Tonkin+Taylor

Job No: 53094.01
22 January 2016

Queenstown Lakes District Council
Private Bag 50072
Queenstown 9348

Attention: Ms A Vanstone

Dear Anita

Shotover Special Housing Area
Peer Review of Hydrological Aspects and Flood Risk

In accordance with our letter of engagement dated 23 December 2015, we are pleased to report on the outcome of our peer review of the hydrological aspects and flood risk in relation to the proposed Special Housing Area on the left bank of the Shotover delta.

The detail of our review is presented below, and our main conclusions are:

- The information in support of the SHA application appears to include a robust consideration of the uncertainty and sensitivity of future design flows and flood levels in the delta
- The modelling of the proposed SHA development identifies a maximum effect on flood levels in the delta to be an increase of up to 0.15 m
- The modelled minimum freeboard to the SHA building platform from projected future 1 % AEP flood level is 1.24 m
- There are aspects of design not reviewed in detail that could be considered further as part of consenting investigations and detailed design if the development proceeds.

1 Background

Shotover Country is one of four Special Housing Areas (SHA) being considered by Queenstown Lakes District Council (QLDC) for recommendation to the Minister for Building and Housing. The proposed SHA would be located on the true left bank of the Shotover River delta, adjoining land recently developed after Plan Change 41 was made fully operative in 2013 (Area 1F). It is proposed that the SHA be located on the edge of an existing river terrace, between Area 1F and the active river fairway. Part of this SHA area is presently exposed to flooding in the 1 % AEP event.

As part of works for the development, the general level of the existing terrain would be raised approximately 1.5 by placement of engineered fill to create a building platform for development.

QLDC has received submissions from Otago Regional Council (ORC) raising concerns in relation to river management and flood risk in proximity to the proposed SHA, and also the potential for the area to be affected by seismic hazards.

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QLDC is seeking a peer review of the information provided with the application, insofar as that relates to hydrological aspects and flood risk. The scope of this review does not include matters related to liquefaction risk

2 Information received

The following information has been received from QLDC:

a Report for Agenda Item 2, 26 November 2015, Special Housing Areas Expression of Interest: Shotover Country, including:
- Attachment A: Special Housing Areas Expression of Interest, Shotover Country Ltd, Activity Area 1F, Clarke Fortune McDonald and Associates, November 2015
- Attachment B: Three Waters Infrastructure Assessment, Holmes Consulting Group, 21 October 2015
- Attachment C: NZTA response, 20 October 2015
- Attachment D: Ministry of Education response, 28 October 2015
- Attachment E: ORC response, 27 October 2015, including:
  - ORC submission evidence, Plan Change (private) 41, Shotover Country Ltd, 9 March 2011
- Attachment F: Shotover Country – Special Housing Area, Comments on ORC letter relating to Natural Hazards, David Hamilton and Associates, 6 November 2015, including:
  - Tonkin + Taylor (T+T) letter to QLDC re Peer Review of Supplementary Hydraulic Modelling Report, 8 April 2013
  - Table 2, Summary of T+T Review flood flow scenarios modelled water levels with freeboard
  - Figure 1: Longsection of Shotover River water surface profile for 2110 bed and flow 1,730 m^3/s adjacent to proposed SHA
  - Shotover Country Expert Caucusing Report, 14 June 2011
  - Clarke Fortune McDonald Plans Job 11494 Drawing 11 Sheets 1 and 2, Revision A, Special Housing Area – Fill Extension, Client Review, 17 September 2015
  - Attachment G: Review of Liquefaction Potential, RD Agritech, 5 November 2015

b ORC Letter to QLDC, Proposed Shotover Country Special Housing Area, 25 November 2015

c Shotover Country Special Housing Area, Flood Elevation Model – Maps 1 to 5, dated 22 October 2015

d Clark Fortune McDonald letter to ORC, Special Housing Area – Shotover Country No 2 Ltd, 23 September 2015, including:
- Attachment A: Special Housing Area, Extension to Activity Area 1F
- Attachment B: District Plan: Minimum Levels Activity Area 1F
- Attachment C: David Hamilton River and Flooding Assessment, February 2010
- Attachment D: David Hamilton: Review of Proposed Development on Design Flood Levels and Mitigation, August 2015

e T+T letter to QLDC, Shotover Country Plan Change 41, Peer Review: Supplementary Hydraulic Modelling, 8 April 2013

f Shotover Country Plan Change 41, Review of Shotover River Flood Risk Profiles, Supplementary Hydraulic Modelling report, David Hamilton and Associates, March 2013

g T+T letter to QLDC, Shotover River, The Ladies Mile Partnership Appeal No 2 to Plan Change 412 (Shotover Country), 27 June 2012.

It is noted that much of the background information in relation to hydrological and flooding risk provided to support the SHA application are background documents provided between 2010 and 2013 for an earlier Plan Change application (Plan Change 41) to QLDC by Shotover Country. In this respect these earlier documents were part of the scope of an earlier Peer Review by T+T of supplementary modelling work, reported under cover of the letter to QLDC dated 8 April 2013 (Item e above).

We have also received from David Hamilton and Associates (15 January 2016):

- Shotover Country Special Housing Area On World Imagery ex ArcMap showing River Cross-Sections 2-5
- Shotover Country Special Housing Area On NZ Imagery ex ArcMap showing River Cross-Sections 2-5.

3 Assessment of hydrological aspects and flood risk

It is noted that the scope of this review has not included for a detailed check of the calculations, model development and detail of the analysis carried out to support the SHA application. The review is based on the methodologies described and the results presented in the various documents provided.

Hydrological aspects in relation to the proposed SHA development have changed little from the earlier Plan Change investigations. The only significant change is fill in two cross sections of the hydraulic model used to identify flood levels and the effects of the development. The filling to form the SHA building platform will extend the Area 1F fill by up to 250 m into the delta.

Otherwise, as identified in the David Hamilton and Associates documents of 6 November 2015 (re Comments on ORC letter relating to Natural Hazards, Item a Attachment F above) and August 2015 (Review of Proposed Development on Flood Levels and Mitigation, Item d Attachment D above), the hydrological analysis for the SHA has considered the following design flow cases reported earlier in the Supplementary Hydraulic Modelling report for the Plan Change 41 (Item f above). These cases allow variously for climate change effects and statistical uncertainty in relation to calculation of the 1 % AEP design flood event:

Flood Flow	Description
1400 m3/s	1% AEP flood as used in original 2011 report. Aulos 1999 flood
1500 m3/s	Adopted 1% AEP flood following expert caucus 2011
1740 m3/s	1% AEP flood plus allowance for 2 deg C climate change
2050 m3/s	1% AEP flood plus allowance for 4.6 deg C climate change
2390m3/s	1% AEP flood + allowance for 2 deg C climate change + 1 Std Deviation
2730 m3/s	1% AEP flood + allowance for 4.6 deg C climate change + 2 Std Deviations

The maximum flow modelled (2,730 m^3/s) has been estimated on the basis of:

- Projected 4.6 ° C increase in temperature due to climate changes effects to 2090, i.e. upper limit average change in temperature as identified by the Ministry for the Environment (cf. Climate Change Effects and Impacts Assessment, 2008)

- Adoption of the upper bound two standard deviations estimate of design flood, as determined by analysis of the existing flood record.

This maximum flow is 1,230 m^3/s greater (82 %) than the present day 1 % AEP flow adopted in caucusing between experts from Shotover Country and ORC in 2011, and 680 m^3/s greater (33 %) than the central estimate of 1 % AEP flow adjusted for upper limit average change in temperature. Preliminary calculations indicate that based on the information provided and a Gumbel distribution fitted to the annual maxima series, this maximum modelled flow has an equivalent return period in excess of 1,000 years.

Earlier modelling also considered changes in delta bed levels due to aggradation, by up to 1.4 m to 2110 (at the Kawarau confluence, reducing upstream). It is reported that these future bed levels have been used to model the effects of the proposed SHA on flood levels in the delta.

The modelling for the assessment of the SHA has also considered two different scenarios, viz. filling or not of the Recreation Area on the left bank downstream of the SHA.

The modelling results of the proposed SHA scenarios show limited effects on the change in water levels, compared to the approved Plan Change 41 scenarios:

- Maximum increase of 0.11 m, adjacent to the SHA with no filling of the Recreation Area for the 2,730 m^3/s flow case (upper limit average climate change to 2090, two standard deviation flow estimate, projected 2110 bed levels)
- Maximum increase of 0.15 m, adjacent to the SHA with filling of the Recreation Area for the 1,740 m^3/s flow case (average climate change to 2090, projected 2110 bed levels), at a different location to the previous case
- The minimum freeboard available to the SHA building platform, for the 2,730 m^3/s flow case, will be 1.24 m (at the downstream end of the SHA, MWD cross section 4)
- The minimum freeboard available for the 1,740 m^3/s flow case, will be 1.99 m.

4 Comments on flood risk assessment

The information provided in relation to hydrological aspects and flood risk for (the 1 % AEP event) to support the SHA application shows that a range of hydrological and hydraulic scenarios has been modelled to assess uncertainty in estimates of and possible future changes in design flows, and also aggradation of delta bathymetry.

It is noted that no discussion has been provided about the effects of the changes in flood levels (at maximum 0.15 m for the cases modelled) for other properties or infrastructure along the banks of the Shotover River.

5 ORC issues

ORC raised the following issues (in relation to flood risk) in its letter of 27 October 2015:

- Consideration of the effect of high consequence events
- Need for careful consideration of development in close proximity to a river with dynamic bed morphology
- Responsibility for maintenance and repair of mitigation works following flood events.

ORC further raised the following issues in its letter of 25 November 2015:

- Creation of a risk that does not exist at present

- Increase in risk contrary to the proposed Regional Policy Statement, and NZS 9401:2008, Managing Flood Risk – A Process Standard.

We comment on these issues as follows:

- The information provided by Shotover Country considers a range of flow cases which tests the sensitivity of the SHA proposal to changes and uncertainty in design flood, and delta aggradation.
  - The model results indicate a minimum freeboard to the proposed building platform level of greater than 1 m above a future 1 % AEP flood level determined with 97.5 % confidence limits (which otherwise would have a return period in excess of 1,000 years).
  - No information is provided specifically on possible dambreak scenarios from landslide-generated dams in the upper catchment. However, earlier modelling in relation to Plan Change 41 showed the proposed Area 1F building platform level would be above the flood levels for a flow of 5,000 m^3/s (i.e. through the delta in such a scenario. It is considered that this is unlikely to differ greatly for the proposed SHA development, though should be checked as part of future detailed risk assessment and development of any risk management plans.
- The information provided in relation to flood hazard does enable careful consideration of the risk to the development from flooding in the Shotover delta.
- The responsibility for maintenance and repair of flood protection measures in the future is a valid issue, but we consider this to be outside the scope of this review.
- The existence of any (new) development will create an exposure to natural hazard risk. We have not reviewed the Proposed ORC RPS, but note that NZS 9401 identifies a framework for managing flood risk. This identifies stakeholder responsibilities for *inter alia* communities, professionals and local government. The elements of the framework include risk management *"to encourage a wider assessment of strategies and options... and awareness of residual risk"*, and comprehensive risk treatment strategies *"including reduction, readiness, response and recovery"*. The SHA application does not include an assessment of the residual SHA flood risk in terms of the principles and outcomes identified in NZS 9401. The information provided with the application together with other information in relation to catchment and hydrological risks would enable such an assessment, and development of comprehensive risk treatment strategies as appropriate.

