REPORT

Tonkin+Taylor

MILLWATER SUBDIVISION - ARRANS POINT PRECINCT 7 STAGE 2B

Geotechnical Completion Report

Prepared for
WFH Properties Ltd
Prepared by
Tonkin & Taylor Ltd
Date
July 2017
Job Number
21854.0037/APP7S2B.v1

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Executive summary

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd to monitor and provide earthworks certification for the 19 No. Residential Lots contained within Stage 2B of Arran's Point Precinct 7 at the Millwater Subdivision in Silverdale. Stage 2B comprises residential Lots 101 to 119 inclusive as shown on the Woods Final Contour As–Built Plan (Woods Ref 37001–02B–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 November 2011 Geotechnical Investigation Report for the North Bridge, Southern Abutment (Ref. [4]).

d November 2013 Geotechnical Investigation Report for Arran's Point Precinct 7 (Ref. [5]).

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

Bulk earthworks associated with development of Stage 2B of Arrans Point (Precinct 7) commenced in March 2014 and were completed by February 2016. Earthworks comprised the following:

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

b Installation of subsoil drains.

c Cut to fill earthworks across the entire Stage 2B area as shown on the Woods Cut & Fill As–Built Plan Lowest to Subgrade (Woods Ref 37001–02B–110-AB) in Appendix A1.

d Construction of a 1 in 1.5 (V:H) engineered fill batter slope (RE 4), up to 9m high along the southern boundary of Lots 101 to 119 as shown on T+T Drawing 21854.0037–APP7S2B–101 in Appendix A2.

Civil earthworks commenced on site in June 2016 and were completed by February 2017, and comprised the following:

a Minor cut to fill earthworks across parts of the site as part of final Lot development.

b Installation of roading and services.

Overall subdivisional soil types are moderately to highly expansive (Class M to H2), based on laboratory testing undertaken in accordance with AS 2870:2011 (Ref. [7]). Due to this classification, soils lie outside the definition of good ground within NZS 3604:2011 (Ref. [8]). Building foundations will require either specific foundation design for expansive soils or foundation design in accordance with AS 2870:2011 (Ref. [7]). Subject to design issues outlined in Section 3, and CSIRO recommendations outlined in the Appendices relating to expansive soils foundation design and home owner maintenance, each residential Lot is considered to have a building platform area generally suitable for domestic residential development subject to specific geotechnical assessment and foundation design due to the presence of expansive soils and where Lots contain, or are adjacent to, land with slopes steeper than 1 in 4 (V:H).

Foundation design for residential development should proceed in accordance with Sections 6.5 to 6.9 of this report.

1 Introduction

1.1 General

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd to monitor and provide earthworks certification for the 19 No. Residential Lots contained within Stage 2B of Arran's Point Precinct 7 at the Millwater Subdivision in Silverdale. Stage 2B comprises residential Lots 101 to 119 inclusive as shown on the Woods Final Contour As–Built Plan (Woods Ref 37001–02B–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 November 2011 Geotechnical Investigation Report for the North Bridge, Southern Abutment (Ref. [4]).

d November 2013 Geotechnical Investigation Report for Arran's Point Precinct 7 (Ref. [5]).

The preliminary (Ref. [1], [2]) and investigation (Ref. [3], [4], [5]) reports noted the presence of existing instability comprising landsliding, soil creep and shallow slope movement across much of Arran's Point Precinct 7. 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 7, such works were not generally required to achieve satisfactory factors of safety against instability for the finished development of Stage 2B. However, undercutting was required to enable installation of the geogrid reinforcement required within the reinforced earth slope (RE04), as well as to ensure the RE slope was founded in competent ground.

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. [6]), including construction of 1 No. reinforced earth slope (RE 4);

c Assessment of soils for expansive conditions in accordance with AS 2870:2011 (Ref. [7]);

d Certification of completed Lots for residential development in accordance with NZS 3604:2011 (Ref. [8]).

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 and the Northern Motorway, to the north by the Orewa Estuary and Grand Drive 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 Arran's Point Precinct 7, Stage 2B area of the Millwater subdivision is located within what is known as Precinct 7 in the Orewa West Structure Plan.

The Arran's Point Precinct 7 area is bound by Arran Drive to the west, and the Orewa estuary to the north, south and east. The overall Arran's Point Precinct 7 and Stage 2B areas are shown on T+T Drawing 21854.0037–APP7S2B–100 in Appendix A2.

Pre-development gradients within the Stage 2B area were gentle to moderately steep (1 in 3 to 1 in 15 (V:H)) with an overall fall to the north.

Post-development gradients within the Stage 2B area remain gentle to moderately steep (1 in 5 to 1 in 15 (V:H)) and generally fall to the north and north-west. In order to form gentler building platform areas, a steep reinforced earth slope of up to 1 in 1.5 (V:H) has been constructed along the southern boundary of Lots 101 to 119 as shown on T+T Drawing 21854.0037–APP7S2B–101.

Stage 2B is presently accessed from the existing Maka Terrace.

1.3 Geological Setting

Published geological mapping and information indicates the Arran's Point Precinct 7 area is underlain by East Coast Bays materials. In addition to the East Coast Bays materials, our investigations identified the presence of alluvial materials on site.

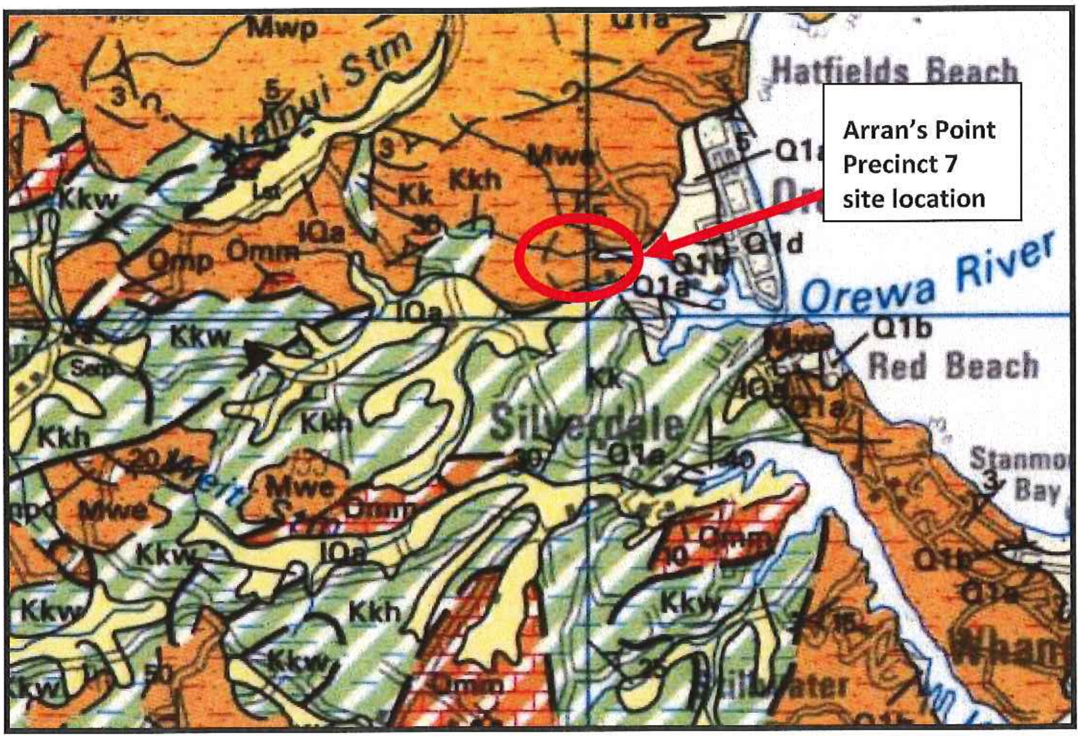


Figure 1 - Local Geology (from Edbrooke)

Summary descriptions of geological units in the Arrans Point area (after Kermode 1991) are as follows:

a East Coast Bays Formation

Alternating sandstone and mudstone with variable volcanic content (volcanic-poor lower in the sequence and mixed volcanic content higher) and interbedded volcaniclastic grit beds. These material typically show a well-developed weathering profile of clay, silt or sand depending on the parent lithology.

