REPORT

Tonkin+Taylor

MILLWATER - PRECINCT 2
STAGE 3B

Geotechnical Completion Report

Prepared for
WFH Properties Ltd
Prepared by
Tonkin & Taylor Ltd
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Executive summary

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd to monitor and provide earthworks certification for the 27 No. Residential Lots contained within Stage 3B of Precinct 2 in the Millwater Subdivision in Silverdale. Stage 3B comprises residential Lots 356 to 370 and 387 to 398 inclusive as shown on the Woods Final Contour As–Built Plan (Woods Ref 33211–03B–AB–100) in Appendix A1. This Geotechnical Completion Report contains information required for subdivisional earthworks completion reporting, as well as outlining geotechnical design issues that need to be considered for subsequent building design and construction on each residential Lot.

Previous geotechnical investigation work across the subdivision was undertaken by T+T and reported in:

a 2000 and 2001 Preliminary feasibility reporting (Ref. [1] and [2]).

b 2003 Major reconnaissance report covering land in the Silverdale North and Orewa West areas (Ref. [3]).

c 2004 Geotechnical Investigation Report for the Wainui Road Subdivision (Ref. [4]), updated in October 2005 following scheme modifications (Ref. [5]).

d 2006 Investigation report following purchase of Westlake property (Ref. [6]).

e May 2014 Geotechnical Investigation Report for Precinct 2 (Ref. [7]).

Woods Ltd (Woods) undertook the engineering design for this stage and the overall subdivision.

Bulk earthworks commenced on site in 2007, temporarily ceased in late 2008, recommenced in 2013, and were completed by March 2016. Earthworks comprised the following:

a Stripping of vegetation, organic materials and topsoil to stockpile.

b Installation of gully and subsoil drains.

c Construction of 1 No. Shear Key (SK03) as shown on T+T Drawing 21854.001–P2S3B–101 in Appendix A2.

d Cut to fill earthworks across the entire site, incorporating construction of 2 No. reinforced earth slopes (i.e. RE 603 and RE 604), as shown on T+T Drawing 21854.001–P2S3B–101 in Appendix A2.

Civil earthworks commenced on site in March 2016 and were completed by July 2016, and comprised the following:

a Minor cut to fill earthworks across parts of the site as part of final Lot development, as shown on the Woods Cut/Fill Contour As–Built Plan Earthworks Surface – Final Surface (Woods Ref 33211–03B–AB–111) in Appendix A1.

b Construction of 2 No. timber pole retaining walls (i.e. Walls 304 and 305) in the location shown on the Woods Retaining Wall As–Built Plans (Woods Ref 33211–03B–AB–150 and –151) in Appendix A1.

c Installation of roading and services.

Overall subdivisional soil types are moderately expansive (Class M), based on laboratory testing undertaken in accordance with AS 2870:2011 (Ref. [9]). Due to this classification, soils lie outside the definition of good ground within NZS 3604:2011 (Ref. [10]). Building foundations will require either specific foundation design for expansive soils or foundation design in accordance with AS 2870:2011 (Ref. [9]). Subject to design issues outlined in Section 3, and CSIRO recommendations outlined in the appendices relating to expansive soils foundation design and home owner maintenance, each residential Lot is considered to have a building platform area generally suitable for domestic residential development subject to specific geotechnical assessment and foundation design due to the

presence of expansive soils and where Lots contain, or are adjacent to, land with slopes steeper than 1 in 4 (V:H).

Foundation design for residential development should proceed in accordance with Sections 6.5 to 6.10 of this report.

1 Introduction

1.1 General

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd to monitor and provide earthworks certification for the 27 No. Residential Lots contained within Stage 3B of Precinct 2 in the Millwater Subdivision in Silverdale. Stage 3B comprises residential Lots 356 to 370 and 387 to 398 inclusive as shown on the Woods Final Contour As–Built Plan (Woods Ref 33211–03B–AB–100) in Appendix A1.

Previous geotechnical investigation work across the subdivision was undertaken by T+T and reported in:

a 2000 and 2001 Preliminary feasibility reporting (Ref. [1], [2]).

b 2003 Major reconnaissance report covering land in the Silverdale North and Orewa West areas (Ref. [3]).

c 2004 Geotechnical Investigation Report for the Wainui Road Subdivision (Ref. [4]), updated in October 2005 following scheme modifications (Ref. [5]).

d 2006 Investigation report following purchase of Westlake property (Ref. [6]).

e May 2014 Geotechnical Investigation Report for Precinct 2 (Ref. [7]).

The preliminary (Ref. [1], [2]) and investigation (Ref. [3], [4], [5], [6], [7]) reports noted the presence of existing instability comprising landsliding, soil creep and shallow slope movement across much of Precinct 2. These features were proposed to be stabilised, and/or undercut and replaced with engineered fill, during development works. Stability analyses further indicated that shear keys and geotechnical remediation works were also required to achieve satisfactory factors of safety against instability for the finished development of Stage 3B.

Earthworks compaction control, in terms of minimum shear strengths and maximum air voids, was recommended, and, along with other recommendations, has been incorporated into our control of the works and, where applicable, included in completion reporting.

The scope of work covered by this completion report includes:

a Review of geotechnical investigation reporting for the site;

b Monitoring and certification of earthworks operations in compliance with NZS 4431:1989 (Ref. [8]);

c Monitoring and certification of construction of 2 No. timber pole retaining walls and 2 No. reinforced earth slopes;

d Assessment of soils for expansive conditions in accordance with AS 2870:2011 (Ref. [9]);

e Certification of completed Lots for residential development in accordance with NZS 3604:2011 (Ref. [10]).

Woods Ltd (Woods) undertook subdivision engineering design and civil works construction observations. As-built plans showing final contours and cut and fill depths have been prepared by Woods and are attached in Appendix A1.

1.2 Description of Subdivision

The Millwater subdivision is situated to the north of the Silverdale Township, and west of the Metro Park East reserve area, and comprises approximately 260 hectares. The subdivision is bound to the south and west by Wainui Road, to the north by the Orewa Estuary and to the east by the Orewa Estuary and Millwater Parkway. The original site comprised a mix of farm properties and associated dwellings and existing residential developments.

The Precinct 2, Stage 3B area of the Millwater subdivision is located within what is known as Precinct 2 in the Silverdale North Structure Plan.

The Precinct 2 area is bound by Manuel Road to the northwest, Old Mill Road to the east, Wainui Road to the south and west, and Precinct 3 to the northeast. The overall Precinct 2 and Stage 3B areas are shown on T+T Drawing 21854.001–P2S3B–100 in Appendix A2.

Pre-development gradients within the Stage 3B area were gentle to moderately steep (1 in 15 to 1 in 3 (V:H)) with an overall fall to the south east.

Post-development gradients within the Stage 3B area remain gentle to moderately steep (1 in 15 to 1 in 3 (V:H)) and generally fall to the south east as before. In order to form more level building platforms, 2 No. timber pole retaining walls and 2 No. reinforced earth slopes of between 1 in 1.5 and 1 in 2 (V:H) have been constructed along some Lot boundaries as shown on T+T Drawing 21854.001–P2S3B–101.

Stage 3B is presently accessed from the existing Manuel Road.

1.3 Geological Setting

Published geological mapping and information indicates the Precinct 2 area is underlain by Northland Allochthon materials. In addition to the Northland Allochthon, our investigations identified the presence of alluvial materials on site.

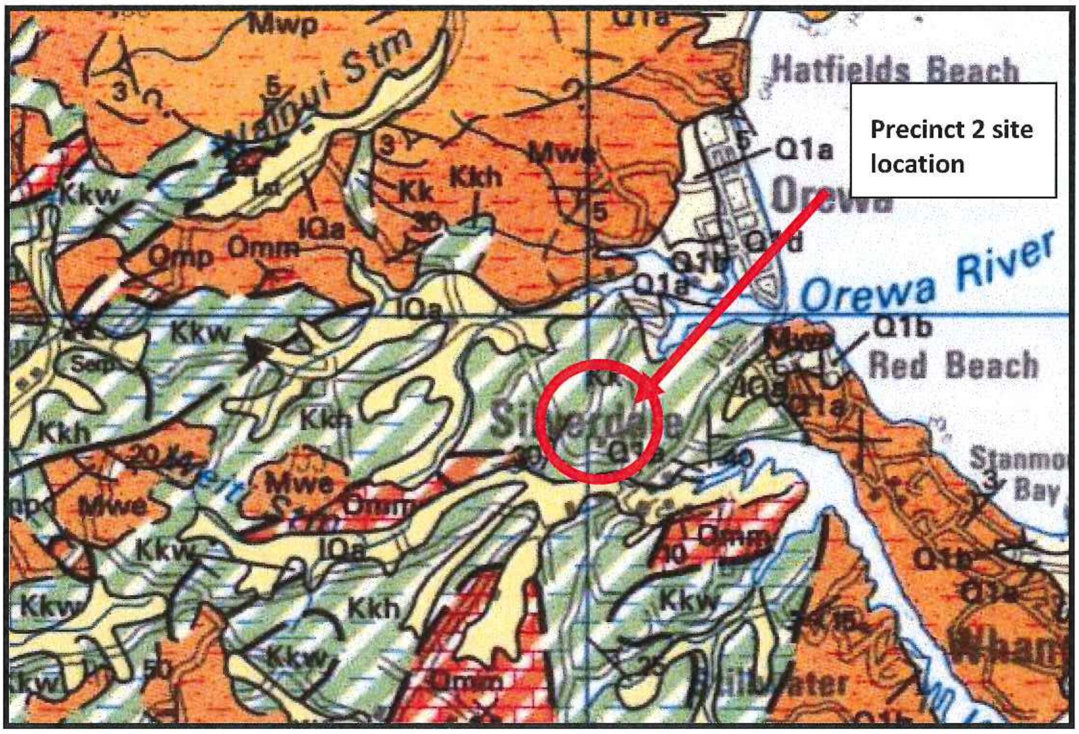


Figure 1 - Local Geology (from Edbrooke)

Land south of the Orewa River is located on an area of extensively deformed and sheared mudstones and muddy to sandy limestones described as Onerahi Chaos – Northland Allochthon material. Recent stream alluvium and slope colluvium derived from residual Northland Allochthon material is mapped towards the base of the gullies at the bottom of the slopes. Recent stream alluvium and discontinuous areas of older Pleistocene Age alluvium are also likely to be present overlying the Northland Allochthon.

Summary descriptions of geological units in Wainui/Manuel Roads area (after Kermode 1991) are as follows:

a **Northland Allochthon**

Deformed sediments, commonly known as Onerahi Chaos - Northland Allochthon: forms hummocky rolling hills covering more than 100 km^2 west of Whangaparaoa Peninsula. Mixture of undifferentiated deposits of various and widely sized (cm-km), randomly oriented blocks comprising conglomerate limestone, mudstone, alternating sandstone and mudstone, and serpentinite in a matrix of closely fractured and crushed, moderately soft, grey, brown, and greenish grey mudstone and some sandstone (calcareous or siliceous). Some of the large blocks, especially of limestone, have been mapped individually.

b **Pleistocene Age Alluvium**

Up to 20 m thick and from 3 to 10 m above present base level: forms higher coastal and valley terraces throughout the map area; in places locally discontinuous or absent. These alluvial deposits are typically very thinly to very thickly bedded, yellow-grey to orange-brown, angular to well rounded, mixed sizes (usually graded, coarse becoming fine upwards) of mud, sand and gravel, comprising rock fragments and weathered rock residue from the hinterland. They include some beds of black, humus-rich clay and white, pumice silt.

Geological cross-sections through the Precinct 2, Stage 3B area are enclosed as Drawing Number 21854.001–P2S3B–103 to –104 in Appendix A2. Borehole logs from the post-earthworks investigations are enclosed in Appendix E.

Fill material placed across the site to form the final design profile typically comprised site-won Northland Allochthon.

2 Earthworks Operations

2.1 Plant

Bulk earthworks were undertaken by Hick Bros Civil Construction Ltd (HBCCL) from early 2013 through to early 2016. Civil works have been completed by JG Civil Ltd (JGCL). Various earthworks equipment was used to undertake the works, comprising D6 and D8 bulldozers and scoops, motor scrapers, tractors and discs, sheepsfoot compactors, padfoot rollers, and a number of 12 to 35 tonne excavators. This plant generally carried out all construction earthworks.

Specialist contractors and plant were brought on site for pavement construction. Certification of the pavement construction is beyond the scope of this report.

2.2 Construction Programme

Subdivisional earthworks were undertaken under HBCCL control from early 2013 through to early 2016. Final civil earthworks and construction for the residential Lots were under JGCL's control and were undertaken progressively from March 2016 through to completion in July 2016.

Key Stage 3B earthworks components included:

a Stripping of vegetation, organic materials and topsoil to stockpile.
b Installation of gully and subsoil drains.
c Construction of 1 No. Shear Key (SK03) as shown on T+T Drawing 21854.001–P2S3B–101 in Appendix A2.
d Cut to fill earthworks across the entire site, incorporating construction of 2 No. reinforced earth slopes (i.e. RE 603 and RE 604), as shown on T+T Drawing 21854.001–P2S3B–101 in Appendix A2.

Key Stage 3B civil works components included:

a Minor cut to fill earthworks across parts of the site as part of final Lot development, as shown on the Woods Cut/Fill Contour As–Built Plan Earthworks Surface – Final Surface (Woods Ref 33211–03B–AB–111) in Appendix A1.
b Construction of 2 No. timber pole retaining walls (i.e. Walls 304 and 305) in the location shown on the Woods Retaining Wall As–Built Plans (Woods Ref 33211–03B–AB–150 and –151) in Appendix A1.
c Installation of roading and services.

The earthworks, retaining walls, shear keys, undercuts and subsoil drainage as-built plans are included in Appendix A1 (Woods Drawings 33211–03B–AB–100, 110 to 112, 120 and 150 to 151), and show the earthworks undertaken across the site.

2.3 Compaction Control

Compaction control criteria, consisting of maximum allowable air voids and minimum allowable shear strengths, were used for cohesive fill control. The Technical Specification included in our Geotechnical Investigation Report (Ref. [4],[5],[6],[7]) included the following requirement for the subdivisional earthworks:

Minimum Shear Strength and Maximum Air Voids Method

Minimum Undrained Shear Strength (Measured by insitu vane – IANZ calibrated)

General fills:

Average value not less than	140 kPa
Minimum single value	110 kPa

High Strength Structural fills (Shear Keys & Reinforced Earth Fill Slopes):

Average value not less than	150 kPa
Minimum single value	120 kPa

Maximum Air Voids Percentage (as defined in NZS 4402:1986)

General fills:

Average value not more than	10%
Maximum single value	12%

High Strength Structural fills (Shear Keys & Reinforced Earth Fill Slopes):

Average value not more than	8%
Minimum single value	10%

The average corrected shear strength value was determined over any ten consecutive tests.

Regular in situ density, strength and water content tests were carried out on the filling at, or in excess of, the frequency recommended by NZS 4431:1989 (Ref. [8]). Test results are contained in Appendix E.

Quality Control (QC) testing showed that the results for the filling were consistently meeting the required undrained shear strength and air voids criteria, demonstrating that the water content of placed fill was consistently at, or close to, optimum. To the best of our knowledge, any problems encountered were rectified, where required, by close monitoring of the selection of borrow materials, discing and remixing of the available soil types, and minor reworking.

3 Geotechnical Development Works

3.1 Subsoil Drainage

A network of subsoil drains has been installed within the original gully alignments across Precinct 2 during the original bulk earthworks, in addition to those drains installed as part of the shear key, reinforced earth slope and timber pole retaining wall construction.

The subsoil drains installed within the original gullies and shear keys were excavated into the underlying rock to intercept groundwater and springs. The subsoil drains comprised 600mm to 1m wide trenches, installed in the base of the mucked out gully alignments, prior to placement of up to 9m of fill, and backfilled with:

a 160mm diameter, Hiway grade, perforated Nexus pipes along the base of the trench.

b SAP50 scoria over the top of the Nexus pipe to within 1m of the ground surface (at time of construction).

c Bidim A19 geotextile filter-cloth over the top of the scoria.

d Compacted, engineered fill within the top metre of the trench.

Subsoil drains installed as part of reinforced earth slope construction comprised the following:

a 160mm diameter, Hiway grade, perforated Nexus pipes along the base of the rear of the reinforced soil block.

b SAP50 scoria over the top of the Nexus pipe and up the back face of the reinforced soil block, to within 2.0 metres of the ground surface (at time of construction).

c Bidim A19 geotextile filter-cloth over the top of the scoria prior to placement of the reinforced soil.

The gully and shear key drains discharge into the main downslope gully that runs centrally through Precinct 2. The reinforced earth slope drains were connected to the reticulated stormwater system.

In addition to the above, subsoil drains were installed as part of the timber pole retaining wall structures. Timber pole wall drainage comprised a 110mm diameter Nexus pipe covered in SAP50 scoria installed along the rear of the timber poles and brought through under the base of the wall to discharge into the reticulated stormwater system and a cap of engineering fill to limit seepage (surface).

The subsoil drainage system and connections are shown on the Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 33211–03B–AB–120) in Appendix A1, and on T+T Drawing 21854.001–P2S3B–102 in Appendix A2.

3.2 Shear Keys

Based on stability analyses undertaken as part of the investigation reporting, shear keys were identified as being required across Precinct 2 to provide satisfactory factors of safety against instability for the finished development of Stage 3B.

1 No. Shear Key (i.e. SK 03) was excavated within Stage 3B during the recent bulk earthworks in the location shown on the T+T Drawing 21854.001–P2S3B–101, included in Appendix A2. Excavations for the Shear Key were inspected and mapped by an Engineering Geologist to check that the key base had been extended sufficiently into the underlying more competent Northland Allochthon rock materials, and that there were no apparent adverse structural features or lower strength materials exposed within the base of the excavation. Any areas of suspect ground, including areas of identified land-slippage, were removed under the instruction of our site Geologist and replaced with well compacted engineered fill, placed in accordance with the bulk earthworks specification (Section 2.3 above).

The shear key long-section for SK 03 was developed based on the mapping undertaken and is included in Appendix A2 (Drawing 21854.001–P2S3B–107). This section shows the materials exposed within the side of the shear key excavation and relevant geological structural information mapped during our inspections.

Following completion of the shear key excavation, drainage blankets were placed along the rear face of the key, and comprised the following:

a 160mm diameter perforated Hiway grade Nexus drain pipe: This was run along the base of the rear of the excavation and connected to the gully subsoil drainage in several locations (as per the Woods As-Built plan 33211–03B–AB–120). Additional Nexus drain pipes were also installed along mid-height benches where appropriate and connected into the key drainage outlet system.

b SAP50 scoria: A layer of minimum 300mm thickness of SAP 50 was placed across the entire rear face, and extended to within 1.0m of the top of the key. It should be noted that the top of the key at this stage generally coincided with the original ground surface.

c Bidim A19 geotextile filtercloth: This was placed over the surface of the SAP 50 scoria to prevent contamination of the drainage aggregate with overlying bulk earthworks materials.

The rear face drainage blanket was extended up to at least 1 metre above the soil / rock interface to intercept perched groundwater flows which typically flows along this interface.

Ground conditions exposed during shear key construction were generally as anticipated from the design stage of the development. The slope stability analysis results from the original design phase are discussed in Section 4.

3.3 Reinforced Earth Slope

Two reinforced earth (RE) slopes (i.e. RE 603 and RE 604) were constructed during the recent bulk earthworks within Stage 3B.

The slopes comprise biaxial geogrids placed at 0.5m (vertical) intervals within the well compacted engineered fill, placed in accordance with the bulk earthworks specification (Section 2.3 above). The grids extend up to within 1.5m (vertical) of the slope crest. They have been placed at various lengths, starting at the face of the slope.

Typical cross-sections through the RE slopes are shown on T+T Drawing 21854.001–P2S3B–105 in Appendix A2.

The placement of the geogrid allows steeper finished gradients than is typically possible with unreinforced bulk fills, and minimises the risk of instability across the face of the slope, particularly where finished gradients across the slopes are up to 1 in 1.5 (V:H).

Construction of the RE slopes comprised the following:

a Foundation preparation;

b Placement and compaction of fill to the required levels;

c Placement of the geogrid layers, ensuring that the grid is held tightly in place;

d Spreading of fill across the surface of the geogrid with lightweight plant;

e Compaction and placement of further fill up to the level of the next grid layer;

f Installation of Enkamat across the face of any slopes steeper than 1 in 2 (V:H) to assist in retention of the topsoil facing while vegetation is established.

The fill was placed and compacted beyond the limit of the final slope face and then trimmed back to ensure full compaction of the slope face was achieved, taking care not to damage the geogrid.

As noted in Section 3.1, a drainage blanket was installed at the rear of the reinforced block of soil and comprised a minimum of 300mm thickness of SAP50 scoria, covered in Bidim A19 geotextile filtercloth and a cap of cohesive fill 2.0m in thickness. A 160mm diameter perforated Nexus pipe at the base of the drainage blanket provides a discharge outlet for any groundwater captured in the drainage blanket. The drainage pipe is connected into the stormwater system.

This slope has been designed to accommodate construction of a lightweight structure of up to 10kPa distributed load at the crest of the slope.

The reinforced earth slope drainage system is also shown on the T+T As–Built plans in Appendix A2.

3.4 Timber Pole Walls

Two timber pole retaining walls have been constructed across this stage of the subdivision, comprising Walls 304 and 305 at the locations shown on T+T Drawing 21854.001–P2S3B–101. Both walls were designed by T+T and allow for the various design conditions encountered across the stage, including toe slopes, slope surcharges and vehicle surcharges, as appropriate. Construction drawings for Walls 304 and 305 were issued in February 2016 and a copy of these is included in Appendix A2. These walls were constructed during the Civils construction package by JGCL.

The walls comprise high density timber poles installed to various depths dependent on design conditions. Inspections for these walls were undertaken by T+T staff to confirm pile hole diameter, depth and spacing, pile sizes, and installation of drainage materials and lagging, in accordance with the design drawings.

The drainage pipes from behind the walls are connected into the stormwater system, as shown on the Woods subsoil drainage as-built plan in Appendix A1.

These walls have been designed to accommodate a maximum 5kPa surcharge, although development immediately behind/above the walls is likely to be precluded by Council planning rules.

Certification of these walls in accordance with the relevant Engineering Approval is to be supplied under separate cover.

4 Stability Analyses

As noted in Section 1, slope stability analyses undertaken during the investigation stage of the project identified the need for shear keys to be constructed across Precinct 2 so as to provide acceptable factors of safety against slope instability for the finished development of Stage 3B.

During excavation of Shear Key 03, the excavated faces were mapped to confirm the key had been extended sufficiently into the underlying rock materials and to check for any apparent adverse oriented geological structure or other features exposed within the lower part of the key.

We are satisfied that the design stability analyses remain valid for the completed works on the following basis:

a the exposed ground conditions generally conform to those assumed for design;

b the as-built profiles match design levels;

c the earthworks monitoring shows compliance with specified criteria, upon which fill properties have been based.

5 Project Evaluation / Building Design Considerations

5.1 General

Ground conditions within Precinct 2, Stage 3B straddle a range of "design conditions" including cut ground, filled ground, expansive soils and constructed slopes up to 1 in 1.5 (V:H). The following sections set out relevant geotechnical design issues.

5.2 Bearing capacity for building foundations

All filled and natural ground within the influence of conventional residential shallow strip and pad foundation loads is assessed as generally having a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011 (Ref. [10]). This corresponds to a factored (Ultimate Limit State) bearing capacity of 150kPa and working (Serviceability Limit State) bearing capacity of 100kPa.

Due to the presence of expansive soils, foundation conditions fall outside the definition of "good ground" contained in NZS 3604:2011 (Ref. [10]). In terms of AS 2870:2011 (Ref. [9]), the soils present are considered to lie within Site Class M (moderately expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm. Due allowance should be made for expansive soils, as discussed in Section 5.12.

Where a geotechnical ultimate bearing capacity greater than 300kPa is required to support any dwelling constructed outside the scope of NZS 3604:2011 (Ref. [10]), further specific site investigation and design of foundations will be required.

5.3 Building Limitation Zones

Steep slopes (steeper than 1 in 4 (V:H)) are present within, or immediately adjacent to, a number of the Lots in the Stage 3B area.

The steep slopes comprise reinforced earth slopes with face gradients of between 1 in 1.5 and 1 in 2 (V:H), and are located in Lots 356 and 360 to 370. Construction within the flatter parts of these Lots is intended, and a Building Restriction Zone ("No Build Zone") has been developed across the steeper areas of the Lots so as to ensure that the reinforcement of the slopes is not detrimentally affected by future development. The extent of the Building Restriction Zone associated with the reinforced earth slopes is shown on T+T Drawing 21854.001–P2S3B–110 (Building Limitation Plan) in Appendix A2. Excavation, fill placement and/or construction within this zone is not permitted.

Vegetation on slopes that are 1 in 4 (V:H) or steeper is recommended to reduce the potential for shallow slope instability and to minimise surface erosion. Where gradients are 1 in 4 (V:H) or steeper, there is potential for minor shallow creep of the topsoil layer. However, such creep is considered unlikely to detrimentally affect the global stability of the slope.

5.4 Settlement

From our inspections during earthworks operations, and the results of compaction quality control testing, we consider that differential settlement induced by self-weight of engineered fill should now be largely complete. Further settlements should be within normally accepted design tolerances of 25mm, as outlined in NZS 3604:2011 (Ref. [10]), with respect to conventional building development.

Settlement plates were installed in the areas of greatest fill thickness, prior to fill placement, to monitor the settlement of the subgrade through Precinct 2. This monitoring shows that settlements of up to 120mm occurred during development. This settlement occurred between December 2014 and April 2015, with negligible movement since that time. We consider that settlement of the underlying soils is also essentially complete under the current surcharge.

In order to minimise the risk of ground settlements exceeding 25 mm, NZS 3604:2011 (Ref. [10]) allows a maximum fill surcharge of 600 mm over the building platform during future development. Filling in excess of this thickness should be subject to specific foundation design and assessment.

5.5 Retaining walls

Due to the shallow grades across most of the Stage 3B Lots, it is not anticipated that significant retaining walls will be required as part of any Lot development. However, if walls are required, then retaining wall design will be dependent on the site specific requirements. For preliminary design we recommend the use of the following geotechnical design parameters:

$\gamma = 18\ kN/m^3$,

$c' = 0\ kPa$,

$\varnothing' = 30°$,

$K_a = 0.30$,

$K_p = 3.33$,

"Su" of 50kPa for the embedment soil (subject to confirmation during construction).

These values are based on level ground above and below the wall and will require appropriate amendment to allow for slope, traffic and other surcharges or toe slopes and the specific lot geometry and development requirements, as applicable.

All retaining walls should include a layer of free draining granular fill (with geotextile over the top) immediately behind the wall covered with a 0.3m thick (minimum) compacted clay fill cap, with intercepted groundwater seepage piped into the reticulated stormwater system.

Any walls greater than 1.5m retained height will require a geotechnical assessment, as a minimum, to check and confirm that the stability of the subject (or adjacent) Lot is not detrimentally affected. Retaining walls downslope of the RE slopes shall also take into account the load imposed by these slopes.

The existing timber pole retaining walls constructed within the Precinct 2 Stage 3B area are shown on the Woods Retaining Wall As–Built Plans (Woods Ref 33211–03B–AB–150 and –151). These walls have been designed to accommodate a maximum 5kPa surcharge, although development immediately behind/above the walls is likely to be precluded by Council planning rules. The presence of these walls should be taken into account for any proposed works downslope of the walls, specifically to ensure that any proposed cuts do not undermine the base of the walls. In general, earthworks should be limited to no closer than 1.5m from the toe of the walls.

For clarity, the Lots within Stage 3B that will need to consider the presence of the existing retaining walls during site development are:

a Timber wall 304 – Lots 378 to 391 inclusive

b Timber wall 305 – Lots 392 to 398 inclusive

5.6 Subsoil Drainage

Following gully muckouts and reinforced earth slope construction during initial bulk earthworks, groundwater drainage was installed using Nexus drains covered in geotextile cloth to permanently handle ground water flows.