6 Conclusions

While we have not carried out a detailed check of the computational hydraulic model development, background calculations and analyses, our review conclusions are as follows:

- The information in support of the SHA application appears to include a relatively robust consideration of the uncertainty and sensitivity of future design flows and flood levels in the delta
- The modelling of the proposed SHA development identifies a maximum effect on flood levels in the delta to be an increase of up to 0.15 m
- The modelled minimum freeboard to the SHA building platform from projected future (i.e. 2090 climate change, 2110 bed levels) 1 % AEP flood level is 1.24 m (for a design flow based in upper limits of climate change and statistical uncertainty).

There are aspects of design (e.g. bank protection measures) that we have not reviewed in detail, and consider that these could be considered further together with other matters to be finalised as part of consenting investigations and detailed design if the development proceeds.

7 Applicability

This report has been prepared for the exclusive use of our client Queenstown Lakes District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

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SENIOR WATER RESOURCES ENGINEER

Authorised for Tonkin & Taylor Ltd by:

.....

Kevin Hind

PROJECT DIRECTOR

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RDAgritech

ENGINEERED BY NATURE

GEOTECHNICAL LIQUIFACTION ASSESSMENT REPORT

JOB TITLE	SHOTOVER COUNTRY SHA
ADDRESS	SHA AREA, SHOTOVER COUNTRY
JOB NUMBER	50295
	19 January 16

Client: Shotover Country Limited
Attention Simon Barr
PO Box 533
Queenstown

TABLE OF CONTENTS

Prepared by

Ollie Behrent
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Senior Engineering Geologist/Geoprofessional

50295 SHA geotech report.docx

1. INTRODUCTION

This report presents the results of an initial geotechnical investigation carried out by RDAgritech on behalf of Shotover Country Limited for the proposed residential development located on the SHA area of Shotover Country as indicated on the site plan in Appendix A.

The work was commissioned by Shotover Country Limited in a signed Short Form Agreement dated 23 December 2015.

The initial scope of work for the geotechnical subsoils investigation included:

- A site Walkover
- Coordinating Two Machine Boreholes to a nominal 20m depth with SPT strength testing at 1.5m intervals.
- Assessing the susceptibility of liquefaction across the site and coordinating Analysis with Tonkin and Taylor Ltd for detailed Liquefaction analysis.
- Preparation of a factual report of the findings

RDAgritech conducted the work in general accordance with our proposal, reference 50295, Shotover Country SHA Geotech, dated 23 December 2015.

The current proposed development concept is for a residential subdivision located on a river terrace. Access is via the existing development taking place to the east of the SHA site.

The following report presents the results of field investigations and provides discussion and recommendations relevant to the above scope of work, particularly in regards to the liquefaction susceptibility of the SHA area.

The Tonkin and Taylor Liquefaction analysis is contained in Appendix D

1.1. LIMITATIONS

Findings presented as a part of this report are for the use of Shotover Country Limited to help assess the conditions of the site in question in accordance with the specific scope and the purposes outlined above. While other parties may find this reporting useful the findings may not contain sufficient information for the purposes of other parties or other uses. Our Liability is only to Shotover country in accordance with the signed agreement, no other party.

Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report.

1.2. RELATED DOCUMENTS

In this report, reference is made to the following documents:

- Geology of the Wakatipu area 1:250,000 QMap (Qm18), GNS Science: 2000

2. SITE INFORMATION

- The site is located on the Special Housing Area (SHA) area of Shotover Country Subdivision (Area 1f extension), which is between stage 1f of the master plan to the northeast and the shotover river and cycle trail to the southwest. A site plan is included in Appendix A.
- The site covers an area of approximately 6.9 hectares.
- The site is currently accessed through via Stalker road through the Shotover Country subdivision development located to the east of the SHA area. The site is currently a vegetated flat grass paddock.
- The sites to the north are occupied by farmland and residential buildings, with the eastern side consisting of a large fill area as part of the Shotover Country development. The Shotover River flows along the western boundary of the SHA site.
- The site is located on a down cut river terrace caused by the Shotover River's previous flow paths. It is a flat site surrounded by elevated river terraces to the north and east.
- The Proposed SHA would involve the importation of a nominal 109,000m3 of fill to create a nominal 1.5 to 2.0m deep fill raft over the current site levels. The Site plan and design levels are attached in Appendix A.

2.1.1. GEOLOGY

The geology of the site has been gained through two boreholes, 20m and 22.5m carried out across the site and through previous local knowledge. The boreholes indicate stratified alluvial deposits consisting of Shotover deltaic gravels with a capping layer of loess. These ranged from gravely SANDS to sandy GRAVELS. The boreholes did not reach bedrock when terminated at 22.5m. There were no silt lenses observed in the 22.5m borehole cores. There is no evidence of flood/silty lake deposits in the SHA area. Silt/lake deposits are confined to the lower southern terraces that are not part of the SHA area. Sediments within the SHA are older than the more elevated surrounding terraces, therefore have undergone consolidation and been through several seismic events to further consolidate the sediments.

No active faults were mapped in the field, however, the QLDC web map indicates an inferred fault trending E-W, 1km to the south. There is a significant seismic risk to the Wakatipu region when the rupture of the alpine fault system occurs; recent probability predictions estimate a magnitude 7.5 or greater is highly likely within the next 45 years. Significant ground shaking is expected from this type of event.

The QLDC Hazard Maps indicate this site as being unmapped for liquefaction and previous desktop reporting has determined a nil to low risk of liquefaction potential.

3. FIELDWORK

Fieldwork was carried out on 6th and 7th January 2016 and comprised of:

- On site review of available desktop information;
- Coordinating and monitoring Two Machine Boreholes utilising sonic drilling techniques with full core recovery
- Machine Borehole SPT testing at each 1.5m depth interval down each hole.
- Measuring Static Groundwater level in the machine holes
- A site walkover by a Senior Engineering Geologist

An RDAgritech representative located the borehole sites and produced Geological Logs of the core, which are contained in Appendix B.

Test sites were located by hand held GPS using NZ topo co-ordinates. Approximate locations are shown on the Borehole Location Plan in Appendix A.

4. RESULTS OF INVESTIGATION

4.1. SURFACE CONDITIONS

The surface conditions at the time of site visit, were as follows:

- No water seeps were observed on site during the field visit.
- Surface vegetation was brown and drought ridden due to a prolonged dry spell.
- The site is predominantly flat with minor relict ephemeral flow paths evident as slightly greener areas due to the higher silt content of these paths. These are also slightly depressed from the main terraces by a nominal 0.2 to 0.5m.

4.2. INTERPRETED SUBSURFACE CONDITIONS

The typical soil types encountered during the field investigations have been divided into two geotechnical units as summarised in Table 1. Geological Logs of the boreholes are presented in Appendix B.

Photos of the Drill core are attached in Appendix C

TABLE 1 – SUMMARY OF GEOLOGICAL UNITS AND SOIL TYPES

UNIT	SOIL TYPE	DESCRIPTION
1	Topsoil	TOPSOIL: organic Gravelly SILT, dark brown, low dilatency, fine to coarse, sub-angular to angular gravel, trace fine to coarse sand. Numerous roots
2	Interbedded Alluvial	SAND; grey, very soft, medium dense, dry, sand fine grain size. Gravely SAND; brown/grey. Soft, moist, medium grain gravel. Sand medium grain. Sandy GRAVEL; grey, dense, moist, soft, gravel medium grain, sand fine-medium.

Table 2 contains a summary of the distribution of the above geotechnical units in each Borehole.

TABLE 2 – SUMMARY OF DISTRIBUTION OF GEOLOGICAL UNITS ENCOUNTERED AT BOREHOLE LOCATIONS

BOREHOLE LOCATION	DEPTH ENCOUNTERED BELOW EXISTING GROUND LEVEL (m)	
	UNIT 1	UNIT 2
BH1	0.0 – 0.2	0.3 > 20.0
BH2	0.0 - 0.2	0.2 > 22.5
> UNIT EXTENTS BELOW DEPTH OF BOREHOLE		

5. GROUNDWATER

Groundwater levels were measured in borehole 1 and 2 at 2.9 and 3m respectively.

It should be noted that fluctuations in the groundwater levels can occur as a result of seasonal variations, temperature, rainfall and other similar factors, the influence of which may not have been apparent at the time of investigation.

Perched groundwater is not expected in this environment due to the lack of fine grain sediments and the full depth of gravels soils encountered.

6. DISCUSSION AND RECOMMENDATIONS

6.1. LIQUEFACTION SUSCEPTIBILTY

There are a range of parameters and conditions required for liquefaction to occur:

- Fine grain soils (silts/sands)
- Deep sand and gravel profiles
- Saturated soils due to groundwater levels
- Unconsolidated loose soils
- Depths of respective soil profiles
- Depth to groundwater
- Bedding and layering of the respective soil profiles
- The number and length of cyclic shaking associated with the PGA from a seismic event.

The previous geological models and desktop studies appeared to be correct in their conclusions on material type for gravels and some sands for the full depth of the machine boreholes.

The core from both boreholes has clearly indicated, there are no silt and sand layers within the SHA area tested, with the majority of the site soils a dense to medium dense gravel. Some looser gravelly Sands were encountered in BH2.

The groundwater level located at 2.9m and 3m across the site provides for sufficient overburden pressure of the overlying soils to prevent liquefaction manifesting at the surface.

The SPT results in BH1 confirms no loose soils are present. However the SPT results from Borehole 2 indicate a marginal density strength for potential liquifaction of the gravels and sands to occur.

We would expect some minor settlement in the vicinty of Borehole 2 as result of seismic shaking during a ULS event.

Tonkin and Taylor will provide detailed analysis of the potential and if present the amounts of settlement expected in the Borehole 2 area.

7. CONCLUSIONS

The liquefaction susceptibility of Shotover Country SHA has been determined using borehole data and previously reported information on the Wakatipu Basin geology. The characteristics of the core from the boreholes have indicated they do not

have all the required parameters for liquefaction to occur at Borehole location 1 area. And therefore, the liquefaction susceptibility of Shotover Country SHA near borehole 1 is considered nil to very low based on current findings.

Borehole 2 however is potentially going to incur Settlement as a result of a larger seismic event, Tonkin And Taylor Ltd have provided the analytical assessment for this area in Appendix D.

While this settlement may be induced as a result of seismic shaking for the BH2 area the addition of the gravel raft for the site earthworks planned and the existing 3m cover of soils would be expected to help mitigate any settlement incurred at the SLS and ULS events

More detailed analysis and some additional investigation is required, this would be covered as part of the next stage of investigation and reporting to council for Resource Consent applications and be contained in the Geotechnical Investigation Report (GIR) as per the councils subdivision standard NZS4404 and ammendments.

While a part of the site has shown a minor susceptibility to liquefaction of gravelly sandy soils based on current ground levels we believe the proposed fill raft to be placed and additional geotechnical investigations required to refine the area in question, will be able to show the SHA borehole 2 area can be mitigated adequately for the proposed subdivision.

8. APPLICABILITY

This report is only to be used by the parties named above for the purpose that it was prepared and shall not be relied upon or used for any other purpose without the express written consent of Shotover Country Limited and RDAgritech Ltd.