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 Arran's Point Precinct 7, Stage 2B area, based on site investigations and observations during construction, are enclosed as Drawing Number 21854.0037–APP7S2B–103 in Appendix A2.

Fill material placed across the site to form the final design profile typically comprised site-won East Coast Bays Formation materials.

2 Earthworks Operations

2.1 Plant

Bulk earthworks and civil works 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.

Various earthworks equipment was used to undertake the works, comprising motor scrapers, articulated dump trucks, 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 from March 2014 through to February 2016 under Hicks' control. Civil earthworks and construction for the residential Lots were also under Hicks' control and were undertaken progressively from June 2016 through to completion in February 2017.

Key Stage 2B earthworks components included:

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

b Installation of subsoil drains.

c Cut to fill earthworks across the entire site as shown on the Woods Cut & Fill As–Built Plan Lowest to Subgrade (Woods Ref 37001–02B–110-AB) in Appendix A1.

d Construction of a 1 in 1.5 (V:H) engineered fill batter slope (RE 4), up to 9m high, along the southern boundary of Lots 101 to 119 as shown on T+T Drawing 21854.0037–APP7S2B–101 in Appendix A2.

Key Stage 2B civil works components included:

a Minor cut to fill earthworks across parts of the site as part of final Lot development.

b Installation of roading and services.

The earthworks, reinforced earth slope, undercuts and subsoil drainage as–built plans are included in Appendix A1 (Woods Drawings 37001–02B–100–AB, –110 to –111 and –120 to –122), and show the earthworks undertaken across the site.

We note that, at time of writing, a topsoil stockpile remains across a number of the Lots, and the as-builts presented herein are based on the subgrade surface prior to placement of the stockpile. We understand this stockpile will be removed prior to release of the Lots.

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]) included the following requirement for the subdivisional earthworks:

Minimum Shear Strength and Maximum Air Voids Method

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

General fills:

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

High Strength Structural fills (Reinforced Earth Fill Slopes):

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

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

General fills:

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

High Strength Structural fills (Reinforced Earth Fill Slopes):

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

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

Regular in situ density, strength and water content tests were carried out on the filling at, or in excess of, the frequency recommended by NZS 4431:1989 (Ref. [6]). 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, density 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 across Arran's Point Precinct 7 during bulk earthworks as part of the reinforced earth slope construction.

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

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

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

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

The reinforced earth slope drains were connected to the reticulated stormwater system, as shown on the Woods Shear Key, Undercuts & Subsoil Drains As–Built Plans (Woods Ref 37001–02B–120–AB) and on T+T Drawing 21854.0037–APP7S2B–102 in Appendix A2.

3.2 Reinforced Earth Slope

A reinforced earth slope (RE 4) was constructed during the bulk earthworks within Stage 2B.

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

A typical cross-section through the RE slope is shown on T+T Drawings 21854.0037–APP7S2B–104 and 105 in Appendix A2.

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

Construction of the RE slope comprised the following:

a Foundation preparation;

b Placement and compaction of fill to the required levels;

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

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

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

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

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

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

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

The slope face will be subject to a planting covenant preventing construction within this area. Protection of the geogrids from damage also precludes construction across the slope face and immediately adjacent to the slope crest. Accordingly, a building restriction zone has been applied across the slope (See Sections 5.3 and 6.6, and T+T Drawing 21854.0037-APP7S2B-110 in Appendix A2).

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

3.3 Undercuts

A 2m deep, minimum 5m wide, undercut was excavated below the toe of RE4 to ensure a consistent subgrade. The undercut was replaced with engineered, compacted fill, placed in accordance with the bulk earthworks specification (Section 2.3 above).

The extent of the undercut areas is shown on the Woods Shear Key, Undercuts & Subsoil Drains As–Built Plan (Woods Ref 37001–02B–120–AB) in Appendix A1.

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 2B.

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 the Arran's Point Precinct 7, Stage 2B area straddle a range of "design conditions" including cut ground, filled ground, expansive soils and constructed slopes up to 1 in 1.5 (V:H). The following sections set out relevant geotechnical design issues.

5.2 Bearing capacity for building foundations

All filled and natural ground within the influence of conventional residential shallow strip and pad foundation loads is assessed as generally having a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011 (Ref. [8]). 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. [8]). In terms of AS 2870:2011 (Ref. [7]), the soils present are considered to lie within Site Class M to H2 (moderately to highly expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm and 60mm to 75mm respectively. Due allowance should be made for expansive soils, as discussed in Section 5.12.

Where a geotechnical ultimate bearing capacity greater than 300kPa is required to support any dwelling constructed outside the scope of NZS 3604:2011 (Ref. [8]), further specific site investigation and design of foundations will be required.

5.3 Building Limitation Zones – RE Slope

Identified steep slopes in the Stage 2B area have been constructed as reinforced earth fill structures with face gradients of up to 1 in 1.5 (V:H). They are located in Lots 101 to 119. Construction within the flatter parts of these Lots is intended, and a Building Limitation Zone ("No Build Zone") has been developed across the steeper sections of the Lots to ensure that the reinforcement of the slopes is not detrimentally affected by future development. The extent of the Building Limitation Zone associated with the RE slope is shown on T+T Drawing 21854.0037–APP7S2B–110 (Building Limitation Plan) in Appendix A2. Excavation, fill placement and/or construction within this zone is not permitted.

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

Where slopes exceed gradients of 1 in 2 (V:H), "Enkamat" or "Geocells" have been anchored to the face of the RE Slope to function as a protective reinforcing layer for the topsoil and plant root system.

5.4 Settlement

From our inspections during earthworks operations, and the results of compaction quality control testing, we consider that differential settlement induced by self-weight of engineered fill should now be largely complete. Further settlements should be within normally accepted design tolerances of 25mm, as outlined in NZS 3604:2011 (Ref. [8]), with respect to conventional building development.

In order to minimise the risk of ground settlements exceeding 25 mm, NZS 3604:2011 (Ref. [8]) allows a maximum fill surcharge of 600 mm over the building platform during future development. Filling in excess of this thickness should be subject to specific foundation design and assessment.

5.5 Retaining walls

Due to the relatively shallow grades across most of the Stage 2B Lots, it is not anticipated that significant retaining walls will be required. 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, or within within 2m of the toe of the RE slope 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.

5.6 Subsoil Drainage

Groundwater drainage was installed during bulk earthworks using Nexus drains covered in scoria and 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 37001–02B–120–AB) in Appendix A1, and on T+T Drawing 21854.0037–APP7S2B–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.

5.7 Post Earthworks Investigations

Following the completion of earthworks operations, T+T have undertaken supplementary fieldwork to confirm the consistency of the natural subsoils and engineered fill. From the investigations, we confirm that the subsoils are considered to have a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011 (Ref. [8]). 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 21854.0037–APP7S2B–111) are attached in Appendix E.

5.8 Stormwater

Public stormwater services have been installed within Arran's Point Precinct 7, Stage 2B. Stormwater and runoff from roofs, decks and paved areas, together with discharges from future retaining wall drains and other subsoil drainage must be connected directly into the public stormwater drainage network.

5.9 Service lines

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

A copy of the stormwater as–built plans for Stage 2 (Woods Ref 37001–02–300–AB to –303) is included in Appendix A1.

5.10 Road subgrades

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

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

5.11 Topsoil

Due to the presence of a stockpile currently present across many of the Lots in this stage, topsoil depths have not been measured.

5.12 Expansive soils

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

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

a Influence of garden watering and site drainage;

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

c Initial soil moisture conditions at construction time.

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

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

Based on the laboratory results (attached in Appendix E), the foundation soils on this stage of the subdivision lie outside the definition of 'good ground' as outlined in NZS 3604:2011 (Ref. [8]).

In terms of AS 2870:2011 (Ref. [7]), the soils present are considered to lie within Site Class M to H2 (moderately to highly expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm and 60mm to 75mm respectively.

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. [7]) for assistance.

