

GREYMOUTH FLOOD WALL UPGRADE DESIGN GEOTECHNICAL REPORT

**Engineers and Geologists** 



#### GREYMOUTH FLOOD WALL UPGRADE DESIGN GEOTECHNICAL REPORT

Report prepared for:

**Good Earth Matters** 

Report prepared by:

Titus Smith, Senior Engineer, CPEng

Report reviewed by:

Don Tate, Director, CPEng

**Report Reference:** 

09828-A

Date:

9 November 2009

Copies to:

Good Earth Matters

2 copies

Riley Consultants Ltd

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## GREYMOUTH FLOOD WALL UPGRADE DESIGN GEOTECHNICAL REPORT

#### 1.0 Introduction

Riley Consultants Ltd (RILEY) has been engaged by Good Earth Matters to provide geotechnical input for the design of upgrading works of the flood protection system along both sides of the Grey River downstream of the rail bridge. The details of the floodwall upgrade are provided in the construction documents completed by others, the main elements of the project from a geotechnical standpoint being:

- Concrete floodwalls founded on existing stopbanks over a length of around 1500 m
- A new section of stopbank around 1 m above existing ground level and 140 m long
- A new section of stopbank around 4 m above existing ground level and 110m long
- Raising of existing stopbanks by 0.2 m to 0.7 m over a length of around 1300 m
- Minor raising/re-contouring of existing stopbanks over a length of around 2800 m.

The design standard for the upgrade is for 600 mm freeboard in a 1:50 flood, and a higher standard of 600 mm freeboard in a 1:150 flood where new floodwalls are proposed.

#### 1.1 Scope

The overall aim of the investigation is principally to provide information to assist the overall design of the upgrade project. The desired end result is to confirm that relevant geotechnical issues have been taken into account and that the risk of failure of the various structures in terms of geotechnical failure modes is acceptably low for the adopted design standard. The geotechnical work is not a condition assessment of the existing stopbanks as such; rather confirmation is required that the proposed works do not exacerbate existing geotechnical risks for the proposed design standard. The purpose of this geotechnical report is to document the results of the investigation, and to summarise conclusions and recommendations on geotechnical aspects of the project.

### 2.0 Geological Setting

Published information (Ref 1) for the site indicates the existing stopbanks adjacent to the Grey River upstream of the estuary (i.e. upstream of the Goods Shed on the true left and Cobden Island on the true right) are generally underlain by river gravel, sand and silt of young river flats. Estuarine deposits are indicated around the periphery of the estuary south of the Fisherman's Wharf area, and marine gravel and sand are indicated along the river banks downstream of the estuary. Significant reclamation efforts have occurred along the banks of the river including training levees and revetments at the river mouth.

At the upstream limit of the true left stopbank, the Cobden Limestone of Peter Range is encountered. This limestone is regionally westward dipping at an angle of around 27°.







#### 3.0 History of Flood Wall Development

From 1979 development of a flood protection scheme in Greymouth had been underway. In 1986, North Tip Road was raised, along with installation of the gated culvert at Range Creek.

Following severe flooding in 1988, a new system of stopbanks and floodwall was proposed. Construction of the new infrastructure was completed in 1991, and no significant upgrading of the scheme has been undertaken since. The nature and extent of reclamation work and stopbank construction previous to the events of 1979 have not been reviewed in detail, however it is understood that significant historical activity has occurred in the area, and variable quality fill is likely to exist beneath the current floodwall arrangement.

A series of performance and risk reviews have been undertaken since completion of the flood wall in 1991, and key relevant findings from these reports (Ref 2, 3) are summarised below.

#### Cobden

- A specific area of low quality historic fill within a reclaimed river channel in the area of Taylor St has been identified, and there has been an associated settlement issue
- The earth stopbank is subject to significant seepage resulting in landward-side flooding, and the majority of this flow is inferred to be via the aforementioned area of historic fill

#### Mawhera Quay

 Flood wall seepage area has been identified around the intersection with Boundary St, and west toward Johnston St pump station. Water pressure has been observed beneath the adjacent road pavement in this area.

#### 4.0 Basis for Investigation

As a condition assessment of the existing stopbank is outside the scope of this report, investigation has been targeted around areas where significant stopbank raising will occur. This is to ensure that the additional floodwall height is appropriately designed and detailed so as not to negatively affect the existing stopbank stability. The key areas selected for targeted investigation generally incorporate a raise for the 1:50 AEP flood standard of more than 200 mm. Investigation has therefore been targeted at:

- Two Bridges
- Mawhera Quay
- Goods Shed
- Fisherman's Wharf
- Cobden around Range Creek Culvert

Note that the section of stopbank at Cobden around Taylor St previously identified as having deficient foundations will not be modified under the proposed works, and has not been targeted for investigation.

The scope of the investigation was derived after a walkover inspection and assessment of the key areas in terms of geotechnical risk. A draft programme of investigation was derived and agreed with WCRC.

#### 5.0 Fieldwork and Laboratory Testing

A programme of sub-surface investigation has been undertaken, including excavation and logging of 24 test pits. Test pit locations are indicated on the drawings in appendix A, and test pit logs are included in appendix B. 4 Machine drillholes were undertaken by CW Drilling. The fieldwork was overseen by technicians or geologists from RILEY and logs are presented in terms of the New Zealand Geotechnical Society Guidelines. Initially hand augers were attempted in some locations but were abandoned at an early stage due to difficulties with gravels.

Laboratory tests have included particle size distribution on selected samples, and a standard Proctor compaction test on a sample of existing stopbank material. Results are included in appendix C.

#### 6.0 Geotechnical Considerations and Recommendations

Observations from the investigations along with comments and recommendations for specific locations are detailed in the follow sections. In each case geotechnical failure modes are considered, these may include:

- Seepage effects and internal erosion
- Slope stability
- Settlement
- Loss of support or undermining
- Foundation instability or overstressing

All of the above failure modes may not be applicable in all locations.

#### 6.1 Two Bridges

This area is located at the base of a large limestone bluff, adjacent to the railway line. The railway appears to have been founded on bedrock, and water flow is exiting the base of the outcrop via open defects and a large solution cavity to the river via covered drains.

To achieve the design stopbank crest level in this area, an earth fill up to 4 m above existing fill height is required. The culvert beneath the fill draining seepage flows from the bluff area is cracked and deformed and will require replacement. In addition a small bridge will be replaced by a culvert. The vertical height from the existing culvert inverts to final stopbank crest level is around 7 m.

#### 6.1.1 Investigations and Geotechnical Model

Four test pits and two boreholes were completed in the two bridges area. Ground conditions generally comprise limestone bedrock overlain by dense river gravels 1 m to 2 m deep, overlain by soft river sediments around 1 m thick, overlain by a minimum of around 1.5 m of granular fill. SPT values in the soft river sediments are very low (as low as 0) increasing to typically in excess of 30 in the denser gravels. The fill is variable in composition and in places contained wood fragments, steel and brick inclusions. Groundwater seeps were noted near the base of the test pits, but flows were only modest. Groundwater level within the pits and boreholes was similar to the level of the adjacent river. However, during drilling of DH3 a higher water table was observed within the underlying rock. The water pressure was not artesian (i.e. stabilised below ground level) however was some meters higher than the piezometric level in the overlying alluvium. It is inferred that interconnected defects within the limestone bluff adjacent to the site provide conduits for water from the bluff, which exit at various locations including the two open drains observed on site, as well as subsurface seepage points, and possibly higher elevation drainage points at times of heavy rainfall and high water pressures within the bluff.

A stability assessment of the proposed fill embankment slope has been completed using a two-dimensional limit equilibrium model. The assessment indicates that the presence of the soft alluvial sediment underlying the existing fill results in acceptable factors of safety under the additional loading of the proposed stopbank fill. However in the event of elevated groundwater levels within the stopbank such as may occur in the event of heavy rainfall locally resulting in seepage pressures from beneath/behind the stopbank from the limestone bluff, factors of safety approach 1 (i.e. a state of failure). Removal of the existing fill and underlying soft sediment, and founding on denser alluvial sediments was then modelled. The resulting factors of safety are around 1.7 for the normal (observed) groundwater profile, and 1.5 for a postulated adverse groundwater profile associated with high seepage rates from the underlying bluff or a rapid drawdown scenario from recession of river flood level. The results are summarised in table 1, and printouts of the stability analysis are included in appendix 4. Note that high water levels in the Grey River do not represent a critical load case for this section of stopbank on the landward side, which is well buttressed by the railway on the landward side.

Scenario	Factor of Safety
New stopbank constructed on existing sediments – normal groundwater levels	1.5
New stopbank constructed on existing sediments – high groundwater levels	1.0
New stopbank foundation excavated to dense alluvial sediment – normal groundwater levels	1.7
New stopbank foundation excavated to dense alluvial sediment – high groundwater levels	1.5

Table 1: Factors of Safety

In addition liquefaction and excessive settlement are significant risks. Liquefaction of this very loose soil is likely in even a moderate earthquake with subsequent major slumping and settlement of the fill embankment. It is therefore recommended that the existing fill and soft underlying sediments be undercut, and the stopbank fill founded on the dense underlying sediments.

#### 6.1.2 Key Considerations

Geotechnical considerations for the area include:

- The strength of the sand/silt in situ river sediments is low, and it is recommended that
  the area be undercut to allow founding of the stopbank and proposed culverts on
  dense materials. Some of the existing fill may be able to be re-used. The plan and
  depth extent of undercutting will require conformation on site.
- 2. Seepage flows from the bluff must be adequately drained to ensure that seepage pressures do not build up within the stopbank fill. The old culverts are scheduled for replacement, and the new culverts should be carried through to interface with the rock bluff. Detailed logging of the rock bluff should be undertaken at the time of construction, and drainage works installed for any open defects in the rock face, so that all seepage flows are collected and passed through the culverts beneath the stopbank fill. Free draining fill materials should be used up to the level of the existing railway, as the lower portion of the stopbank will not be required to retain water due to the site geometry.
- 3. Erosion protection of the new stopbank is required, as it forms the outside of a river bend and will be impacted by the main channel of the river during flood flows. Heavy rock protection should be allowed for the full extent of the stopbank batter.
- 4. The necessary sub-excavations are below the river level and groundwater inflows should be expected. Careful management of these inflows and the natural springflows are required by contractors to ensure that fill standards are not compromised. In particular contingency measures should be in place such as pumps and construction methodology to minimise the time of exposure within the lowest excavation levels.
- 5. The existing fill embankment where it supports the railway is relatively steep, and design concepts should aim to avoid any significant destabilising effects. It is recommended the existing fill is not undercut except for minor trimming of the face and that temporary slopes do not exceed the existing slope.

#### 6.2 Mawhera Quay

This refers to the section of stopbank incorporating existing prefabricated concrete retaining walls that run adjacent Mawhera Qy and Richmond Qy roads. It is proposed to install a freestanding concrete wall around 0.9m high along the crest of the existing stopbank.

The design stopbank cross section is known from a drawing supplied by the WCRC (reproduced in figure 1). This incorporates a sloping, low permeability upstream core zone extending around 2.5m vertically. The core then runs horizontally into the centre of the stopbank, and ties into a "clay core" cutoff indicated to be 6m deep within founding soils. The landside batter is supported by 2 low precast concrete retaining walls. The main potential issues associated with the floodwalls are seepage along or near the interface with the underlying soils, and foundation resistance to various potential failure modes. Due to the low height of these walls settlement or bearing capacity are not likely to be issues.

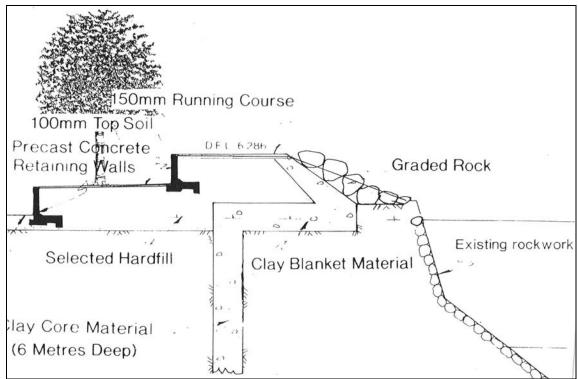


Figure 1: Original Design Section for Mawhera Quay Flood Wall

#### 6.2.1 Investigations

Six shallow test pits and one drill hole were completed along this section of stopbank

#### (a) Floodwall Section

Generally the supplied design stopbank profile was confirmed by the investigation, although pits only extended to around 0.5m deep to ensure damage to the existing stopbank was minimised. Laboratory testing including 2 particle size distribution tests on each of the sloping silty gravel core and general fill zone were completed in addition to a standard compaction test on core material. Grading curves for the samples are indicated in figure 2. Laboratory testing indicates the low permeability upstream core is a silt with sand and gravel that is expected to effectively limit seepage flows. The grading of the adjacent gravel fill has been checked for filter compatibility with the core, and is found to generally comply with the "no erosion" criteria. The materials exhibit a degree of gap-grading, however given the short duration of any seepage flow through the upper part of the stopbank, it is considered unlikely that piping features or internal erosion would develop.

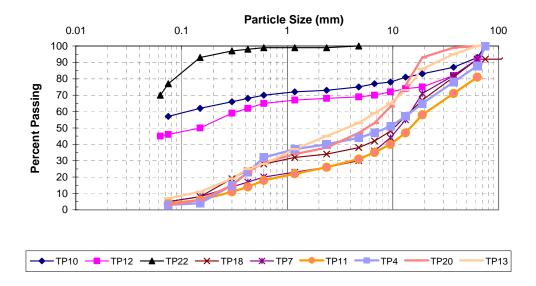


Figure 2: Plot of Laboratory Grading Curves

#### (b) Area of Observed Seepage Pressure

The drill hole was located to the west of the section near the intersection of Mawhera Qy and Richmond Qy roads, where seepage has been experienced in recent flood events. The borehole was located on the landward side of the 6m deep clay cutoff indicated in the supplied design drawing. The materials encountered by the drill hole generally comprised fill to around 3.4m, gravel and sandy gravel to around 7m, with sand and gravelly sand below this to the hole target depth of 10m. None of the sediments encountered in the hole would provide significant resistance to seepage flow from the adjacent river, and as the stopbank central clay cutoff extends only 6m, it is interpreted that seepage flows are able to pass beneath the cutoff zone and discharge in the stopbank toe area. It is also quite likely that the clay cutoff is not very effective in reducing flow or pressure in the upper founding soils. and minimal head loss due to seepage is occurring in even the near surface soils.

The permeability of the founding soils at this location are likely at the upper limit of the hardfills tested, as the nature of the founding gravel soils is similar. Based on various correlations from grading curves the permeability is assessed as in the range 4 to  $8 \times 10^{-4}$  m/s. This is significantly higher than the in situ permeability test, but this test appears to give an unrealistically low permeability.

Based on previous transient groundwater modelling we have undertaken for stopbanks a head loss due to seepage can be derived, based on permeability. A head loss of only 1m is predicted at the toe of the stopbank (i.e. the carriageway), and thus for only moderate flood events artesian pressure is predicted beneath the carriageway. This is consistent with the observed heaving of the carriageway seal in previous flood events i.e. artesian uplift pressure exceeds the weight of the overlying materials.

#### 6.2.2 Key Considerations

#### (a) Floodwall Section

For design of the floodwall RILEY recommends the following:

- 1. The wall be located near the river-side of the stopbank, with the footing cast insitu directly on the low permeability core zone after removal of topsoil etc, and extending onto the free draining bulk fill zone.
- 2. A key be incorporated in the footing to increase resistance to sliding. The key should be located within the free-draining gravel rather than the low permeability core, to ensure minimal disturbance to the core zone.
- 3. During construction, the core zone should be exposed and tested to ensure it has appropriate density and moisture content to act as a footing foundation and water retaining material for concrete structure interface. It may be appropriate to recondition the core zone by addition of water/scarifying/re-compaction.
- 4. The footing should found on the low-permeability zone a minimum width of 200mm and preferably more. It is possible the low permeability material may not be encountered or at marginal thickness at tentative founding level (for example if hardfill thickness is greater than about 300mm). For this scenario placement of low permeability soil will be required to create a continuous seepage barrier, as it may not be desirable to lower the founding wall level.
- 5. A worst-case overturning and uplift stability check be undertaken including full water pressure on the wall face, and full water pressure along the foundation slab (i.e. seepage pressure assuming a crack forms at the interface). A factor of safety greater than 1.0 would be appropriate for such an extreme flood case if the flood level is taken to the top of the wall.
- 6. To ensure erosion/deterioration at the river-side foundation interface of the wall does not occur, it is recommended that a filter fabric detail down the face of the wall and between the core and riprap be incorporated. Riprap should be placed on the fabric against the base of the wall and marry in with the existing rip rap.
- 7. Wall stability should be checked for failure modes of uplift, sliding and overturning. A typical required factor of safety is 1.5 for these modes, for a conservative assumption of a flood level at the top of the wall. This water level is higher than the 1% AEP flood level. We recommend that the base width be a minimum of 1m, in order to provide a minimum seepage length. Each of these failure modes should be checked for a triangular uplift distribution i.e. headwater at the upstream end to zero at the downstream toe. We have considered placement of a drain at the landward toe, but due to the free draining hardfill we consider this is not required. Also it is most likely no seepage will reach the downstream toe, and even if it did would be expected to be only modest flows.
- 8. Consideration should be given to the detail at the end of the walls ie how seepage is minimised around the end of the wall.

#### (b) Area Of Observed Seepage Pressure

At this position there is a risk of initiation of erosion by a ground heave mechanism possibly leading to a breach of the stopbank by piping. Although the risk of initiation is high (particularly in floods greater than encountered to date) there must be other factors present for a breach to potentially occur. The gravel soils are unlikely to hold a roof or be highly erodible in seepage flow and thus gross enlargement of a piping hole is unlikely. Some loss of the finer fractions within the matrix may occur, leading to higher permeability and flow rates. In a worst case scenario if sufficient erosion occurred the crest may slump and/or the walls be undermined and then the crest may overtop if the flood is high enough at the time.

The short duration of peak flood loading would reduce this risk. Overall the risk of a breach in say a 1:100 flood event is assessed as moderate to low.

The options to improve stopbank security could involve;

- Seepage reduction measures
- Drainage / buttressing
- Combination of the above

It appears the existing clay cutoff at this location is not fully effective. Seepage reduction measures could involve a deep cut off using plastic concrete or conventional concrete. These however are very expensive solutions and more suited to large dams. Drainage or buttressing are considered more cost effective options. These are described below.

- (a) Raising of the ground to add weight. This would involve removal of existing seal and placing fill.
- (b) A deep toe drain or similar. This would be a trench backfilled with highly permeable gravel excavated to the maximum practical depth.

Option (b) above is considered most cost effective solution. Further design analyses are recommended to develop the concept, in particular the required geometry, grading and required design standard. Option (a) would be very disruptive as a significant fill depth may be required. With any option there are various practical constraints to be considered.

#### 6.3 Goods Shed

A new section of stopbank up around 1 m high is required adjacent to the existing Goods Shed.

#### 6.3.1 Investigations

Three test pits up to 4 m depth were completed in the Goods Shed area. Fill comprising variable silt, sand, gravel and boulders and was encountered to at least 2 m depth. The soils encountered are generally considered to be an appropriate foundation for the proposed stopbank in terms of strength and potential settlement. Some permeable materials were encountered along with boulders.

#### 6.3.2 Key Considerations

The new stopbank requires a competent foundation, and an appropriate detail for keying the low permeability upstream core zone into the foundation to limit foundation seepage.

All loose, permeable or soft materials require removal from the stopbank footprint, an undercut over the whole footprint of 0.5 to 1 m is envisaged. In places a deeper sub-excavation may be required either over the whole footprint or as a cut off for seepage control. The typical cross section for the new stopbank should incorporate an upstream silt core and downstream free draining shoulder similar to the existing stopbanks in the area. The upstream core zone should be keyed into in situ ground. The recommended new stopbank cross section is indicated in drawing 09828-5.

#### 6.4 Fisherman's Wharf

A freestanding wall around 0.9 m high is proposed for the Fisherman's Wharf section of stopbank.

#### 6.4.1 Investigations

Four test pits were completed in the area. These pits revealed an upstream core zone and free draining bulk fill typical cross section, incorporating a similar cross section and materials to those at Mawhera Quay. It is unlikely however, that the stopbank incorporates the 6 m cut-off zone of Mawhera Quay, as the stopbank is significantly lower at this location.

#### 6.4.2 Key Considerations

It is considered appropriate to use a similar wall detail to that suggested for Mawhera Quay, with the wall being located at the river-side of the existing stopbank crest, and keying into the existing low-permeability upstream core zone. Design loadings and considerations for the wall are anticipated to be similar to those at Mawhera Quay, although additional consideration of wave impact loading and overtopping effects due to the proximity of the site to the river mouth.

#### 6.5 Cobden

The existing stopbank in the area within around 300 m upstream of the existing Range Creek culvert is very steep, and has a narrow cross section and crest width due to the constraint of the adjacent road. Seepage has been noted around and/or beneath the culvert, and remediation of this structure has been raised as item for consideration in our brief. During the site visit, seepage was observed exiting adjacent to the culvert toward the Grey River. It is therefore likely that the seepage direction will reverse during flooding of the river, and the seepage flows will exit toward Cobden.

It is proposed to raise the entire road embankment to achieve the design stopbank height, rather than attempting to raise the already steep and narrow existing banks adjacent to the road. In the Range Creek culvert location, new culvert sections will be added on either side of the existing structure, and earth fill placed to tie in to the existing stopbank batter.

#### 6.5.1 Investigations

Three test pits and one drill hole were completed in the area. The test pits determined that the river side low permeability facing is present on the stopbank.

The drill hole identified sandy gravel beneath the culvert level (base of stopbank fill). The in situ foundation material is likely to be highly permeable, and it is also considered likely that seepage along the interface of the culverts with natural ground and backfill is occurring. Design details of the wing wall extensions have been sighted, but nothing of the original wing wall and culvert installation which apparently predates the stopbank upgrade of the late 1980's. No internal inspection of the culverts was undertaken however it is considered likely that settlement of the culverts has occurred to some extent, as the stopbank height has been raised at least once following original construction.

#### 6.5.2 Key Considerations

RILEY supports the idea of raising the road embankment across its full width in this area. The existing road surface should be removed and the upstream core be extended appropriately, as indicated in drawing 09828-5 attached.

At the culvert location, the recommended detail for limiting seepage is a new earth liner layer within the fill surrounding the culvert extension. There is the potential for seepage pressure from either direction (i.e. the Grey River side during flood, and the Cobden side during normal operation/local rainfall events). Therefore the recommended detail incorporates an

internal low permeability core zone on the Grey River side of the culvert, with a supporting shoulder of general stopbank fill material. This arrangement is indicated in drawing 09828-6. It is important that the low permeability core zone is well keyed into the existing low permeability facing layer on the river-side stopbank batter. The previously noted possibility of culvert settlement raises the potential for seepage originating from pipe joints, and it is recommended that an internal inspection of the culverts be completed as part of the structure upgrade.

