REPORT

Tonkin+Taylor

Huia Water Treatment Plant Replacement Project

Addendum to the Preliminary Land Stability Assessment Report

Prepared for

Watercare Services Limited

Prepared by

Tonkin & Taylor Ltd

Date

July 2019

Job Number

30848.2000

Exceptional thinking together

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Document Control

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Table of contents

1 Introduction

Watercare Services Limited (Watercare) is proposing to construct a new water treatment plant (WTP) near Titirangi to replace the aging Huia WTP. The replacement WTP is to be constructed on the southern side of Woodlands Park Road, between Manuka Road and Scenic Drive. Watercare is also proposing to construct two 25 ML treated water reservoirs as part of the overall scheme.

A single 25 ML reservoir (Reservoir No. 1) is to be constructed on the northern side of the Woodlands Park Road, directly opposite the proposed replacement WTP. Associated with Reservoir No. 1 is a tunnel shaft and valve chamber required for the North Harbour No. 2 (NH2) pipeline. A second 25 ML reservoir (Reservoir No. 2) will be constructed within the existing Huia WTP once the latter is decommissioned.

Tonkin & Taylor Ltd (T+T) prepared a Preliminary Land Stability Assessment[1] as part of the Assessment of Environmental Effects (AEE) documentation submitted to Auckland Council in June 2019 in support of a resource consent for the project. This addendum presents the results of additional assessments undertaken since completion of the AEE.

2 Geotechnical Design Parameters

In 2010, T+T undertook a comprehensive assessment of the existing WTP as part of a proposed redevelopment project[2]. Part of this assessment was the derivation of geotechnical design parameters for the various geological units identified on site. These are reproduced below as Table 2.1. Subsequent to this work, Opus undertook additional geotechnical investigations in the general vicinity of the tunnel shaft and Reservoir No. 1[3]. This work was used by T+T to develop the geological sections presented in the land stability and the groundwater and settlement assessments[4] submitted as part of the AEE.

A detailed review of the geotechnical data that preceded and post-dated T+T (2010), undertaken as part of the AEE assessment, confirmed that the geotechnical parameters presented in Table 2.1 were representative of the broader replacement WTP project area, and that they were sufficient to be used for the analyses presented in this addendum. A review of these parameters will be undertaken following the completion of planned additional site-specific investigations. Elastic parameters used in consolidation settlement assessments were presented in the Groundwater and Settlement Report. These were based on a consideration of site-specific data (undrained shear strength and SPT).

[1] Tonkin & Taylor, 2019. Huia Water Treatment Plant Replacement Project. Preliminary Land Stability Assessment. Report prepared for Watercare Services Limited dated May 2019.
[2] Tonkin & Taylor, 2010. Huia Water Treatment Plant Rebuild, Geotechnical Investigation and Assessment. Report prepared for Watercare Services Limited dated October 2010.
[3] Opus, 2013. Woodlands Park Road Reservoirs, Geotechnical Investigation Report. Report to Watercare Services Limited dated December 2013.
[4] Tonkin & Taylor, 2019. Huia Water Treatment Plant Replacement Project. Groundwater and Settlement Effects. Report prepared for Watercare Services Limited dated May 2019.

Table 2.1: Geotechnical design parameters (T+T, 2010)

Geotechnical Unit	Bulk Density (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle (º)
Colluvium/Fill(	16.0	2	30
CW-HW Cornwallis Formation	17.5	8	28
Shear Surface	17.5	0	16
MW Cornwallis Formation	18.0	5	35
SW Cornwallis Formation	20.0	30	38

Notes: CW = completely weathered, HW = highly weathered, MW = moderately weathered and SW – slightly weathered

3 Geological Conditions

This section provides additional geological assessments of the Reservoir No. 2 site and the Scenic Drive escarpment.

3.1 Reservoir No. 2

Reservoir No. 2 will be an above-ground structure located partially within the existing WTP and partially within adjacent undeveloped land. The area has been subject to a number of geotechnical investigations as shown on Figure A1 (Appendix A). The base map has been taken from the geotechnical assessment undertaken by T+T in 2010. This represents the full extent of known geotechnical investigations for this area.

A geological long section was constructed through what is now the proposed Reservoir No. 2 site in 2010. This is presented as Figure A2 (Appendix A). This figure has been modified to show the proposed location of Reservoir No. 2 and the fill embankment proposed to form part of the building platform.

Figure A2 show the same fundamental stratigraphy presented in T+T (2010) with up to 5 m of fill and colluvium overlying variably weathered Cornwallis Formation volcaniclastic sandstones and conglomerates. Slightly weathered rock is encountered at a depth of approximately 15 m below ground level. The contacts between the geological/weathering units dips to the south approximately parallel to the ground surface.

The T+T (2010) geological and geotechnical assessment of the Reservoir No. 2 site, together with the current geotechnical review, is considered adequate for the AEE in support of resource consent application.

3.2 Exhibition Drive Escarpment

The escarpment behind Reservoir No. 1 and the tunnel shaft is steep and formed within weak to moderately strong volcaniclastic sandstone[5]. The steep nature of the escarpment can be seen in Figures 3.1 and 3.2. The rock forming the escarpment is exposed within the cutting used to form the track known as Exhibition Drive (Figure 3.3).

Below exhibition drive the slope consists of a chaotic mixture of soil and rock that has been deposited at the base of the escarpment through both natural slope forming processes (colluvium and talus) and from the construction of Exhibition Drive. This talus slope is geologically distinct from

[5] Potentially mostly Nihotupu Formation although Cornwallis Formation may occur below Exhibition Drive.

that forming the slope above exhibition drive. It was noted, however, that the upper 1/3 or so of the talus slope is thin, with some rock outcrops present.

The geological section of the escarpment presented in the AEE and reproduced in Figure 3.4 below reflects the description presented above.