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

I, Mr A.P. Stiles 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 Arran's Point Precinct 7 Stage 2B (comprising residential Lots 101 to 119 inclusive) of the Millwater Residential Subdivision Development off Arran Drive 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 investigations are described in Tonkin + Taylor Ltd Geotechnical Investigation Report for Arran's Point Precinct 7 Ref No. 21854.0037 dated November 2013. 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 Contractor has 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 Contractor 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 37001, Millwater, Arran's Point Precinct 7, Stage 2B, Drawing Numbers 37001–02B–100–AB, –110 to –111 and –120, have been generally placed in compliance with NZS 4431:1989 (Ref. ([6]).

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

6.5 **For Lots 101 to 119 inclusive:**

6.5.1 These Lots contain a "Building Line Limitation" relating to the reinforced earth slope which forms the 1 in 1.5 (V:H) slope along the Lot boundaries. The limitation zone is shown on T+T Drawing 21854.0037–APP7S2B–110 in Appendix A2. Excavation, filling and/or construction within this zone is not to be undertaken, to ensure stability of the slope is not compromised.

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

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

6.5.3 Any cut or fill walls greater than 1.5m retained height, or of any height within 2m of the building limitation lines shown on T+T Drawing 21854.0037–APP7S2B–110 in Appendix A2, will require a geotechnical assessment, as a minimum, to ensure stability of the subject or adjacent Lot is not detrimentally affected.

6.5.4 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 6.5.5 to 6.5.9.

6.5.5 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. [8]).

6.5.6 Expansive soils – Lots 101 to 108 and 116 to 119

Due to the presence of expansive clay soils, foundation soils lie outside the definition of 'good ground' in NZS 3604:2011 (Ref. [8]). Soils on these Lots are considered to lie in Site Class M (moderately expansive) as defined in AS 2870:2011 (Ref. [7]) with anticipated characteristic surface ground movements of 20mm to 40mm. Clause 6.5.6.1 of this Geotechnical Completion Report may be used for expansive soil foundation design on Lots 101 to 108 and 116 to 119 inclusive:

6.5.6.1 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. [7]), Section 4 and related documents.

6.5.7 Expansive soils – Lots 109 & 115

Due to the presence of expansive clay soils, foundation soils lie outside the definition of 'good ground' in NZS 3604:2011 (Ref. [8]). Soils on these Lots are considered to lie in Site Class H1 (highly expansive) as defined in AS 2870:2011 (Ref. [7]) with anticipated characteristic surface ground movements of 40mm to 60mm. Clause 6.5.7.1 of this Geotechnical Completion Report may be used for expansive soil foundation design on Lots 109 and 115:

6.5.7.1 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. [7]), Section 4 and related documents.

6.5.8 Expansive soils – Lots 110 to 114

Due to the presence of expansive clay soils, foundation soils lie outside the definition of 'good ground' in NZS 3604:2011 (Ref. [8]). Soils on these Lots are considered to lie in Site Class H2 (highly expansive) as defined in AS 2870:2011 (Ref. [7]) with anticipated characteristic surface ground movements of 50mm to 75mm. Clause 6.5.8.1 of this Geotechnical Completion Report may be used for expansive soil foundation design on Lots 110 to 114 inclusive:

6.5.8.1 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:

vii) Minimum foundation embedment of 900 mm following topsoil removal and benching of building platform areas to finished ground levels

viii) Four bar steel reinforcing cages should be used

ix) 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. [7]), Section 4 and related documents.

6.5.9 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.

6.5.10 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.

6.5.11 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 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 37001–02B–120–AB) in Appendix A1, and on T+T Drawing 21854.0037–APP7S2B–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.

6.7 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.

6.8 Road and Access Lots

Based on the fill monitoring and site observations undertaken during site development, the filled and natural ground within Arran's Point Precinct 7, Stage 2B 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 Arran's Point Precinct 7 Stage 2B development, within natural ground, a design CBR of 2% is considered appropriate, while within engineered fill areas, a design CBR of 7% is appropriate.

6.9 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:

....

Andrew Linton

Senior Geotechnical Engineer

Authorised for Tonkin & Taylor Ltd by:

....

Andrew Stiles

Project Director

JXXL
p:\21854\21854.0037 - arrans hill p7\gcr\stage 2b\jxxl.070508.app7s2b-gcr.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 2011. *Millwater – North Bridge, Southern Abutment, Geotechnical Investigation Report,* T+T Ref. 21854.012.

[5] Tonkin & Taylor Ltd., November 2013. *Millwater Subdivision, Arrans Hill – Precinct 7 – Geotechnical Investigation Report,* T+T Ref. 21854.0037.

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

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

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

Appendix A1: Woods Drawings

- 37001–02B–100–AB Final Contour As–Built Plan
- 37001–02B–110–AB Cut & Fill As–Built Plan - Lowest to Subgrade
- 37001–02B–111–AB Cut & Fill As–Built Plan – Original to Subgrade
- 37001–02B–120–AB Shear Key, Undercuts & Subsoil Drains As–Built Plan
- 37001–02B–300–AB to –303 Stormwater Drainage As-Built Plans

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

Signed: Registered Professional Surveyor

Date: 08/05/2017

Name: ROWAN HALLAM

REVISION DETAILS	NAME	DATE
1.		

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

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

CLIENT:

WFH PROPERTIES

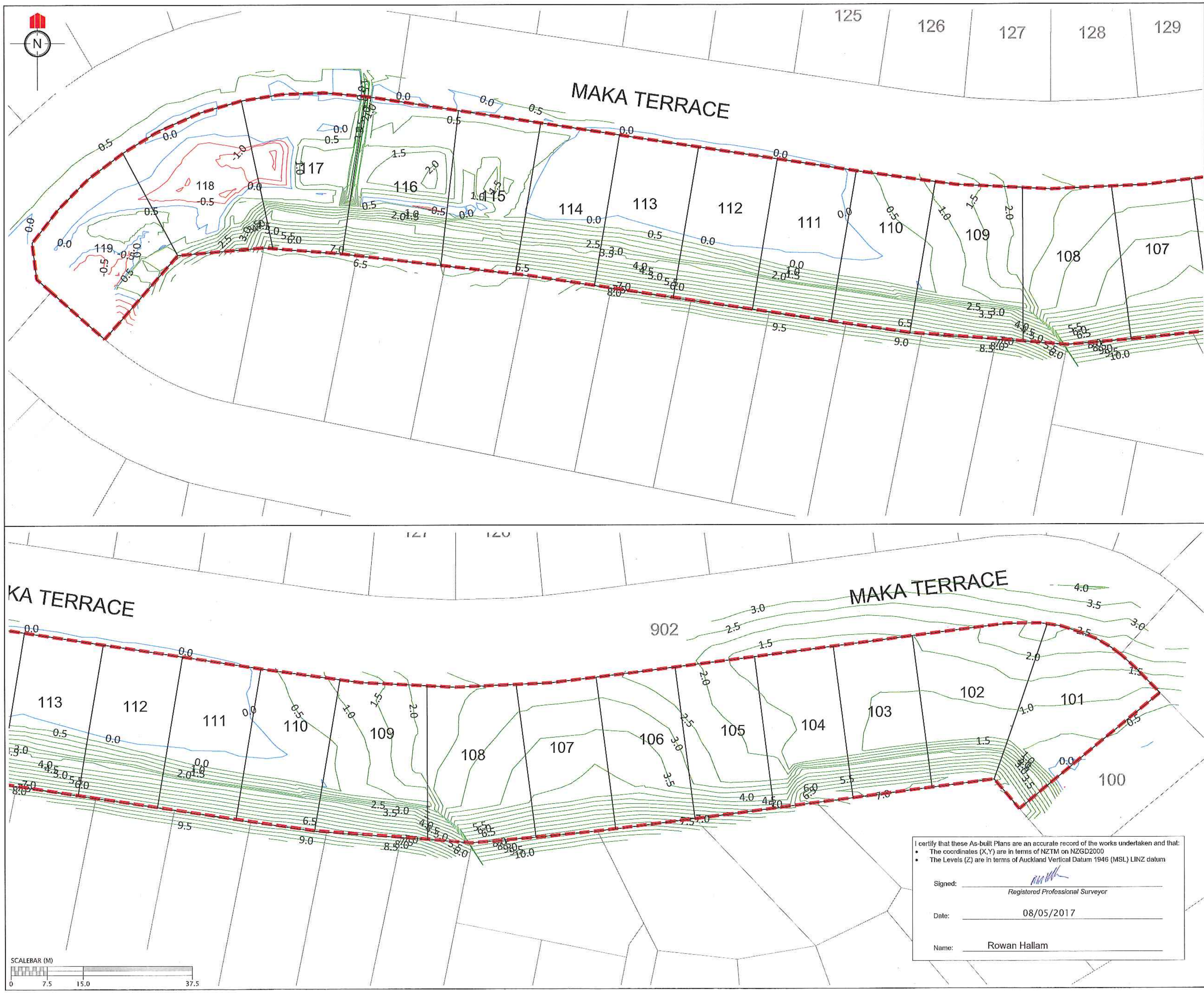
WOODS
Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER ARRAN POINT STAGE 2B

