organic CLAY**, some fibrous organic material and roots, brown and some grey, moist	
2.5	2.6			
	2.5		**SILT**, pumiceous, creamy grey brown, moist	
			medium to coarse **SAND**, grey, wet	
3.0	2.2		**PEAT**, fibrous, dark brown	
	1.7			
3.5			EOB washing in	
4.0				
4.5				

ICE GEO & CIVIL
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Appendix H

Particle Gradings

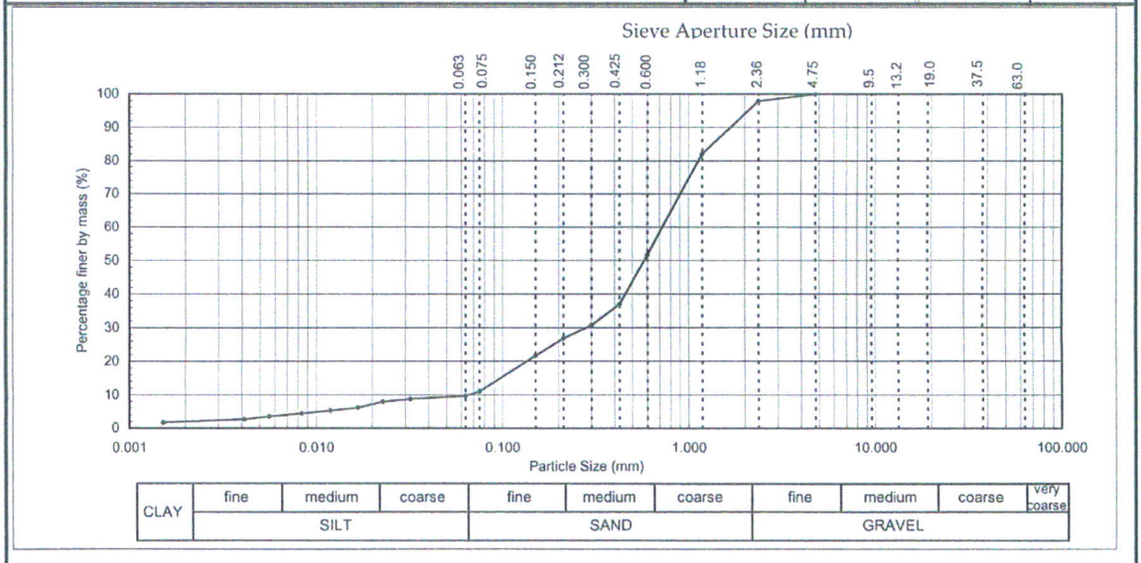
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

TEST REPORT

Project :	**Stopbanks**
Location :	**Unknown**
Client :	**Ice Construction Ltd**
Client/Sample Ref :	**Campbell**
Contractor :	**N/A**
Borehole No:	**1** Depth: **2.90 Metres**
Sampled by :	**Marrianne O'Halloran (Ice Construction Ltd)**
Date received :	**13 November 2009**
Sampling method :	**Unknown**
Sample condition :	**Natural State**
Sample description :	**Slightly Gravelly SAND, minor Silt, trace of Clay**
Solid Particle Density (t/m^3):	**2.40** **(assumed)**
Water Content (as received):	**43.6** **%**

Project No:	**255549.00/0TL**
Lab Ref No:	**09/637A**
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	31	0.0319	9	0.0041	3
37.5	--	2.36	98	0.212	27	0.0227	8	0.0015	2
19.0	--	1.18	82	0.150	22	0.0167	6	--	--
13.2	--	0.600	52	0.075	11	0.0118	5	--	--
9.5	--	0.425	37	0.063	10	0.0083	4	--	--
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0056	4		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.5 (Whatmans Full Range pH Indicator paper)

Date Tested: 27 November 2009

Date Reported: 2 December 2009

IANZ Approved Signatory

Designation : *Senior Civil Engineering Technician*

Date : 2 December 2009

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

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Website www.opus.co.nz

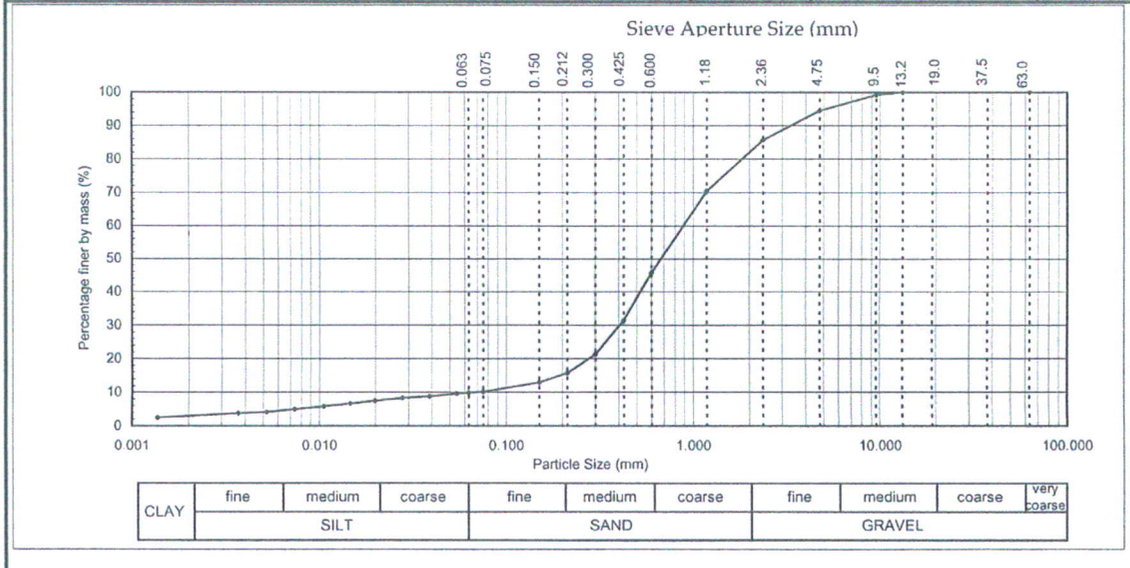
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