The extent of testing associated with this assessment is limited to discrete locations and variations in ground conditions can occur between and away from such locations. If subsurface conditions encountered during construction differ from those given in this report further advice should be sought without delay.

9. PHOTOS

Looking south from BH1

APPENDIX A. SITE PLANS

1. SHA Site Plan and Design Earthworks
2. Borehole Testing Location Plan

NORTH

FALL

FALL 1%

FALL 1%

FALL 2%

SECTION C - C'

SECTION A - A'

FILL RL = 317.34

FILL RL = 317.24

MWD XS3

317.00

LONGSECTION B - B'

FILL RL = 316.79

20.26

ACTIVITY AREA 1F EXTENSION

ORIGINAL ACTIVITY AREA 1F FILL

316.50

EARTHWORKS EXTENT

22.31

2730 m3/s flood extent

20.37

MWD XS4

FILL RL = 315.99

316.00

Fill extension

SHA extension (Lot area)

CLIENT REVIEW 17.09.15

Shotover Design Limited trading as
Clark Fortune McDonald & Associates
Licensed Cadastral Surveyors - Land Development - Planning Consultants
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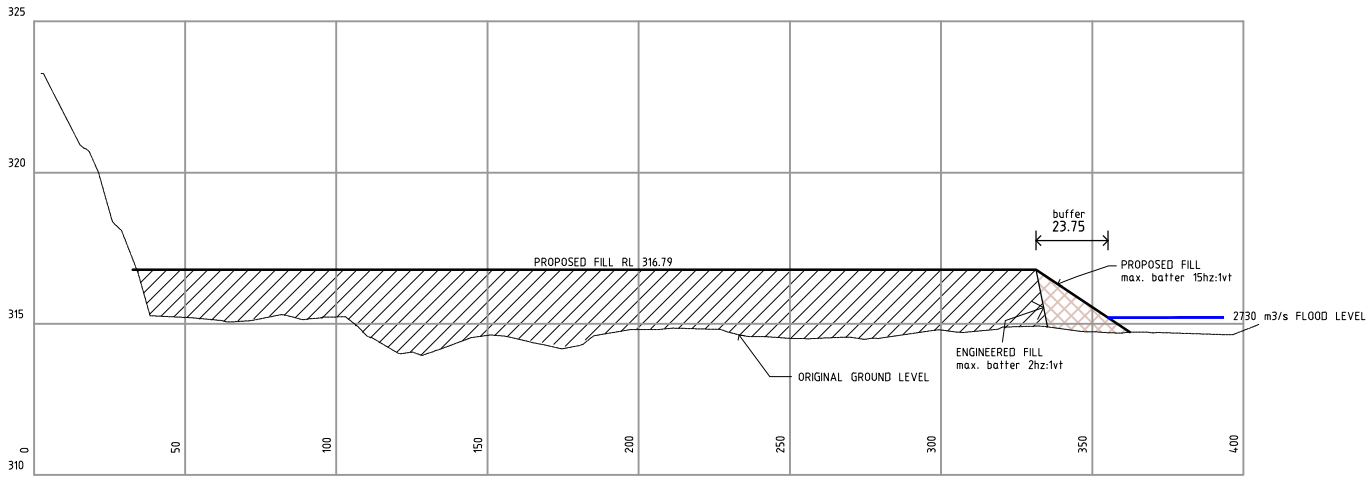
Rev.	Date	Revision Details	By
A	15.09.15	Change batter to 1 in 8 to provide buffer	RB

SPECIAL HOUSING AREA
FILL EXTENSION

Client	Surveyed	Signed	Date	Job No.	Drawing No.
SHOTOVER COUNTRY LTD	-		-	11494	11 Sheet 001
	Drawn	Signed	Date	Scale	
	RWB		20.08.14		1:1000 @ A1 1:2000 @ A3
	Designed	Signed	Date	Datum & Level	Rev.
	-		-	Mt Nic 2000 & MSL	A

Notes:
All dimensions shown are in meters unless shown otherwise.
Any person using Clark Fortune McDonald drawings and other data accepts the risk of:
- Using the drawings and other data in electronic form without requesting and checking them for accuracy against the original hard copy versions.
- Ensuring the information is the most recent issue.

S:\JOBS\11400\11494\acad\11494_11_SHA Fill concept_RevA.dwg Plotted: 17.09.2015



MWD SECTION 3 - 3'

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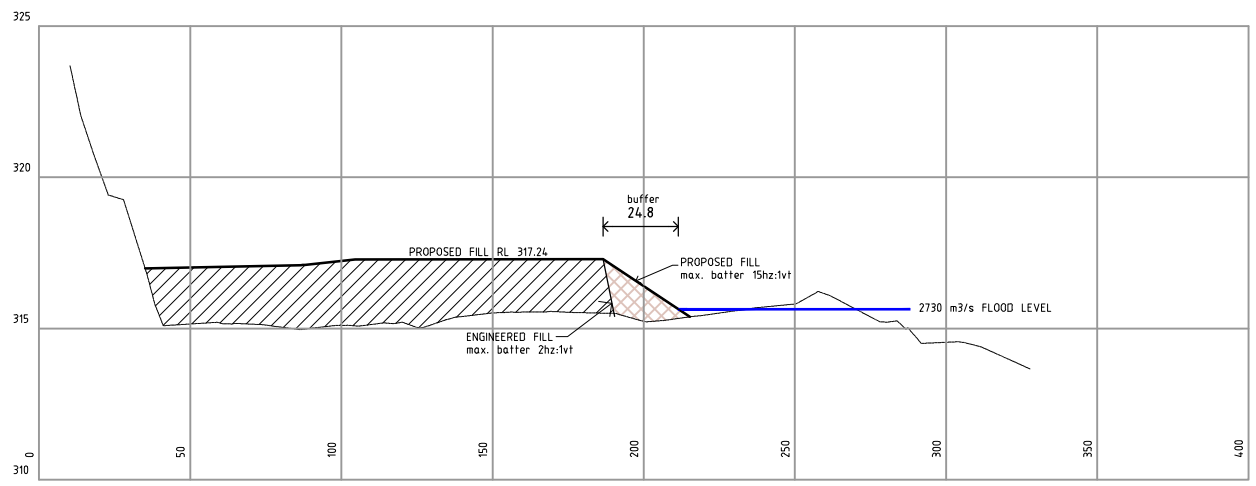
A3 SCALE: 1:2000hz 1:200 vt
10 x VERTICAL EXAGGERATION



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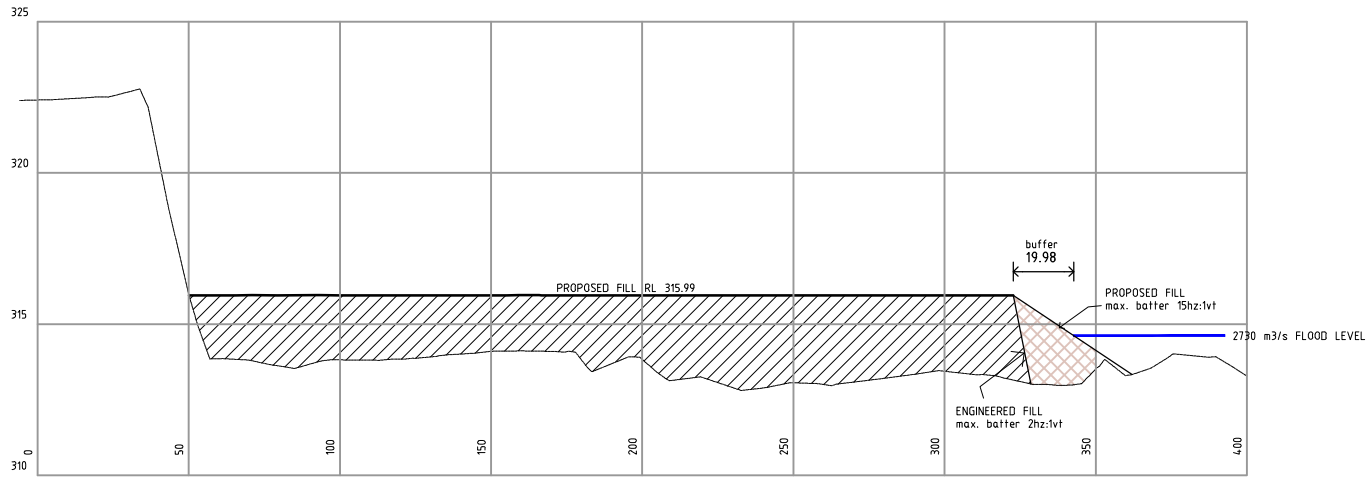
10 x VERTICAL EXAGGERATION



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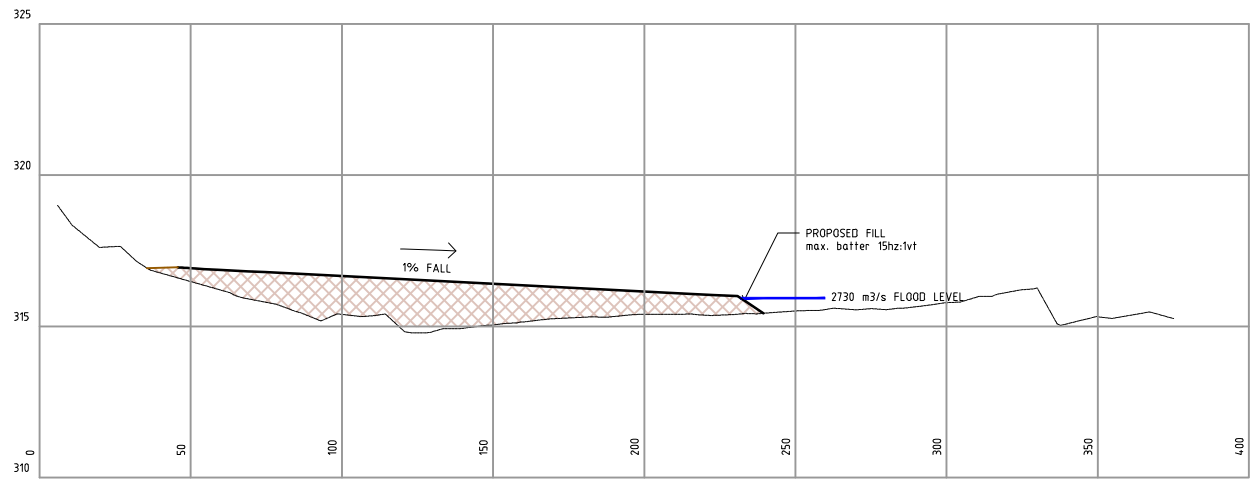
10 x VERTICAL EXAGGERATION



SECTION C - C'