SUBGRADE CONTOUR AS-BUILT PLAN (SLC-62000)

AUCKLAND COUNCIL

DESIGNED: MB		AS-BUILT	
CHECKED: KR		DRAWN: KR	
APPROVED: MRH		SURVEYED: HICKS	
JOB NUMBER: 37001		SCALE: 1:750 @ A3	
ISSUED: MAY 2017			
DWG. NO. 37001-02B-100-AB			REV.



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

Signed: ______________ Registered Professional Surveyor

Date: 08/05/2017

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1.		

NOTES

1. CONTOURS ARE AT 1.0 METRE INTERVALS

LEGEND

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

CLIENT:

WFH PROPERTIES

WOODS Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER ARRAN POINT STAGE 2B

CUT & FILL AS-BUILT LOWEST TO SUBGRADE SHEET 1 OF 2 (SLC-62000)

AUCKLAND COUNCIL

DESIGNED: MB		AS-BUILT	
CHECKED: KR		DRAWN: KR	
APPROVED: MRH		SURVEYED: HICKS	
JOB NUMBER: 37001		SCALE: 1:750 @ A3	
ISSUED: FEB 2017			
DWG. NO. 37001-02B-110-AB		REV.	

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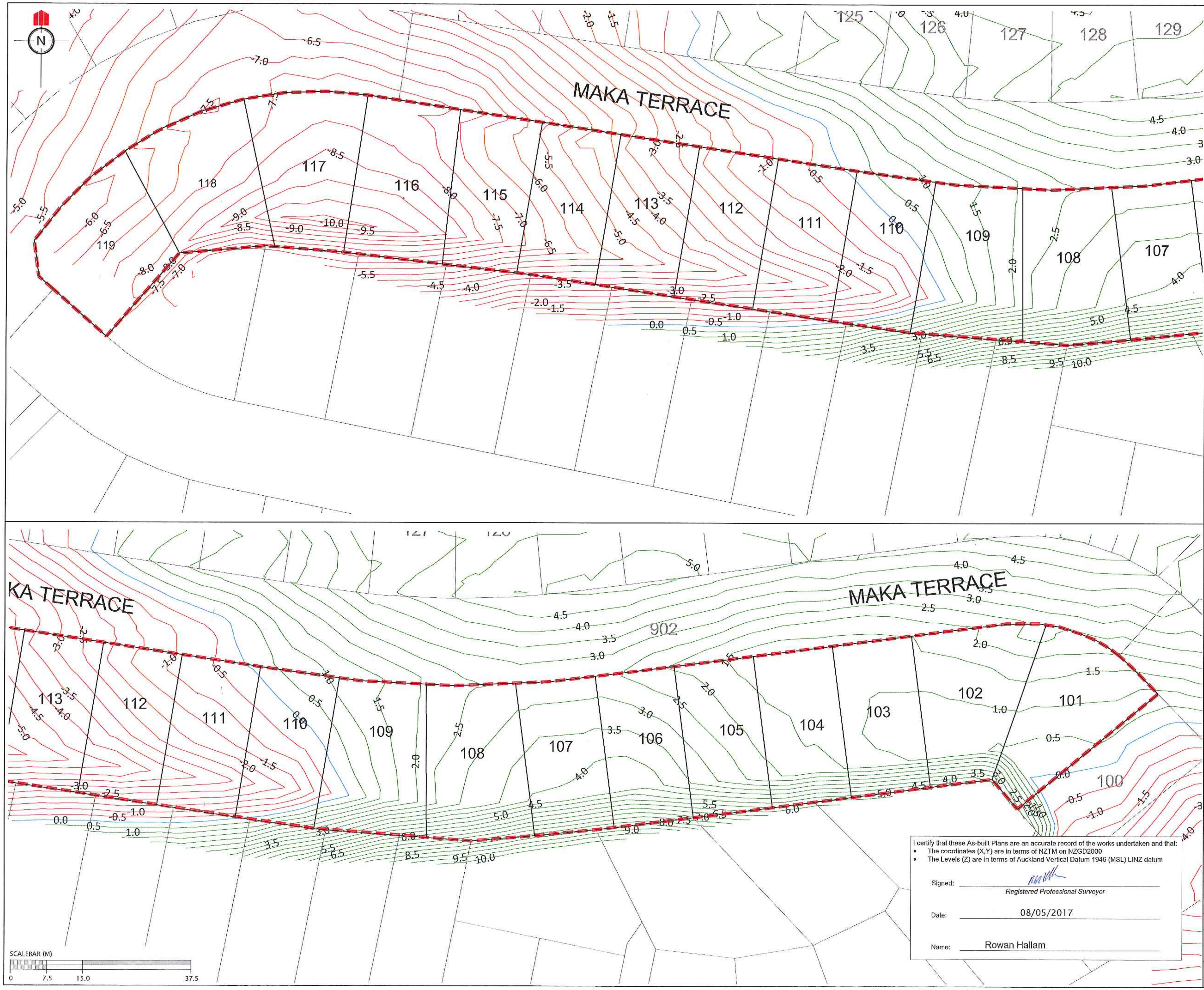

I certify that these As-built Plans are an accurate record of the works undertaken and that:

- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: *Registered Professional Surveyor*

Date: 08/05/2017

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1.		

NOTES

1. CONTOURS ARE AT 1.0 METRE INTERVALS

LEGEND

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

CLIENT:

WFH PROPERTIES

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Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER ARRAN POINT STAGE 2B

CUT & FILL AS-BUILT ORIGINAL TO SUBGRADE SHEET 2 OF 2 (SLC-62000)

AUCKLAND COUNCIL

DESIGNED: MB		AS-BUILT	
CHECKED: KR		DRAWN: XXX	
APPROVED: MRH		SURVEYED: AP	
JOB NUMBER: 37001		SCALE: 1:750 @ A3	
ISSUED: FEB 2017			
DWG. NO. 37001-02B-111-AB			REV.

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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

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MILLWATER ARRAN POINT STAGE 2B