The extent of the subsoil drainage systems are shown on the Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 33211–03B–AB–120) in Appendix A1, and on T+T Drawing 21854.001–P2S3B–102 in Appendix A2.

This drainage system is relatively deep and located so that it is unlikely to be encountered during future residential site development and is expected to be maintenance free. Any deep excavations should take account of the presence of these drains nonetheless. If a drain is encountered, damaged, or identified as defective, repairs should be observed by a Chartered Professional (Geotechnical) Engineer familiar with this report, and notified to Auckland Council.

The Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 33211–03B–AB–120) shows the location and invert of the subsoil drainage through this Stage.

5.7 Post Earthworks Investigations

Following the completion of earthworks operations, T+T have undertaken supplementary fieldwork to confirm the consistency of the natural subsoils and engineered fill. From the investigations, we confirm that the subsoils are considered to have a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011 (Ref. [10]). This corresponds to a factored (Ultimate Limit State) bearing capacity of 150kPa and working (Serviceability Limit State) bearing capacity of 100kPa. Associated borehole logs and site plan (T+T Drawing 21854.001–P2S3B–111) are attached in Appendix E.

5.8 Stormwater

Public stormwater services have been installed within the Precinct 2, Stage 3B. Stormwater and runoff from roofs, decks and paved areas, together with discharges from retaining wall drains and other subsoil drains must be connected directly into the public stormwater drainage network.

5.9 Service lines

Trench backfill has been compacted to minimise potential for future settlements. However, where building envelopes lie adjacent to or across service lines, all foundations should extend and be founded below the 45 degree zone of influence line from pipe inverts. This requirement is to avoid excessive pipe surcharges, and to allow for future maintenance of the system without detrimentally affecting adjacent structures. Subject to approval from Auckland Council, foundations may extend and bridge over service lines provided specific foundation design is undertaken.

A copy of the stormwater as–built plan (Woods Stormwater Drainage As-Built Overall Layout Plan, Woods Ref 33211–3B–AB–300) is included in Appendix A1.

5.10 Road subgrades

Based on the fill monitoring and site observations during development, filled and natural ground within the road and vehicle access Lots is considered generally suitable for the proposed residential pavements. Subgrade strength testing was carried out following excavation to formation levels along the road alignments. These subgrade test results were passed on to Woods for use in their pavement design. All road subgrades have been lime and cement stabilised to assist in pavement strengths, and to minimise the impact of expansive soils on road pavements.

For future road construction in other parts of the Precinct 2 Stage 3B development, within natural ground, a design CBR of 2% is considered appropriate while, within engineered fill areas, a design CBR of 7% is appropriate.

5.11 Topsoil

Following completion of topsoil spreading and grassing, topsoil depths were measured in each of the Lots and these are shown on T+T Drawing 21854.001–P2S3B–112 attached in Appendix E. Due to variations in placement depths and earth worked surface levels, topsoil depths may vary from those recorded.

5.12 Expansive soils

Expansive soils (or "reactive soils" using Australian terminology) are clay soils that undergo appreciable volume change upon changes in moisture content. The reactivity and the typical range of movement that could be expected from soils underlying any given building site depend on the amount of clay present, clay mineral type, and proportion, depth and distribution of clay throughout the soil profile. Moisture changes tend to occur slowly in clays and produce swelling upon wetting and shrinkage upon drying.

Apart from seasonal moisture changes (wet winters / dry summers) other factors that can influence soil moisture content include:

a Influence of garden watering and site drainage;

b The presence of large trees (especially fast growing Australian species such as eucalyptus) close to building envelopes, and;

c Initial soil moisture conditions at construction time.

Visually, the surfaces of expansive soils are noted for developing extensive cracking during dry periods (especially late summer through autumn in Auckland) and can be locally identified by this feature when sites are excavated and left for a week or two to dry out. Further information on expansive soils is given in Appendices C and D of this report.

In order to assess for the presence of expansive soils within this stage of the development, representative soil samples were retrieved from near surface strata and tested by Geotechnics Ltd to determine soil shrinkage characteristics in accordance with AS 1289.7.1.1.

Based on the laboratory results (attached in Appendix E), the foundation soils on this stage of the subdivision lie outside the definition of 'good ground' as outlined in NZS 3604:2011 (Ref. [10]).

In terms of AS 2870:2011 (Ref. [9]), the soils present are considered to lie within Site Class M (moderately expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm.

Accordingly, building foundations on this stage of the subdivision will need to be subject to specific foundation design by a Chartered Professional Engineer familiar with the contents of this report and responsible for design of structural elements (including foundations) of the building. Reference should be made to AS 2870:2011 (Ref. [9]) for assistance.

6 Statement of Professional Opinion as to the Suitability of Land for Building Development

I, Mr C.J. Freer of Tonkin + Taylor Ltd, P O Box 5271, Wellesley St, Auckland, hereby confirm that:

6.1 I am a Chartered Professional Engineer experienced in the field of geotechnical engineering and an authorised representative of Tonkin + Taylor who was retained by WFH Properties Ltd as the Geotechnical Engineer on Precinct 2 Stage 3B (comprising residential Lots 356 to 370 and 387 to 398 inclusive) of the Millwater Residential Subdivision Development off the Millwater Parkway in Silverdale. Inspection and observation of the works have been carried out during construction by either myself or staff acting under my direction.

6.2 The extents of preliminary investigations are described in Tonkin + Taylor Ltd Precinct 2 Geotechnical Investigation Report Ref No. 21854.001 dated May 2014. The conclusions and recommendations of those documents have been re-evaluated in the preparation of this report. Details of all earthworks control tests performed are enclosed (Appendix E).

6.3 The Contractors have confirmed that the work undertaken has been completed in accordance with the drawings, specifications and any variations issued and is consistent with the inspections and observations carried out by Tonkin + Taylor Ltd. Complete Construction Certificates have been provided by the Contractors and are presented in Appendix B. Tonkin + Taylor Ltd accepts no liability for any errors or omissions represented by those documents.

6.4 On the basis of our observations and inspections together with the information supplied by others, including the Contractor's Construction Certificates, it is my professional opinion, not to be construed as a guarantee that:

6.4.1 The earth fills shown on the attached Woods drawings, Project No 33211, Millwater, Precinct 2, Stage 3B, Drawing Numbers 33211–03B–AB–100 and –110 to –112, have been generally placed in compliance with NZS 4431:1989 (Ref. ([8]).

6.4.2 The completed earthworks give due regard to land slope and foundation stability considerations.

6.5 **For Lots 357 to 359 and 387 to 398 inclusive:**

6.5.1 Foundation design

The filled and natural ground within residential Lot boundaries is considered generally suitable for the erection thereon of light timber framed, flexibly clad residential buildings subject to clauses 6.5.2 to 6.5.5.

6.5.2 Bearing capacity

Foundation design for these Lots should limit geotechnical ultimate bearing capacity to 300 kPa (factored (ULS) 150 kPa, working (SLS) 100 kPa). This is as specified in NZS 3604:2011 (Ref. [10]).

6.5.3 Expansive soils

Due to the presence of expansive clay soils, foundation soils lie outside the definition of 'good ground' in NZS 3604:2011 (Ref. [10]). Soils are considered to lie in Site Class M (moderately expansive) as defined in AS 2870:2011 (Ref. [9]) with anticipated characteristic surface ground movements of 20mm to 40mm. Clause 6.5.3.1 of this Geotechnical Completion Report may be used for expansive soil foundation design on this subdivision:

6.5.3.1 Specific foundation design for expansive soils

Specific foundation design should be undertaken by a Chartered Professional Engineer familiar with the contents of this report and responsible for design of structural elements (including foundations) of the building.

The minimum specific design requirements set for expansive soils within this clause are:

i) Minimum foundation embedment of 600 mm following topsoil removal and benching of building platform areas to finished ground levels

ii) Four bar steel reinforcing cages should be used

iii) For buildings having brittle exterior cladding, for example brick veneer, stucco plaster, solid plaster, block work, styrofoam type cladding or sprayed plaster over harditex systems etc, the potential effects of seasonal ground movements need to be considered by the building designer.

The above minimum requirements within this clause may be superceded if individual engineers are able to demonstrate their specific design solutions are applicable to site soil conditions to the satisfaction of Auckland Council. Specific design may be undertaken by first principles or by reference to AS 2870:2011 (Ref. [9]), Section 4 and related documents.

6.5.4 Floor Slab Construction

Slab on grade construction is expected to be relatively straightforward across the subdivision, but problems can occur with slab construction on shrink/swell sensitive soils. In soils which become desiccated in summer, subsequent capillary moisture rise may cause dry soils to wet up and swell, causing slab uplift and building distress. Alternatively, construction during winter may result in subgrade soils with high moisture contents drying out through summer, with subsequent soil shrinkage and possible building deformation.

The structural engineer should take likely construction timeframes into account and confirm that their design and construction methodologies will accommodate the soil shrinkage or swelling that may occur.

The Contractor should ensure that the ground beneath the floor slab areas is suitably conditioned to ensure that the subgrade is neither too dry nor too wet prior to hardfill placement and concrete pouring to avoid undue shrink or swell movements.

6.5.5 Building maintenance - Owners responsibility

The owner is responsible for maintenance of the building and site and should be familiar with the performance and maintenance requirements set out in CSIRO sheet BTF18 Foundation Maintenance and Footing Performance: A Home Owners Guide. A copy of this sheet is included in Appendix D.

6.5.6 Retaining walls / Earthworks

No retaining wall construction in excess of 1.5 metres height and no earthworks involving fills in excess of 600mm depth should take place on these Lots unless endorsed by a suitable design undertaken by a Chartered Professional (Geotechnical)

Engineer familiar with the contents of this report and responsible for design of structural elements of the building.

6.6 For Lots 356 and 360 to 370 inclusive:

6.6.1 These Lots contain a "Building Line Restriction" relating to the reinforced earth slopes which form the 1 in 1.5(V:H) slopes along the Lot boundaries. The restriction zone is shown on T+T Drawing 21854.001–P2S3B–110 in Appendix A2. Excavation, filling and/or construction within this zone is not to be undertaken, to ensure stability of the slope is not compromised.

6.6.2 The presence of geogrids within the reinforced earth slopes is brought to the attention of future building and services designers. The topmost grid is located between 1 to 2 metres below the surface at the top of the slope, and does not generally extend more than 2 metres back from the crest of the slope. It is not expected that the grids will be encountered during future development of these Lots, however, the presence of the grids should be recognized. Any exposure and/or damage and subsequent repair to the grids during any future development must be observed and certified by a Chartered Professional Engineer (Geotechnical) familiar with the contents of this report.

Design of the reinforced earth slope has assumed a maximum distributed load of 10kPa (dead plus live loads) up to the edge of the Building Limitation Line.

6.6.3 Any cut or fill walls greater than 1.5m retained height, or of any height within 2m of the building restriction lines shown on T+T Drawing 21854.001–P2S3B–110 in Appendix A2, will require a geotechnical assessment, as a minimum, to ensure stability of the subject or adjacent Lot is not detrimentally affected.

6.6.4 Development outside of the Building Line Limitation zone may proceed in accordance with the recommendations outlined in Section 6.5.

6.7 Underfill (Subsoil) drainage

Underfill (Subsoil) drains have been installed during subdivisional development in the locations shown on the Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 33211–03B–AB–120) in Appendix A1, and on T+T Drawing 21854.001–P2S3B–102 in Appendix A2. These drains are considered to be maintenance free. This drainage system is relatively deep and located so that it is unlikely to be encountered during future residential site development. Although future works are unlikely to encounter the drains, their location should be considered prior to designing deep foundations and, if damaged, repairs should be observed by a Chartered Professional (Geotechnical) Engineer familiar with this report, and notified to Auckland Council.

The Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 33211–03B–AB–120) shows the location and invert of the subsoil drains through these Lots.

6.8 Stormwater and Sanitary Sewer Lines

Where building envelopes lie adjacent to or across service lines, all foundations should extend and be founded below the 45 degree zone of influence line extending from pipe inverts. This requirement is to avoid excessive pipe surcharges, and to allow for future maintenance of the system without detrimentally affecting adjacent structures. Subject to approval from Auckland Council, foundations may extend and bridge over service lines provided specific foundation design is undertaken. A copy of the stormwater as-built plans are included in Appendix A1.

6.9 Road and Access Lots

Based on the fill monitoring and site observations undertaken during site development, the filled and natural ground within Precinct 2, Stage 3B is considered generally suitable for residential road and accessway construction. Scala penetrometer testing should be undertaken when road subgrades have been prepared to confirm subgrade strengths. Subject to such subgrade testing, for future road construction in other parts of the Precinct 2 Stage 3B development, within natural ground, a design CBR of 2% is considered appropriate, while within engineered fill areas, a design CBR of 7% is appropriate.

6.10 Unexpected ground conditions

Our assessment is based on interpolation between borehole positions, site observations and periodic earthworks control visits. Local variations in ground conditions may occur. Although unlikely, unfavourable ground conditions may be encountered during site benching and footing excavations. It is important that we be contacted in this eventuality, or in the event that any variation in subsoil conditions from those described in the report are found. Design assistance is available as required to accommodate any unforeseen ground conditions present.

7 Applicability

This report has been prepared for the benefit of WFH Properties 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 without our prior review and agreement.

It does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any dwelling, especially in cases where concrete blockwork and/or brick veneer or stucco plaster buildings are sited partly on fill or partly on natural ground, or where they are entirely sited on filling whose depth changes significantly across the building platform.

Tonkin & Taylor Ltd

Report prepared by:	Technical review by:
....	....
Andrew Linton Senior Geotechnical Engineer	Andrew Stiles Senior Geotechnical Engineer

Authorised for Tonkin & Taylor Ltd by:

....

Chris Freer
Project Director BE (Civil), MIPENZ, C.P. Eng.

JXXL
p:\21854\21854.001 - precinct 2\gcr\stage 3b\jxxl.160907.p2s3b-gcr.rep.docx

8 References

[1] Tonkin & Taylor Ltd., October 2001. *Stoney Block,* T+T Ref. 18214.

[2] Tonkin & Taylor Ltd., May 2001. *Silverdale Blocks, Silverdale, Geotechnical Issues – Future Medium Density Development,* T+T Ref. 18213.

[3] Tonkin & Taylor Ltd., November 2003. *Silverdale North and Orewa West Blocks, Silverdale, Geotechnical Issues – Future Medium Density Development,* T+T Ref. 20914.

[4] Tonkin & Taylor Ltd., November 2004. *Wainui Road Subdivision, Silverdale, Geotechnical Investigation Report,* T+T Ref. 21854.

[5] Tonkin & Taylor Ltd., October 2005. *Wainui Road Subdivision, Silverdale, Geotechnical Investigation Report – Scheme Plan 7,* T+T Ref. 21854.

[6] Tonkin & Taylor Ltd., March 2006. *Silverdale North – Westlake Block, Geotechnical Investigation Report,* T+T Ref. 21854.

[7] Tonkin & Taylor Ltd., June 2014. *Millwater – Precinct 2, Geotechnical Investigation Report.* T+T Ref. 21854.001

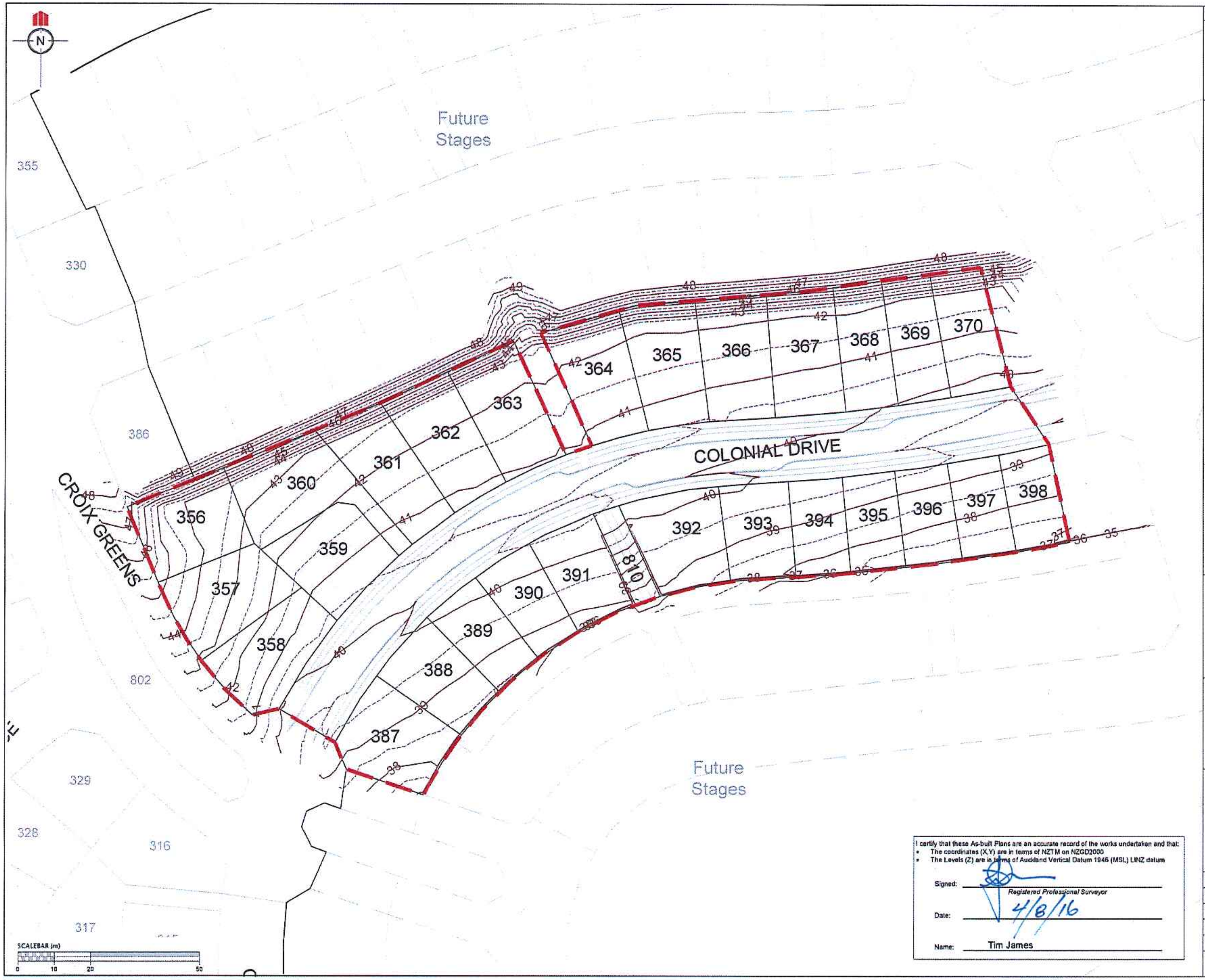
[8] New Zealand Standards, 1989. *NZS 4431:1989 Code of Practice for Earth Fill for Residential Development.*

[9] Standards Australia, 2011. *AS 2870:2011 Residential slabs and footings.*

[10] New Zealand Standards, 2011. *NZS 3604:2011 Timber Framed Buildings.*

Appendix A1: Woods Drawings

33211–03B–AB–100	Final Contour As–Built Plan
33211–03B–AB–110	Cut/Fill Contour As–Built Plan Original Surface – Earthworks Surface
33211–03B–AB–111	Cut/Fill Contour As–Built Plan Earthworks Surface – Final Surface
33211–03B–AB–112	Cut/Fill Contour As–Built Plan Original Surface – Final Surface
33211–03B–AB–120	Shear Key, Undercuts & Subsoil Drains As–Built Plan
33211–03B–AB–150 to –151	Retaining Wall As–Built Plan
33211–3B–AB–300 to –302	Stormwater Drainage As-Built Plans



I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: Registered Professional Surveyor

Date: 4/8/16

Name: Tim James

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	22/07/2016

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

———	CONTOURS MAJOR
- - - - - -	CONTOURS MINOR
— — —	STAGE BOUNDARIES
———	LOT BOUNDARIES

CLIENT:

WFH PROPERTIES

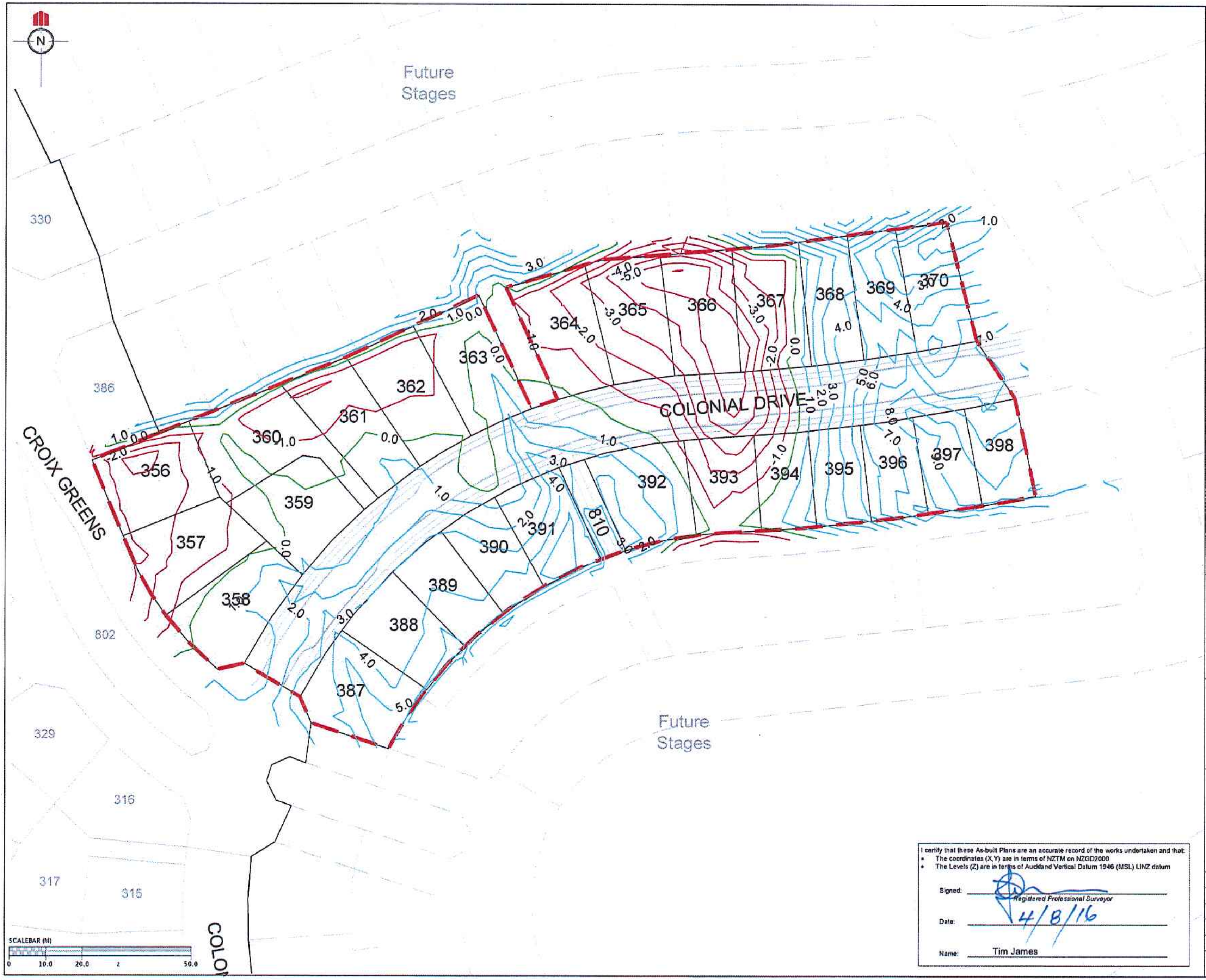
WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

FINAL CONTOUR
AS-BUILT PLAN

AUCKLAND COUNCIL

DESIGNED:	SB		ASBUILT
CHECKED:		DRAWN:	AAC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:1000 @ A3
ISSUED:	JULY 2016		
DWG. NO.	33211-03B-AB-100	REV.	1



REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	22/07/2016

NOTES

1. CONTOURS ARE AT 1.0 METRE INTERVALS

LEGEND

—	ZERO CONTOUR
—	CUT CONTOUR
—	FILL CONTOUR
— —	STAGE BOUNDARIES
—	LOT BOUNDARIES

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER PRECINCT 2 STAGE 3B

CUT/FILL CONTOUR AS-BUILT ORIGINAL SURFACE - EARTHWORKS SURFACE

AUCKLAND COUNCIL

DESIGNED:	SB	ASBUILT	
CHECKED:		DRAWN:	AAC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:1000 @ A3
ISSUED:	JULY 2016		
DWG. NO.	33211-03B-AB-110	REV.	1

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______________ Registered Professional Surveyor

Date: 4/8/16

Name: Tim James

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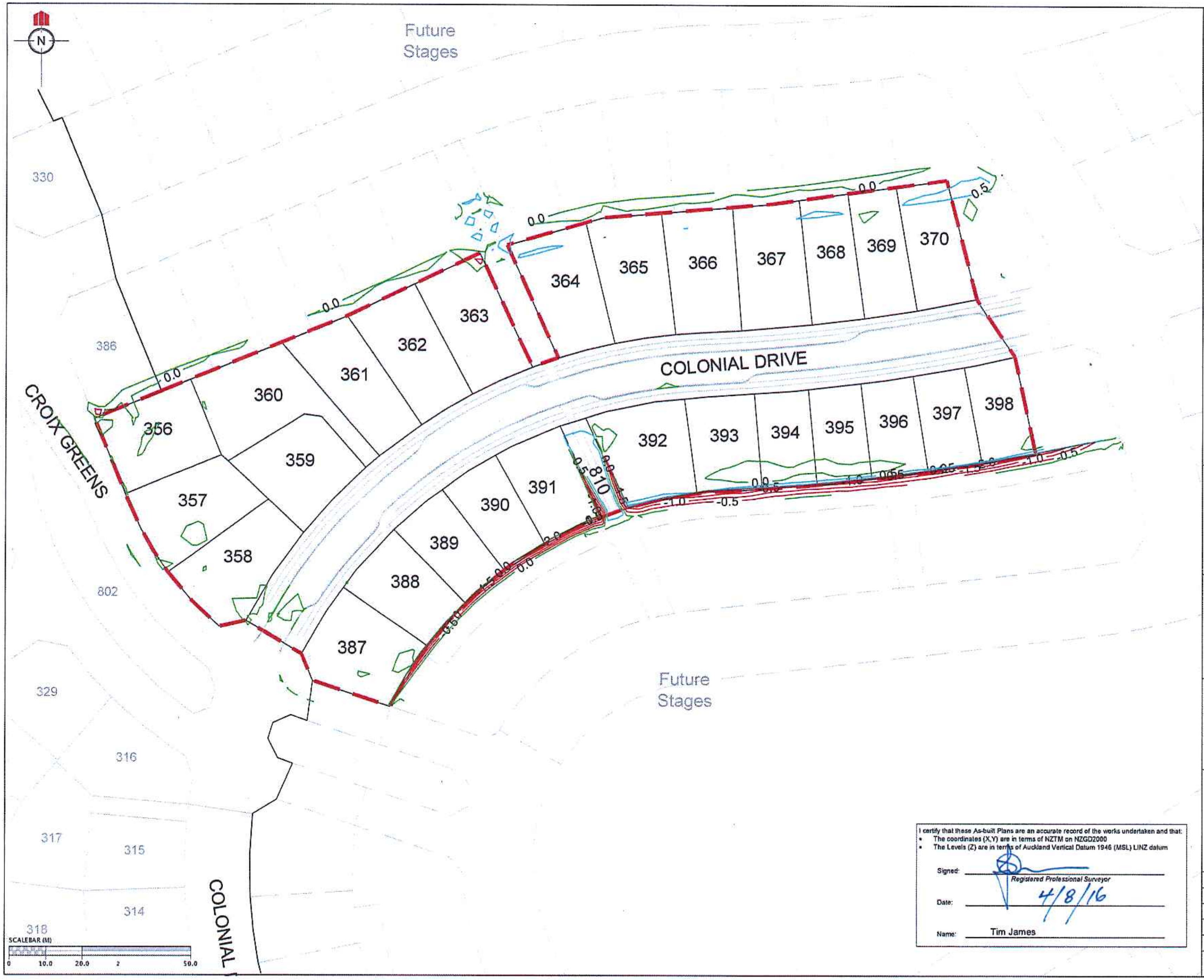