Figure 3.1: View of the escarpment from the existing tank north of Woodlands Park Road.

Figure 3.2: Steep cutting upslope of Exhibition Drive behind Reservoir No. 1 location

Figure 3.3: Thickly and horizontally bedded volcaniclastic sandstone seen on the inside of the Exhibition Drive cutting immediately upslope of Reservoir No. 1.

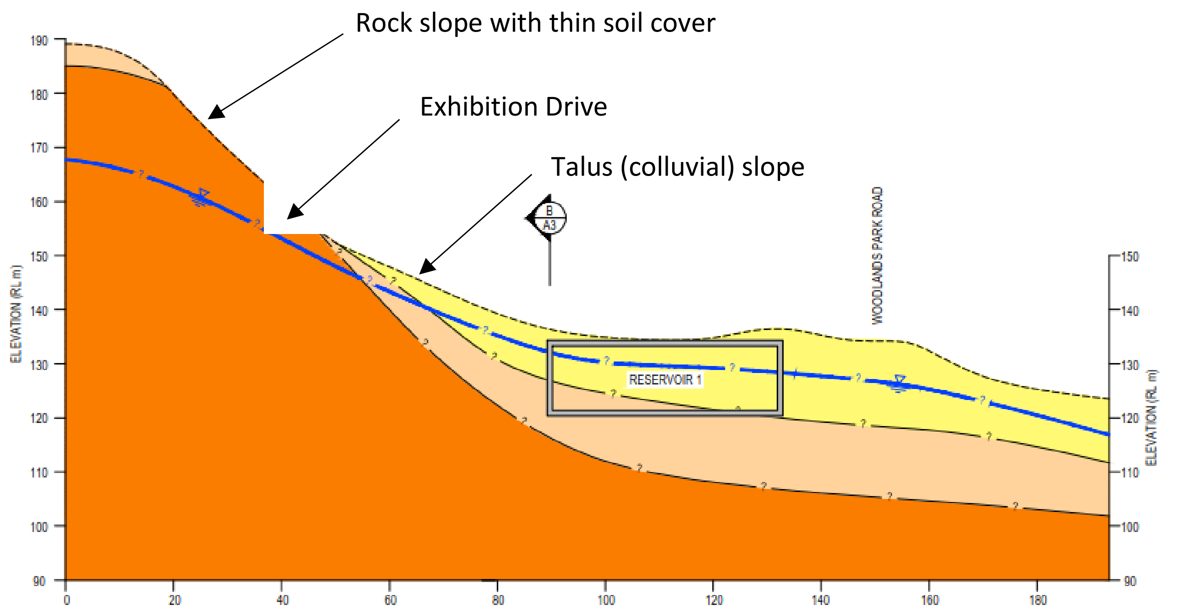


Figure 3.4: Geological section showing the escarpment located north of the Reservoir No. 1 site

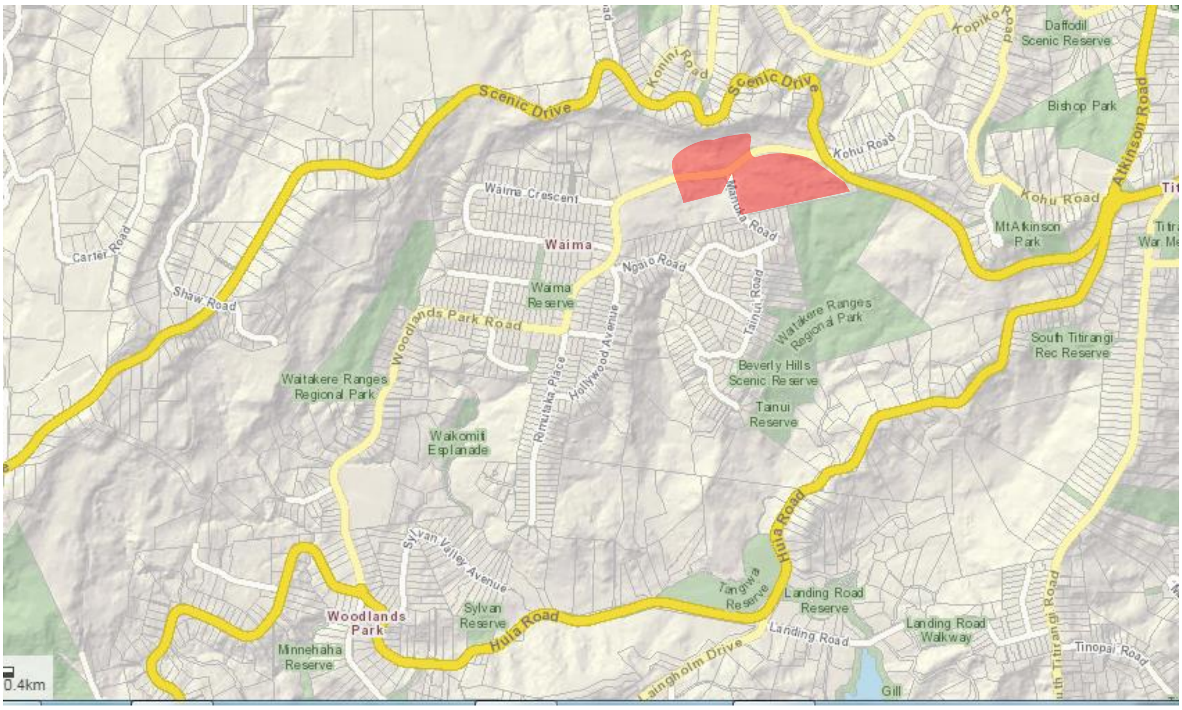
4 Slope Stability Considerations

4.1 Ancient landslide

The Groundwater and Settlement Report (Appendix H of the AEE) described the potential presence of a large regional-scaled landslide that had been discussed in a number of previous reports. The escarpment below Scenic Drive can be inferred from the topographic map presented in Figure 4.1 to be the headscarp of a very large landslide approximately 3 km^2 in area. The proposed WTP site is located at the extreme eastern end of the headscarp. The vast majority of the landslide is located to the west, with the most significant portion being located in the Waitakere Ranges Regional Park.