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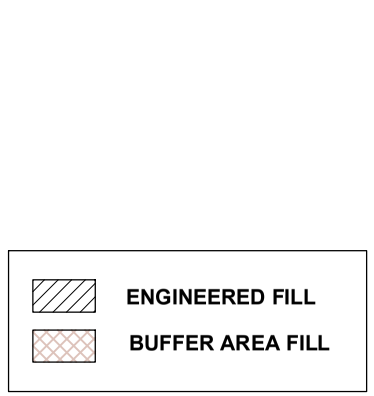
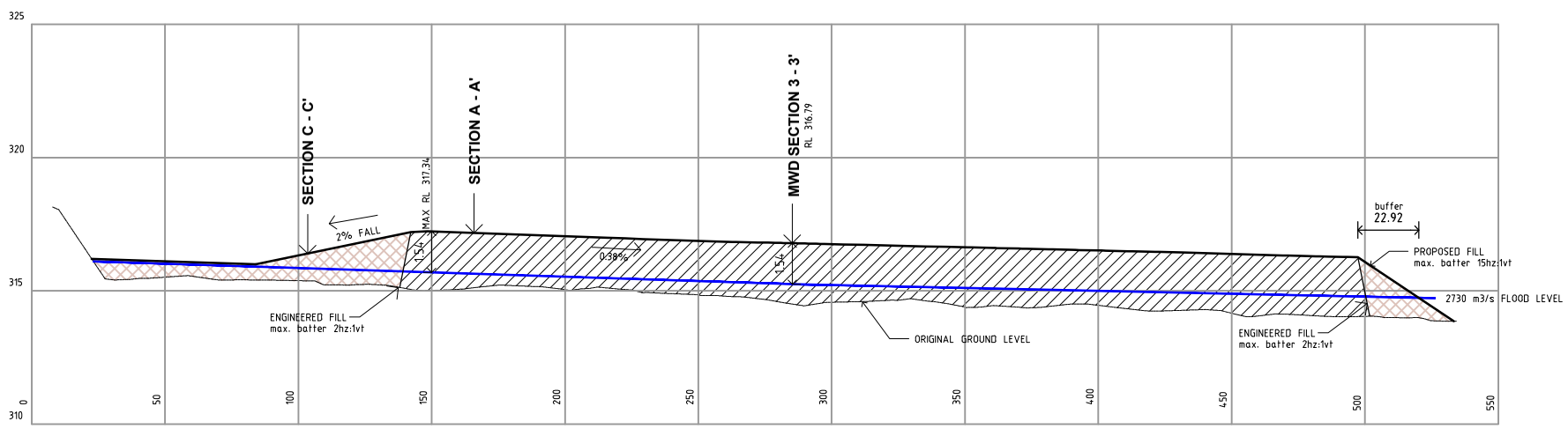
A3 SCALE: 1:2000hz 1:200 vt
10 x VERTICAL EXAGGERATION





LONGSECTION B - B'

A1 SCALE: 1:1000hz 1:100 vt
A3 SCALE: 1:2000hz 1:200 vt
10 x VERTICAL EXAGGERATION

CLIENT REVIEW 17.09.15

Shotover Design Limited trading as
Clark Fortune McDonald & Associates
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Rev.	Date	Revision Details	By
A	15.09.15	Change batter to 1 in 8 to provide buffer	RB

SPECIAL HOUSING AREA
FILL EXTENSION - SECTIONS

Client: SHOTOVER COUNTRY LTD

Notes:
All dimensions shown are in meters unless shown otherwise.
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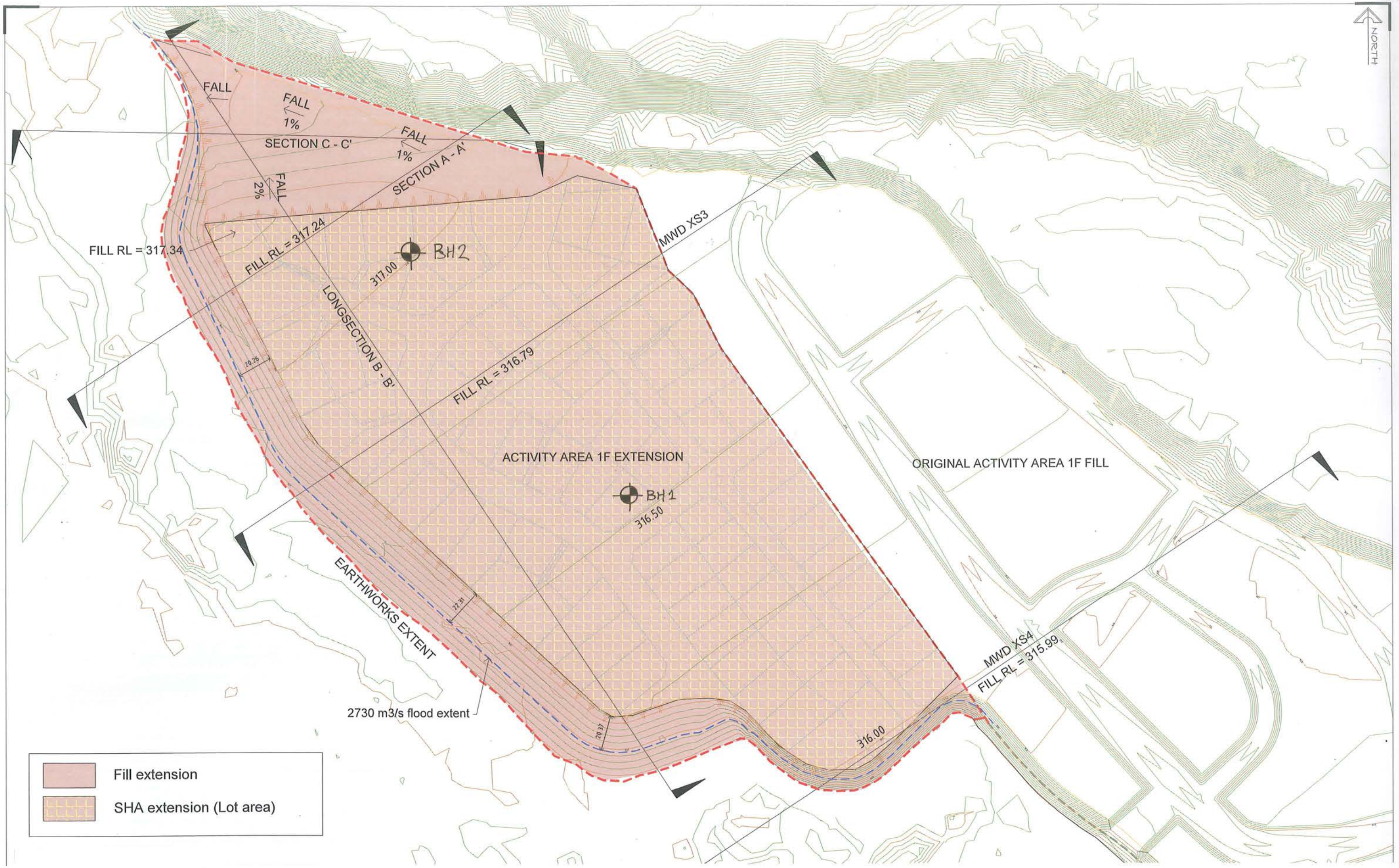
	Surveyed	Signed	Date	Job No.	Drawing No.
	-		-	11494	11 Sheet 002
	Drawn	Signed	Date	Scale	1:1250 @ A1 1:2500 @ A3
	RWB		20.08.15		
	Designed	Signed	Date	Datum & Level	Rev.
	-		-	Mt Nic 2000 & MSL	A

S:\JOBS\11400\11494\acad\11494_11_SHA Fill concept_RevA.dwg Plotted: 17.09.2015



RDAgritech ENGINEERED BY NATURE	**Engineering Firm:** RDAgritech Ltd Po Box 1880 Queenstown	**Project:** Shotover Country SHA Geotech SHA area, Shotover Country Queenstown	**Client:** Shotover Country Limited Po Box 553 Queenstown	**Drawing Title:** Borehole Location Map	Scale: 1:2000 @ A3 **Job No.** 50295	**Drawing Number** **Revision:**

APPENDIX B. BOREHOLE LOG SHEETS

1. RDA Borehole Logs (BH1-BH2)
2. Drillers Logs

BH-1

BOREHOLE LOG

RDAgritech
ENGINEERED BY NATURE

JOB NUMBER: 50295	PROJECT:	Shotover Country SHA Geotech	
	LOCATION:	SHA borehole 1	
CO-ORDINATES: 1266371 mE	HOLE STARTED:	0.0m	
5007537 mN	HOLE FINISHED:	20.0m	
ELEVATION: m	OPERATOR:	Bryan	
DATUM: site RL	COMPANY:	McNeil Drilling	EQUIP.: Sonic Drill Rig

ENGINEERING DESCRIPTIONS								GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	SPT N Values	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
					ww	Topsoil/Organic	M	Topsoil
			1.0		o..o. o.o.. .o.o.	sandy Gravel; grey, sand fine - medium grain size, dense, dry, soft	D	Alluvial
	▽	4/4/6/9/8/7	2.0	N=30 N60=45	...o.. o..... ..o...	gravely SAND; brown/grey. Soft, medium grain gravel. Sand medium grain, loose	M	Alluvial
		2/2/1/2/3/2	3.0	N=12 N60=18	.....o o...o ..o...			
			4.0		.....o o.....			
		5/6/6/6/6/4	5.0	N=22 N60=33	.o.... ..o...			
			6.0		....o.			
		4/7/5/5/5/4	7.0	n=19 N60=29	o..... ..o... o.....			
		5/5/4/4/4/5 Sample to CTS	8.0	N=19 N60=29	....o. ..o... o.....	gravely SAND; grey, dense, moist, soft, gravel medium grain, sand fine-medium grain	M	Alluvial
			9.0		.....o o.....			
		4/5/7/9/9/8	10.0	N=33 N60=50	...o.. ...o			

OTHER COMMENTS: Key: ww = Organic/Topsoil ..... = Sand
oo = Gravel

Piezo details: refer driller log

Logged By: OMB
Checked Date: 15-Jan-16
Sheet: 1 of 2

BH-1

BOREHOLE LOG

RDAgritech
ENGINEERED BY NATURE

JOB NUMBER: 50295	PROJECT:	Shotover Country SHA Geotech	
	LOCATION:	SHA borehole 1	
CO-ORDINATES: 1266371 mE	HOLE STARTED:	0.0m	
5007537 mN	HOLE FINISHED:	20.0m	
ELEVATION: m	OPERATOR:	Bryan	
DATUM: site RL	COMPANY:	McNeil Drilling	EQUIP.: Sonic Drill Rig

ENGINEERING DESCRIPTIONS								GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	SPT N Values	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
		4/6/7/7/10/13	11.0	N=37 N60=56	..o... o... .o.. ...o..	gravely SAND; grey, dense, moist, soft, gravel medium grain, sand fine-medium grain	M	Alluvial
		7/8/10/10/11/11	12.0 13.0	N=42 N60=63.5	o..... ..o... .....o			
		4/5/8/10/12/12	14.0	N=42 N60=63.5	o..... o..o. .o..o	sandy GRAVEL; dark grey, moist, dense, gravel medium-coarse grain size, sand coarse grained	M	Alluvial
		4/8/12/10/10/9	15.0	N=41 N60=62	o..o. .oo..			
		10/9/13/11/10/10	16.0 17.0	N=44 N60=66.5	o..o. o..o. .o.o.	gravely SAND; grey, soft, moist, dense, gravel medium grain size, sand fine - medium	M	Alluvial
		5/6/9/10/8/9	18.0 19.0	N=36 N60=54.5	o..o. .o..o o...o .oo..			
		8/10/11/13/13/14	20.0	N=51	o..o. .o..o o.o.. o...o			
					EOH	End of borehole at 20.0m		