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	22/07/2016

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

🟩	ZERO CONTOUR
🟥	CUT CONTOUR
🟦	FILL CONTOUR
▬ ▬	STAGE BOUNDARIES
—	LOT BOUNDARIES

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER PRECINCT 2 STAGE 3B

CUT/FILL CONTOUR AS-BUILT EARTHWORKS SURFACE - FINAL SURFACE

AUCKLAND COUNCIL

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______________
Registered Professional Surveyor

Date: 4/8/16

Name: Tim James

DESIGNED:	SB	ASBUILT	
CHECKED:		DRAWN:	AAC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:1000 @ A3
ISSUED:	JULY 2016		
DWG. NO.	33211-03B-AB-111	REV.	1

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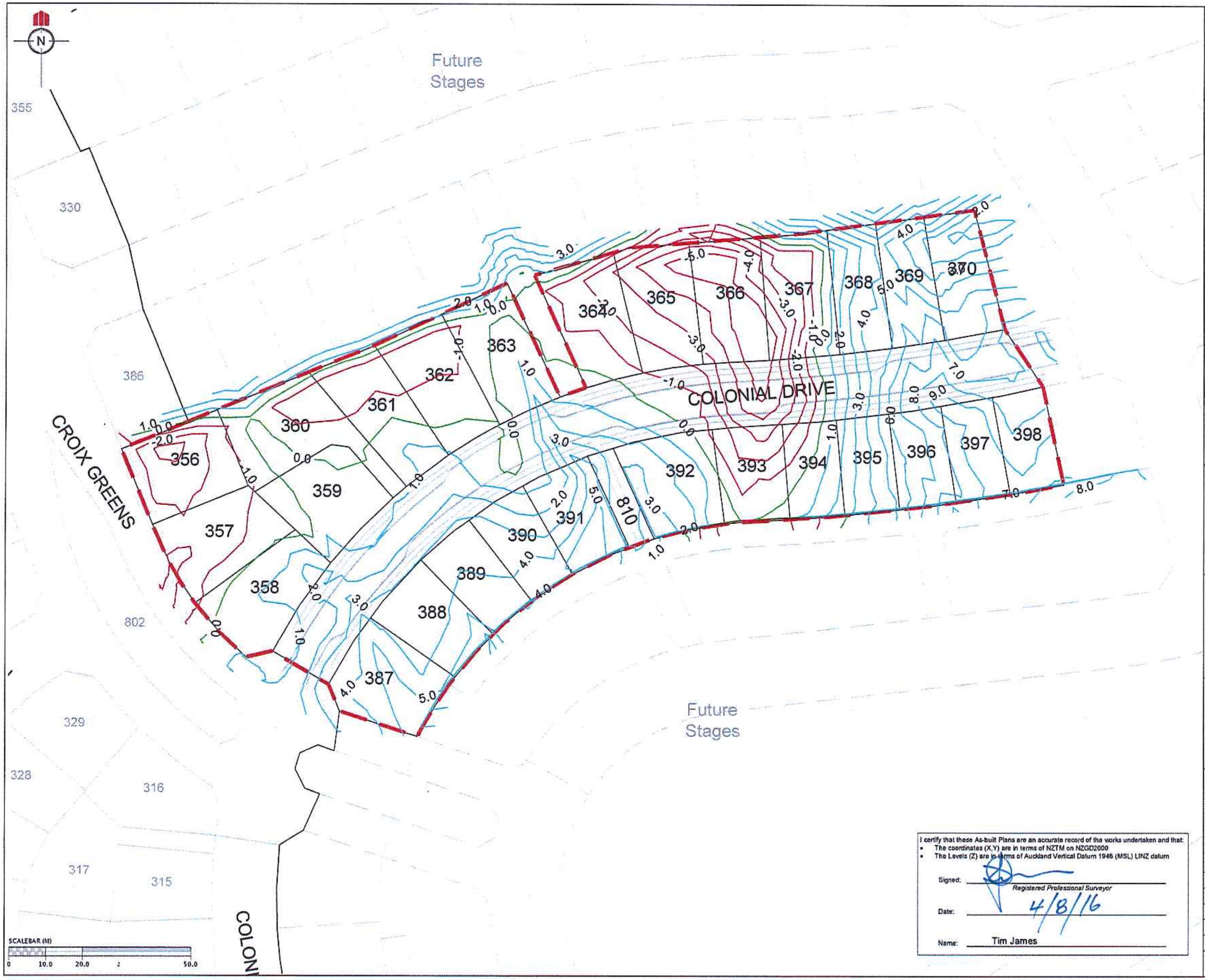

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	22/07/2016

NOTES

1. CONTOURS ARE AT 1.0 METRE INTERVALS

LEGEND

🟩	ZERO CONTOUR
🟥	CUT CONTOUR
🟦	FILL CONTOUR
🟥 - -	STAGE BOUNDARIES
—	LOT BOUNDARIES

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

CUT/FILL CONTOUR AS-BUILT
ORIGINAL SURFACE - FINAL
SURFACE

AUCKLAND COUNCIL

DESIGNED:	SB	ASBUILT	
CHECKED:		DRAWN:	AAC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:1000 @ A3
ISSUED:	JULY 2016		
DWG. NO.	33211-03B-AB-112	REV.	1

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: _______ Registered Professional Surveyor

Date: 4/8/16

Name: Tim James

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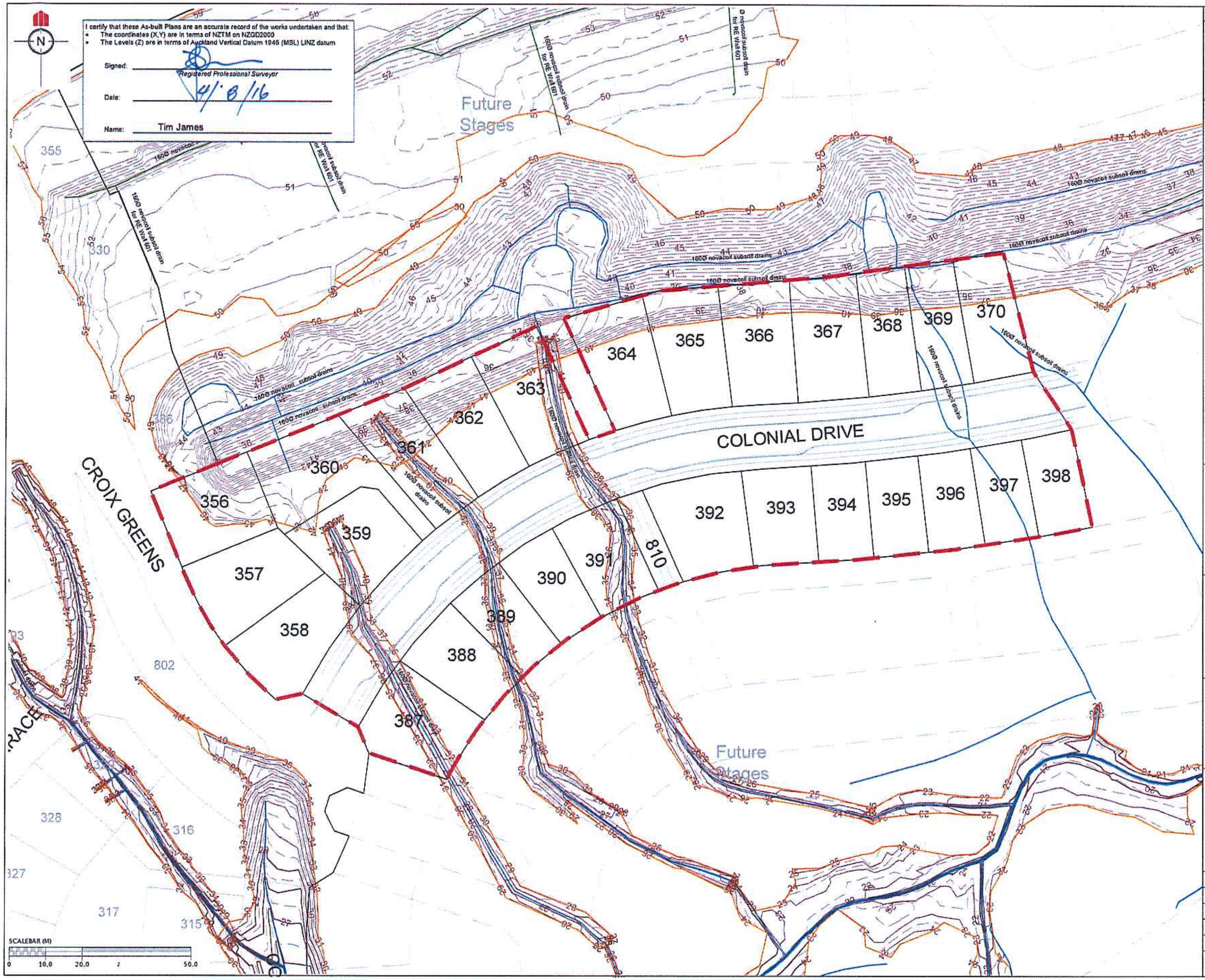
I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______ Registered Professional Surveyor

Date: 4/8/16

Name: Tim James



REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	22/07/2016

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

- NOVACOIL SUBSOIL DRAINS
- REINFORCED EARTH & RETAINING WALL SUBSOIL DRAINS
- EXISTING STORMWATER DRAINAGE
- NEW STORMWATER DRAINAGE
- STAGE BOUNDARIES
- LOT BOUNDARIES
- CONTOURS
- SHEAR KEY & UNDERCUT AREAS

CLIENT:

WFH PROPERTIES

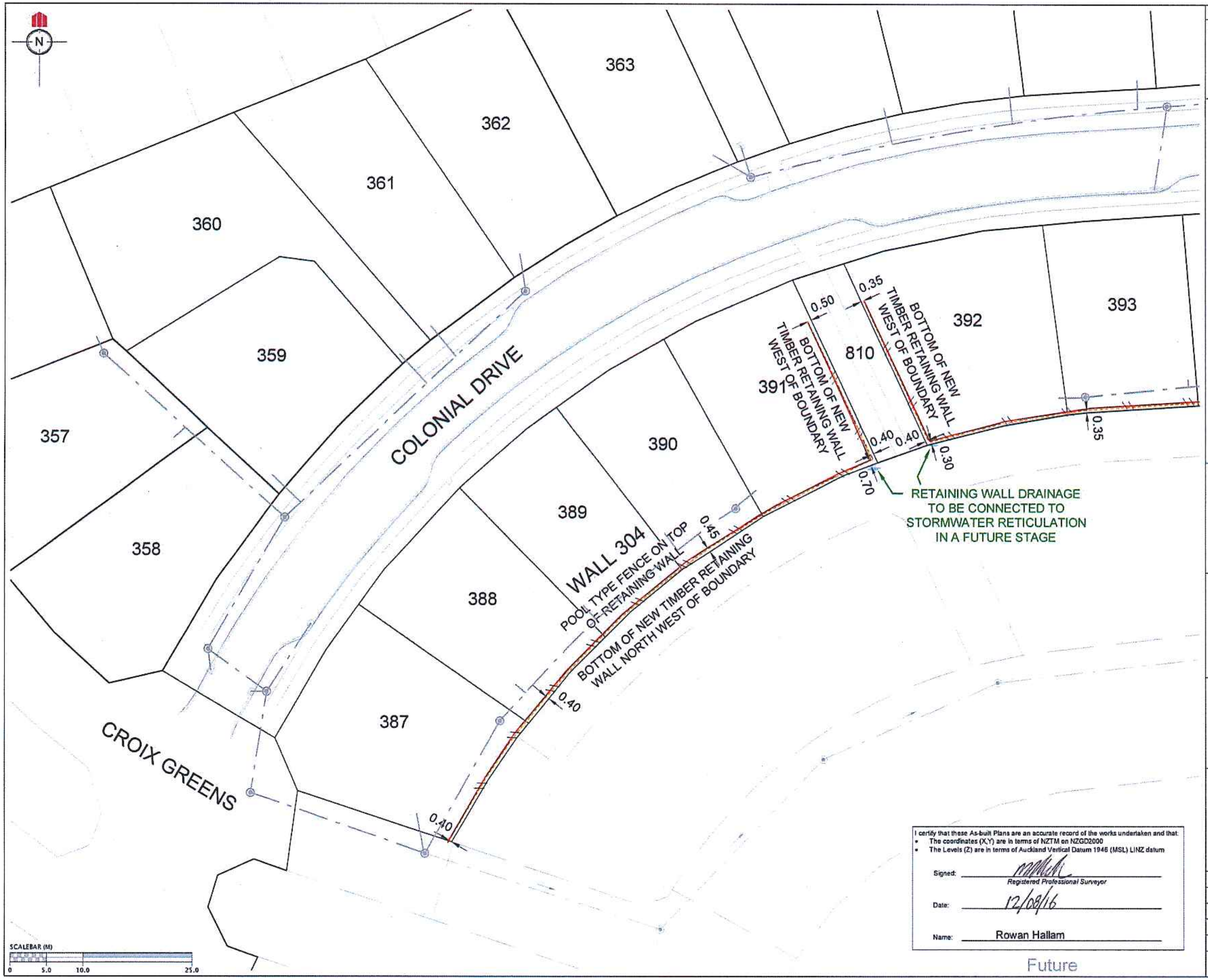
WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

SHEAR KEY, UNDERCUTS & SUBSOIL DRAINS AS-BUILT PLAN

AUCKLAND COUNCIL

DESIGNED:	SB	ASBUILT	
CHECKED:		DRAWN:	AAC
APPROVED:		SURVEYED:	HICKS
JOB NUMBER:	33211	SCALE:	1:1000 @ A3
ISSUED:	JULY 2016		
DWG. NO.	33211-03B-AB-120	REV.	1



I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______ Registered Professional Surveyor

Date: 12/08/16

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	12/08/2016

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

RETAINING WALL
AS-BUILT
Sheet 1 of 2

AUCKLAND COUNCIL

DESIGNED: SB		AS-BUILT	
CHECKED: AC		DRAWN: AAC	
APPROVED: MLH		SURVEYED: WOODS	
JOB NUMBER: 33211		SCALE: 1:500 @ A3	
ISSUED: AUG 2016			
DWG. NO.	33211-03B-AB-150		REV. 1

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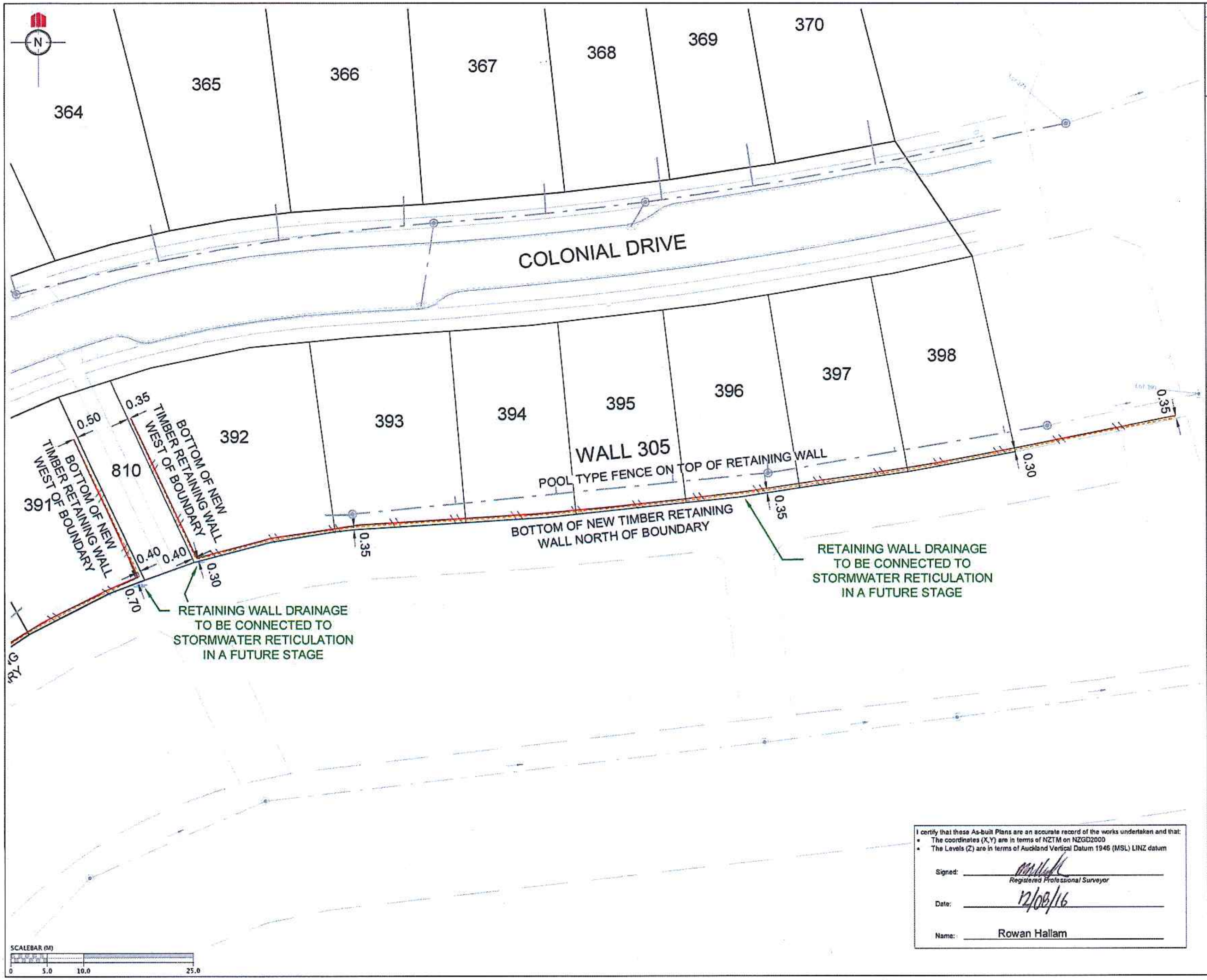

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: Registered Professional Surveyor
Date: 12/08/16
Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	12/08/2016

LEGEND:

┄	BOTTOM FACE OF WALL
┄	TOP FACE OF WALL
▨	CATCH PIT/BERM SUMP
●	STORMWATER MANHOLE
─	FENCE
┄	STORMWATER LINE
─	BOUNDARY

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

RETAINING WALL
AS-BUILT
Sheet 2 of 2

AUCKLAND COUNCIL

DESIGNED:	SB		AS-BUILT
CHECKED:	AC	DRAWN:	AAC
APPROVED:	MAH	SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:500 @ A3
ISSUED:	AUG 2016		
DWG. NO.	33211-03B-AB-151	REV.	1

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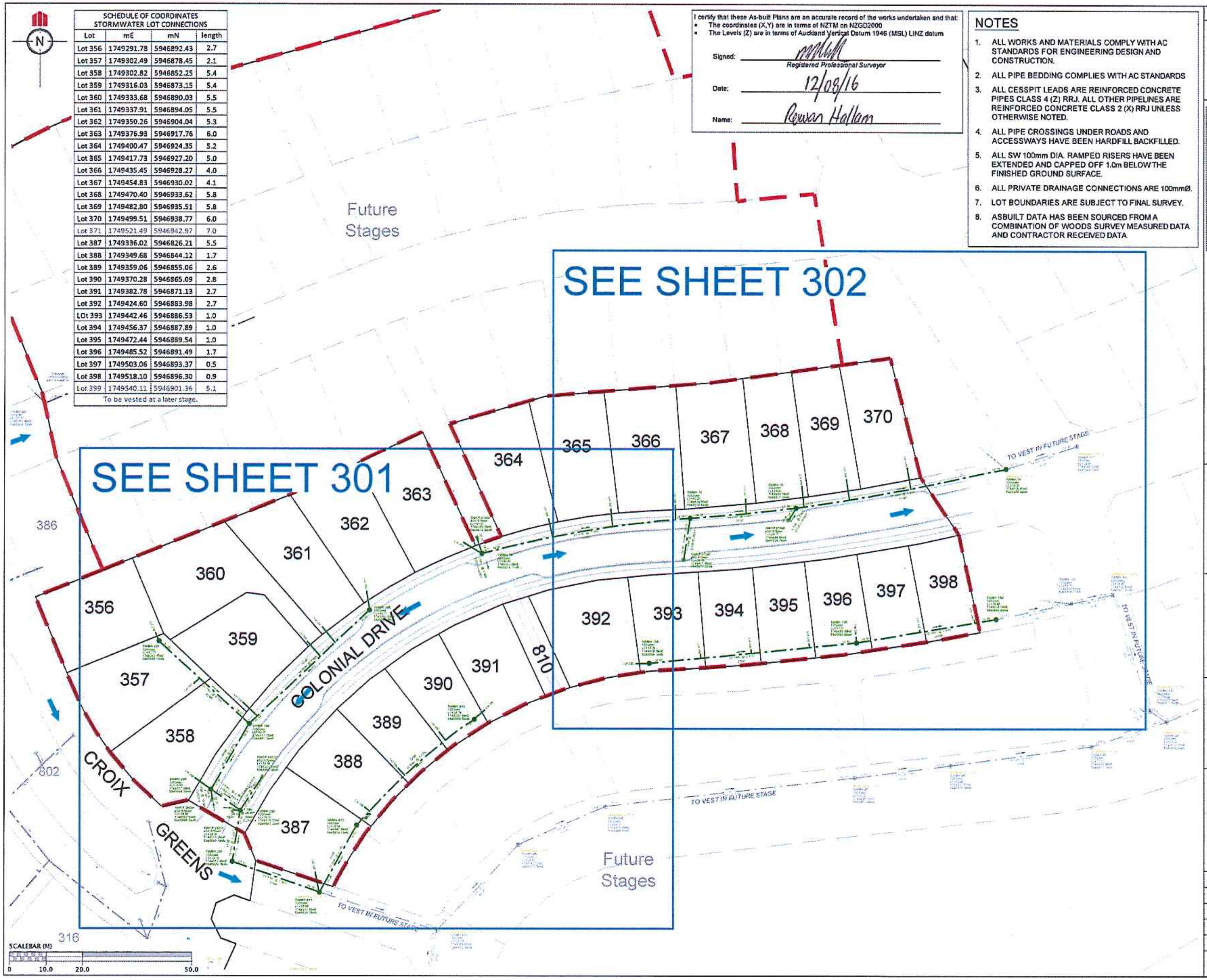

SCHEDULE OF COORDINATES STORMWATER LOT CONNECTIONS			
Lot	mE	mN	length
Lot 356	1749291.78	5946892.43	2.7
Lot 357	1749302.49	5946878.45	2.1
Lot 358	1749302.82	5946852.25	5.4
Lot 359	1749316.03	5946873.15	5.4
Lot 360	1749333.68	5946890.03	5.5
Lot 361	1749337.91	5946894.05	5.5
Lot 362	1749350.26	5946904.04	5.3
Lot 363	1749376.93	5946917.76	6.0
Lot 364	1749400.47	5946924.35	5.2
Lot 365	1749417.73	5946927.20	5.0
Lot 366	1749435.45	5946928.27	4.0
Lot 367	1749454.83	5946930.02	4.1
Lot 368	1749470.40	5946933.62	5.8
Lot 369	1749482.80	5946935.51	5.8
Lot 370	1749499.51	5946938.77	6.0
Lot 371	1749521.49	5946942.97	7.0
Lot 387	1749336.02	5946826.21	5.5
Lot 388	1749349.68	5946844.12	1.7
Lot 389	1749359.06	5946855.06	2.6
Lot 390	1749370.28	5946865.09	2.8
Lot 391	1749382.78	5946871.13	2.7
Lot 392	1749424.60	5946883.98	2.7
LOt 393	1749442.46	5946886.53	1.0
Lot 394	1749456.37	5946887.89	1.0
Lot 395	1749472.44	5946889.54	1.0
Lot 396	1749485.52	5946891.49	1.7
Lot 397	1749503.06	5946893.37	0.5
Lot 398	1749518.10	5946896.30	0.9
Lot 399	1749540.11	5946901.36	5.1
To be vested at a later stage.			

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed:
Registered Professional Surveyor

Date: 12/08/16

Name: Rowan Hallam

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
2. ALL PIPE BEDDING COMPLIES WITH AC STANDARDS
3. ALL CESSPIT LEADS ARE REINFORCED CONCRETE PIPES CLASS 4 (Z) RRJ. ALL OTHER PIPELINES ARE REINFORCED CONCRETE CLASS 2 (X) RRJ UNLESS OTHERWISE NOTED.
4. ALL PIPE CROSSINGS UNDER ROADS AND ACCESSWAYS HAVE BEEN HARDFILL BACKFILLED.
5. ALL SW 100mm DIA. RAMPED RISERS HAVE BEEN EXTENDED AND CAPPED OFF 1.0m BELOW THE FINISHED GROUND SURFACE.
6. ALL PRIVATE DRAINAGE CONNECTIONS ARE 100mmØ.
7. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED DATA AND CONTRACTOR RECEIVED DATA

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	12/08/2016

LEGEND

STORMWATER MANHOLE	⊙
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
OVERLAND FLOW	➡
NEW STORMWATER	— · — · —
EXISTING STORMWATER	——
RETAINING WALL DRAINAGE	——
STAGE BOUNDARY	— — —

CLIENT:

WFH PROPERTIES

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Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

STORMWATER AS-BUILT
OVERALL LAYOUT
Sheet 1 of 3

AUCKLAND COUNCIL

DESIGNED:	SB	ASBUILT	
CHECKED:	AC	DRAWN:	AAC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:1250 @ A3
ISSUED:	AUG 2016		
DWG. NO.	33211-3B-AB-300	REV.	1

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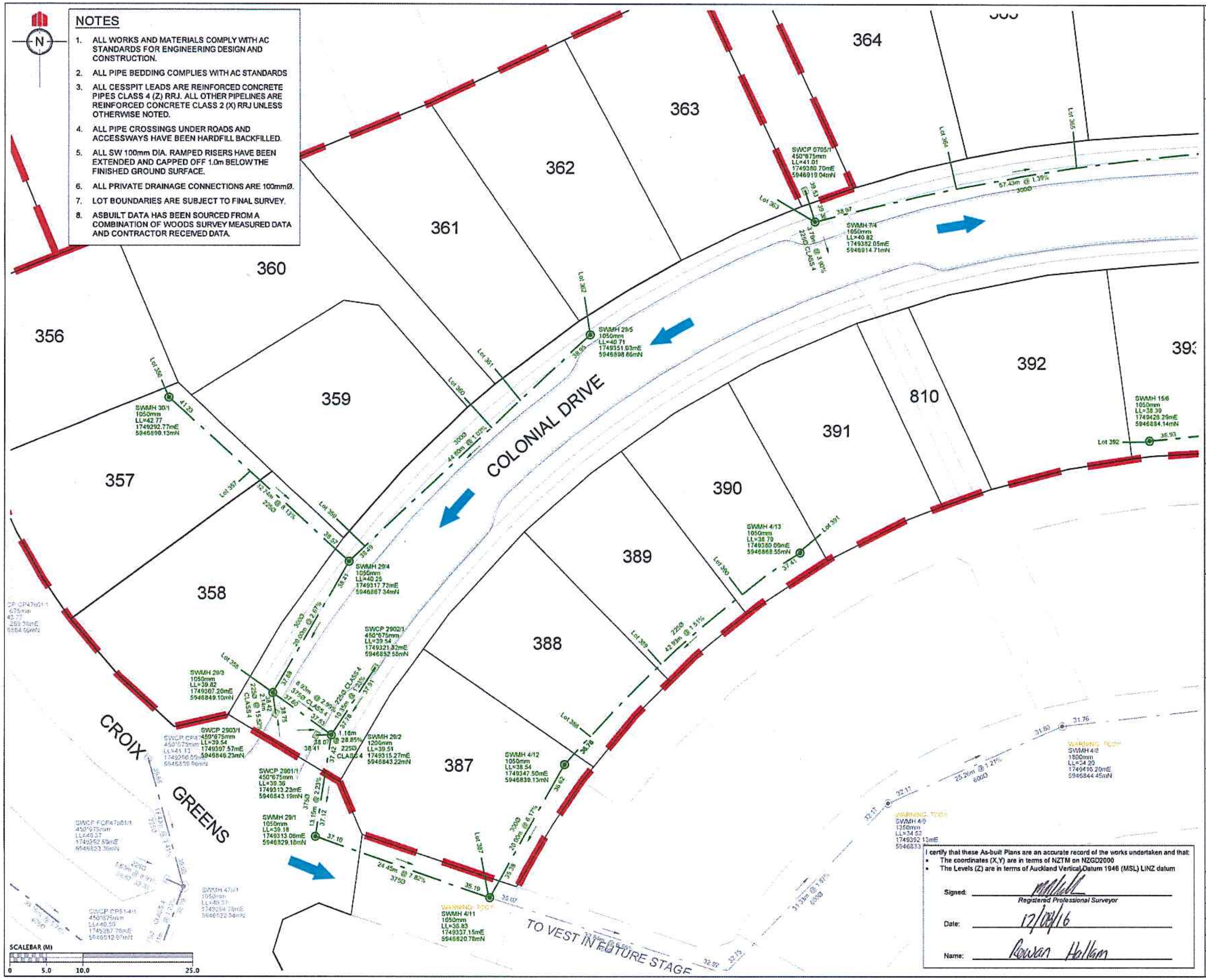

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
2. ALL PIPE BEDDING COMPLIES WITH AC STANDARDS
3. ALL CESSPIT LEADS ARE REINFORCED CONCRETE PIPES CLASS 4 (Z) RRJ. ALL OTHER PIPELINES ARE REINFORCED CONCRETE CLASS 2 (X) RRJ UNLESS OTHERWISE NOTED.
4. ALL PIPE CROSSINGS UNDER ROADS AND ACCESSWAYS HAVE BEEN HARDFILL BACKFILLED.
5. ALL SW 100mm DIA. RAMPED RISERS HAVE BEEN EXTENDED AND CAPPED OFF 1.0m BELOW THE FINISHED GROUND SURFACE.
6. ALL PRIVATE DRAINAGE CONNECTIONS ARE 100mmØ.
7. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED DATA AND CONTRACTOR RECEIVED DATA.