In the culvert location, the founding level for compacted fill is beneath river level, and occupies the normal drainage path for the Cobden estuary area. Construction will therefore require careful planning and execution, with consideration given to drainage so that fill quality is not adversely affected by water within the excavation. Very high compaction standards are required below and around the pipes in particular.

#### 7.0 Summary of Main Points

- Investigations have been completed with the purpose of assisting the overall design
  of the upgrade project. There have been no major issues identified which could
  detrimentally affect the project, although in some areas challenging ground
  conditions have been identified requiring specific measures to minimise risk to an
  acceptably low level.
- 2. As expected the two Bridges section had the most challenging ground conditions, i.e. soft founding soils requiring undercutting and high groundwater levels.
- 3. Recommendations are included in this report for each of the areas investigated.
- 4. Confirmation of assumptions will be required during construction to ensure that the design objectives are fulfilled, and appropriate action taken if conditions differ from those encountered to date. Recommended construction methods and inspection procedures are included in appendix 5: Construction Specification Clauses.

#### 8.0 Limitation

This report has been prepared solely for the benefit of Good Earth Matters as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design based upon this report.

Riley Consultants Ltd would be pleased to provide this service to Good Earth Matters and believes the project would benefit from such continuity. In any event, it is essential Riley

Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

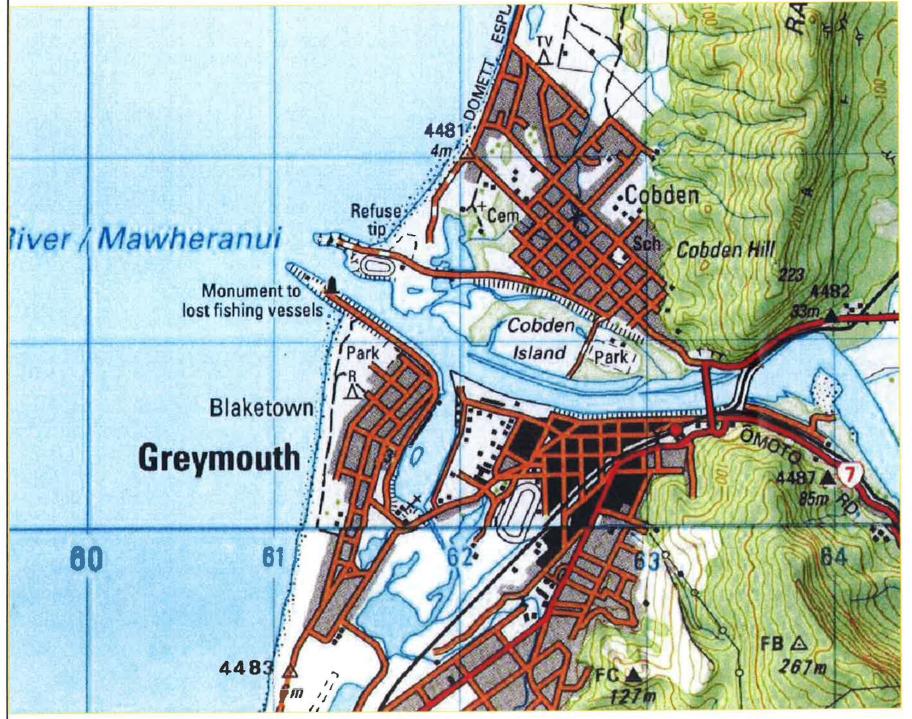
#### 9.0 References

- Nathan, S (1978) 1:63,360 Scale Geological Map, Sheet S44 Greymouth. New Zealand Geological Survey.
- Young A.J.A. (1998) Review of Condition of Greymouth Floodwall. RiskCorp Australia Pty Ltd
- 3 Hall R.J. (1999) Report: Greymouth Flood Protection: System Integrity. Civil & Environmental Consulting Ltd.

APPENDIX 1

Drawings





DRAFT

BY DATE 09/2008

## **GOOD EARTH MATTERS**

# GREYMOUTH FLOOD WALL, GREYMOUTH DRAWING INDEX - TENDER ISSUE NOVEMBER 2008

DRAWING	DRAWING	DRAWING
NUMBER	NAME	REVISION
09828-0 09828-1 09828-2 09828-3 09828-4 09828-5 09828-6 09828-7 09828-8 09828-8	LOCATION PLAN & DRAWING LIST GEOTECHNICAL INVESTGATION — SITE PLAN — SHEET 1 OF 3 GEOTECHNICAL INVESTGATION — SITE PLAN — SHEET 2 OF 3 GEOTECHNICAL INVESTGATION — SITE PLAN — SHEET 3 OF 3 GEOTECHNICAL INVESTGATION — CROSS SECTIONS AT 2 BRIDGES SITE CONCEPTUAL STOPBANK RAISING DETAILS RANGE CREEK CULVERT UPGRADE — CONCEPT DRAWING GEOTECHNICAL INVESTGATION — CLINOMETER CROSS SECTIONS GEOTECHNICAL INVESTGATION — CLINOMETER CROSS SECTIONS GEOTECHNICAL INVESTGATION — CLINOMETER CROSS SECTIONS	

LOCATION PLAN SCALE 1:20000

FIRST ISSUE

CONCEPTUAL - NOT FOR CONSTRUCTION

GOOD EARTH MATTERS

P.O.BOX 4355
CHRISTCHURCH

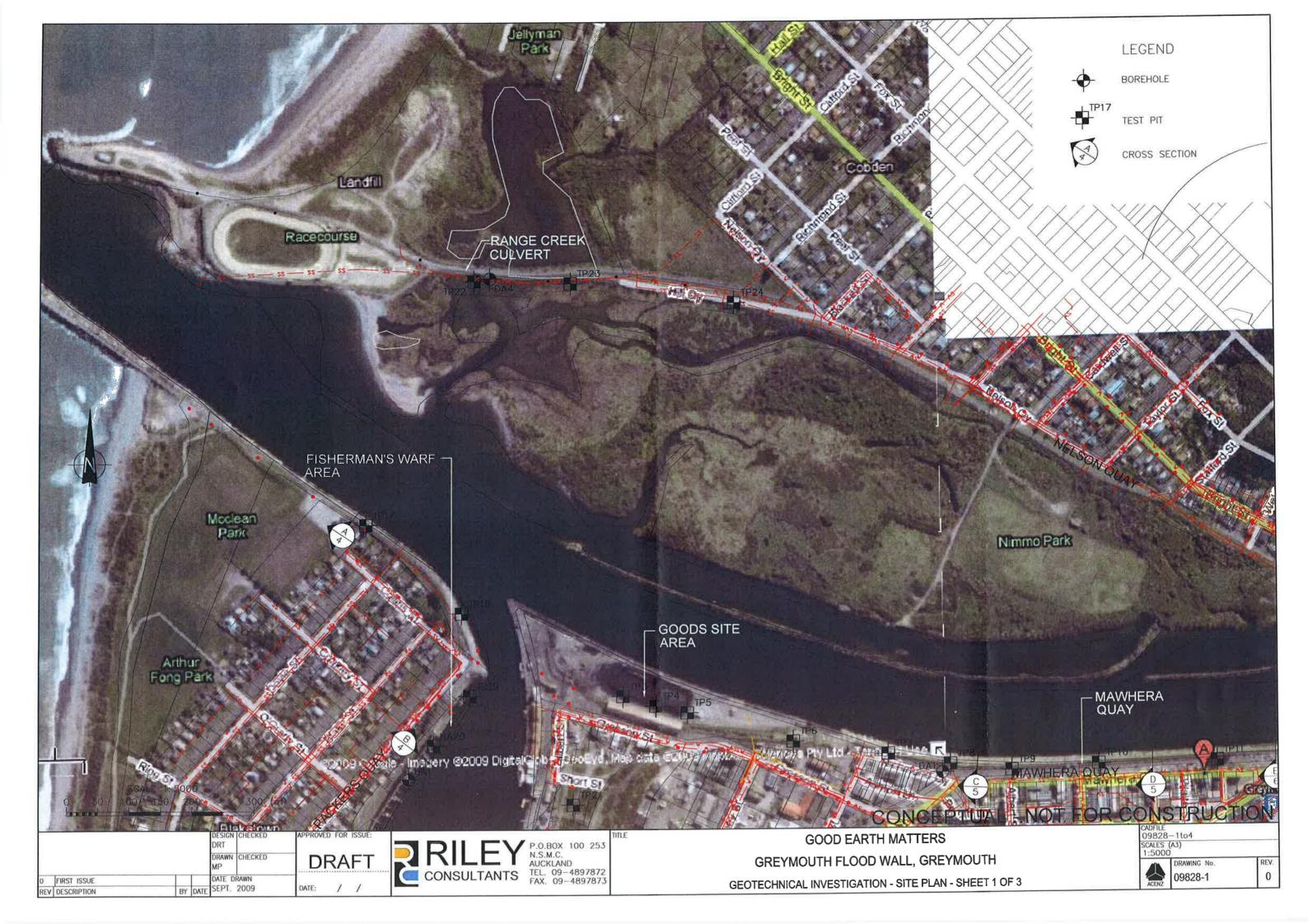
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FAX. 03-3794403

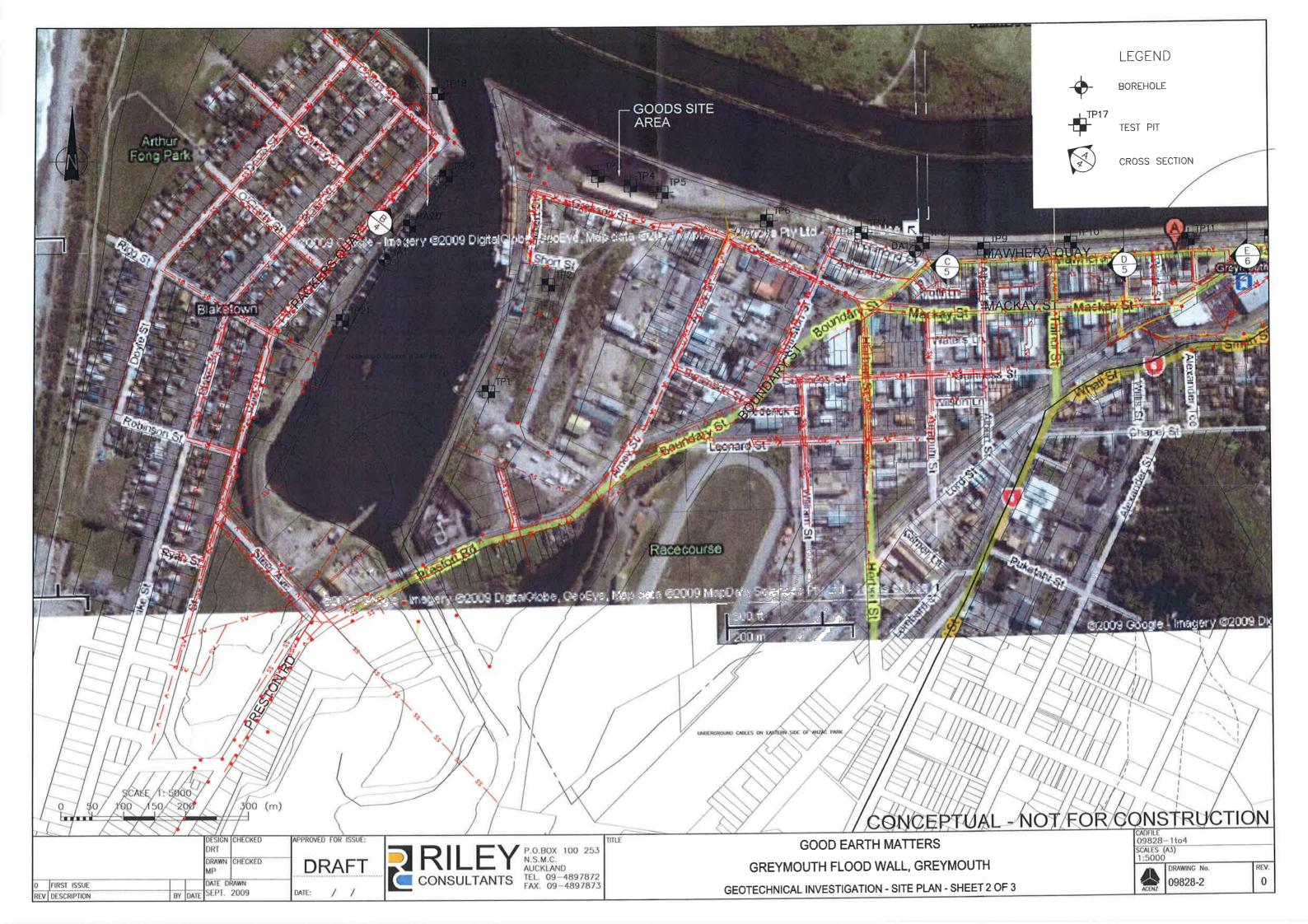
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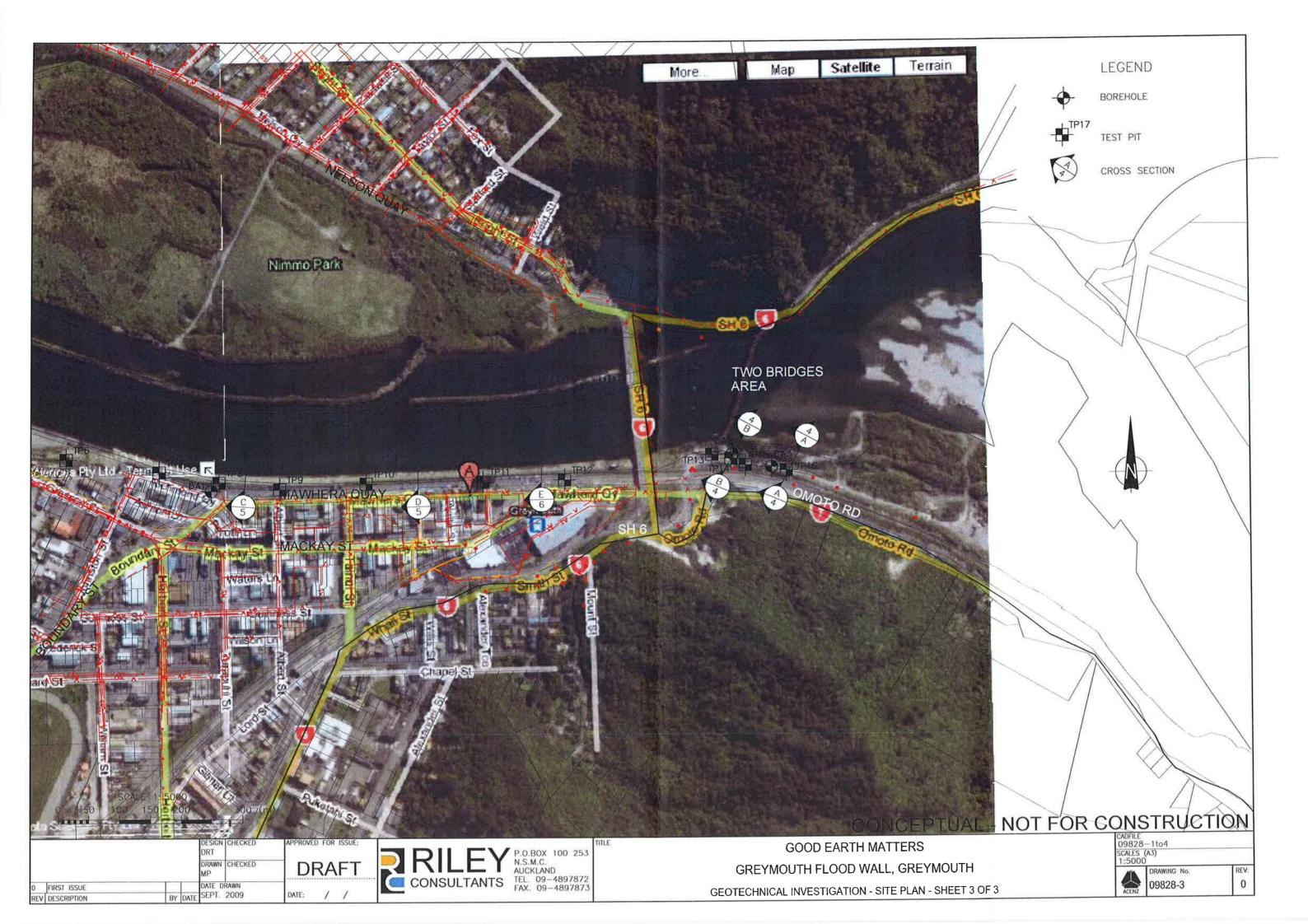
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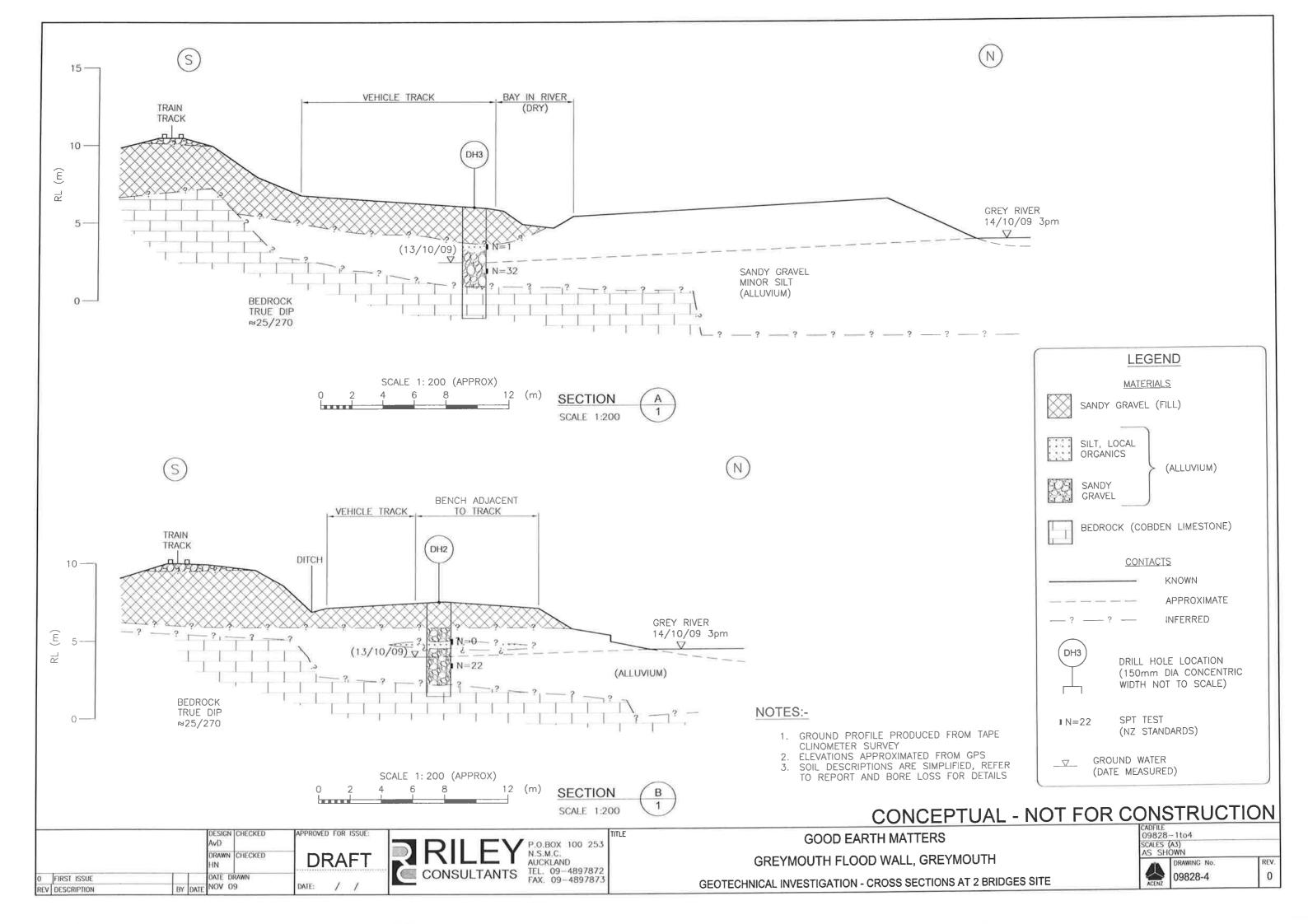
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AS SHOWN

