REPORT

Tonkin+Taylor

MILLWATER - PRECINCT 2 STAGE 4E

Geotechnical Completion Report

Prepared for
WFH Properties Ltd
Prepared by
Tonkin & Taylor Ltd
Date
July 2017
Job Number
21854.001/S4E.v1

Exceptional thinking together
www.tonkintaylor.co.nz

Distribution:

WFH Properties Ltd	2 copies
Woods Ltd	2 copies
Tonkin & Taylor Ltd (FILE)	1 copy

Table of contents

Executive summary

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd (WFH) to monitor and provide earthworks certification for the 32 No. Residential Lots contained within Stage 4E of Precinct 2 in the Millwater Subdivision in Silverdale. Stage 4E comprises residential Lots 411 to 424 and 471 to 488, and Jointly Owned Access Lane (JOAL) Lot 720 inclusive as shown on the Woods Final Contour As–Built Plan (Woods Ref 33222–04E–100–AB) 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 were generally completed and certified as part of the adjacent Precinct 3 development, undertaken between April 2008 and February 2010 (T+T Ref. 21854.008, Millwater Precinct 3, Geotechnical Completion Report, dated March 2010), with additional bulk earthworks within Stage 4E undertaken between December 2015 and September 2016. Earthworks comprised the following:

a Stripping of vegetation, organic materials and topsoil to stockpile.
b Installation of gully and subsoil drains.
c Cut to fill earthworks across the entire Stage 4E site as shown on the Woods Cut/Fill Contour As–Built Plan Original Surface – Earthworks Surface (Woods Ref 33222–04E–110–AB) in Appendix A1.

Civil earthworks commenced on site in February 2017 and were completed by May 2017, 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 33222–04E–111–AB) in Appendix A1.
b Installation of roading and services.

Overall subdivisional soil types are moderately to highly expansive (Class M to H1), 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.

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 (WFH) to monitor and provide earthworks certification for the 32 No. Residential Lots contained within Stage 4E of Precinct 2 in the Millwater Subdivision in Silverdale. Stage 4E comprises residential Lots 411 to 424 and 471 to 488, and Jointly Owned Access Lane (JOAL) Lot 720 inclusive as shown on the Woods Final Contour As–Built Plan (Woods Ref 33222–04E–100–AB) 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. While these stabilisation works are required across much of Precinct 2, such works were not required to achieve satisfactory factors of safety against instability for the finished development of Stage 4E.

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

d 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 4E 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 4E areas are shown on T+T Drawing 21854.001–P2S4E–100 in Appendix A2.

Pre-development gradients within the Stage 4E area were gentle (1 in 15 to 1 in 10 (V:H)) with an overall fall to the east.

Post-development gradients within the Stage 4E area are gentle (1 in 15 to 1 in 10 (V:H)) and generally fall to the east as before.

Stage 4E is presently accessed from the existing Grut Greens.

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.

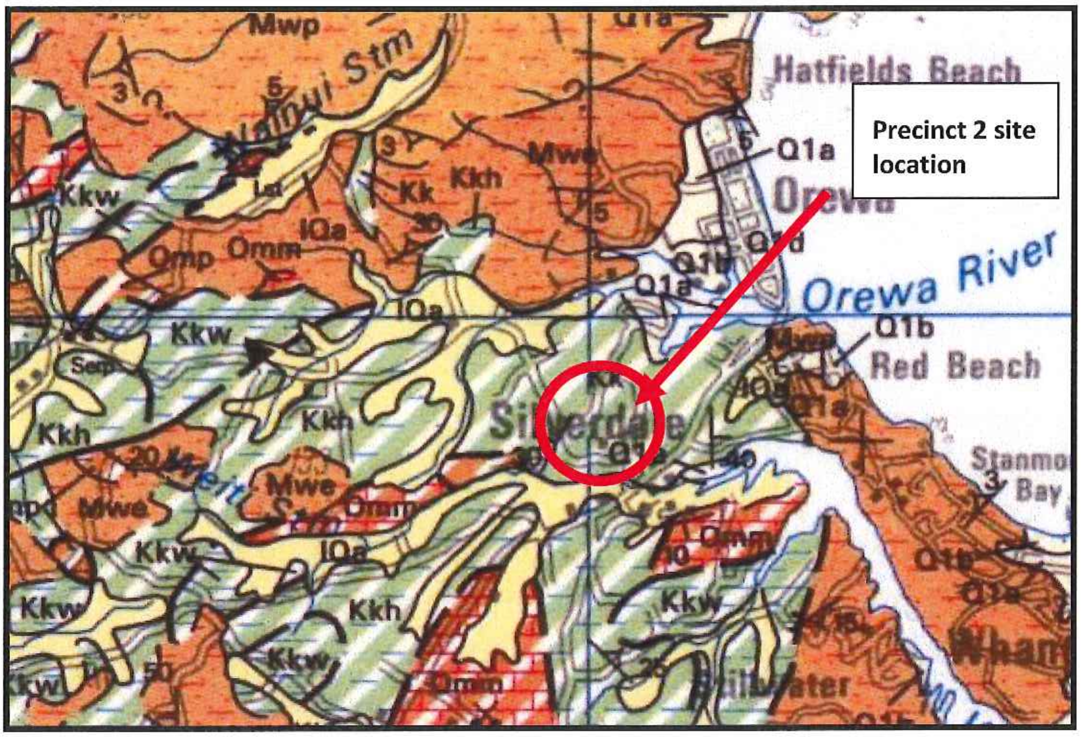


Figure 1 - Local Geology (from Edbrooke)

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 4E area are enclosed as Drawing Numbers 21854.001–P2S4E–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 (Hicks). Various areas of soft and/or wet materials were encountered during the works and were undercut and replaced with engineered fill. Much of this undercut material was considered suitable for re-use as engineered fill if conditioned appropriately. Accordingly, mixing of the cohesive fill materials with lime/cement to facilitate fill placement and compaction was undertaken by Hiway Stabilizers Ltd (Hiway) under Hicks' control.

Civil works construction has been completed by Hibiscus Contractors Ltd (Hibiscus).

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 commenced in the adjacent Precinct 3 site in April 2008 and progressed through to February 2010. These works comprised cleaning out of the gullies that extended into the Precinct 2 site, followed by backfilling with engineered fill up to the proposed design levels. Additional bulk earthworks within Stage 4E were undertaken between December 2015 and September 2016, also by Hicks, and were predominantly related to general regrading across the site.

Civil earthworks and construction for the residential Lots were under Hibiscus' control and were undertaken progressively from February 2017 through to completion in May 2017.

Key Stage 4E earthworks components included:

a Stripping of vegetation, organic materials and topsoil to stockpile.
b Installation of gully and subsoil drains.
c Cut to fill earthworks across the entire Stage 4E site as shown on the Woods Cut/Fill Contour As–Built Plan Original Surface – Earthworks Surface (Woods Ref 33222–04E–110–AB) in Appendix A1.

Key Stage 4E 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 33222–04E–111–AB) in Appendix A1.
b Installation of roading and services.

The earthworks, undercuts and subsoil drainage as-built plans are included in Appendix A1 (Woods Drawings 33222–04E–100–AB, –110 to –112, and –120), 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

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

General fills:

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

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.

The subsoil drains installed within the original gullies 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 13m 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.

The gully drains discharge into the main downslope gully that runs centrally through the adjacent Precinct 3.

The subsoil drainage system and connections are shown on the Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 33222–04E–120–AB) in Appendix A1, and on T+T Drawing 21854.001–P2S4E–102 in Appendix A2.

4 Stability Analyses

As noted in Section 1, slope stability analyses undertaken during the investigation stage of the project identified that shear keys were not required to achieve satisfactory factors of safety against slope instability for the finished development of Stage 4E.

Observations and monitoring were undertaken during bulk earthworks construction to confirm that the ground conditions exposed were consistent with the assumptions made in the stability analyses.

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 4E straddle a range of "design conditions" including cut ground, filled ground and expansive soils. 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 to H1 (moderately to highly expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm and 40mm to 60mm respectively. Due allowance should be made for expansive soils, as discussed in Section 5.11.

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 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, predominantly placed between 2008 and 2010, 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.

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.

5.4 Retaining walls

Due to the shallow grades across most of the Stage 4E 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.

5.5 Subsoil Drainage

Following gully muckouts 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 33222–04E–120–AB) in Appendix A1, and on T+T Drawing 21854.001–P2S4E–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.

5.6 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–P2S4E–111) are attached in Appendix E.

5.7 Stormwater

Public stormwater services have been installed within the Precinct 2, Stage 4E. 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.

5.8 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 plans (Woods Stormwater As–Built Plans, Woods Ref 33222–04E–300–AB to –302) are included in Appendix A1.

5.9 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 4E development, within natural ground, a design CBR of 2% is considered appropriate while, within engineered fill areas, a design CBR of 7% is appropriate.

5.10 Topsoil

Following completion of topsoil spreading and grassing, topsoil depths were measured in representative Lots and these are shown on T+T Drawing 21854.001–P2S4E–112 attached in Appendix E. Due to variations in placement depths and earth worked surface levels, topsoil depths may vary from those recorded.

5.11 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 to H1 (moderately to highly expansive) with characteristic surface movements anticipated to be in the range of 20mm to 60mm.

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 4E (comprising residential Lots 411 to 424 and 471 to 488, and JOAL Lot 720 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 33222, Millwater, Precinct 2, Stage 4E, Drawing Numbers 33222–04E–100–AB 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 Residential Lots 411 to 424 and 474 to 488 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 6.5.6.

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 Residential Lots 471 to 473 inclusive:

6.6.1 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 6.6.2 to 6.6.6.

6.6.2 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]).

6.6.3 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 H1 (highly expansive) as defined in AS 2870:2011 (Ref. [9]) with anticipated characteristic surface ground movements of 40mm to 60mm. Clause 6.6.3.1 of this Geotechnical Completion Report may be used for expansive soil foundation design on this subdivision:

6.6.3.1 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:

iv) Minimum foundation embedment of 750 mm following topsoil removal and benching of building platform areas to finished ground levels

v) Four bar steel reinforcing cages should be used

vi) 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.

6.6.4 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.

6.6.5 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.

6.6.6 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.

6.7 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 33222–04E–120–AB) in Appendix A1, and on T+T Drawing 21854.001–P2S4E–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.

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 4E 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 4E

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 4e\jxxl.170526.p2s4e-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

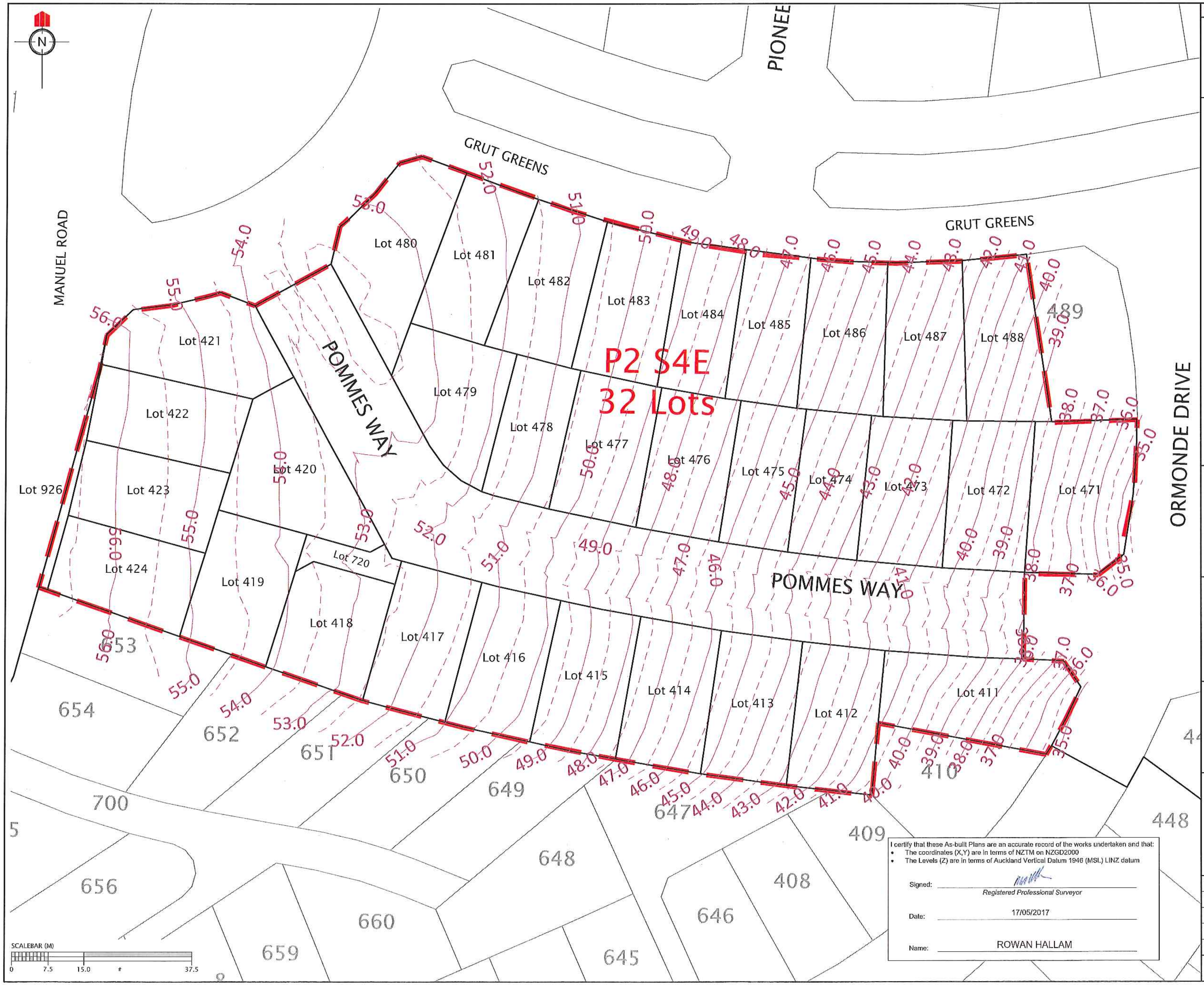
[8] New Zealand Standards, 1989. *NZS 4431:1989 Code of Practice for Earth Fill for Residential Development.*

[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

33222–04E–100–AB	Final Contour As–Built Plan
33222–04E–110–AB	Cut/Fill Contour As–Built Plan Original Surface – Earthworks Surface
33222–04E–111–AB	Cut/Fill Contour As–Built Plan Earthworks Surface – Final Surface
33222–04E–112–AB	Cut/Fill Contour As–Built Plan Original Surface – Final Surface
33222–04E–120–AB	Shear Key, Undercuts & Subsoil Drains As–Built Plan
33222–04B–300–AB to –302	Stormwater 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: *[signature]* Registered Professional Surveyor

Date: 17/05/2017

Name: ROWAN HALLAM

REVISION DETAILS	NAME	DATE

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.

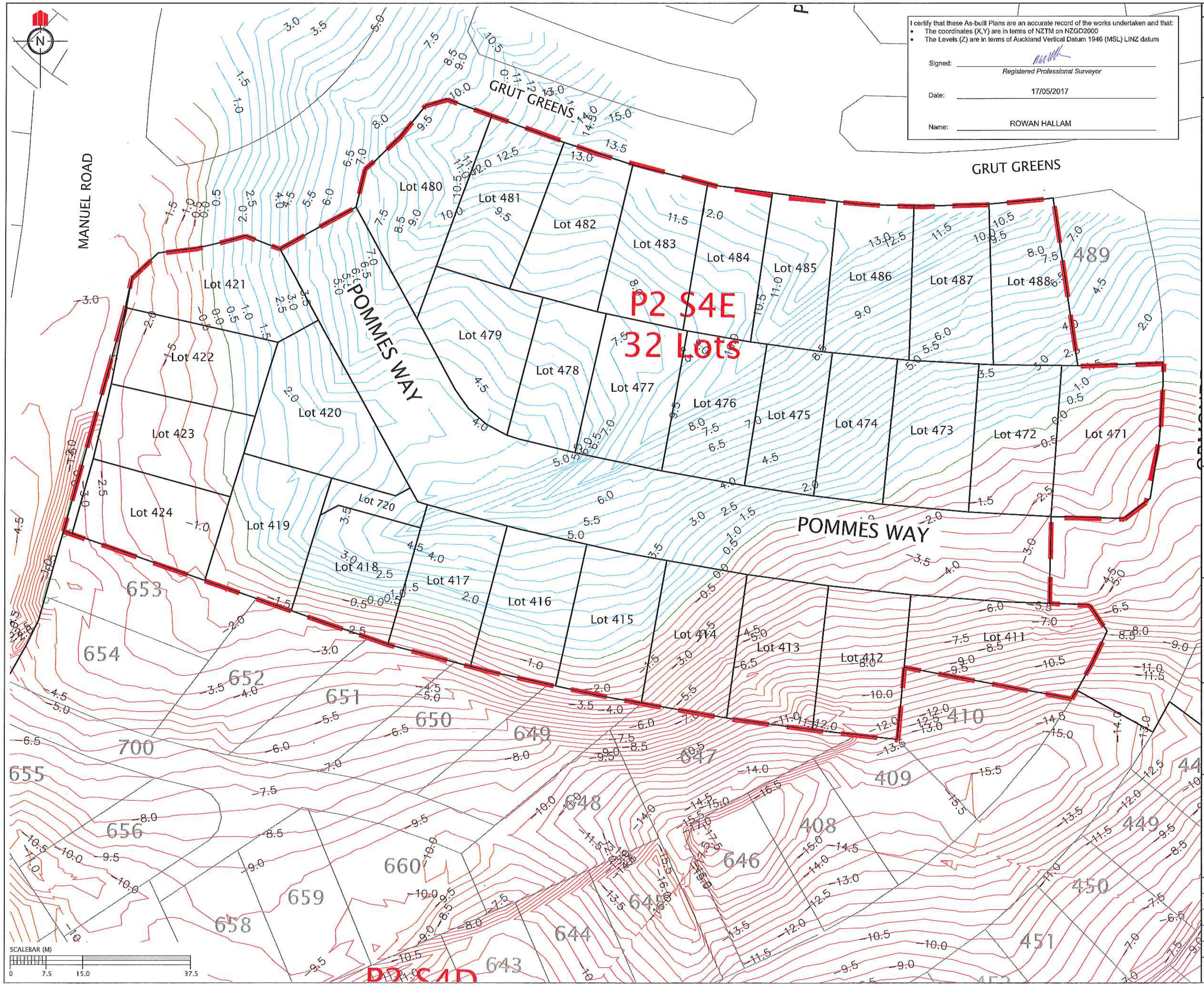
MILLWATER PRECINCT 2 STAGE 4E

FINAL CONTOUR AS-BUILT PLAN

AUCKLAND COUNCIL

DESIGNED:	JG	ASBUILT	
CHECKED:	KR	DRAWN:	KH
APPROVED:	WC	SURVEYED:	WOODS
JOB NUMBER:	33222	SCALE:	1:750 @ A3
ISSUED:	JULY 2017		
DWG. NO.	33222-04E-100-AB	REV.	