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	12/08/16

LEGEND

STORMWATER MANHOLE	⦿
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
OVERLAND FLOW	➡
NEW STORMWATER	— · — · —
EXISTING STORMWATER	———
RETAINING WALL DRAINAGE	———
STAGE BOUNDARY	▬ ▬ ▬

CLIENT:

WFH PROPERTIES

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MILLWATER
PRECINCT 2
STAGE 3B

STORMWATER AS-BUILT
Sheet 2 of 3

AUCKLAND COUNCIL

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______________
Registered Professional Surveyor

Date: 12/08/16

Name: Rowan Hallam

DESIGNED: SB		ASBUILT	
CHECKED: AC		DRAWN: AAC	
APPROVED: MH		SURVEYED: WOODS	
JOB NUMBER: 33211		SCALE: 1:500 @ A3	
ISSUED: AUG 2016			
DWG. NO. 33211-3B-AB-301			REV. 1

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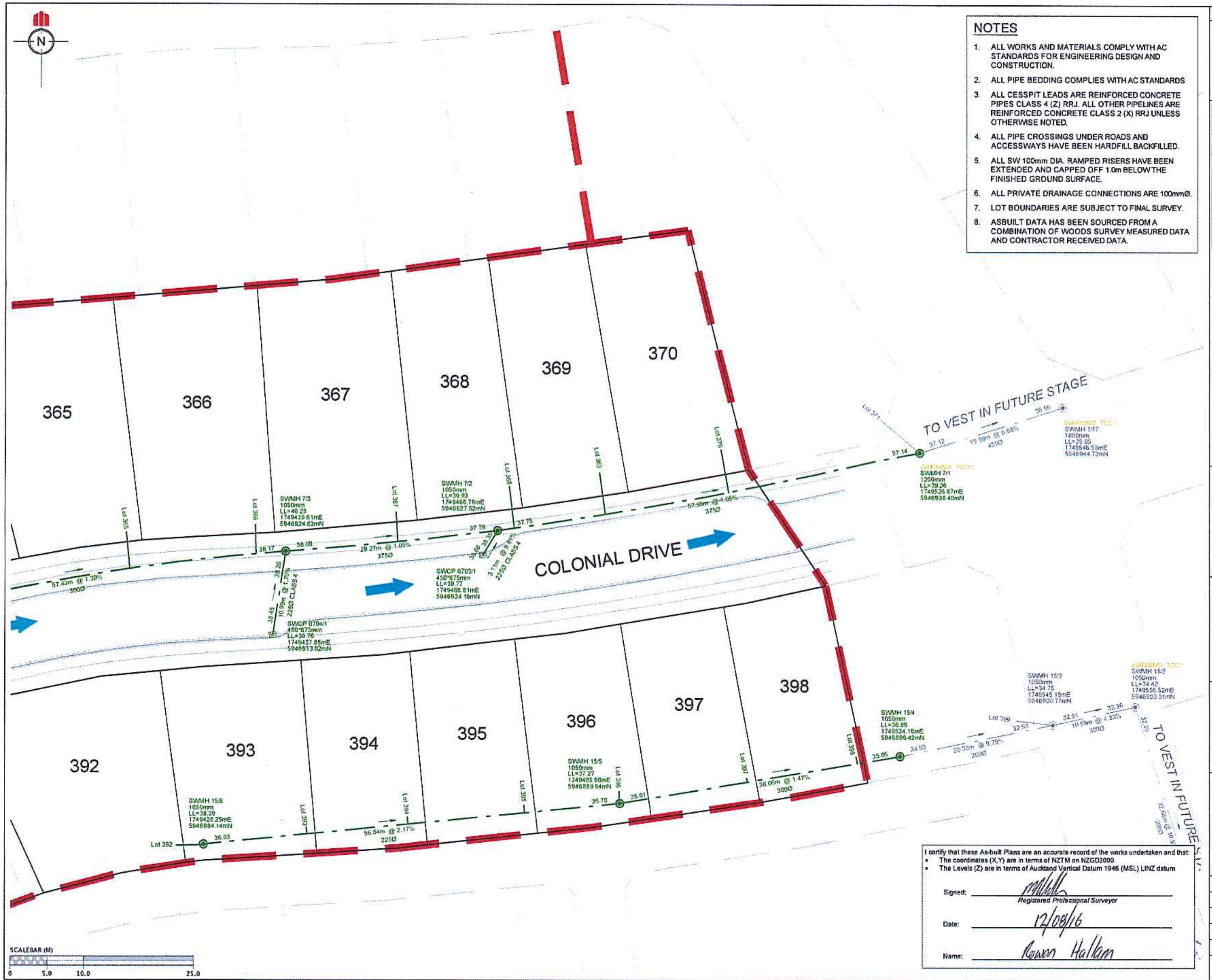

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
2. ALL PIPE BEDDING COMPLIES WITH AC STANDARDS
3. ALL CESSPIT LEADS ARE REINFORCED CONCRETE PIPES CLASS 4 (Z) RRJ. ALL OTHER PIPELINES ARE REINFORCED CONCRETE CLASS 2 (X) RRJ UNLESS OTHERWISE NOTED.
4. ALL PIPE CROSSINGS UNDER ROADS AND ACCESSWAYS HAVE BEEN HARDFILL BACKFILLED.
5. ALL SW 100mm DIA. RAMPED RISERS HAVE BEEN EXTENDED AND CAPPED OFF 1.0m BELOW THE FINISHED GROUND SURFACE.
6. ALL PRIVATE DRAINAGE CONNECTIONS ARE 100mmØ.
7. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED DATA AND CONTRACTOR RECEIVED DATA.

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AAC	12/08/2016

LEGEND

STORMWATER MANHOLE	⦿
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
OVERLAND FLOW	➡
NEW STORMWATER	— · — · —
EXISTING STORMWATER	———
RETAINING WALL DRAINAGE	———
STAGE BOUNDARY	▬ ▬ ▬

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: _______ Registered Professional Surveyor

Date: 12/08/16

Name: Rowan Hallam

CLIENT:

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MILLWATER
PRECINCT 2
STAGE 3B

STORMWATER AS-BUILT
Sheet 3 of 3

AUCKLAND COUNCIL

DESIGNED:	SB		ASBUILT
CHECKED:	AC	DRAWN:	AAC
APPROVED:	MH	SURVEYED:	WOODS
JOB NUMBER:	33211	SCALE:	1:500 @ A3
ISSUED:	AUG 2016		
DWG. NO.	33211-3B-AB-302	REV.	1

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Appendix A2: T+T Drawings

21854.001–P2S3B–100	Drawing List and Site Location Plan
21854.001–P2S3B–101	Geotechnical Works Plan
21854.001–P2S3B–102	Geotechnical Works Subsoil Drain Plan
21854.001–P2S3B–103	Geological Cross Section 3
21854.001–P2S3B–104	Geological Cross Section 4
21854.001–P2S3B–105	Typical Reinforced Earth Slope Details
21854.001–P2S3B–106	Shear Key 03 Plan
21854.001–P2S3B–107	Shear Key 03 Longsection
21854.001–P2S3B–108	Geology Legend and Definition of Terms
21854.001–P2S3B–110	Building Limitation Plan

Timber Pole Walls 304 and 305 Drawings

21854.001–P2S3–120	Typical Timber Pole Retaining Wall Details
21854.001–P2S3–122	Standard Fence Panel Detail

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RESIDENTIAL SUBDIVISION
MILLWATER-PRECINCT 2 (STAGE 3B)
Completion Report Issue

DRAWING	Rev	Title
GENERAL		
• 21854.001-P2S3B-100	1	Drawing List and Site Location Plan
• 21854.001-P2S3B-101	1	Geotechnical Works Plan
• 21854.001-P2S3B-102	1	Geotechnical Works Subsoil Drain Plan
• 21854.001-P2S3B-103	1	Geological Cross Section 3
• 21854.001-P2S3B-104	1	Geological Cross Section 4
• 21854.001-P2S3B-105	1	Typical Reinforced Earth Slope Details
• 21854.001-P2S3B-106	1	Shear Key 03 Plan
• 21854.001-P2S3B-107	1	Shear Key 03 Longsection
• 21854.001-P2S3B-108	1	Geology Legend and Definition of Terms
• 21854.001-P2S3B-110	1	Building Limitation Plan
APPENDIX E		
• 21854.001-P2S3B-111	1	Post Earthworks Investigation Plan
• 21854.001-P2S3B-112	1	Topsoil Depths Plan
• 21854.001-P2S3B-113	1	Earthworks Testing Location Plan

• Denotes drawing this issue: 24/08/2016

Street map sourced from Land Information New Zealand data (Crown Copyright Reserved).

A3 SCALE 1: 10000
0 0,1 0,2 0,3 0,4 0,5 (km)

ORIGINAL IN COLOUR

LOCATION PLAN
SCALE 1: 10000

DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue			DESIGNED :	JXXL	Aug.16
				DRAWN :	JC	Aug.16
				DESIGN CHECKED :		
				DRAFTING CHECKED :		
				CADFILE : \\21854.001-P2S3B-100.dwg		
				APPROVED : NOT FOR CONSTRUCTION		
REVISION	DESCRIPTION	BY	DATE	This drawing is not to be used for construction purposes unless signed as approved		

NOTES :
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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Drawing List and Site Location Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
AS SHOWN	21854.001-P2S3B-100	1

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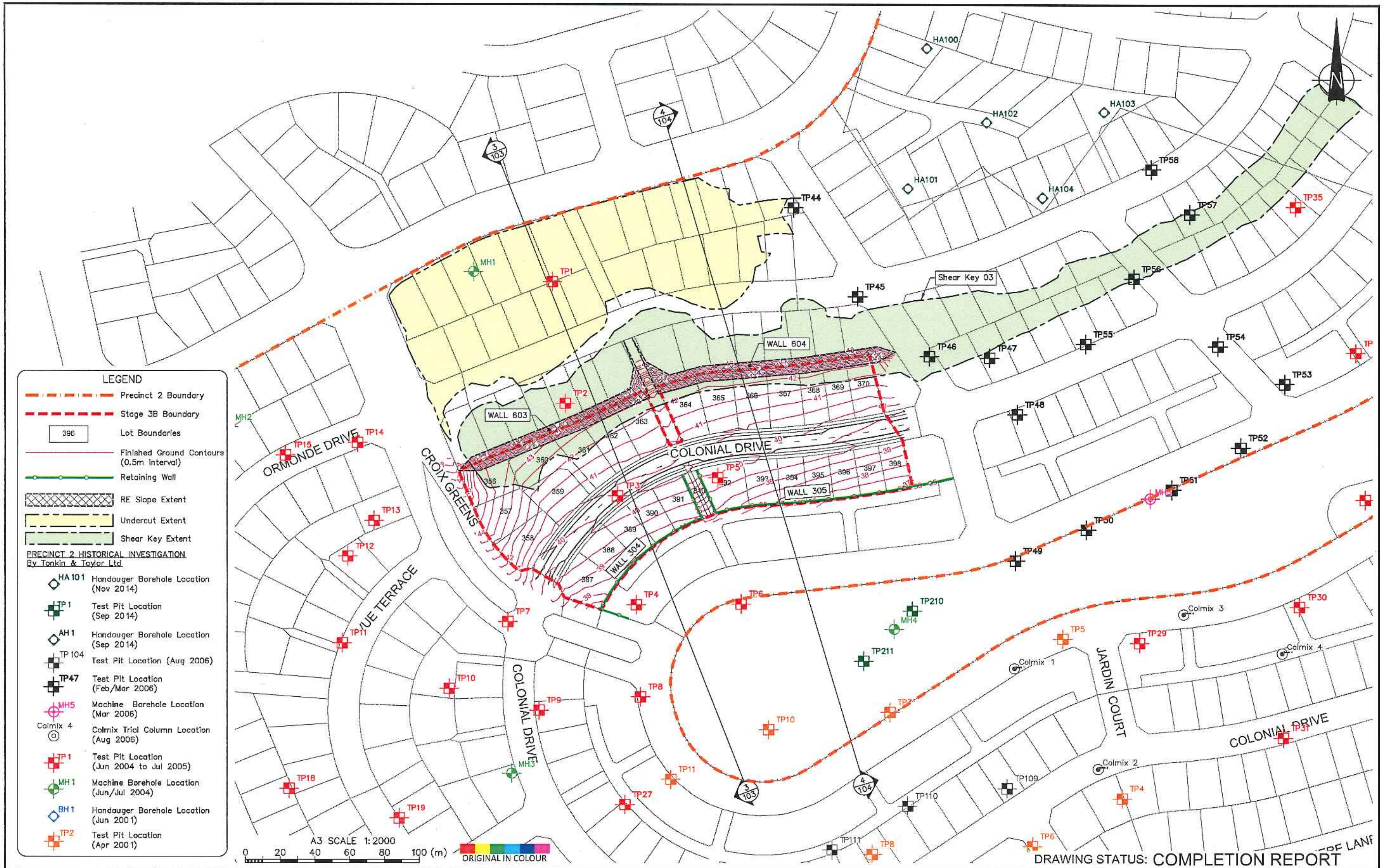

DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue		
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DRAWN :	JC	Sep.16
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.001-P2S3B-101.dwg		
APPROVED :		

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1. All dimensions are in metres unless noted otherwise.
2. As-built plan supplied by WOODS, reference file name "33211-03B-AB-100 FINAL CONTOURS.dwg" dated 4 Aug 2016.
3. Undercuts, shearkey & subsoil drains supplied by WOODS, reference file name 33211-03B-AB-120 SK UC & SUBSOIL.dwg" dated 4 Aug 2016.
4. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946

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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Geotechnical Works Plan

SCALES (AT A3 SIZE) 1: 2000
DWG. No. 21854.001-P2S3B-101
REV. 1

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ORIGINAL IN COLOUR

DRAWING STATUS: COMPLETION REPORT

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				DRAWN :	JC	Aug. 16
				DESIGN CHECKED :		
				DRAFTING CHECKED :		
				CADFILE : \\21854.001-P2S3B-102.dwg		
				APPROVED :		
1	Completion Report Issue					
REVISION DESCRIPTION		BY	DATE			

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3. Undercuts, shearkey & subsoil drains supplied by WOODS, reference file name 33211-03B-AB-120 SK UC & SUBSOIL.dwg" dated 4 Aug 2016.
4. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946

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TITLE
MILLWATER - PRECINCT 2 (STAGE 3B)
Geotechnical Works Subsoil Drain Plan

SCALES (AT A3 SIZE) 1:2000
DWG. No. 21854.001-P2S3B-102
REV. 1

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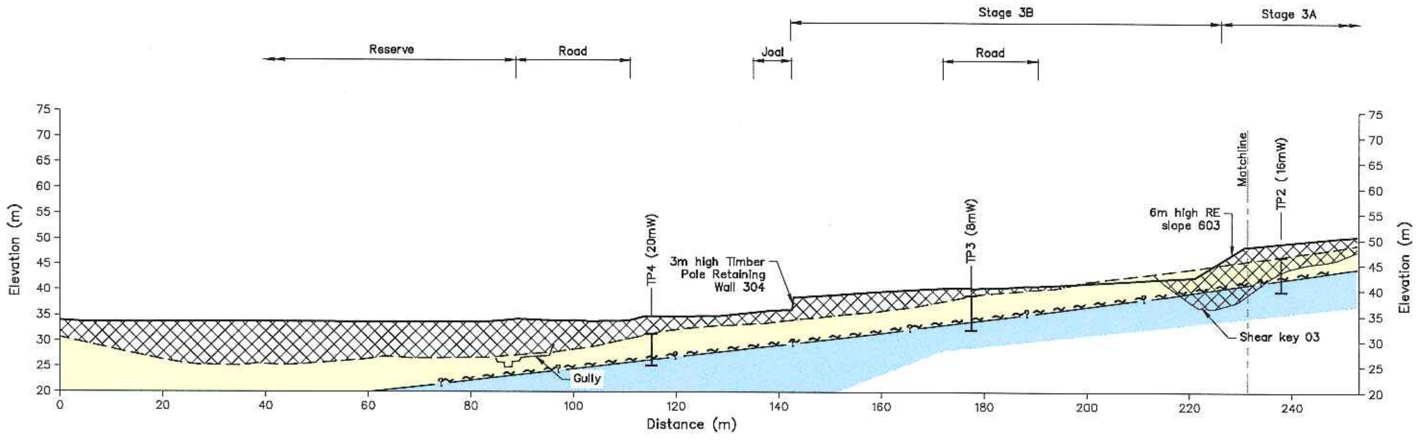
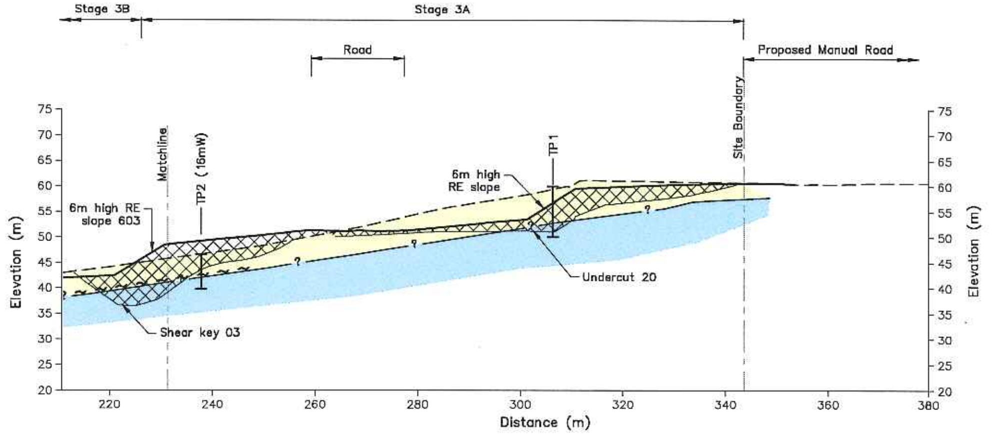


SECTION 3/101
SCALE 1:1000



SECTION 3/101 CONT'D
SCALE 1:1000

LEGEND

▨	Engineered Fill
🟨	Northland Allochthon Residual Soil
🟦	Northland Allochthon Rock
- - - - - -	Original Ground Level
———	Finished Ground Level
—?—	Inferred geology interface
~~	Inferred shear surface

A3 SCALE 1: 1000
0 5 10 15 20 30 40 50 (m)

DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue		
REVISION DESCRIPTION	BY	DATE	

DESIGNED :
DRAWN : JXXL Aug. 16
DESIGN CHECKED : JC Aug. 16
DRAFTING CHECKED :
CADFILE : \\21854.001-P2S3B-103_104.dwg
APPROVED :
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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Geological Cross Section 3
SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S3B-103
REV. 1

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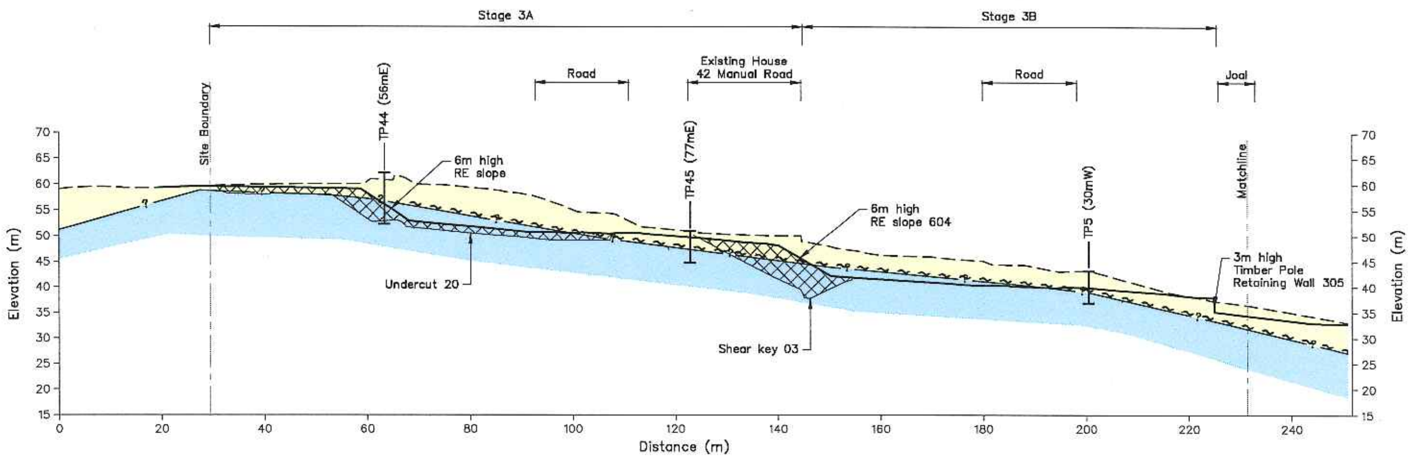

SECTION 4/101
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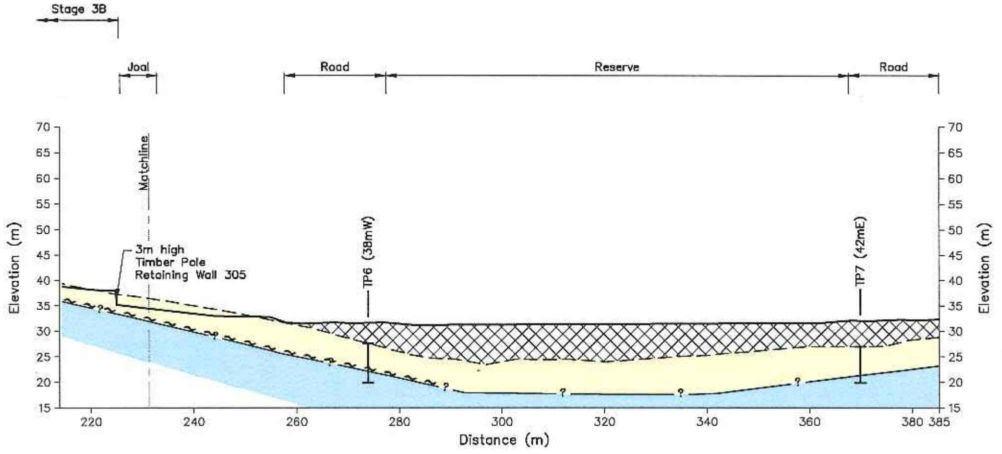