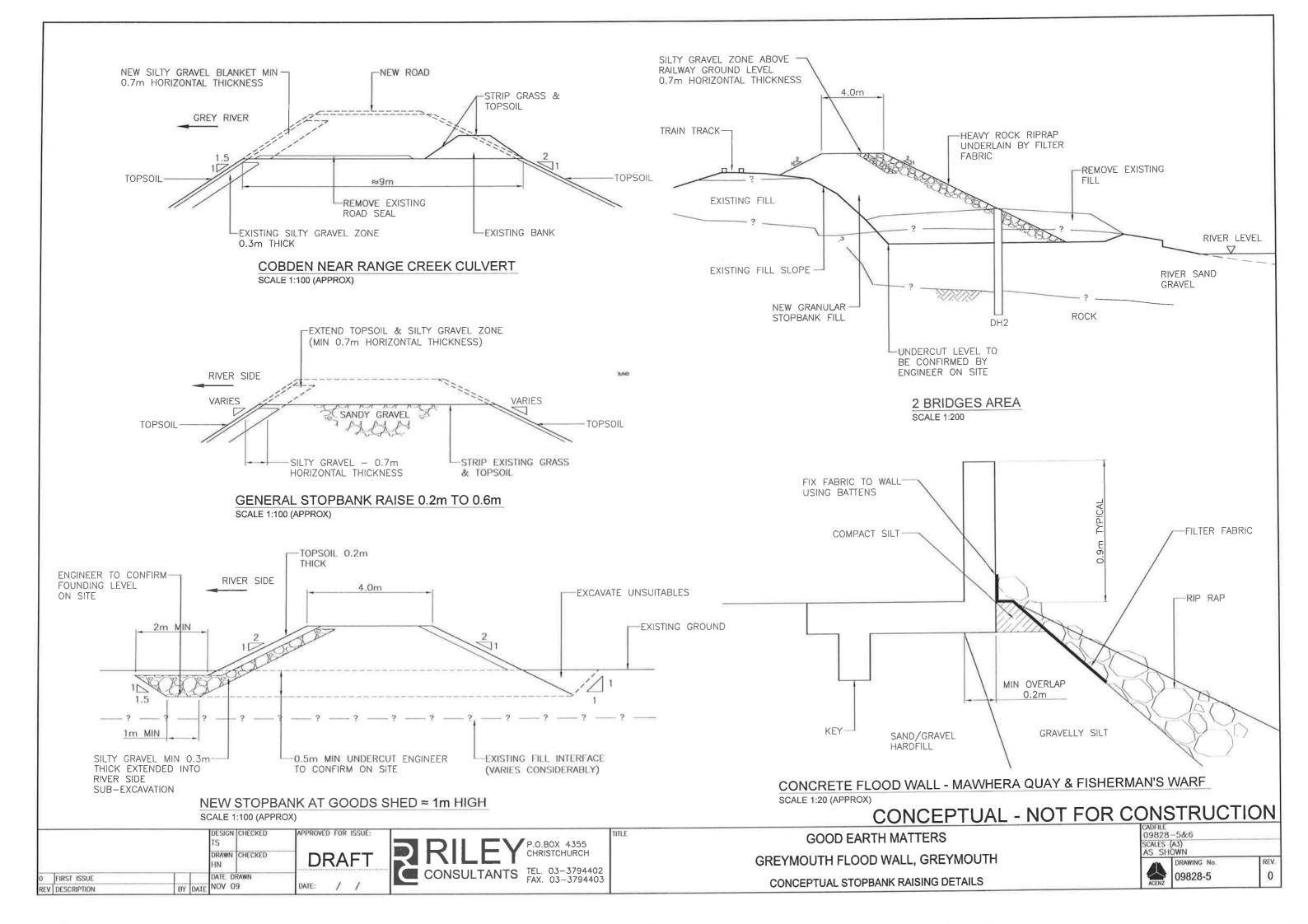
DRAWING No. REV.
09828-0 0

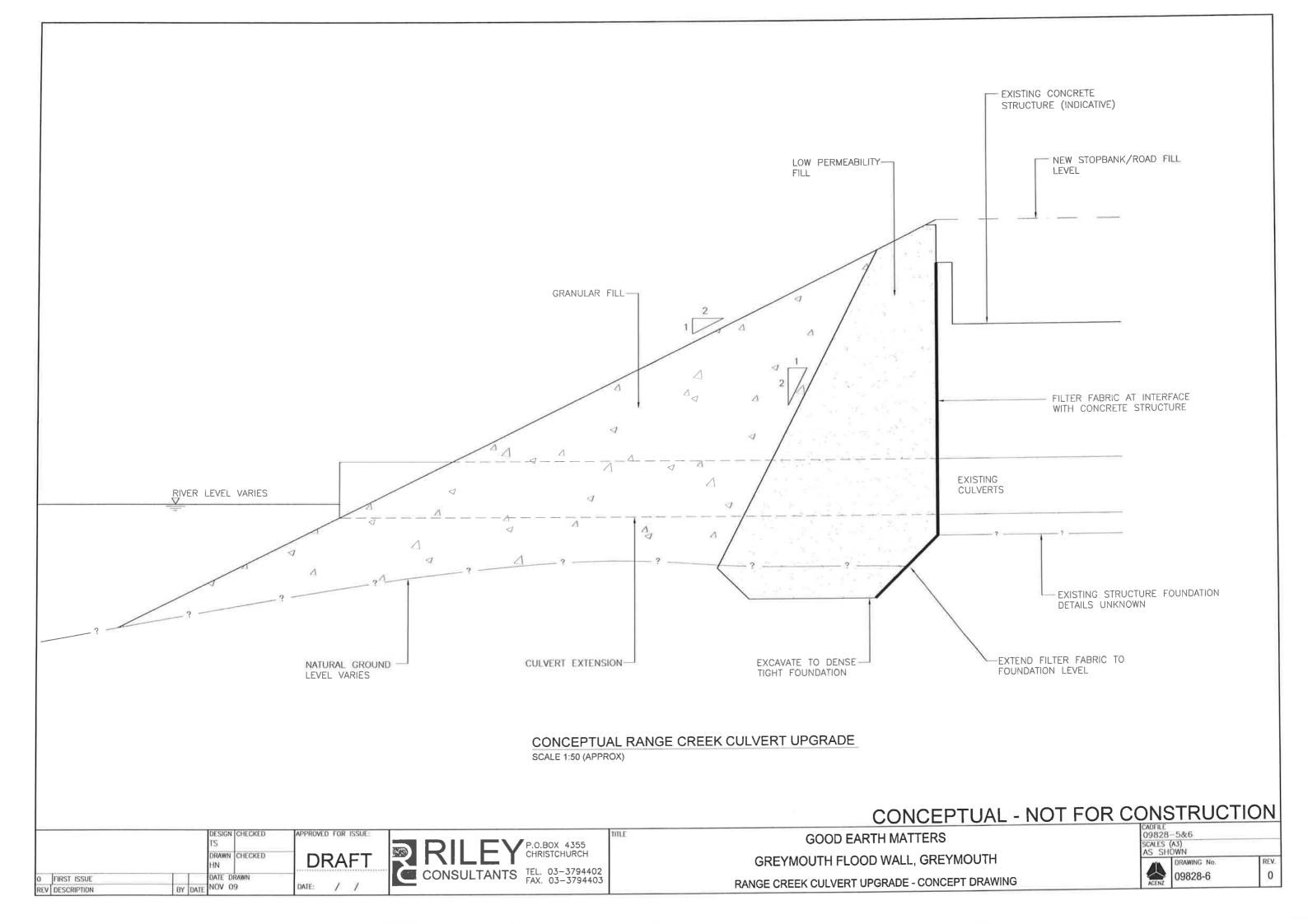


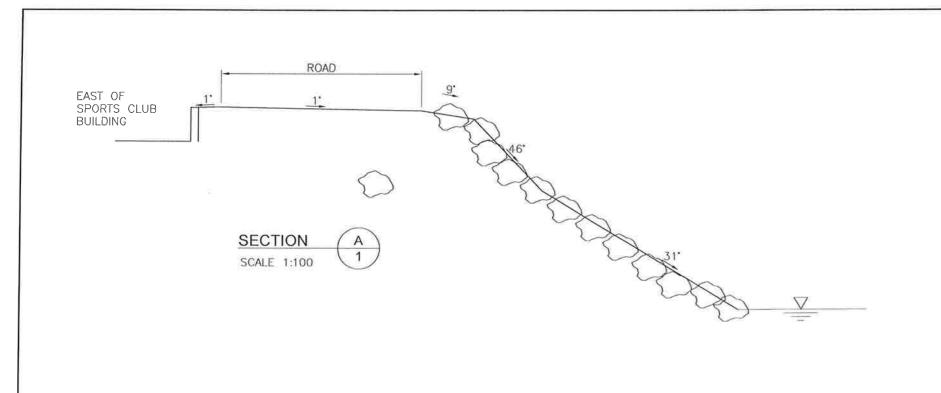


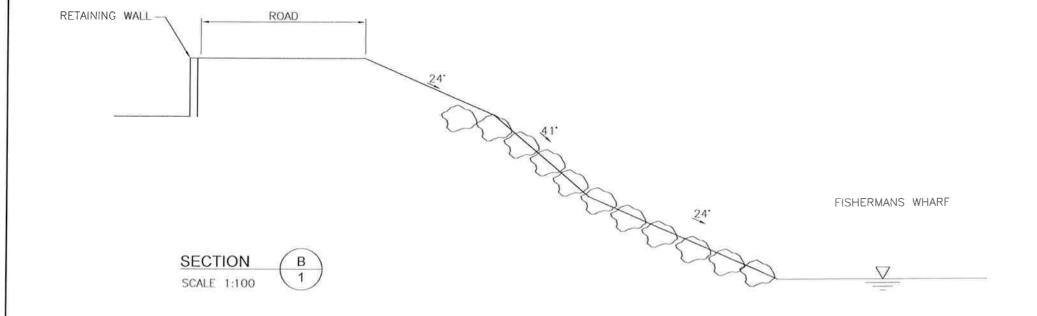














## **CONCEPTUAL - NOT FOR CONSTRUCTION**

DESIGN CHECKED APPROVED FOR ISSUE:

MJB

DRAFT

O FIRST ISSUE

DATE DRAWN

REV DESCRIPTION

BY DATE SEPT 2009

DATE: / /

P.O.BOX 100 253
N.S.M.C.
AUCKLAND
TEL. 09-4897872
FAX. 09-4897873

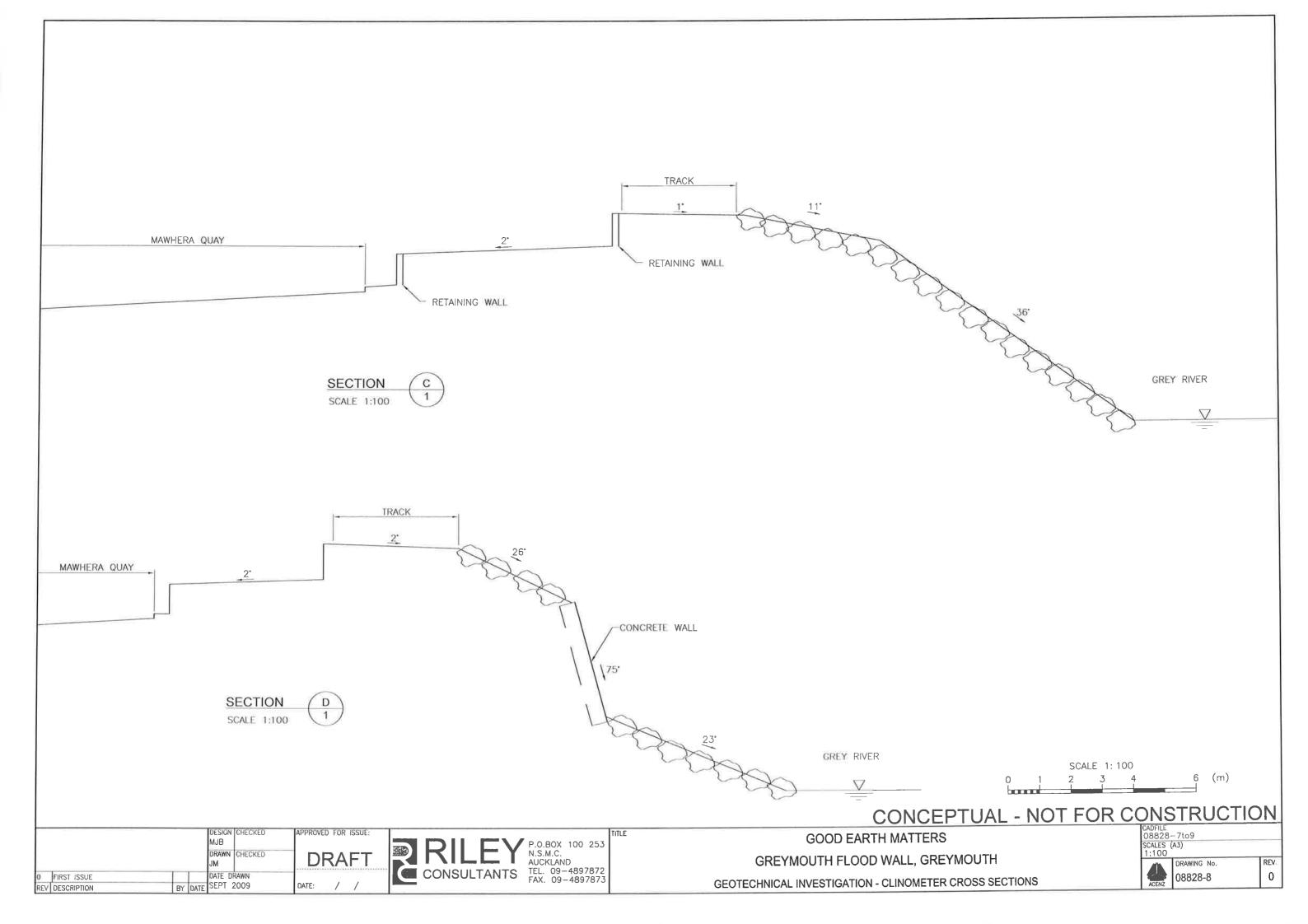
GOOD EARTH MATTERS

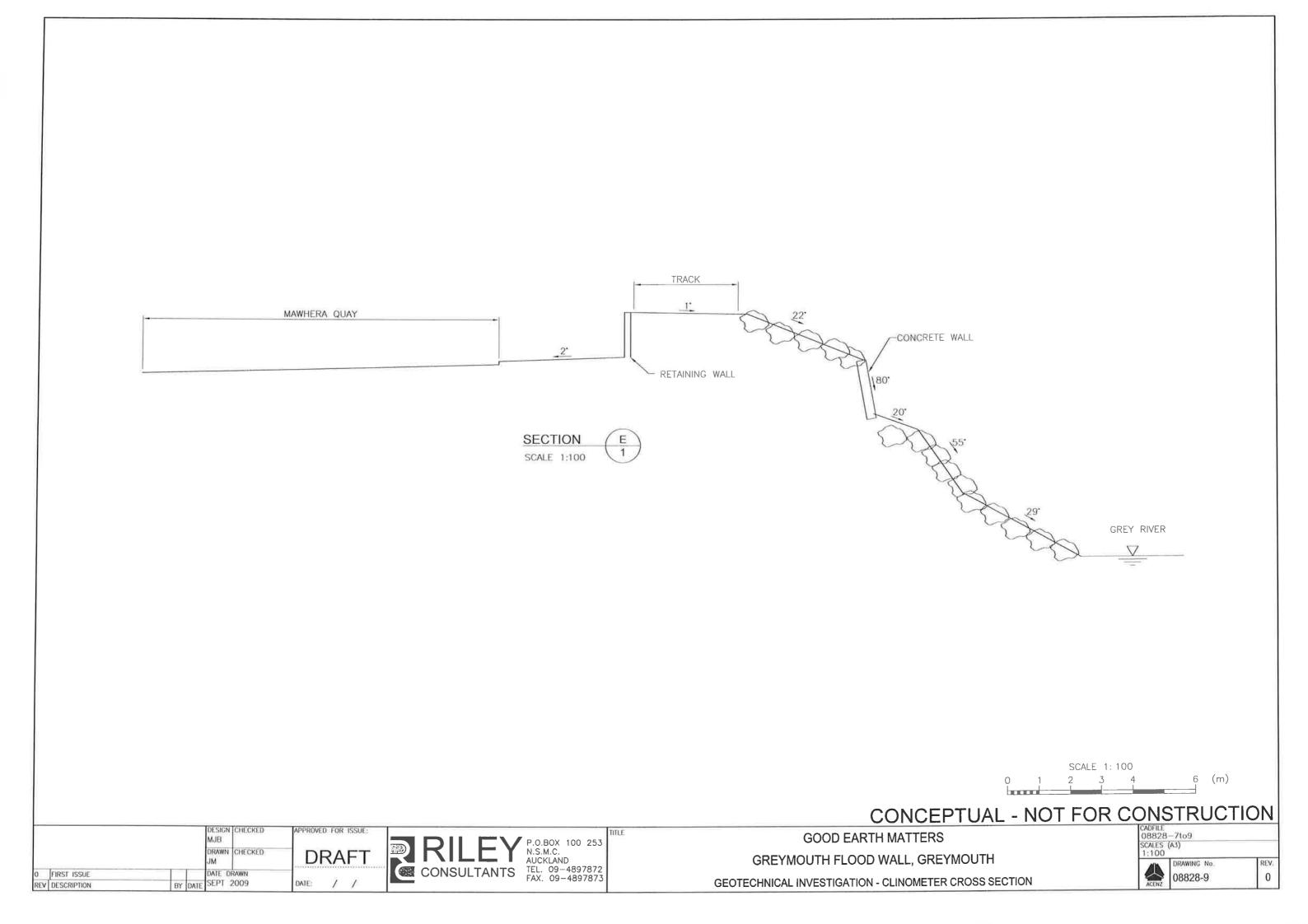
GREYMOUTH FLOOD WALL, GREYMOUTH

CADFILE 08828-7to9 SCALES (A3) 1:100 DRAWING No. 08828-7

REV.

GEOTECHNICAL INVESTIGATION - CLINOMETER CROSS SECTIONS





APPENDIX 2
Geotechnical Logs

Proje		SULTAN and Geold	TS -	Riley ( 4 Fred Th Takapuna Tel: 09 4 Fax: 09 4	nomas D a, AKL 897872	rive	its L		4:									11-1			TF	<b>2 </b> 7	LOC		
	mouth	Flood	l					Loc: Gre												osition: of stopbank				10.:	
Job N		828			t Date sh Da					Grou	ınd Le	evel	(m):		Co	o-Ord	dinate	es ():					T	P1	
Clier Go	nt: ood Ea	ırth Ma	atters	I								e De	epth:		.1								Sheet:	of 1	
Elevation (m )	Depth (m)	Soil Desc strength; qualificat qualificat Rock Des strength;	cription: sub moisture at ions; weath ions; additions cription: weadditional of	Geolo cordinate, condition; quering of co conal struct veathering description	gical praticle s grading; t lasts; sul ture; (GE g; colour; n, (GEOL	Description of the control of the co	Cripi AJOR ; plast te qua IC UN ; fabri UNIT)	tion , minor; licity; se lification IT). c and or	colour nsitivit ns; min ientatio	, structu ty; major nor on; NAM	re; Fedend		HW Weathering SW UW	Field Soil Skip Skip Skip Skip Skip Skip Skip Skip		-	1		, orier	Description ntation, spacing, ersistence aperture, illing etc)		Samples	-	Γests	
	-	inclusi	race clay ons up to	, very la 300mm	rge anç nø	gular li	mest	one bo	oulder	r	X	X X											No. 1 1, 2, 1, 2, 2, 1, 3, 2, 3, 4, 20		
	0.70	mediui graded greywa		se gravi stic, gra	elly SAI vels an	ND; mi	inor o	cobble:	s, gre inded	y, well	X	X											No. 2 2, 1, 2, 1, 1, 2, 2, 2, 2,		
	2	EOH (	ฏ 1.00 m																				2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2		
	- - - - - - - - 3																								
	-																								
	4    																								
	-5																								
SKET	ГСН:								T			<u> </u>	<del>                                      </del>							MAP					
   -   -		00.7m	  -  -  -  -  -  -  -  -  -	 		- X - *	LTY		X						       	-+ + +				)					
	+ -  - + -  - + -  - L -  - + -  -			4	¥-+	18-A			30	¥:	STPI	 			       	- † - + - + - +									0 m
Shorin	g/Supp	ort:									Sample			G	ROU	JNDW	/ATEI	R	_	None			Remar	ks	1:100
Stabili		A		В	<b>↑</b>		<b>■</b>	U100 Perme Schm Insitu P=Pe: UTP=	Undi: eabilit idt Ha Vane ak, R Unab	sturbe ty Test ammer Shea =Residule to p	r Stren	ole gth (l		PI	SI Ra T TE	low S apid I	eep ( nflow NATE depth	depth (dept) D DU	th )	)					
All dir		ons in e 1:50	metres															Ī		Shear Vane N	 10.	Lo	gged by:	Chec	ked by

	Engineers	LEY 4	Riley Consultan I Fred Thomas Drive Fakapuna, AKL Fel: 09 4897872 Fax: 09 4897873								PI	r LOC	
Proje Grey		Flood		Location Greym						position: obank			No.:
Job N		328	Start Date: 1 Finish Date:	7-09-09	Grou	nd Level	(m):	Co-Ordin	nates ():			Т	P2
Clien Go		rth Matters	L			Hole De 1.00 m						Sheet: 1	of 1
Elevation (m)	Depth (m)	Soil Description: sub strength; moisture or qualifications; weath qualifications; additio Rock Description: w strength; additional or	Geological Descondinate, praticle size, Mandition; grading; bedding; ering of clasts; subordinat onal structure; (GEOLOGIe athering; colour; texture; lescription, (GEOLOGIC U	Cription  AJOR, minor; cold; ; plasticity; sensitive qualifications; no UNIT). c UNIT). ; fabric and orients JNIT).	our, structure ivity; major ninor ation; NAME	Legend	듩	I Strength  Rock		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	-	Tests
	- - - - - 0.60		inor clay, minor large									No. 1 0, 1, 1, 1, 0, 1, 2, 2, 5, 2, 0, 0,	
	- 1.00		rounded greywacke ເ ionally up to 300mmຄ		illy up to	X						1, 5, 2, 3, 3, 6, 3 No. 2 1, 1, 1, 2, 3, 3,	
	-2 -3 -4 -5	EOH @ 1.00 m										2, 2, 3, 4, 7, 8, 6, 5, 6, 6, 5, 5, 5	
SKET				Omim TO	SANI SANI sturbed Sisturbed Sisturbed S	ample ample		EAST		MAP  None		Remar	0 m 10 m 20 m 1:1000 ks
D		A C	H B ↓	<ul><li>✓ Permeab</li><li>✓ Schmidt I</li><li>✓ Insitu Var</li><li>✓ P=Peak,</li><li>UTP=Una</li></ul>	ility Test Hammer ne Shear R=Residi able to pe	Strength (k ual,		Rapid Infl IT TERMINA X Target de	ow (dept	TO: Flooding  Machine limit			
All dir		ons in metres e 1:50								Shear Vane No	).   Lo	ogged by: MJB	Checked by

Enginee	SULTANTS	4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873								WF1/14/E-19	T PI	T LO	3
Project: Greymout	h Flood		Location Greymo							le position: /estern end good	shed	I	No.:
Job No.:	9828	Start Date: 17 Finish Date:	7-09-09	Grour	nd Lev	/el (m):		Co-Ord	dinates (			٦	<b>P</b> 3
Client: Good E	arth Matters				Hole 3.70	Depth:						Sheet:	of 1
Elevation (m) Depth (m)	Soil Description: sul strength; moisture of qualifications; weath qualifications; additi Rock Description: v strength; additional	Geological Desci bordinate, praticle size, MA. condition; grading; bedding; hering of clasts; subordinate ional structure; (GEOLOGIC weathering; colour; texture; f description, (GEOLOGIC U	ription IOR, minor; colour, plasticity; sensitivity qualifications; min UNIT). abric and orientatio	, structure, y; major or on; NAME	Legend	cw cw HW Weathering Sw Uw		Strength Rock ເຂື່ອ≅ຫລືພື	(tvi	efect Description  pe, orientation, spacing, ness, persistence aperture, infilling etc)	Samples		Tests
- 0.30	[EII I ] condy Ci	RAVELS; mixed with co			X	#0120J	>0L0>						
- 0.90		s up to 300mmø, light g	rey										
- 1 - 1.20	gan 40mm room	d chip, angular, dark bro	own		X							No. 1 0, 1, 2,	
1.70	80mmø to <20n	trace to minor rounded nmø, light brown	greywacke grav	vels,	X							2, 2, 3, 5, 5, 4, 5, 4, 4, 5, 2, 2,	
-2	moderately plas 500mm across grey/brown whit	y, trace sand, yellow/ora stic, minor - some grave (greatest dimension) gr te	els & boulders u									5, 20	
2.50		eenish grey, angular limest dimension	— — — — — nestone boulder	 rs									
-3					X								
3.70					$\boxtimes$								
-4 5 5													
SKETCH:								_	_ L _ l	MAP			
													0.10.1
-	-		- <del>   -  </del> - <del>   - +</del>	_			<u> </u>	_ _					20 r
Shoring/Supp Stability:	ort:	B T	Schmidt Ha Insitu Vane P=Peak, R= UTP=Unabl	rbed Sa turbed S y Test mmer Shear S Residua e to per	mple Sample Strengthal, netrate	ı (kPa)		Rapid Ir TERMIN Target o	eep (dept nflow (de NATED DI depth	pth )  JE TO:  Flooding		Remar	1:10
	С		Scala Penel	trometer	r - blow	s/50mm		Refusal		Machine limit	<u>                                     </u>		Γ
	ons in metres e 1:50									Shear Vane N	lo. Lo	ogged by: MJB	Checked