K:\33222 - Precinct 2 Stage 4E\Project Data\Acad Drawings\Survey\As-Built\33222-04E-100-AB FINAL CONTOURS.dwg, 17/05/2017 12:17:17 p.m.



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: 17/05/2017

Name: ROWAN HALLAM

REVISION DETAILS	NAME	DATE

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.

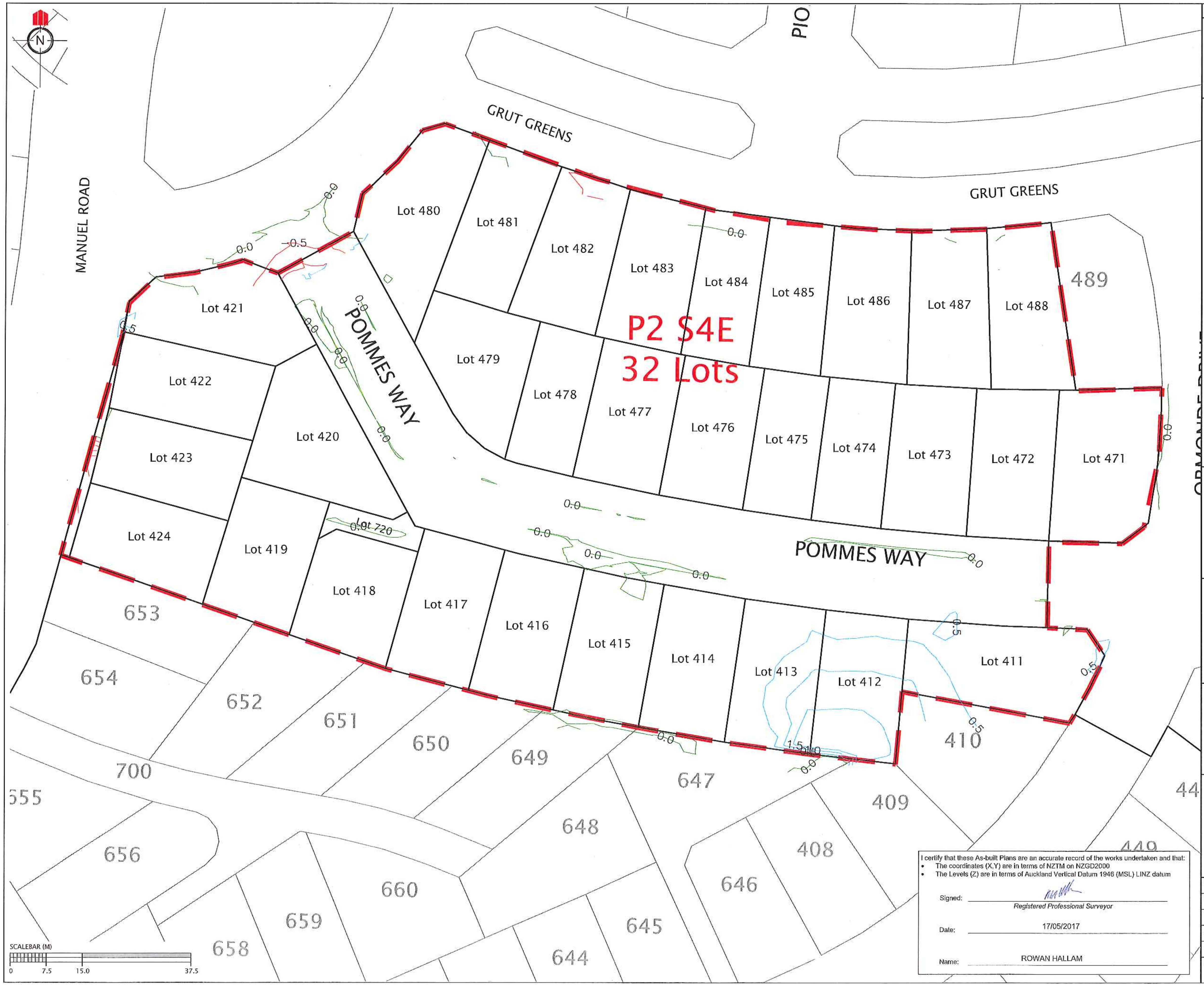
MILLWATER
PRECINCT 2
STAGE 4E

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

AUCKLAND COUNCIL

DESIGNED: JG	ASBUILT
CHECKED: KR	DRAWN: KH
APPROVED: WC	SURVEYED: WOODS
JOB NUMBER: 33222	SCALE: 1:750 @ A3
ISSUED: JULY 2017	
DWG. NO. 33222-04E-110-AB	REV.

K:\33222 - Precinct 2 Stage 4E\Project Data\Acad Drawings\Survey\As-Built\33222-04E-110-AB CUT FILL CONTOURS.dwg, 17/05/2017 12:26:54 p.m.



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: 17/05/2017

Name: ROWAN HALLAM

REVISION DETAILS	NAME	DATE

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

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

CLIENT:

WFH
PROPERTIES

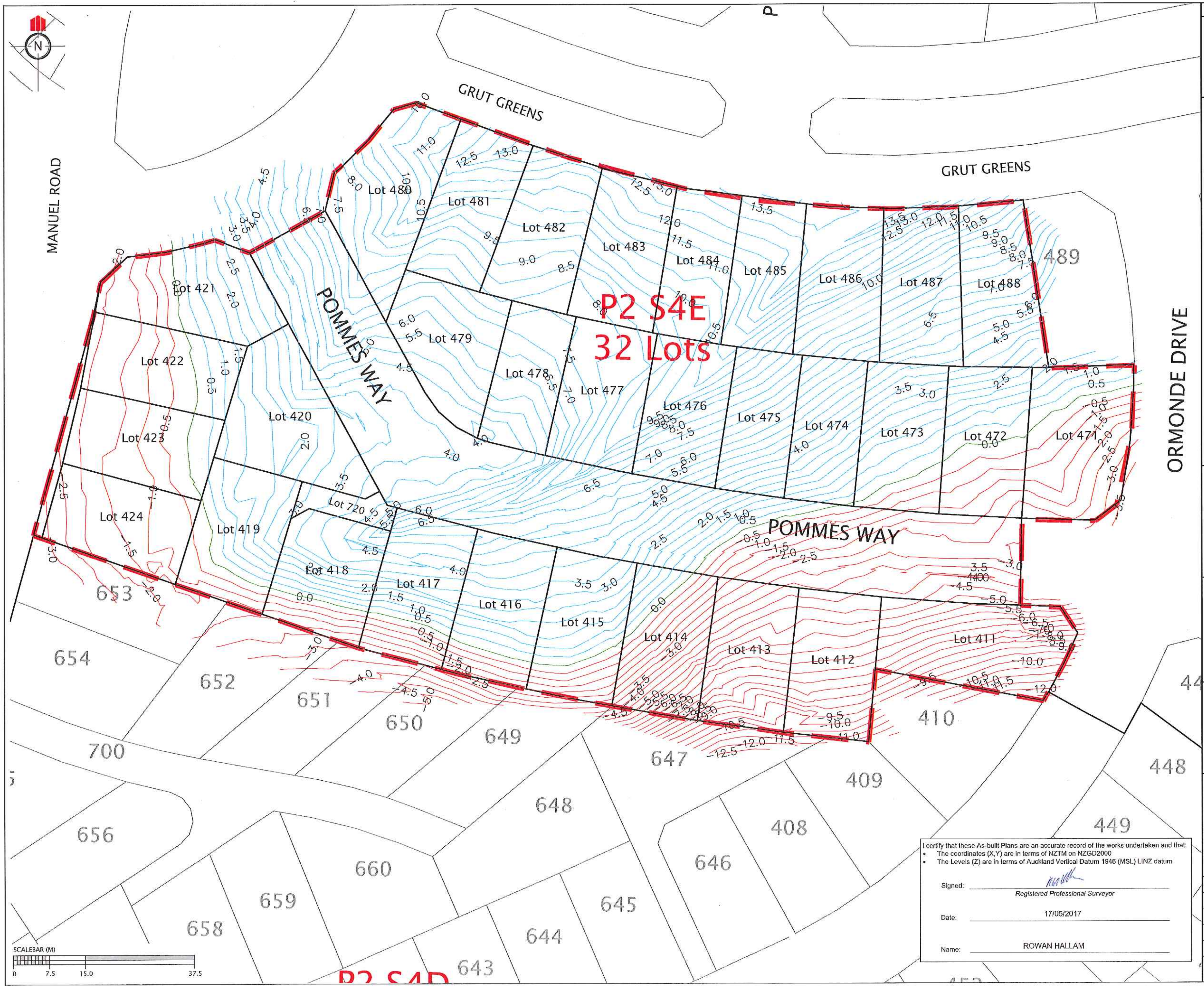
WOODS
Engineers. Surveyors. Planners.

MILLWATER PRECINCT 2 STAGE 4E

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

AUCKLAND COUNCIL

DESIGNED:	JG		ASBUILT
CHECKED:	KR	DRAWN:	KH
APPROVED:	WC	SURVEYED:	WOODS
JOB NUMBER:	33222	SCALE:	1:750 @ A3
ISSUED:	JULY 2017		
DWG. NO.	33222-04E-111-AB	REV.	



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: 17/05/2017

Name: ROWAN HALLAM

REVISION DETAILS	NAME	DATE

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

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

CLIENT:

WFH PROPERTIES

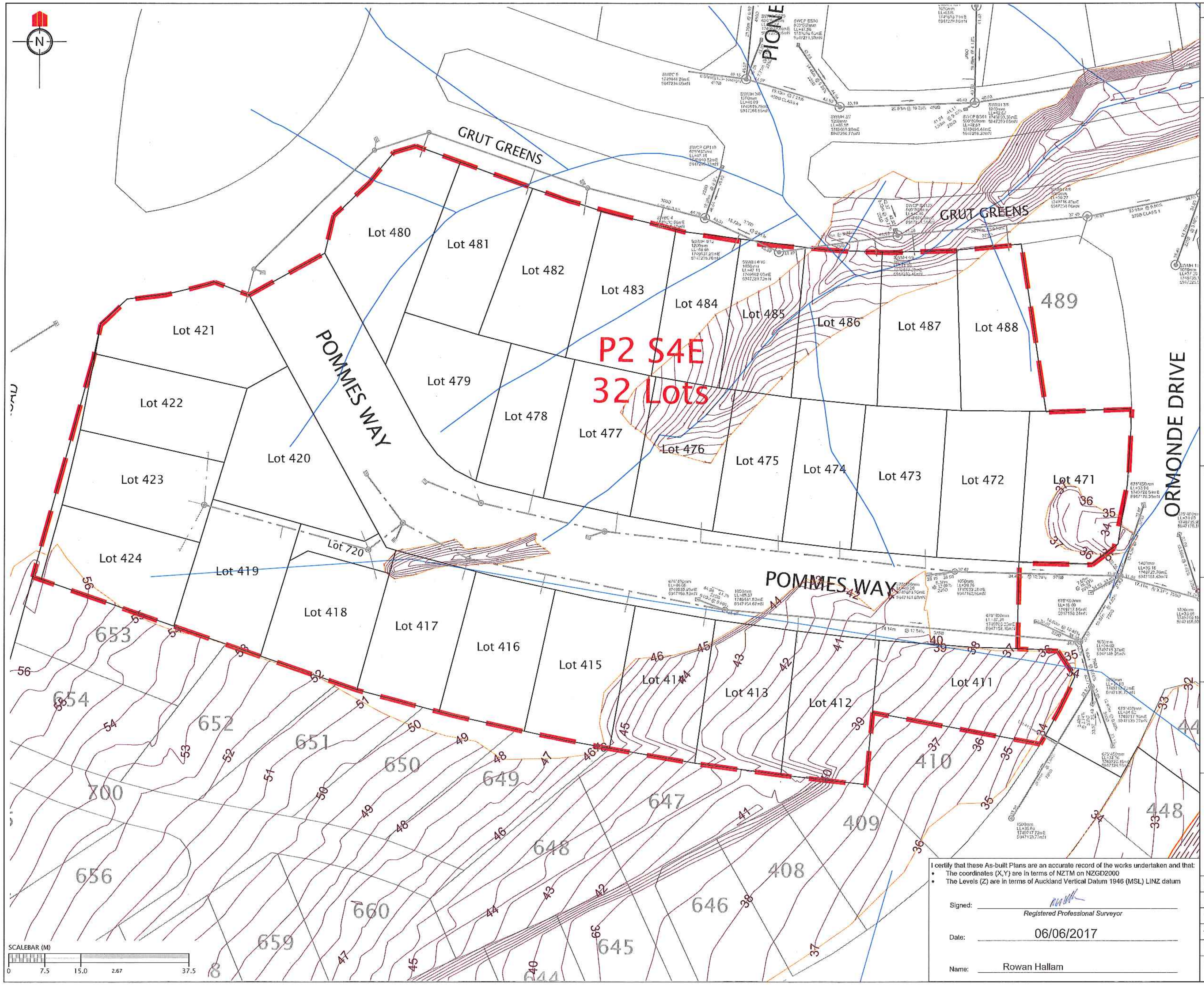
WOODS
Engineers. Surveyors. Planners.

MILLWATER PRECINCT 2 STAGE 4E

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

AUCKLAND COUNCIL

DESIGNED: JG	ASBUILT
CHECKED: KR	DRAWN: KH
APPROVED: WC	SURVEYED: WOODS
JOB NUMBER: 33222	SCALE: 1:750 @ A3
ISSUED: JULY 2017	
DWG. NO. 33222-04E-112-AB	REV.



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: nuill

Registered Professional Surveyor

Date: 06/06/2017

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE

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.

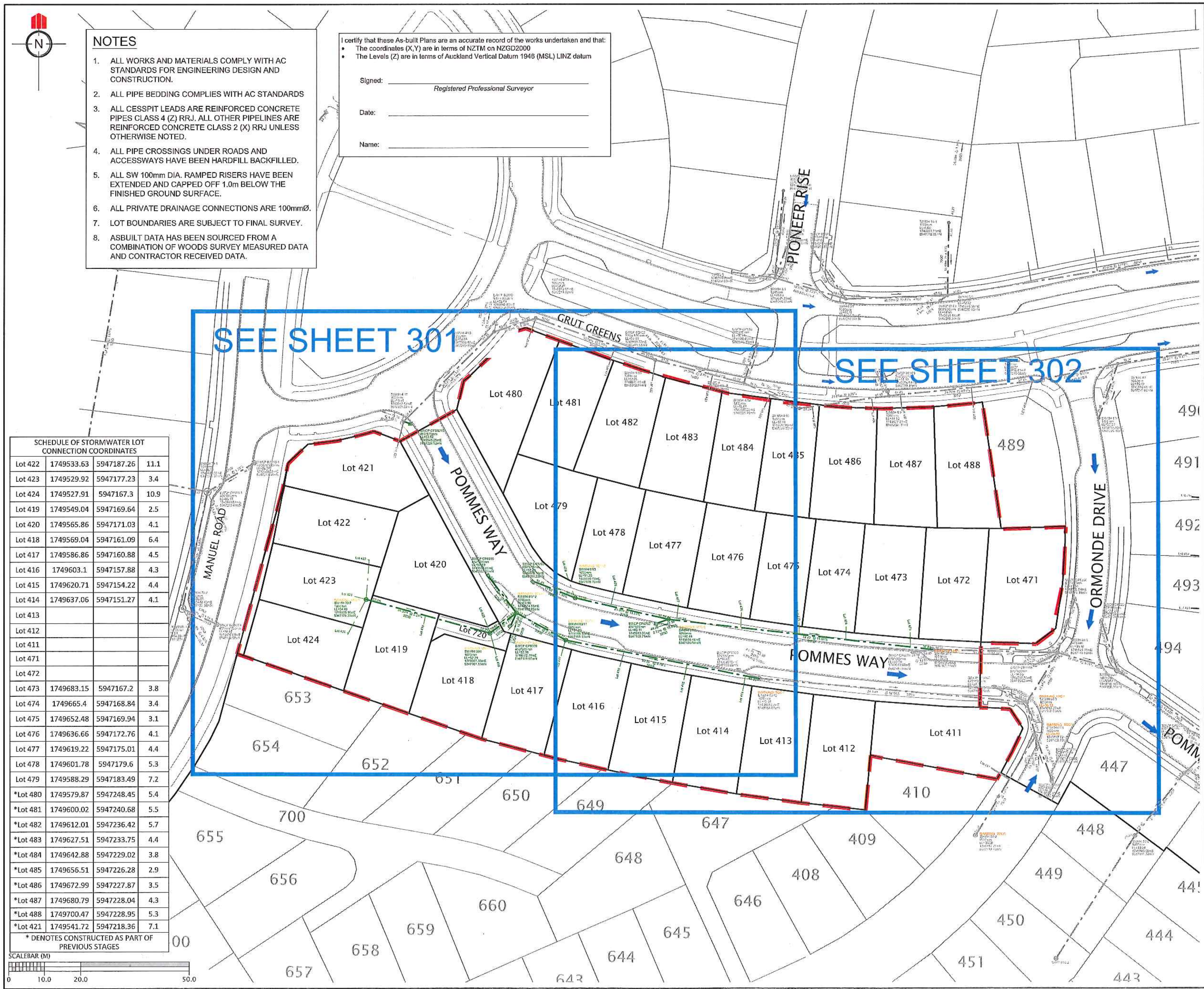
MILLWATER PRECINCT 2 STAGE 4E

SHEAR KEY, UNDERCUTS & SUBSOIL DRAINS AS-BUILT PLAN

AUCKLAND COUNCIL

DESIGNED: JG	ASBUILT
CHECKED: KR	DRAWN: KR
APPROVED: RH	SURVEYED: HICKS
JOB NUMBER: 33222	SCALE: 1:750 @ A3
ISSUED: JUNE 2017	
DWG. NO. 33222-04A-120-AB	REV.