SECTION 4/101 CONT'D
SCALE 1:1000

LEGEND

- ▨ Engineered Fill
- 🟨 Northland Allochthon Residual Soil
- 🟦 Northland Allochthon Rock
- - - - - - - Original Ground Level
- ——— Finished Ground Level
- ——?—— Inferred geology interface
- ~~~~~~ Inferred shear surface

A3 SCALE 1: 1000
0 5 10 15 20 30 40 50 (m)

DRAWING STATUS: COMPLETION REPORT

			DESIGNED :	JXXL	Aug. 16	NOTES :
			DRAWN :	JC	Aug. 16	1. All dimensions are in millimetres unless noted otherwise.
			DESIGN CHECKED :			
			DRAFTING CHECKED :			
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			APPROVED : NOT FOR CONSTRUCTION			
1	Completion Report Issue		This drawing is not to be used for construction purposes unless signed as approved			
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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Geological Cross Section 4

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S3B-104
REV. 1

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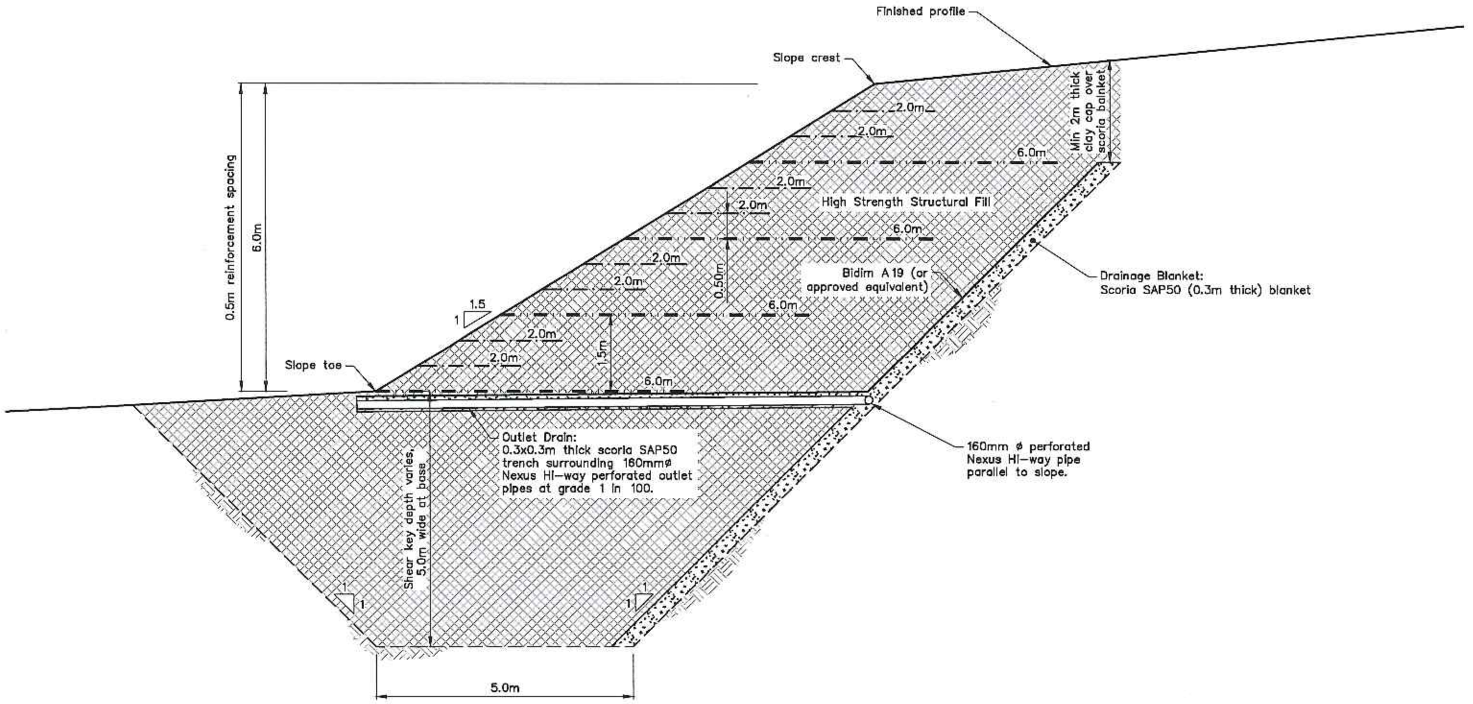

TYPICAL REINFORCED EARTH SLOPE DETAIL (6m HIGH)
SCALE 1: 100

LEGEND

- —·—·—·— 2m long Tensar SS20 (secondary) reinforcement (number indicates grid length)
- —··—··— 6.0m long Miragrid GX60/30 (primary) reinforcement (number indicates grid length)

A3 SCALE 1: 100
0 1 2 3 4 5 (m)

DRAWING STATUS: COMPLETION REPORT

		DESIGNED :	JXXL	Aug. 16
		DRAWN :	JC	Aug. 16
		DESIGN CHECKED :		
		DRAFTING CHECKED :		
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		APPROVED : NOT FOR CONSTRUCTION This drawing is not to be used for construction purposes unless signed as approved		
1 Completion Report Issue				
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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Typical Reinforced Earth Slope Details

SCALES (AT A3 SIZE) AS SHOWN
DWG. No. 21854.001-P2S3B-105
REV. 1

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SHEAR KEY 03 PLAN
SCALE 1: 1000

A3 SCALE 1: 1000
0 5 10 15 20 30 40 50 (m)

ORIGINAL IN COLOUR

DRAWING STATUS: COMPLETION REPORT

			DESIGNED :	JXXL	Sep.16
			DRAWN :	JC	Sep.16
			DESIGN CHECKED :		
			DRAFTING CHECKED :		
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			APPROVED :		
1 Completion Report Issue					
REVISION DESCRIPTION	BY	DATE			

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NOTES :
1. All dimensions are in metres unless noted otherwise.
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3. Undercuts, shearkey & subsoil drains supplied by WOODS, reference file name 33211-03B-AB-120 SK UC & SUBSOIL.dwg" dated 4 Aug 2016.
4. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000).
Level Datum: LINZ (MSL) Auckland Vertical Datum 1946

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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Shear Key 03 Plan

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S3B-106
REV. 1

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(2) F 18–47°/010° UN, SL, T, CN
(3) F 14°/194° UN, SL, T, CV
(4) F 14°/192° PL, SL, T, CV

(5) B 15°/337° UN, SM, VT, CN
(6) B 20°/295° PL, SM, VT, CN
(7) B 21°/012° PL, SM, VT, CN
(8) F 12°/336° PL, SL, T, CV

(9) B 15°/334° UN, RO, T, CN
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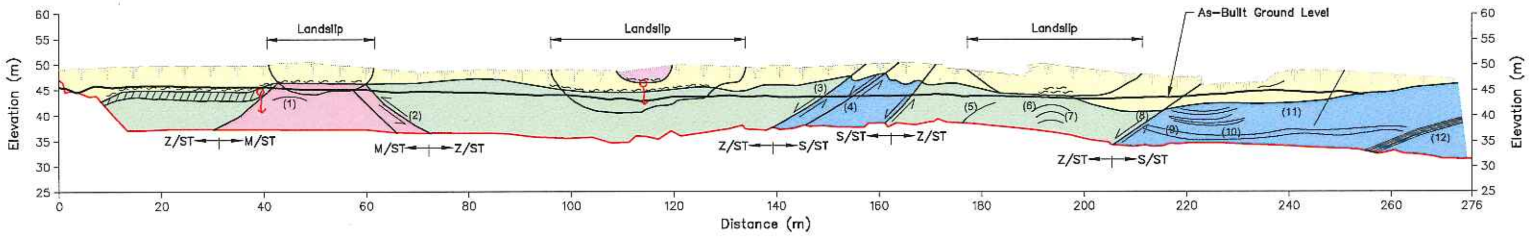
(11) B 11°/285° PL, RO, VT, CN
(12) SZ 14°/260° UN, SL, T, CV



LONG SECTION 1/106
SCALE 1:1000

Note: Refer Dwg. No. 21854–001–P2S3B–108 for Geology Legend and Definition of Terms

A3 SCALE 1: 1000
0 5 10 15 20 30 40 50 (m)

🟥🟨🟩🟦🟦🟪 ORIGINAL IN COLOUR

DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue			
REVISION	DESCRIPTION	BY	DATE	

DESIGNED : JXXL Aug. 16
DRAWN : JC Aug. 16
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\21854.001–P2S3B–106_107.dwg
APPROVED :
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2. As–built plan supplied by WOODS, reference file name "33211–03B–AB–100 FINAL CONTOURS.dwg" dated 4 Aug 2016.
3. Undercuts, shearkey & subsoil drains supplied by WOODS, reference file name 33211–03B–AB–120 SK UC & SUBSOIL.dwg" dated 4 Aug 2016.
4. Geological boundaries and feature approximate only.

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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Shear Key 03 Longsection

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001–P2S3B–107
REV. 1

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LONGSECTION MATERIAL LEGEND

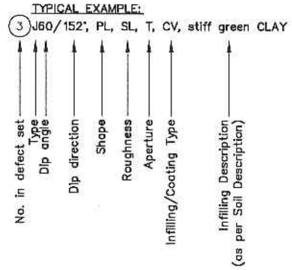
🟪	Alluvium Silty Clay and Clayey Silt, firm to stiff, moist to wet, light grey to white, organic layers, generally thinly bedded (subhorizontal)
🟨	Colluvium Clayey Silt, firm to stiff, moist, light grey mottled orange/brown
🟧	East Coast Bays Formation Soils Stiff to very stiff Silty Clay, Clayey Silt and minor Silty Sand, moist to wet, light yellow to light grey
🟫	MW East Coast Bays Formation Moderately Weathered ECBF, Silty Clay and Clayey Silt, minor Silty Sand, very stiff, wet, dark grey, thinly bedded
🟩	SW–UW East Coast Bays Formation Slightly to unweathered ECBF. Interbedded Sandstone, Siltstone and Mudstone. Sandstone, Silty, very weak, dark grey. Siltstone and Mudstone, extremely weak to very weak, dark grey
🟨	Northland Allochthton residual soil, stiff to very stiff silts and clays, moist, moderately to highly plastic, light yellow grey
⬜	Northland Allochthon "softened zone" Moderately to Slightly weathered siltstone and/or mudstone, extremely to very weak, grey, red/brown and dark grey, sheared fabrics, breaks apart easily in hand, many polished surfaces. Some green grey and black beds.
🟩	NORTHLAND ALLOCHTHON Siltstone, highly weathered to moderately weathered, grey, dark grey and light brown, fractured, common minor polished surfaces at various orientations, generally dry
🟪	NORTHLAND ALLOCHTHON Mudstone, highly weathered, grey and red/brown, fractured, common minor polished surfaces at various orientations, dry to damp
🟦	NORTHLAND ALLOCHTHON Sandstone, highly weathered to moderately weathered, grey/brown and light green/grey, fractured, generally dry
▩	Engineered Fill
▨	Saturated Zone
▦	Concretion Typically moderately strong, Sandstone units
↓	Groundwater seepage
→	Shear Surface
—	Existing Ground Level
—	Undercut Level

DEFECT CODE LEGEND

SHAPE		ROUGHNESS		APERTURE		
TERM	CODE	DESCRIPTION OF JOINT SURFACE	CODE	TERM	SYMBOL	DESCRIPTION (Seperation)
Planar	PL	Slickensided	SL	Very Tight	VT	less than 0.1mm
Slightly Curved	SC	Smooth	SM	Tight	T	0.1 to 1.0mm
Curved	CV	Defined Ridges	DR	Open	O	1.0 to 10.0mm
Irregular	IR	Small Steps	ST	Very Open	VO	more than 10mm
Stepped	ST	Rough	R			
Wavy	WV	Very Rough	VR			
Undulated	UN					

INFILLINGS AND COATINGS		
Clay Gouge	CG	Joints have openings between opposing faces of intact rock substance in excess of 1mm filled with clay gouge. Clay is generally described in terms of soil properties.
Clay Veneers	CV	Joints contain clay coating whose maximum thickness does not exceed 1mm. Note: Describe clay in terms of soil properties.
Penetrative Limonite	PL	Joint traces are marked in terms of well defined zones of slightly to moderately weathered ferruginised rock–substance within the adjacent rock.
Limonite Stained	FeSt	Joint surfaces are stained or coated with limonite, although the rock substance immediately adjacent to the joints is fresh.
Coated	CT SC	Joints exhibit Coatings other than clay or limonite, eg. Carbonate (CT) or silica (SC)
Cemented	CL CS CC	Joints are cemented with limonite (CL), silica (CS), or carbonates (CC)
Clean	CN	Joint surfaces show no trace of clay, limonite, or other coatings

TYPE		
TERM	CODE	SYMBOL
Bedding	B	15° Dip angle Strike
Joint	J	88° Dip angle Strike
Shear zone	SZ	20° Dip angle Strike
Fault trace	F	40° Dip angle Strike



ORIGINAL IN COLOUR

1	Completion Report Issue		
	REVISION DESCRIPTION	BY	DATE

DESIGNED :	JXXL	Aug. 16
DRAWN :	JC	Aug. 16
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.001-P2S3B-108.dwg		
APPROVED :		

NOT FOR CONSTRUCTION
This drawing is not to be used for construction purposes unless signed as approved

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

REFERENCE :

Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkintaylor.co.nz

DRAWING STATUS: COMPLETION REPORT

CLIENT, PROJECT
WFH PROPERTIES LTD
RESIDENTIAL SUBDIVISION

TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Geology Legend and Definition of Terms

SCALES (AT A3 SIZE)	DWG. No.	REV.
AS SHOWN	21854.001-P2S3B-108	1

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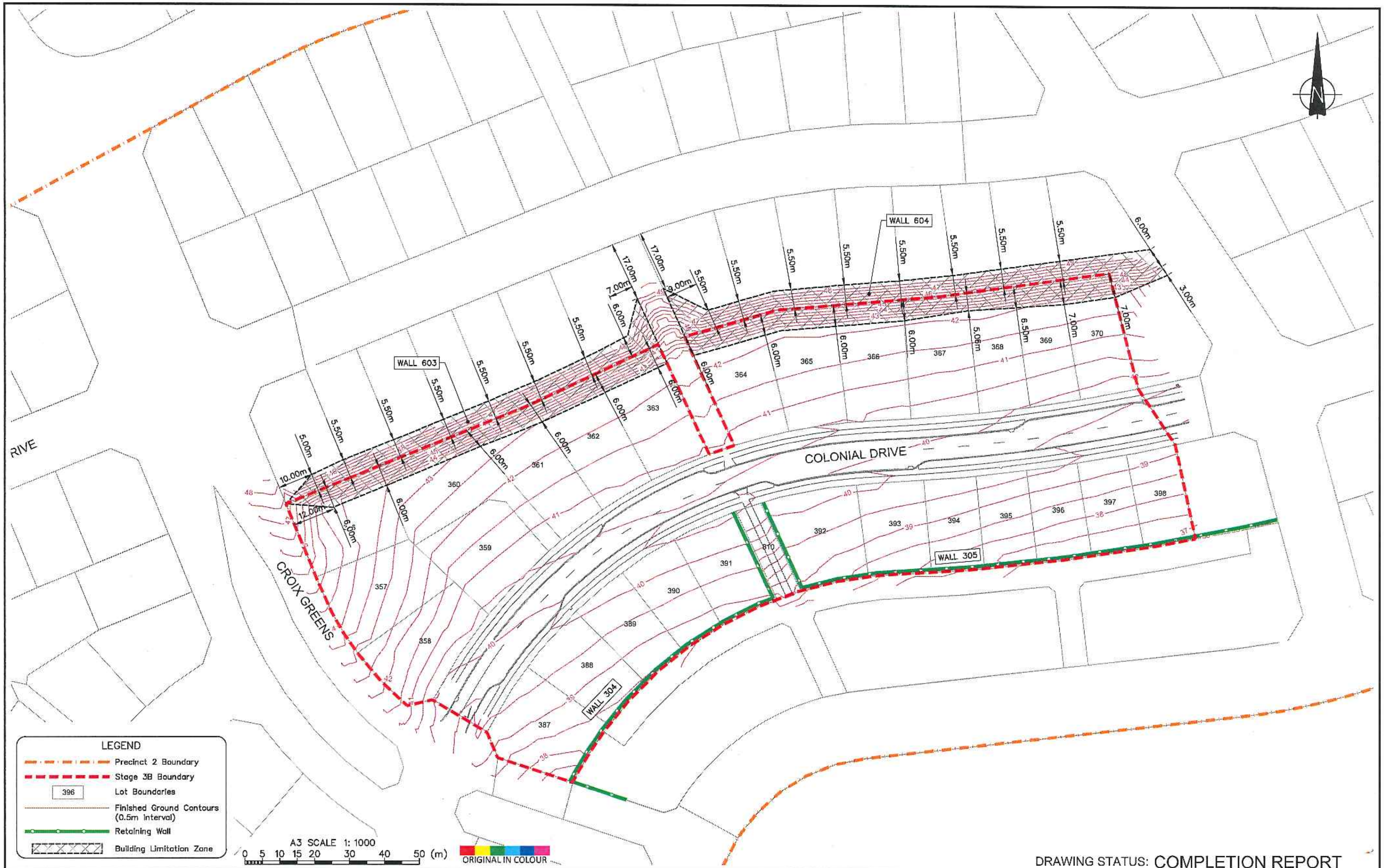

DRAWING STATUS: COMPLETION REPORT

			DESIGNED :		JXXL	Aug. 16
			DRAWN :		JC	Aug. 16
			DESIGN CHECKED :			
			DRAFTING CHECKED :			
			CADFILE : \\21854.001-P2S3B-110.dwg			
			APPROVED :			
1	Completion Report Issue			NOT FOR CONSTRUCTION This drawing is not to be used for construction purposes unless signed as approved		
REVISION DESCRIPTION		BY	DATE	COPYRIGHT ON THIS DRAWING IS RESERVED		

NOTES :
1. All dimensions are in metres unless noted otherwise.
2. As-built plan supplied by WOODS, reference file name "33211-03B-AB-100 FINAL CONTOURS.dwg" dated 4 Aug 2016.
3. Undercuts, shearkey & subsoil drains supplied by WOODS, reference file name 33211-03B-AB-120 SK UC & SUBSOIL.dwg" dated 4 Aug 2016.
4. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000).
Level Datum: LINZ (MSL) Auckland Vertical Datum 1946

REFERENCE :

Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkintaylor.co.nz

CLIENT, PROJECT
WFH PROPERTIES LTD
RESIDENTIAL SUBDIVISION

TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Building Limitation Plan

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S3B-110
REV. 1

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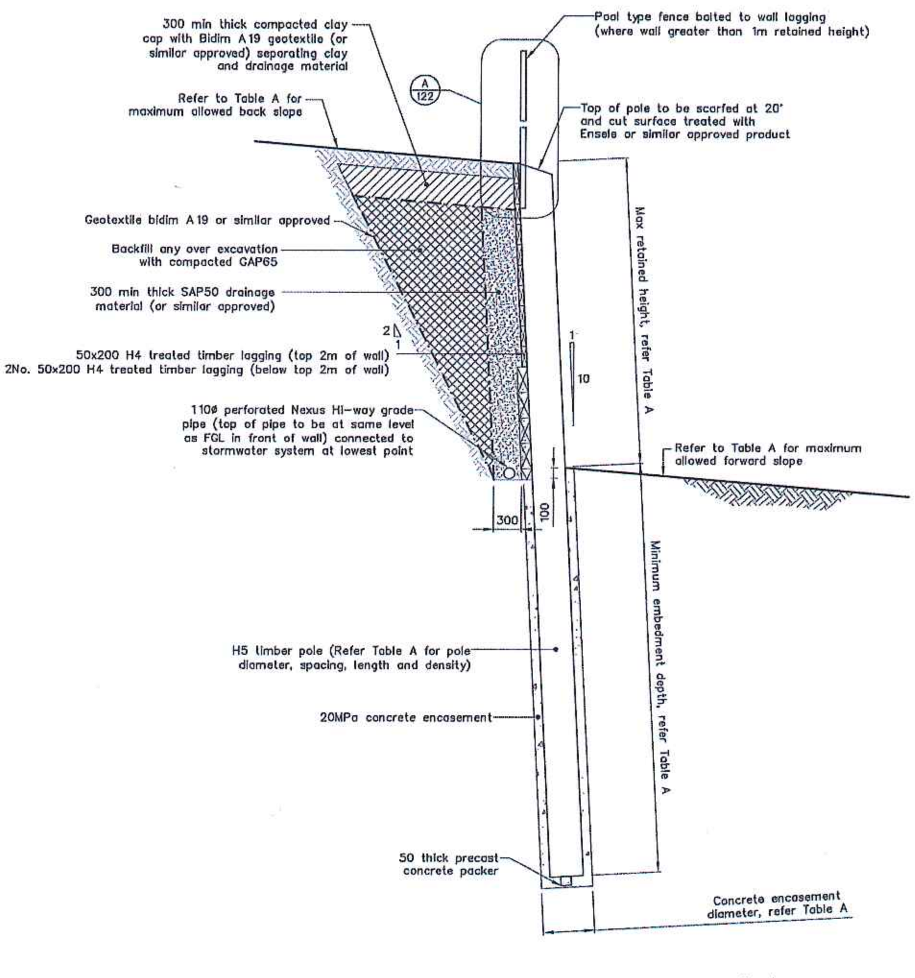


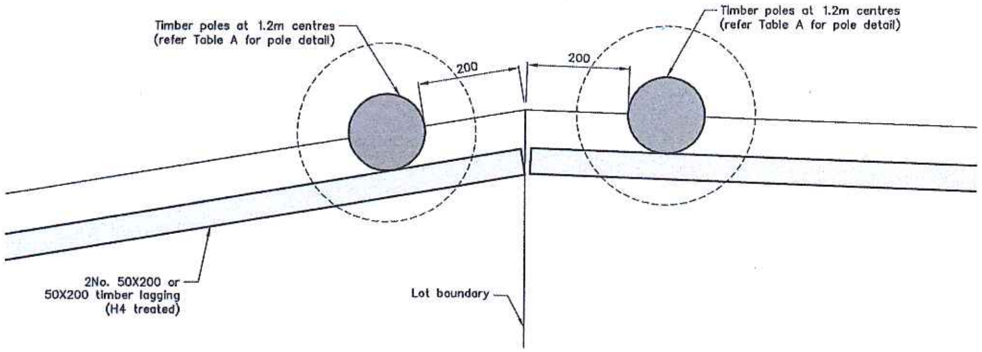
TYPICAL DETAIL – TIMBER POLE RETAINING WALL (TP)
SCALE 1:50

Refer to Table A

TABLE A: TIMBER POLE DETAIL TABLE

Wall No.	Wall Type	Pile Type	Retained Height (m)	Pile Length (m)	Miminum Embedment (m)	Pole/Pile Size (mm)	Pole Density	Pole Spacing (m)	Min Hole Size (mm)	Maximum Backslope	Maximum Frontslope
306, 308	C	Timber Pole	≤3.0	9	6	375	High	1.2	525	1v:12h	1v:12h
	E3	Timber Pole	≤2.5	7.5	5	300	High	1.2	450	1v:12h	1v:12h
	F1	Timber Pole	≤2.0	6	4	225	High	1.2	375	1v:12h	1v:12h
	G	Timber Pole	≤1.5	4.2	2.7	200	High	1.2	350	1v:12h	1v:12h
	H	Timber Pole	≤1.0	2.4	1.4	150	High	1.2	300	1v:12h	1v:12h
304, 305	D	Timber Pole	≤3.0	8	5	350	High	1.2	500	1v:12h	1v:12h
	E3	Timber Pole	≤2.5	7.5	5	300	High	1.2	450	1v:12h	1v:12h
	F1	Timber Pole	≤2.0	6	4	225	High	1.2	375	1v:12h	1v:12h
	G	Timber Pole	≤1.5	4.2	2.7	200	High	1.2	350	1v:12h	1v:12h
	H	Timber Pole	≤1.0	2.4	1.4	150	High	1.2	300	1v:12h	1v:12h
307	E	Timber Pole	≤2.5	7	4.5	275	High	1.2	425	1v:12h	1v:12h
	F1	Timber Pole	≤2.0	6	4	225	High	1.2	375	1v:12h	1v:12h
	G	Timber Pole	≤1.5	4.2	2.7	200	High	1.2	350	1v:12h	1v:12h
	H	Timber Pole	≤1.0	2.4	1.4	150	High	1.2	300	1v:12h	1v:12h

NOTE
1. All poles shall be sourced from the same region and documentation shall be provided.
2. For each pole size, 10% of all poles shall be tested in accordance with the specification.
3. Retaining walls have been designed with 10kPa surcharge on upslope side for residential use purposes.
4. Design makes no provision for over excavation in front of wall (e.g. for service trenches). All such temporary excavations, if required, should be reviewed and confirmed as acceptable by a suitably qualified Geotechnical Engineer.



TYPICAL DETAIL AT LOT BOUNDARY
SCALE 1:10

A3 SCALE 1:50
0 0.5 1.0 1.5 2.0 2.5 (m)

A3 SCALE 1:10
0 0.1 0.2 0.3 0.4 0.5 (m)

DRAWING STATUS: CONSTRUCTION ISSUE

A	Construction Issue			DESIGNED :	JXXL	Feb. 16
REVISION DESCRIPTION		BY	DATE	DRAWN :	JC	Feb. 16
				DESIGN CHECKED :		2/16
				DRAFTING CHECKED :		2/16
				CADFILE : \\21854.001-P2S3-120_122.dwg		
				APPROVED :		15/2/16

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NOTES :
1. All dimensions are in millimetres unless noted otherwise.
2. Wall setout to be provided by WOODS
3. Small end diameter to be placed at top of wall.
4. All cut surfaces to be treated with Ensile or similar approved timber sealant.
5. All pile holes to be inspected by T&T prior to pouring concrete.

REFERENCE :

Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkintaylor.co.nz

CLIENT, PROJECT
WFH PROPERTIES LTD
MILLWATER PRECINCT 2

TITLE
STAGE 3 RETAINING WALLS
Typical Timber Pole Retaining Wall Detail

SCALES (AT A3 SIZE)
AS SHOWN

DWG. No.
21854.001-P2S3-120

REV.
A

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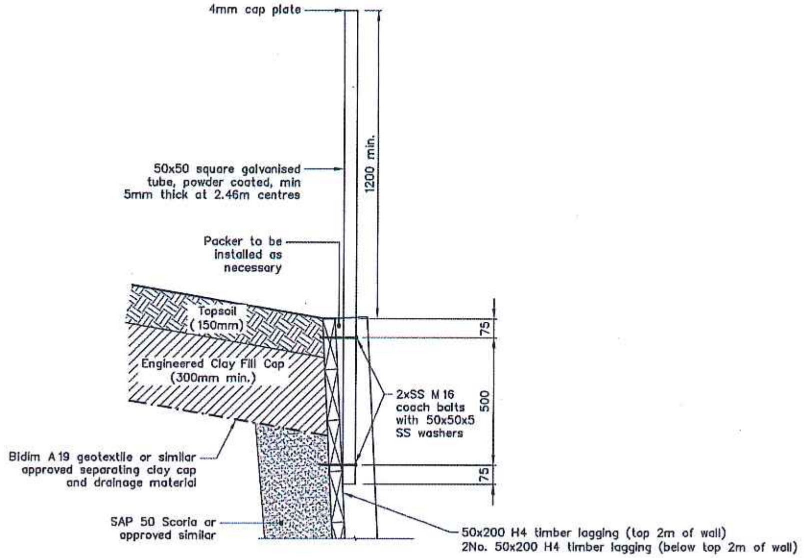
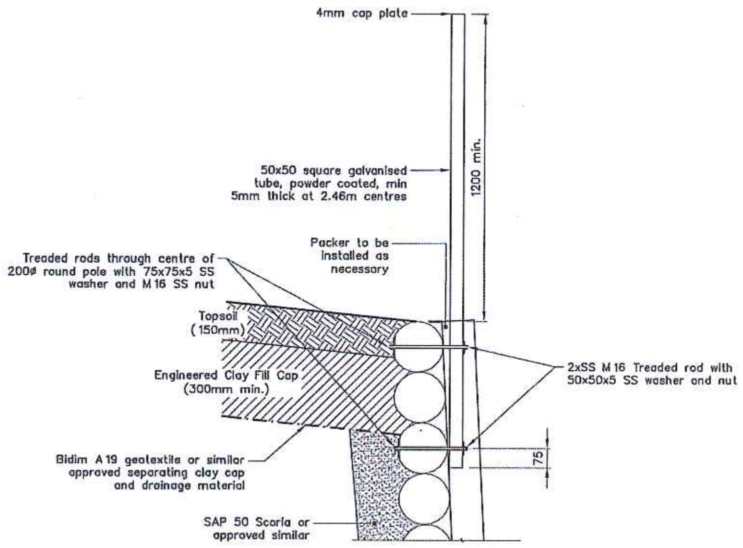
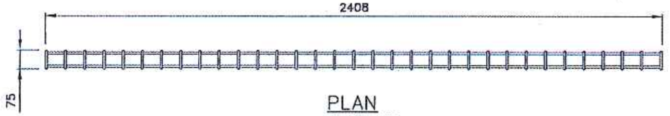


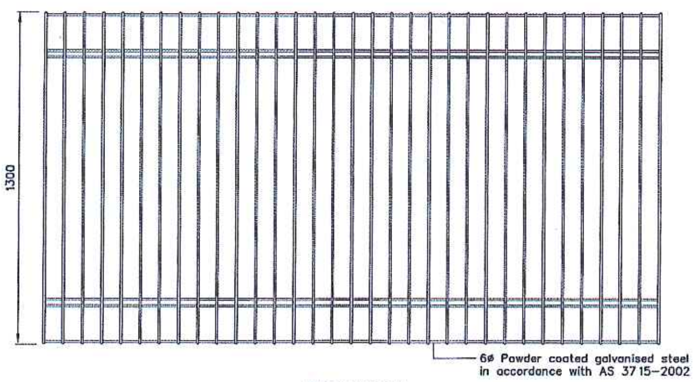
DETAIL (A/120) POST DETAIL
SCALE 1:20



DETAIL (B/121) POST DETAIL
SCALE 1:20



PLAN
SCALE 1:20



A3 SCALE 1:20
0 0.2 0.4 0.6 0.8 1.0 (m)

SECTION
SCALE 1:20

ELEVATION
SCALE 1:20

DRAWING STATUS: CONSTRUCTION ISSUE

A	Construction Issue		
REVISION DESCRIPTION		BY	DATE

DESIGNED : JXXL Feb. 16
DRAWN : JC Feb. 16
DESIGN CHECKED : ML 2/16
DRAFTING CHECKED : 2/16
CADFILE : \\21854.001–P2S3–120_122.dwg
APPROVED : 15/2/16
This drawing is not to be used for construction purposes unless signed as approved
COPYRIGHT ON THIS DRAWING IS RESERVED

NOTES :
1. All dimensions are in millimetres unless noted otherwise.
2. Fence panels to be hot dip galvanised and black powder coated.
3. Fence panels must not have more than 100mm gap from ground level to base of installed panel.
4. Posts to be 50ømm hot dip galvanised pipe and black powder coated.
5. Posts to be installed vertically and packed out appropriately.
6. Fence panels & posts to be installed in accordance with manufacturers specifications.

REFERENCE :

Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkintaylor.co.nz

CLIENT, PROJECT
WFH PROPERTIES LTD
MILLWATER PRECINCT 2
TITLE
STAGE 3 RETAINING WALL
Standard Fence Panel Detail
SCALES (AT A3 SIZE) 1:20
DWG. No. 21854.001–P2S3–122
REV. A

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Appendix B: Contractors Certificates

- **Hick Bros Ltd – Sixth Schedule (Bulk Earthworks)**
- **JG Civil Ltd – Sixth Schedule (Civil Earthworks)**
- **JG Civil Ltd – Producer Statement 3 (Timber Pole Retaining Walls Construction)**
- **Pinepac Group Ltd – Timber Pole Grading and Treatment Certification**
- **Getgroup.co.nz Ltd – Producer Statement 3 (Pool Fence Installation for Retaining Walls)**

PS3 - FORM OF PRODUCER STATEMENT- CONSTRUCTION

ISSUED BY: HICK BROS CIVIL CONSTRUCTION LIMITED

TO: WFH PROPERTIES

IN RESPECT OF: MILLWATER PRECINT 2 STAGE 3 GEOTECHNICAL REMEDIATION AND BULK EARTHWORKS
AT: PRECINCT 2 STAGE 3 CONTRACT 33213 - 01

HICK BROS CIVIL CONSTRUCTION LTD has contracted to WFH PROPERTIES to carry out and complete certain building works in accordance with a contract, titled MILLWATER PRECINT 2 STAGE 3 GEOTECHNICAL REMEDIATION AND BULK EARTHWORKS ("the contract")

I JAMES BILKEY a duly authorized representative of HICK BROS CIVIL CONSTRUCTION LIMITED believe on reasonable grounds that HICK BROS CIVIL CONSTRUCTION LIMITED has carried out and completed part only as specified in the attached particulars of the contract works in in accordance with the contract.

Date: 23rd August 2016

(Signature of Authorized Agent on behalf of)

HICK BROS CIVIL CONSTRUCTION LIMITED
(Contractor)

42 FORGE ROAD, SILVERDALE
(Address)

Attachments:
1) List detailing works carried out

ATTACHMENT 1

MILLWATER PRECINT 2 STAGE 3 GEOTECHNICAL REMEDIATION AND BULK EARTHWORKS

LIST OF WORK CARRIED OUT:

1) All the earthworks within Stage 3
2) Construction of Reinforced Earth Wall 601 including drainage
3) Construction of Reinforced Earth Wall 602 including drainage
4) Construction of Reinforced Earth Wall 603 including drainage
5) Construction of Reinforced Earth Wall 604 including drainage
6) Construction of Reinforced Earth Wall 605 including drainage
7) Construction of Reinforced Earth Wall 606 including drainage
8) Construction of Reinforced Earth Wall 404 including drainage
9) Construction of Reinforced Earth Wall 405 including drainage
10) Subsoil drainage as instructed and asbuilted

NZS 3910:2013 Conditions of contract for building and civil Engineering construction

Schedule 6 – Form of Producer Statement – Construction

ISSUED BY JG Civil Ltd *(Contractor)*

TO WFH PROPERTIES Ltd *(Principal)*

IN RESPECT OF SEPARABLE PORTION A PRECINCT 2 STAGE 3B CONTRACT 33211-01 *(Description of Contract Works)*

AT Colonial Drive , Millwater *(Address)*

JG Civil Ltd *(Contractor)* has contracted to WFH PROPERTIES Ltd *(Principal)* to carry out and complete certain building works in accordance with a Contract titled PRECINCT 2 STAGE 3B ('the Contract')

I Joel Giddy *(Duly Authorised Agent)* a duly authorised representative of JG Civil Ltd *(Contractor)* believe on reasonable grounds that JG Civil Ltd *(Contractor)* has carried out and completed:

☑ All

☐ Part only as specified in the attached particulars of the contract works in accordance with the Contract

(Signature of Authorised Agent on behalf of)

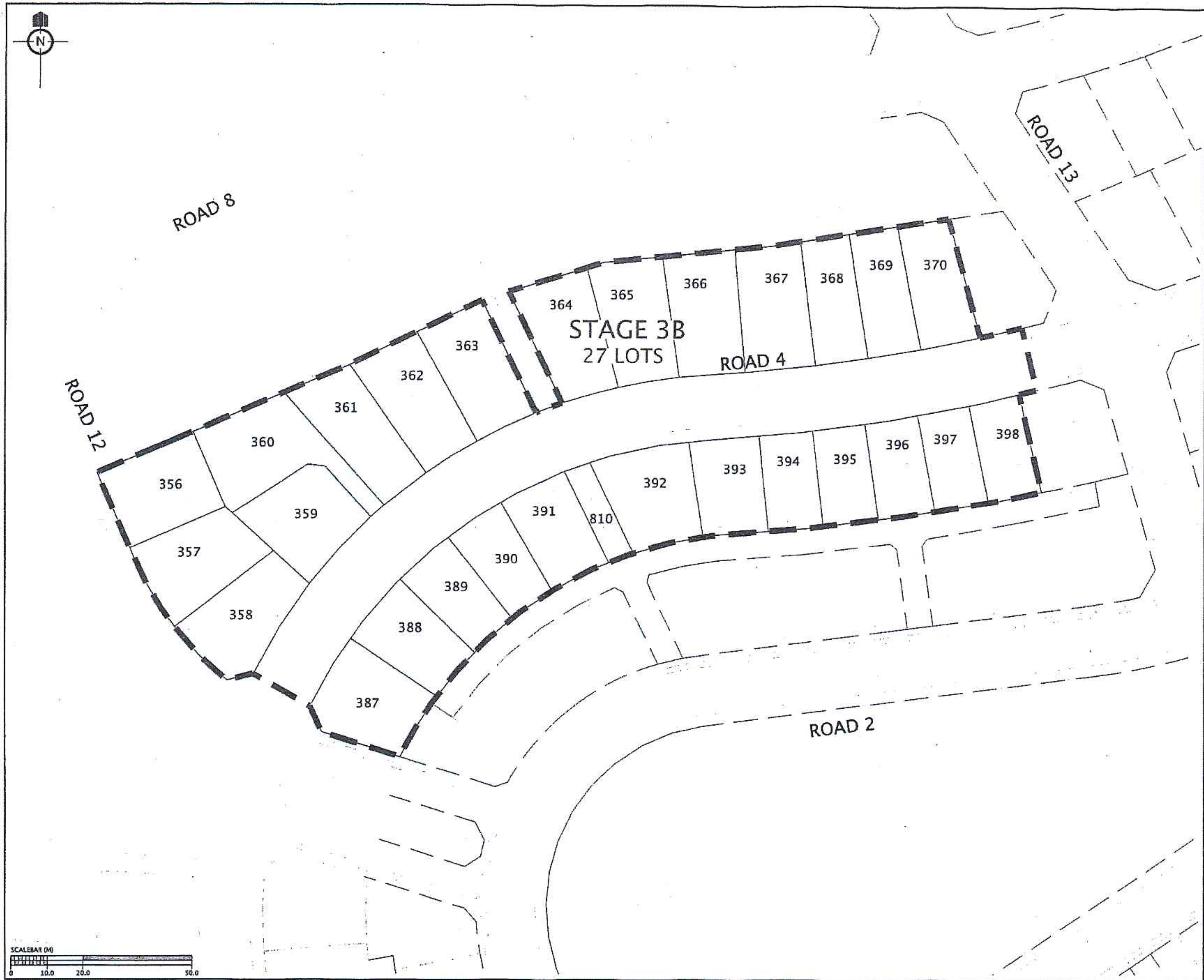
Date 10-08-2016