CONS Engineers	ULTANTS T	Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873								TEST	「PI⊺	r LOG	j
Project: Greymouth	Flood		Locati Greyn							position: I of good shed		N	lo.:
Job No.: 09	328	Start Date: 'Finish Date:	17-09-09	Grour	nd Lev	vel (m):		Co-Ordi	nates ():			Т	P4
Client: Good Ea	rth Matters				Hole 3.70	Depth:						Sheet:	of 1
Elevation (m ) Depth (m)	Soil Description: subc strength; moisture cor qualifications; weather qualifications: addition	Geological Descordinate, praticle size, Mindition; grading; bedding bring of clasts; subordina nal structure; (GEOLOGieathering; colour; texture escription, (GEOLOGIC)	AJOR, minor; colo ; plasticity; sensit te qualifications; r IC UNIT).	our, structure tivity; major minor tation; NAME	Legend	RS CW HW Weathering SW UW		Strength    Rock	(type,	ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	7	Tests
0.30		me coal and rounde			X	#OIZOD	>0E0>	ĪS≷≅o,>₩				▼ No. 1 1, 2, 20	
- - - - - 1 1.10	generally no coa cobbles, grey, no greywacke	al, medium to coarse on plastic, gravels ar	gravelly SANI nd cobbles are	D; minro rounded									➤ PSD test
-2 2.10	boulders up to 30	, trace sand, minor li 00mm across, occas , orange and light gre	ionally up to 5	600mm,								No. 2 1, 1, 1, 1, 6, 3, 3, 2, 6, 7, 3, 5, 3, 8, 4, 9, 4, 3, 7, 4	
	course SAND; m and cobbles	ninor to some rounde	d greywacke ς	gravels								V	
-3 - - - - - - 3.70													
-5	EOH @ 3.70 m												
SKETCH:	PRTH   -   -   -   -   -   -   -   -   -		AND &	X   X			2.4m	SOUTH -		MAP			0: 10: 20: 1:10
Shoring/Supp Stability:	ort:			sturbed Sa		L I	GF	ROUNDWA	ATER	None		Remarl	
<b>—</b>	A	 ] <sub>B</sub>	U100 Ur  ☐ Permeat  ☐ Schmidt  ☐ Insitu Va  ☐ P=Peak,	ne Shear R=Residu	Sample Strengt	th (kPa)	PI	Rapid In		th )			
)	С	<b>」</b>		nable to pe enetromete				Refusal	- F	Machine limit			

	LEY ULTANTS	Riley Consultants 4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873	LIU							TES	T PI	T LOC	è
Project: Greymouth	Flood	4,000	Locatio							e position: st end good shed	4	١	No.:
Job No.:	828	Start Date: 17- Finish Date:			nd Lev	vel (m):	T	Co-Ord	inates ():		4	Т	P5
Client:	rth Matters	Tillisti Date.			Hole 3.90	Depth:	1					Sheet:	of 1
Elevation (m) Depth (m)	Soil Description: sul strength; moisture c qualifications; weath qualifications: additi	Geological Descri bordinate, praticle size, MAJO condition; grading; bedding; pla nering of clasts; subordinate q onal structure; (GEOLOGIC U weathering; colour; texture; fat description, (GEOLOGIC UNI	R, minor; color asticity; sensitivualifications; m	ur, structure vity; major ninor ation; NAME	Legend	RS CW HW Weathering SW UW	Field S	-	(type	ect Description orientation, spacing, ss, persistence aperture, infilling etc)	Samples		Tests
- - - 0.40	[FILL] medium t grey, non plstic	to coarse gravelly SAND , gravels and cobbles are	; coal, minor e rounded gr	r cobbles, reywacke	$\boxtimes$		20,100						
- 0.65	silty gravelly SA graded, rounde	AND; gravels are fine to o	coarse grain	 ed, well									
- 1 1.10 - - - -	generally dark t		nø, coal inclu	usions,	X								
-2	sandy gravelly s	medium brown, no coal  — — — — — — —  SILT; minor clay, angular ders up to 700mm across	to subangu	 ılar									
2.20	SAND; medium rounded greywa	grained gravels and bou acke gravels, grey, non pels with silty weathered m	ılders, mino	kts of	X X								
- 2.90 - 3 	grained, rounde	light medium grey, grave d greywacke, occasiona ingular limestone cobble	I rounded gr	reywacke	0								
-4	EOH @ 3.90 m												
SKETCH:		1 1 1 1	<u></u>	L_L	1-1		<del>                                     </del>			MAP	<u> </u>		
						     			- <del> </del> - <del> </del>             -	-			
						 	- <del> </del>   -   -   -   -   -   -   -   -   -		- <del></del>				0
	+-+- -					 			- <del> </del>	_			20 1:10
Shoring/Suppostability:	A		Small Dis Large Dis U100 Und Permeabi Schmidt H Insitu Van P=Peak, I UTP=Una Scala Per	turbed Sa disturbed lity Test Hammer ne Shear R=Residu able to pe	ample Sample Strengthual, netrate	n (kPa)		Rapid In	ep (depth flow (dep ATED DU	th )		Remar	ks
	ns in metres 1:50							. wiusai		Shear Vane N	Lo	ogged by:	Checked

Project: Greymouth F Job No.: 0982 Client: Good Eart			Location	on.									
Job No.: 0982 Client: Good Eart			Greym							position: st of stopbank		1	No.:
Client: Good Eart		Start Date: 17- Finish Date:			d Lev	/el (m):		Co-Ordina				T	P6
	U- <b>N</b> 4 - U -					Depth:						Sheet:	
	G	Seological Descri	ntion		0.75		T			PARTY IN THE CONTRACT OF THE C	<u> </u>	1 T	of 1
Elevation (m ) Depth (m)	Soil Description: subo strength; moisture cor qualifications; weathe qualifications; addition Rock Description: we strength; additional de	prdinate, praticle size, MAJO ndition; grading; bedding; pla ring of clasts; subordinate q nal structure; (GEOLOGIC U bathering; colour; texture; fat escription, (GEOLOGIC UNI'	PR, minor; color asticity; sensitivualifications; m JNIT). oric and orienta T).	ur, structure; vity; major ninor ation; NAME;	Legend	RS CW HW Weathering SW UW	Field Str	·		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples		Tests
0.30	SILT; minor clay, greywacke grave	trace to minor sand, m	ninor rounde	d	$\bigotimes$								
- 0.75	medium to coarse plastic, gravels a	e gravelly SAND; mino nd cobbles are rounded	r cobbles, gr d greywacke	rey, non	$\triangleright$							No. 1	✓ PSD test
-3	EOH @ 0.75 m											0, 1, 0, 1, 1, 1, 20 No. 2 1, 1, 1, 1, 20	
SKETCH:	NORTH	TP6 - + -	GRAVEL	 	CK					MAP			,
i		0.3m \$IL	T; MINC	R CLA	1   1   1   C	AP							10
						 	<u> </u>		_				20 1:10
	A	I I I V V	Small Dist Large Dist U100 Und Permeabil Schmidt H Insitu Van P=Peak, F UTP=Una	turbed Sal disturbed S lity Test Hammer de Shear S R=Residua dble to pen	mple Sample Strengthal, netrate	ı (kPa)	PIT	OUNDWATI Slow Seep Rapid Inflor FERMINAT Target dep	(depth w (deptl	TO:		Remar	
All dimensions	s in metres		Scala Per	ieu ometer	WOIG -	s/oumm		Refusal		Machine limit Shear Vane No.	1.	ogged by:	Checked

(a) Depth (a) Depth (b) Control (c) Contro	rth Matters  Soil Description: sub strength; moisture co qualifications; additional description: we strength; additional description: we strength; additional description: we strength; additional description: we obtain the coarse plastic, gravels addrk brown tops i.e. wood	Start Date: Finish Date: Finish Date:  Geological Des ordinate, praticle size, h ordinate, praticle size, h ordinate, praticle size, h ordinate, praticle size, h ordinate, bedring bedring of dasts; subordinal structure; (GEOLOX easthering; colour; texture description, (GEOLOX see gravelly SAND; n and cobbles are rou soil stained layer with see gravelly SAND; n and cobbles are rou	Scription MAJOR, minor, co ng, plasticity, sens rate qualifications; GIC UNIT), rer, fabric and orier UNIT). minor cobbles, unded greywach th trace organic	lour, structure titivity; major minor tration; NAME grey, non ke	Hole 0.8	vel (m):  Depth 5 m  Significant with the second control of the se		-	Defe	dle of stopbank		Sheet: 1	No.:  P7  of 1  Fests  ✓ PSD tes
Client: Good Ear  Good Ear	rth Matters  Soil Description: sub strength; moisture co qualifications; additions; additions; additions; additions; additional description: we strength; additional description: we strength; additional description; additio	Geological Des Ordinate, praticle size, N. Ordinate, Sederal S	Scription MAJOR, minor; co mg, plasticity; sens nate qualifications; GIC UNIT), re; fabric and orier C UNIT). minor cobbles, unded greywach th trace organic	lour, structure titivity; major minor tration; NAME grey, non ke	Hole 0.8	Depth 5 m	Field Stre	ength	Defe	orientation, spacing, s. persistence aperture.		Sheet: 1	of 1
(m) 10.40 - 0.65 - 0.65 - 0.85	Soil Description: sub strength; moisture or qualifications; weath qualifications; additio Rock Description: w strength; additional d medium to coars plastic, gravels a dark brown tops i.e wood	ordinate, praticle size, hordinate, praticle size, hordinary, bedding; bedding of dasts; subordinanal structure; (GEOLOX ereathering; colour; textur description, (GEOLOXIC see gravelly SAND; nand cobbles are rouse) stained layer with second stained layer with second stained layer with second second stained layer with second secon	MAJOR, minor, co ng, plasticity, and ng, plasticity, and GIC UNIT). re; fabric and orier c UNIT). minor cobbles, unded greywach th trace organic	grey, non ke material,	T	RS C C C C C C C C C C C C C C C C C C C		-	(type, c	orientation, spacing, s. persistence aperture.	Samples	T No. 1	rests -
- 0.40	dark brown tops i.e wood  medium to coars plastic, gravels a	se gravelly SAND; rand cobbles are rouseil stained layer with	minor cobbles, unded greywack	grey, non ke material,			SOCOSTA	<b>≥0</b>				T No 1	✓ PSD tes
- 0.85	i.e wood  — — — — —  medium to coars plastic, gravels a		- — — — — minor cobbles,	 arev. non								T No 1	✓ PSD tes
-3	plastic, gravels a	se gravelly SAND; n	minor cobbles, unded greywaci	grey, non ke								1, 1, 2, 2, 3, 3, 4, 5, 20	
-3	EOH @ 0.85 m												
KETCH:				+						MAP			1:
	A C	H B 1	Large Di U100 Ur Permeat Schmidt Insitu Va P=Peak, UTP=Un	isturbed Sa isturbed Sa ndisturbed so bility Test Hammer ane Shear S , R=Residu nable to per	ample Sample Strengt ial, netrate	th (kPa)	SI R	JNDWAT Slow Seep Rapid Inflo ERMINAT Target dep	o (depth ow (depth FED DUE	۱)		Remark	

		ULTANTS	4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873	•							TES	T PI	T LOC	}
Project: Greymo		Flood		Location Greyn							e position: d stopbank track			No.:
Job No.	: 098	328	Start Date: Finish Date		Grou	nd Lev	el (m):	:	Co-Ordi	nates ()	:		T	P8
Client: Good	l Ea	rth Matters				Hole 0.75		:			,		Sheet:	of 1
Elevation (m )	Depth (m)	Soil Description: su strength; moisture of qualifications; weat qualifications; addit Rock Description: strength: additional	Geological Doubordinate, praticle size condition; grading; bed thering of clasts; subontional structure; (GEOL weathering; colour; tex description, (GEOLOG	escription  a, MAJOR, minor; cold ding; plasticity; sensiti dinate qualifications; r OGIC UNIT). ture; fabric and orient alic UNIT)	our, structure ivity; major ninor ation; NAME	Legend	Rs CW HWW WWW Weathering SW UW		trength Rock ≶≳≋ຶ∞≌≌		fect Description a, orientation, spacing, case, persistence aperture, infilling etc)	Samples	-	Tests
	0.30	medium to coa	rse gravelly SAND and cobbles are r	; minor cobbles, q	rev. non		¥O£≥65	)	S≷≅øÿ₩				No. 1 1, 3, 3, 10, 20 No. 2	
	0.60 0.75	SILT; trace to r	minor clay, brownis staining	h orange, orange	and								1, 2, 1, 3, 5, 12, 20	
<u>-</u> 1		medium to coa plastic, gravels	rse gravelly SAND and cobbles are re	; minor cobbles, g ounded greywack	rey, non									
Ē		EOH @ 0.75 m	1											
-2														
-3														
-														
Ē														
-4														
-														
-5 -5														
-														
-										·				
SKETCH	<b>1</b> :		_   _   _   _	TP8	<u> </u>	1-1		 	_ _  _		MAP			
	NÓR	RIP RAI	B+-+- -	+-+-	+  - 	<del>- -+</del>	_	+-+	- -+-	<del>                                      </del>				
-					{	↓ SIL	_T;	RACE	SAND TO	-				
	-					) 		DR CL	AY   					
	- -  -		)		<del>+ -</del> GF       - -	<b>?AVE</b> ∄ │	L¥ -S/   	4ND +   	- - + - 	- <del>   -</del> - <del>   -</del>				
_ _ -	_ _						<u> </u>			-   _   _				
Shoring/S	uppo	ort:		Small Dis	sturbed S	ample			OLINDA(A	TED			Remar	1
Stability:   <b>⋖</b>	, IF .		<del>-  </del>	Large Dis	sturbed S disturbed	ample		GR	OUNDWA		None None		Remai	
		Α	<b>T</b>	<ul><li>Permeab</li><li>▼ Schmidt I</li><li>✓ Insitu Val</li></ul>	Hammer	Strength	ı (kPa)	PIT	Rapid Inf		í			
		-	В ↓	P=Peak, UTP=Un: ▼ Scala Pe	able to pe	enetrate	s/50mm	X	Target de	_	Flooding  Machine limit			
		ns in metres	s						1 Ciusai	L	Shear Vane N	o. Lo	ogged by:	Checke
		1:50											MJB	

CONSULTANTS Engineers and Geologists  4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873									1	TEST PIT LOG				
Project: Location: Greymouth Flood Greymouth			nd Level (m): Co-Ordina  Hole Depth: 0.90 m					Hole position: Middle of stopbank track ates ():			No.: <b>TP9</b>			
							linates ()							
										Sheet: 1 of 1				
Elevation (m )	Soil Description: su strength; moisture of qualifications; weath qualifications; additi Rock Description: v strength; additional	Geological Describordinate, praticle size, MAJ condition; grading; bedding; phering of clasts; subordinate ional structure; (GEOLOGIC weathering; colour; texture; fix description, (GEOLOGIC UN	ription OR, minor; colo clasticity; sensit qualifications; r UNIT). abric and orient	our, structure ivity; major ninor ation; NAME	Legend	RS CW HW WW WW WW WW		Strength   Rock	(type	fect Description c, orientation, spacing, sss, persistence aperture, infilling etc)	Samples	-	Tests	
0.30		rse gravelly SAND; grey			X	#0£≥#5	>0E5	E≶≹≦øĕŬ						
- 0.75 - 0.90	medium to coal	rse gravelly SAND; mine and cobbles are rounde	or cobbles, g ed greywack	rey, non e		<b>4</b>						No. 1		
1  	silty TOPSOIL :	staining, dark brown										1, 4, 3, 2, 3, 3, 7, 5, 20		
-	pockets of tops	oil/silty material, predon	ninantly grav	elly sand	1							7, 5, 20		
-3	EOH @ 0.90 m													
-4														
SKETCH:		_		<u> </u>	<u> </u>	L _ L .	<u> </u>	_ _	_	MAP				
													0	
<u> </u>	<u> </u>	- + -	-  -		<u> </u>		<u> </u>	_i_ +	_				20 1:10	
Shoring/Support: Stability:  A  Small Disturbed Sa Large Disturbed Sa U100 Undisturbed Sa Permeability Test Schmidt Hammer Insitu Vane Shear S P=Peak, R=Residu UTP=Unable to per Scala Penetromete					ample Sample  Slow Seep Rapid Inflo Strength (kPa) Ial, netrate  X Target dep				eep (depti nflow (dep IATED DU	oth) JE TO: ] Flooding		Remar	ks	
	С	7	Joura I E		J. DIOV	.5,5011111	1 1	Refusal	1	Machine limit	11			

RILE CONSULTAN Engineers and Geolo		Ltd					TES1	ГРІТ	LOG	}
Project: Greymouth Flood		Location: Greymouth					ole position: Above concrete stop	hank wa		lo.:
Job No.: 09828	Start Date: 17-		nd Lev	el (m):	Co	-Ordinates		Dank Via		<b>P10</b>
Client: Good Earth Ma			Hole I 0.90	Depth:					Sheet:	of 1
Elevation  (m) Soil Description  (m) Characteristics Soil Description Soil Description Soil Description Soil Description Soil Description Strength : Soil Description Stre	Geological Descri ption: subordinate, praticle size, MAJC oisture condition; grading; bedding; pla ns; weathering of clasts; subordinate q ns; additional structure; (GEOLOGIC L ription: weathering; colour; texture; fall dittional description, (GEOLOGIC UNI	DR, minor; colour, structure asticity; sensitivity; major jualifications; minor JNIT)	=:	Rs CW HW Weathering SW Uw	Field Stren	, th	Defect Description  rpe, orientation, spacing, iness, persistence aperture, infilling etc)	Samples	-	Гests
- mediun	to coarse gravelly SAND; mino gravels and cobbles are rounde	r cobbles, grey, non	X	ΩΟΙΣΌ⊃	>0L0>I>≶≥0					
SILT; n	inor clay, minor sand, dark brow	vn topsoil staining								➤ PSD test Proctor test
-23										
SKETCH:    LARGE   LIN			ILIT; T INIT;	ORI-CI		IDWATER  w Seep (dep	11		Remark	10 m 10 m 20 m 1:1000
A C	B I V	Permeability Test Schmidt Hammer Insitu Vane Shear P=Peak, R=Residi UTP=Unable to pe Scala Penetromete	ual, enetrate		PIT TEI	pid Inflow(de RMINATED E get depth { fusal	· '			
All dimensions in n Scale 1:50	netres						Shear Vane No	D. Lo	gged by:	Checked by:

	ULIANIS	Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873									) I PI	T LOC	j
Project: Greymouth	Flood		Locati Greyn							e position: ddle of stopbank	track	1	No.:
Job No.: 09	828	Start Date: 18 Finish Date:	3-09-09	Grour	nd Lev	vel (m):		Co-Ordi	nates ()	:		T	P11
Client: Good Ea	rth Matters				Hole 0.5	Depth: 5 m	:			Politica		Sheet:	of 1
Elevation (m) Depth (m)	Soil Description: su strength; moisture of qualifications; weatl qualifications; additi Rock Description: v strength; additional	Geological Describordinate, praticle size, MAJ condition; grading; bedding; phering of clasts; subordinate ional structure; (GEOLOGIC weathering; colour; texture; description, (GEOLOGIC Ut	ription IOR, minor; coloblasticity; sensit qualifications; r UNIT). fabric and orient NIT).	our, structure ivity; major minor ation; NAME	Legend	RS CW HW HW WW SW UW	Field S			fect Description e, orientation, spacing, ess, persistence aperture, infilling etc)	Samples		Tests
0.20	medium to coa	rse gravelly SAND; min and cobbles are round	or cobbles, o	rey, non	X	601283	>0ш0>1	>>20/>W					
- 0.55	dark brown stai	 ining, trace silt										No. 1 1, 1, 2,	
-1-2	EOH @ 0.55 m											4, 3, 4, 10, 5, 10, 10, 10, 10	
SKETCH:										MAP			0 m 10 m 20 m 1:100
Shoring/Supp Stability:	A C	►   I	Large Dis U100 Und Permeab Schmidt I Insitu Var P=Peak, UTP=Und		ample Sample Strengtl Ial, netrate	h (kPa)		DUNDWA Slow See Rapid Inf TERMINA Target de	ep (depti flow (dep	oth )		Remar	

Engi		JLTANTS nd Geologisi	⊃ Te	d: 09 4	ia, AKL 489787: 489787	2															1 F	IT LO			
Project: Greymo	uth	Flood							atior eymc									H	lole	position:				0.:	
lob No.:	098	28			rt Da ish D			09-09	9	Grou	und	Leve	el (m	1):		Co-	Ordii	nates	():				TF	<b>212</b>	
Client: Good	Ear	th Matte	ers						I			ole [		h:		-						Sheet		of 1	
(m)	Depin (m)	Soil Descript trength; moi qualifications qualifications Rock Descrip trength; add	Gion: subor sture con ; weather ; addition otion: wei itional de	rdinate idition; ring of dial struct athering	gica, praticle grading clasts; seture; (Cg; color, (GE)	l Des e size, l g; beddir subordir GEOLO ur; textur OLOGIO	SCrip MAJOF ng; pla: nate qu GIC UI re; fabi C UNIT	otion R, minor; sticity; se alificatio NIT). ric and o	; colour, ensitivit ons; min	, structu y; majo nor on; NAM	ire; ΛΕ;	Legend	cw HW Weathering		Field S	_			type, o	ct Description rientation, spacing, persistence aperture, infilling etc)	Somolog	200	Т	ests	
-	0.10	medium to	o coarse	e grav	elly S/	AND; r	minor	cobble	es, gre		Z		YOIS	Ø⊃   >	-Ø⊑Ø>:	⊆> <b>≶</b> Σφ	>w					No. 7 1, 2, 2, 2, 7, 20	2, 2,	✓ PSD te	est
	A A	SILT; trac gravels ar plastic	e to mir nd angu	nor cla	iy, trac neston	e to m	ninor i	rounde oulders	d greys, grey	wacke , non	,	1										No. 2 1, 1, 3, 3, 10, 6 11, 8	2 2, 4, , 8,		
		medium to	o coarse avels ar	e grav	elly S/ obles a	AND; r	minor unded	cobble greyw	es, gre vacke	y, non												8, 6, 4, 9, 3, 3,	5, 5,		
-		EOH @ 0	.65 m									- 1		- 1											
-2 - -																									
-																									
-3												- 1													
-																									
-4 -																									
-																									
-5																									
-																									
-																									
KETCH		LIME	STON	JF	<u> </u>	TP1	12		_	NC	) RTI	_	- -		_	- -	<u> </u>	<u> </u>	 	MAP					
		S/BOL					     				-	- <del> </del>		-		- -	1	<u>.</u>	   						
-	- -   - -	4-+		<del> </del>	1	  x -	  x=	1 X 1	<del>/</del>	   <u>\$</u>	- 31 <del>1.</del> ∏;	RAY TF		- 1	4A <del>2</del> + 07	IÐ   	+-	-	   						
	-1/2		*	<u> </u>					-	- GI	AI RAVI	ELL.	7	<del>-</del> - T		- -	<u> </u>	<u> </u>	 						
<u> </u>	-  -	<del></del>	-	<u> </u>  -	+-		-		- +			- †	-	- <del> </del>	-	- -	-								
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horing/S tability:	uppo	rt:			1		•			urbed					GF	ROUN	DWA	TER		None		Re	mark		=
<del> </del>			-	l			Ī	U100 Perm	Undi: eabilit	urbed sturbe ty Tes	d Sar t	nple				-		ep (de low (d							
		Α		В	<b>T</b>		^ •	Insitu	Vane	amme Shea =Resi	r Stre	ength	(kPa	)		TER	MINA	TED	•	TO:					
				Ь	Ţ					ole to p		ate			X	Tar	get de	epth		Flooding					
					1		V	Scala	Pene	etrome	ter - I		/50m	ım		Ref	usal			Machine limit					