The landslide is considered to be an ancient (dormant) feature that does not represent a realistic hazard to the proposed WTP. Evidence for stability includes the pattern of drainage channels cross the surface of the landslide (Figure 4.2). The fact that such a well-established drainage pattern has developed is indicative of a landslide that is probably many thousands of years old. Furthermore, there are no offsets to the pattern that would indicate any movement of the landslide since its initial formation. The landslide is not actively being eroded at its toe by a river, a common source of ongoing instability within ancient landslides.

A number of boreholes were drilled into the landslide by Opus as part of their 2013 investigation. None of these boreholes encountered evidence of landsliding, although they were only 15 m deep. A future site investigation could potentially gain information of the location and nature of the landslide through the drilling of one or more deep boreholes.



Figures 4.1: Topographic map showing the likely presence of a very large ancient landslide covering the area between Scenic Drive and Huia Road. The approximate location of the Huia WTP replacement project is indicated in red.

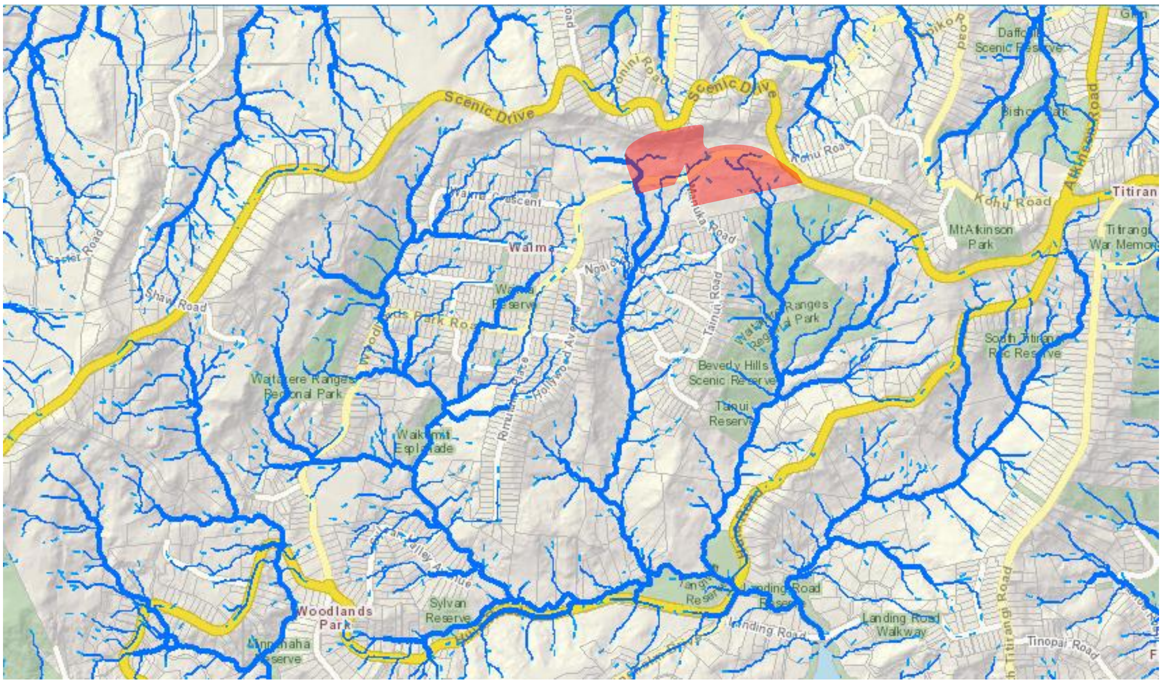


Figure 4.2: Drainage patterns developed over the surface of the ancient landslide.

4.2 Reservoir No. 1/Tunnel Shaft

Both Reservoir No. 1 and the tunnel shaft are located on flat ground and are subsurface structures. There is potentially only one source of slope instability and that is the escarpment located to the north. Two forms of instability are possible: rock fall from the escarpment and failure of the talus (colluvium) slope located at the base of the escarpment.

The stability of the rock escarpment is entirely independent of the proposed development in terms of the proposed development affecting the escarpment. There is however potential for rock falls to send boulders down into the reservoir site. This has happened relatively recently at the nearby abandoned filter station where a security fence was damaged. This is an issue of asset protection that should be accounted for in detailed design.

The talus slope has formed from the deposition of soil and rock that have either naturally fallen from the escarpment and/or come from the excavation of exhibition drive. Being deposited in this fashion, the talus slope can be considered to be at its angle of repose and therefore marginally stable. That being said, the slope is fully vegetated and site examination did not identify any slope instability other than minor surface soil creep.

There is potential for earthworks undertaken without appropriate controls to initiate slips within the talus slope. It will be necessary as part of the project design and construction that the talus slope be left unaltered or retained where material is removed from its toe.