K:\33222 - Precinct 2 Stage 4E\Project Data\Acad Drawings\Survey\As-Built\33222-04E-120-AB SK UC & SUBSOIL.dwg, 6/06/2017 9:25:03 a.m.



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.

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: ______________________

Name: ______________________

SCHEDULE OF STORMWATER LOT CONNECTION COORDINATES			
Lot 422	1749533.63	5947187.26	11.1
Lot 423	1749529.92	5947177.23	3.4
Lot 424	1749527.91	5947167.3	10.9
Lot 419	1749549.04	5947169.64	2.5
Lot 420	1749565.86	5947171.03	4.1
Lot 418	1749569.04	5947161.09	6.4
Lot 417	1749586.86	5947160.88	4.5
Lot 416	1749603.1	5947157.88	4.3
Lot 415	1749620.71	5947154.22	4.4
Lot 414	1749637.06	5947151.27	4.1
Lot 413			
Lot 412			
Lot 411			
Lot 471			
Lot 472			
Lot 473	1749683.15	5947167.2	3.8
Lot 474	1749665.4	5947168.84	3.4
Lot 475	1749652.48	5947169.94	3.1
Lot 476	1749636.66	5947172.76	4.1
Lot 477	1749619.22	5947175.01	4.4
Lot 478	1749601.78	5947179.6	5.3
Lot 479	1749588.29	5947183.49	7.2
*Lot 480	1749579.87	5947248.45	5.4
*Lot 481	1749600.02	5947240.68	5.5
*Lot 482	1749612.01	5947236.42	5.7
*Lot 483	1749627.51	5947233.75	4.4
*Lot 484	1749642.88	5947229.02	3.8
*Lot 485	1749656.51	5947226.28	2.9
*Lot 486	1749672.99	5947227.87	3.5
*Lot 487	1749680.79	5947228.04	4.3
*Lot 488	1749700.47	5947228.95	5.3
*Lot 421	1749541.72	5947218.36	7.1

* DENOTES CONSTRUCTED AS PART OF PREVIOUS STAGES

SCALEBAR (M)
0 10.0 20.0 50.0

REVISION DETAILS	NAME	DATE
1.		

LEGEND

STORMWATER MANHOLE	◉
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
OVERLAND FLOW	➡
NEW STORMWATER	— · — · —
EXISTING STORMWATER	— · · — · · —
STAGE BOUNDARY	▬ ▬ ▬

CLIENT:

WFH PROPERTIES

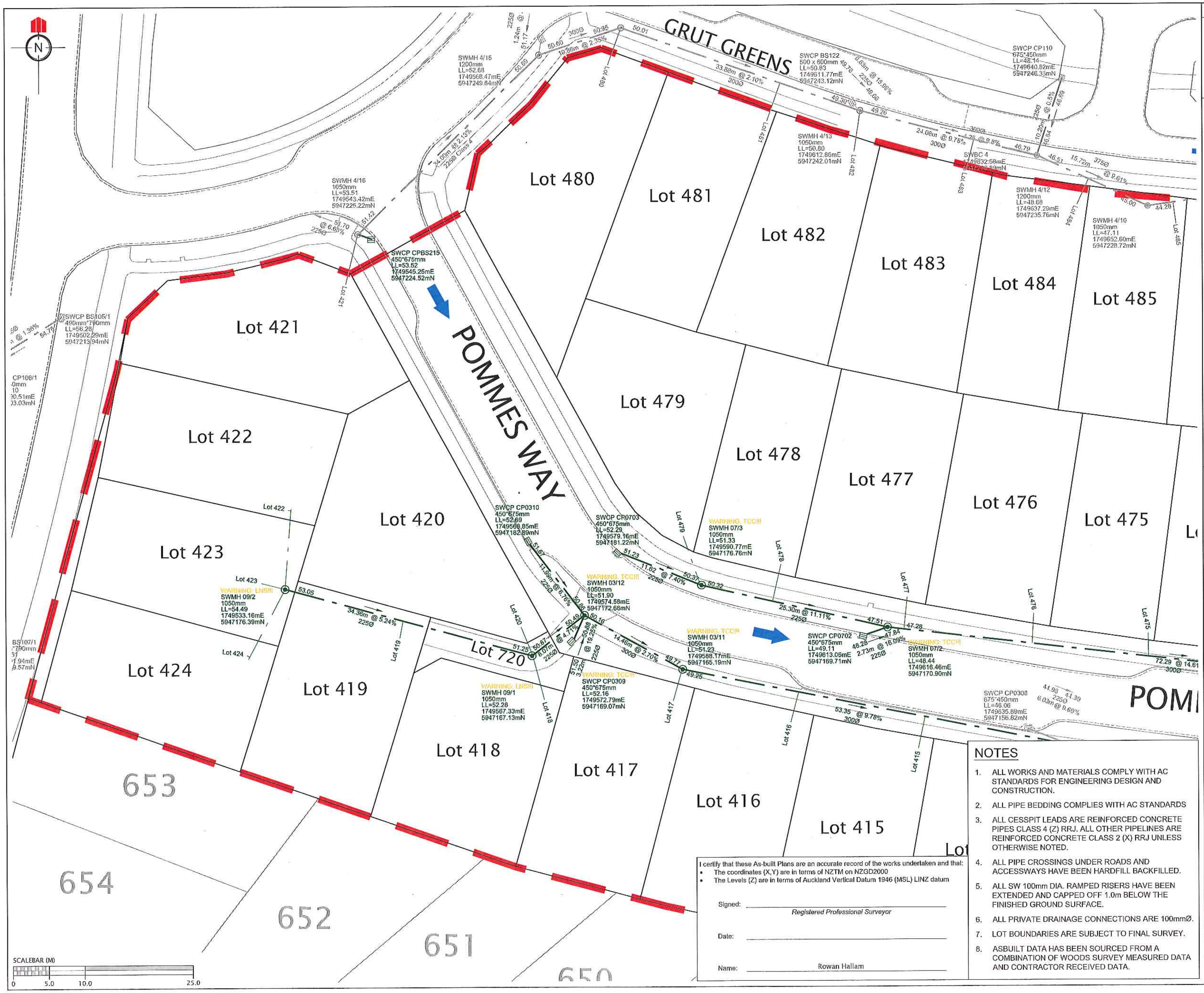
WOODS
Engineers. Surveyors. Planners.

MILLWATER
PRECINCT 2
STAGE 4E

STORMWATER AS-BUILT
Sheet 1 of 3

AUCKLAND COUNCIL

DESIGNED:	JG	ASBUILT	
CHECKED:	KR	DRAWN:	KH
APPROVED:	MRH	SURVEYED:	WOODS
JOB NUMBER:	33222	SCALE:	1:1000 @ A3
ISSUED:	JULY 2017		
DWG. NO.	33222-4E-300-AB	REV.	



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.

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: ______________________

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE

LEGEND

STORMWATER MANHOLE	⦿
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
OVERLAND FLOW	➡
NEW STORMWATER	— - — - —
EXISTING STORMWATER	-·-·-·-
STAGE BOUNDARY	🟥 🟥 🟥 🟥

CLIENT:

WFH
PROPERTIES

WOODS
Engineers. Surveyors. Planners.

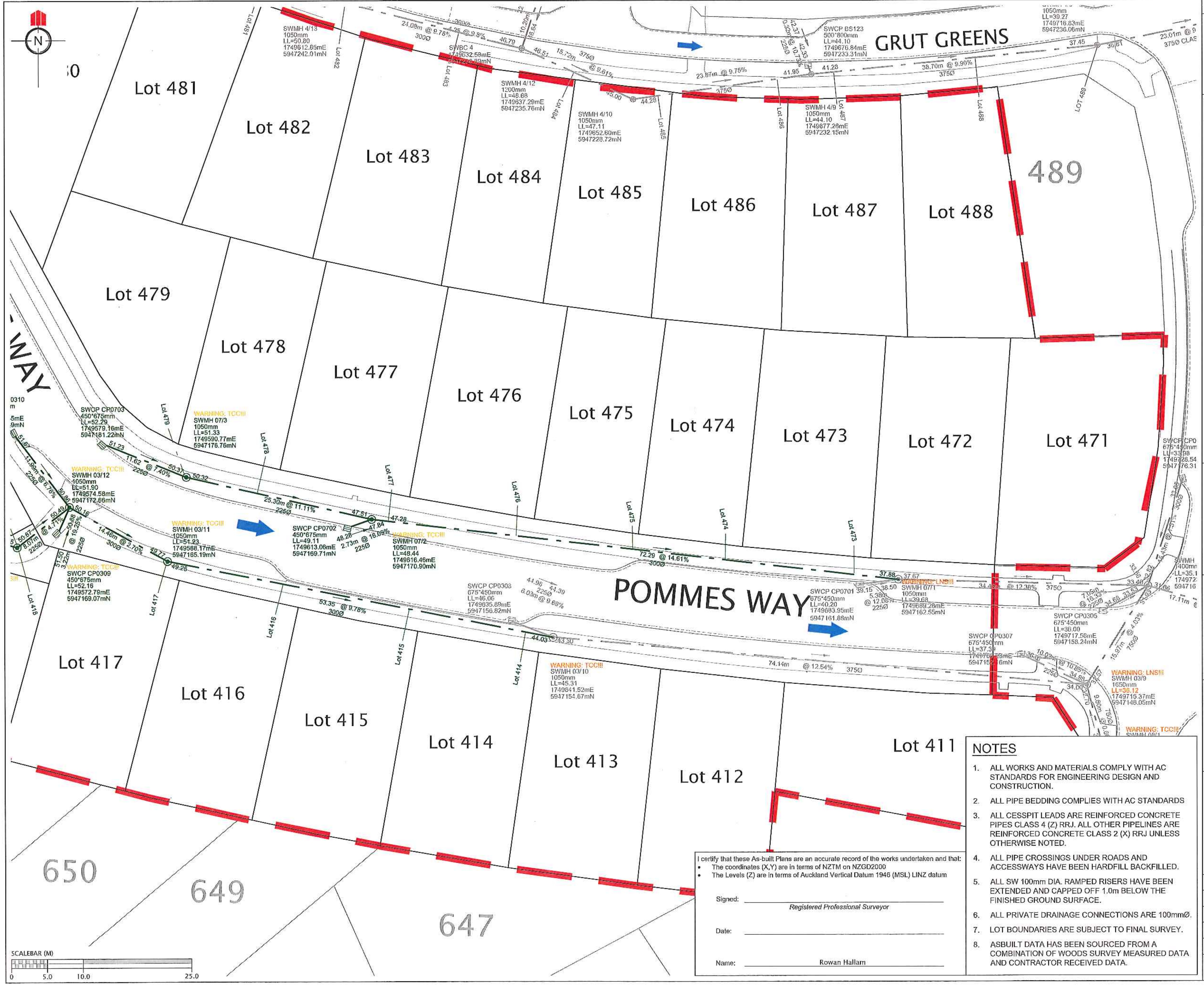
MILLWATER
PRECINCT 2
STAGE 4E

STORMWATER AS-BUILT
Sheet 2 of 3

AUCKLAND COUNCIL

DESIGNED: JG	ASBUILT
CHECKED: KR	DRAWN: KH
APPROVED: MRH	SURVEYED: WOODS
JOB NUMBER: 33222	SCALE: 1:500 @ A3
ISSUED: JULY 2017	
DWG. NO. 33222-4E-301-AB	REV.

K:\33222 - Precinct 2 Stage 4E\Project Data\Acad Drawings\Survey\As-Built\33222-04E-300-AB STORMWATER.dwg, 17/05/2017 3:14:55 p.m.



REVISION DETAILS	NAME	DATE

LEGEND

STORMWATER MANHOLE	◉
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
OVERLAND FLOW	➡
NEW STORMWATER	— · —
EXISTING STORMWATER	- · -
STAGE BOUNDARY	▬ ▬ ▬

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners.

MILLWATER PRECINCT 2 STAGE 4E

STORMWATER AS-BUILT
Sheet 3 of 3

AUCKLAND COUNCIL

DESIGNED:	JG	ASBUILT	
CHECKED:	KR	DRAWN:	KH
APPROVED:	MRH	SURVEYED:	WOODS
JOB NUMBER:	33222	SCALE:	1:500 @ A3
ISSUED:	JULY 2017		
DWG. NO.	33222-4E-302-AB	REV.	

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: ______________________

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.

K:\33222 - Precinct 2 Stage 4E\Project Data\Acad Drawings\Survey\As-Built\33222-04E-300-AB STORMWATER.dwg, 17/05/2017 3:14:58 p.m.

Appendix A2: T+T Drawings

21854.001–P2S4E–100	Drawing List and Site Location Plan
21854.001–P2S4E–101	Geotechnical Works Plan
21854.001–P2S4E–102	Geotechnical Works Subsoil Drain Plan
21854.001–P2S4E–103	Geological Cross Section 6
21854.001–P2S4E–104	Geological Cross Section 7

WFH PROPERTIES LTD
MILLWATER PRECINCT 2
STAGE 4E
COMPLETION REPORT ISSUE

DRAWING	Rev	Title
GENERAL		
• 21854.001-P2S4E-100	1	Drawing List and Site Location Plan
• 21854.001-P2S4E-101	1	Geotechnical Works Plan
• 21854.001-P2S4E-102	1	Geotechnical Works Subsoil Drain Plan
• 21854.001-P2S4E-103	1	Geogical Cross Sections 6 & 7
• 21854.001-P2S4E-104	1	Geogical Cross Sections 8 & 18
APPENDIX E		
• 21854.001-P2S4E-111	1	Post Earthworks Investigation Plan
• 21854.001-P2S4E-112	1	Topsoil Depths Plan
• 21854.001-P2S4E-113	1	Earthworks Testing Location Plan

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

- Denotes drawing this issue: 7/15/2017

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

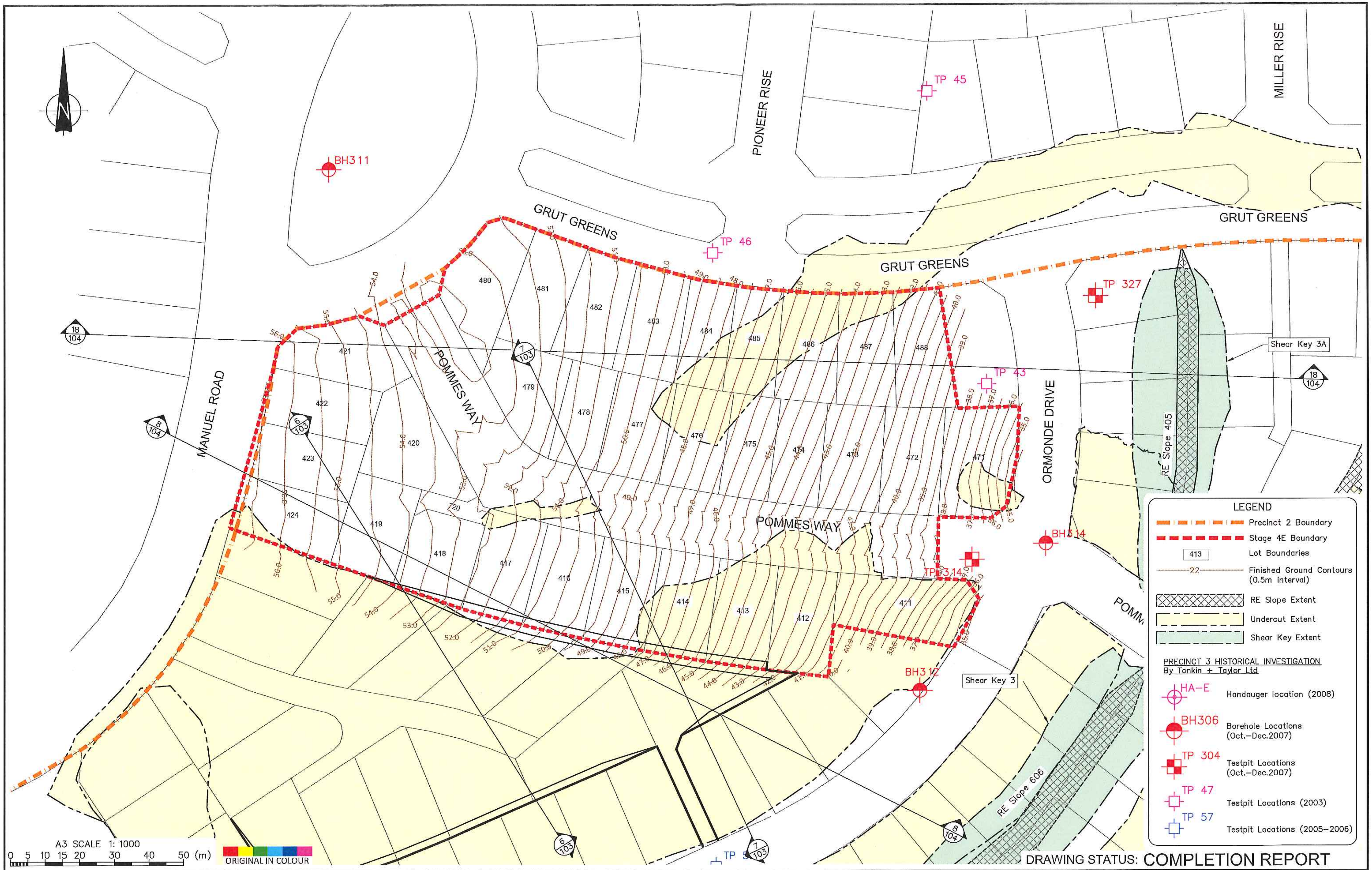
				DESIGNED :	JXXL	Jul. 17	NOTES : 1. All dimensions are in millimetres unless noted otherwise.
				DRAWN :	JC	Jul. 17	
				DESIGN CHECKED :			
				DRAFTING CHECKED :			
				CADFILE : \\21854.001-P2S4E-100.dwg			
				APPROVED : NOT FOR CONSTRUCTION This drawing is not to be used for construction purposes unless signed as approved			
1	Completion Report Issue						
REVISION	DESCRIPTION	BY	DATE	COPYRIGHT ON THIS DRAWING IS RESERVED			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 4E)
Drawing List and Site Location Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
AS SHOWN	21854.001-P2S4E-100	1



DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue		
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	JXXL	Jul. 17
DRAWN :	JC	Jul. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		

CADFILE : \\21854.001-P2S4E-101.dwg

APPROVED :
NOT FOR CONSTRUCTION
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. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946
3. As-built plan supplied by WOODS reference "33222-04E-100-AB FINAL CONTOURS.dwg" & "33222-04E-110-AB CUT FILL CONTOURS.dwg", dated July 2017.
4. Undercuts, shearkey & subsoil drains supplied by WOODS, reference "33222-04E-120-AB SK UC & SUBSOIL.dwg", dated July 2017.