JG Civil Ltd

(Contractor)

180 Foundry Road, Silverdale

(Address)



REVISION DETAILS	NAME	DATE
A. ISSUED FOR CONSTRUCTION	SB	FEB 2016

LEGEND
——— PROPOSED BOUNDARIES
– – – STAGE BOUNDARY

CLIENT:
WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 3B

SCHEME LAYOUT PLAN

AUCKLAND COUNCIL

DESIGNED: SB	ISSUED FOR CONSTRUCTION
CHECKED:	DRAWN: SB
APPROVED:	SURVEYED:
JOB NUMBER: 33211	SCALE: 1:1000 @ A3
ISSUED: FEB 2016	
DWG. NO. 33211-3B-GE-001	REV. A

K:\33211 - Precinct 2 Stage 3B\Project Data\Acad Drawings\Working Drawings\Stage 3B\33211-3B-GE-001.dwg, 26/02/2016 1:04:47 p.m.

NZS 3910:2013 Conditions of contract for building and civil engineering construction

Schedule 6 – Form of Producer Statement – Construction

ISSUED BY JG Civil Ltd *(Contractor)*

TO WFH PROPERTIES Ltd *(Principal)*

IN RESPECT OF Precinct 2 Stage 3B 33211-01 – Timber Pole Retaining wall *(Description of Contract Works)*

AT Millwater P2 Stage 3B *(Address)*

JG Civil Ltd *(Contractor)* has contracted to WFH Properties *(Principal)* to carry out and complete certain building works in accordance with a Contract titled Precinct 2 Stage 3B 33211-01 – Timber Pole Retaining wall the Contract')

I Joel Giddy *(Duly Authorised Agent)* a duly authorised representative of JG Civil Ltd *(Contractor)* believe on reasonable grounds that JG Civil Ltd *(Contractor)* has carried out and completed:

- ☑ All
- ☐ Part only as specified in the attached particulars of the contract works in accordance with the Contract

(Signature of Authorised Agent on behalf of)

Date 18-07-2016

JG Civil Ltd
(Contractor)

180 Foundry Road
Silverdale
0932

(Address) FH Properties Ltd

Precinct 2 Stage 3B 33211-01 – Timber Pole Retaining wall

Producer statement construction (PS3)
General construction work

Auckland Council
Te Kaunihera o Tāmaki Makaurau

All sections of this form must be completed

TO BE COMPLETED BY THE PERSON WHO HAS UNDERTAKEN THE BUILDING WORK

Author name:	DANIEL WRIGHT	Building consent No:	
Author company:	GETGROUP. CO. NZ LTD	Author Registration No:	
Description of building work:	FENCING TO RETAINING WALLS		
Performance standard for maintenance and inspection, if applicable	SUBJECT TO ONGOING CORROSION PROTECTION. ☐ N/A		
Legal description:	MILLWATER P2 STAGE 3B RW304		
Site address:	MILLWATER P2 STAGE 3B		

NZBC clauses: (select as applicable)

[✓ B1]	[✓ B2]	C1	C2	C3	C4	C5	C6	D1	D2	E1	E2	E3
F1	F2	F3	F4	F5	F6	F7	F8	G1	G2	G3	G4	G5
G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	H1		

I have sighted the above building consent and read the attached conditions of consent and confirm that I have undertaken the building work described above in accordance with the consented plans and specifications.

I understand that Council will rely upon this producer statement, for the purposes of establishing compliance with the above building consent.

Signature: D. Wright
Date: 2/8/16

Tradesperson's contact details:

Address:	17 KAHIKATEA FLAT ROAD, DAIRY FLAT	Postcode:	0794.
Business:	09 4275421	Fax:	
Mobile:	027 2525227	Email	dan@getgroup.co.nz

COUNCIL USE ONLY

☐ Central ☐ Henderson ☐ Manukau ☐ Orewa ☐ Papakura ☐ Pukekohe ☐ Takapuna

☐ Accepted in support of inspection ☐ Accepted instead of inspection

Register checked: Council ☐ LBP ☐ N/A ☐

Name:
Date:

Producer statement accepted as establishing compliance with the consented plans: YES ☐ NO ☐

Producer statements are accepted solely at Auckland Council's discretion; please refer to the Producer Statement Policy which can be found on Councils website for further details

http://www.aucklandcouncil.govt.nz/EN/ratesbuildingproperty/consents/Consent%20documents/ac2301producerstatementpolicy.pdf

Producer statement construction (PS3)
General construction work

Auckland Council
Te Kaunihera o Tāmaki Makaurau

All sections of this form must be completed

TO BE COMPLETED BY THE PERSON WHO HAS UNDERTAKEN THE BUILDING WORK

Author name: DANIEL WRIGHT

Building consent No:

Author company: GETGROUP. CO. NZ

Author Registration No:

Description of building work: FENCING TO RETAINING WALLS

Performance standard for maintenance and inspection, if applicable: SUBJECT TO ONGOING CORROSION PROTECTION. ☐ N/A

Legal description: MILLWATER P2 STAGE 3B RW305

Site address: MILLWATER P2 STAGE 3B

NZBC clauses: (select as applicable)

[✓ B1]	[✓ B2]	C1	C2	C3	C4	C5	C6	D1	D2	E1	E2	E3
F1	F2	F3	F4	F5	F6	F7	F8	G1	G2	G3	G4	G5
G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	H1		

I have sighted the above building consent and read the attached conditions of consent and confirm that I have undertaken the building work described above in accordance with the consented plans and specifications.

I understand that Council will rely upon this producer statement, for the purposes of establishing compliance with the above building consent.

Signature:

Date: 2/8/16.

Tradesperson's contact details:

Address: 17 KAHIKATEA FLAT ROAD, DAIRY FLAT Postcode: 0794

Business: 09 4275421

Fax:

Mobile: 027 2525227

Email dan@getgroup.co.nz

COUNCIL USE ONLY

☐ Central ☐ Henderson ☐ Manukau ☐ Orewa ☐ Papakura ☐ Pukekohe ☐ Takapuna

☐ Accepted in support of inspection ☐ Accepted instead of inspection

Register checked: Council ☐ LBP ☐ N/A ☐

Name:

Date:

Producer statement accepted as establishing compliance with the consented plans: YES ☐ NO ☐

Producer statements are accepted solely at Auckland Council's discretion; please refer to the Producer Statement Policy which can be found on Councils website for further details

http://www.aucklandcouncil.govt.nz/EN/ratesbuildingproperty/consents/Consent%20documents/ac2301producerstatementpolicy.pdf

PINEPAC
GROUP

PINEPAC ROUNDWOOD
246 Main Road, Kumeu
Auckland, New Zealand
Telephone: (09) 412 7011
Facsimile: (09) 412 6293

PRODUCERS STATEMENT

All construction poles supplied to JG civil on behalf of Albany ITM, on order number 397 110767SP, meet or exceed the minimum standards of NZS3605:2001.

Species:	Radiata Pine
Timber Pile and Poles:	NZS3605:2001
Characteristic stress tables as per:	NZS3603
Timber Treatment:	NZS3640 [hazard class: H5]
Treatment plant brand:	687 01 H5

The construction poles supplied meet or exceed the "High Density" Threshold of 450kg/m³. Core samples from the outer 20% of the radius of the feedstock logs have been measured for dry weight over wet volume, as per the standard, to ensure that the density requirements are met.

Treatment:
This is to certify that all poles supplied are free of any visible signs of fungal attack, bark and have been treated with Sarmix Oxcel C 680 – CCA wood preservative to charge retention of not less than 8.4 kg/m³.

Sarmix Oxcel C 680 is a copper chrome arsenic wood preservative to meet the optimum formulation ratio recommended by the Forest Research Institute. It is widely used in New Zealand and corresponds to the CCA formulations used in Australia.

Sarmix Oxcel C 680 conforms to NZS3640:2003 having relative proportions.

Chromium 38 – 45%
Copper 23 – 25%
Arsenic 30 – 37%

The Preservative is approved by the Timber Preservation Council for use at the following retentions:

Hazard Class		**Brand Identification**
H5	**0.95% TAE (8.4 kg / m3)**	**687 01 H5**

The timber treatment process has been carried out by Pinepac, 246 Main Road Kumeu, Auckland, New Zealand. Pinepac Group is "Woodmark" registered and a member of the Timber Preservation Council (TPC)

Should you require any further information in this regard, please do not hesitate to contact me.

John van Zijl
Site Manager – Pinepac Roundwood
PINEPAC GROUP

Mobile: 0272289283 | Office: 09 412 7011 | Fax: 09 412 6293 | DDI: 09 412 6702
246 MainRoad, Kumeu, Auckland 0618
Email: john.vanzijl@pinepac.co.nz
Web: www.pinepac.co.nz

Appendix C: NZS 3604:2011 Expansive Soils (Extract)

NZS 3604:2011 Expansive Soils (Extract)

Expansive soils tend to be moderately to highly plastic clays that undergo appreciable volume change upon changes in moisture content. Technically, they are defined in NZS 3604:2011 as those soils having a liquid limit of more than 50% and a linear shrinkage of more than 15%. Where soils are quite silty or sandy, shrink and swell is less of a problem, due to the lower clay contents.

Building damage resulting from expansive soil movement can range from relatively minor brick veneer cracking and internal cracking on wall corners and wall ceiling corners with attendant door and windows jamming, through to extensive cracking of foundation block framework, extensive internal visual cracking and significant warping of building frames. Damage is dependent on building construction and materials and is rarely of structural concern.

NZS 3604:2011 "Timber Framed Buildings" defines good ground as follows:

"Any soil or rock capable of permanently withstanding an ultimate bearing capacity of 300 kPa (i.e. an allowable bearing pressure of 100 kPa using a factor of safety of 3.0), but excludes:

a) *Potentially compressible ground such as topsoil, soft soils such as clay which can be moulded easily in the fingers, and uncompacted loose gravel which contains obvious voids;*

b) *Expansive soils being those that have a liquid limit of more than 50% when tested in accordance with NZS 4402 Test 2.2, and a linear shrinkage of more than 15% when tested in accordance with NZS 4402 Test 2.6, and*

c) *Any ground which could forseeably experience movement of 25 mm or greater for any reason including one or a combination of: land instability, ground creep, subsidence, seasonal swelling and shrinking, frost heave, changing ground water level, erosion, dissolution of soil in water, and effects of tree roots."*

Foundations on expansive soils are outside the scope of NZS 3604:2011 as an acceptable solution to the New Zealand Building Code (NZBC). Specific engineering design of foundation elements is involved where expansive soils are present with a recommendation that AS 2870:2011 is used for building design. While not mandatory, AS 2870 designs will allow for a non-specific design foundation to be used without resorting to further ongoing investigation or design.

This geotechnical completion report has classified the soils present on this subdivision to be in Site Class M as per the requirements of AS 2870:2011. Descriptions of the various site classes, together with characteristic surface ground movements are outlined below.

Allowing for some correlation with NZS 3604, the various site classes applicable to NZ conditions are considered to be:

Characteristic Surface Movements	Site Class	Description
a) 20 mm (Note NZS 3604:2011 assumes movement of 25 mm as part of underlying design.	Class A (sand) and/or Class S (Silts) Equivalent to NZS 3604:2011 "Good Ground" sites	Poor to slightly expansive
b) 20 mm – 40 mm	Class M	Moderately expansive
c) 40 mm – 60 mm	Class H1	Highly expansive
d) 60 mm – 75mm	Class H2	Highly expansive
e) > 75 mm	Class E	Extremely expansive

AS 2870 uses a range of factors to assess characteristic soil movement including:

i. Building distress due to ground movement visible on adjacent structures,
ii. Known soil properties and site specific testing to determine the shrink / swell index of a soil (Test 7.1.1 in AS 1289 – Methods of Testing Soils for Engineering Purposes).

AS 2870 is based on defining soil types into various hazard classes based on expected surface movement and depth of desiccation that could occur. It then applies various foundation designs and embedment depths based on the form of building construction (slab on ground, strip footing, stiffened raft, stiffened slab with deep edge beams, etc). AS2870 uses more reinforcing steel than NZ designs generally would to create stiffer foundations that are better able to tolerate ground movement.

The Australian approach also regards expansive soil to a considerable extent being a home owner maintenance issue and significant emphasis is put into ensuring that people understand the influence that trees and dry summers etc may have on foundation performance. See Appendix D.

Appendix D: CSIRO – BTF18 – Foundation Maintenance and Footing Performance: A Homeowners Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

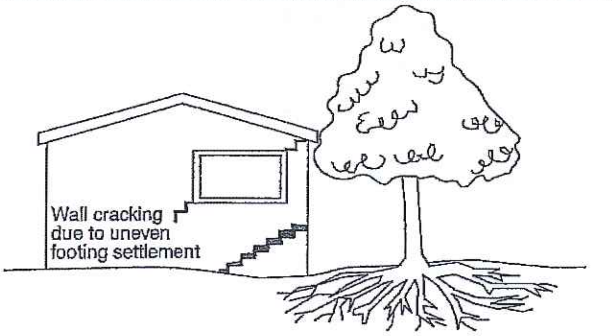
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

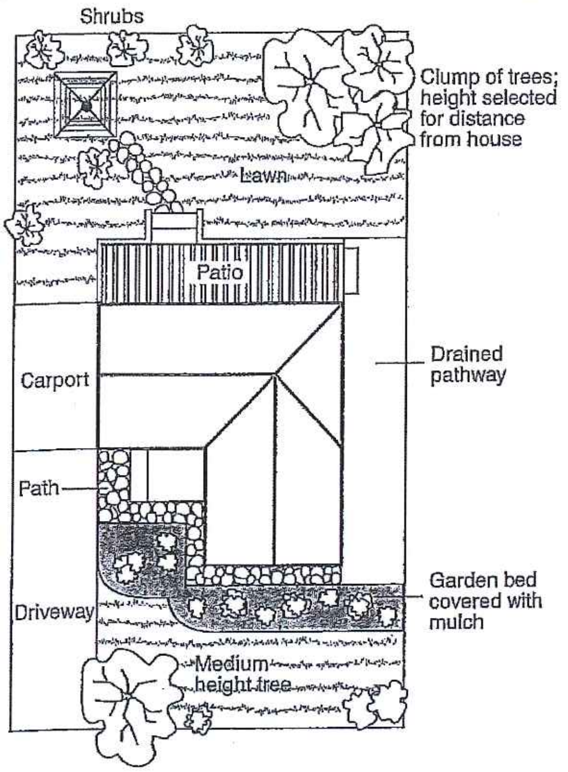
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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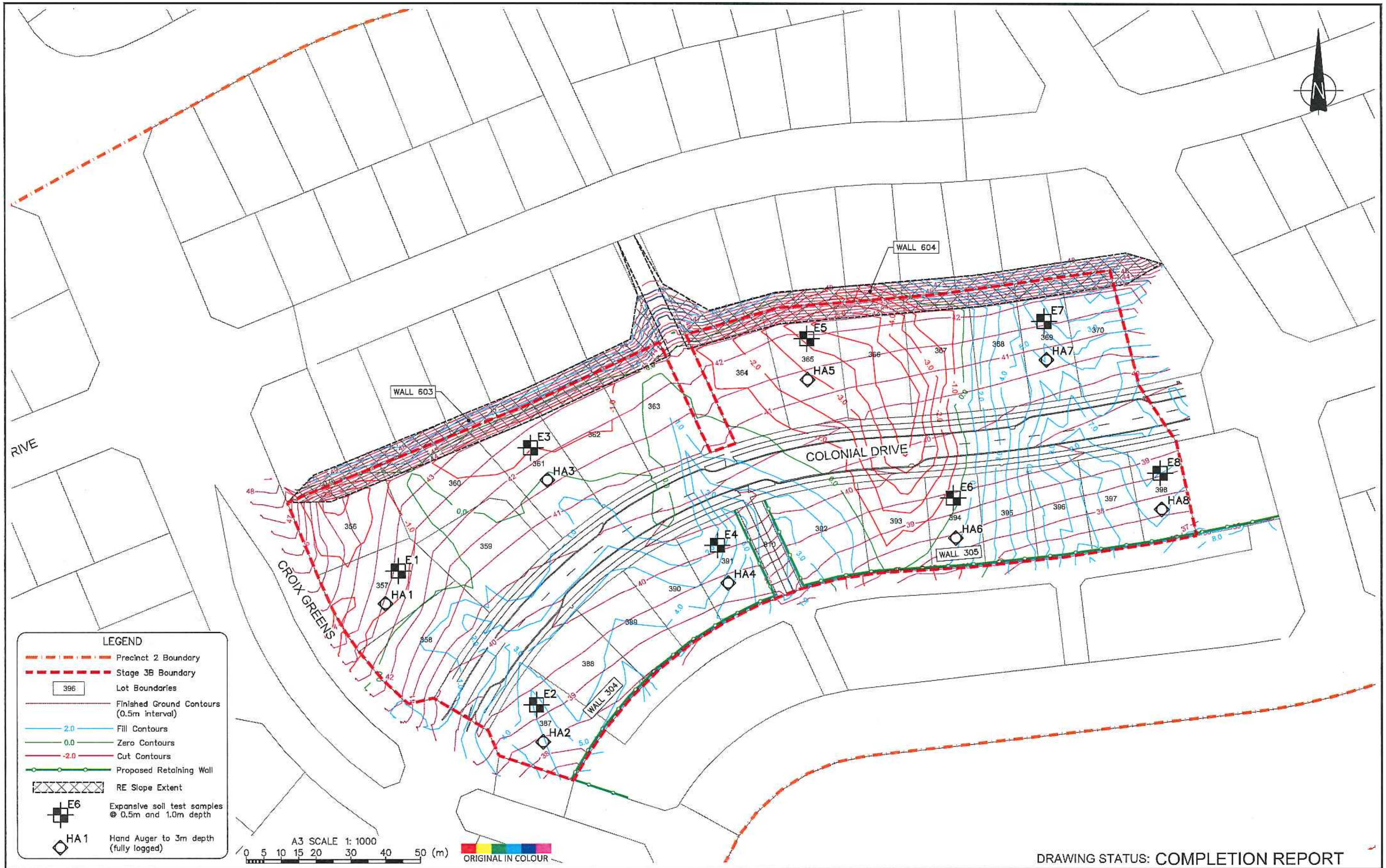
Appendix E: Test Results

- 21854.001–P2S3B–111 Post Earthworks Investigation Plan
- 21854.001–P2S3B–112 Topsoil Depths Plan
- 21854.001–P2S3B–113 Earthworks Testing Location Plan
- Soil Expansion Test Results
- Post Earthworks Investigation Borehole Logs (HA1 to HA8)
- Earthworks Test Results



DRAWING STATUS: COMPLETION REPORT

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1. All dimensions are in metres unless noted otherwise.
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4. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946

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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Post Earthworks Investigation Plan

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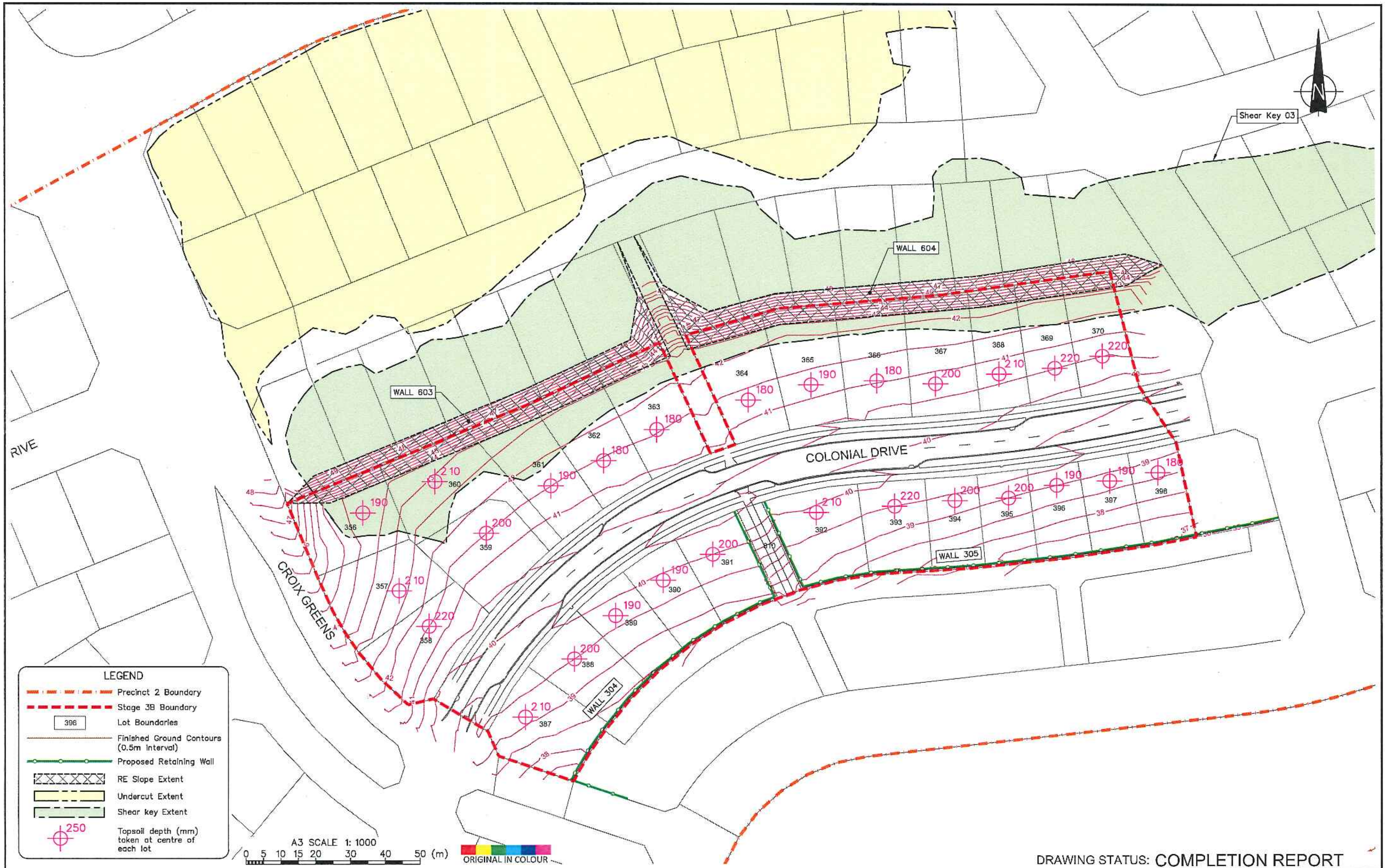

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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Topsoil Depths Plan

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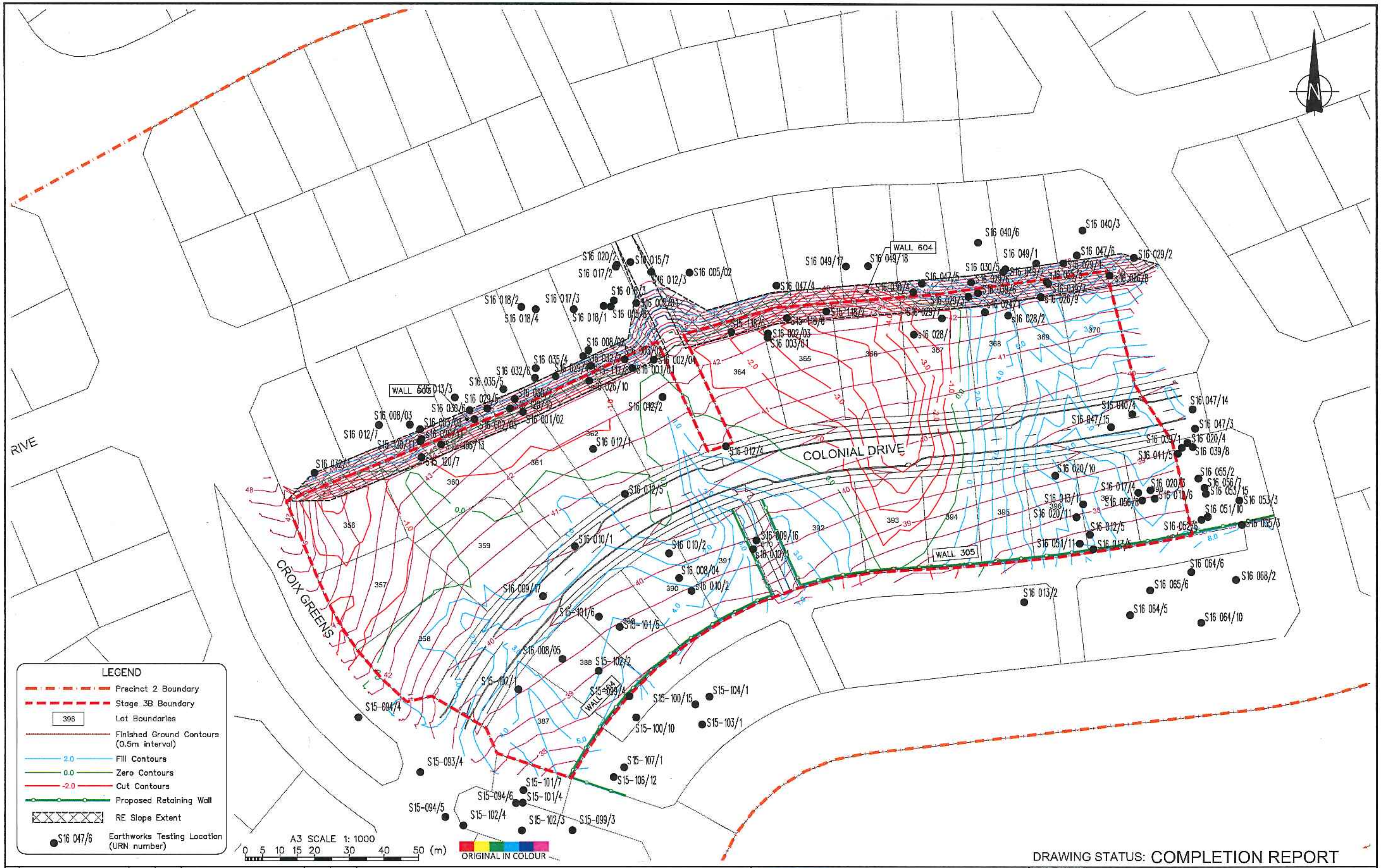

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TITLE
MILLWATER – PRECINCT 2 (STAGE 3B)
Earthworks Testing Location Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1000	21854.001-P2S3B-113	1

L:\21854\21854.001\WorkingMaterial\CAD\Dwg\P2-S3B\21854.001-P2S3B-113.dwg, 113, 7/09/2016 3:27:45 p.m., jc

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File:P:\616830.003\Working Material\Stage_3B_Shrink_Swell_Summary.xlsx

Site: **Precinct 2, Stage 3B, Millwater**

Page 1 of 2

Your Job No: 21854.001
Our Job No: 616830.003

Test Method Used: **AS 1289.7.1.1 - 2003 Determination of the Shrink - Swell Index**

SUMMARY OF SHRINK - SWELL TEST RESULTS

Lot No.:			**357**	**357**	**361**	**361**	**365**	**369**	**369**	**387**
DEPTH		**(m)**	**0.4 - 0.6**	**0.9 - 1.1**	**0.4 - 0.6**	**0.9 - 1.1**	**0.4 - 0.6**	**0.4 - 0.6**	**0.9 - 1.1**	**0.4 - 0.6**
Applied Pressure		**(kPa)**	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	36.1	42.2	16.8	32.4	10.6	16.4	23.8	13.6
	Bulk Density	(t/m³)	1.87	1.78	2.03	1.89	2.31	2.03	1.93	2.10
	Dry Density	(t/m³)	1.37	1.25	1.74	1.43	2.09	1.74	1.56	1.85
	Final Water Content	(%)	36.8	42.7	18.4	33.7	12.5	19.0	26.1	15.3
	Swelling Strain	(%)	0.02	0.02	0.01	0.03	0.82	0.04	0.01	0.14
SHRINKAGE TEST	Initial Water Content	(%)	37.0	40.1	15.4	34.4	9.8	18.6	28.4	21.6
	Estimated Shrinkage Limit	(%)	7.1	8.7	3.1	6.5	3.6	6.0	6.8	5.4
	Shrinkage Strain	(%)	3.0	10.0	0.60	7.2	1.8	2.0	2.8	3.4
	Inert Material Estimate in the Soil Specimen	(%)	0	0	0	0	0	0	0	0
	Soil Crumbling During Shrinkage		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Cracking of the Shrinkage Specimen		Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
SHRINK - SWELL INDEX		**(%)**	**1.7**	**5.5**	**0.30**	**4.0**	**1.2**	**1.1**	**1.6**	**1.9**

Entered by: ST Date: 1/07/2016 Checked by: MP Date: 1/07/2016

File:P:\616830.003\Working Material\Stage_3B_Shrink_Swell_Summary.xlsx

Site: **Precinct 2, Stage 3B, Millwater**

Page 2 of 2

Your Job No: 21854.001

Our Job No: 616830.003

Test Method Used: **AS 1289.7.1.1 - 2003 Determination of the Shrink - Swell Index**

SUMMARY OF SHRINK - SWELL TEST RESULTS

Lot No.:			**387**	**391**	**391**	**394**	**394**	**398**	**398**
DEPTH		**(m)**	**0.9 - 1.1**	**0.4 - 0.6**	**0.9 - 1.1**	**0.4 - 0.6**	**0.9 - 1.1**	**0.4 - 0.6**	**0.9 - 1.1**
Applied Pressure		**(kPa)**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	18.0	24.3	28.9	18.1	16.3	17.3	26.4
	Bulk Density	(t/m³)	2.07	1.88	1.90	2.08	2.07	2.05	1.92
	Dry Density	(t/m³)	1.75	1.51	1.47	1.76	1.78	1.75	1.52
	Final Water Content	(%)	19.5	26.2	29.9	19.4	19.0	19.6	27.3
	Swelling Strain	(%)	0.49	0.66	0.11	0.35	1.10	0.18	0.13
SHRINKAGE TEST	Initial Water Content	(%)	17.4	20.1	36.5	17.8	22.3	16.0	27.0
	Estimated Shrinkage Limit	(%)	4.5	4.9	9.4	5.4	5.6	3.8	5.6
	Shrinkage Strain	(%)	2.4	1.2	6.0	3.2	2.5	0.9	3.8
	Inert Material Estimate in the Soil Specimen	(%)	0	0	0	0	0	0	0
	Soil Crumbling During Shrinkage		Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Cracking of the Shrinkage Specimen		Moderate	Moderate	Major	Moderate	Moderate	Moderate	Moderate
SHRINK - SWELL INDEX		**(%)**	**1.5**	**0.90**	**3.3**	**1.9**	**1.7**	**0.5**	**2.2**

Entered by: ST Date: 1/07/2016 Checked by: MP Date: 1/07/2016

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA1
Hole Location: LOT 357

SHEET 1 OF 1

PROJECT: Millwater Precinct 2	LOCATION: Stage 3B	JOB No: 12854.001
CO-ORDINATES:	DRILL TYPE: 50mm HA	HOLE STARTED: 25/5/16
	DRILL METHOD: HA	HOLE FINISHED: 25/5/16
R.L.:		DRILLED BY: geotechnics
DATUM:	DRILL FLUID:	LOGGED BY: BZZB/TAJ CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour.