OTHER COMMENTS: Key: ww = Organic/Topsoil ..... = Sand
oo = Gravel

Piezo details: refer driller log

Logged By: OMB
Checked Date: 15-Jan-16
Sheet: 2 of 2

BH-2

BOREHOLE LOG

RDAgritech
ENGINEERED BY NATURE

JOB NUMBER: 50295	PROJECT:	Shotover Country SHA Geotech	
	LOCATION:	SHA borehole 2	
CO-ORDINATES: 1266237 mE	HOLE STARTED:	0.0m	
5007675 mN	HOLE FINISHED:	22.5m	
ELEVATION: m	OPERATOR:	Bryan	
DATUM: site RL	COMPANY:	McNeil Drilling	EQUIP.: Sonic Drill Rig

ENGINEERING DESCRIPTIONS								GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	SPT N Values	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
				N60=7	ww	Topsoil/Organic	M	Topsoil
				7	.....	SAND; grey, very soft, medium dense, dry, sand fine grain size	D	Alluvial
			1.0		.....			
		3/3/4/4/5/4		N=17 N60=25	..O... O..... ...O.. .O.... O.....	gravely SAND; dark grey, sand fine-medium grain, gravel fine-medium grain, soft	M	Alluvial
			2.0					
			3.0					
		5/7/6/4/5/5		N=20 N60=3	....O.			
				0	..O.O	sandy GRAVEL; dark grey, sand coarse grain, gravel fine-coarse grain, medium dense	M	Alluvial
			4.0		O...O			
		Sample to CTS			O...O			
		2/2/4/3/4/3		N=14 N60=21	O.O..			
			5.0					
					O...O			
			6.0		...OO			
		5/4/4/3/4/5		N=16 N60=24	.O.O.			
					.O..O			
			7.0		O..O.			
					..O.O			
		3/3/3/3/4/4		N=14 N60=21	..O.O		M	Alluvial
			8.0					
					O.....	gravely SAND; dark grey, moist, soft, sand medium-coarse grain, grael small-medium grain with some coarse, medium dense	M	Aluvial
					.....O			
			9.0		O.....			
		2/2/4/5/5/5		N=19 N60=29	...O..			
					O.....			
			10.0					
					..O...			

OTHER COMMENTS: Key: ww = Organic/Topsoil ..... = Sand
oo = Gravel

Piezo details: refer driller log

Logged By: OMB
Checked Date: 15-Jan-16
Sheet: 1 of 3

BH-2

BOREHOLE LOG

RDAgritech
ENGINEERED BY NATURE

JOB NUMBER: 50295	PROJECT:	Shotover Country SHA Geotech	
	LOCATION:	SHA borehole 2	
CO-ORDINATES: 1266371 mE	HOLE STARTED:	0.0m	
5007537 mN	HOLE FINISHED:	22.5m	
ELEVATION: m	OPERATOR:	Bryan	
DATUM: site RL	COMPANY:	McNeil Drilling	EQUIP.: Sonic Drill Rig

ENGINEERING DESCRIPTIONS								GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	SPT N Values	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
		4/5/5/4/6/5	11.0	N=20 N60=30	..O.O O...O O..O. O.O.. O.O.. .O.O. O...O	sandy GRAVEL; dark grey, medium dense, moist, sand coarse grain size, gravel fine-medium grain	M	Alluvial
		5/8/7/6/6/7	13.0	N=26 N60=39.5	O..... ..O... O..... ..O... .O.... ....O. O..... ...O.. .....O ..O... O..... ....O. O..... ...O.. O..... ....O. O..... ...O..	gravely SAND; dark grey, dense, soft, sand medium-coarse grain, gravel fine-medium grain, moist	M	Alluvial
		6/6/10/9/10/9 Sample to CTS	14.0	N=38 N60=57.5				
		9/9/10/8/8/8	15.0	N=34 N60=51.5				
		2/2/2/2/2/1	16.0	N=11 N60=16.5				
		4/4/5/7/10/12	17.0	N=34 N60=51.5				
		9/8/9/9/10/9	18.0	N=37 N60=56				
			19.0					
			20.0					

OTHER COMMENTS: Key: ww = Organic/Topsoil ..... = Sand
oo = Gravel

Piezo details: refer driller log

Logged By: OMB
Checked Date: 15-Jan-16
Sheet: 2 of 3

BH-2

BOREHOLE LOG

RDAgritech
ENGINEERED BY NATURE

JOB NUMBER: 50295	PROJECT:	Shotover Country SHA Geotech	
	LOCATION:	SHA borehole 2	
CO-ORDINATES: 1266371 mE	HOLE STARTED:	0.0m	
5007537 mN	HOLE FINISHED:	22.5m	
ELEVATION: m	OPERATOR:	Bryan	
DATUM: site RL	COMPANY:	McNeil Drilling	EQUIP.: Sonic Drill Rig

ENGINEERING DESCRIPTIONS								GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	SPT N Values	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
			21.0		o..... ..o... o..... ..o... ....o. .o.... ....o.	gravely SAND; dark grey, dense, soft, sand medium-coarse grain, gravel fine-medium grain, moist		
		8/8/10/11/11/10	22.0	N=42 N60=63.5				
		9/8/10/10/12/11		N=43	EOH			
			23.0	N60=65		End of borehole at 22.5m		
			24.0					
			25.0					
			26.0					
			27.0					
			28.0					
			29.0					
			30.0					

OTHER COMMENTS: Key: ww = Organic/Topsoil ..... = Sand
oo = Gravel

Piezo details: refer driller log

Logged By: OMB
Checked Date: 15-Jan-16
Sheet: 3 of 3

STANDARD PENETRATION TEST

Site: Shotover Country Job No.:

Bore No.: BH2. Date: 7-1-16. Equip No.:

Co-Ords: Datum: m Surface R.L.:

Plant & Technique.: Sonic.

Rod: 3" mm Casing: 5" mm G.W.L.

Technician Bryan. Checked:

TEST SPECIFICATION NZS 4402 TEST 6.5.1:1988

Penetration (blows)	
6	75mm
6	150
10	225
9	300
10	375
9	450

Depth: 13.5m
Soil Description

N = 38.
N = blows/300mm

Penetration (blows)	
9	75mm
8	150
9	225
9	300
10	375
9	450

Depth: 19.5m
Soil Description

N = 37.
N = blows/300mm

Penetration (blows)	
9	75mm
9	150
10	225
8	300
8	375
8	450

Depth: 15m.
Soil Description

N = 34.
N = blows/300mm

Penetration (blows)	
8	75mm
8	150
10	225
11	300
11	375
10	450

Depth: 21m
Soil Description

N = 42.
N = blows/300mm

Penetration (blows)	
2	75mm
2	150
2	225
2	300
2	375
1	450

Depth: 16.5m.
Soil Description

N = 7.
N = blows/300mm

Penetration (blows)	
9	75mm
8	150
10	225
10	300
12	375
11	450

Depth: 22.5m.
Soil Description

N = 43.
N = blows/300mm

Penetration (blows)	
4	75mm
4	150
5	225
7	300
10	375
12	450

Depth: 18m
Soil Description

N = 34.
N = blows/300mm

Penetration (blows)	
	75mm
	150
	225
	300
	375
	450

Depth:
Soil Description

N =
N = blows/300mm

STANDARD PENETRATION TEST

Site: Shotover County Job No.:

Bore No.: BH2 Date: 6-1-16 Equip No.:

Co-Ords: Datum: m Surface R.L.:

Plant & Technique.: Sonic

Rod: 3in mm Casing: 5" mm G.W.L.

Technician Bryan Checked:

TEST SPECIFICATION NZS 4402 TEST 6.5.1:1988

Penetration (blows)	
3	75mm
3	150
4	225
4	300
5	375
4	450

Depth: 1.5
Soil Description

N = 17.
N = blows/300mm

Penetration (blows)	
3	75mm
3	150
3	225
3	300
4	375
4	450

Depth: 7.5m
Soil Description

N = 14.
N = blows/300mm

Penetration (blows)	
5	75mm
7	150
6	225
4	300
5	375
5	450

Depth: 3m
Soil Description

N = 20.
N = blows/300mm

Penetration (blows)	
2	75mm
2	150
4	225
5	300
5	375
5	450

Depth: 9m
Soil Description

N = 19.
N = blows/300mm

Penetration (blows)	
2.	75mm
2	150
4	225
3	300
4	375
3	450

Depth: 4.5.
Soil Description

N = 14.
N = blows/300mm

Penetration (blows)	
4	75mm
5	150
5	225
4	300
6	375
5	450

Depth: 10.5m
Soil Description

N = 20.
N = blows/300mm

Penetration (blows)	
5	75mm
4	150
4	225
3	300
4	375
5	450

Depth: 6m
Soil Description

N = 16
N = blows/300mm

Penetration (blows)	
5	75mm
8	150
7	225
6	300
6	375
7	450

Depth: 12m
Soil Description

N = 26
N = blows/300mm

STANDARD PENETRATION TEST

Site: Shotover Country Job No.:

Bore No.: BH1 Date: 6-1-16 Equip No.:

Co-Ords: Datum: m Surface R.L.:

Plant & Technique.: Sonic

Rod: Bw mm Casing: 5" mm G.W.L.

Technician Bryan. Checked:

TEST SPECIFICATION NZS 4402 TEST 6.5.1:1988

Penetration (blows)	
4	75mm
5	150
8	225
10	300
12	375
12	450

Depth: 13.5m.
Soil Description

N = 42.
N = blows/300mm

Penetration (blows)	
8	75mm
10	150
11	225
13	300
13	375
14	450

Depth: 20m.
Soil Description

N = 51.
N = blows/300mm

Penetration (blows)	
4	75mm
8	150
12.	225
10	300
10	375
9	450

Depth: 15m
Soil Description

N = 41
N = blows/300mm

Penetration (blows)	
	75mm
	150
	225
	300
	375
	450

Depth:
Soil Description

N =
N = blows/300mm

Penetration (blows)	
10	75mm
9	150
13	225
11	300
10	375
10	450

Depth: 16.5m
Soil Description

N = 44.
N = blows/300mm

Penetration (blows)	
	75mm
	150
	225
	300
	375
	450

Depth:
Soil Description

N =
N = blows/300mm

Penetration (blows)	
5	75mm
6	150
9	225
10	300
8	375
9	450

Depth: 18m.
Soil Description

N = 36
N = blows/300mm

Penetration (blows)	
	75mm
	150
	225
	300
	375
	450

Depth:
Soil Description

N =
N = blows/300mm

STANDARD PENETRATION TEST

Site: Shotover County Job No.:

Bore No.: BH1 Date: 6-1-15. Equip No.:

Co-Ords: Datum: m Surface R.L.:

Plant & Technique.: Sonic

Rod: 3w mm Casing: 5" mm G.W.L.