SHEAR KEY, UNDERCUTS, & SUBSOIL DRAINS AS-BUILT PLAN SHEET 1 Of 1

AUCKLAND COUNCIL

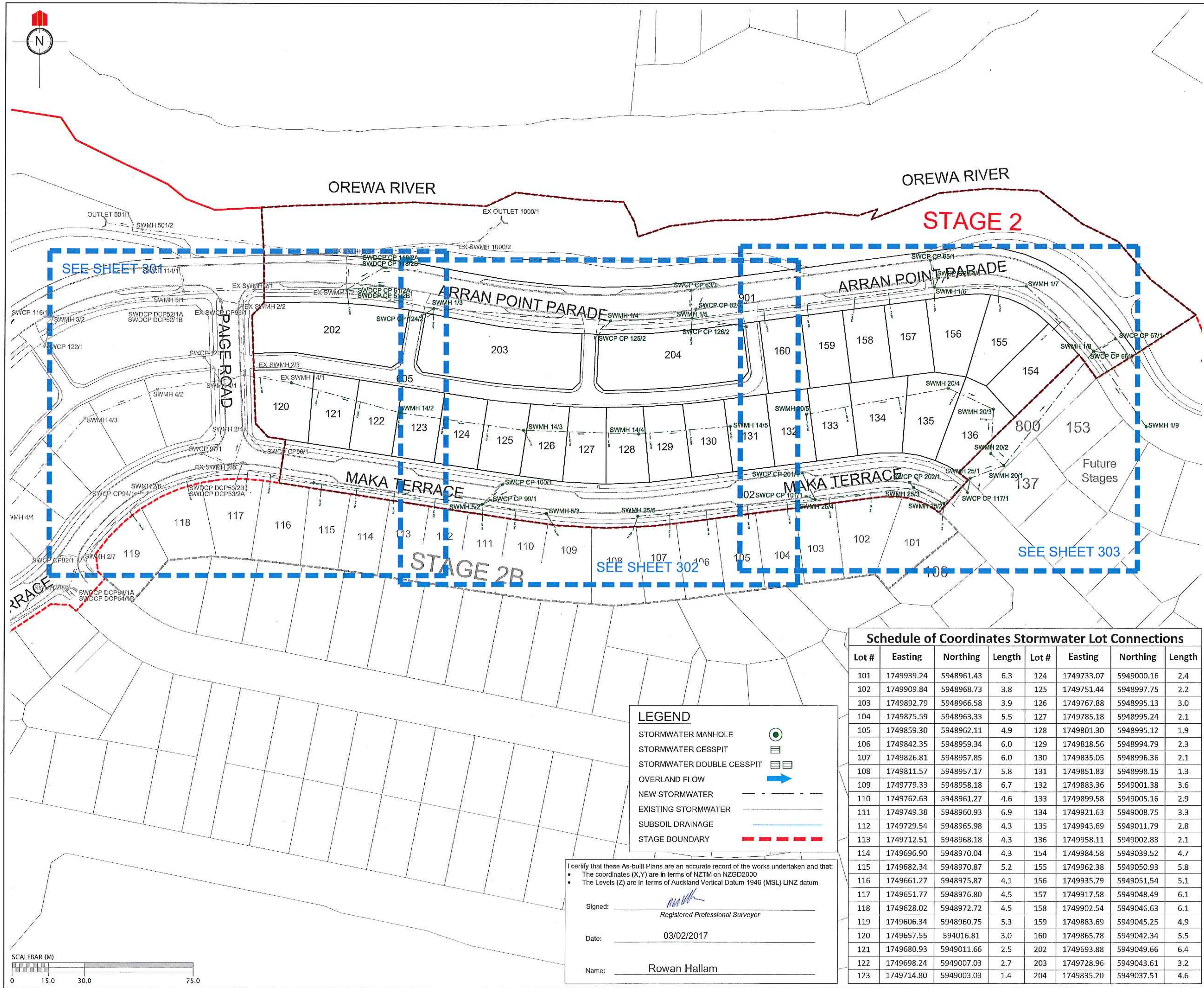
I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ____________________
Registered Professional Surveyor

Date: ____________________

Name: Rowan Hallam

DESIGNED:	MB		ASBUILT
CHECKED:		DRAWN:	KR
APPROVED:	MRH	SURVEYED:	HICKS
JOB NUMBER:	37001	SCALE:	1:750 @ A3
ISSUED:	MAY 2017		
DWG. NO.	37001-02B-120-AB	REV.	



REVISION DETAILS	NAME	DATE
Issued for information.	KR	11/01/2017

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 AND PIPES UNDER THE ROAD AND CARRIDGEWAYS 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.

LEGEND

- STORMWATER MANHOLE
- STORMWATER CESSPIT
- STORMWATER DOUBLE CESSPIT
- OVERLAND FLOW
- NEW STORMWATER
- EXISTING STORMWATER
- SUBSOIL DRAINAGE
- STAGE BOUNDARY

Schedule of Coordinates Stormwater Lot Connections

Lot #	Easting	Northing	Length	Lot #	Easting	Northing	Length
101	1749939.24	5948961.43	6.3	124	1749733.07	5949000.16	2.4
102	1749909.84	5948968.73	3.8	125	1749751.44	5948997.75	2.2
103	1749892.79	5948966.58	3.9	126	1749767.88	5948995.13	3.0
104	1749875.59	5948963.33	5.5	127	1749785.18	5948995.24	2.1
105	1749859.30	5948962.11	4.9	128	1749801.30	5948995.12	1.9
106	1749842.35	5948959.34	6.0	129	1749818.56	5948994.79	2.3
107	1749826.81	5948957.85	6.0	130	1749835.05	5948996.36	2.1
108	1749811.57	5948957.17	5.8	131	1749851.83	5948998.15	1.3
109	1749779.33	5948958.18	6.7	132	1749883.36	5949001.38	3.6
110	1749762.63	5948961.27	4.6	133	1749899.58	5949005.16	2.9
111	1749749.38	5948960.93	6.9	134	1749921.63	5949008.75	3.3
112	1749729.54	5948965.98	4.3	135	1749943.69	5949011.79	2.8
113	1749712.51	5948968.18	4.3	136	1749958.11	5949002.83	2.1
114	1749696.90	5948970.04	4.3	154	1749984.58	5949039.52	4.7
115	1749682.34	5948970.87	5.2	155	1749962.38	5949050.93	5.8
116	1749661.27	5948975.87	4.1	156	1749935.79	5949051.54	5.1
117	1749651.77	5948976.80	4.5	157	1749917.58	5949048.49	6.1
118	1749628.02	5948972.72	4.5	158	1749902.54	5949046.63	6.1
119	1749606.34	5948960.75	5.3	159	1749883.69	5949045.25	4.9
120	1749657.55	594016.81	3.0	160	1749865.78	5949042.34	5.5
121	1749680.93	5949011.66	2.5	202	1749693.88	5949049.66	6.4
122	1749698.24	5949007.03	2.7	203	1749728.96	5949043.61	3.2
123	1749714.80	5949003.03	1.4	204	1749835.20	5949037.51	4.6

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: 03/02/2017

Name: Rowan Hallam

CLIENT:

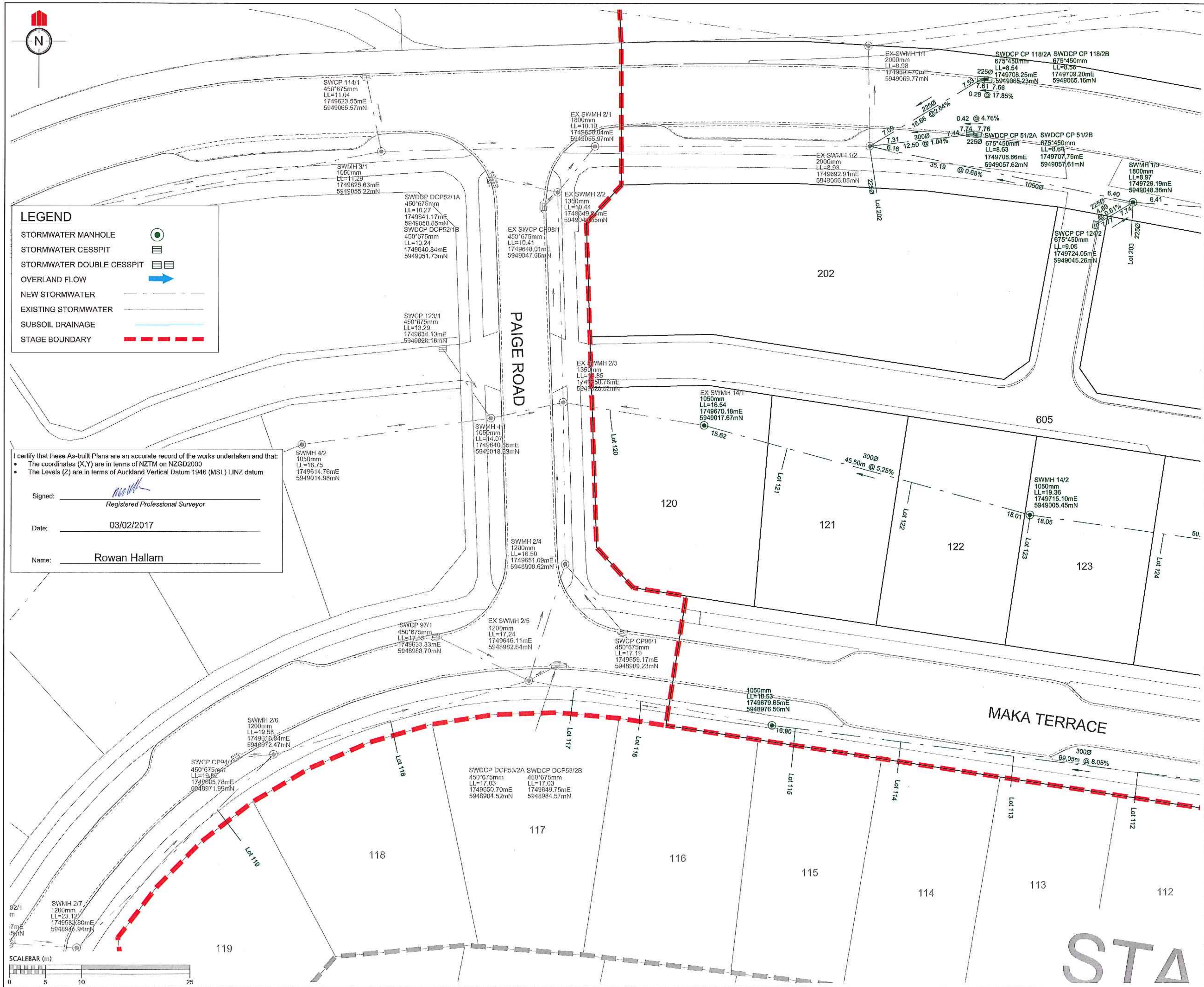
WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER ARRAN POINT STAGE 2