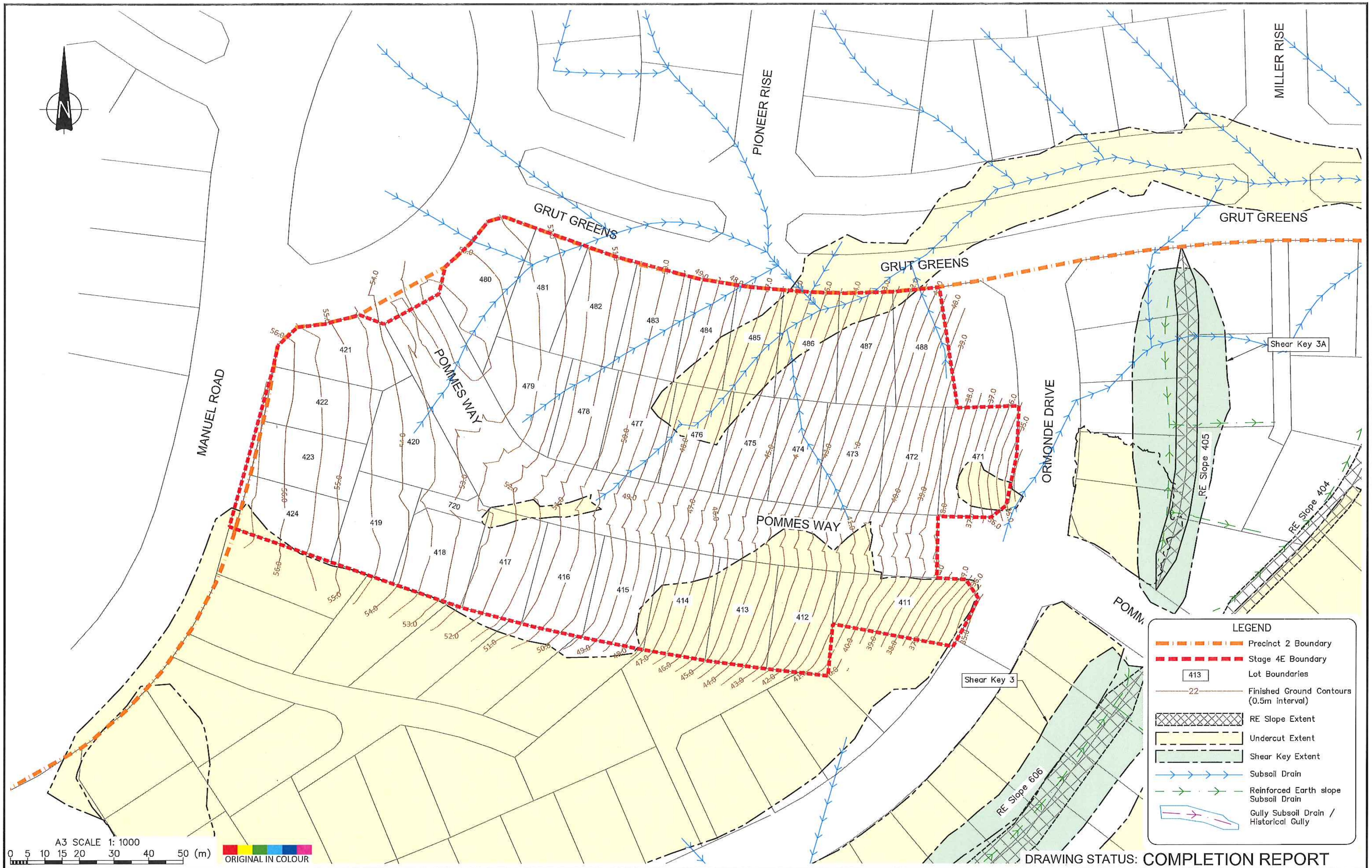
REFERENCE :

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 4E)
Geotechnical Works Plan

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S4E-101
REV. 1



DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue	
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	JXXL	Jul. 17
DRAWN :	JC	Jul. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.001-P2S4E-102.dwg		
APPROVED :		

NOT FOR CONSTRUCTION
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. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946
3. As-built plan supplied by WOODS reference "33222-04E-100-AB FINAL CONTOURS.dwg" & "33222-04E-110-AB CUT FILL CONTOURS.dwg", dated July 2017.
4. Undercuts, shearkey & subsoil drains supplied by WOODS, reference "33222-04E-120-AB SK UC & SUBSOIL.dwg", dated July 2017.

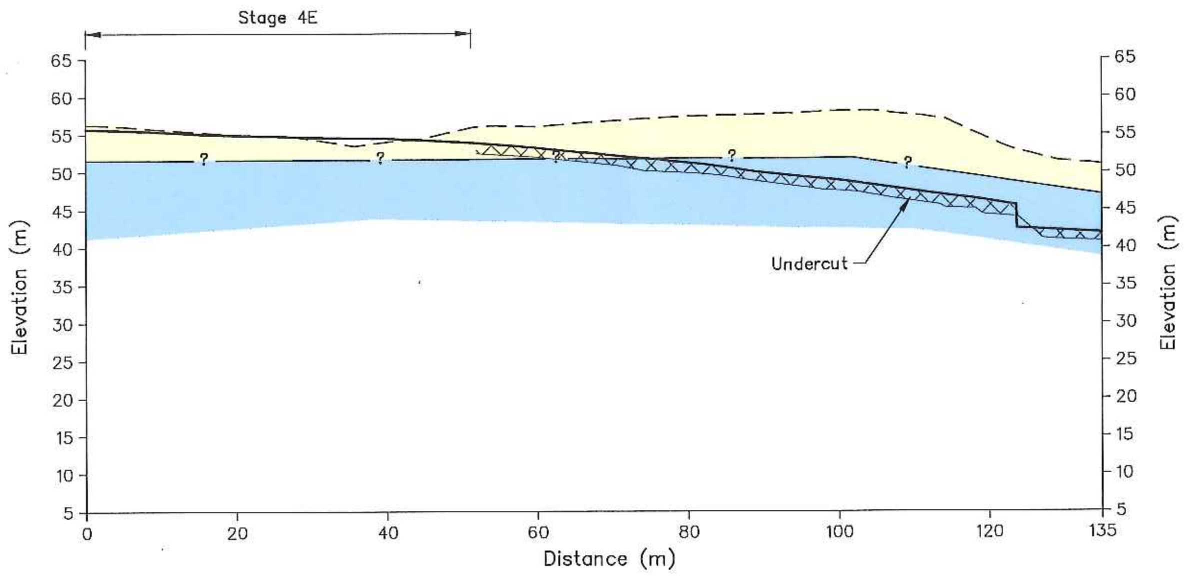
REFERENCE :

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

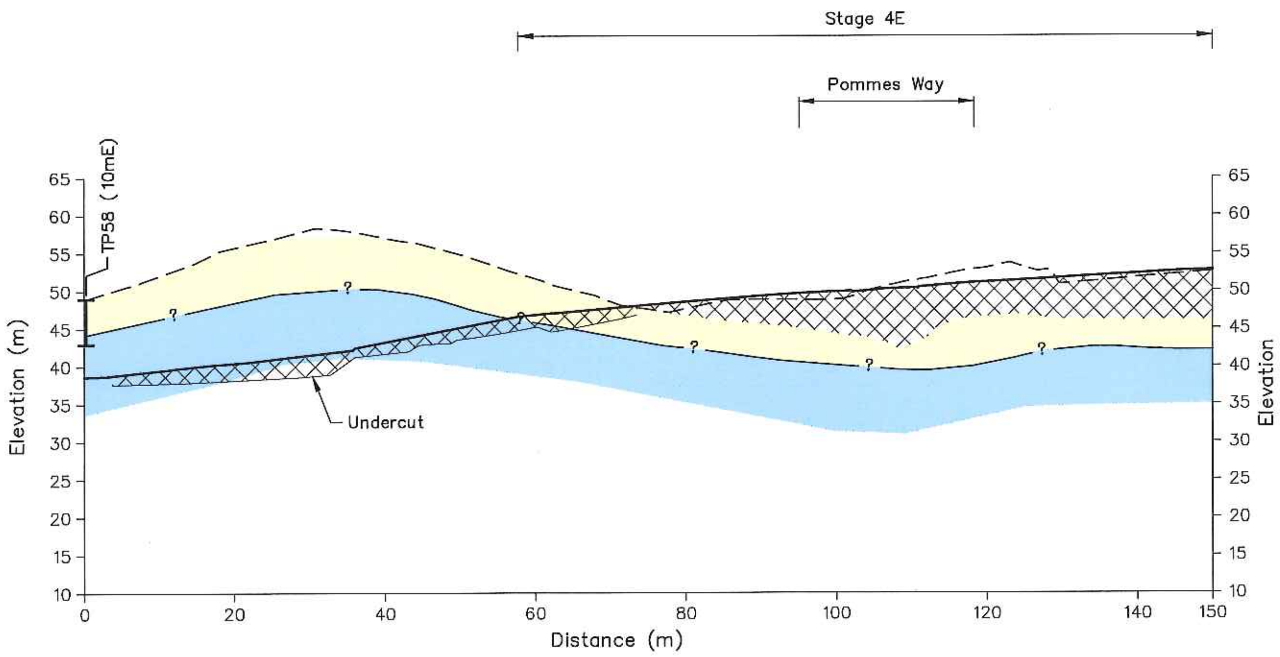
CLIENT, PROJECT
WFH PROPERTIES LTD
RESIDENTIAL SUBDIVISION

TITLE
MILLWATER - PRECINCT 2 (STAGE 4E)
Geotechnical Works Subsoil Drain Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1000	21854.001-P2S4E-102	1



SECTION 6/101
SCALE 1:1000



SECTION 7/101
SCALE 1:1000

LEGEND

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

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 :	JXXL	Jul. 17
DRAWN :	JC	Jul. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		

CADFILE : \\21854.001-P2S4E-103_104.dwg
APPROVED :
NOT FOR CONSTRUCTION
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 metres unless noted otherwise.

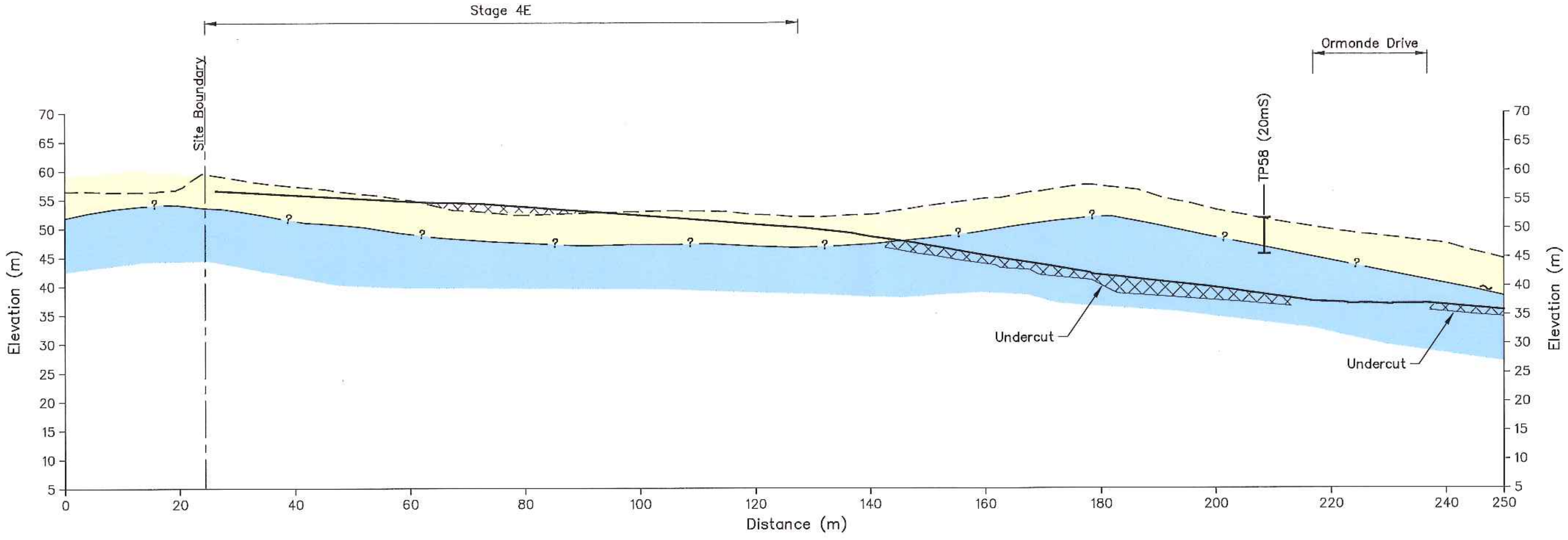
REFERENCE :

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

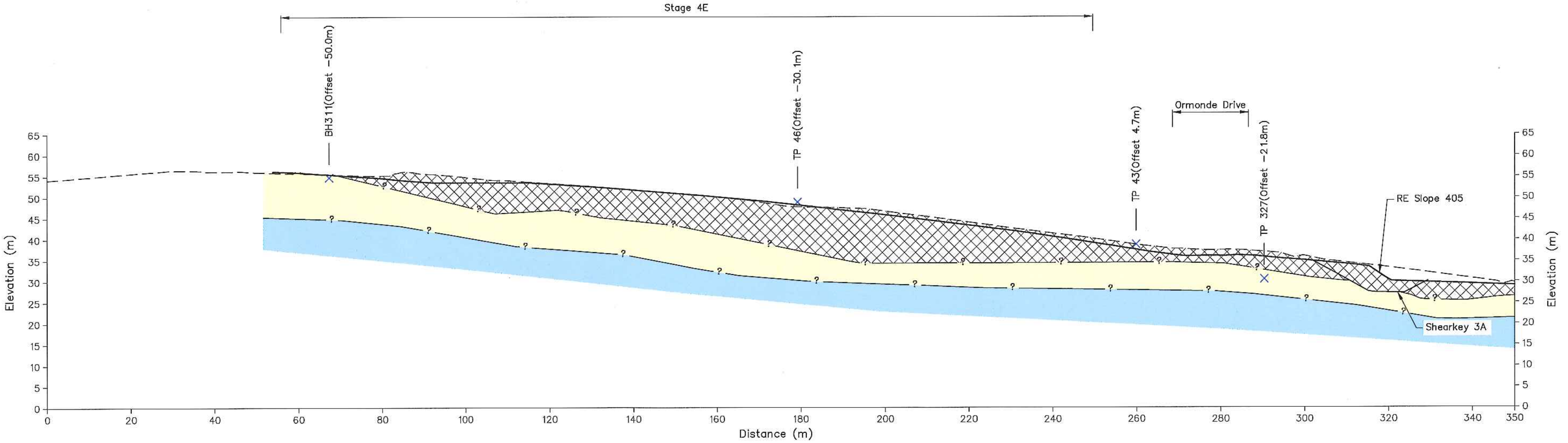
TITLE
MILLWATER – PRECINCT 2 (STAGE 4E)
Geogical Cross Sections 6 & 7

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S4E-103
REV. 1



SECTION 8/101
SCALE 1: 1000

LEGEND	
▨	Engineered Fill
🟪	Alluvium
🟨	Northland Allochthon Residual Soil
🟦	Northland Allochthon Rock
- - - - - -	Original Ground Level
———	Finished Ground Level
——?——	Inferred geology interface



SECTION 18/101
SCALE 1: 1000

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 :	JXXL	Jul. 17
DRAWN :	JC	Jul. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		

CADFILE : \\21854.001-P2S4E-103_104.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 metres unless noted otherwise.

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 4E)
Geoqical Cross Sections 8 & 18

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S4E-104
REV. 1

Appendix B: Contractors Certificates

- **Hick Bros Ltd – Sixth Schedule (Bulk Earthworks – Stage 3)**
- **Hibiscus Contractors Ltd – Sixth Schedule (Civil Earthworks)**

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

Schedule 6 – Form of Producer Statement – Construction

ISSUED BY HIBISCUS CONTRACTORS LTD (Contractor)

TO WFH PROPERTIES Ltd (Principal)

MILWATER PRICINCT 2 STAGE 4E

IN RESPECT OF CONTRACT 33222-01 (Description of Contract Works)

AT MILWATER PRICINCT 2 STAGE 4E (Address)

HIBISCUS CONTRACTORS 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 4E ('the Contract')

I ...Bryn Morgan............... *(Duly Authorised Agent)* a duly authorised representative of HIBISCUS CONTRACTORS LTD *(Contractor)* believe on reasonable grounds that HIBISCUS CONTRACTORS 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 **24/05/2017**

(Contractor) Hibiscus Contractors Ltd

(Address)

P.O.Box 153,Silverdale,Auckland,New Zealand

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 to H1 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.

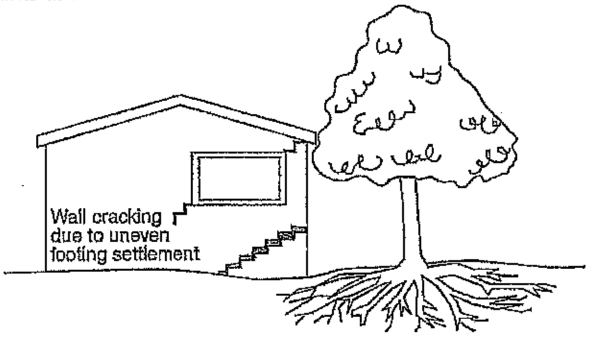
Seasonal swelling/shrinkage in clay

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

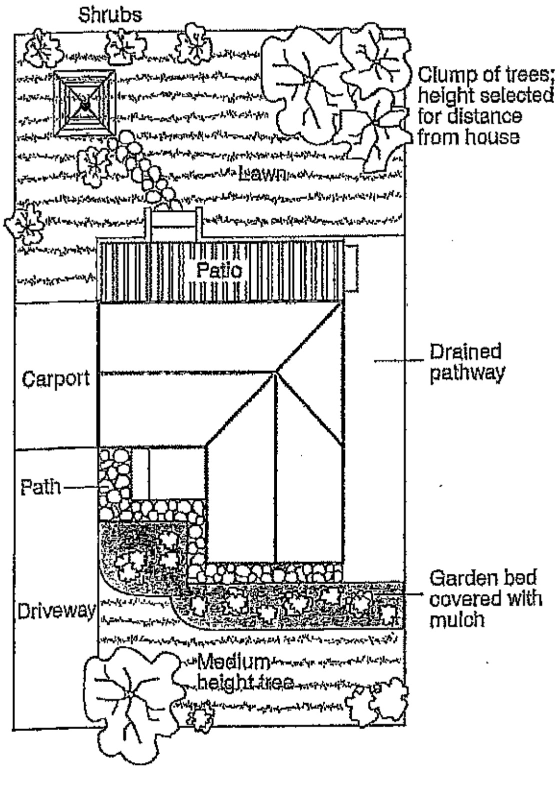
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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.