Technician Bryan Checked:

TEST SPECIFICATION NZS 4402 TEST 6.5.1:1988

Penetration (blows)	
4	75mm
4	150
6	225
9	300
8	375
7	450

Depth: 1.5m
Soil Description

N = 30.
N = blows/300mm

Penetration (blows)	
5	75mm
5	150
4	225
4	300
4	375
5	450

Depth: 7.5m.
Soil Description

N = 17.
N = blows/300mm

Penetration (blows)	
2	75mm
2	150
1	225
2	300
3	375
2	450

Depth: 3m
Soil Description

N = 8
N = blows/300mm

Penetration (blows)	
4	75mm
5	150
7	225
9	300
9	375
8	450

Depth: 9m
Soil Description

N = 33
N = blows/300mm

Penetration (blows)	
5.	75mm
6	150
6	225
6	300
6	375
4	450

Depth: 4.5m
Soil Description

N = 22.
N = blows/300mm

Penetration (blows)	
4	75mm
6	150
7	225
7	300
10	375
13	450

Depth: 10.5.
Soil Description

N = 37.
N = blows/300mm

Penetration (blows)	
4	75mm
7	150
5	225
5	300
5	375
4	450

Depth: 6m.
Soil Description

N = 19.
N = blows/300mm

Penetration (blows)	
7	75mm
8	150
10	225
10	300
11	375
11	450

Depth: 12m
Soil Description

N = 42.
N = blows/300mm

2353

McNEILL DRILLING CO. LTD

LOCATION: Shotover Country. | HOLE No. BH1 | Drill Rig Type: Sonic.

DRILLING LOG | Length of hole: 20m. | Inclination: | Bearing: | Sheet of

DRILLER Bryan | TYPE: Open holing from to (m). Tubexing from to (m). Rotary from to (m). | Rig Engine Hours START: 1684.6

OFFSIDER Ryan / Cody. | SHIFT START DATE: 6-1-16 TIME: 0600 SHIFT FINISH DATE: 6-1-16 TIME: 1930. 13.5 | FINISH: 1691.4.

TIME Start	TIME Finish	RUN LENGTH	INTERVAL From	INTERVAL To	Drilling Method/ Hole Diameter	DESCRIPTION: Hardness, material, colour	Water Pressure (kPa)	Water Flow (l/time)	COMMENTS Breakdowns etc
0600						Workshop / Travel to Qtwn.			
									Water level - 2.9m.
0845						On Site - Shotover Country			
						Site inspection			Peizo BH1
0900						Set up on BH1			
							Recovery	Set @	
1000		1.5	0	1.5m	Sonic 3"	Top Soil - Sandy Gravels	1.5	1.5m.	
		1.5	1.5	3m		Sand bound River Gravels	1.5	3m.	
		1.5	3m	4.5m		Fine Sands - Small Gravels	1.5	4.5m.	
		1.5	4.5	6m		Fine/Corse Sands - Small Gravels	1.5	6m.	3m / 6m
		1.5	6m	7.5m		"	1.5	7.5m.	
		1.5	7.5m	9m		Fine Corse Sandy Gravels.	1.5m	9m	
		1.5	9m	10.5m		↓	1.5m	10.5m	
		1.5	10.5	12m			1.5m	12m	
		1.5	12m	13.5m			1.5m	13.5m	Used: 1x 3m Screen
		1.5	13.5	15m			1.5m	15m	1x 3m 50mm PVC
		1.5	15m	16.5		Fine Sandy River Gravels.	1.5m	16.5m	2x End Caps 50mm
		1.5	16.5	18m		↓	1.5m	18m.	3x Bentonite.
		1.5	18m	19.5			1.5m	-	9x Boxes.
		.500	19.5	20m			.500	20m	
1430						Down 20m T.D			
						Pull out of hole			
						Install 6m Peizo.			
1530						Pack up Site - Move to BH2.			
1700	1930.					Travel to Inv.			

INSTALLATIONS | CASING: from to (m). Diameter: Comments:

SCREEN: from to (m). Diameter: Comments:

TESTING (packer/permeability/flow rate): see test sheets for data

Craigs 121785

2354

McNEILL DRILLING CO. LTD

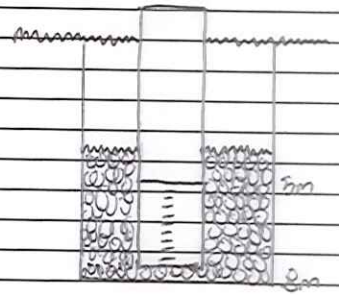
LOCATION: Shotover Country. | HOLE No. BH2. | Drill Rig Type: Sonic.

DRILLING LOG | Length of hole: 22.5m | Inclination: | Bearing: | Sheet of

DRILLER Bryan | TYPE: Open holing from to (m). Tubexing from to (m). Rotary from to (m). | Rig Engine Hours START: 1691.4

OFFSIDER Ryan / Codey | SHIFT START DATE: 7-1-16 TIME: 0600 SHIFT FINISH DATE: 7-1-16 TIME: 1800 12 | FINISH: 1697.5

TIME Start	TIME Finish	RUN LENGTH	INTERVAL From	INTERVAL To	Drilling Method/ Hole Diameter	DESCRIPTION: Hardness, material, colour	Water Pressure (kPa)	Water Flow (l/time)	COMMENTS Breakdowns etc
0600						Travel to Queenstown			
0800						on Site - Pre-Start			
0815						Warm Rig up			Perzo BH2.
0830									
		1.5m	0	1.5	Sonic 3"	Top Soils - Sandy Gravels	Recovery 1.5	Spt@ 1.5	
		1.5m	1.5	3m		Sandy Gravels.	1.5	3m.	
		1.5	3m	4.5		Sand bound Gravels	1.5	4.5.	
		1.5	4.5	6m		loose River Gravels	1.5	6m	
		1.5	6m	7.5.		loose Sandy River Gravels	1.5	7.5.	
		1.5	7.5	9m		Sand bound small Gravels	1.5	9m	
		1.5	9m	10.5		Fine / coarse Sands	1.5.	10.5	
		1.5	10.5	12m		Fine Sand bound Gravel	1.5	12m	
		1.5	12m	13.5		↓	1.5	13.5	
		1.5	13.5	15m			1.5	15m	
		1.5	15m	16.5m		Sandy River Gravels	1.5	16.5	Used: 1x 3m 50mm PVC Screen
		1.5	16.5	18m		↓	1.5	18m	2x 3m 50mm PVC
		1.5	18m	19.5			1.5	19.5	2x B PVC Caps
		1.5	19.5	21m		↓	1.5.	21m	4x Bentonite
		1.5	21m	22.5		Sand bound River Gravels	1.5m	22.5	8x Boxes.
1400						Down 22.5m T.D			
1415						Pull out of hole			
						Install 7.5m Perzo			
1445						Pack up Site. / Pack up Gear.			
1500	1800					Travel to Inv			



INSTALLATIONS | CASING: from to (m). Diameter: Comments:

SCREEN: from to (m). Diameter: Comments:

TESTING (packer/permeability/flow rate): see test sheets for data

Craigs 121785

APPENDIX C. CORE PHOTOS

Borehole 1 – SHA 50295

Bore Hole 1 – SHA 50295

Bore Hole 2 – SHA 50295

Bore Hole 2 – SHA 50295

APPENDIX D. TONKIN AND TAYLOR LTD LIQUEFACTION ASSESSMENT.

Tonkin+Taylor

Job No: 53953
19 January 2016

Shotover Country Ltd
C/- RDAgritech Ltd
PO Box 1880
Queenstown 9348

Attention: David Rider

Dear David

Shotover Country, Queenstown
Liquefaction assessment and factual report

Introduction

Tonkin & Taylor Ltd were engaged by Shotover Country Ltd to undertake a liquefaction assessment based on the results of SPT testing completed in two boreholes drilled on the site in January 2016 and present a factual assessment of the analysis. HDCP tests were completed by others on a nearby site. At the time of writing, T+T are awaiting information to complete an analysis as a comparison for the SPT liquefaction analysis.

Site investigation

The locations of the boreholes and (HDCP tests) are shown on Figure 1, attached. The output from the liquefaction analysis is attached.

The borelogs describe the stratigraphy at the site as:

- Topsoil 0.2 – 0.4m thick, overlying
- Alluvium comprising sandy Gravel or gravelly Sand, medium dense to dense.

The extent of the alluvium was not established by the two boreholes, which extended to 22.5m below ground level (bgl).

Groundwater level, measured in the boreholes at the end of drilling were 2.9 – 3.0m bgl.

Liquefaction analysis

A liquefaction analysis was completed utilizing the method of Idriss and Boulanger (2014)[1]

The analysis considered serviceability limit state (SLS) and ultimate limit state (ULS) peak ground accelerations (PGA). The PGA adopted for this analysis were 0.09g SLS and 0.36g ULS, assuming an

[1] Idriss, I and Boulanger, R, 2014, "Soil liquefaction during earthquakes" Earthquake Engineering Research Institute.

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importance level (IL) 2 and Class D ground conditions. The groundwater level adopted for liquefaction analysis was 3.0m bgl.

The liquefaction analysis indicated the following liquefaction susceptibility.

- No liquefaction triggering indicated at borehole 1 for either the SLS or ULS assessment. However, one test point at 3m depth is marginal for liquefaction/no liquefaction.
- No liquefaction triggering indicated at borehole 2 for the SLS assessment.
- Liquefaction triggering indicated at borehole 2 for the ULS assessment between 4.5m and 10.5m depth. One SPT test point at 16.5m also indicated that liquefaction triggering could occur at this depth. Two test points at 9m and 10.5m were marginal for liquefaction/no liquefaction.

Table 1 below reports index settlement values for the SLS and ULS conditions for the upper 10m and for the full depth of the boreholes.

Table 1: SLS and ULS index settlement values

	Borehole 1		**Borehole 2**	
	Index settlements for upper 10m (mm)	**Index settlements for full depth (mm)**	**Index settlements for upper 10m (mm)**	**Index settlements for full depth (mm)**
SLS	0	0	0	<5
ULS	15	15	85	150

HDCP tests

Four HDCP test results completed nearby to depths of between 7.5 and 15.2m. The approximate location of these are indicated on Figure 1. At the time of writing, T+T are awaiting further technical information, to enable completion of an assessment for liquefaction triggering. This assessment will be completed on receipt of the information.

Applicability

This letter has been prepared for the use of our client Shotover Country Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Yours sincerely

Grant Lovell
Project Director

19-Jan-16
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Attachments: Figure 1 – site location plan
SPT liquefaction assessment

Aerial photograph sourced from Google Earth. Copyright Digital Globe.