The strengt qualific Rook B. (FILL non ) root:  - 0.80  - 1	Start Date: Finish Date	escription e, MAJOR, minor, dings plasticity, se dindrate qualification. CGIC UNIT). Atture; fabric and or GIC UNIT).	colour, structur nsitivity; major ns; minor ientation; NAMI	Hole 3.70 e; puebel	athering	Co-Ordii Field Strength	nates ():	osition: een two bridges	Sheet:	No.: <b>TP13</b>
O9828  Client: Good Earth M  OODENAL Soil Destrengt qualific quali	Geological D  Geological D  secription: subordinate, praticle size th: moisture condition; grading; becations; weathering of clasts; subco- ations; weathering of clasts; subco- ations; weathering; colour, te- th; additional description, (GEOLO  I] medium to coarse gravelly plastic, gravels and cobbles and organic debris inclusion  ium to coarse silty gravelly S plastic, gravels and cobbles	escription e, MAJOR, minor, Iding, plasticity, se dinate qualification LOGIC UNIT).  VSAND; minor of are rounded gr	colour, structur nsitivity; major ns; minor ientation; NAMI	Hole 3.70 e; puebel	Depth: ) m	Field Strength	Defect			
Good Earth M  Soil De Strengt qualific qualific qualific process of the strengt pro	Geological D secription: subordinate, praticle siz th; moisture condition; grading; bec ations; weathering of clasts; subo secription: weathering of clasts; subo secription: weathering; colour, te th; additional description, (GEOLO  ] medium to coarse gravelly plastic, gravels and cobbles and organic debris inclusion ium to coarse silty gravelly S plastic, gravels and cobbles	e, MAJOR, minor; dding; plasticity; se dding; plasticity; se dding; plasticity kture; fabric and or GIC UNIT). ' SAND; minor of are rounded gr	ensitivity; major ns; minor nientation; NAM	3.70 e; pueben	athering m (	•			Sheet:	1 of 1
Strengt	secription: subordinate, praticle size, th: moisture condition; grading; becations; weathering of clasts; subo- cations: additional structure; (GEO) elescription: weathering; colour; tes th; additional description, (GEOLO additional description, (GEOLO additional description); (GEOLO additional description); (GEOLO additional description); (GEOLO and organic debris inclusion and organic debris inclusion additional descriptions; (GEOLO plastic, gravels and cobbles plastic, gravels and cobbles	e, MAJOR, minor; dding; plasticity; se dding; plasticity; se dding; plasticity kture; fabric and or GIC UNIT). ' SAND; minor of are rounded gr	ensitivity; major ns; minor nientation; NAM		ts SW WW Weathering SW JW	•			<del></del>	1 01 1
- 0.80 - 1 medi non plack - 1.50 - 2 organ steel - 2 - 2 - 3 organ steel - 3 organ steel - 3 organ steel - 4 to ha	_] medium to coarse gravelly plastic, gravels and cobbles and organic debris inclusion ium to coarse silty gravelly S plastic, gravels and cobbles	SAND; minor of are rounded gr	cobbles, grey	$\sim$		Soil   Rock	(type, orie roughness, pr inf	Description entation, spacing, ersistence aperture, filling etc)	Samples	Tests
- 1.50 organ steel - 2 - 2 - very steel - 3 - 3 - 3 - 3 - 3 - 4 - to ha	plastic, gravels and cobbles								No. 1 1, 1, 1 1, 1, 1 1, 1, 6 3, 2, 2 3, 3, 1 2, 2, 2	1, 6, 2, 1,
- 2.50 - very steel - 3 .30 - large - 3.70 - to ha		are rounded gr	bbles, grey, eywacke,						<b>V</b>	➤ PSD test
- very steel - 3 .3.30 - large - 3.70 - to ha	nic content, reducing with de Linclusions	epth, occasiona	l brick and							
- 3.70 large	large wood fragments inclus and brick inclusions	sions(up to 600	. — — — — mm across),							
- - - 4 -	angular limestone BOULDE	ERS		X						
- - - - -	ard to dig due to large limesto	one boulders/b	edrock							
SKETCH:								MAP		
		-	- <del> </del> <del> </del> - <del> </del> <del> </del> - <del> </del> <del> </del> - <del> </del> - <del> </del>	   		-   -   -   -   -   -   -   -   -   -	- <del>                                    </del>			
			- + -  - - + -  - - + -  -							1
		-+	_ + -  -							1:1
Shoring/Support: Stability:	<b>→</b>   B ↓	Large U100 Perm Schn Insitu P=Pe	Disturbed Se Disturbed Se Disturbed Se Undisturbed eability Test anidt Hammer Vane Shea eak, R=Resid=Unable to per Penetrome	Sample d Sample t r Strengt dual, benetrate	th (kPa)	=	ep (depth ) flow (depth  ATED DUE Tepth	11	Rer	marks
C All dimensions in		, , ,				l liveinegi	1 11	THE THE TENTE I		

RILEY CONSULTANTS Engineers and Geologists Engineers and Geologists Engineers and Geologists Riley Consul 4 Fred Thomas Driv Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873							TEST	· Pl	T LOG	•
Project: Greymouth Flood	Location Greymo						position: ween two bridges		N	o.:
Job No.: Start Date: 09828 Finish Date	: (		Level (m):		Co-Ordir				TF	P14
Client: Good Earth Matters	<u>v.                                    </u>		ole Depth: 3.00 m	1					Sheet:	of 1
Soil Description: subordinate, praticle size strength; moisture condition; grading; be qualifications; weathering of clasts; subordinate strength; moisture condition; grading; be qualifications; additional structure; (GEO Rock Description: weathering; colour; te strength; additional description, (GEOLO	Description  ze, MAJOR, minor; colour, dding; plasticity; sensitivity ordinate qualifications; mino LOGIC UNIT). skutne; fabric and orientation OGIC UNIT).	structure; y; major or on; NAME;	Legend RS CW HW Weathering SW UW	Field S	-		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	Т	ests
[FILL] medium to coarse gravelly non plastic, gravels and cobbles  1.30  1.50 sitty gravelly SAND; dark brown, and inorganic debris angular limestone boulders included in the plastic, gravels and cobbles are limestone boulders  3.00  EOH @ 3.00 m	y SAND; minor cobblet are rounded greywac greywac organic pockets, trace	es, grey, cke								
SKETCH:							MAP			0 m
							_			20 m
	-+			+ +-			1			~ 1:100
Shoring/Support: Stability:  A  D  C	P=Peak, R= UTP=Unab	urbed Sam sturbed Sa ty Test ammer Shear Str =Residual, ole to penel	pple ample rength (kPa)		,	ep (depth flow (dep	oth )		Remar	KS .
All dimensions in metres Scale 1:50				1 -	J		Shear Vane N	o. L	ogged by:	Checked b

CONSULTANTS	Riley Consultants Ltd 4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873							TES	T PI	ΓLOC	ì
Project: Greymouth Flood	Gre	ation: ymouth					Bet	position: ween two bridge:	S		lo.:
Job No.: 09828	Start Date: 18-09-09 Finish Date:	Grour	nd Lev	vel (m):		Co-Ordin	nates ():			TI	P15
Client: Good Earth Matters			Hole 5.00	Depth: ) m	•					Sheet:	of 1
Soil Description: sut strength; moisture or strength; additional o	Geological Description pordinate, praticle size, MAJOR, minor, pondition; grading; bedding; plasticity; se ening of clasts; subordinate qualification polal structure; (GEOLOGIC UNIT), reathering; colour; texture; fabric and or description, (GEOLOGIC UNIT).	colour, structure nsitivity; major ns; minor ientation; NAME	Legend	RS CW HW WW WW UW	Field Si	-		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	-	Гests
[FILL] SAND; sc brown, non plas	ome silt and rounded greywacke titic rootlets	gravels,		COSTION	SOUGST!	Ø					
are well graded boulder inclusio	trace silt, minor cobbles, gravels rounded greywacke, aungular lins, occasional silty band/pocket	mestone									
- medium grained inclusions	SAND; grey, occasional tree/wo										
-4											
EOH @ 5.00 m											
SKETCH: NORT	CZ CAND	SOME SOME VELLY VELLY LUVIAL SAND		0.3				MAP			0 10 20 1:1(
Shoring/Support: Stability:  A  C	☐ Large U100 ☐ Perme ▼ Schmi	Disturbed Sa Disturbed Sa Undisturbed Bability Test dt Hammer Vane Shear ak, R=Residu Unable to per	ample Sample Strengtl ial, netrate	h (kPa)	PIT	DUNDWAT Slow Seel Rapid Influ TERMINA Target de Refusal	p (depth ow (depti	h )		Remar	
All dimensions in metres Scale 1:50		2012 401			1 —			Shear Vane N	o. Lo	ogged by:	Checked

Engineers	LEY ULTANTS	Riley Consultants 4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873				···					ΓPI	r Loc	<b>;</b>
Project: Greymouth	Flood		Location Greym							position: ween two bridges	,	١	No.:
Job No.: 098	828	Start Date: 21- Finish Date:	-09-09	Grour	nd Lev	el (m):		Co-Ord	inates ():			TI	P16
Client: Good Ea	rth Matters	.1			Hole 3.80	Depth:	:					Sheet: 1	of 1
Elevation (m ) Depth (m)	Soil Description: sul strength; moisture c qualifications; weath qualifications; additic Rock Description: v strength; additional	Geological Descri bordinate, praticle size, MAJC condition; grading; bedding; planering of clasts; subordinate q onal structure; (GEOLOGIC L weathering; colour; texture; fal description, (GEOLOGIC UNI	ption  PR, minor; colo asticity; sensitir ualifications; m JNIT).  pric and orienta T).	ur, structure vity; major ninor ation; NAME	Legend	cw CW HW Weathering SW UW		trength Rock		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	-	Tests
- 0.50	[FILL] medium t non plastic, gra	to coarse gravelly SAND vels and cobbles are rou	; minon cobb unded greyw	oles, grey, vacke	X	101200	>00.00>1	2×20×ш					
-1	trace large sub: 1m in diameter,	angular limestone bould , occasional wood inclus	ers inclusion sions	ns, up to									
2.50 	plastic	e gravels, minor rounded		own, non	× × × × × × × × × × × × × × × × × × ×								
-4	3.60 m seepage	d SAND; grey, non plasti											
-5	EOH @ 3.80 m												
SKETCH:			L	L L						MAP			
													1:
Shoring/Suppostability:	ort:	1	Small Dis	turbed Sa	ample		GR	OUNDWA		None		Remarl	(S
-	A		U100 Und Permeabi Schmidt H Insitu Van P=Peak, I UTP=Una Scala Per	disturbed dity Test Hammer ne Shear S R=Residu able to per	Sample Strength ial, netrate	ı (kPa)	PIT	Rapid Int	ep (depth flow (deptl ATED DUE epth	۱)			
	ns in metres									Shear Vane No	T 10	gged by:	Checked

Engineers a	JLIANIS .	Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873	1								11	T LOG	7
oject: reymouth	Flood		Locati Greyr							e position: jacent sportsclub		N	10.:
b No.: 098	28	Start Date: 2 Finish Date:	1-09-09	Grou	nd Lev	vel (m):		Co-Ord	inates ():			TI	217
lient: Good Ear	th Matters	1		1	Hole 0.60	Depth:						Sheet:	of 1
(m ) Depth (m)	Soil Description: sut strength; moisture c qualifications; weath qualifications; additi Rock Description: w strenath; additional	Geological Descondinate, praticle size, MA condition; grading; bedding; lering of clasts; subordinat onal structure; (GEOLOGII veathering; colour; texture; description, (GEOLOGIC L	cription  JOR, minor; color  plasticity; sensite  qualifications; ic  UNIT).  fabric and orient	our, structur tivity; major minor tation; NAMI	Legend	RS CW HWW Weathering SW SW UW	Field S			fect Description , orientation, spacing, ss, persistence aperture, infilling etc)	Samples	-	Γests
- 0.20 - - 0.45	medium to coar	se gravelly SAND; mi and cobbles are roun	nor cobbles, o	grey, non	X	#0f≥65	<b>%</b> ∂⊑6531	≶≩≅øŸ₩					
- 0.60 - -	SILT; some lime	estone gravels, light o	range/brown,	non									
- 1 -	medium to coar plastic, gravels	se gravelly SAND; mi and cobbles are roun	nor cobbles, g ded greywack	grey, non (e									
	EOH @ 0.60 m			1 10 27 2	_								
-2													
-													
-3													
-4													
- - - 5													
-													
ETCH:	NORTH L	EAST		<u> </u>	<u> </u>				_	MAP			
_			GR	AVELL	Y SA	ND.O							
-+			\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	SILT			+ - +	- - + - - - + -	- <del>   -</del> 				
- - - - -						 	-	- -  - - -  -  - -  -	- <del> </del> -   -				
-+- <u> -</u>  - - -	<del>/</del>		- <del></del> -	+	-i	- ≃βR L	4VEL¦L' 	Y   SANI 	∪ <del> </del>	· <del>-</del>   · -			
-+	+-+- -	+-+-		+		 	<del>  -  </del>	_ - + -		-			
ring/Suppo pility:		<b>→</b>	Large Di	isturbed S isturbed S ndisturbed	ample	e	GR	Slow Se	ATER ep (depth	None n )		Remar	ks
	Α	· 7 <b>*</b>	Schmidt Insitu Va	bility Test Hammer ane Shear		:h (kPa)	PIT		nflow (dep				
	-	B ↓	UTP=Ur	, R=Resid nable to pe enetromet	enetrate		X	Target o	_	Flooding  Machine limit			
dimensio	ns in metres	3								Shear Vane No	D. L	ogged by:	Check

	SULTANTS ers and Geologists	4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873								TES	T PI	T LO	3
Project: Greymout	h Flood		Location							position: st of sports club			No.:
lob No.:	9828	Start Date: 2 Finish Date:		·	nd Le	vel (m):		Co-Ordin				Т	P18
Client:	arth Matters			<u>.                                    </u>	Hole 0.6	Depth:	L					Sheet:	of 1
<del></del>		Geological Desc	cription		1	T							01 1
(m ) Depth (m)	Soil Description: s strength; moisture qualifications; wea qualifications; add Rock Description: strength; additiona	subordinate, praticle size, M/condition; grading; bedding athering of clasts; subordinational structure; (GEOLOGI weathering; colour; texture al description, (GEOLOGIC I	AJOR, minor; colo ; plasticity; sensiti le qualifications; n C UNIT). ; fabric and orient; JNIT).	our, structure ivity; major ninor ation; NAME	Legend	RS CW HW HW WW SW UW	Field S	ŭ		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples		Tests
- 0.5	trace fine grav	ulders generally <400mi /els, trace sand, minor void infill	m in diameter v clay, predomin	with SILT; antly	$\bigotimes$								
	medium to coa	arse gravelly SAND; mi s and cobbles are roun	nor cobbles, g ded greywack	rey, non e	×								
- 1 - -	EOH @ 0.65 r	n											
-													
-2													
E													
-													
-3													
Ė													
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-4													
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-5 -													
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-													
КЕТСН:	NORTH	EAST			1		I _ L .		L LL	MAP			
			- <u>+</u>	<u>+ -                                   </u>			7/	<del>-</del>	 				
i-i-i i-i-i			SIL					-					
			\_\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\-\		1.1	G	 RAVEL	 _Y- SAN[	 				
		_   _   _				7-	<u> </u>	-					
  - - -							+ — + - 	- +   +	 	1			
<u> </u>	-4-1-	_   _   _   _	-  -	<u> </u>	<u> </u>		<u> </u>	<u> </u>	- -	-			
1-+-1		_ + - + -   - +		<del></del>	+-+		+-+-	- - + - <del> </del>					
horing/Sup tability:	port:		<ul><li>Small Dis</li><li>Large Dis</li></ul>	turbed Sa	mple			UNDWAT		None		Remar	ks
-	— ——— А	<b>→</b>	U100 Und  ✓ Permeabi  ✓ Schmidt F	lity Test	Sample	•		Slow Seep Rapid Inflo		1			
		∏ <sub>B</sub> ₹	<ul><li>✓ Insitu Var</li><li>P=Peak, I</li></ul>	ne Shear S		h (kPa)	PIT	FERMINAT	ED DUE	TO:			
	С		UTP=Una ▼ Scala Per	able to per	netrate	rs/50mm		Target dep Refusal	oth	Flooding  Machine limit			
II dimensi	ons in metre	s							$=$ $\frac{1}{1}$	Shear Vane N	0 1	ogged by:	Checke

3	RI CONS Engineers	LEY ULTANTS	Riley Consultan 4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873	iis <sub>,</sub> Liu							TEST	ΓPI	T LOC	3
Proje Grev	ect: /mouth	Flood		Location							position: rth fishermans wh	narf	١	No.:
Job N	No.:	828	Start Date: 2 Finish Date:			nd Le	vel (m):		Co-Ordi	nates ():	ar nonormano w		TI	P19
Clier		rth Matters					Depth: 5 m	:					Sheet:	of 1
Elevation (m)	Depth (m)	Soil Description: su strength; moisture q qualifications; weat qualifications; addit Rock Description: strength; additional	Geological Desi- bordinate, praticle size, M- condition; grading; bedding hering of clasts; subordina ional structure; (GEOLOG weathering; colour; texture description, (GEOLOGIC	Cription  AJOR, minor; colo  ;; plasticity; sensiti  te qualifications; n  IC UNIT).  ; fabric and orienta  UNIT).	ur, structure vity; major ninor ation; NAME	Legend	RS CW HW Weathering MW Weathering UW	Field St	9		ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	-	Tests
	- - 0.40		rse silty gravelly SAN avels and cobbles are											
	- 0.55 - - - - - 1	medium to coa plastic, gravels	rse gravelly SAND; m and cobbles are rour	inor cobbles, g nded greywacke	rey, non									
	-2													
	-3													
	- - - - - - - - -													
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SKE	гсн:	1 1 1	1 1 1 1	T 1						T T	MAP			
	+	- \$0UTH- E	EA\$T		1 1m	+		       ////	-	-				
  	                       	Y GRAVEL	LY SAND				CRA				- - - -			0 m
			-+-+-					;   _ ;   _ ; - ;		 - + - L _				20 m 1:100
Shorir Stabili	ng/Supp	oort:	→ B ↓	Small Dis Large Dis U100 Und Permeab Schmidt I VInsitu Var P=Peak, UTP=Und	sturbed S disturbed ility Test Hammer ne Shear R=Reside able to pe	ample Sampl Streng ual, enetrate	th (kPa)	PIT	Rapid Inf TERMINA Target de	ep (depth ilow (dept	h ) E TO: ] Flooding		Remar	ks
All di		ons in metre	S	▼ Scala Per	neu OMER	OIG - 15	พอเจบเทท		Refusal		Machine limit Shear Vane N	0. L	ogged by: MJB	Checked b

CONSULTA Engineers and Ge							TEST	PI	r Loc	è
Project: Greymouth Flo	od	Location: Greymouth					position: ove Fishermans w	harf	١	lo.:
Job No.: 09828	Start Date: Finish Date:	Groui	nd Level (	m):	Co-Ordi	nates ():	A Maria and a second		TI	P20
Client: Good Earth I	Matters		Hole De 0.70 m	pth:					Sheet:	of 1
Elevation (m) (m) Depth (m) State of a control of a contr	Geological Descr rescription: subordinate, praticle size, MAJ tht: moisture condition; grading; bedding; pr cations; weathering of clasts; subordinate cations; additional structure; (GEOLOGIC Description: weathering; colour; texture; fr th; additional description, (GEOLOGIC UM)	iption OR, minor; colour, structure lasticity; sensitivity; major qualifications; minor UNIT). abric and orientation; NAME	Legend	₩	eld Strength oil Rock	(type.	ect Description orientation, spacing, s, persistence aperture, infilling etc)	Samples	-	Гests
- (Top gen plas	osoil) gravelly silty SAND; rounded erally minor rounded graywacke co	greywacke gravels bble, dark brown, non		<b>₹</b> 85   %8	1565±5≥≥654					✓ PSD test
-1 EOH	H @ 0.70 m									
SKETCH:	OUTH EAST SIL-		ample		=	TER  ep (depth	· II		Remarl	0 r 10 r 20 r 1:10
С	B I		ıal, netrate		PIT TERMINA  X Target de	ATED DUE				
All dimensions in Scale 1:5							Shear Vane No	. Lo	gged by: MJB	Checked

CONSULTANTS Engineers and Geologists	4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873	····		P		****				ΓPI	ΓLOC	<b>.</b>
Project: Greymouth Flood		Location Greyn							position: st of stopbank		١	lo.:
Job No.: 09828	Start Date: 21 Finish Date:	1-09-09	Grour	nd Leve	(m):	(	Co-Ordin	ates ():			TI	P21
Client: Good Earth Matter	<u> </u>			Hole D 0.80 r							Sheet: 1	of 1
Elekation  (m)  Soil Description strength; moists qualifications; w qualifications; a qualifications; and strength; moists qualifications; a second strength; additional strength	Geological Descr subordinate, praticle size, MAJ re condition; grading; bedding; p eathering of clasts; subordinate ditional structure; (GEOLOGIC n: weathering; colour; texture; fa nal description, (GEOLOGIC UN	iption OR, minor; colo lasticity; sensiti qualifications; r UNIT). abric and orient	ur, structure vity; major ninor ation; NAME	Legend	ŧ	Field Str	-	(type, o	ct Description prientation, spacing, persistence aperture, infilling etc)	Samples	-	Гests
(Topsoil) gra	ivelly silty SAND; rounded nor rounded graywacke co	greywacke g	ravels		\$\$\$\$\$ \$\$\$\$\$\$	<u>%5€8%±</u> >:	<u>&gt;</u> ≊∞%∭					
0.80 medium to 0	oarse gravelly SAND; mine els and cobbles are rounde	or cobbles, g ed greywack	rey, non	//								
EOH @ 0.8	) m											
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		- <del> </del>	T -  -  -  -  - 		  - 	- † - - + -						20 1:1
Shoring/Support: Stability:	1		sturbed Sa	ample			UNDWA		None		Remar	ks
A	<b>→</b>	U100 Un Permeab Schmidt I	ility Test Hammer		_		Rapid Infl	p (depth ow (deptl	ו )			
	B ¥	P=Peak, UTP=Una	R=Residu able to pe	ıal, netrate		X	Target de	TED DUE	Flooding			
С		Scala Pe	netromete	r - blows/	o0mm	F	Refusal		Machine limit			