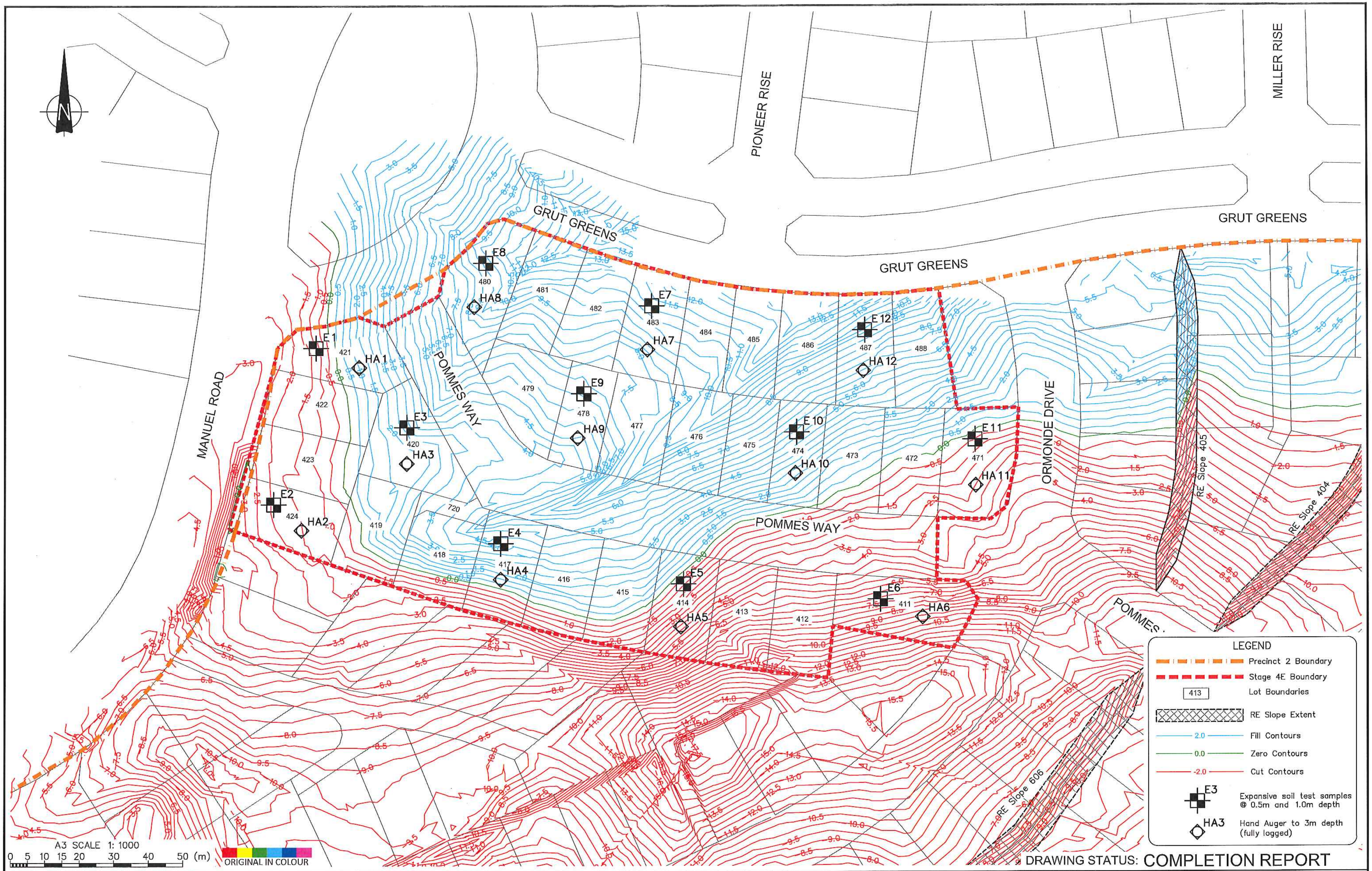
Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking 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 formightly.

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

Distributed by
CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia
Freecall 1800 645 051 Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au
Email: publishing.sales@csiro.au

Appendix E: Test Results

- 21854.001–P2S4E–111 Post Earthworks Investigation Plan
- 21854.001–P2S4E–112 Topsoil Depth Plan
- 21854.001–P2S4E–113 Earthworks Testing Location Plan
- Soil Expansion Test Results
- Post Earthworks Investigation Borehole Logs (BH E1 to BH E12)
- Earthworks Test Results



DRAWING STATUS: COMPLETION REPORT

REV.	REVISION DESCRIPTION	BY	DATE
1	Completion Report Issue		

DESIGNED : JXXL Jul. 17
DRAWN : JC Jul. 17
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\21854.001-P2S4E-111.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.
2. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946
3. As-built plan supplied by WOODS reference "33222-04E-100-AB FINAL CONTOURS.dwg" & "33222-04E-110-AB CUT FILL CONTOURS.dwg", dated July 2017.
4. Undercuts, shearkey & subsoil drains supplied by WOODS, reference "33222-04E-120-AB SK UC & SUBSOIL.dwg", dated July 2017.

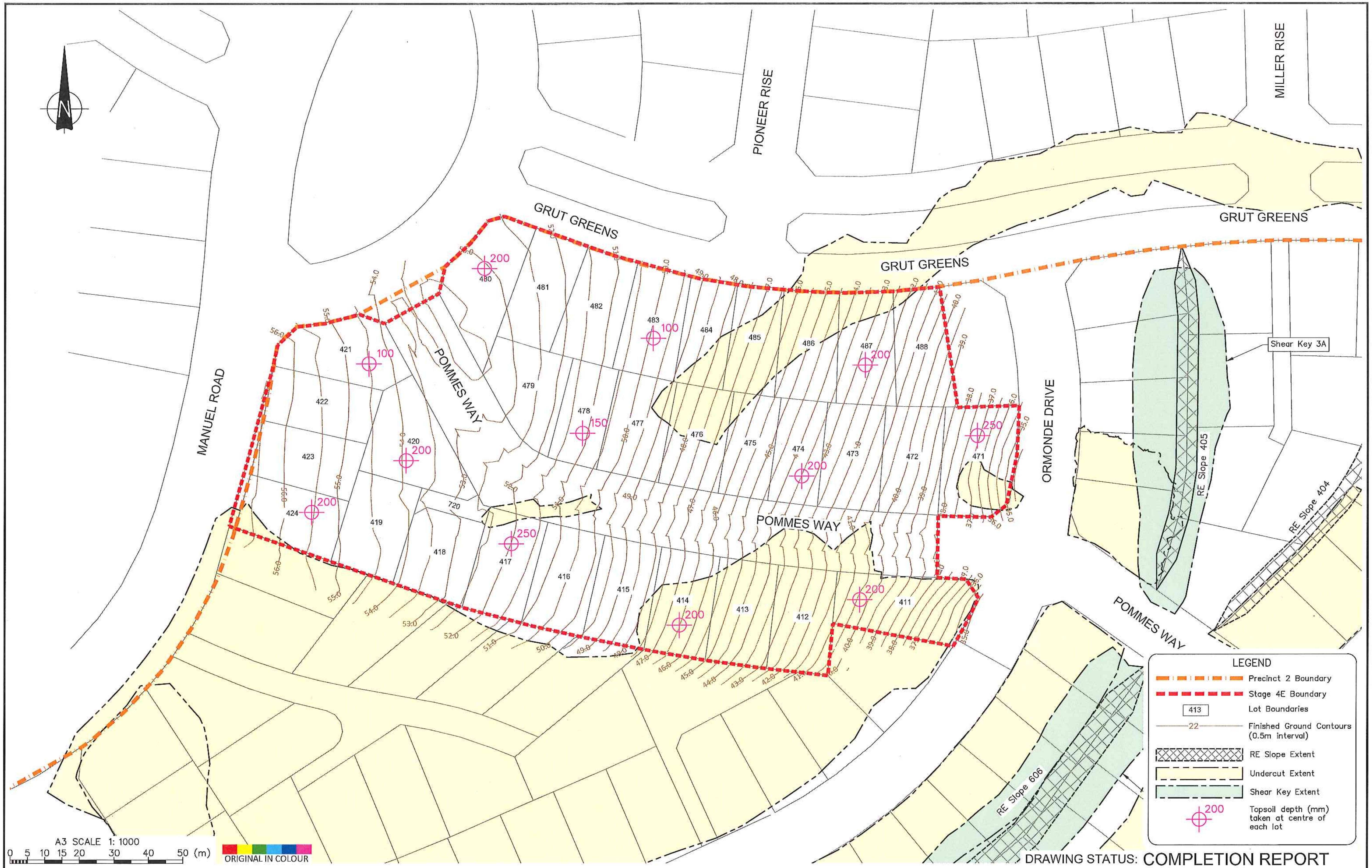
REFERENCE :

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 4E)
Post Earthworks Investigation Plan

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.001-P2S4E-111
REV. 1



DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue		
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	JXXL	Jul. 17
DRAWN :	JC	Jul. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		

CADFILE : \\21854.001-P2S4E-112.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.
2. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946
3. As-built plan supplied by WOODS reference "33222-04E-100-AB FINAL CONTOURS.dwg" & "33222-04E-110-AB CUT FILL CONTOURS.dwg", dated July 2017.
4. Undercuts, shearkey & subsoil drains supplied by WOODS, reference "33222-04E-120-AB SK UC & SUBSOIL.dwg", dated July 2017.

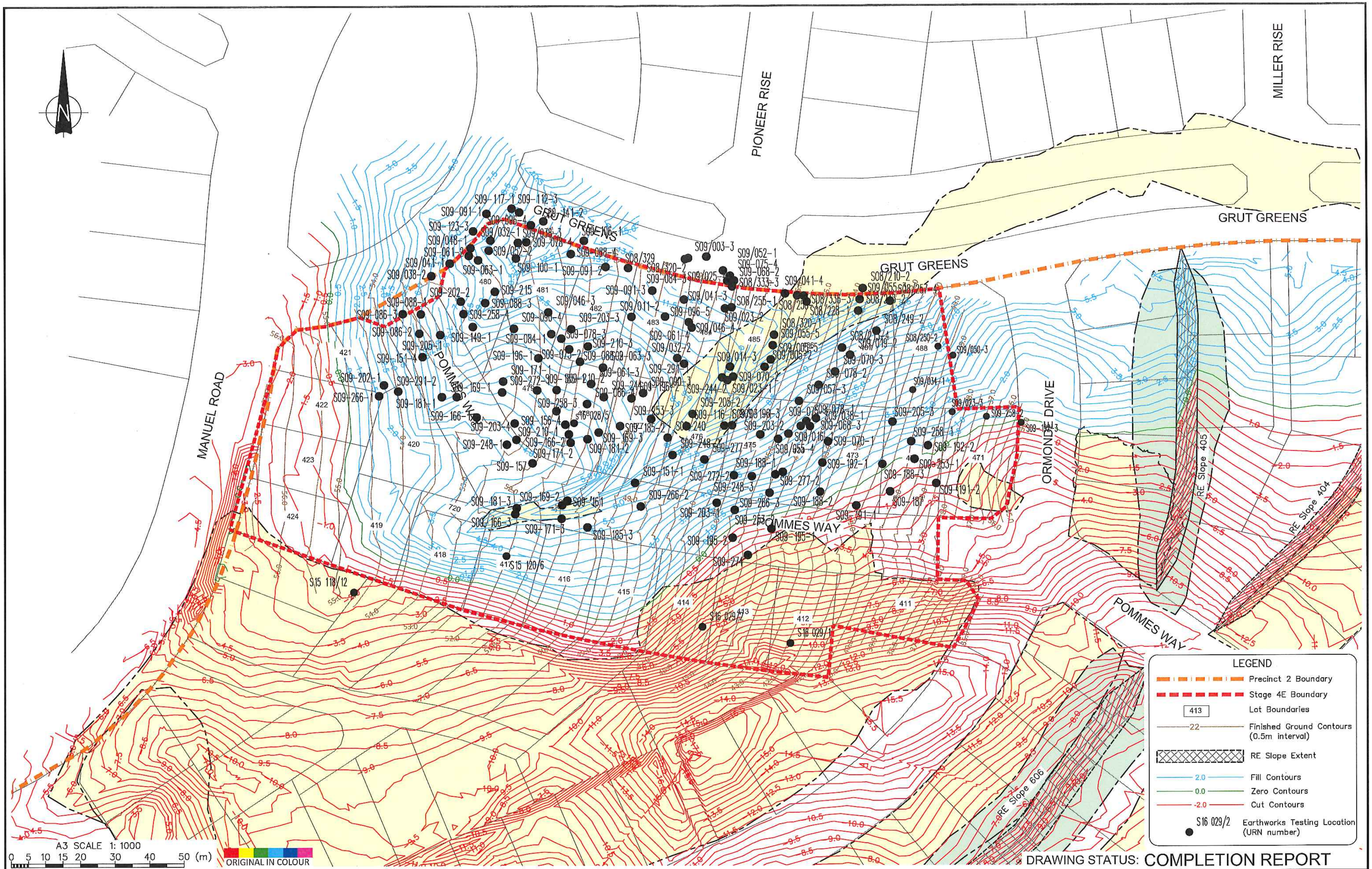
REFERENCE :

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 4E)
Topsoil Depths Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1000	21854.001-P2S4E-112	1



DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue		
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	JXXL	Jul. 17
DRAWN :	JC	Jul. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.001-P2S4E-113.dwg		
APPROVED : NOT FOR CONSTRUCTION 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. Coordinate Datum: NZGD2000, New Zealand Transverse Mercator (NZTM2000). Level Datum: LINZ (MSL) Auckland Vertical Datum 1946
3. As-built plan supplied by WOODS reference "33222-04E-100-AB FINAL CONTOURS.dwg" & "33222-04E-110-AB CUT FILL CONTOURS.dwg", dated July 2017.
4. Undercuts, shearkey & subsoil drains supplied by WOODS, reference "33222-04E-120-AB SK UC & SUBSOIL.dwg", dated July 2017.

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 4E)
Earthworks Testing Location Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1000	21854.001-P2S4E-113	1

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Site: **Precinct 2, Stage 4E, Millwater**

Page 1 of 3

Your Job No: 21854.001
Our Job No: 1002124.0000.0.0

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

Sample No.:			**E1**	**E1**	**E2**	**E2**	**E3**	**E3**	**E4**	**E4**
DEPTH		(m)	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		**(kPa)**	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	19.7	19.8	27.7	24.2	23.1	28.9	26.4	23.5
	Bulk Density	(t/m³)	1.96	1.90	1.85	1.93	1.98	1.90	1.91	1.97
	Dry Density	(t/m³)	1.64	1.59	1.45	1.55	1.61	1.47	1.51	1.60
	Final Water Content	(%)	21.0	23.2	30.0	26.9	24.5	29.9	28.9	25.6
	Swelling Strain	(%)	0.03	-0.04	0.23	0.22	0.29	0.06	-0.26	0.33
SHRINKAGE TEST	Initial Water Content	(%)	13.6	16.8	29.0	23.1	22.4	27.2	29.7	24.4
	Estimated Shrinkage Limit	(%)	5.5	7.0	14.3	11.9	10.6	15.1	10.5	9.3
	Shrinkage Strain	(%)	0.9	2.1	2.6	3.4	2.8	6.4	5.3	3.2
	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		Minor	Major	Major	Major	Moderate	Moderate	Moderate	Major
SHRINK - SWELL INDEX		**(%)**	**0.5**	**1.2**	**1.5**	**1.9**	**1.6**	**3.6**	**2.9**	**1.9**

Remarks: The test results are IANZ accredited.

Entered by: ST Date: 9/06/2017 Checked by: JK Date: 9/06/2017

Site: **Precinct 2, Stage 4E, Millwater**

Page 2 of 3

Your Job No: 21854.001
Our Job No: 1002124.0000.0.0

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

Sample No.:			**E5**	**E5**	**E6**	**E6**	**E7**	**E7**	**E8**	**E8**
DEPTH		(m)	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		(kPa)	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	32.6	32.7	27.8	24.3	29.8	15.2	16.5	14.3
	Bulk Density	(t/m³)	1.84	1.86	1.92	1.91	1.86	2.15	2.09	1.94
	Dry Density	(t/m³)	1.39	1.40	1.50	1.54	1.43	1.87	1.79	1.70
	Final Water Content	(%)	33.8	33.6	29.2	26.7	31.5	17.0	18.0	15.0
	Swelling Strain	(%)	0.02	0.11	0.18	0.12	0.01	0.03	0.22	0.19
SHRINKAGE TEST	Initial Water Content	(%)	34.3	23.5	26.8	27.6	29.2	14.4	20.2	22.3
	Estimated Shrinkage Limit	(%)	12.7	12.4	16.4	8.8	9.9	8.1	7.7	8.6
	Shrinkage Strain	(%)	7.4	4.3	4.0	4.9	3.3	1.0	2.9	2.6
	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		(%)	**4.1**	**2.4**	**2.3**	**2.7**	**1.8**	**0.6**	**1.7**	**1.5**

Remarks: The test results are IANZ accredited.