Approximate borehole location

Approximate location of four HDCP

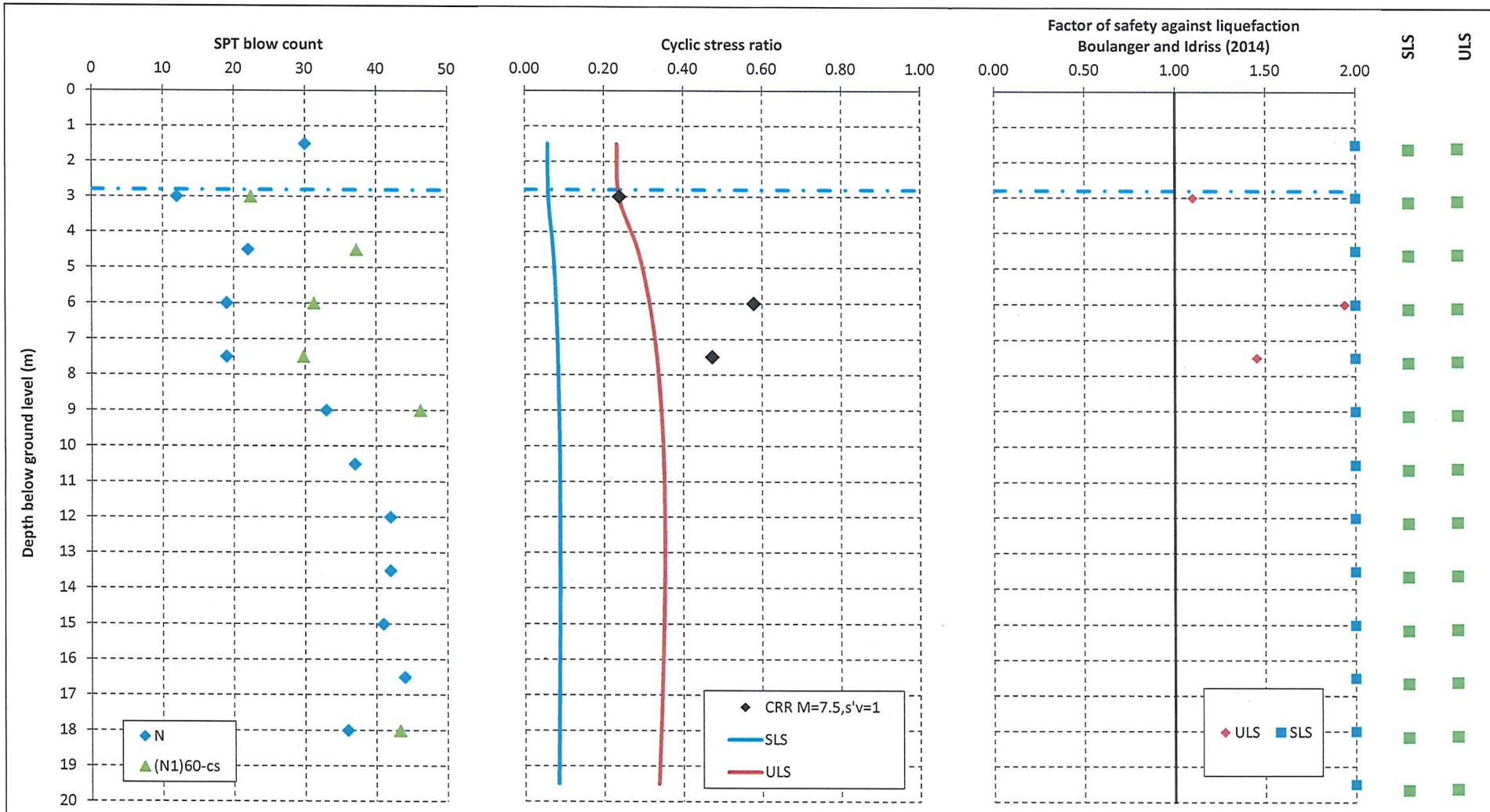
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	AFS	01/16
DRAFTING CHECKED	SJK	01/16
APPROVED		01/16
FILE: 53953		
APPROX. SCALE: Not to scale		
PROJECT No. 53953		

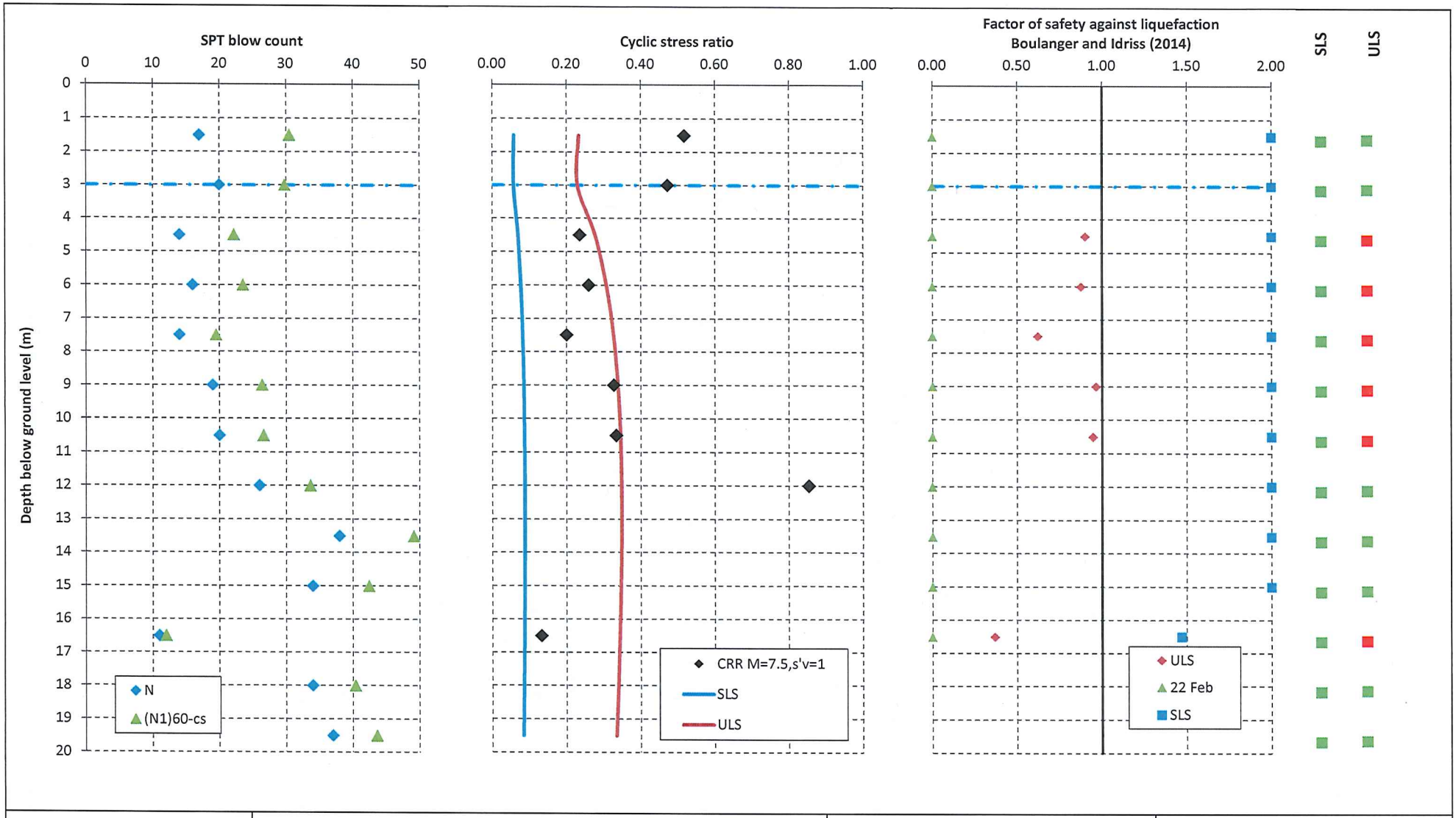
SHOTOVER COUNTRY LTD
GEOTECHNICAL INVESTIGATION
Shotover Country SHA
Site investigation locations

FIG. No. Figure 1

REV. 0



Tonkin & Taylor	CLIENT	RD Agritech	LOCATION	BH-1	DATE 19/01/2016
	PROJECT	Shotover Country	JOB NUMBER	53953	ANALYSED BY JIMB
	DESCRIPTION	Liquefaction assessment from SPT results			CHECKED BY AFS



Tonkin & Taylor	CLIENT: RD Agritech PROJECT: Shotover Country DESCRIPTION: Liquefaction assessment from SPT results	LOCATION: BH-2 JOB NUMBER: 53953	DATE: 19/01/2016 ANALYSED BY: JIMB CHECKED BY: AFS

Shotover Country Special Housing Area

Managing Flood Risk New Zealand Standard

The Otago Regional Council have raised the issue of the New Zealand Standard NZS 9401:2008 "Managing Flood Risk-A Process Standard" methodology in analyzing flood risk. This standard expects that the flood risk context will be established and that the flood risk will be understood. The risks should be identified, analysed, evaluated and treated. On going monitoring, review and adapting to changing circumstances is considered a part of the flood risk management framework.

It is considered that the studies to date and the proposed Special Housing Area (SHA) works have taken account of the matters to be covered and provisions made in the design of the works to the "treated" stage. It is agreed that provisions should be made for ongoing monitoring and review of changing circumstances. The ORC currently undertakes cross-section surveys downstream of the highway bridge for river management and gravel extraction purposes and has published information on analysis of these surveys.

The proposed developments on the lower Shotover River left bank included in both Plan Change 41 and the proposed SHA have taken account of many issues.

1. The Shotover delta area historically includes Frankton and the airport area and formed at this level about 12,000 years ago. Originally Lake Wakatipu discharged at Kingston into the headwaters of the Mataura River. This occurred until the Kawarau River down cut and captured the Shotover River and the lake outflow. This downcutting continued and the area where Shotover Country is situated was a part of the active floodplain. As downcutting continued the lower terrace area where the SHA is proposed became elevated above the normal flood levels and became a non-active part of the delta.

2. The investigations into the potential development of the old floodplain commenced in 2003. Flood levels from the November 1999 flood were available. The Otago Regional Council has regularly surveyed the delta below the bridge on the lines originally established in 1980 by the Ministry of Works and Development. The ORC produced a report "Shotover River Sedimentation" October 2002 and undertook further work described in "Kawarau and Shotover Rivers Sedimentation Investigation" in January 2006. This work has been useful in the planning for the Shotover Country proposals.

3. The ORC, working with QLDC, investigated options for reducing flooding from Lake Wakatipu. They concluded that a training bank in the Lower Shotover River as now constructed was the best solution to improve the outflows from Lake Wakatipu under flood conditions. The investigations and modeling work for that has provided a robust basis for the subsequent modeling work for the SHA.

4. Plan Change 41 included developments on the old left bank floodplain of the Lower Shotover. This was the subject of the hearing commissioners requesting expert caucusing. As part of the expert caucusing for issues raised by the ORC thorough reviews of the flood hydrology, flood hydraulics, and potential for landslide debris dams both up and downstream of the site were covered and results presented to the QLDC Commissioners in 2011.

5. In 2013 the QLDC commissioned a peer review of the hydrology and hydraulics of the Shotover Country development for Plan Change 41. This was carried out by Tonkin & Taylor Ltd. They requested additional hydraulic modeling runs be undertaken to assess risks from uncertainties in the flood hydrology estimates, climate change, and the potential impact of failure of landslide debris dams upstream.

6. That modeling used the latest river cross-sections available from 2010 and conservative assessment of mean bed level trends out 100 years to 2110. The 2110 bed levels used are higher than the 2010 bed levels surveyed. No allowance was made for the large volume of material extracted for the airport extension, ORC training bank or for the fill for Plan Change 41 and SHA in Shotover Country. This adds to conservatism in the modeling.

7. The climate change scenarios were based on the Ministry for the Environment guidance to local government of a medium and high scenarios at 2 degrees and 4.6 degrees Celsius respectively increase in mean temperature by 2090. High intensity rainfall is predicted to increase by about 8% for every degree rise in mean temperature and flood flows are predicted to rise by a similar amount or 16% and 36.8% for the two scenarios.

8. The landslide debris dam failure was based on Jeff Bryant's assessment of the size of impoundment upstream and predicted failure rate with a most realistic scenario being a flow of up to 4600 m^3/s. Four bounding scenarios were modeled from 3000 to 6000 m^3/s.