TOPSOIL FILL			0.0		VSt	Topsoil and fill
FILL?		142/53kPa				clayey SILT, medium plasticity, moist, dark brown, with light grey mottles
		>212kPa	0.5		H	
		>212kPa				SILT, minor clay, low plasticity, moist, orange
			1.0			SILT, with some clay, moist, low plasticity, light grey and orange
		144/47kPa			VSt	clayey SILT, medium plasticity, moist, orange
		>212kPa	1.5		H	
NATURAL GROUND?		>212kPa		ML		SILT, dry, low plasticity, grey
		>212kPa	2.0			
		>212kPa				
	Hole dry on completion	>212kPa	2.5			
		>212kPa	3.0			**END OF BOREHOLE 3m (target depth)**
			3.5			
			4			

Other column headings: FLUID LOSS, CORE RECOVERY (%), METHOD, CASING, SAMPLES, R.L. (m), GRAPHIC LOG, MOISTURE CONDITION / WEATHERING, SHEAR STRENGTH (kPa) 10 25 50 100 200, COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250, DEFECT SPACING (mm) 50 250 1000 2000; ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA2
Hole Location: LOT 387

SHEET 1 OF 1

PROJECT: Millwater Precinct 2
LOCATION: Stage 3B
JOB No: 12854.001

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm HA
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 2/6/16
HOLE FINISHED: 2/6/16
DRILLED BY: geotechnics
LOGGED BY: BZZB
CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

Geological unit	Water	Tests	Depth (m)	Strength/Density	Description
TOPSOIL FILL				H	Topsoil
FILL					clayey SILT, moist, low plasticity, brown with orange and grey mottles
		● >212kPa			
			0.5		SILT, minor clay, moist, non plastic to low plasticity, grey with orange mottles (mixed fill)
		● >212kPa			
		● >212kPa			
			1.0		clayey SILT, moist, low plasticity, brownish grey and light grey with orange mottles
		● >212kPa			
		● >212kPa	1.5		
		● >212kPa			
					SILT, non plastic, dry, grey
			2.0		
		● UTP			
					clayey SILT, moist, medium plasticity, light grey, with grey and orange mottles
		● >212kPa			
	Hole dry on completion		2.5		-low plasticity
		● >212kPa			clayey SILT, medium plasticity, moist, orange with grey mottles
		● >212kPa	3.0		**END OF BOREHOLE 3m (target depth)**
			3.5		
			4		

T+T DATATEMPLATE.GDT jlb

Log Scale 1:20

BORELOG 21854.001-P2 STAGE3B.GPJ 31-Aug-2016

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA3
Hole Location: LOT 361

SHEET 1 OF 1

PROJECT: Millwater Precinct 2	LOCATION: Stage 3B	JOB No: 12854.001
CO-ORDINATES:	DRILL TYPE: 50mm HA	HOLE STARTED: 27/5/16
		HOLE FINISHED: 27/5/16
R.L.:	DRILL METHOD: HA	DRILLED BY: geotechnics
DATUM:	DRILL FLUID:	LOGGED BY: BZZB CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

Geological	Tests	Classification symbol	Strength/density	Description
TOPSOIL FILL			H	Topsoil, with fill
FILL	● UTP ● UTP			SILT, non plastic, moist, grey
NATURAL GROUND	● 127/67kPa ● 103/47kPa	MC	VSt	clayey SILT, moist, medium plasticity, orange mottled light grey
	● 94/39kPa ● 103/41kPa	MC	St VSt	clayey SILT, moist, medium plasticity, light grey with orange mottles
	● >212kPa	MC	H	clayey SILT, moist, low plasticity, brown
	● 197/77kPa	MC	VSt	clayey SILT, moist, low plasticity, brownish grey
	● >212kPa	ML	H	SILT, non plastic, dry, grey
	● UTP			**END OF BOREHOLE 3m (target depth)**

Water: Hole dry on completion

Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4

Log Scale 1:20

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA4
Hole Location: LOT 391
SHEET 1 OF 1

PROJECT: Millwater Precinct 2	LOCATION: Stage 3B	JOB No: 12854.001
CO-ORDINATES:	DRILL TYPE: 50mm HA	HOLE STARTED: 2/6/16
		HOLE FINISHED: 2/6/16
R.L.:	DRILL METHOD: HA	DRILLED BY: geotechnics
DATUM:	DRILL FLUID:	LOGGED BY: BZZB CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION \ WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

GEOLOGICAL UNIT	WATER	TESTS	DEPTH (m)	STRENGTH/DENSITY CLASSIFICATION	DESCRIPTION
TOPSOIL FILL				VSt	Topsoil
FILL					clayey SILT, moist, low plasticity, grey with orange mottles
		● 151/71kPa			
					-medium plasticity, moist, orange
			0.5		
		● 168/51kPa			SILT, non plastic, dry, grey
				H	
		● UTP			SILT, moist, low plasticity, orange with grey and brown mottles
			1.0	VSt	
		● 151/77kPa			
				H	
		● >212kPa	1.5		
		● >212kPa			
			2.0		
		● >212kPa			
		● >212kPa			SILT, moist, low plasticity, brownish orange with grey mottles
	Hole dry on completion		2.5		
		● >212kPa			SILT, non plastic, dry, grey
		● UTP	3.0		**END OF BOREHOLE 3m (target depth)**
			3.5		
			4		

T+T DATATEMPLATE.GDT ilb

Log Scale 1:20

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA5
Hole Location: LOT 365

SHEET 1 OF 1

PROJECT: Millwater Precinct 2
LOCATION: Stage 3B
JOB No: 12854.001

CO-ORDINATES:
DRILL TYPE: 50mm HA
HOLE STARTED: 27/5/16
HOLE FINISHED: 27/5/16
DRILL METHOD: HA
DRILLED BY: geotechnics
R.L.:
DATUM:
DRILL FLUID:
LOGGED BY: BZZB
CHECKED:

GEOLOGICAL										ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
TOPSOIL FILL										⊠			H	▩			Topsoil and fill
NATURAL GROUND		Hole dry on completion				● >212kPa				× ×	ML			▩			SILT, non plastic, dry, brown
									0.5	× ×				▩			
						● UTP				× ×	ML			▩			SILT, non plastic, dry, grey
						● UTP											**END OF BOREHOLE 0.9m (natural ground, unable to penetrate)**
									1.0								
									1.5								
									2.0								
									2.5								
									3.0								
									3.5								
									4								

T+T DATATEMPLATE.GDT ilb

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA6
Hole Location: LOT 394
SHEET 1 OF 1

PROJECT: Millwater Precinct 2
LOCATION: Stage 3B
JOB No: 12854.001

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm HA
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 1/6/16
HOLE FINISHED: 1/6/16
DRILLED BY: geotechnics
LOGGED BY: BZZB/TAJ CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	CLASSIFICATION SYMBOL	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
TOPSOIL FILL	Hole dry on completion			H	Topsoil
FILL?		>212kPa >212kPa >212kPa			SILT, low plasticity, moist, grey with yellow mottles
NATURAL GROUND?		>212kPa 181/89kPa >212kPa >212kPa >212kPa >212kPa >212kPa	ML	H VSt H	clayey SILT, low plasticity, moist, yellowish brown
					END OF BOREHOLE 3m (target depth)

Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No:HA7
Hole Location: LOT 369

SHEET 1 OF 1

PROJECT: Millwater Precinct 2
LOCATION: Stage 3B
JOB No: 12854.001
CO-ORDINATES:
DRILL TYPE: 50mm HA
HOLE STARTED: 27/5/16
HOLE FINISHED: 27/5/16
DRILL METHOD: HA
DRILLED BY: geotechnics
R.L.:
DATUM:
DRILL FLUID:
LOGGED BY: BZZB
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION \ WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	ENGINEERING DESCRIPTION SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
TOPSOIL FILL										▨			H				Topsoil
FILL										▨							SILT, non plastic, dry, grey
						● >212kPa				▨							clayey SILT, non plastic, moist, grey with orange inclusions
						● >212kPa ● >212kPa			0.5 1.0	▨							clayey SILT, medium plasticity, moist, orange,
						● >212kPa				▨							SILT, non plastic to friable, moist, orange
						● UTP			1.5	▨							SILT, minor clay, moist, non plastic, grey and orange mixed
						● UTP				▨							SILT, minor clay, non plastic, dry, grey
						● UTP			2.0	▨							clayey SILT, non plastic, moist, orange and light grey
						● >212kPa			2.5	▨							SILT, non plastic, dry, grey
NATURAL GROUND?		Hole dry on completion				● 194/91kPa				×	ML		VSt				clayey SILT, moist, low plasticity, orange and grey
						● 133/76kPa			3.0								**END OF BOREHOLE 3m (target depth)**
									3.5								
									4								

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BOREHOLE LOG

BOREHOLE No:HA8
Hole Location: LOT 398
SHEET 1 OF 1

PROJECT: Millwater Precinct 2
LOCATION: Stage 3B
JOB No: 12854.001
CO-ORDINATES:
DRILL TYPE: 50mm HA
HOLE STARTED: 1/6/16
HOLE FINISHED: 1/6/16
DRILL METHOD: HA
DRILLED BY: geotechnics
R.L.:
DATUM:
DRILL FLUID:
LOGGED BY: TAJ/BZZB
CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

Geological unit	Water	Tests	Depth (m)	Strength/density classification	Soil description
TOPSOIL FILL	Hole dry on completion			H	Topsoil
FILL		● >212kPa			clayey SILT, non plastic, moist, grey and orange
					SILT friable to non plastic, dry, grey
		● UTP	0.5		
		● >212kPa			clayey SILT, non plastic, moist, grey and orange
		● >212kPa	1.0		clayey SILT, medium plasticity, moist, orange and grey
		● >212kPa	1.5		
		● >212kPa			clayey SILT, non plastic, moist, grey and orange
		● >212kPa	2.0		
		● >212kPa			clayey SILT, non plastic, moist, grey and orange
		● >212kPa	2.5		
		● >212kPa	3.0		**END OF BOREHOLE 3m (target depth)**
			3.5		
			4		

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Job: Silverdale PRECINCT 2 Stage 3B
Client: Tonkin & Taylor
T&T Job #: 21854.0010
Job # 614089.000/1
Entered By: YA/RHN/JED
Checked By:

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

URN	**Easting**	**Northing**	**RL**	**Location**	**Tech.**	**Date**	**Nuclear Wet Density (t/m^3)**	**Oven Dry Density (t/m3)**	**Oven Moisture content (%)**	**Solid Density (t/m3) assumed**	**Oven Calculated Air Voids (%)**	Shear Strength (kPa) (UTP = Unable to penetrate)				**Average Shear Strength (kPa)**	**Re - Test (Y)**	**pass / fail Specification > 140 kPa and < 10 % Air Voids)**
												Test 1	Test 2	Test 3	Test 4			
S15-093/4	2659786.857	6508541.277	38.323	Above Wall 304	TAJ	13/11/2015	1.74	**1.24**	40.1	2.7	**4.0**	196	196	196	196	**196**		**P**
							1.76	**1.25**	40.1	2.7	**3.3**							
S15-094/4	2659769.061	6508557.19	41.851	Above Wall 304	TAJ	14/11/2015	1.87	**1.40**	33.5	2.7	**1.5**	196	196	196	196	**196**		**P**
							1.88	**1.41**	33.5	2.7	**0.8**							
S15-094/5	2659794.039	6508528.341	37.149	Above Wall 304	TAJ	14/11/2015	1.86	**1.42**	31.3	2.7	**3.1**	196	196	196	196	**196**		**P**
							1.87	**1.42**	31.3	2.7	**2.7**							
S15-094/6	2659814.358	6508532.285	33.755	Above Wall 304	TAJ	14/11/2015	1.94	**1.55**	25.5	2.7	**3.2**	196	196	196	196	**196**		**P**
							1.94	**1.54**	25.5	2.7	**3.4**							
S15-099/3	2659830.585	6508524.486	32.981	Wall 304 Area	TAJ	25/11/2015	2.03	**1.73**	17.1	2.7	**6.3**	196	196	196	196	**196**		**P**
							2.05	**1.75**	17.1	2.7	**5.1**							
S15-099/4	2659847.093	6508563.177	33.745	Wall 304 Area	TAJ	25/11/2015	2.09	**1.72**	21.4	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.10	**1.73**	21.4	2.7	**0.0**							
S15-100/10	2659848.981	6508556.961	33.594	Wall 304 Area	TAJ	26/11/2015	1.97	**1.60**	22.9	2.7	**4.2**	196	196	196	196	**196**		**P**
							1.98	**1.61**	22.9	2.7	**3.7**							
S15-100/15	2659866.023	6508560.697	32.906	Wall 304 Area	TAJ	26/11/2015	2.08	**1.71**	21.6	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.07	**1.71**	21.6	2.7	**0.0**							
S15-101/4	2659816.315	6508532.404	34.925	Wall 304 Area	TAJ	27/11/2015	1.98	**1.60**	23.8	2.7	**2.6**	196	196	196	196	**196**		**P**
							1.99	**1.60**	23.8	2.7	**2.5**							
S15-101/5	2659844.338	6508583.327	36.013	Wall 304 Area	TAJ	27/11/2015	2.12	**1.75**	20.8	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.10	**1.74**	20.8	2.7	**0.0**							
S15-101/6	2659838.36	6508586.289	36.541	Wall 304 Area	TAJ	27/11/2015	2.08	**1.60**	29.8	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.08	**1.60**	29.8	2.7	**0.0**							
S15-101/7	2659816.526	6508536.018	35.349	Wall 304 Area	TAJ	27/11/2015	2.05	**1.62**	26.5	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.05	**1.62**	26.5	2.7	**0.0**							
S15-102/1	2659815.148	6508565.178	36.84	Wall 304 Area	TAJ	30/11/2015	2.29	**2.05**	11.7	2.7	**0.1**	196	196	196	196	**196**		**P**
							2.09	**1.87**	11.7	2.7	**8.8**							
S15-102/2	2659838.277	6508570.514	36.009	Wall 304 Area	TAJ	30/11/2015	2.09	**1.76**	18.8	2.7	**2.0**	196	196	196	196	**196**		**P**
							2.09	**1.76**	18.8	2.7	**1.8**							
S15-102/3	2659816.055	6508524.438	35.84	Wall 304 Area	TAJ	30/11/2015	2.09	**1.75**	19.4	2.7	**1.1**	196	196	196	196	**196**		**P**
							2.09	**1.75**	19.4	2.7	**1.3**							
S15-102/4	2659799.214	6508525.939	37.272	Wall 304 Area	TAJ	30/11/2015	1.74	**1.18**	47.4	2.7	**0.2**	196	196	196	196	**196**		**P**
							1.73	**1.18**	47.4	2.7	**0.7**							
S15-103/1	2659867.946	6508554.908	32.58	Wall 304 Area	TAJ	1/12/2015	2.06	**1.67**	23.2	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.06	**1.67**	23.2	2.7	**0.0**							
S15-104/1	2659870.11	6508562.959	33.128	Wall 304 Area	TAJ	2/12/2015	1.95	**1.68**	16.3	2.7	**10.4**	196	196	182	196	**193**		**F**
							1.96	**1.68**	16.3	2.7	**10.3**							
S15-106/12	2659842.5	6508539.719	34.342	Wall304 Area	TAJ	4/12/2015	1.90	**1.46**	30.2	2.7	**2.1**	196	196	196	196	**196**		**P**
							1.89	**1.45**	30.2	2.7	**2.4**							
S15-106/13	2659793.101	6508636.073	39.115	Shear Key	TAJ	4/12/2015	1.99	**1.64**	21.1	2.7	**4.5**	196	196	196	196	**196**		**P**
							1.99	**1.64**	21.1	2.7	**4.4**							
S15-107/1	2659845.495	6508542.567	34.945	Wall 304 Area	TAJ	7/12/2015	2.02	**1.79**	12.9	2.7	**10.7**	196	196	196	196	**196**		**F**
							2.01	**1.78**	12.9	2.7	**11.0**							
S15-117/8	2659836.278	6508658.692	38.979	Shear Key	TAJ	18/12/2015	2.11	**1.81**	16.4	2.7	**3.0**	196	196	196	196	**196**		**P**
							2.11	**1.81**	16.4	2.7	**3.1**							
S15 118/5	2659876.614	6508668.443	38.997	Shear Key	TAJ	21/12/2015	2.08	**1.71**	21.5	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.08	**1.71**	21.5	2.7	**0.0**							
S15 118/6	2659892.652	6508672.448	39.110	Shear Key	TAJ	21/12/2015	2.06	**1.80**	14.5	2.7	**7.4**	196	196	196	196	**196**		**P**
							2.07	**1.81**	14.5	2.7	**6.9**							
S15 118/7	2659903.974	6508674.367	39.400	Shear Key	TAJ	21/12/2015	2.00	**1.52**	31.8	2.7	**0.0**	196	196	196	196	**196**		**P**
							1.99	**1.51**	31.8	2.7	**0.0**							
S15 120/7	2659787.433	6508632.368	42.007	Shear Key	TAJ	22/12/2015	1.93	**1.52**	26.5	2.7	**3.3**	196	196	196	196	**196**		**P**
							1.94	**1.53**	26.5	2.7	**2.6**							

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Job: Silverdale PRECINCT 2 Stage 3B

Client: Tonkin & Taylor
T&T Job #: 21854.0010

Job # **614089.000/1**
Entered By: YA/RHN/JED
Checked By:

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

URN	**Easting**	**Northing**	**RL**	**Location**	**Tech.**	**Date**	**Nuclear Wet Density (t/m^3)**	**Oven Dry Density (t/m3)**	**Oven Moisture content (%)**	**Solid Density (t/m3) assumed**	**Oven Calculated Air Voids (%)**	Shear Strength (kPa) (UTP = Unable to penetrate)				**Average Shear Strength (kPa)**	**Re - Test (Y)**	**pass / fail Specification > 140 kPa and < 10 % Air Voids)**
												Test 1	Test 2	Test 3	Test 4			
S15 120/10	2659812.964	6508646.363	41.296	Shear Key	TAJ	22/12/2015	2.07	**1.51**	37.4	2.7	**0.0**	196	196	196	196	**196**		**P**
							1.94	**1.41**	37.4	2.7	**0.0**							
S15 120/11	2659787.047	6508637.002	42.114	Shear Key	TAJ	22/12/2015	1.98	**1.57**	25.8	2.7	**1.1**	196	196	196	196	**196**		**P**
							1.98	**1.57**	25.8	2.7	**1.3**							
S16 001/01	2659848.172	6508657.974	40.861	Shear Key	NTW	5/01/2016	2.07	**1.82**	13.8	2.7	**7.6**	196	126	196	194	**178**		**P**
							2.05	**1.81**	13.4	2.7	**8.7**							
S16 001/02	2659816.613	6508645.306	41.627	Shear Key	NTW	5/01/2016	2.07	**1.79**	15.9	2.7	**5.3**	196	196	196	196	**196**		
							2.02	**1.77**	14.3	2.7	**9.4**							
S16 002/03	2659887.155	6508667.994	41.203	Shear Key	NTW	6/01/2016	2.22	**2.00**	11.0	2.7	**4.1**	196	196	196	-	**196**		
							2.19	**1.98**	10.6	2.7	**5.6**							
S16 002/04	2659854.263	6508660.362	41.15	Shear Key	NTW	6/01/2016	2.07	**1.79**	15.9	2.7	**5.5**	196	196	196	-	**196**		
							2.05	**1.77**	16.0	2.7	**6.2**							
S16 002/05	2659802.682	6508643.325	42.839	Shear Key	NTW	6/01/2016	2.08	**1.84**	13.3	2.7	**7.5**	196	196	196	-	**196**		
							2.08	**1.83**	13.6	2.7	**7.5**							
S16 003/01	2659887.079	6508666.733	41.041	Shear Key	NTW/TA	7/01/2016	2.13	**1.87**	13.9	2.7	**4.6**	196	196	196	196	**196**		
							2.14	**1.87**	13.9	2.7	**4.5**							
S16 003/03	2659787.067	6508640.478	42.296	Shear Key	NTW/TA	7/01/2016	2.06	**1.80**	14.8	2.7	**6.8**	168	168	156	196	**172**		
							2.07	**1.80**	15.3	2.7	**5.9**							
S16 005/01	2659849.303	6508676.812	42.601	Reserve	NTW	11/01/2016	-	-	-	-	-	112	140	101	196	**137**		
							-	-	-	-	-							
S16 005/02	2659864.649	6508685.638	42.994	Reserve	NTW	11/01/2016	-	-	-	-	-	196	120	179	196	**173**		
							-	-	-	-	-							
S16 008/02	2659835.525	6508663.203	42.011	Shear Key	NTW	14/01/2016	2.06	**1.85**	11.80	2.7	**9.8**	196	196	196	196	**196**		**Very dry test pads**
							2.05	**1.83**	12.00	2.7	**10.1**							
S16 008/03	2659784.06	6508641.779	43.634	Shear Key	NTW	14/01/2016	1.97	**1.66**	18.9	2.7	**7.2**	196	182	196	196	**193**		
							1.98	**1.67**	18.2	2.7	**7.6**							
S16 008/04	2659861.437	6508597.475	38.237	Shear Key	NTW		2.00	**1.75**	14.7	2.7	**9.7**	152	196	196	196	**185**		
							2.07	**1.80**	14.8	2.7	**6.5**							
S16 008/05	2659827.805	6508573.984	38.803	Shear Key	NTW	14/01/2016	2.06	1.81	14.00	2.7	**7.7**	196	196	196	196	**196**		
							2.01	1.67	20.30	2.7	**4.1**							
S16 009/16	2659883.68	6508608.258	38.561	Above wall 304	NTW	15/01/2016	1.87	**1.61**	15.9	2.7	**14.6**	196	196	196	196	**196**		