STORMWATER ASBUILT OVERALL LAYOUT SHEET 1 OF 4 (SLC-62000) AUCKLAND COUNCIL

DESIGNED:	MB		ASBUILT
CHECKED:	KR	DRAWN:	KR
APPROVED:	MRH	SURVEYED:	AP
JOB NUMBER:	37001	SCALE:	1:1500 @ A3
ISSUED:	JAN 2017		
DWG. NO.	37001-02-300-AB	REV.	1.



LEGEND

STORMWATER MANHOLE	
STORMWATER CESSPIT	
STORMWATER DOUBLE CESSPIT	
OVERLAND FLOW	
NEW STORMWATER	
EXISTING STORMWATER	
SUBSOIL DRAINAGE	
STAGE BOUNDARY	

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

Signed: Registered Professional Surveyor

Date: 03/02/2017

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
Issued for information.	KR	11/01/2017

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 AND PIPES UNDER THE ROAD AND CARRIDGEWAYS 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.

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER
ARRAN POINT
STAGE 2

STORMWATER ASBUILT
SHEET 2 OF 4
(SLC-62000)

AUCKLAND COUNCIL

DESIGNED: MB		ASBUILT	
CHECKED: KR		DRAWN: KR	
APPROVED: MRH		SURVEYED: AP	
JOB NUMBER: 37001		SCALE: 1:500 @ A3	
ISSUED: JAN 2017			
DWG. NO. 37001-02-301-AB		REV. 1.	

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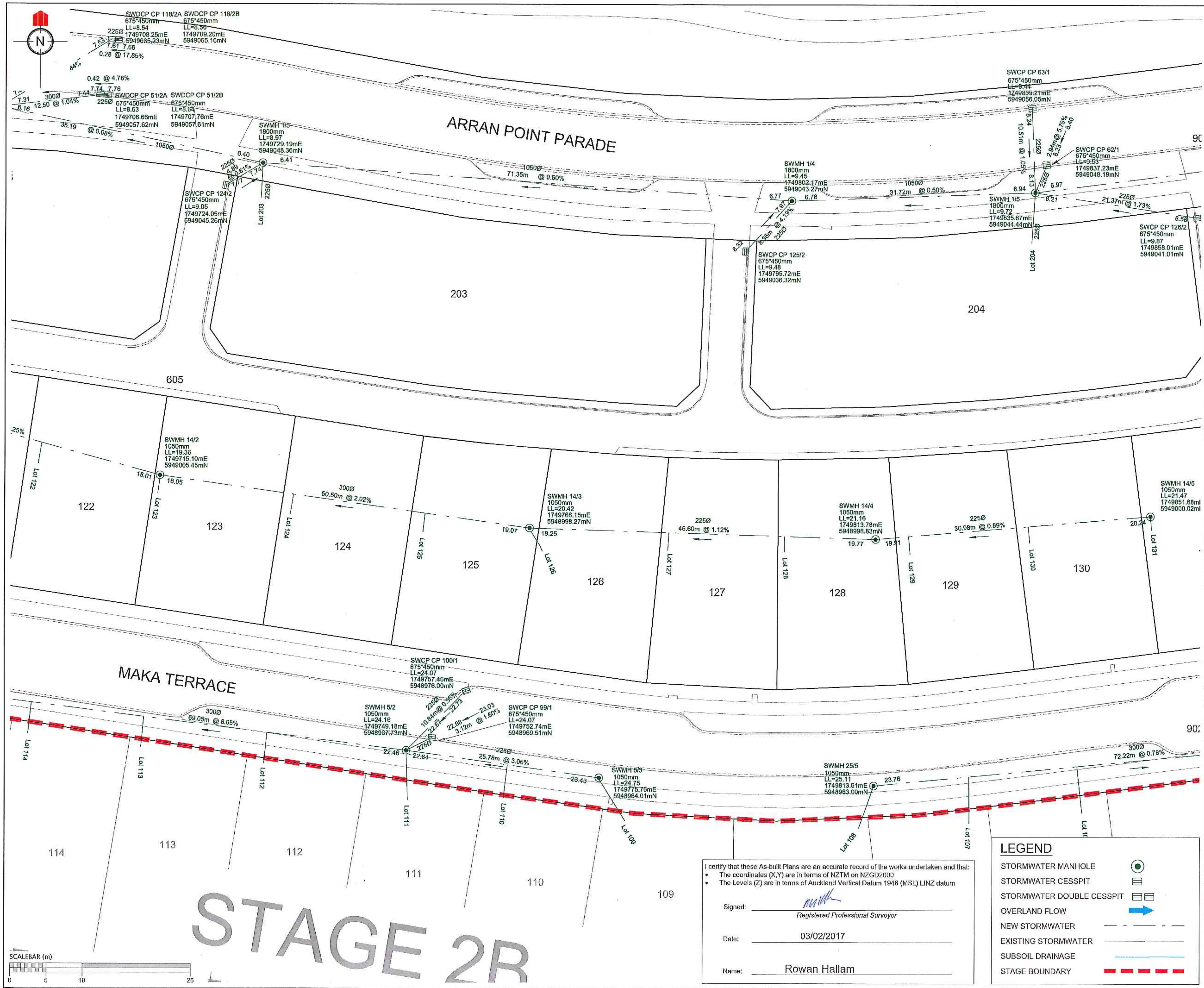

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Signed: ____________ Registered Professional Surveyor

Date: 03/02/2017

Name: Rowan Hallam

LEGEND

STORMWATER MANHOLE	
STORMWATER CESSPIT	
STORMWATER DOUBLE CESSPIT	
OVERLAND FLOW	
NEW STORMWATER	
EXISTING STORMWATER	
SUBSOIL DRAINAGE	
STAGE BOUNDARY	

REVISION DETAILS	NAME	DATE
Issued for information.	KR	11/01/2017

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
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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.

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER ARRAN POINT STAGE 2

STORMWATER ASBUILT SHEET 3 OF 4 (SLC-62000)

AUCKLAND COUNCIL

DESIGNED: MB		ASBUILT	
CHECKED: KR		DRAWN: KR	
APPROVED: MRH		SURVEYED: AP	
JOB NUMBER: 37001		SCALE: 1:500 @ A3	
ISSUED: JAN 2017			
DWG. NO. 37001-02-302-AB		REV.	