4.3 Replacement WTP

The replacement WTP is located on a gently sloping site (Figure 4.3). Other than temporary cut slope stability, we consider that there are no slope stability issues that require assessment at this stage, although detailed design will need to account for the long term stability of the slopes below Woodlands Park Road (presumably by retaining walls) and the stability of the fill platform at the southern end of the site. The analysis of very similar geology at the existing WTP demonstrates that such development is possible without inducing slope instability (see Section 4.4)

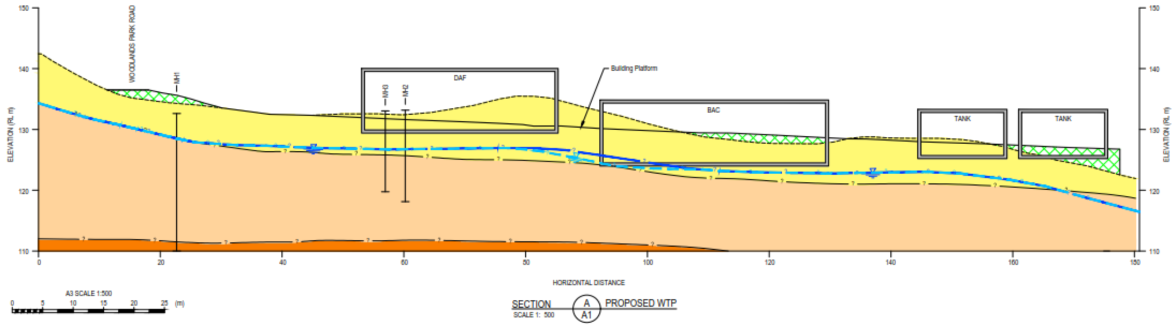


Figure 4.3: Replacement WTP profile.

4.4 Reservoir No. 2

Reservoir No. 2 will be constructed on a building platform that consists partly of cut and partly of an engineered earth embankment. A detailed assessment of this area was undertaken by T+T in 2010.

The then-proposed development was broadly similar to that currently proposed with Reservoir No. 2. Slope stability assessments undertaken in 2010 showed that the Reservoir No. 2 site had a static Factor of Safety of 2.4, well above the typically required minimum of 1.5. Under the design earthquake loading of 0.31g, the site's FoS reduced to 1.1. Typically, a FoS of 1.0 to 1.1 is adequate under seismic loading, depending upon the magnitude of induced displacement. The slope was also reported to have a high FoS under elevated groundwater conditions.

Indicative stability analyses have been undertaken for the same geological section modified to include Reservoir No. 2 and the proposed fill embankment (Figure 4.4). The results of the analyses (Figures 4.5 to 4.9) returned similar results as the 2010 analyses and therefore confirm the suitability of the site for the proposed development. The removal of the underlying colluvium and/or the use of higher strength reinforcement could readily increase the stability of the fill should this be required/desired.

These results are considered conservative as they do not take into account the presence of any deep foundations constructed to support Reservoir No. 2 nor the removal of colluvium from beneath the fill embankment.

The investigation undertaken by T+T in 2010 specifically investigated the potential of low strength shear surfaces beneath the Reservoir No. 2 site that had been identified within some historic boreholes. A programme of investigations at the Reservoir No. 2 location was undertaken in 2010 specifically undertaken to establish the presence, or otherwise, of a low strength surface(s) potentially associated with the historic landslide. Although a limited number of polished surfaces where found in some boreholes (commonly steeply dipping), others did not and no continuous shear surface(s) could be established. These where subsequently excluded from slope stability analyses.

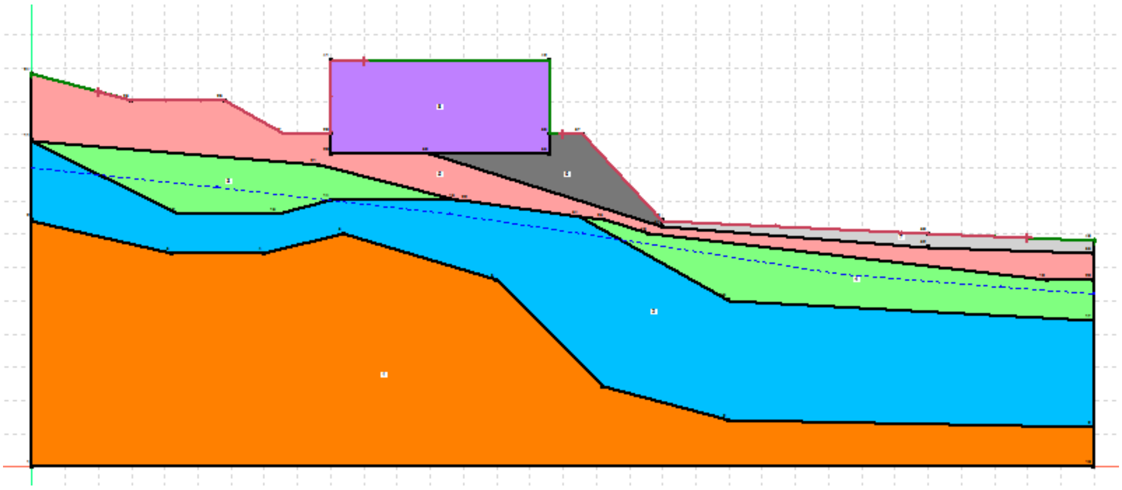


Figure 4.4: 2D slope stability model of Reservoir No. 2. See Figure A2 for geological units