							2.00	**1.73**	15.1	2.7	**9.6**							
S16 009/17	2659822.274	6508592.317	38.946	Above wall 304	NTW	15/01/2016	1.99	**1.72**	15.5	2.7	**9.4**					**#DIV/0!**		
							-	-	-	-	-							
S16 010/1	2659831.474	6508606.691	38.684	Below Shear Key	BZZB	16/01/2016	1.89	**1.44**	31.0	2.7	**2.0**	196	196	196	196	**196**		**P**
							1.89	**1.44**	31.0	2.7	**2.0**							**P**
S16 010/2	2659858.562	6508604.592	39.178	Below Shear Key	BZZB	16/01/2016	1.90	**1.50**	26.9	2.7	**4.3**	196	196	196	196	**196**		**P**
							1.90	**1.50**	26.9	2.7	**4.1**							**P**
s16 010/1	2659882.765	6508605.772	39.385	Below Shear Key	TAJ	18/01/2016	2.05	**1.86**	10.4	2.7	**11.8**	196	196	196	196	**196**		**F**
							2.06	**1.87**	10.4	2.7	**11.4**							**F**
s16 010/2	2659865.006	6508593.788	39.474	Below Shear Key	TAJ	18/01/2016	2.05	**1.79**	14.8	2.7	**7.3**	196	196	196	196	**196**		**P**
							2.04	**1.77**	14.8	2.7	**8.1**							**P**
S16 012/4	2659875.008	6508635.401	40.127	Below Shear Key	TAJ	19/01/2016	2.02	**1.77**	14.4	2.7	**9.1**	196	196	196	196	**196**		**P**
							2.05	**1.79**	14.4	2.7	**7.9**							**P**
S16 012/5	2659845.927	6508621.57	40.608	Below Shear Key	TAJ	19/01/2016	2.03	**1.77**	14.9	2.7	**8.1**	196	196	196	196	**196**		**P**
							2.03	**1.77**	14.9	2.7	**8.2**							**P**
S16 012/1	2659836.804	6508634.685	41.348	Beside Shear Key	TAJ	20/01/2016	2.05	**1.70**	20.6	2.7	**2.3**	196	196	196	196	**196**		**P**
							2.04	**1.69**	20.6	2.7	**2.3**							**P**
S16 012/2	2659856.804	6508649.623	41.55	Beside Shear Key	TAJ	20/01/2016	1.81	**1.41**	28.2	2.7	**7.8**	196	196	196	196	**196**		**P**
							1.82	**1.42**	28.2	2.7	**7.2**							**P**

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Job: Silverdale PRECINCT 2 Stage 3B

Client: Tonkin & Taylor
T&T Job #: 21854.0010

Job # 614089.000/1
Entered By: YA/RHN/JED
Checked By:

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

URN	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m^3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate)				Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)
												Test 1	Test 2	Test 3	Test 4			
S16 012/3	2659853.623	6508685.892	44.261	Shear Key	TAJ	20/01/2016	1.91	**1.50**	27.5	2.7	**3.5**	196	196	196	196	**196**		**P**
							1.93	**1.51**	27.5	2.7	**2.5**							**P**
S16 012/5	2659979.723	6508609.726	30.258	Above reserve	TAJ	20/01/2016	2.09	**1.80**	16.3	2.7	**4.0**	196	196	196	196	**196**		**P**
							2.07	**1.78**	16.3	2.7	**4.9**							**P**
S16 012/6	2659998.466	6508620.037	29.936	Above reserve	TAJ	20/01/2016	2.06	**1.74**	18.4	2.7	**3.4**	196	196	196	196	**196**		**P**
							2.05	**1.73**	18.4	2.7	**4.1**							**P**
S16 012/7	2659775.152	6508641.697	47.037	Shear key	TAJ	20/01/2016	1.96	**1.61**	21.9	2.7	**5.1**	196	196	196	196	**196**		**P**
							1.96	**1.61**	21.9	2.7	**5.1**							**P**
S16 013/1	2659977.845	6508618.427	31.377	Above reserve	TAJ	21/01/2016	2.00	**1.58**	26.9	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.00	**1.58**	26.9	2.7	**0.0**							**P**
S16 013/2	2659960.766	6508590.31	32.029	Above reserve	TAJ	21/01/2016	1.70	**1.26**	35.0	2.7	**9.5**	196	196	196	196	**196**		**P**
							1.72	**1.27**	35.0	2.7	**8.4**							**P**
S16 013/3	2659797.027	6508649.583	43.833	above shearkey	TAJ	21/01/2016	2.02	**1.70**	18.7	2.7	**5.1**	196	196	196	196	**196**		**P**
							2.03	**1.71**	18.7	2.7	**4.9**							**P**
S16 015/7	2659847.68	6508688.761	45.47	shear key	TAJ	23/01/2016	1.92	**1.60**	20.5	2.7	**8.1**	196	196	196	196	**196**		**P**
							1.93	**1.60**	20.5	2.7	**7.8**							**P**
S16 015/8	2659842.026	6508675.845	45.699	shear key	TAJ	23/01/2016	1.99	**1.52**	30.5	2.7	**0.0**	196	196	196	196	**196**		**P**
							1.99	**1.52**	30.5	2.7	**0.0**							**P**
S16 017/2	2659843.463	6508687.387	47.639	Behind Shear Key	NTW	26/01/2016	1.96	**1.52**	28.3	2.7	**0.4**	159	150	140	196	**161**		**P**
							1.97	**1.53**	28.3	2.7	**0.0**							**P**
S16 017/3	2659831.301	6508675.099	47.766	Behind Shear Key	NTW	26/01/2016	2.01	**1.64**	22.5	2.7	**2.3**	139	152	196	159	**162**		**P**
							2.03	**1.65**	22.5	2.7	**1.6**							**P**
S16 017/4	2659993.733	6508621.745	31.514	Above Reserve	NTW	26/01/2016	2.00	**1.68**	19.2	2.7	**5.5**	196	196	196	196	**196**		**P**
							2.02	**1.69**	19.2	2.7	**4.9**							**P**
S16 017/5	2659980.734	6508605.597	31.346	Above Reserve	NTW	26/01/2016	1.91	**1.63**	17.4	2.7	**11.3**	144	48	116	78	**97**	**Y**	**F**
							1.90	**1.62**	17.4	2.7	**11.7**							**F**
S16 018/1	2659839.931	6508675.986	48.898	Behind Shear Key	NTW	27/01/2016	1.89	**1.58**	20.0	2.7	**10.0**	137	196	117	179	**157**	**Y**	**F**
							1.88	**1.56**	20.0	2.7	**10.9**							**F**
S16 018/2	2659816.245	6508675.775	49.300	Behind Shear Key	NTW	27/01/2016	1.92	**1.46**	32.2	2.7	**0.0**	89	98	101	75	**91**	**Y**	**F**
							1.92	**1.45**	32.2	2.7	**0.0**							**F**
S16 018/3	2659842.861	6508677.579	49.034	Behind Shear Key	NTW	27/01/2016	2.00	**1.71**	16.4	2.7	**8.4**	196	196	196	196	**196**		**P**
							2.00	**1.72**	16.4	2.7	**8.3**							**P**
S16 018/4	2659820.362	6508675.077	48.993	Behind Shear Key	NTW	27/01/2016	1.97	**1.60**	22.9	2.7	**4.1**	196	196	196	196	**196**		**P**
							1.96	**1.59**	22.9	2.7	**4.5**							**P**
S16 020/2	2659843.744	6508687.998	49.282	Behind Shear Key	NTW	28/01/2016	1.92	**1.60**	20.6	2.7	**8.0**	196	196	196	196	**196**		**P**
							1.93	**1.60**	20.6	2.7	**7.8**							**P**
S16 020/3	2659997.238	6508622.495	32.135	Beside Reserve	NTW	28/01/2016	2.03	**1.81**	12.4	2.7	**10.7**	157	196	137		**163**	**Y**	**F**
							2.02	**1.80**	12.4	2.7	**11.1**							**F**
S16 020/4	2660007.901	6508636.269	31.708	Beside Reserve	NTW	28/01/2016	1.86	**1.56**	19.2	2.7	**12.4**	81	98	81	196	**114**	**Y**	**F**
							1.87	**1.57**	19.2	2.7	**11.7**							**F**
S16 020/10	2659969.819	6508626.735	32.670	Behind Shear Key	TAJ	28/01/2016	2.04	**1.76**	16.1	2.7	**6.7**	196	196	196	196	**196**		**P**
							2.02	**1.74**	16.1	2.7	**7.4**							**P**
S16 020/11	2659975.882	6508614.710	32.538	Behind Shear Key	TAJ	28/01/2016	2.10	**1.88**	11.6	2.7	**8.5**	196	196	196	196	**196**		**P**
							2.10	**1.88**	11.6	2.7	**8.7**							**P**
s16 024/1	2659949.621	6508674.087	37.015	shear key	TAJ	2/02/2016	2.00	**1.67**	19.6	2.7	**5.3**	205	157	150	139	**163**		**P**
							1.99	**1.66**	19.6	2.7	**5.7**							**P**
s16 025/3	2659967.486	6508682.819	36.895	shear key	TAJ	3/02/2016	1.89	**1.53**	23.2	2.7	**7.8**	192	205	183	161	**185**		**P**
							1.88	**1.53**	23.2	2.7	**8.0**							**P**
s16 026/8	2659985.593	6508684.652	36.906	shear key	TAJ	4/02/2016	1.96	**1.56**	25.2	2.7	**2.6**	205	205	205	205	**205**		**P**
							1.96	**1.57**	25.2	2.7	**2.4**							**P**
s16 026/9	2659965.751	6508678.446	37.723	shear key	TAJ	4/02/2016	2.00	**1.61**	24.2	2.7	**1.6**	205	205	205	205	**205**		**P**
							1.99	**1.60**	24.2	2.7	**1.9**							**P**

Job: Silverdale PRECINCT 2 Stage 3B

Client: Tonkin & Taylor
T&T Job #: 21854.0010

Job # **614089.000/1**
Entered By: YA/RHN/JED
Checked By:

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

URN	**Easting**	**Northing**	**RL**	**Location**	**Tech.**	**Date**	**Nuclear Wet Density (t/m^3)**	**Oven Dry Density (t/m3)**	**Oven Moisture content (%)**	**Solid Density (t/m3) assumed**	**Oven Calculated Air Voids (%)**	Shear Strength (kPa) (UTP = Unable to penetrate)				**Average Shear Strength (kPa)**	**Re - Test (Y)**	**pass / fail Specification > 140 kPa and < 10 % Air Voids)**
												Test 1	Test 2	Test 3	Test 4			
s16 028/1	2659929.175	6508667.593	41.007	shear key	TAJ	9/02/2016	2.02	**1.63**	23.9	2.7	**0.8**	205	205	205	205	**205**		**P**
							2.02	**1.63**	23.9	2.7	**0.7**							**P**
s16 028/2	2659956.336	6508673.149	39.505	shear key	TAJ	9/02/2016	2.07	**1.81**	14.3	2.7	**6.8**	205	205	205	205	**205**		**P**
							2.06	**1.80**	14.3	2.7	**7.4**							**P**
s16 029/1	2659972.299	6508688.299	39.988	Shear Key	TAJ	10/02/2016	1.86	**1.45**	28.3	2.7	**5.2**	205	205	205	205	**205**		**P**
							1.86	**1.45**	28.3	2.7	**5.3**							**P**
s16 029/2	2659992.667	6508689.917	39.215	Shear Key	TAJ	10/02/2016	1.86	**1.41**	32.1	2.7	**2.6**	205	162	166	137	**168**		**P**
							1.86	**1.41**	32.1	2.7	**2.6**							**P**
s16 029/3	2660068.862	6508600.150	24.795	silt pond	TAJ	10/02/2016	1.87	**1.50**	24.5	2.7	**7.6**	192	205	205	171	**193**		**P**
							1.87	**1.50**	24.5	2.7	**7.5**							**P**
S16 029/4	2659826.078	6508655.709	45.481	RE Wall	TAJ	11/02/2016	2.01	**1.67**	20.3	2.7	**4.3**	205	205	205	205	**205**		**P**
							1.99	**1.65**	20.3	2.7	**5.2**							**P**
S16 029/5	2659806.379	6508646.331	45.588	Re Wall	TAJ	11/02/2016	2.03	**1.72**	17.7	2.7	**5.8**	205	205	205	205	**205**		**P**
							2.03	**1.72**	17.7	2.7	**5.8**							**P**
S16 029/6	2659945.723	6508682.688	41.161	Shear Key	TAJ	11/02/2016	1.84	**1.48**	30.1	2.7	**0.6**	150	150	150	150	**150**		**P**
							1.84	**1.41**	30.1	2.7	**5.2**							**P**
S16 029/7	2659937.238	6508672.302	41.294	Shear Key	TAJ	11/02/2016	1.91	**1.52**	25.7	2.7	**4.6**	150	152	150	150	**151**		**P**
							1.91	**1.52**	25.7	2.7	**4.8**							**P**
S16 030/4	2659929.033	6508679.880	42.123	Shear Key	TAJ	12/02/2016	1.96	**1.45**	35.0	2.7	**-4.4**	205	205	205	205	**205**		**P**
							1.95	**1.45**	35.0	2.7	**-4.1**							**P**
S16 030/5	2659954.929	6508685.725	41.084	Shear Key	TAJ	12/02/2016	1.82	**1.39**	31.2	2.7	**5.2**	205	205	205	205	**205**		**P**
							1.81	**1.38**	31.2	2.7	**5.7**							**P**
S16 030/6	2659801.314	6508645.853	46.443	RE Wall	TAJ	12/02/2016	1.94	**1.75**	10.7	2.7	**16.3**	205	205	205	205	**205**		**F**
							1.94	**1.75**	10.7	2.7	**16.4**							**F**
S16 030/7	2659814.295	6508649.149	46.590	RE Wall	TAJ	12/02/2016	1.89	**1.48**	28.2	2.7	**3.6**	205	205	205	205	**205**		**P**
							1.89	**1.47**	28.2	2.7	**3.9**							**P**
S16 032/1	2659756.607	6508627.893	48.066	RE Wall	TAJ	15/02/2016	1.92	**1.53**	25.3	2.7	**4.4**	205	205	205	205	**205**		**P**
							1.91	**1.53**	25.3	2.7	**4.8**							**P**
S16 032/6	2659820.140	6508655.226	47.658	RE wall	TAJ	15/02/2016	2.05	**1.78**	15.2	2.7	**7.1**	205	205	205	205	**205**		**P**
							2.03	**1.76**	15.2	2.7	**7.9**							**P**
S16 035/3	2660023.465	6508612.466	31.545	Silt pond	TAJ	22/02/2016	2.10	**1.68**	24.8	2.7	**0.0**	205	205	205	205	**205**		**P**
							2.10	**1.68**	24.8	2.7	**0.0**							**P**
S16 035/4	2659820.329	6508658.004	49.090	Re wall	TAJ	22/02/2016	1.95	**1.55**	25.8	2.7	**2.7**	205	205	205	205	**205**		**P**
							1.94	**1.55**	25.8	2.7	**2.9**							**P**
S16 035/5	2659811.009	6508651.941	49.138	Re wall	TAJ	22/02/2016	2.02	**1.68**	19.9	2.7	**4.2**	205	205	205	205	**205**		**P**
							2.02	**1.69**	19.9	2.7	**4.0**							**P**
S16 039/1	2660006.269	6508634.832	33.464	Silt pond	TAJ	24/02/2016	1.87	**1.28**	46.3	2.7	**0.0**	205	205	205	205	**205**		**P**
							1.89	**1.29**	46.3	2.7	**0.0**							**P**
S16 039/6	2659947.649	6508679.529	42.579	Above Shear Key	TAJ	24/02/2016	1.90	**1.53**	24.4	2.7	**6.1**	205	205	205	205	**205**		**P**
							1.90	**1.53**	24.4	2.7	**6.0**							**P**
S16 039/7	2659967.908	6508682.310	42.700	Above Shear Key	TAJ	24/02/2016	2.01	**1.60**	25.4	2.7	**0.2**	205	205	205	205	**205**		**P**
							1.99	**1.58**	25.4	2.7	**1.1**							**P**
S16 039/8	2660009.417	6508635.049	33.355	Above Shear Key	TAJ	24/02/2016	1.91	**1.49**	28.4	2.7	**2.5**	205	205	205	205	**205**		**P**
							1.93	**1.50**	28.4	2.7	**1.9**							**P**
S16 040/3	2659977.855	6508697.841	44.022	Above Shear Key	TAJ	25/02/2016	2.03	**1.66**	21.9	2.7	**2.1**	205	205	205	205	**205**		**P**
							2.03	**1.66**	21.9	2.7	**2.0**							**P**
S16 040/4	2659992.034	6508644.489	34.400	silt pond	TAJ	25/02/2016	2.07	**1.76**	17.5	2.7	**4.0**	205	205	205	205	**205**		**P**
							2.06	**1.75**	17.5	2.7	**4.5**							**P**
S16 040/6	2659947.717	6508694.324	44.324	Above Shear Key	TAJ	25/02/2016	1.95	**1.62**	20.5	2.7	**7.0**	205	205	205	205	**205**		**P**
							1.95	**1.61**	20.5	2.7	**7.1**							**P**
S16 041/5	2660005.085	6508633.106	34.437	silt pond	TAJ	26/02/2016	2.04	**1.79**	14.0	2.7	**8.7**	205	205	205	205	**205**		**P**
							2.05	**1.80**	14.0	2.7	**8.1**							**P**

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Job: Silverdale PRECINCT 2 Stage 3B

Client: Tonkin & Taylor
T&T Job #: 21854.0010

Job # 614089.000/1
Entered By: YA/RHN/JED
Checked By:

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

URN	**Easting**	**Northing**	**RL**	**Location**	**Tech.**	**Date**	**Nuclear Wet Density (t/m^3)**	**Oven Dry Density (t/m3)**	**Oven Moisture content (%)**	**Solid Density (t/m3) assumed**	**Oven Calculated Air Voids (%)**	Shear Strength (kPa) (UTP = Unable to penetrate)				**Average Shear Strength (kPa)**	**Re - Test (Y)**	**pass / fail Specification > 140 kPa and < 10 % Air Voids)**
												Test 1	Test 2	Test 3	Test 4			
S16 047/1	2660066.678	6508656.757	37.115	Silt pond	TAJ	10/03/2016	1.84	**1.40**	31.4	2.7	**4.1**	205	205	205	205	**205**		**P**
							1.85	**1.41**	31.4	2.7	**3.8**							**P**
S16 047/3	2660010.128	6508640.327	38.214	Silt pond	TAJ	10/03/2016	1.94	**1.59**	22.3	2.7	**5.8**	205	205	205	205	**205**		**P**
							1.95	**1.60**	22.3	2.7	**5.2**							**P**
S16 047/4	2659889.639	6508681.816	45.117	Re Wall	TAJ	10/03/2016	2.03	**1.72**	17.9	2.7	**5.4**	205	205	205	205	**205**		**P**
							2.02	**1.72**	17.9	2.7	**5.7**							**P**
S16 047/5	2659931.48	6508682.326	44.979	Re Wall	TAJ	10/03/2016	2.03	**1.70**	19.0	2.7	**4.6**	205	205	205	205	**205**		**P**
							2.03	**1.71**	19.0	2.7	**4.3**							**P**
S16 047/6	2659976.169	6508690.564	44.995	Re Wall	TAJ	10/03/2016	2.06	**1.72**	19.6	2.7	**2.3**	205	205	205	205	**205**		**P**
							2.06	**1.73**	19.6	2.7	**2.3**							**P**
S16 047/14	2660009.409	6508645.889	38.735	Silt pond	TAJ	10/03/2016	2.00	**1.67**	19.4	2.7	**5.6**	205	205	205	205	**205**		**P**
							2.00	**1.67**	19.4	2.7	**5.6**							**P**
S16 047/15	2659985.904	6508640.814	39.249	Silt pond	TAJ	10/03/2016	2.06	**1.84**	11.7	2.7	**10.3**	205	205	205	205	**205**		**F**
							2.06	**1.85**	11.7	2.7	**10.0**							**F**
S16 049/2	2659955.597	6508686.531	46.933	Re Wall	TAJ	14/03/2016	1.93	**1.57**	23.2	2.7	**5.5**	196	196	196	196	**196**		**P**
							1.95	**1.59**	23.2	2.7	**4.5**							**P**
S16 049/17	2659909.668	6508687.468	47.393	Re wall	TAJ	14/03/2016	1.98	**1.64**	21.3	2.7	**4.6**	196	196	196	196	**196**		**P**
							2.00	**1.64**	21.3	2.7	**4.1**							**P**
S16 049/18	2659916.04	6508687.543	47.498	Re wall	TAJ	14/03/2016	2.03	**1.76**	15.8	2.7	**7.2**	196	196	196	196	**196**		**P**
							2.02	**1.74**	15.8	2.7	**7.9**							**P**
S16 051/10	2660013.715	6508614.771	33.792	Silt pond	TAJ	16/03/2016	1.95	**1.67**	16.7	2.7	**10.1**	196	196	196	196	**196**	**Y**	**F**
							1.94	**1.66**	16.7	2.7	**10.8**							**F**
S16 051/11	2659976.825	6508607.17	34.718	Silt pond	TAJ	16/03/2016	1.88	**1.43**	31.5	2.7	**2.0**	196	196	196	196	**196**		**P**
							1.87	**1.42**	31.5	2.7	**2.4**							**P**
S16 052/6	2660011.894	6508613.908	34.146	Silt pond	TAJ	17/03/2016	1.81	**1.27**	42.6	2.7	**0.0**	196	196	196	196	**196**		**P**
							1.80	**1.26**	42.6	2.7	**0.0**							**P**
S16 053/3	2660022.786	6508619.486	34.502	Re wall	TAJ	18/03/2016	1.95	**1.65**	18.0	2.7	**9.3**	196	196	196	196	**196**	**Y**	**F**
							1.96	**1.66**	18.0	2.7	**8.8**							**F**
S16 053/15	2660013.175	6508621.413	35.134	Shear key	TAJ	18/03/2016	2.07	**1.74**	18.8	2.7	**2.7**	196	196	196	196	**196**		**P**
							2.08	**1.75**	18.8	2.7	**2.2**							**P**
S16 055/2	2660011.032	6508625.872	35.693	silt pond	TAJ	21/03/2016	2.12	**1.69**	25.6	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.10	**1.67**	25.6	2.7	**0.0**							**P**
S16 056/7	2660012.78	6508623.2	35.963	Silt pond	TAJ	22/03/2016	2.04	**1.73**	17.9	2.7	**5.1**	196	196	196	196	**196**		**P**
							2.03	**1.72**	17.9	2.7	**5.4**							**P**
S16 056/8	2659994.831	6508619.537	36.483	Silt pond	TAJ	22/03/2016	2.03	**1.65**	22.9	2.7	**0.9**	196	196	196	196	**196**		**P**
							2.03	**1.65**	22.9	2.7	**1.0**							**P**
S16 064/5	2659991.3	6508586.48	33.096	Beside reserve	TA	7/04/2016	2.02	**1.78**	13.8	2.7	**9.8**	196	196	196	196	**196**		**P**
							2.02	**1.77**	13.8	2.7	**9.9**							**P**
S16 064/6	2660008.948	6508598.95	32.069	Beside reserve	TA	7/04/2016	2.11	**1.77**	19.0	2.7	**0.9**	196	196	196	196	**196**		**P**
							2.09	**1.76**	19.0	2.7	**1.4**							**P**
S16 064/10	2660011.719	6508584.23	31.991	Beside reserve	TA	7/04/2016	2.07	**1.62**	27.7	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.07	**1.62**	27.7	2.7	**0.0**							**P**
S16 065/6	2659997.104	6508593.678	33.377	Beside reserve	TA	8/04/2016	2.01	**1.59**	25.9	2.7	**0.0**	196	196	196	196	**196**		**P**
							2.00	**1.59**	25.9	2.7	**0.0**							**P**
S16 068/2	2660021.766	6508596.68	34.156	Beside reserve	TA	12/04/2016	1.98	**1.64**	20.1	2.7	**6.0**	196	196	196	196	**196**		**P**
							1.98	**1.65**	20.1	2.7	**5.8**							**P**

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