		SULTANTS and Geologists	Tel: 09	na, AKL 489787 9 489787	2			,									1 P	IT LO	ق
Proje Grey		Flood					Loca Grey	tion: mout	h						ole positic djacent c				No.:
Job N	No.: 09	828		art Da iish D		22-0				d Lev	el (m):	:	Co-Ordi					<b>⊤</b> ⊤	P22
Clier		rth Matters								Hole 1.80	Depth m	:						Sheet:	of 1
Elevation (m)	Depth (m)	Soil Description: si strength; moisture qualifications; wea qualifications; addi Rock Description: strength; additiona	ubordinat condition thering of tional stru weatheri	Ogica e, praticle ; grading f clasts; s ucture; (G ng; colou ion, (GEC	e size, M ; bedding ubordina EOLOG r; texture	AJOR, g; plast te qua IC UNI g; fabrio	ion minor; co icity; sens ifications T). and orie	olour, stru sitivity; m ; minor ntation; N	ucture; najor NAME;	Legend	Rs CW MW Weathering SW UW	Soil o	Strength   Rock		efect Desci pe, orientation, ness, persisten infilling etc	spacing, ce aperture,	Samples		Tests
	- 0.25		); minor	silt(top:	soil), ro	unde				X	<u>&amp;</u> OI≥65	5 × 3 × 3 × 3	<b>\$</b> \$₹øŸ₩						
	- -1 <sub>1.10</sub>	SILT; minor cla minor sand, lig roots, occasior	ht grey	and ora	ange, n	ywack on pla	e grave estic, tra	els, trac ice to m	e to ninor	$\bigotimes$									✓ PSD te
	- - - - 1.80	large limestone block, approxir	e BOUL nately 1	DERS, I.Om	occasio	onal la	arge co	ncrete											
	- -2 - - - - -	EOH @ 1.80 m	n																
	-3																		
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SKET	CH:		-	T					1			T T			MAP	•			
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horing tability	g/Suppo y:	А	<b>→</b>	<b>↑</b>			arge D J100 U Permea Schmidt nsitu V: P=Peak JTP=U	isturbe isturbe ndisturi bility To t Hamn ane Sh ane Sh nable to	ed Sar bed S est ner ear S esidua o pen	mple Sample trength al, etrate			OUNDWA Slow See Rapid Int TERMINA Target de	ep (dep flow (de ATED D	pth ) UE TO:	-		Rema	rks
		C ns in metres	. 1			<b>V</b> :	ocala P	enetror	neter	- DIOW:	s/50mm		Refusal	L	Machir	ne limit  ur Vane N		Logged by:	Checke

	CONS	LEY SULTANTS s and Geologists	Takap Tel: 0	d Thomas ouna, AKL 09 489787 09 48978	- 72												TES	T F	PIT	LOC	}
	mouth	n Flood						mouth		****					C	res	oosition: t of stopbank				lo.:
Job N		828		tart Da nish D		22-0	09-09	Grou	nd L	evel	(m):		Co-	Ordin	ates (	():				TP	23a
Clien Go		arth Matters								le D 60 n	epth: n								5	Sheet: 1	of 1
Elevation (m)	Depth (m)	Soil Description: s strength; moisture qualifications; wea qualifications; add Rock Description: strength; additions	Geo subordina conditional athering itional st weather al descrip	ologica ate, praticl on; grading of clasts; s tructure; (0 ering; color ption, (GE	al Des le size, M g; bedding subordina GEOLOG ur; texture OLOGIC	AJOR g; plas ate qua BIC UN e; fabri UNIT)	tion , minor; co ticity; sens alifications; IIT). c and orie	olour, structui sitivity; major ; minor ntation; NAM	re; Cud	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	WW Weathering		Strengt   Roc		(tv	pe, ori ness,	t Description lentation, spacing, persistence aperture, nfilling etc)		Samples	-	Гests
	0.60	SILT; trace cla greywacke gra	av. trac	e sand.	minor to	o som	ne round	ed	X	X											
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horing	/Supp	ort:				-	Small Di	isturbed S	amnle				ROUNE	) A ( A T	TED.			1		Remark	1.
tability	r:		_1			I	Large D	isturbed S ndisturbed	ample	•			_		c (dep	th)	None			TCIIIaii	\ <del>5</del>
		A	- -	<b>T</b>		<b>∓</b>	Permeal Schmidt	bility Test Hammer			_		Rapi	d Inflo	ow (de	epth	)				
			В	1			P=Peak	ane Shear , R=Resid	ual,		(Pa)	Pi	-	ΛINA⁻ et dep	TED D		TO: Flooding				
L	·····	С		<u> </u>				nable to pe enetromet			60mm		Refu		[	=	Machine limit				
		ns in metre	s												1474-474-4	T	Shear Vane N	lo.	Log	ged by: MJB	Checke

Signature   Section   Sect		LEY 4F Ta ULTANTS Te	Riley Consultants L Fred Thomas Drive akapuna, AKL al: 09 4897872 ax: 09 4897873	_td					TEST	PIT	LOG	<b>)</b>
Do No.: 08828   Start Date: 22-99-99   Ground Level (m):   Co-Ordinates ():   TP23b    Illiont   Cood Earth Matters   Hole Depth:   Sheet   1 of 1	Project: Grevmouth	Flood									N	lo.:
Good Earth Melters  Geological Description Set Decorption Section (as principle) Set Decorption Section (as	Job No.:			<del></del>	und Level (r	n):	Co-Ordi		ow road		TP	23b
A Semial Designation southern control and trace and a statuture of the sta	Client: Good Ea	rth Matters				th:						of 1
SETCH:    Small Standard Sample   Larger Delayford Sample   Larger Del	Elevation (m )	Soil Description: subor strength; moisture con- qualifications; weather qualifications; addition: Rock Description: wea- strength: additional de-	Geological Descrip rdinate, praticle size, MAJOR dition; grading; bedding; plas ring of clasts; subordinate que aal structure; (GEOLOGIC UN athering; colour; texture; fabri secription, (GEOLOGIC UNIT)	tion , minor; colour, structu ticity; sensitivity; majo alifications; minor IT). c and orientation; NAM	Legend san	Field	-	(type, o	orientation, spacing, s. persistence aperture.	Samples	Т	ests
CETCH:  ECH @ 0.00 m  ECH @ 0.00 m  ECH @ 0.00 m  A  Somitime Sample Large Disturbed Sample		gravelly silty SAN	ID (topsoil); rounded gre		2011	:05   Y0E 0X	I≶≅≅øÿ₩					
ETCH:  BOH @ 0.00 m  A  BOH BO 100 m  BOH BO	0.60	coarse grained gr	ravelly SAND; rounded of ded greywacke cobbles.	— — — — — greywacke gravels	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \							
KETCH:  Serior Disturbed Sample Large Disturbed Sample Permasability Test  A Particular Harmer	- 1 											
KETCH:  Serior Disturbed Sample Large Disturb	- - - -											
RETCH:    MAP	-2											
RETCH:    MAP	-											
RETCH:    MAP	-											
A  MAP   Small Disturbed Sample Large Disturbed Sample U100 Undisturbed Sample U100 Undisturbed Sample Large Disturbed Sample Large Disturbed Sample Schmidt Hammer  A  Remarks	-3											
A  MAP   Small Disturbed Sample Large Disturbed Sample U100 Undisturbed Sample U100 Undisturbed Sample Large Disturbed Sample Large Disturbed Sample Schmidt Hammer  A  Remarks	-											
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om	-											
Small Disturbed Sample Large Disturbed Sample U1000 Undisturbed Sample Large Disturbed Sample Slow Seep (depth ) Rapid Inflow (depth )	SKETCH:					_   _			MAP			
Doring/Support: ability:  A  Small Disturbed Sample Large Disturbed Sample U100 Undisturbed Sample  U100 Undisturbed Sample  Fermeability Test Schmidt Hammer  GROUNDWATER Slow Seep (depth ) Rapid Inflow (depth )			+ - <del> </del> -   -   -     -   -   -   -		-   -     -   -	- + - + 	· - - + -  - + -	- <del>   -</del> - <del>   -</del>				
Doring/Support: ability:  A  Small Disturbed Sample Large Disturbed Sample U100 Undisturbed Sample U100 Undisturbed Sample U100 Undisturbed Sample Fermeability Test Schmidt Hammer  GROUNDWATER None Remarks  Rapid Inflow (depth ) Rapid Inflow (depth )			<del> </del>	_   _   _		_   _	-   -	-  -  -				
Doring/Support: ability:  Small Disturbed Sample  Large Disturbed Sample  U100 Undisturbed Sample  Fermeability Test  Schmidt Hammer   GROUNDWATER  None  Remarks  Remarks				_   _   _		_   _		-   -   -	_			0 m
1:1000 A Small Disturbed Sample ability:  ■ Small Disturbed Sample		+-+-	+		-	- <del> </del> - <del> </del> - <del> </del>	·  + ·  +		-			10 m
Oring/Support: ability:  Small Disturbed Sample Large Disturbed Sample U100 Undisturbed Sample U100 Undisturbed Sample Fermeability Test Schmidt Hammer  GROUNDWATER None Remarks  Rapid Inflow (depth )		<u> </u>		_		_   _	· _   _   _					20 m
ability:  Large Disturbed Sample U100 Undisturbed Sample  U100 Undisturbed Sample  Permeability Test Schmidt Hammer  Rapid Inflow (depth )	Shoring/Suppo	ort:	•	Small Disturbed	Sample	G	SOLINDWA	TER	None		Remark	
A Schmidt Hammer	Stability:	- <del></del>	. I	Large Disturbed U100 Undisturbe	Sample d Sample		Slow See	ep (depth	)			
			<u> </u>	Schmidt Hamme Insitu Vane Shea	r ar Strength (kPa	a)   L	_					
P=Peak, R=Residual, UTP=Unable to penetrate  Scala Penetrometer - blows/50mm  Refusal  Machine limit			<b>J</b>	UTP=Unable to p	oenetrate	1 =	╡ ゛	epth	i I			
Il dimensions in metres Scale 1:50 Shear Vane No. Logged by: Checked by MJB		ns in metres							Shear Vane No.			Checked by

RILEY CONSULTANTS Engineers and Geologists	Riley Consultants Ltd 4 Fred Thomas Drive Takapuna, AKL Tel: 09 4897872 Fax: 09 4897873							TEST	ΓPI	T LOG	;
Project: Greymouth Flood	Loca Grey	tion: mouth						position: st of stopbank		N	lo.:
Job No.: 09828	Start Date: Finish Date:		nd Lev	vel (m):		Co-Ordin				TP	24a
Client: Good Earth Matters			Hole 1.00	Depth: 0 m						Sheet:	of 1
Soil Description: strength; moisture qualifications; we qualifications; add Rock Description: strength; additional	Geological Description ubordinate, praticle size, MAJOR, minor, condition; grading; bedding; plasticity; sen thering of clasts; subordinate qualifications itional structure; (GEOLOGIC UNIT) weathering; colour; texture; fabric and orie il description, (GEOLOGIC UNIT).	olour, structur sitivity; major s; minor entation; NAM	Legend	RS CW HW Weathering SW UW	Field Str	-	(type, c	ct Description orientation, spacing, , persistence aperture, infilling etc)	Samples	٦	ests
- 0.00	nd, minor silt, round greywacke grav		X	4		>20) / LL					
gravelly SANI <50mm in dia medium grey,	D; rounded greywacke gravels gene meter, trace rounded greywackey c non plastic	erally obbles,									
- 4 5 5 5											
SKETCH:								MAP			0 m 10 m 20 m 1:100
Shoring/Support: Stability:  A  C	Large I U100 U Perme Schmid Institut P=Pea UTP=L	Disturbed S Disturbed S Undisturbed S Indisturbed S Indist	Sample d Sample  Strengt lual, enetrate	th (kPa)	PIT	Slow Seep Rapid Inflor ERMINA Target dep Refusal	p (depth ow (deptl	n )		Remar	
All dimensions in metre Scale 1:50	es							Shear Vane N	o. L	ogged by: MJB	Checked by

	ject	:	Flood V	-	Fax: 03.379.4403  Geotech	Locatio	on: nouth, West	Coast			Но	le position:		No.:
	No	.:	828	vali	Start Date: 1 Finish Date: 1	3-10-09	Ground Le		IZ): (		dinates (l	NZMG): 12.0 N 5,86	ก 582 ก	DH1
	ent: Nes			ional			Hole	e Depth:			2,002,0	2.0 14 3,00	0,002.0	Sheet:
TRC	Run	Eluid & Water	pueber pu	Soill Minne grace qual qual geol Roce oriel Grey 2.500  Sanuta 4.00 trace 5.50 minne 5.50 minne 5.700 7.155 7.23	Geological Description: suborcor; colour, structure ding; bedding; plast lifications; weather lifications; minor quilogic unit. k Description: wea ntation; NAME; streety sandy fine GRAVEL.  O m - 2.95 m Medium to display the display of the displa	linate, partic strength; modern strength; modern sensitives and strength; modern sensitives and strength; modern sensitives and strength; color and strength; geological sensitives and strength; modern sensitives and streng	cle size, MAJOI poisture conditivity; major subordinate additional structure; fabgic unit.  VEL.  VEL.  VEL with some settence VEL with some settence velocities with some settence versilt and size or silt and size of silt and silt	on;  cture;  cric and  and and  cand and	Elevation (m LINZ)	(m) Hideo 2 3 4 5 5 6 7 8	2-3m SPT2-5m 3-4m SPT4.0m 4-5m 5-6m SPT5.5m 6-7m SPT7m 7-8m	SPT 2.50 m 2, 2, 2, 3, 3, 5; N = 13 SPT 4.00 m 3, 14, 12, 7, 7, 5; N = 31 SPT 5.50 m 4, 8, 6, 9, 6, 6; N = 27 SPT 7.00 m 7, 10, 11, 8, 8, 9; N = 36	HOROGON SON SON SON SON SON SON SON SON SON S	1 of 1
Ex	xpla	<b>2</b> ————————————————————————————————————	ns:	ЕОН	1 @ 10.00 m	D#4			-3.10	-10-	9-10m			

All dimensions in metres Scale 1:73 Contractor: CW Drilling & Investigation Ltd Rig/Plant Used: Hitachi Ex60 Multidrill Driller: Barclay Moir

Logged by: Checked by:

	Er	gineers	JLTANTS	Tel: 03.379.4402 ts Fax: 03.379.4403	T								<del>.</del>	
	oject eym		Flood V	Vall Geotech	Location Greym		West Coast			Ho	le position:			lo.:
Jol	o No		828	Start Date: 13 Finish Date: 13		Grou	nd Level (m Ll 6.40	NZ):		dinates (1 2,363,49	NZMG): 90.0 N 5,86	60,617.0	D	H2
	ient: Wes		ast Reg	ional Council			Hole Depth: 6.10 m						Sheet:	of 1
Туре	Run	Fluid & Water	Pregend	Geological Desci Soil Description: subord minor; colour, structure; grading; bedding; plastic qualifications; weatherin qualifications; minor qua geologic unit. Rock Description: weat orientation; NAME; strer Grey fine to medium GRAV (FILL)	inate, partic strength; m city; sensitiv g of clasts; llifications; a nering; colo ngth; geolog	noisture o vity; majo subordir additiona pur; textur gic unit.	condition; r rate al structure; re; fabric and	Elevation (m LINZ)	Depth (m)	Samples	Tests	Backfill / Piezometer		
TRC			0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Sandy GRAVEL with minor  2.50 m - 2.80 m (SPT core) sitty SAND. Moist  2.80 m - 2.90 m (SPT core) wet; low plasticity  3.20 m - 4.80 m Becomes	Dark grey m	noderately with trace	densely packed	+4.60	1 2 3	1-2m 2-3m SPT2.5m	SPT 2.50 m Self Pen. 225mm; 1, 1, 0, 0, 0, 0; N = 0			
TRC		15 \( \frac{1}{2} \)		4.00 m - 4.20 m (SPT core) 4.20 m - 4.30 m (SPT core) 4.30 m - 4.45 m (SPT core) 4.80 m - 5.40 m Becomes (	Boulder Sandy medi Sandy fine C	ium GRAV GRAVEL.		+1.00	4	3-4m SPT4.0m 4-5m	SPT 4.00 m 19, 7, 9, 6, 4, 3; N = 22			
				Angular chips of light brow	n mudstone (	(COBDEN	LIMESTONE)	+0.30	- - - - - - - - - - - - - - - - - - -	5-6m				
E 1 1 2 -	Wa Wa Ris	ter Ris e Time all Dist	ns: ke (1st, 2n e (1st, 2nd (minutes) urbed San urbed San	) and 500m	DH4	DH	1 <b>D</b> H	23	Ma	cated on ber			ot for SPT split spoo t, 3.5m off north ec	

3			LE ULTANTS and Geologis	395 CHF Tel:	ey Consultants Madras Street RISTCHURCH 8011 03.379.4402 : 03.379.4403								В	OF	RE	НО	LE LC	G
	oject evm		Flood V			Locati	ion: nouth, We:	st Coast				Hol	le positi	on:			N	lo.:
-	o No	).:	828		Start Date: 13- Finish Date: 14-	10-09		Level (m L 8.30	.INZ):	Co		 dinates (f 2,363,55			,610.0	)	D	H3
	ient: Wes		ast Reg	ional C	ouncil			ole Depth: 7.20 m									Sheet:	of 1
Туре	Run	Fluid & Water	Legend	Soil De minor; grading qualific qualific geologi Rock D	cological Descrip escription: subordin: colour, structure; st g; bedding; plasticit; ations; weathering ations; minor qualific ic unit. bescription: weathe tion; NAME; streng	ate, partice rength; n y; sensition of clasts; ications; ering; colo	noisture cond vity; major ; subordinate additional str our; texture; f	dition; ructure;	(FIN 1 m)	בופעמנוטוו (ווו בוועב)	Depth (m)	Samples	Tes	ts	Backfill / Piezometer			
TRC		28	8 2 8 2 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	Grey fin (FILL)  Sandy ( 2.60 m plasticit 2.80 m	GRAVEL with minor si - 2.70 m lens of organ y Becomes moist to were - 4.45 m (SPT core) God	L with som	ne sand and mi	JM) fibrous) silt, lo	- +3	20 -	-2 -3 -4 -4 -5 -5	1-2m 2-3m SPT2.5m 3-4m SPT4.0m 4-5m 5-6m	SPT 2.50 1, 0, 0, 1, N = 1 SPT 4.00 4, 11, 6, 10, 7; N =	0, 0; m 11,				
1 1 2	Wa Wa Ris	ter Ris e Time all Dist	ns: ke (1st, 2n e (1st, 2nd (minutes) curbed San turbed San	) and	MAP  0 m  500m 000 05:	DH4	DH1	υģ	H3 <b>€</b>	<u></u>	Mate	•	th edge of	road, 3	-	•	or SPT split spoo	•
Al	l din		ons in m e 1:48	netres	Contractor: CW Drilling &	Investig	gation Ltd		Rig/PI Hitach			d: Iultidrill		Oriller Barcla	: ay Moi	r	Logged by: AvD	Checked b

	_ C	ONS	ULTANT: and Geologis	5	CHRIST Tel: 03 Fax: 03		402	011									ьо	NE I	JUL	E LC	)G
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_	b No	).:	828		Sta	art D			10-09	9		nd Level 6.60	(m LIN	Z): (		dinates (I	NZMG): 1.0 N 5,86	1 372 0		D	H4
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			LIGHT TO G					escri	otion			10.40									01 1
Type	Run	Fluid & Water	Legend	mine grad qua qua geo Rod	or; col ling; b lificati lificati logic u k Des	lour, peddi ons; ons; unit. scripti	structing; p weath mino	ture; s lastici hering r quali weath	trength y; sen of clas fication ering; o	h; mo sitivi sts; s ns; a colou	oisture o ty; majo subordir additiona			Elevation (m LINZ)	Depth (m)	Samples	Tests	Backfill / Piezometer			
					/ fine to bles. M			GRAVE	L with s	some	sand an	d minor silt	and local		-1						
				1.20	m - 1.	.70 m	Bould	der (we	ak light	brow	vn mudste	one)			-1 2	1-2m					
		15 <u>±</u>	× × ×	San	— — dy GR	AVEL	with	— — minor s	— — ·	st to v	vet (ALLI	 UVIUM)	. — — —	+4.10	3	2-3m SPT2.5m	SPT 2.50 m 4, 3, 3, 1, 4, 3; N = 11				
		1 1 1	× · · · · × · · · · · · · · · · · · · ·												- 4	3-4m SPT4m					
0		<del>-</del>	× · · · × .													4-5m	SPT 4.00 m 2, 3, 3, 2, 3, 3; N = 11				
TRC			× · · · · · · · · · · · · · · · · · · ·												5	5-6m					
			×												6	6-7m					
			×	7.13 7.25	m - 7. m - 7.	.27 m .45 m	(SPT (SPT	core) (	andy G Coarse No reco	SAN	'EL d with mi	nor SILT			7	SPT7m 7-8m	SPT 7.00 m 4, 9, 16, 10, 9, 11; N = 46				
			×						S-144		4				8	8-9m	ODT 0.50				
			× · · · × .	8.62	m - 8.	71 m	(SPT	core) [	Cobble/ Dark gre No reco	ev silt	der ty SAND.	Wet			9	SPT8.5m	SPT 8.50 m 6, 6, 11, 8, 10, 6; N = 35				
SPT		<u>*</u>	°0 0 0	10.0	0 m - '	10.45	m (SI	PT core	e) Coars	se to	medium	GRAVEL		-3.85	10	9-10m SPT10m	SPT 10.00 m 2, 3, 5, 4, 5, 4; N = 18				
				EOH	1@10	).45 m	1								-11						
= 1	-	natio	ns: ke (1st, 2n	····		N 0 m	IAP	)	DH4					<u> </u>		marks terial descrip	otion is of drilled	tailings exc	cept for SI	PT split spoc	on core
	Wa Ris	ter Ris e Time all Dist	e (1st, 2nd e (1st, 2nd (minutes) curbed San turbed San	) ar ıple	d	1:50,000			-		DH	1		4	Loc roa		iately southwes	t of culvert	on Hill Qu	ay, Cobden	(south