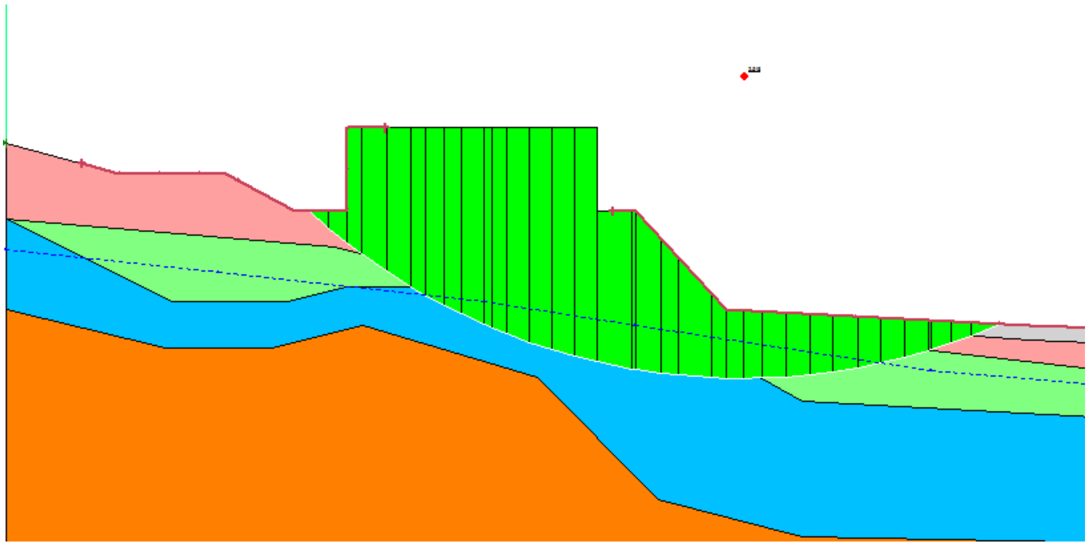


Figure 4.5: 2D static slope stability analysis for Reservoir No. 2 (FoS=2.4)

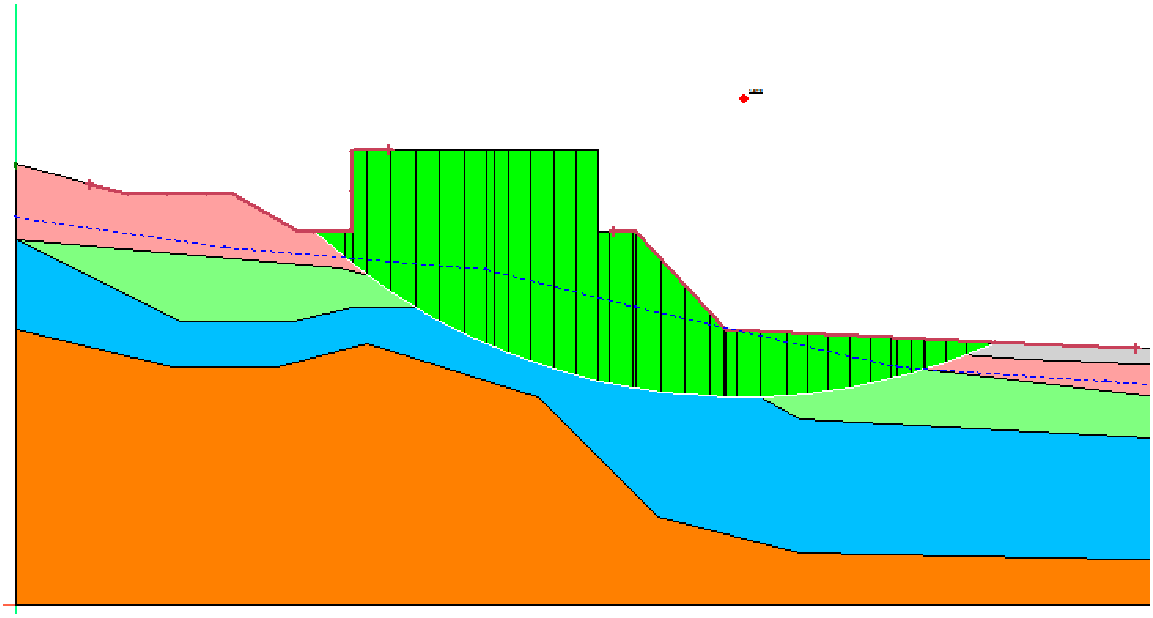


Figure 4.6: 2D static slope stability analysis with elevated groundwater conditions (FoS = 2.0)

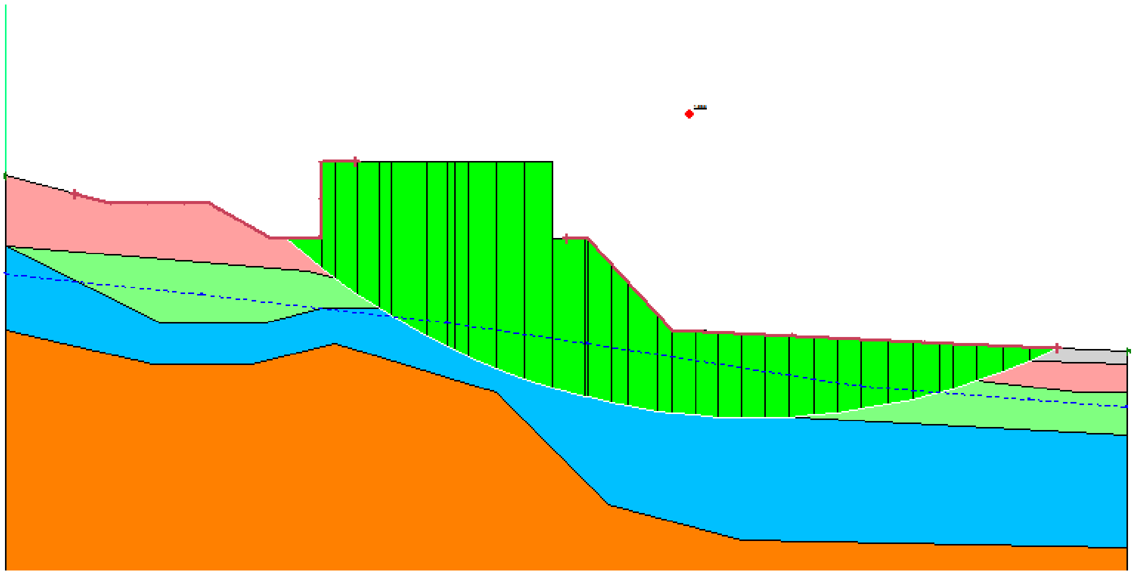


Figure 4.7: 2D seismic slope stability analysis for Reservoir No. 2 (FoS=1.1)