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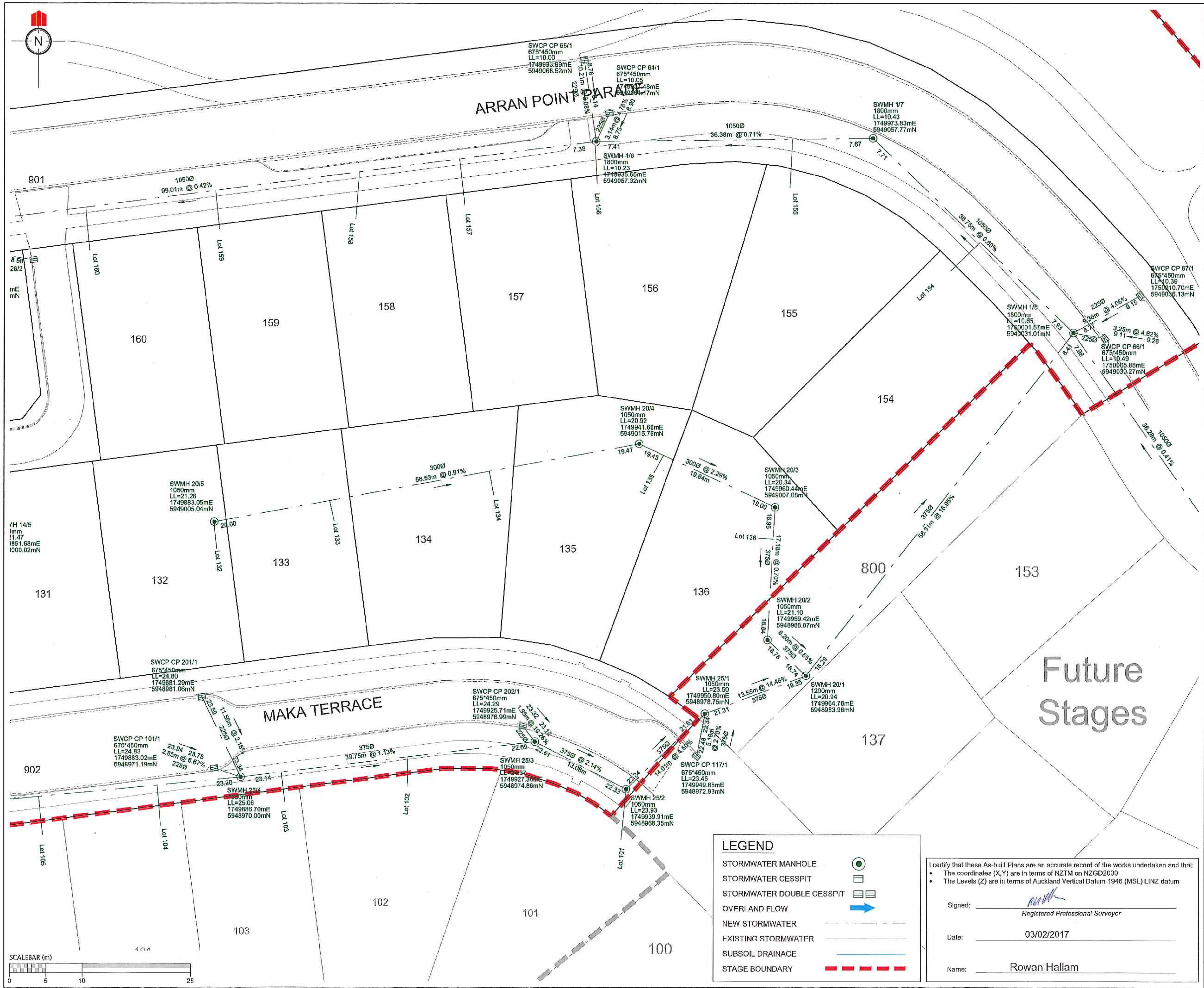

LEGEND

- STORMWATER MANHOLE
- STORMWATER CESSPIT
- STORMWATER DOUBLE CESSPIT
- OVERLAND FLOW
- NEW STORMWATER
- EXISTING STORMWATER
- SUBSOIL DRAINAGE
- STAGE BOUNDARY

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

Signed: ____ Registered Professional Surveyor

Date: 03/02/2017

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
Issued for information.	KR	11/01/2017

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
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8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED DATA AND CONTRACTOR RECEIVED DATA.

CLIENT:

WFH PROPERTIES

WOODS
Engineers. Surveyors. Planners. Urban Designers. Architects.

MILLWATER ARRAN POINT STAGE 2

STORMWATER ASBUILT SHEET 4 OF 4 (SLC-62000)

AUCKLAND COUNCIL

DESIGNED: MB		ASBUILT	
CHECKED: KR		DRAWN: KR	
APPROVED: MRH		SURVEYED: AP	
JOB NUMBER: 37001		SCALE: 1:500 @ A3	
ISSUED: JAN 2017			
DWG. NO. 37001-02-303-AB		REV.	

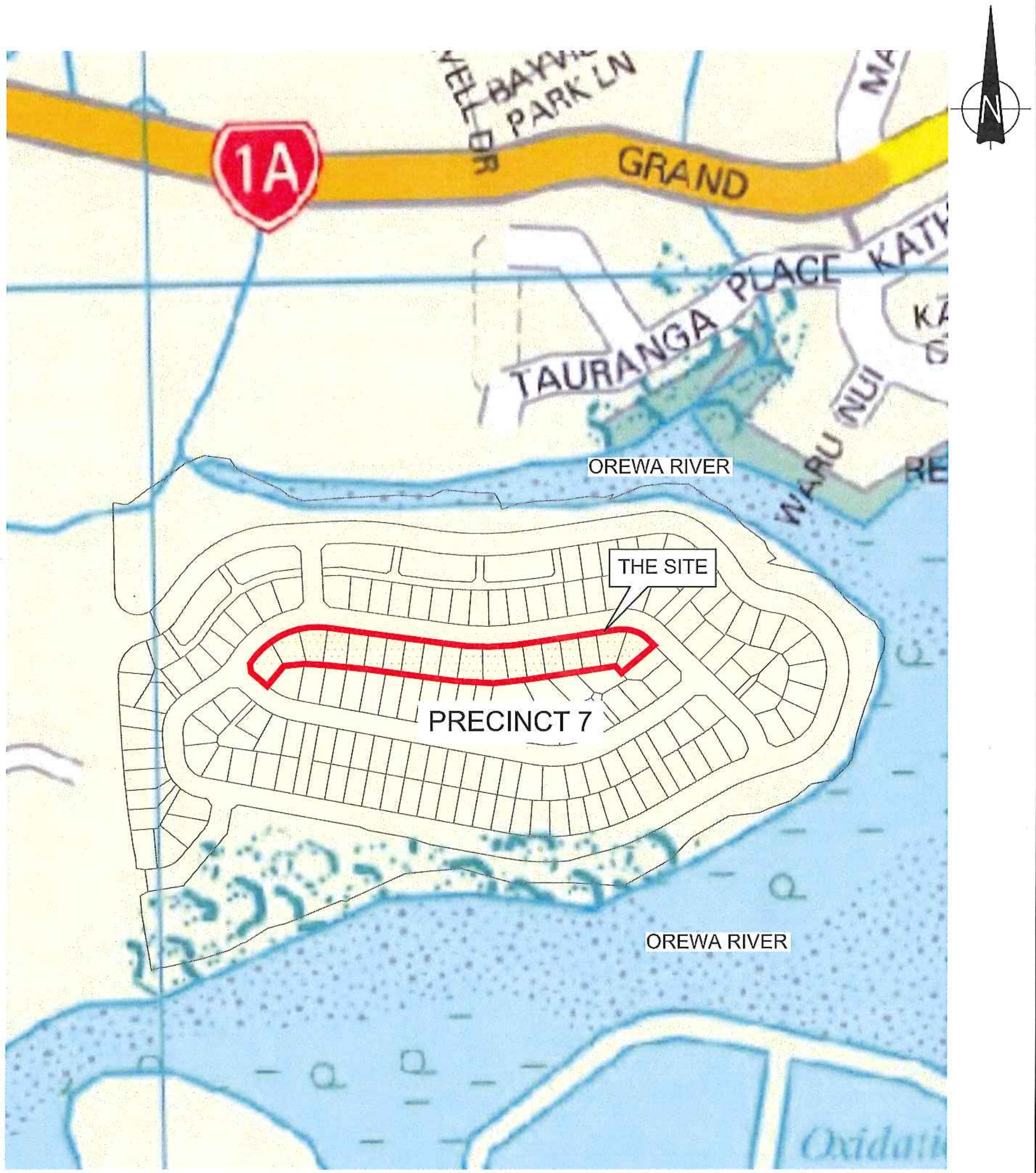
Appendix A2: T+T Drawings

- 21854.0037–APP7S2B–100 Drawing List and Site Location Plan
- 21854.0037–APP7S2B–101 Geotechnical Works Plan
- 21854.0037–APP7S2B–102 Geotechnical Works Subsoil Drain Plan
- 21854.0037–APP7S2B–103 Geological Cross Sections 1 & 2
- 21854.0037–APP7S2B–104 1(V):1.5(H) RE Slope Typical Details (1 of 2)
- 21854.0037–APP7S2B–105 1(V):1.5(H) RE Slope Typical Details (2 of 2)
- 21854.0037–APP7S2B–110 Building Limitation Plan