APPENDIX 3

Laboratory Test Results



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www.fultonhogan.com 0800 LABORATORY

Report No: MAT:CAN09S-6040

Limits

## **Material Test Report**

Client:

Riley Consultants Ltd

PO Box 4355

Christchurch Mail Centre

Christchurch 8140

Project:

QA Testing - Aggregates



**Other Test Results** 

Description

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Jul/scal Approved Signatory: Max Burford

(Supervisor) IANZ Accreditation No:200 Date of Issue: 30/09/09

Method

Sample Details

Sample ID:

CAN09S-6040

Client Sample ID:

TP10 O/N 09828

Material:

Clay

Sample Source:

Miscellaneous Source

Site/Sampled From:

Greymouth Flood Walls TP10

Date Sampled:

18/09/2009

Specification:

No Specification

Sampled By:

Advised - See Comments

Sampling Method:

As Received - Not Accredited 30/09/2009

**Date Tested:** Technician:

Max Burford

Sampling Endorsed: No

## **Particle Size Distribution**

% Passing Sieve Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
75.0mm	100	0 - 100
63.0mm	93	0 - 100
37.5mm	87	0 - 100
19.0mm	83	0 - 100
13.2mm	81	0 - 100
9.5mm	78	0 - 100
6.7mm	77	0 - 100
4.75mm	75	0 - 100
2.36mm	73	0 - 100
1.18mm	72	0 - 100
600µm	70	0 - 100
300µm	66	0 - 100
150µm	62	0 - 100
75µm	57	0 - 100

Comments

N/A

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Page 1 of 1



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0800 LABORATORY

Report No: MAT:CAN09S-6043

Issue No: 1

## **Material Test Report**

Client:

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Christchurch 8140

Project:

QA Testing - Aggregates



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Ambus ow Approved Signatory: Max Burford

(Supervisor) IANZ Accreditation No:200 Date of Issue: 30/09/09

## Sample Details

Sample ID:

CAN09S-6043

Client Sample ID:

TP12 O/N 09828

Material:

Gravelly Sandy SILT Miscellaneous Source

Sample Source: Site/Sampled From:

Greymouth Flood Walls TP 12

Date Sampled: Specification:

18/09/2009 No Specification

Sampled By:

Advised - See Comments

Sampling Method:

As Received - Not Accredited

Date Tested: Technician:

30/09/2009 Max Burford

Sampling Endorsed: No

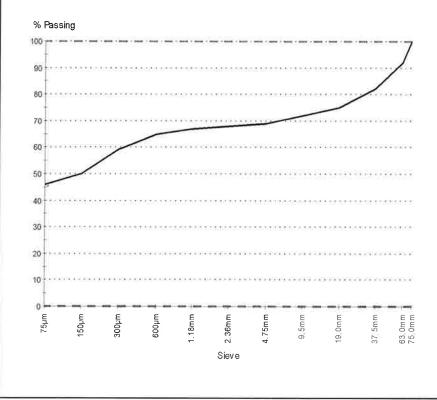
## **Other Test Results**

Description

Method

Result Limits

## **Particle Size Distribution**



Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
75.0mm	100	0 - 100
63.0mm	92	0 - 100
37.5mm	82	0 - 100
19.0mm	75	0 - 100
9.5mm	72	0 - 100
4.75mm	69	0 - 100
2.36mm	68	0 - 100
1.18mm	67	0 - 100
600µm	65	0 - 100
300µm	59	0 - 100
150µm	50	0 - 100
75µm	46	0 - 100
63µm	45	0 - 100

Comments

Sampled by Alan Williams Field Moisture Content = 20.7%



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Report No: MAT:CAN09S-6047

Issue No: 1

## **Material Test Report**

Client:

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PO Box 4355

Christchurch Mail Centre

Christchurch 8140

ΝZ

Project:

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Julocal Approved Signatory: Max Burford

(Supervisor) IANZ Accreditation No:200

## Sample Details

Sample ID:

CAN09S-6047

Client Sample ID:

TP 22 O/N 90828

Material: Sample Source: Sandy SILT

Site/Sampled From:

Miscellaneous Source

Greymouth Flood Walls TP 22

Date Sampled:

21/09/2009

Specification: Sampled By:

No Specification

Sampling Method:

Advised - See Comments As Received - Not Accredited

**Date Tested:** Technician:

30/09/2009 Max Burford

Sampling Endorsed: No

## Other Test Results

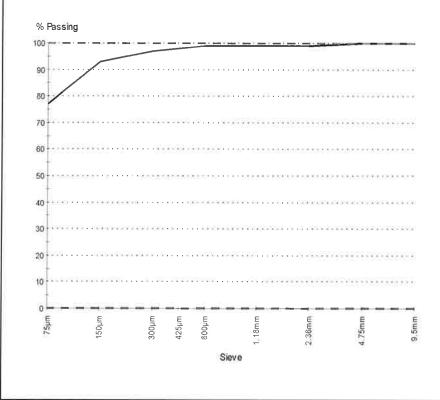
Description

Method

Result

Limits

## **Particle Size Distribution**



Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
9.5mm	100	0 - 100
4.75mm	100	0 - 100
2.36mm	99	0 - 100
1.18mm	99	0 - 100
600µm	99	0 - 100
425µm	98	0 - 100
300µm	97	0 - 100
150µm	93	0 - 100
75µm	77	0 - 100
63µm	70	0 - 100

Comments

Sampled by Alan Williams Field Moisture Content = 37.6%



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Report No: MDD:CAN09S-6040

# **Maximum Dry Density Report**

Client:

Riley Consultants Ltd

PO Box 4355

Christchurch Mail Centre

Christchurch 8140

Project: QA Testing - Aggregates



The test (s) reported herein (unless indicated) have been performed in accordance with the laboratory's scope of accreditation. Results only apply to samples as received. This report must be reproduced in full.

Approved Signatory: Max Burford

(Supervisor)
IANZ Accreditation No:200

Date of Issue: 30/09/09

Sample Details

Sample ID:

CAN09S-6040

Client Sample ID:

TP10 O/N 09828

Date Sampled:

18/09/09

Sampling Method:

As Received - Not Accredited

Date Tested:

30/09/09

Technician:

Max Burford

Material: Clay

**Material Source:** 

Miscellaneous Source

Sampled By:

Advised - See Comments Greymouth Flood Walls TP10

Sampled From: Specification:

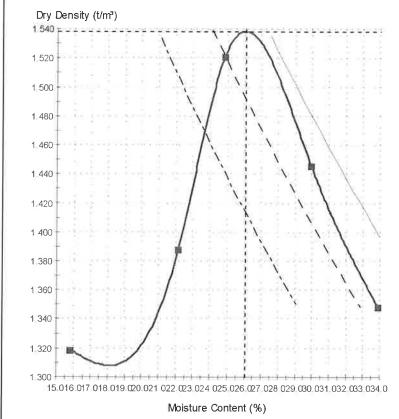
No Specification

Endorsed Sample?: No

## Dry Density - Moisture Relationship

0% Air Voids 5% Air Voids





## Test Results

NZS 4402:1986 Test 4.1.1

Maximum Dry Density (t/m³): Optimum Moisture Content (%): 26 Assumed Solid Density (t/m³): Oversize Sieve (mm): 19.0 Oversize Material (%): 17 Sample History: Natural

## Comments

As received moisture content = 33.8% Sorry about X axis - this computer system is a work in progress



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Report No: MAT:CAN09S-6045

Issue No: 1

## **Material Test Report**

Client:

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Christchurch 8140

NZ

Project:

Material:

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Approved Signatory: Max Burford

(Supervisor) IANZ Accreditation No:200 Date of Issue: 30/09/09

## Sample Details

Sample ID:

CAN09S-6045

Client Sample ID:

TP18 O/N 09828 Sandy Gravel

Sample Source:

Miscellaneous Source

Site/Sampled From:

Greymouth Flood Walls TP18

Date Sampled: Specification:

21/09/2009 No Specification

Sampled By:

Advised - See Comments

Sampling Method:

As Received - Not Accredited

Date Tested:

30/09/2009

Technician:

Max Burford

Sampling Endorsed: No

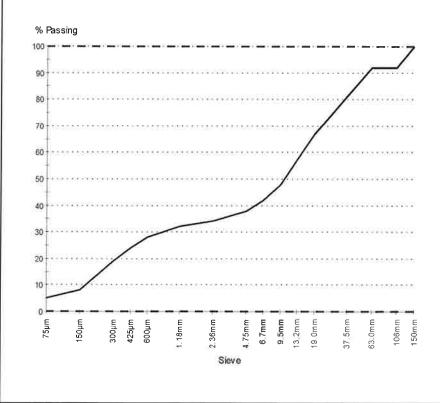
## Other Test Results

Description

Method

Result Limits

**Particle Size Distribution** 



Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	0 - 100
106mm	92	0 - 100
63.0mm	92	0 - 100
37.5mm	81	0 - 100
19.0mm	67	0 - 100
13.2mm	57	0 - 100
9.5mm	48	0 - 100
6.7mm	42	0 - 100
4.75mm	38	0 - 100
2.36mm	34	0 - 100
1.18mm	32	0 - 100
600µm	28	0 - 100
425µm	24	0 - 100
300µm	19	0 - 100
150µm	8	0 - 100
75µm	5	0 - 100

## Comments

Sampled by Alan Williams Field Moisture Content = 5.1%



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Report No: MAT:CAN09S-6041

Issue No: 1

Limits

## **Material Test Report**

Client:

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Christchurch 8140

ΝZ

Project:

QA Testing - Aggregates



**Other Test Results** 

Description

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Result

HMLJUSJOCO
Approved Signatory: Max Burford

(Supervisor)
IANZ Accreditation No:200
Date of Issue: 30/09/09

Method

## Sample Details

Sample ID:

CAN09S-6041

Client Sample ID: Material:

TP7 O/N 09828

Sample Source:

Sandy Gravel Miscellaneous Source

Site/Sampled From:

Greymouth Flood Walls TP7

Date Sampled:

17/09/2009

Specification: Sampled By: No Specification

Sampling Method:

Advised - See Comments As Received - Not Accredited

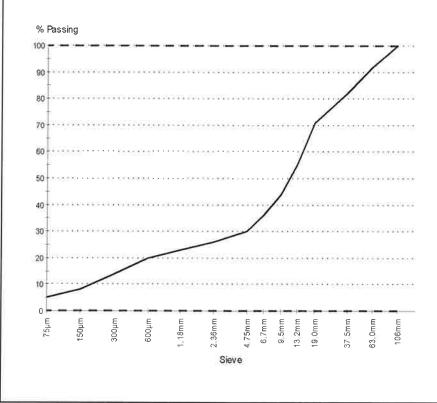
Date Tested:

30/09/2009

Technician: Ma Sampling Endorsed: No

Max Burford

## Particle Size Distribution



Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
106mm	100	0 - 100
63.0mm	92	0 - 100
37.5mm	82	0 - 100
19.0mm	71	0 - 100
13.2mm	55	0 - 100
9.5mm	44	0 - 100
6.7mm	36	0 - 100
4.75mm	30	0 - 100
2.36mm	26	0 - 100
1.18mm	23	0 - 100
600µm	20	0 - 100
300µm	14	0 - 100
150µm	8	0 - 100
75µm	5	0 - 100

## Comments

Sampled by Alan Williams Field moisture Content = 15.5%



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Report No: MAT:CAN09S-6042

Issue No: 1

0800 LABORATORY

# **Material Test Report**

Client:

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Christchurch Mail Centre

Christchurch 8140

ΝZ

Project:

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Justocal Approved Signatory: Max Burford

(Supervisor) IANZ Accreditation No:200 Date of Issue: 30/09/09

## Sample Details

Sample ID:

Client Sample ID:

TP11 O/N 90828

Material:

Sandy Gravel

CAN09S-6042

Sample Source: Site/Sampled From:

Miscellaneous Source Greymouth Flood Walls TP11

Date Sampled:

18/09/2009

Specification: Sampled By:

No Specification Advised - See Comments

Sampling Method:

As Received - Not Accredited

**Date Tested:** Technician:

30/09/2009 Max Burford

Sampling Endorsed: No

## Other Test Results

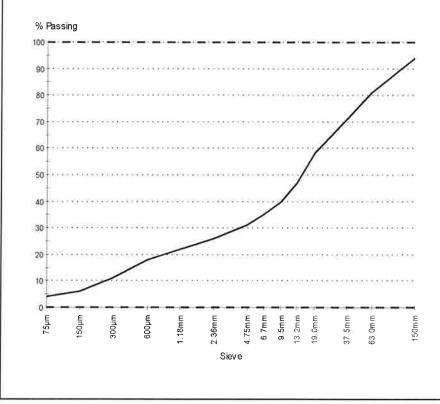
Description

Method

Result

Limits

## **Particle Size Distribution**



Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
150mm	94	0 - 100
63.0mm	81	0 - 100
37.5mm	71	0 - 100
19.0mm	58	0 - 100
13.2mm	47	0 - 100
9.5mm	40	0 - 100
6.7mm	35	0 - 100
4.75mm	31	0 - 100
2.36mm	26	0 - 100
1.18mm	22	0 - 100
600µm	18	0 - 100
300µm	11	0 - 100
150µm	6	0 - 100
75µm	4	0 - 100

## Comments

Sampled by Alan Williams Field Moisture Content = 4.5%



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Report No: MAT:CAN09S-6044

Issue No: 1

Limits

# **Material Test Report**

Client:

Riley Consultants Ltd PO Box 4355

Christchurch Mail Centre

Christchurch 8140

NΖ

Project:

Specification:

QA Testing - Aggregates



Other Test Results

Description

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Result

Approved Signatory: Max Burford

(Supervisor)
IANZ Accreditation No:200
Date of Issue: 30/09/09

Method

Sample Details

Sample ID: CAN09S-6044 Client Sample ID: TP4 O/N 09828

Material: Sand

Sample Source: Miscellaneous Source

**Site/Sampled From:** Greymouth Flood Walls TP4 **Date Sampled:** 17/09/2009

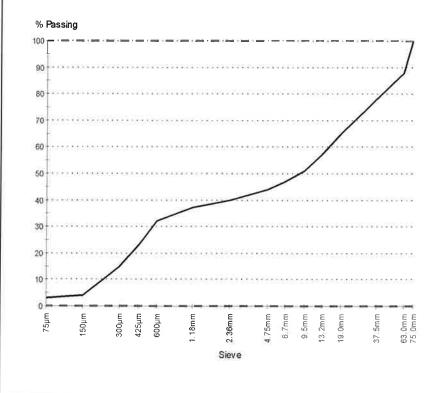
Sampled By: Advised - See Comments
Sampling Method: As Received - Not Accredited

No Specification

Date Tested:30/09/2009Technician:Max Burford

Sampling Endorsed: No

## Particle Size Distribution



Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size 75.0mm 63.0mm 37.5mm 19.0mm 13.2mm 9.5mm	% Passing 100 88 78 65 57	Limits 0 - 100 0 - 100 0 - 100 0 - 100 0 - 100 0 - 100 0 - 100
6.7mm	47	0 - 100
4.75mm	44	0 – 100
2.36mm	40	0 - 100
1.18mm	37	0 - 100
600µm	32	0 - 100
425µm	23	0 - 100
300µm	15	0 - 100
150µm	4	0 - 100
75µm	3	0 - 100

#### Comments

Field moisture content = 4.3%



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0800 LABORATORY

Report No: MAT:CAN09S-6046

Limits

## **Material Test Report**

Client:

Riley Consultants Ltd PO Box 4355

Christchurch Mail Centre

Christchurch 8140

Project:

QA Testing - Aggregates



**Other Test Results** 

Description

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Amsul ow Approved Signatory: Max Burford

(Supervisor) IANZ Accreditation No:200 Date of Issue: 30/09/09

**Sample Details** 

Sample ID:

CAN09S-6046

Client Sample ID:

TP20 O/N 09828 Sandy Gravel

Material: Sample Source:

Miscellaneous Source

Site/Sampled From:

Greymouth Flood Walls TP20

Date Sampled: Specification:

21/09/2009

Sampled By:

No Specification

Sampling Method:

Advised - See Comments As Received - Not Accredited

Date Tested: Technician:

30/09/2009 Max Burford

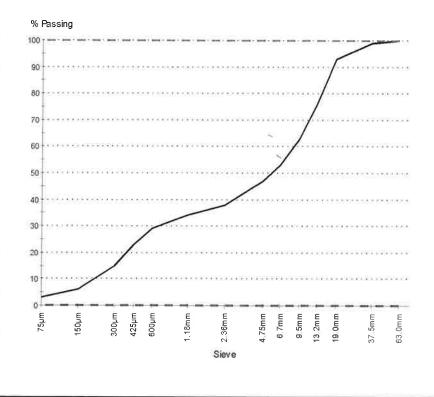
Sampling Endorsed: No

Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Method

## **Particle Size Distribution**



Sieve Size	% Passing	Limits
63.0mm	100	0 - 100
37.5mm	99	0 - 100
19.0mm	93	0 - 100
13.2mm	76	0 - 100
9.5mm	63	0 - 100
6.7mm	53	0 - 100
4.75mm	47	0 - 100
2.36mm	38	0 - 100
1.18mm	34	0 - 100
600µm	29	0 - 100
425µm	23	0 - 100
300µm	15	0 - 100
150µm	6	0 - 100
75µm	3	0 - 100

### Comments

Sampled by Alan Williams Field Moisture Content = 15.9%



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Report No: MAT:CAN09S-6048

Issue No: 1

Limits

## **Material Test Report**

Client:

Riley Consultants Ltd PO Box 4355

Christchurch Mail Centre

Christchurch 8140

ΝZ

Project:

QA Testing - Aggregates



**Other Test Results** 

Description

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Result

Approved Signatory: Max Burford

(Supervisor)
IANZ Accreditation No:200
Date of Issue: 30/09/09

Method

## **Sample Details**

Sample ID: Client Sample ID: CAN09S-6048

Client Sample ID: Material:

TP 13 O/N 90828 Sandy Gravel

Sample Source:

Miscellaneous Source

Site/Sampled From:

Greymouth Flood Walls TP 13

Date Sampled:

18/09/2009 No Specification

Specification: Sampled By:

Advised - See Comments

Sampling Method:

As Received - Not Accredited

Date Tested: Technician:

30/09/2009 Max Burford

Sampling Endorsed: No

· No

## **Particle Size Distribution**

 Method: NZS 4407:1991 Test 3.8.2

Drying by: Oven

Sieve Size	% Passing	Limits
63.0mm	100	0 - 100
37.5mm	95	0 - 100
19.0mm	86	0 - 100
13.2mm	73	0 - 100
9.5mm	65	0 - 100
6.7mm	59	0 - 100
4.75mm	53	0 - 100
2.36mm	45	0 - 100
1.18mm	37	0 - 100
600µm	28	0 - 100
300µm	19	0 - 100
150µm	11	0 - 100
75µm	7	0 - 100

#### Comments

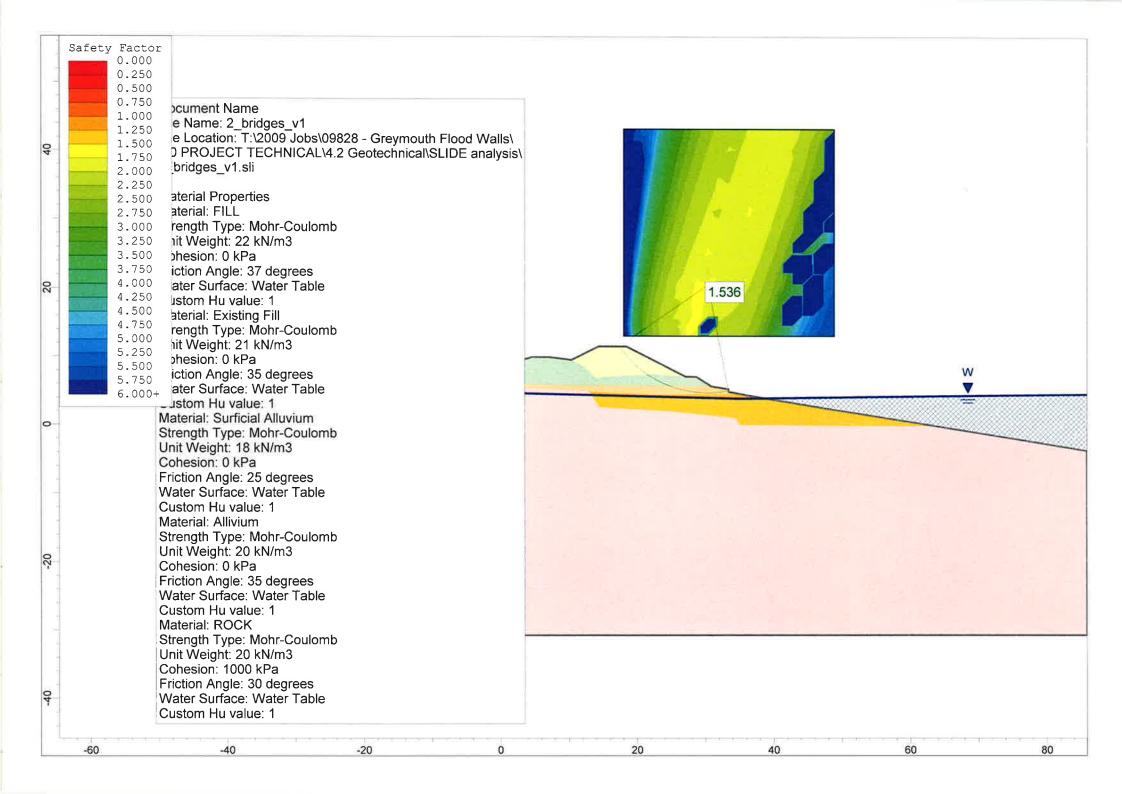
Sampled by Alan Williams - Field Moisture Content = 18.9%