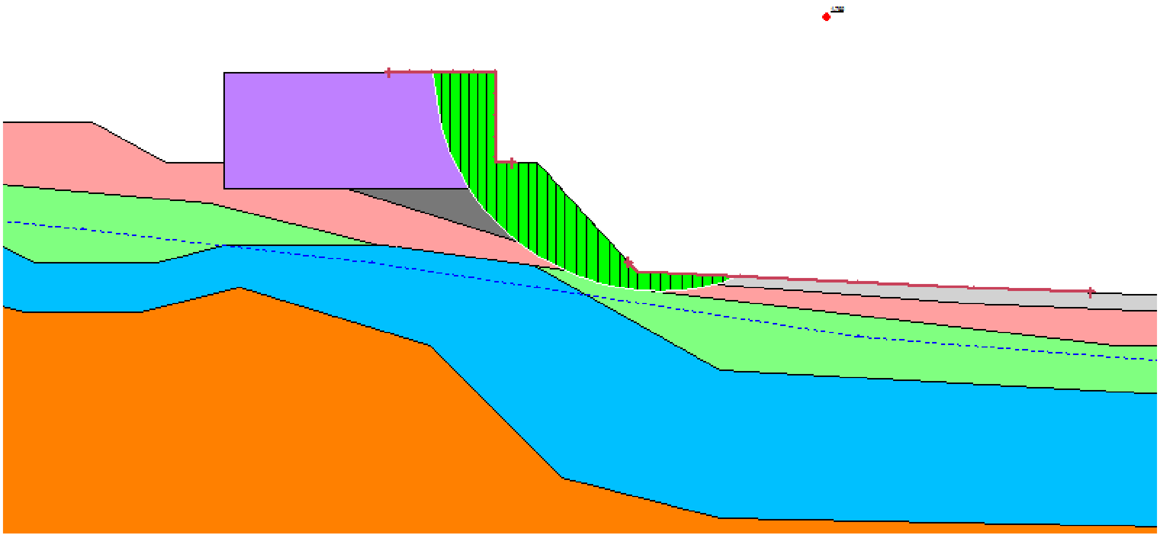


Figure 4.8: 2D static slope stability analysis for the fill in front of Reservoir No. 2 (FoS = 1.77)

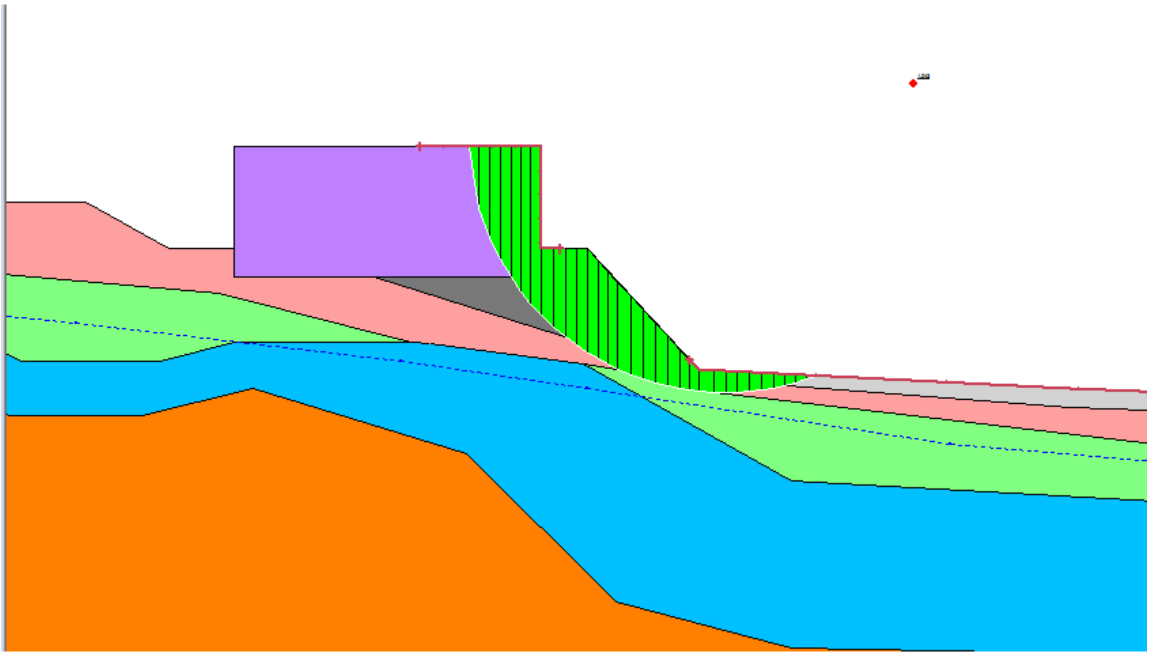


Figure 4.9: *2D seismic slope stability analysis for the fill in front of Reservoir No. 2 (FoS =* 1.04)

5 Settlement

Fill will be placed on both the replacement WTP and Reservoir No. 2 sites. The latter has by far the greatest thickness of fill (up to 10 m). Placement of fill will result in the consolidation of the underlying soils and completely weathered rock. An assessment of the magnitude of this consolidation settlement has been undertaken at the Reservoir No. 2.

Based on the available borehole and laboratory data for the existing WTP, the colluvium and completely weathered to highly weathered Cornwallis Formation materials were assigned Coefficient of Volume Compressibility (Mv) values of 0.25 m^2/MN and 0.1 m^2/MN respectively.