9. The floods assessed were:

Flood Flow m3/s	Description
1400	1% AEP flood as used in original 2011 report. Aulos 1999 flood flow.
1500	Adopted 1% AEP flood following Environment Court expert caucusing 2011
1740	1% AEP flood plus allowance for 2 deg C climate change
2050	1% AEP flood plus allowance for 4.6 deg C climate change
2390	1% AEP flood + allowance for 2 deg C climate change + 1 Std deviation (84 % Confidence limits)
2730	1% AEP flood + allowance for 4.6 deg C climate change + 2 Std Deviations (97.5% Confidence limits)
3000	Debris Dam Flow I
4000	Debris Dam Flow II
5000	Debris Dam Flow III
6000	Debris Dam Flow IV

10. This peer reviewed report "Shotover Country Plan Change 41 – Review of Shotover River Flood Risk Profiles – Supplementary Hydraulic Modelling" March 2013, was used as the basis for the further work undertaken for the SHA.

11. The effects of the placing of fill for the SHA, including the Recreation Area fill, on flood levels in the Shotover River has been assessed through hydraulic modeling using the 2013 model undertaken for the QLDC peer review as the base.

12. The SHA main fill level is based on being at least 1.1 m above the 2730 m^3/s derived flood profile. Consideration was given to using this level as a stopbank crest level. Stopbanks have been known to breach or allow seepage under, and it was decided that the fill should be placed to the full height with no banking, thus eliminating bank failure risk.

13. The model outputs demonstrate that the maximum effect is a raising of the flood level for a 1740 m^3/s flood (> 100 year return period event – 1% AEP with medium climate change) by 0.15m at the Recreation Area of the SHA tapering off to a zero impact about 200m upstream of the SHA main fill. For the currently assessed 1% AEP flood of 1500 m^3/s the extra flood water depth is 0.14m.

14. The banks on the QLDC oxidation ponds on the opposite or right bank are 1 m above the 1999 flood levels and 0.5m above the modeled 1500 m^3/s flow (1% AEP and based on 2110 mean bed levels (MBL)). The modeled flow for the 1% AEP flood High climate change of 2050 m^3/s would pass with minimal freeboard with the 2110 MBL and the SHA in place. It is understood that the proposed new sewage treatment system for Queenstown will result in the phasing out of the ponds over the next twenty or so years.

15. The immediately adjacent and upstream property (Section 140 Block III Shotover Survey District) to the SHA is owned by Longshot Limited (NR, GW, EM and DG Wilson). Buildings on the riverbank would be flooded by the modeled 1% AEP flood with or without the SHA works. The water depth as modeled would however be about 0.04 m deeper for that size event.

16. No other properties or existing infrastructure, outside of Shotover Country Limited itself, appear to be affected by the proposed SHA proposed fill placement.

17. Bank erosion is currently managed by live riverbank tree protection. This needs to be maintained and enhanced. The proposed fill is to have a batter slope of 15H:1V that is relatively flat given river bank works are often at a slope of 2H:1V. The purpose of this flatter batter is to provide an additional 20m of buffer for the SHA. The batter toe is to be planted with suitable species for toe protection. The responsibilities for the maintenance and repair of the river bank works does need to be arranged.

18. A recent seismic hazard report "Seismic hazard in the Queenstown Lakes district" August 2015, has identified the generation of sediment from seismic shaking. The report states:
"Increased sediment transport in rivers following a large earthquake is anticipated to take decades to work through the river system (e.g., Robinson and Davies, 2013), meaning that delta growth and channel aggradation at the Shotover/Kawarau confluence will be a long- term issue following a large earthquake."

19. The Seismic Report also identifies the potential for a large landslide in the narrow Kawarau Gorge downstream of the confluence with the Arrow River, in the vicinity of the suspension bridge. Should this occur water could back up into Lake Wakatipu. Lower Queenstown starts flooding at about RL 312m. The proposed SHA fill levels are RL 315.5m and above. It is expected that work to lower any landslide dam that would affect downtown Queenstown would be well in hand before flooding would be experienced at the SHA site.

20. The T&T 2013 review considered the landslide debris dam dambreak scenarios provided by Jeff Bryant in 2011 as suitable, and the effects of large flows released by the failure of such debris dams were modelled. The modeling work has thus shown that the Shotover River can accommodate approximately 3 times the current estimated 1 % AEP flood event before flows would start to impact on the filled level of the proposed SHA.

21. Three times the current 1% AEP flow is equivalent to a greater than a 0.01% AEP (1 in 10,000 year) flood and indeed be similar to the estimated Probable Maximum Flood (PMF). This is a super-cautious approach for the SHA that recognizes the potential hazards in a

responsible manner. The residual flood risk for the SHA is considered to be low.

Conclusion

The Tonkin & Taylor peer review dated 22 January 2016 included two caveats that have been addressed in this document:

- The effects of the change in flood levels for other properties or infrastructure along the banks of the Shotover River (T&T Section 4), and

- The residual risk (T&T last bullet point Section 5) has been reviewed through covering off the identified flood risk factors and how they have been addressed from a technical viewpoint. The residual risk is considered to be low, subject to satisfactory arrangements being in place for ongoing monitoring of the Shotover River bed, and for maintenance of the edge protection works for the SHA.

David Hamilton
Consulting Engineer

Tonkin+Taylor

Job No: 53094.01
19 February 2016

Queenstown Lakes District Council
Private Bag 50072
Queenstown 9348

Attention: Ms A Vanstone

Dear Anita

Shotover Special Housing Area
Peer Review of Hydrological Aspects and Flood Risk
Further Information

In accordance with our letter of engagement dated 23 December 2015, and following from our initial repoint dated 22 January 2016, we are pleased to report on our review of the additional information provided by Shotover Country per David Hamilton, received by e-mail on 3 February 2016.

Our 22 January review report noted that:

- No discussion had been provided about the effects of the changes in flood levels (at maximum 0.15 m for the cases modelled) for other properties or infrastructure along the banks of the Shotover River.
- The SHA application did not include an assessment of the residual SHA flood risk in terms of the principles and outcomes identified in NZS 9401: Managing Flood Risk – A Process Standard, which had been identified by Otago Regional Council in its submissions.

1 Effects on other properties

In terms of effects on other properties, the further information provided shows that:

- The banks of the QLDC oxidation ponds are 0.5 m above the modelled present day 1 % AEP event (1,500 m^3/s)
- There would be minimal freeboard to these for the high climate change future flood peak (2,050 m^3/s) with project aggraded bed levels in 2110
- There would be a 40 mm increase in flood levels on the immediately upstream property on the left bank, which would already be flooded in the 1 % AEP event without the proposed SHA works.

David Hamilton indicates that there are "*no other properties or existing infrastructure ... appear to be affected by the proposed fill placement*".

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The effects of possible future flood levels identified appear to be limited. However, we presume that a detailed analysis of the effects of any works would be required as part of any future resource consent application for the development, including consultation with affected parties as part of the process.

2 NZS 9401: Managing flood risk

ORC has indicated its position that the proposed SHA will result in a net increase in flood risk, notwithstanding the mitigation measures proposed (ground raising, toe protection and strengthening and on-going maintenance). The Regional Council refers to NZS 9401, which identifies a framework for managing flood risk, and suggests that the increased and residual risk associated with the SHA are contrary to the flood management guidelines included in the standard.

The standard identifies its purpose is "*to provide an agreed best-practice approach ... to ensure that proper consideration is given to all aspects of flood risk when making decisions, so that over the longer term, the risk of adverse effects from flooding decreases.*"

The NZS 9401 framework identifies stakeholder responsibilities for *inter alia* communities, professionals and local government. The elements of the framework include risk management "*to encourage a wider assessment of strategies and options... and awareness of residual risk*", and comprehensive risk treatment strategies "*including reduction, readiness, response and recovery*".

The application of the framework includes for:

- Communication, consultation and collaboration
- Establishment of flood risk context
- Identification, analysis and evaluation of risks
- Treatment of risks
- Monitoring and review of risks and adaptation.

In the further information provided by David Hamilton he suggests that the studies to date have "*taken account of the matters to be covered and provisions made in the design of the works to the "treated" stage*". Certainty the information provided by Shotover Country (and others) has helped to establish the flood risk context for the Shotover catchment. Modelling results have identified and enabled an evaluation of the flood risks, both for the existing situation and for the scenario including the proposed SHA development. The modelling results for the post-development scenario provide information for the assessment of the residual flood risk, both for the SHA development and the general delta area, as anticipated in NZS 9410. This information can also be used for the planning of readiness, response and recovery activities to manage the residual risks for extreme events, which are also perhaps matters that can be addressed as part of any future resource consent application process.

In this respect Shotover Country and its advisors are contributing as Organisational and Professional stakeholders to the flood risk management framework identified by the standard. Others identified as part of the process include individuals, communities and governmental stakeholders, with a collaborative and partnership approach identified for the control and management of flood risk.

We presume that the information provided by Shotover Country is communicated and incorporated with other flood management initiatives, e.g. district and regional policy development, annual and long term community planning, to ensure that flood risks in the Queenstown Lakes District are identified and treated appropriately.

3 Applicability

This report has been prepared for the exclusive use of our client Queenstown Lakes District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

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Tom Bassett

SENIOR WATER RESOURCES ENGINEER

Authorised for Tonkin & Taylor Ltd by:

.....

Kevin Hind

PROJECT DIRECTOR

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Otago Regional Council

Our Reference: A881303

10 February 2016

Anita Vanstone
Queenstown Lakes District Council
PO Box 50072
Queenstown

Dear Anita

ORC feedback on expression of interest for development of a Retirement Village for the Ayrburn Special Housing Area

Otago Regional Council (ORC) provided Queenstown Lakes District Council (QLDC) feedback on a former proposal for the Ayburn Special Housing Areas in June 2015.

Given the information supporting the proposal is not detailed, nor complete at this time, I can only provide an indication of issues the ORC would expect to see further addressed before considering a decision on its position.

As with ORC's previous response, ORC considers it as important to provide QLDC with any preliminary concerns ORC holds in respect to aspects of the proposals prior to making their decision.

There is an active debris-dominated alluvial fan through the centre of the proposed development area (with a 100 annual return interval). Residential development will significantly increase risk. It is noted the supporting information recognises an appropriate investigation will be required to assess this, and other, geotechnical and hazard related matters.

Storm water proposed to be discharged to Mill Stream will be required to have no decrease in the quality of storm water discharge from this site nor an increase in its rate of discharge. It is noted that the supporting information recognises ORC resource consent will be required to be applied for.

ORC seeks that a strategic approach is considered to address transport issues, particularly public transport, to, from and within these developments as well as connection to other necessary infrastructure.

ORC public transport staff note that the proposed development is isolated from other residential areas and this can be problematic for providing public transport. Isolated developments results in a lot of "dead" running where there are no passengers to pick up- e.g. running past paddocks and this type of land use leads to indirect services, as the routes need to deviate to pick people up.

The traffic report assumes that public transport would be provided without consideration of the likely cost implications and uptake of the service.

Compliance with other higher level regulations such as National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health will also be important.

Please contact me at this office if you have any further questions.

Yours sincerely

Warren Hanley
Resource Planner – Liaison