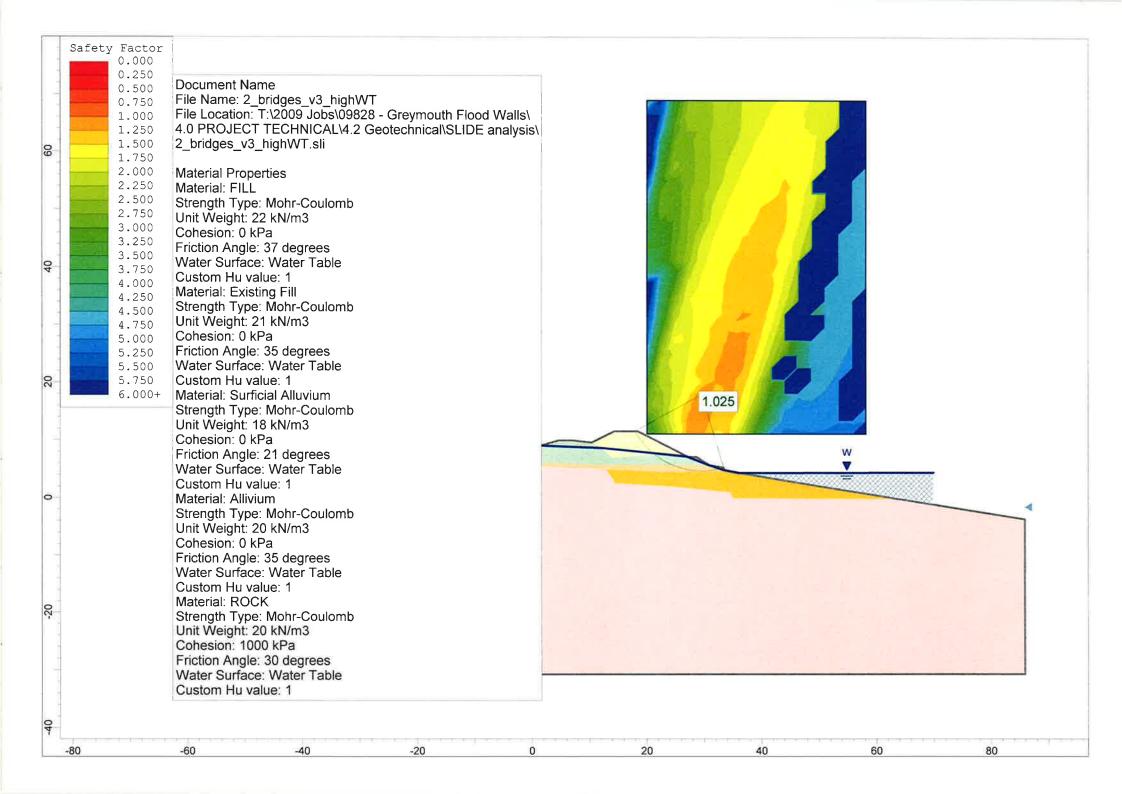
Estimated Total Coal Content of Sample = 46% (Calculated from 19.0mm - 4.75mm by mass )

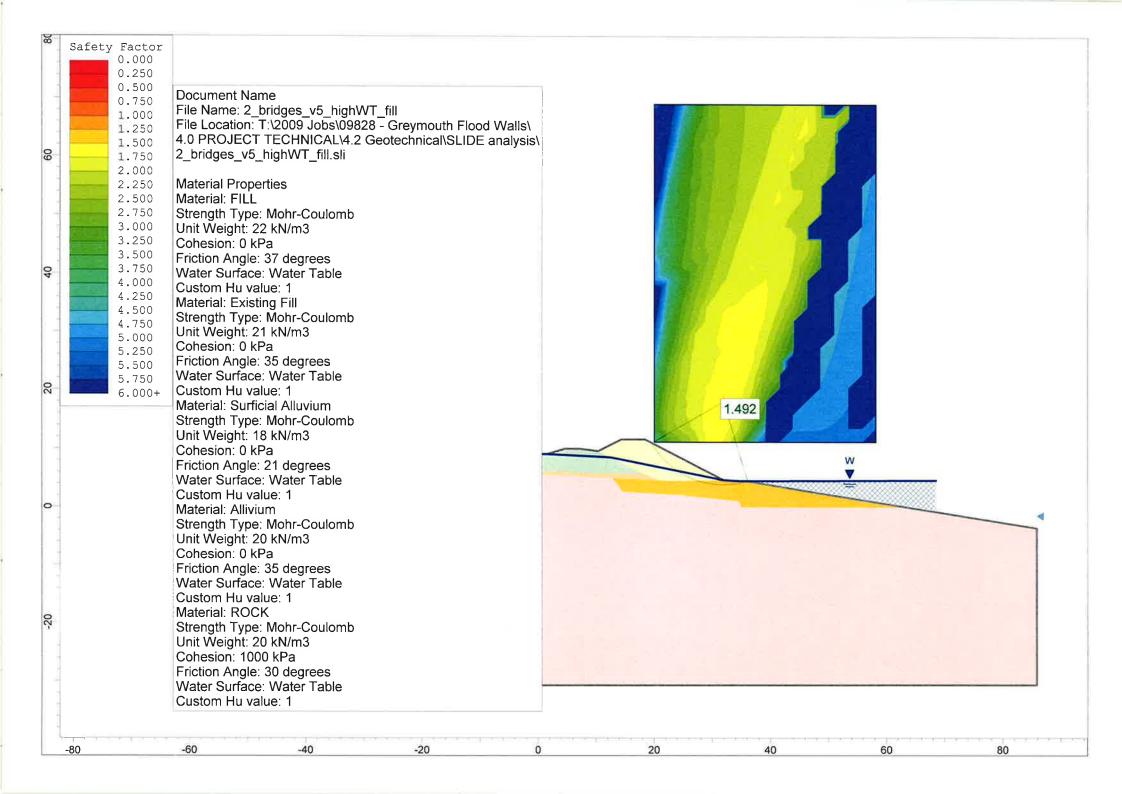
(minus 4.75mm fraction by bulk density)

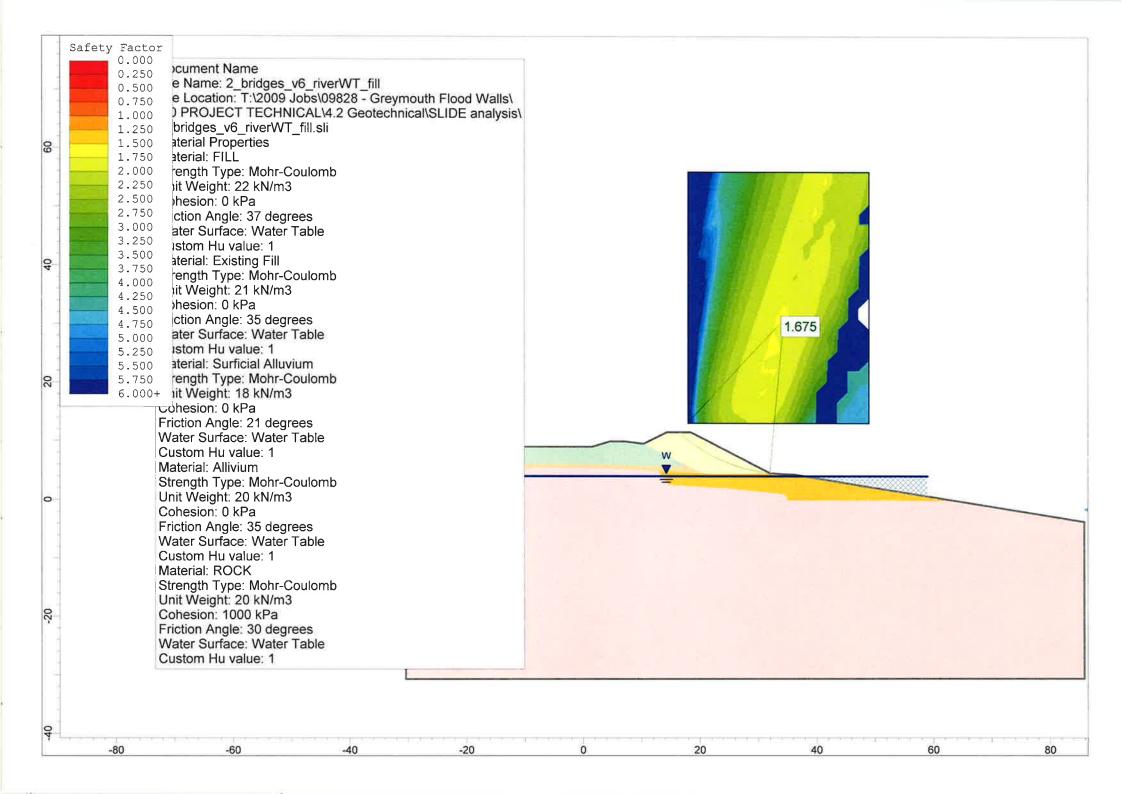
APPENDIX 4

Stability Assessment Printouts









APPENDIX 5

Construction
Specification Clauses

## **SECTION C: PROJECT SPECIFICATION**

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#### C.3 STOPBANK CONSTRUCTION – EARTHWORKS

### C.3.1 SCOPE

This section of the specification covers:

- All earthworks for the stopbank raising inclusive of fill materials brought from off site.
- Preparation of ground surfaces for filling and concrete structures.
- Temporary drainage.

### C.3.2 GROUND CONDITIONS

RILEY has completed a geotechnical investigation in new stopbank foundation areas and existing stopbanks where raising is to take place. The results of the ground investigation are presented in RILEY report 09828-A (attached). The contractor shall familiarise themselves with the contents of this report, which provides background information on soil types, groundwater and constructability aspects of the project.

### C.3.3 EXCAVATIONS AND PREPARATION FOR FILL

This work consists of excavation below the stripped surfaces until suitable foundations for placement of fill materials is uncovered and includes:

- removal of materials within the stopbank footprint for areas of new stopbank,
- preparation of existing stopbanks for placement of additional fill,
- preparation of existing stopbanks for construction of concrete flood walls.

## C.3.3.1 Clearing

All areas to be occupied by the permanent construction shall be cleared of all vegetation, such as grass, scrub, exposed roots, and any other organic material prior to stripping. Cleared materials shall be disposed of in dump areas to be designated by the Engineer.

## C.3.3.2 Stripping

Stripping refers to the removal from all areas subject to excavation or filling, of all organic material remaining after clearing, i.e. topsoil, peat and humus. These materials shall be removed to expose soil or rock containing insignificant amounts of organic material.

All significant volumes of topsoil shall be stockpiled for later re-use. Materials containing insufficient amounts of topsoil for practical separation shall be disposed of in dump areas to be designated by the Engineer.

## C.3.3.3 Drainage

All areas to be filled shall have effective surface drainage at all times. Temporary diversions or other suitable methods shall be utilised to keep surface and subsurface water away from the works area. All earthworks shall be carried out in the dry.

Any remedial work or extra excavation that could have been avoided by good drainage and sound earthwork practices shall be completed at no cost to the Principal.

## C.3.3.4 New Stopbank Foundations

## **C.3.3.4** (a) General

New stopbanks will be constructed in the Goods Shed, 2-Bridges and Cobden areas. Geotechnical investigations indicate undercut to varying extents will be required to provide a suitable foundation of stopbank fill. Final undercut profiles will be determined by the Engineer on site. Prior to any filling, the stopbank footprint will be exposed and inspected by the Engineer. The Contractor shall be responsible for maintenance of the approved surface until filling commences.

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### (b) Goods Shed

The new stopbank section is located within a previously reclaimed goods loading area. Recently the area appears to have been used to stockpile coal. It is anticipated that at least 0.5 m of undercut will be required to remove the disturbed upper layer of fill, which contains coal fragments and other deleterious material.

## (c) 2-Bridges

The new stopbank abuts the existing railway fill, and is located in an area of previously reclaimed riverbed. Geotechnical investigations indicate that 1 m to 3 m of fill overlies 1 m to 2 m of soft river sediment, which overlies 0 m to 2 m of dense granular river sediment, over bedrock. Where the new stopbank crest is to be more than 3 m above existing ground level, it is envisaged that the existing fill be removed along with the soft river sediment, and the stopbank founded on the underlying dense gravel. The deeper sub-excavations will be below the groundwater level (as well as the typical Grey River level), and Contractors shall also note extensive seepage occurs from the base of the rock bluff.

## (d) Cobden

The new stopbank will be founded on top of the existing stopbank/road embankment. It is anticipated that no undercut will be required to obtain a suitable fill foundation; however the existing road pavement should be removed, along with all grass, topsoil and soft fill materials associated with the existing small stopbank adjacent to the road.

## C.3.3.5 Preparation of Existing Stopbanks for Raising

Existing stopbanks to be raised by less than 200 mm shall be cleared of grass and/or vegetation along the crest, exposing topsoil free of grass, scrub, exposed roots, and any other organic material.

Existing stopbanks to be raised by more than 200 mm shall be cleared and stripped along the crest, exposing the underlying granular bank fill and low permeability river-side silty gravel capping layer.

### C.3.3.6 Preparation for Concrete Flood Walls

This applies to the proposed concrete flood walls in the Mawhera Quay and Fisherman's Wharf areas. The walls are generally located on the river-side of the stopbank, with their foundation keying into the existing silty gravel zone identified in the geotechnical investigation.

The specified wall foundation cut shall be made to the river-side portion of the stopbank, exposing the silty gravel zone. If the silty gravel zone is not exposed, additional excavation will be directed. Testing shall be completed by the Contractor on the exposed silty gravel zone to confirm material type, consistency, density and moisture content. Scarifying, moisture conditioning, and compaction of the in situ soil may be directed by the Engineer depending on the results of testing.

If the additional excavation is more than 200 mm below the design wall foundation level for a significant length, compacted type 2 earth fill may be used to bring the foundation to design level.

### C.3.4 FILL MATERIALS

### C.3.4.1 General

The stopbank fill materials shall be obtained from borrow areas off site.

## C.3.4.3 General Stopbank Fill (Type 1)

General stopbank fill shall be sourced off site. The material shall consist of a well graded sand/gravel mix conforming to the grading limits indicated in Table 1. The envelope is based on the envelope of tests on the existing stopbank material. In addition the d15 value shall be less than 0.7 mm to maintain filter compatibility with Type 1 material.

Table 1: Grading envelope for general stopbank fill (type 1 fill)

Particle Size (mm)	Percent Passing (%)
200	100
9.5	40 - 80
1.18	20 - 50
0.075	0 – 15

## C.3.4.4 Low Permeability Fill (Type 2)

River-side low permeability fill (where specified) shall be sourced off site from an appropriate quarry or borrow area. The material shall consist of well graded silt, sand and gravel mix of low permeability( or a silt/ sand mixture?). The envelope is based on the envelope of tests on the existing stopbank material. The particle size distribution after handling and placement shall conform to Table 2. If the material is produced by mixing two materials the contractor shall demonstrate to the Engineers satisfaction that effective mixing is obtained at all times. In locations where concrete structures will be in direct contact with type 2 fill (i.e. concrete flood walls) the maximum particle size shall be 20mm.

Table.2: Grading envelope for low permeability fill (type 2 fill)

Particle Size (mm)	Percent Passing (%) - General type 2 fill	Percent Passing (%) - Type 2 fill in contact with concrete structures
75	100	100
20	80 - 100	100
1.18	60 -100	60-100
0.075	35 - 85	35 - 85

## C.3.4.6 Filter Cloth and Riprap

Riprap is specified in a separate section of this specification. However, the following points should be observed where riprap is specified over type 2 fill on new sections of stopbank, and adjacent to new sections of concrete floodwall.

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Filter cloth shall be placed between riprap and the underlying soil to protect the stopbank fill and ensure it does not disperse into the riprap. Cloth joints shall be lapped 500 mm minimum. No material shall be permitted between the lapped sections of cloth. The cloth shall be placed without folds or wrinkles.

Where riprap abuts concrete structures, filter fabric shall be affixed to the concrete by battens or similar prior to placement of riprap. The fabric shall be in continuous contact with the underlying soil, requiring the overlying riprap to be sufficiently well graded to effectively hold it in place.

Riprap shall be placed in such a way that the underlying fabric is not damaged.

#### C.3.5 PLACEMENT AND COMPACTION OF FILL

#### C.3.5.1 General

Fill shall be placed to the lines and levels indicated on the drawings or otherwise instructed by the Engineer. The requirements for fill quality are specified in Section C.3.6.

Any material not complying with the specified requirements shall be removed at no cost to the Principal.

All bulk earthworks shall be carried out in fully drained conditions with no free water on the working surfaces. Cut and fill areas shall be sloped and graded adequately so that they do not pond stormwater, and drains shall be installed as necessary on a regular basis to deflect run off from the areas of operation or to drain ponded water as soon as ponds are seen to develop.

No fill shall be placed during periods of wet weather. In the event of fill operations ceasing in any area on account of wet weather or for more than two days for any reason, the Contractor shall obtain the Engineer's approval of the conditions of the fill surface before recommencing fill operations. The engineer may direct removal, conditioning or scarifying of all or part of the exposed sections of fill prior to earthworks resuming.

No new fill shall be placed over previously placed fill that has not achieved the required standard of compaction, has become contaminated, or has deteriorated from the required fill standards. Previously placed fill which does not comply shall be reinstated or removed at no cost to the Principal. Positive and effective drainage shall be maintained during filling operations to minimise deterioration of material exposed in the upper fill layers. Special care shall be taken to avoid hollows which could pond runoff.

The combined operations of spreading and compacting shall be undertaken using very systematic and properly managed procedures to the satisfaction of the Engineer, to ensure that the entire surface of each loose layer receives the specified minimum number of passes of the roller before further loose material is spread.

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The specified minimum number of passes shall apply even if tests indicate the compaction requirements are met with fewer passes. Compaction of all material shall be carried out using specialised compacting equipment, separate from that used for transportation.

## C.3.5.1 Placement and Compaction of Type 1 Fill

The fill shall be spread out in a uniform thickness layer. Loose layer thickness shall not exceed 200 mm.

Compaction of fill shall be carried out using a 10-tonne (static weight), smooth steel drum vibrating roller. Each fill layer shall be given at least four passes, even if compaction tests are met with fewer passes.

Where stopbank fill abuts sloping ground steeper than 18° (1V:3H), the natural ground or fill being filled against shall be keyed in. The horizontal width of the key shall be equal to the thickness of the compacted layer.

Prior to placement of the next lift, compaction tests in accordance with section 3.7 shall be carried out, and any areas found to be deficient repaired. All areas in which remediation of deficient fill has been necessary shall be re-tested in accordance with section 3.7 prior to additional fill being placed.

## C.3.5.5 Acceptance Standards for Fill

## **General Fill** (Type 1)

Deflection of the fill during a proof roll shall be less than 3 mm, and no weaving shall be permitted.

At the 2 Bridges location, type 1 fill shall also be subject to:

Minimum of 95% of optimum dry density as obtained from a Standard Compaction Test, and

maximum of 5% air voids averaged over 10 consecutive tests, and 7% on any one test.

### Low Permeability Fill (Type 2)

Minimum of 95% of optimum dry density as obtained from a Standard Compaction Test. and

maximum of 5% air voids averaged over 10 consecutive tests, and 7% on any one test.

#### C.3.5.6 Unsuitable Material

Unsuitable material shall be placed removed from the site, and disposed of by the contractor.

## C.3.5.7Topsoil and Grassing

Topsoil shall be placed on all stopbank batters and crests that will not be otherwise surfaced (i.e. roads). Topsoil shall be free of stones and vegetation or roots. It shall be placed with a minimum thickness of 200 mm, and be compacted via track rolling. Grassing is covered in a separate section of this specification.

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#### C.3.5.8Tolerances and Profiles

The construction tolerances for the project are defined elsewhere, however in relation to the type 2 fill zone located on the river-side of the stopbank, the dimensions indicated on the drawings are minimum dimensions. The type 2 fill material is permitted to extend up to half the total stopbank width, with the final thickness to be nominated by the contractor on the basis of material costs and anticipated construction methodologies.

#### C.3.6 QUALITY CONTROL

The Contractor shall appoint an experienced full time earthworks supervisor, whose duties shall include the control of filling operations in accordance with this specification.

The Contractor shall undertake sufficient tests on site to become thoroughly familiar with fill types and behaviour under compaction, and satisfy himself that the compacted fill meets the specified requirements.

All material control tests shall be carried out and paid for by the Contractor.

The testing shall be carried out by an IANZ registered laboratory or their representative for the tests indicated. This shall include both laboratory and field testing. The results shall be supplied to the Engineer demonstrating compliance with this specification, at no less than every two weeks. Any non compliance shall be reported at the weekly meeting and actions taken. Formal results shall be provided to the Engineer for each monthly progress payment. Up to 10% payment over and above retentions will be withheld if this information is not provided, or is incomplete, accompanying the progress payment application, at the Engineer's discretion. The scope and frequency of testing can only be altered at the instruction of the Engineer.

If requested by the Engineer, testing shall be carried out in the full time presence of the Engineer or his representative.

At any location the Engineer may carry out his own tests at his discretion. If there is any discrepancy the Engineer's results shall prevail.

### C.3.7 TESTING REQUIREMENTS

#### C.3.6.1 Compaction Testing

Control tests shall be carried out by the Contractor.

The fill compaction requirements and related tests are defined in Table 3 and the list of qualifying notes.

Table.3: Test methods

Test	Test Method and/or Test Description	
Optimum moisture/density	Standard compaction test as per NZS 4402:1986	
Air voids	As defined in NZS 4402:1986 and involving intermediate tests in situ density, water content and solid density below	
In-situ density	NDM Method	
Water content	NDM Method, with confirmatory laboratory tests as per NZS 4402:1986, Test 2.1	
Solid density	NDM Method	
Sieve analysis	NZS 4402:1986, Test 2.8.1	

**Note 1:** In situ Density - The air voids content of the compacted soil at any test location shall be taken as the mean of the air voids results from a set of density tests. A set of density tests shall comprise two or more individual tests made within an area of  $0.5 \, \text{m}^2$ .

The frequency of testing will depend on the consistency of the fill operations and materials. The testing rate will be generally as follows at the commencement of filling.

Table 4: Fill testing regime

Test	Material	Frequency
In situ moisture/ density (NDM method with laboratory moisture content)	Type 1 fill (at new 2 Bridges and Cobden stopbanks only)	1 set per 1000 m³ fill placed
	In situ silty gravel river- side face on existing stopbanks (at new concrete flood wall	1 set per 50 m length
	locations only)	1 set per lift over 50 m length
	Type 2 fill	
Standard Compaction test (Proctor Test)	Type 1 fill (specifically the material to be used at the 2 Bridges fill)	2 sets prior to start of construction
	Type 2 fill	2 sets prior to start of construction, 1 set per 500 m <sup>3</sup> thereafter
Sieve Analysis	Type 1 fill	3 sets prior to start of construction, 1 set per 2,000 m <sup>3</sup> thereafter.
	Type 2 fill	3 sets prior to start of construction, 1 set per 500 m <sup>3</sup> thereafter.

The Engineer may reduce or increase the frequency of testing as he judges appropriate, depending on the consistency of the results.

## C.3.6.2Inspections and Approvals

The following critical points during construction must be inspected by the Engineer prior to further work being carried out in the area. No filling, concrete work, or quarry excavation for fill purposes shall commence without the Engineer's approval. All surfaces are to be surveyed for quantity measurement purposes. The Engineer must be informed at least 48 hours prior to the following hold points being reached, to ensure construction is not delayed.

## **Hold Points**

- Inspection of each section of stripped, excavated and trimmed concrete floodwall foundation, prior to placement of concrete.
- For all sections of stopbank to be raised by more than 200 mm, inspection of each section of stripped, excavated and trimmed stopbank prior to placement of fill.
- Inspection of the prepared subgrade prior to placement of any fill at each of the Goods Shed, 2-Bridges and Cobden areas.
- At the 2-Bridges site, inspection of the installed culverts and their interfaces with the in situ rock and associated drainage works prior to backfilling.