Entered by: ST Date: 9/06/2017 Checked by: JK Date: 9/06/2017

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Site: **Precinct 2, Stage 4E, Millwater**

Your Job No: 21854.001
Our Job No: 1002124.0000.0.0

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

Sample No.:			**E9**	**E9**	**E10**	**E10**	**E11**	**E11**	**E12**	**E12**
DEPTH		**(m)**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		**(kPa)**	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	25.5	29.4	14.5	15.6	41.0	39.5	16.4	16.7
	Bulk Density	(t/m³)	1.94	2.00	2.10	2.07	1.77	1.72	2.01	1.76
	Dry Density	(t/m³)	1.55	1.55	1.83	1.79	1.26	1.23	1.73	1.51
	Final Water Content	(%)	27.0	30.1	16.0	17.3	45.1	42.9	19.0	18.5
	Swelling Strain	(%)	0.02	0.29	0.20	0.20	0.57	0.04	0.10	-1.71
SHRINKAGE TEST	Initial Water Content	(%)	21.5	25.4	17.6	22.4	30.0	46.1	19.1	20.4
	Estimated Shrinkage Limit	(%)	8.9	11.3	6.6	9.0	12.0	21.9	7.1	8.2
	Shrinkage Strain	(%)	3.2	4.0	2.5	2.2	4.0	9.3	2.3	2.3
	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		**(%)**	**1.8**	**2.3**	**1.5**	**1.3**	**2.4**	**5.2**	**1.3**	**0.8**

Remarks: The test results are IANZ accredited.

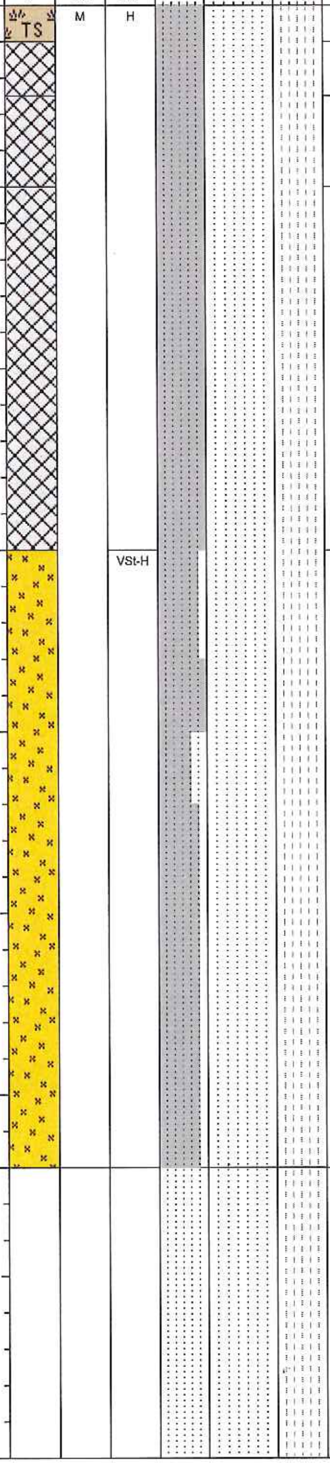
Entered by: ST   Date: 9/06/2017   Checked by: JK   Date: 9/06/2017

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E1 (421)**
Hole Location: Refer to site plan
SHEET: 1 OF 1

PROJECT: P2S4 2017	LOCATION: Millwater Precinct 2	JOB No.: 21854.001 P2S4
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 03/04/2017
		HOLE FINISHED: 03/04/2017
R.L.:	DRILL METHOD: HA	DRILLED BY: Geotechnics Ltd
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED: AJL



GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	ENGINEERING DESCRIPTION Description and Additional Observations
Fill										TS	M	H				SILT, non plastic, moist, dark brown
																clayey SILT, low plasticity, moist, yellowish brown and grey
						● UTP										SILT, non plastic, moist, grey, with fine gravel (siltstone)
						● >211 kPa										clayey SILT, low plasticity, moist, yellowish brown, and SILT, non plastic, grey with fine silstone gravel
						● >211 kPa			1							
						● >211 kPa										
Residual Soil						● 193/42 kPa						VSt-H				SILT, non plastic, moist, yellowish brown and light whitish grey
																1.80m: yellowish brown, and brown with light reddish tint
						● >211 kPa			2							
						● 84/15 kPa										*2.20m:* light whitish brown and light yellowish brown
						● 148/39 kPa										
						● 112/32 kPa										
		03/04/2017 Dry				● 113/21 kPa			3							
																3.2m: Target depth

COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

BoreLog - 14/07/2017 10:18:01 a.m. - Produced with Core-GS by GeRoc

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E2 (424)**

Hole Location: Refer to site plan

SHEET: **1 OF 1**

PROJECT: P2S4 2017	LOCATION: Millwater Precinct 2	JOB No.: 21854.001 P2S4
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 03/04/2017
R.L.:	DRILL METHOD: HA	HOLE FINISHED: 03/04/2017
		DRILLED BY: Geotechnics Ltd
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED: AJL

GEOLOGICAL									ENGINEERING DESCRIPTION						
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	Description and Additional Observations
Fill										TS	M	H				SILT, non plastic, moist, brown
						● >211 kPa										SILT, minor clay, non plastic, moist, light yellowish brown mottled light greyish white, minor grey inclusions
						● >211 kPa ● UTP ● 193/65 kPa			1			VSt-H				SILT, non plastic, moist, grey, with fine siltstone gravel, minor orange brown inclusions *1.00m:* grey and yellowish brown
Hukerenui Mudstone		03/04/2017 Dry				● UTP					D-M	H				SILT, non plastic, moist then dry, grey
									2							1.5m: Refusal
									3							

COMMENTS:

Hole Depth
1.5m

Scale 1:20

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: E3 (420)

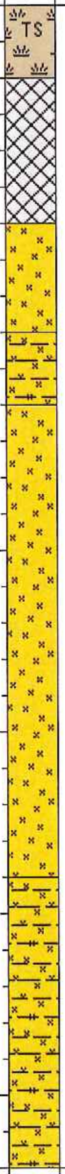
Hole Location: Refer to site plan

SHEET: 1 OF 1

PROJECT: P2S4 2017	LOCATION: Millwater Precinct 2	JOB No.: 21854.001 P2S4
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 03/04/2017
	DRILL METHOD: HA	HOLE FINISHED: 03/04/2017
R.L.:		DRILLED BY: Geotechnics Ltd
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED: AJL

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	Description and Additional Observations
Fill										TS	M	VSt				SILT, minor clay, low to no plasticity, moist, dark brown
						● 155/69 kPa										clayey SILT, low to medium plasticity, moist, yellowish brown, with grey inclusions
						● 199/69 kPa										SILT, minor clay, low to no plasticity, moist, grey and yellowish brown
						● 86/24 kPa			1			St				clayey SILT, low to medium plasticity, moist, grey and yellowish brown
						● >211 kPa						VSt-H				SILT, minor clay, gravelly, non plastic, moist, grey, with yellowish brown inclusions. Gravel is fine grained, mudstone
						● 184/75 kPa										
						● >211 kPa			2							
						● UTP										
Residual Soil						● 154/77 kPa						St-VSt				clayey SILT, low to medium plasticity, moist, yellowish brown and light greyish white
						● 133/77 kPa										
		03/04/2017 Dry				● 92/51 kPa			3							
																3.2m: Target depth



COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E4 (427)**
Hole Location: Refer to site plan
SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4

CO-ORDINATES:
R.L.:
DATUM:
DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:
HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
DRILLED BY: Geotechnics Ltd
LOGGED BY: rbe
CHECKED: AJL

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION: Fill

FLUID LOSS (%) 25 50 75 | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACINGS (cm) 20 60 200 600 2000 | Description and Additional Observations

WATER: 03/04/2017 Dry

TESTS	DEPTH (m)
● >211 kPa	
● 84/48 kPa	
● >211 kPa	
	1
● 145/71 kPa	
● 155/68 kPa	
● UTP	
	2
● >211 kPa	
● UTP	
● UTP	
● UTP	3

GRAPHIC LOG	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
TS	M	H	SILT, some clay, low to no plasticity, moist, dark brown
		VSt-H	clayey SILT, and SILT, low plasticity, moist yellowish brown and grey
		VSt	SILT, some clay, low to no plasticity, moist, grey and yellowish brown
			SILT, non plastic, moist, yellowish orange brown and light greyish white, with grey inclusions
		H	SILT, non plastic, moist, grey with yellowish brown inclusions
	D-M		SILT, non plastic, dry to moist, grey, withy minor yellowish brown inclusions

3.1m: Target depth

COMMENTS:

Hole Depth
3.1m

Scale 1:20

Rev.: A

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E5 (414)**

Hole Location: Refer to site plan

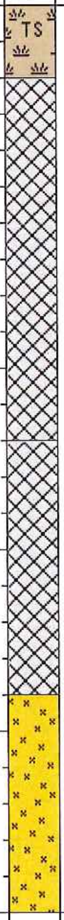
SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4

CO-ORDINATES:
R.L.:
DATUM:

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

HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
DRILLED BY: Geotechnics Ltd
LOGGED BY: rbe
CHECKED: AJL



GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	ENGINEERING DESCRIPTION Description and Additional Observations
Fill										TS	M	VSt				SILT, non plastic, moist, dark brown
						● 151/81 kPa ● 127/44 kPa ● 81/36 kPa			1			St-VSt				clayey SILT, low plasticity, moist, yellowish brown and grey *0.60m:* medium plasticity
						● UTP ● 154/63 kPa ● 163/29 kPa						VSt				SILT, non plastic, moist, light greyish white, grey and yellowish brown
Hukerenui Mudstone		03/04/2017 Dry				● UTP ● UTP			2			H				SILT, non plastic, dry to moist, grey, very hard to auger
									3							2.5m: Effective refusal

COMMENTS:

Hole Depth
2.5m

Scale 1:20

Rev.: A

BoreLog - 14/07/2017 10:18:01 a.m. - Produced with Core-GS by GeRoc

GEOTECHNICS

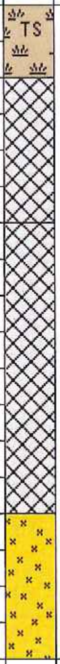
BOREHOLE LOG

BOREHOLE No.: **E6 (411)**

Hole Location: Refer to site plan

SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
R.L.:
DRILL METHOD: HA
DRILLED BY: Geotechnics Ltd
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED: AJL



GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	ENGINEERING DESCRIPTION Description and Additional Observations
Fill										TS	M	VSt				SILT, non plastic, moist, brown
						● 200/75 kPa										clayey SILT, low plasticity, moist, yellowish brown with grey inclusions
						● 161/80 kPa ● 193/95 kPa ● 137/66 kPa			1							SILT, minor clay, non plastic, moist, yellowish brown and grey, and SILT, non plastic, grey
Hukerenui Mudstone		03/04/2017 Dry				● UTP						H				SILT, non plastic, moist, grey, becoming dry to moist, very hard to auger
						● UTP			2 3							1.8m: Effective refusal

COMMENTS:

Hole Depth
1.8m

Scale 1:20

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E7 (483)**

Hole Location: Refer to site plan

SHEET: 1 OF 1

PROJECT: P2S4 2017	LOCATION: Millwater Precinct 2	JOB No.: 21854.001 P2S4
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 03/04/2017
R.L.:	DRILL METHOD: HA	HOLE FINISHED: 03/04/2017
		DRILLED BY: Geotechnics Ltd
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED: AJL

GEOLOGICAL										ENGINEERING DESCRIPTION						
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	Description and Additional Observations
Fill										TS	M	VSt				SILT, non plastic, moist, dark brown
						● 143/54 kPa										SILT, some clay, low plasticity, moist, yellowish brown and light greyish white
						● UTP						H				SILT, minor clay, non plastic, grey, minor yellowish brown inclusions; abundant fine siltstone gravel (crushed siltstone)
						● UTP										
									1							
						● 134/63 kPa						VSt				SILT, some clay, low plasticity, moist, grey with minor yellowish brown inclusions
						● 196/51 kPa						H				SILT, gravelly, moist, grey (crushed siltstone)
						● UTP										
									2							
						● >211 kPa										
						● >211 kPa										
																SILT, non plastic, moist, grey with yellowish brown and orange brown inclusions
		03/04/2017 Dry				● >211 kPa										
						● UTP			3							3m: Target depth

COMMENTS:

Hole Depth
3m

Scale 1:20

Rev.: A

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E8 (480)**

Hole Location: Refer to site plan

SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4

CO-ORDINATES:
R.L.:
DATUM:

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

HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
DRILLED BY: Geotechnics Ltd
LOGGED BY: rbe
CHECKED: AJL

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	WATER	TESTS	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
Fill				TS	M	H	SILT, some clay, non plastic, wet, dark brown
		● UTP ● 169/93 kPa ● UTP	1			VSt-H	SILT, non plastic, moist, grey with minor yellowish brown inclusions *0.70m:* fine siltstone gravel, grey
		● 122/62 kPa ● UTP			D-M		SILT, abundant fine siltstone gravel, non plastic, dry to moist, grey
		● UTP				H	SILT, non plastic, moist to dry, yellowish brown, light greyish white and grey
Hukerenui Mudstone	03/04/2017 Dry	● UTP	2		D		SILT, non plastic, dry, friable, grey. Solid refusal at bottom of hole
			3				2.2m: Refusal

Other columns: FLUID LOSS (%) 25 50 75; CORE RECOVERY (%); METHOD; CASING; SAMPLES; RL (m); SHEAR STRENGTH (kPa) 10 25 50 100 200; COMPRESSIVE STRENGTH (MPa) 1 5 25 50 100 250; DEFECT SPACING (cm) 20 60 200 600 2000

COMMENTS:

Hole Depth
2.2m

Scale 1:20

Rev.: A

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E9 (478)**

Hole Location: Refer to site plan

SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4

CO-ORDINATES:
R.L.:
DATUM:

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

HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
DRILLED BY: Geotechnics Ltd
LOGGED BY: rbe
CHECKED: AJL

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	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 (cm) 20 60 200 600 2000	ENGINEERING DESCRIPTION Description and Additional Observations
Fill										TS	M	St				SILT, some clay, non plastic, moist, dark brown
						● 62/21 kPa										clayey SILT, low plasticity, moist, yellowish brown
												VSt				SILT, non plastic, moist, grey, abundant fine siltstone gravel
						● 136/41 kPa ● 145/51 kPa										clayey SILT, low plasticity, moist, light greyish brown and grey
						● 161/68 kPa ● 125/41 kPa			1			VSt-H				SILT, some clay, low to no plasticity, moist, yellowish brown and grey
						● UTP										*1.80m:* abundant fine siltstone gravel, trace yellowish clayey silt (crushed siltstone)
		03/04/2017 Dry				● UTP ● UTP ● UTP			2							
									3							2.8m: Effective refusal

COMMENTS:

Hole Depth
2.8m

Scale 1:20

Rev.: A

GEOTECHNICS

BOREHOLE LOG

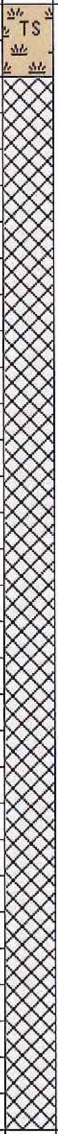
BOREHOLE No.: **E10 (474)**
Hole Location: Refer to site plan
SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
DRILL METHOD: HA
R.L.:
DRILLED BY: Geotechnics Ltd
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED: AJL

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.

FLUID LOSS (%) 25 50 75 | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | 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 (cm) 20 60 200 600 2000 | Description and Additional Observations



Water	Tests	Depth (m)	Description and Additional Observations
			SILT, some clay, non plastic, moist, dark brown
	● UTP		clayey SILT, and SILT, low to no plasticity, moist, light greyish white, grey and yellowish brown *0.30m:* dry to moist, grey with minor yellowish brown inclusions, abundant fine siltstone gravel
	● 154/53 kPa		
	● 151/77 kPa		
		1	
	● >211 kPa		
	● UTP		
	● UTP		
		2	
	● UTP		
	● 131/60 kPa		
	● UTP		
03/04/2017 Dry	● 139/63 kPa	3	
			3.1m: Target depth

COMMENTS:

Hole Depth
3.1m

Scale 1:20

Rev.: A

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E11 (471)**

Hole Location: Refer to site plan

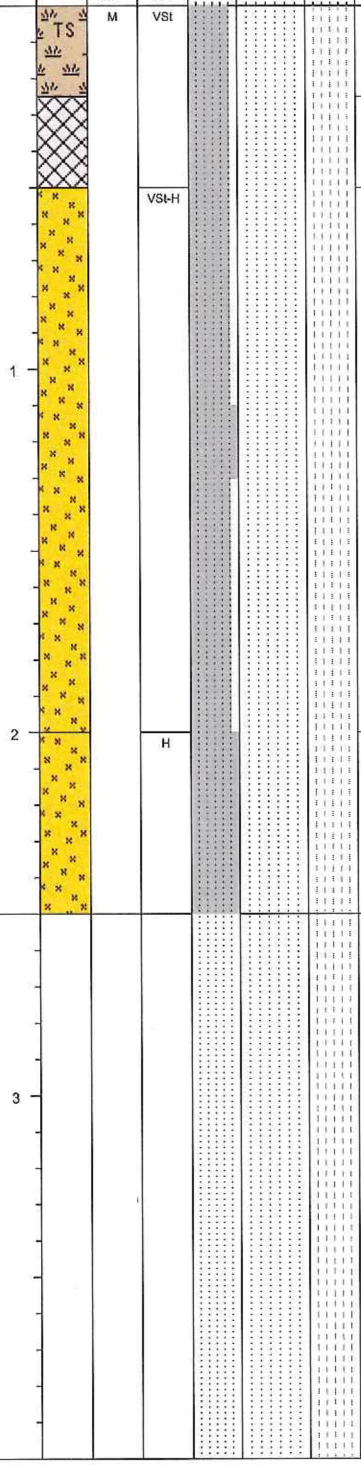
SHEET: 1 OF 1

PROJECT: P2S4 2017	LOCATION: Millwater Precinct 2	JOB No.: 21854.001 P2S4
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 03/04/2017
		HOLE FINISHED: 03/04/2017
R.L.:	DRILL METHOD: HA	DRILLED BY: Geotechnics Ltd
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED: AJL