TEST REPORT

Project :	**Stopbanks**
Location :	**Unknown**
Client :	**Ice Construction Ltd**
Client/Sample Ref :	**Blacks**
Contractor :	**N/A**
Borehole No:	**3** Depth: **1.50 Metres**
Sampled by :	**Marriane O'Halloran (Ice Construction Ltd)**
Date received :	**13 November 2009**
Sampling method :	**Unknown**
Sample condition :	**Natural State**
Sample description :	**SAND with some Gravel, minor SILT, trace of Clay**
Solid Particle Density (t/m^3):	**2.65** **(assumed)**
Water Content (as received):	**11.0** **%**

Project No:	**255549.00/0TL**
Lab Ref No:	**09/637B**
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	**21**	0.0543	**10**	0.0074	**5**
37.5	--	2.36	**86**	0.212	**16**	0.0389	**9**	0.0052	**4**
19.0	--	1.18	**70**	0.150	**13**	0.0277	**8**	0.0037	**4**
13.2	**100**	0.600	**46**	0.075	**10**	0.0198	**8**	0.0014	**3**
9.5	**99**	0.425	**31**	0.063	**10**	0.0146	**7**	--	--
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0105	**6**		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 9.0 (Whatmans Full Range pH Indicator paper)

Date Tested: 27 November 2009

Date Reported: 2 December 2009

IANZ Approved Signatory

Designation : *Senior Civil Engineering Technician*

Date : 2 December 2009

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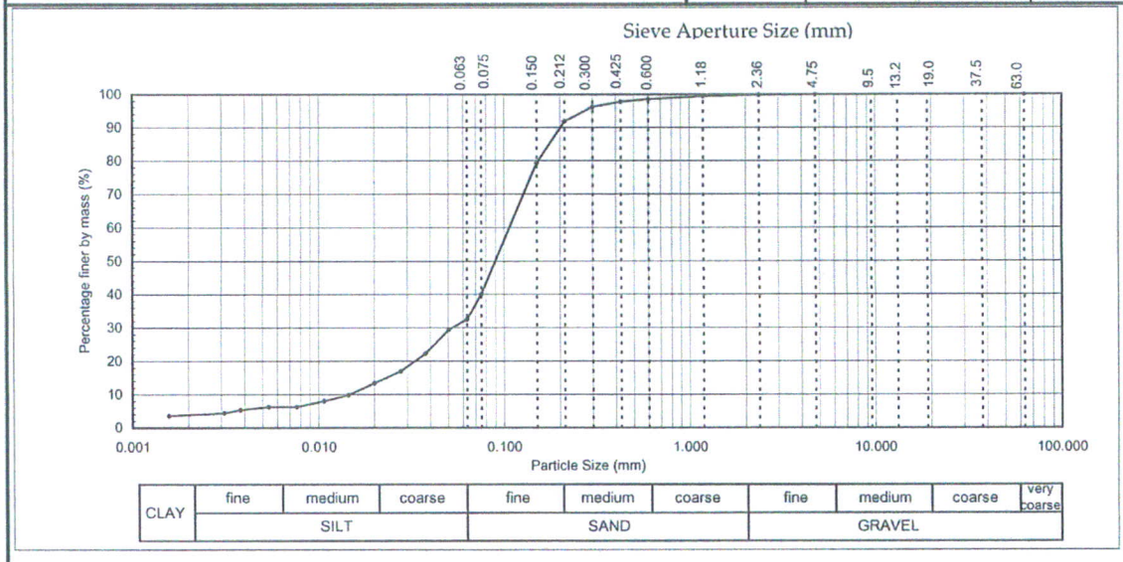
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)

TEST REPORT

Project :	**Stopbanks**
Location :	**Unknown**
Client :	**Ice Construction Ltd**
Client/Sample Ref :	**Blacks**
Contractor :	**N/A**
Borehole No:	**8** Depth: **1.30 Metres**
Sampled by :	**Unknown**
Date received :	**13 November 2009**
Sampling method :	**N/A**
Sample condition :	**Natural State**
Sample description :	**Silty SAND, trace of Clay**
Solid Particle Density (t/m^3):	**2.65** **(assumed)**
Water Content (as received):	**61.1** **%**

Project No:	**255549.00/0TL**
Lab Ref No:	**09/637C**
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	0.0504	29	0.0076	6
37.5	--	2.36	100	0.212	92	0.0377	22	0.0054	6
19.0	--	1.18	99	0.150	79	0.0276	17	0.0038	5
13.2	--	0.600	99	0.075	40	0.0200	13	0.0031	4
9.5	--	0.425	98	0.063	33	0.0145	10	0.0016	4
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0107	8		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 9.0 (Whatmans Full Range pH Indicator paper)

Date Tested: 1 December 2009

Date Reported: 2 December 2009

IANZ Approved Signatory

Designation : *Senior Civil Engineering Technician*

Date : 2 December 2009

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