Standard elastic compression calculations show that under a 10 m thickness of engineered fill, 50 mm of consolidation can be expected for each metre of colluvium and 20 mm for each metre of completely weathered to highly weathered Cornwallis Formation. Adopting the geological profile used in the stability analyses (2 m of colluvium and 2 m of Cornwallis Formation soil), 10 m of fill is expected to result in a settlement of 150mm.

Settlement of the indicated magnitude is in excess of what would be acceptable for a structure such as Reservoir No. 2. This can be addressed by either removing the colluvium prior to construction or the installation of pile foundations that penetrate to rock. Preloading the site is also a possibility depending on the available construction programme, although potentially detrimental effects on the stability of the slope will likely preclude this as a ground improvement option.

With respect to the replacement WTP site, the heavy structures will all be buried to a significant depth and will therefore induce negligible settlement. Some minor settlement can be expected to occur in areas where fill is used to raise the site above current elevations, however these settlements can be expected to be minor given the absence of any significant thickness of soft soils. Management of the settlements are a matter for detailed design.

No fill is to be placed outside of Watercare properties and will not impact adjacent properties nor roads.

Mechanical settlements will also occur in immediate proximity to the deep excavations required for structures such as Reservoir No. 1. The deflection and resultant vertical settlement will depend on the actual construction methodology, however it can be expected that up to 5 mm of settlement over and above that induced by groundwater drawdown could occur within 10 m of excavations.

6 Applicability

This report has been prepared for the exclusive use of our client Watercare Services Limited, 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

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Kevin J. Hind	Peter Roan
Technical Director, CMEngNZ (PEngGeol)	Project Director

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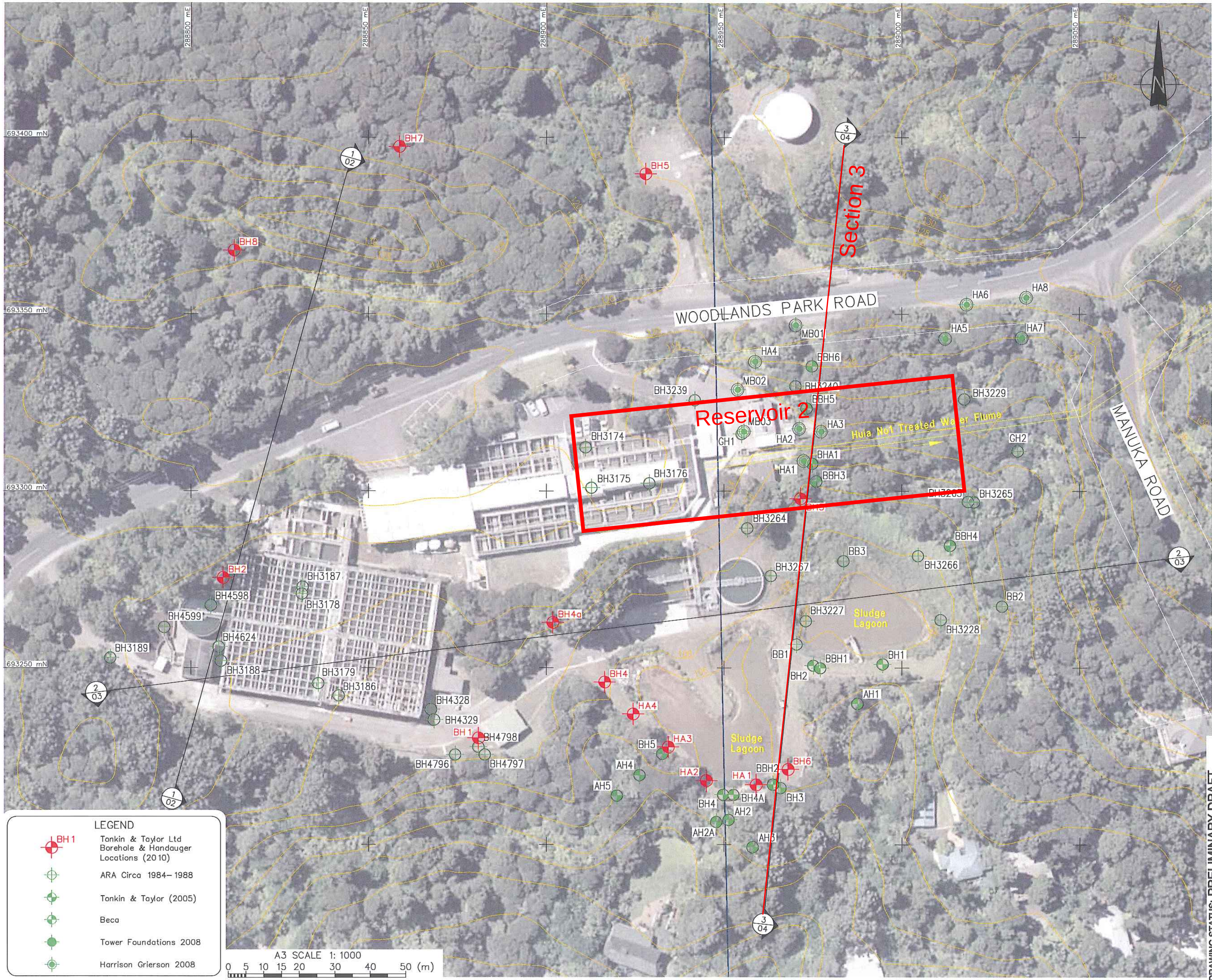
Appendix A: Figures



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NOTES :

1. All dimensions are in metres unless noted otherwise.
2. Existing contours from WSL survey. Drawings E3X144 dated 10.10.05, E3X122 dated 08.04.04, E3X123 dated 04.05.04, E3X130 date 15.06.04 and E3X132 dated 23.06.04.
3. Borehole positions from GHD report No. 2585 dated september 2002, BECA – Fig 1 dated 17.11.05 and Tonkin & Taylor Ltd report dated October 2005.