GEOLOGICAL		ENGINEERING DESCRIPTION		
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION	TESTS	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
Fill		M	VSt	SILT, some clay, non plastic, moist, dark brown
	● 203/93 kPa			clayey SILT, low plasticity, moist, yellowish brown and grey
Residual Soil	● 133/54 kPa ● 133/51 kPa ● >211 kPa ● 133/39 kPa ● 124/54 kPa		VSt-H	SILT, non plastic, moist, yellowish brown and light greyish white *1.20m:* light brown mottled yellowish brown *1.40m:* low to no plasticity, light grey mottled yellowish brown and orange brown
Hukerenui Mudstone	● UTP ● UTP		H	SILT, low to no plasticity, moist, grey; very hard to auger
				2.5m: Effective refusal

WATER: 03/04/2017 Dry

Column headings: 25 50 75 FLUID LOSS (%) · WATER · CORE RECOVERY (%) · METHOD · CASING · TESTS · SAMPLES · RL (m) · DEPTH (m) · GRAPHIC LOG · 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 (m) 20 60 200 600 2000



COMMENTS:

Hole Depth
2.5m

Scale 1:20

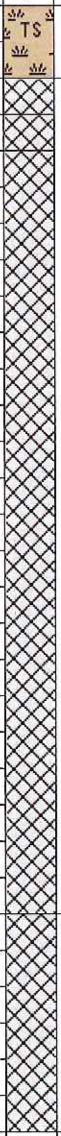
Rev.: A

GEOTECHNICS

BOREHOLE LOG

BOREHOLE No.: **E12 (487)**
Hole Location: Refer to site plan
SHEET: 1 OF 1

PROJECT: P2S4 2017
LOCATION: Millwater Precinct 2
JOB No.: 21854.001 P2S4
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 03/04/2017
HOLE FINISHED: 03/04/2017
R.L.:
DRILL METHOD: HA
DRILLED BY: Geotechnics Ltd
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED: AJL



GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	WATER	TESTS	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
				TS	M-W	H	SILT, some clay, low to no plasticity, moist to wet, dark brown
		● >211 kPa			M		clayey SILT, low plasticity, moist, yellowish brown and grey
						VSt-H	clayey SILT, and SILT, low to no plasticity, moist, yellowish brown and grey
							SILT, non plastic, moist, grey, minor yellowish brown inclusions
		● UTP					*0.60m:* dry to moist, abundant fine siltstone gravel
		● UTP	1				*1.00m:* yellowish brown inclusions
		● UTP					*1.40m:* moist, grey and yellowish brown
Fill		● 169/93 kPa					
		● >211 kPa	2				
		● 134/62 kPa					
		● UTP					
					D-M		SILT, non plastic, dry to moist, grey with minor yellowish brown inclusions
		● UTP					
	03/04/2017 Dry	● 193/83 kPa	3				*3.00m:* yellowish brown and grey
							3.1m: Target depth

Other columns (blank): FLUID LOSS (%) 25 50 75; CORE RECOVERY (%); METHOD; CASING; SAMPLES; RL (m); SHEAR STRENGTH (kPa) 10 25 50 100 200; COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250; DEFECT SPACING (cm) 20 60 200 600 2000

COMMENTS:

Hole Depth
3.1m

Scale 1:20

Rev.: A

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL

Page of

URN	New No.	Northing	Easting	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) Test 1	Test 2	Test 3	Test 4	Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 120 kPa and < 10 % Air Voids)	Comments
SO8/210-2	241	830069.278	391902.963	HC	18/02/2009	1.84	**1.47**	25.8	2.7	**7.9**	125	156	218	101	**150**		p	
						1.84	**1.46**	25.8	2.7	**8.1**								
SO8/213-4	245	830052.061	391897.316	HC	19/02/2009	-	-	23.9	2.7	-	218	218	218	218	**218**		p	
						-	-	23.9	2.7	-								
SO8/228-1	259	830065.147	391886.846	HC	25/02/2009	1.96	**1.76**	11.0	2.7	**15.4**	utp	utp	utp	utp	**utp**		f	
						1.94	**1.75**	11.0	2.7	**15.9**								
SO8/243-2	281	830062.754	391901.797	HC	5/03/2009	1.95	**1.51**	29.0	2.7	**0.2**	utp	utp	utp	utp	**utp**		p	
						1.95	**1.51**	29.0	2.7	**0.3**								
SO8/249-2	294	830057.062	391907.114	HC	11/03/2009	2.02	**1.68**	19.7	2.7	**4.4**	158	200	218	utp	**192**		p	
						2.01	**1.68**	19.7	2.7	**4.7**								
SO8/250-1	297	830066.889	391884.010	HC	11/03/2009	1.97	**1.69**	17.0	2.7	**9.0**	187	203	218	200	**202**		p	
						1.97	**1.69**	17.0	2.7	**9.0**								
SO8/250-2	298	830052.830	391925.102			2.06	**1.73**	19.0	2.7	**3.1**	218	utp	utp	utp	**218**		p	
						2.05	**1.72**	19.0	2.7	**3.6**								
SO8/255-1	308	830063.201	391865.084	HC	16/03/2009	2.05	-	-	2.7	-	utp	utp	utp	utp	**utp**		p	
						2.03	-	-	2.7	-								
SO8/257-4	316	830065.741	391910.936	HC	17/03/2009	1.92	**1.47**	30.1	2.7	**1.1**	utp	utp	utp	utp	**utp**		p	
						1.92	**1.47**	30.1	2.7	**0.9**								
SO8/320-1	420	830055.456	391877.544	HC	14/04/2009	1.88	**1.43**	31.3	2.7	**2.1**	218	156	218	140	**183**		p	
						1.88	**1.43**	31.3	2.7	**2.4**								
SO8/320-2	421	830076.922	391851.402			1.98	**1.66**	19.7	2.7	**6.0**	utp	utp	utp	utp	**utp**		p	
						1.98	**1.65**	19.7	2.7	**6.1**								
SO8/329	433	830074.084	391834.958	HC	16/04/2009	1.93	**1.41**	36.3	2.7	**0.0**	utp	utp	utp	utp	**utp**		p	
						1.93	**1.42**	36.3	2.7	**0.0**								
SO8/333-3	436	830069.203	391865.161	HC	17/04/2009	2.04	**1.78**	14.8	2.7	**7.8**	utp	utp	utp	utp	**utp**		p	
						2.04	**1.78**	14.8	2.7	**8.0**								
SO8/336-3	440	830066.828	391885.912	HC	21/04/2009	1.96	**1.58**	23.9	2.7	**3.5**	utp	utp	utp	utp	**utp**		p	
						1.96	**1.58**	23.9	2.7	**3.8**								
SO9/003-1	494	830152.239	391895.862	HC	14/10/2009	2.10	**1.85**	13.5	2.7	**6.4**	utp	utp	utp	utp	**utp**		P	
						2.10	**1.85**	13.5	2.7	**6.5**								
SO9/003-3	496	830077.748	391857.585	HC	14/10/2009	2.09	**1.82**	14.9	2.7	**5.6**	utp	utp	utp	utp	**utp**		P	
						2.11	**1.83**	14.9	2.7	**4.9**								
SO9/005-2	498	830046.201	391874.934	HC	20/10/2009	2.04	**1.72**	18.9	2.7	**3.9**	145	162	96	96	**125**		F	
						2.03	**1.71**	18.9	2.7	**4.3**								
SO9/005-5	501	830048.338	391876.690			-	-	-	-	-	226	226	226	162	**210**	**Y**	P	Retesting S09/005-2
						-	-	-	-	-								
SO9/011-2	507	830060.007	391836.147	HC	22/10/2009	2.09	**1.84**	13.6	2.7	**6.7**	utp	utp	utp	utp	**utp**		P	
						2.10	**1.85**	13.6	2.7	**6.6**								
SO9/014-3	511	830046.096	391864.935	HC	23/10/2009	2.09	**1.81**	15.4	2.7	**5.2**	utp	utp	utp	utp	**utp**		P	
						2.10	**1.82**	15.4	2.7	**4.7**								

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL
Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09/016-1	512	830027.047	391882.127	HC	27/10/2009	-	-	-	-	-	140	140	140	140	140		P	
						-	-	-	-	-								
S09/019-2	515	830050.009	391899.658	HC	28/10/2009	1.99	1.48	34.2	2.7	0.0	UTP	UTP	UTP	UTP	UTP		P	
						1.98	1.47	34.2	2.7	0.0								
S09/023-1	522	830042.181	391864.215	HC	30/10/2009	2.06	1.81	13.4	2.7	8.5	UTP	UTP	UTP	UTP	UTP		P	
						2.04	1.80	13.4	2.7	9.2								
S09/023-2	523	830062.862	391863.191			2.06	1.66	24.3	2.7	0.0	UTP	UTP	UTP	UTP	UTP		P	
						2.07	1.66	24.3	2.7	0.0								
S09/023-3	524	830034.019	391929.488			2.06	1.81	13.8	2.7	8.2	UTP	UTP	UTP	UTP	UTP		P	
						2.05	1.80	13.8	2.7	8.6								
S09/025-4	528	830073.748	391862.468	HC	2/11/2009	2.02	1.74	16.0	2.7	7.7	UTP	UTP	UTP	UTP	UTP		P	
						2.00	1.72	16.0	2.7	8.6								
S09/032-1	541	830081.366	391795.006	HC	6/11/2009	1.97	1.63	20.9	2.7	5.6	UTP	UTP	UTP	UTP	UTP		P	
						1.98	1.63	20.9	2.7	5.3								
S09/032-2	542	830048.282	391849.589			2.04	1.58	29.1	2.7	0.0	UTP	UTP	UTP	UTP	UTP		P	
						2.02	1.57	29.1	2.7	0.0								
S09/034-1	545	830040.183	391917.961	HC	9/11/2009	2.04	1.64	24.1	2.7	0.0	UTP	UTP	UTP	UTP	UTP		P	
						2.04	1.64	24.1	2.7	0.0								
S09/038-1	548	830031.612	391890.134	HC	10/11/2009	1.99	1.68	18.8	2.7	6.4	UTP	UTP	UTP	UTP	UTP		P	
						1.98	1.67	18.8	2.7	7.0								
S09/038-2	549	830070.819	391778.120			2.04	1.83	11.2	2.7	11.6	UTP	UTP	UTP	UTP	UTP		F	
						2.04	1.84	11.2	2.7	11.4								
S09/038-3	550	830080.830	391803.017			2.11	1.83	15.2	2.7	4.4	UTP	UTP	UTP	UTP	UTP		P	
						2.11	1.83	15.2	2.7	4.1								
S09/041-1	551	830074.526	391783.345	HC	11/11/2009	2.00	1.72	16.7	2.7	7.8	UTP	UTP	UTP	UTP	UTP	Y	P	Retesting S09/038-2
						1.98	1.69	17.3	2.7	8.2								
S09/041-3	553	830065.217	391851.242	HC	11/11/2009	2.06	1.76	16.6	2.7	5.4	UTP	UTP	UTP	UTP	UTP		P	
						2.05	1.75	17.3	2.7	5.2								
S09/041-4	554	830067.417	391880.499			2.02	1.77	14.0	2.7	9.7	UTP	UTP	UTP	UTP	UTP		P	
						2.04	1.80	13.4	2.7	9.1								
S09/046-3	560	830060.913	391812.026	HC	13/11/2009	1.97	1.70	16.1	2.7	9.7	UTP	UTP	UTP	UTP	UTP		F	
						1.97	1.70	16.1	2.7	10.0								
S09/046-4	561	830058.748	391852.774			2.07	1.76	17.4	2.7	4.2	UTP	UTP	UTP	UTP	UTP		P	
						2.07	1.76	17.4	2.7	4.1								
S09/048-1	563	830079.048	391789.253	HC	13/11/2009	2.16	1.69	27.9	2.7	0.0	UTP	UTP	UTP	UTP	UTP	Y	P	Retesting S09/046-3
						2.31	1.81	27.9	2.7	0.0								
S09/050-3	566	830050.319	391929.454	HC	16/11/2009	1.87	1.45	28.7	2.7	4.4	UTP	UTP	UTP	UTP	UTP		P	
						1.96	1.52	28.7	2.7	0.1								

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL
Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09/052-1	569	830070.774	391863.729	HC	17/11/2009	2.13	**1.64**	30.1	2.7	**0.0**	UTP	UTP	UTP	UTP	UTP		P	
						2.11	**1.62**	30.1	2.7	**0.0**								
S09/052-2	570	830078.456	391794.565			2.05	**1.74**	17.9	2.7	**4.6**	UTP	UTP	UTP	UTP	UTP		P	
						2.05	**1.74**	17.9	2.7	**4.3**								
S09/055-3	574	830066.061	391902.129	HC	18/11/2009	2.12	**1.83**	15.8	2.7	**3.2**	UTP	UTP	UTP	UTP	UTP		P	
						2.12	**1.83**	15.8	2.7	**3.4**								
S09/055-4	575	830025.486	391879.159			1.95	**1.72**	13.0	2.7	**13.7**	UTP	UTP	UTP	UTP	**UTP**		F	
						1.95	**1.72**	13.0	2.7	**13.7**								
S09/055-5	576	830052.449	391877.206			2.01	**1.51**	32.9	2.7	**0.0**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.01	**1.51**	32.9	2.7	**0.0**								
S09/057-3	579	830036.508	391885.033	HC	19/11/2009	1.84	**1.32**	39.3	2.7	**0.0**	81	145	97	81	**101**	Y	F	Retesting S09/055-4
						1.83	**1.32**	39.3	2.7	**0.0**								
S09-061-2	581	830076.838	391788.798	HC	20/11/2009	2.10	**1.75**	20.1	2.7	**0.1**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.09	**1.74**	20.1	2.7	**0.7**								
S09-061-3	582	830040.474	391824.847			2.03	**1.67**	21.5	2.7	**2.0**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.03	**1.67**	21.5	2.7	**2.2**								
S09-061-4	583	830057.167	391853.707			2.13	**1.84**	15.4	2.7	**3.4**	UTP	UTP	UTP	UTP	**UTP**	Y	P	Retesting S09/055-4 & 057-3
						2.11	**1.83**	15.4	2.7	**4.3**								
S09-063-1	584	830075.594	391791.524	HC	23/11/2009	2.13	**1.89**	12.7	2.7	**5.9**	UTP	UTP	UTP	UTP	UTP		P	
						2.13	**1.89**	12.7	2.7	**6.0**								
S09-063-3	586	830045.242	391828.149			2.00	**1.66**	20.0	2.7	**5.1**	UTP	UTP	UTP	UTP	UTP		P	
						2.00	**1.67**	20.0	2.7	**5.0**								
S09-068-2	588	830070.915	391865.726	HC	24/11/2009	2.05	**1.75**	16.7	2.7	**5.7**	UTP	UTP	UTP	UTP	UTP		P	
						2.05	**1.76**	16.7	2.7	**5.6**								
S09-068-3	589	830029.276	391888.382			2.08	**1.77**	17.2	2.7	**3.9**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.07	**1.77**	17.2	2.7	**4.2**								

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL

Page of

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	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-070-1	590	830024.986	391893.770	HC	25/11/2009	2.03	1.73	17.2	2.7	6.0	UTP	UTP	UTP	UTP	UTP		P	
						2.01	1.72	17.2	2.7	6.9								
S09-070-2	591	830043.216	391865.894			2.10	1.84	13.7	2.7	6.5	UTP	UTP	UTP	UTP	UTP		P	
						2.10	1.85	13.7	2.7	6.4								
S09-070-3	592	830045.122	391895.458			2.07	1.78	16.5	2.7	4.9	UTP	UTP	UTP	UTP	UTP		P	
						2.08	1.78	16.5	2.7	4.6								
S09-075-1	593	830029.320	391885.681	HC	26/11/2009	2.07	1.68	23.0	2.7	0.0	UTP	UTP	UTP	UTP	UTP		P	
						2.07	1.68	23.0	2.7	0.0								
S09-075-2	594	830050.342	391818.344			2.13	1.81	17.7	2.7	0.7	UTP	UTP	UTP	UTP	UTP		P	
						2.00	1.70	17.7	2.7	6.9								
S09-075-4	596	830072.290	391864.498	HC	26/11/2009	1.93	1.65	17.0	2.7	10.7	UTP	UTP	UTP	UTP	UTP		P	
						1.92	1.64	17.0	2.7	11.4								
S09-078-1	597	830030.753	391887.251	HC/MP	27/11/2009	1.98	1.62	22.0	2.7	4.4	162	UTP	UTP	UTP	162		P	
						1.98	1.62	22.0	2.7	4.4								
S09-078-2	598	830041.225	391890.737			1.95	1.59	23.2	2.7	4.4	UTP	UTP	UTP	UTP	UTP		P	
						1.94	1.58	23.2	2.7	5.0								
S09-078-3	599	830053.393	391815.981			1.98	1.73	14.5	2.7	11.0	UTP	UTP	UTP	UTP	UTP		F	
						1.97	1.72	14.5	2.7	11.5								
S09-078-4	600	830081.079	391805.412			2.06	1.77	16.4	2.7	5.3	UTP	UTP	UTP	UTP	UTP		P	
						2.08	1.78	16.4	2.7	4.6								
S09-084-1	601	830054.634	391813.055	HC/MP	30/11/2009	2.04	1.76	16.1	2.7	6.8	UTP	UTP	UTP	UTP	UTP	Y	P	Retesting S09/078-3
						2.02	1.74	16.1	2.7	7.4								
S09-084-3	603	830077.240	391852.295	HC/MP	30/11/2009	2.05	1.84	11.3	2.7	11.1	UTP	UTP	UTP	UTP	UTP		P	
						2.07	1.86	11.3	2.7	10.2								
S09-086-2	605	830054.150	391774.862			1.87	1.52	23.3	2.7	8.6	UTP	UTP	UTP	UTP	UTP		P	
						1.89	1.53	23.3	2.7	7.8								
S09-086-3	606	830059.750	391769.946			2.09	1.80	16.3	2.7	4.1	UTP	UTP	UTP	UTP	UTP		P	
						2.10	1.80	16.3	2.7	3.8								
S09-086-4	607	830034.651	391823.766			2.02	1.79	12.6	2.7	11.0	UTP	UTP	UTP	UTP	UTP		P	
						2.02	1.80	12.6	2.7	10.9								
S09-088-1	608	830059.759	391775.247	HC/MP	1/12/2009	2.05	1.68	21.8	2.7	1.1	UTP	UTP	UTP	UTP	UTP		P	
						2.05	1.68	21.8	2.7	0.9								

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL
Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-088-2	609	830046.806	391821.516	HC/MP	1/12/2009	1.90	1.55	22.7	2.7	7.6	UTP	UTP	UTP	UTP	UTP		P	
						1.89	1.54	22.7	2.7	7.9								
S09-088-3	610	830063.339	391793.775			1.99	1.53	30.2	2.7	0.0	162	226	210	UTP	199		P	
						1.99	1.53	30.2	2.7	0.0								
S09-088-4	611	830077.845	391818.380			1.91	1.57	21.5	2.7	8.1	UTP	UTP	UTP	UTP	UTP		P	
						1.90	1.57	21.5	2.7	8.3								
S09-090-3	614	830038.082	391839.897	HC	2/12/2009	2.00	1.70	17.9	2.7	6.9	UTP	UTP	UTP	UTP	UTP		P	
						2.00	1.69	17.9	2.7	7.0								
S09-090-4	615	830056.012	391802.226			2.09	1.76	18.7	2.7	1.9	UTP	UTP	UTP	UTP	UTP		P	
						2.10	1.77	18.7	2.7	1.2								
S09-091-1	617	830089.041	391793.748	HC/MP	3/12/2009	2.08	1.80	15.2	2.7	5.8	UTP	UTP	UTP	UTP	UTP		P	
						2.07	1.80	15.2	2.7	6.0								
S09-091-2	618	830074.251	391828.454			1.93	1.62	19.2	2.7	9.1	UTP	UTP	UTP	UTP	UTP		P	No Sample, NDM results applied.
						1.91	1.59	20.2	2.7	8.9								
S09-091-3	619	830067.630	391842.091			1.97	1.65	19.7	2.7	6.4	UTP	UTP	UTP	UTP	UTP		P	
						1.98	1.65	19.7	2.7	6.1								
S09-096-4	623	830086.004	391806.612	HC	8/12/2009	2.05	1.63	25.9	2.7	-2.3	UTP	UTP	UTP	UTP	UTP		P	
						2.06	1.64	25.9	2.7	-2.8								
S09-096-5	624	830060.206	391845.844			2.03	1.74	16.4	2.7	6.7	UTP	UTP	UTP	UTP	UTP		P	
						2.06	1.77	16.4	2.7	5.5								
S09-100-1	626	830076.319	391802.510	HC	9/12/2009	2.01	1.74	15.7	2.7	8.3	UTP	UTP	UTP	UTP	UTP		P	
						2.03	1.76	15.7	2.7	7.3								
S09-106-1	637	830081.721	391822.101	HC/MP	11/12/2009	2.12	1.87	13.2	2.7	5.8	UTP	UTP	UTP	UTP	UTP	Y	P	Retesting S09/103-4
						2.11	1.87	13.2	2.7	6.3								
S09-112-3	648	830089.635	391803.237	HC/MP	16/12/2009	2.16	1.91	13.2	2.7	4.3	UTP	UTP	UTP	UTP	UTP		P	
						2.16	1.91	13.2	2.7	4.0								
S09-116-1	649	830028.742	391852.590	HC/MP	17/12/2009	2.17	1.84	17.9	2.7	0.0	UTP	UTP	UTP	UTP	UTP		P	
						2.16	1.84	17.9	2.7	0.0								
S09-117-1	653	830090.690	391801.015	HC/MP	17/12/2009	1.98	1.63	21.5	2.7	4.8	UTP	UTP	UTP	UTP	UTP	Y	P	Retesting S09/116-2
						1.97	1.62	21.5	2.7	5.3								
S09-123-3	662	830083.962	391789.952	HC/MP	21/12/2009	2.05	1.82	12.9	2.7	9.4	UTP	UTP	UTP	UTP	UTP		P	
						2.04	1.80	12.9	2.7	10.0								
S09-141-2	681	830087.178	391810.188	HC	7/01/2010	2.00	1.62	23.5	2.7	1.8	UTP	UTP	UTP	UTP	UTP		P	
						2.01	1.62	23.5	2.7	1.7								
S09-149-1	695	830056.368	391790.318	HC/MP	12/01/2010	2.08	1.76	18.1	2.7	3.1	UTP	UTP	UTP	UTP	UTP	Y	P	Retesting S09/146-4
						2.08	1.76	18.1	2.7	3.1								
S09-151-1	699	830012.142	391838.029	HC/MP	13/01/2010	2.13	1.83	16.0	2.7	2.8	UTP	UTP	UTP	UTP	UTP		P	
						2.14	1.84	16.0	2.7	2.4								
S09-151-4	702	830047.471	391775.899	HC/MP	13/01/2010	2.02	1.73	16.9	2.7	6.7	129	226	UTP	UTP	178		P	
						1.98	1.69	16.9	2.7	8.8								

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL
Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-156-4	708	830028.624	391817.589	HC/MP	14/01/2010	1.75	**1.31**	33.5	2.7	**7.6**	UTP	UTP	UTP	226	**226**		P	
						1.76	**1.32**	33.5	2.7	**7.1**								
S09-157	709	830017.331	391808.220	HC	14/01/2010	-	-	-	-	-	120	110	130	120	**120**		n/a	Shear vane testing after topsoil stripping (south-eastern corner of site)
						-	-	-	-	-								
S09-161	710	830006.742	391818.538	HC	15/01/2010	-	-	-	-	-	120	110	130	120	**120**		n/a	Shear vane testing bottom of gully (southern end of site)
						-	-	-	-	-								
S09-166-1	716	830030.297	391791.852	HC/MP	18/01/2010	1.90	**1.51**	26.1	2.7	**4.7**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.90	**1.51**	26.1	2.7	**4.7**								
S09-166-2	717	830025.846	391818.646			1.86	**1.41**	31.9	2.7	**2.8**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.86	**1.41**	31.9	2.7	**2.8**								
S09-166-3	718	830002.634	391803.520			1.84	**1.31**	40.8	2.7	**0.0**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.84	**1.31**	40.8	2.7	**0.0**								

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL
Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-169-1	723	830036.076	391785.933	HC/MP	18/01/2010	1.90	**1.51**	26.0	2.7	**4.7**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.91	**1.51**	26.0	2.7	**4.6**								
S09-169-2	724	830005.412	391817.065			2.02	**1.63**	24.1	2.7	**0.3**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.03	**1.63**	24.1	2.7	**0.2**								
S09-169-3	725	830026.522	391827.233			1.90	**1.56**	21.7	2.7	**8.4**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.90	**1.56**	21.7	2.7	**8.4**								
S09-171-1	726	830040.751	391799.339	HC/MP	19/01/2010	1.88	**1.46**	28.4	2.7	**4.2**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.91	**1.49**	28.4	2.7	**2.5**								
S09-171-2	727	830023.457	391819.195			2.01	**1.63**	23.4	2.7	**1.4**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.00	**1.62**	23.4	2.7	**2.0**								
S09-171-3	728	830001.509	391816.945			1.79	**1.33**	34.4	2.7	**4.7**	194	226	UTP	UTP	**210**		P	
						1.78	**1.33**	34.4	2.7	**5.2**								
S09-181-1	738	830035.990	391781.735	HC/MP	20/01/2010	2.05	**1.72**	19.3	2.7	**3.3**	194	178	178	UTP	**183**		P	
						2.06	**1.73**	19.3	2.7	**2.7**								
S09-181-2	739	830024.557	391824.073			2.01	**1.62**	23.8	2.7	**1.1**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.01	**1.63**	23.8	2.7	**1.1**								
S09-181-3	740	830004.341	391803.885			1.99	**1.58**	26.2	2.7	**0.4**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.98	**1.57**	26.2	2.7	**0.6**								
S09-185-1	741	830038.353	391809.189	HC/MP	21/01/2010	2.02	**1.68**	20.3	2.7	**3.6**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.14	**1.78**	20.3	2.7	**0.0**								

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL
Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-185-2	742	830028.448	391833.394	HC/MP	21/01/2010	2.01	**1.66**	21.5	2.7	**3.1**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.01	**1.66**	21.5	2.7	**3.1**								
S09-185-3	743	829999.163	391824.493			2.02	**1.57**	28.8	2.7	**0.0**	UTP	UTP	226	178	**202**		P	
						2.01	**1.56**	28.8	2.7	**0.0**								
S09-187	744	830010.855	391911.862	HC	22/01/2010	-	-	-	-	-	200	226	UTP	UTP	**213**		P	Shear vane testing for earthwork
						-	-	-	-	-								
S09-188-1	745	830015.273	391878.568	MP	25/01/2010	2.09	**1.81**	15.6	2.7	**4.9**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.10	**1.82**	15.6	2.7	**4.4**								
S09-188-2	746	830010.441	391891.668			2.08	**1.77**	17.5	2.7	**3.7**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.05	**1.75**	17.5	2.7	**4.7**								
S09-188-3	747	830018.708	391909.500			2.02	**1.71**	18.2	2.7	**5.4**	159	159	159	100	**144**		P	
						2.02	**1.71**	18.2	2.7	**5.6**								
S09-191-1	748	830006.656	391902.147	MP	25/01/2010	2.11	**1.76**	19.5	2.7	**0.4**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.11	**1.77**	19.5	2.7	**0.1**								
S09-191-2	749	830013.429	391925.210			2.03	**1.75**	16.0	2.7	**7.2**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.03	**1.75**	16.0	2.7	**7.3**								
S09-192-1	750	830018.853	391892.196	MP	26/01/2010	2.09	**1.73**	20.7	2.7	**0.1**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.10	**1.74**	20.7	2.7	**0.0**								
S09-192-2	751	830024.277	391922.587			1.96	**1.64**	19.7	2.7	**6.9**	UTP	UTP	202	202	**202**		P	
						1.96	**1.64**	19.7	2.7	**6.9**								
S09-192-3	752	830031.230	391949.547			1.89	**1.53**	23.5	2.7	**7.4**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.89	**1.53**	23.5	2.7	**7.5**								
S09-195-1	754	829999.554	391877.690	MP	26/01/2010	2.07	**1.73**	19.3	2.7	**2.5**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.05	**1.72**	19.3	2.7	**3.2**								
S09-195-2	755	829996.825	391866.545			1.99	**1.63**	22.4	2.7	**3.1**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.98	**1.62**	22.4	2.7	**3.7**								
S09-196-1	756	830047.658	391809.398	MP	27/01/2010	2.00	**1.66**	20.5	2.7	**4.5**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.01	**1.67**	20.5	2.7	**4.2**								
S09-196-2	757	830036.513	391836.529			2.07	**1.73**	19.8	2.7	**1.8**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.07	**1.73**	19.8	2.7	**1.7**								
S09-196-3	758	830029.212	391865.781			1.94	**1.55**	25.1	2.7	**3.6**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.93	**1.54**	25.1	2.7	**4.3**								
S09-202-1	759	830039.144	391764.868	MP	27/01/2010	1.89	**1.50**	25.9	2.7	**5.4**	145	195	174	101	**154**		P	
						1.89	**1.50**	25.9	2.7	**5.4**								
S09-202-2	760	830063.593	391786.669			1.87	**1.41**	32.4	2.7	**2.0**	202	202	UTP	UTP	**202**		P	
						1.88	**1.42**	32.4	2.7	**1.7**								

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL

Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-203-1	761	830006.828	391861.740	MP	28/01/2010	1.95	**1.52**	27.9	2.7	**1.0**	108	UTP	UTP	UTP	**140**		P	
						1.93	**1.51**	27.9	2.7	**2.2**								
S09-203-2	762	830026.681	391874.034			1.91	**1.48**	29.3	2.7	**2.0**	101	202	130	130	**141**		P	
						1.92	**1.49**	29.3	2.7	**1.4**								
S09-203-3	763	830056.152	391818.825			1.95	**1.54**	26.2	2.7	**2.4**	202	202	UTP	UTP	**202**		P	
						1.94	**1.54**	26.2	2.7	**2.9**								
S09-203-4	764	830028.723	391802.886			2.04	**1.71**	19.0	2.7	**4.1**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.05	**1.72**	19.0	2.7	**3.6**								
S09-205-1	765	830053.876	391780.968	MP	28/01/2010	1.96	**1.53**	27.6	2.7	**0.7**	UTP	UTP	UTP	202	**202**		P	
						1.94	**1.52**	27.6	2.7	**1.6**								
S09-205-2	766	830032.278	391854.317			1.98	**1.67**	18.7	2.7	**7.0**	UTP	UTP	UTP	UTP	**UTP**		P	
						2.00	**1.69**	18.7	2.7	**6.1**								
S09-205-3	767	830030.965	391912.249			1.99	**1.54**	29.3	2.7	**0.0**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.98	**1.53**	29.3	2.7	**0.0**								
S09-210-1	768	830024.035	391803.482	MP	29/01/2010	1.99	**1.58**	25.8	2.7	**0.8**	202	166	UTP	UTP	**184**		P	
						1.98	**1.57**	25.8	2.7	**1.2**								
S09-210-2	769	830038.570	391814.885			1.92	**1.56**	22.9	2.7	**6.3**	166	141	104	166	**144**		P	
						1.90	**1.54**	22.9	2.7	**7.4**								
S09-210-3	770	830051.252	391823.726			1.96	**1.62**	20.8	2.7	**6.4**	188	152	123	108	**143**		P	
						1.94	**1.60**	20.8	2.7	**7.2**								
S09-215	771	830066.595	391796.509	HC	2/02/2010	-	**-**	-	-	**-**	130	140	150	140	**140**		P	
						-	**-**	-	-	**-**								
S09-240	788	830025.330	391847.159	MP	9/02/2010	1.97	**1.60**	22.9	2.7	**3.7**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.96	**1.59**	22.9	2.7	**4.5**								
S09-244-1	791	830036.749	391828.523	MP	10/02/2010	1.94	**1.46**	32.9	2.7	**0.0**	159	115	101	202	**144**		P	
						1.94	**1.46**	32.9	2.7	**0.0**								
S09-244-2	792	830042.950	391862.699			1.97	**1.59**	23.3	2.7	**3.8**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.96	**1.59**	23.3	2.7	**4.0**								
S09-248-1	794	830022.578	391800.711	MP	11/02/2010	1.93	**1.57**	22.9	2.7	**6.0**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.94	**1.58**	22.9	2.7	**5.6**								
S09-248-2	795	830020.361	391848.661			1.96	**1.57**	25.1	2.7	**2.6**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.95	**1.56**	25.1	2.7	**3.2**								
S09-248-3	796	830014.634	391871.781			1.93	**1.51**	28.3	2.7	**1.5**	173	UTP	202	202	**192**		P	
						1.93	**1.51**	28.3	2.7	**1.5**								
S09-253-1	797	830020.298	391918.769	MP	12/02/2010	1.99	**1.53**	30.5	2.7	**0.0**	180	195	123	202	**175**		P	
						1.96	**1.50**	30.5	2.7	**0.0**								
S09-253-2	798	830004.835	391866.981			1.93	**1.52**	26.6	2.7	**2.9**	180	159	150	170	**165**		P	
						1.93	**1.52**	26.6	2.7	**3.2**								

GEOTECHNICS

23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

Job: Silverdale North
Precinct 3
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.

Client: Tonkin & Taylor
T&T Job #: 21854.008

Job # 614089.008
Entered By: HC
Checked By: AJL

Page of

URN	New No.	Northing	Easting	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 > 120 kPa and < 10 % Air Voids)	Comments
											Test 1	Test 2	Test 3	Test 4				
S09-253-3	799	830030.632	391842.350	MP	12/02/2010	1.93	**1.52**	27.2	2.7	**2.7**	202	156	170	202	**183**		P	
						1.93	**1.51**	27.2	2.7	**2.8**								
S09-258-1	801	830025.378	391917.764	MP	15/02/2010	1.87	**1.41**	33.1	2.7	**1.3**	202	202	202	202	**202**		P	
						1.87	**1.41**	33.1	2.7	**1.3**								
S09-258-2	802	830032.822	391939.414			1.78	**1.26**	41.2	2.7	**1.6**	202	139	167	UTP	**169**		P	
						1.77	**1.25**	41.2	2.7	**2.2**								
S09-258-3	803	830032.470	391814.910			1.92	**1.53**	25.6	2.7	**4.2**	UTP	UTP	UTP	UTP	**UTP**		P	
						1.97	**1.56**	25.6	2.7	**2.0**								
S09-258-4	804	830060.011	391787.543			1.97	**1.51**	30.1	2.7	**0.0**	202	139	UTP	UTP	**171**		P	
						1.96	**1.51**	30.1	2.7	**0.0**								
S09-266-1	805	830036.017	391763.532	MP	16/02/2010	1.85	**1.36**	35.8	2.7	**0.8**	202	202	195	UTP	**200**		P	
						1.91	**1.41**	35.8	2.7	**0.0**								
S09-266-2	806	830005.377	391839.767			1.80	**1.33**	35.4	2.7	**3.9**	119	142	152	159	**143**		P	
						1.79	**1.32**	35.4	2.7	**4.1**								
S09-266-3	807	830009.940	391876.977			1.85	**1.37**	35.1	2.7	**1.0**	101	127	145	152	**131**		P	
						1.86	**1.37**	35.1	2.7	**1.0**								
S09-272-1	808	830037.646	391799.102	MP	17/02/2010	1.86	**1.47**	27.0	2.7	**6.1**	200	UTP	197	UTP	**199**		P	
						1.85	**1.46**	27.0	2.7	**6.6**								
S09-272-2	809	830014.827	391866.576			1.71	**1.15**	48.6	2.7	**1.6**	94	98	108	130	**108**		F	
						1.70	**1.15**	48.6	2.7	**1.8**								
S09-274	810	829991.917	391871.046			-	-	-	-	-	87	104	145	104	**110**		F	Shear vane testing finding extent of soft ground
						-	-	-	-	-								
S09-277-1	811	830019.252	391857.985	MP	17/02/2010	1.80	**1.36**	32.7	2.7	**5.4**	202	202	182	202	**197**		P	Retesting S09/274
						1.80	**1.36**	32.7	2.7	**5.5**								
S09-277-2	812	830016.016	391880.653			1.75	**1.25**	39.9	2.7	**3.9**	166	127	133	162	**147**		P	Retesting S09/272-2
						1.75	**1.25**	39.9	2.7	**3.8**								
S09-291-1	813	830046.724	391851.621	MP	19/02/2010	2.01	**1.62**	24.0	2.7	**1.1**	202	UTP	164	180	**182**		P	
						2.00	**1.61**	24.0	2.7	**1.5**								
S09-291-2	814	830037.429	391769.004			1.90	**1.43**	33.4	2.7	**0.0**	202	176	178	159	**179**		P	
						1.90	**1.42**	33.4	2.7	**0.0**								