REVISION DESCRIPTION	BY	DATE
0 First Issue		

DESIGNED :	STMM	Jun. 10
DRAWN :	LJD	Jun. 10
DESIGN CHECKED :		
DRAFTING CHECKED :		
REFERENCE :		

CADFILE : \\27064.001–01.dwg

APPROVED : NOT FOR CONSTRUCTION

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Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

DRAWING STATUS: PRELIMINARY DRAFT

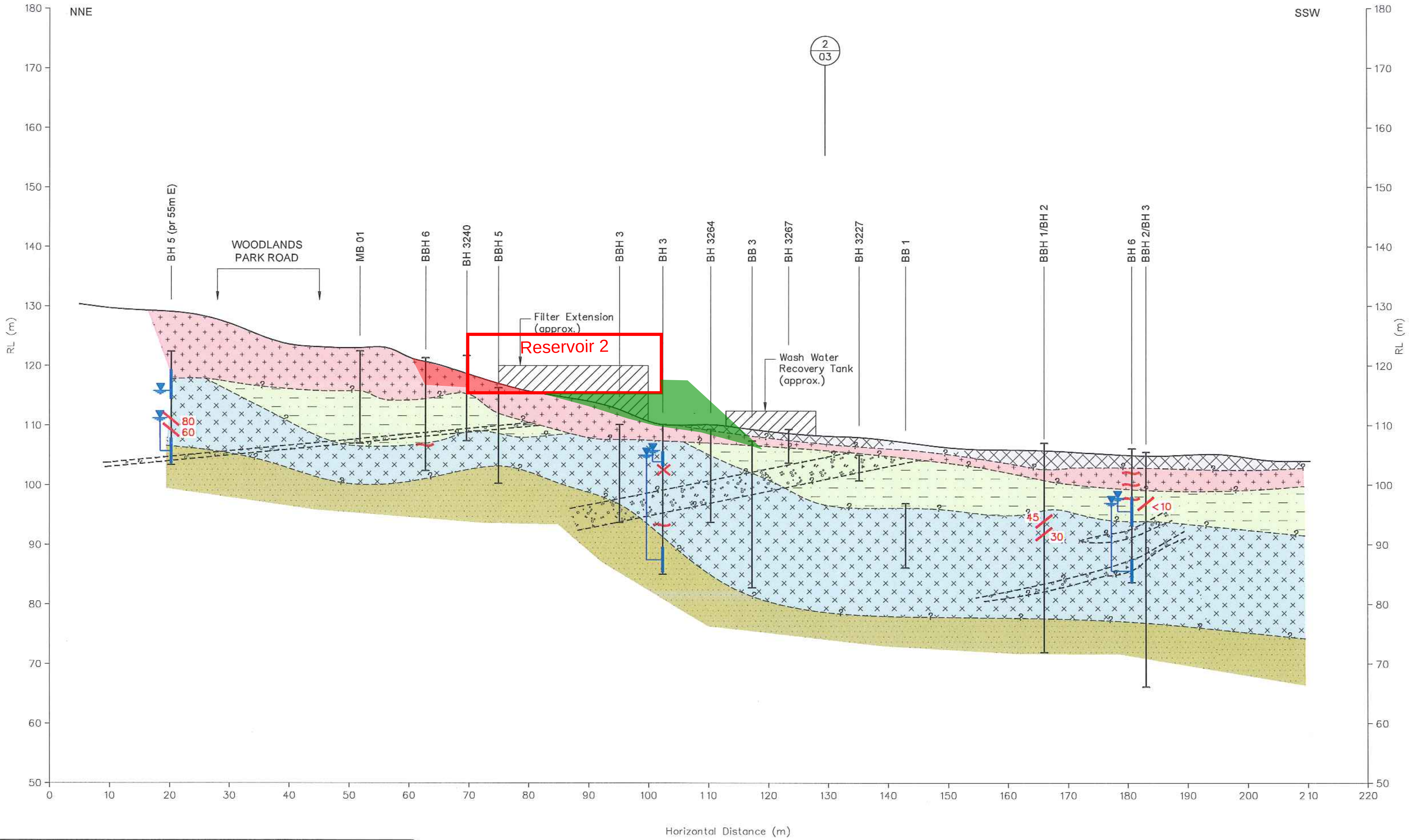
WATERCARE SERVICES LTD

HUIA WATER TREATMENT PLANT INVESTIGATION PROPOSED INFRASTRUCTURE UPGRADE T&T 2010

Site Investigation Location Plan

SCALES (AT A3 SIZE) AS SHOWN

Figure A1



SECTION 3
SCALE 1:750

LEGEND

- Fill
- Colluvium
- CW – HW Cornwallis Formation
- HW Cornwallis Formation
- SW Cornwallis Formation
- Polished surface along bedding
- 40 Polished surface not following bedding (inclination from horizontal shown)
- Polished surface unknown orientation
- Piezometer

A3 SCALE 1:750
0 5 10 15 20 25 30 35 40 (m)

DRAWING STATUS: **PRELIMINARY DRAFT**

DESIGNED :	STMM	Jul. 10
DRAWN :	AGI	Jul. 10
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\27064.001-04.dwg		
APPROVED : NOT FOR CONSTRUCTION		

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NOTES :
1. All dimensions are in millimetres unless noted otherwise.

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Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

CLIENT, PROJECT
WATERCARE SERVICES LTD
HUIA WATER TREATMENT PLANT INVESTIGATION

TITLE
PROPOSED INFRASTRUCTURE UPGRADE
Geological Cross Section 3

SCALES (AT A3 SIZE)
1: 750

Figure A2

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