WFH PROPERTIES LTD
RESIDENTIAL SUBDIVISION
MILLWATER-ARRANS POINT PRECINCT 7 (STAGE 2B)
Completion Report Issue

DRAWING	Rev	Title
GENERAL		
• 21854.0037-APP7S2B-100	1	Drawing List and Location Plan
• 21854.0037-APP7S2B-101	1	Geotechnical Works Plan
• 21854.0037-APP7S2B-102	1	Geotechnical Works Subsoil Drain Plan
• 21854.0037-APP7S2B-103	1	Geolgical Cross Sections 1 & 2
• 21854.0037-APP7S2B-104	1	1(V):1(H) RE Slope Typical Details (Sheet 1 of 2)
• 21854.0037-APP7S2B-105	1	1(V):1(H) RE Slope Typical Details (Sheet 2 of 2)
• 21854.0037-APP7S2B-110	1	Building Limitation Plan
APPENDIX E		
• 21854.0037-APP7S2B-111	1	Post Earthworks Investigation Plan
• 21854.0037-APP7S2B-112	1	Earthworks Testing Location Plan

• Denotes drawing this issue: 13/07/2017



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

LOCATION PLAN
SCALE 1:5000

A3 SCALE 1:5000
0 50 100 150 200 250 (m)

ORIGINAL IN COLOUR

DRAWING STATUS: COMPLETION REPORT

1	Completion Report Issue			DESIGNED : JXXL May.17	NOTES :
				DRAWN : JC May.17	
				DESIGN CHECKED :	
				DRAFTING CHECKED :	
				CADFILE : \\21854.0037-APP7S2B-100.dwg	
				APPROVED : NOT FOR CONSTRUCTION	
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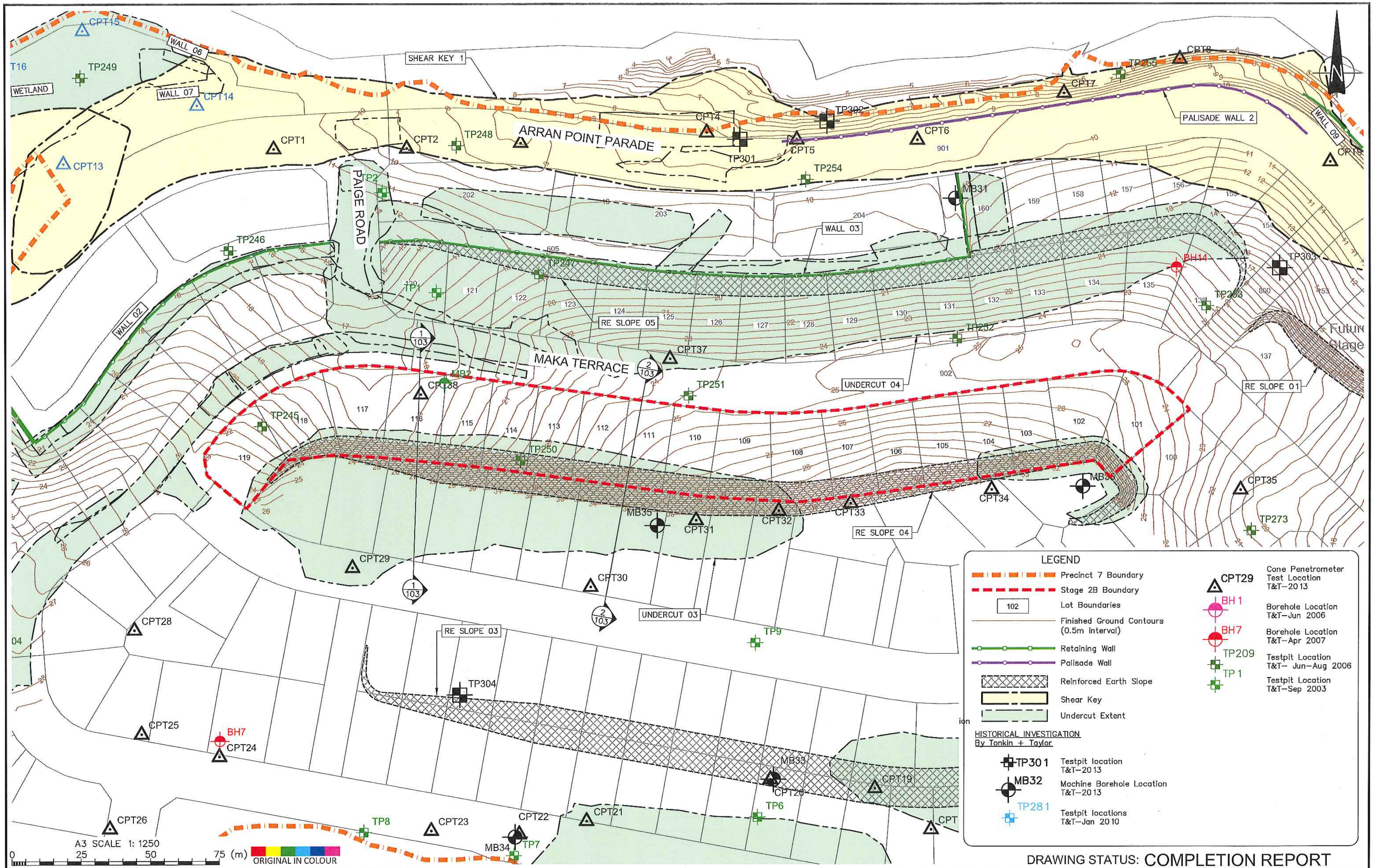
TITLE: MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Drawing List and Location Plan

SCALES (AT A3 SIZE): 1:5000
DWG. No. 21854.0037-APP7S2B-100
REV. 1



DRAWING STATUS: COMPLETION REPORT

DESIGNED :		AJL	May.17
DRAWN :		JC	May.17
DESIGN CHECKED :			
DRAFTING CHECKED :			

CADFILE : \\21854.0037–APP7S1–00.dwg

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REV.	REVISION DESCRIPTION	BY	DATE
1	Completion Report Issue		

NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. Coordinate Datum: NZGD2000, Mt Eden Circuit Circuit Coordinates. Origin: Lat 36 52 47S Long 174 45 51E 800,000mN 400,000mE
3. Baseplan and final contour supplied by WOODS, reference data "37001–02B–AB–100–FINAL CONTOURS" dated May 2017.
4. Undercut and shearkey supplied by WOODS, reference data "37001–02B–AB–120 SK UC & SUBSOIL" dated May 2017.

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TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Geotechnical Works Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1250	21854.0037–APP7S2B–101	1

DRAWING STATUS: COMPLETION REPORT

DESIGNED :	AJL	May. 17		
DRAWN :	JC	May. 17		
DESIGN CHECKED :				
DRAFTING CHECKED :				
CADFILE : \\21854.0037-APP7S1-00.dwg				
APPROVED : NOT FOR CONSTRUCTION				
1	Completion Report Issue			
REVISION DESCRIPTION		BY	DATE	

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3. Baseplan and final contour supplied by WOODS, reference data "37001-02B-AB-100-FINAL CONTOURS" dated May 2017.
4. Undercut and shearkey supplied by WOODS, reference data "37001-02B-AB-120 SK UC & SUBSOIL" dated May 2017.

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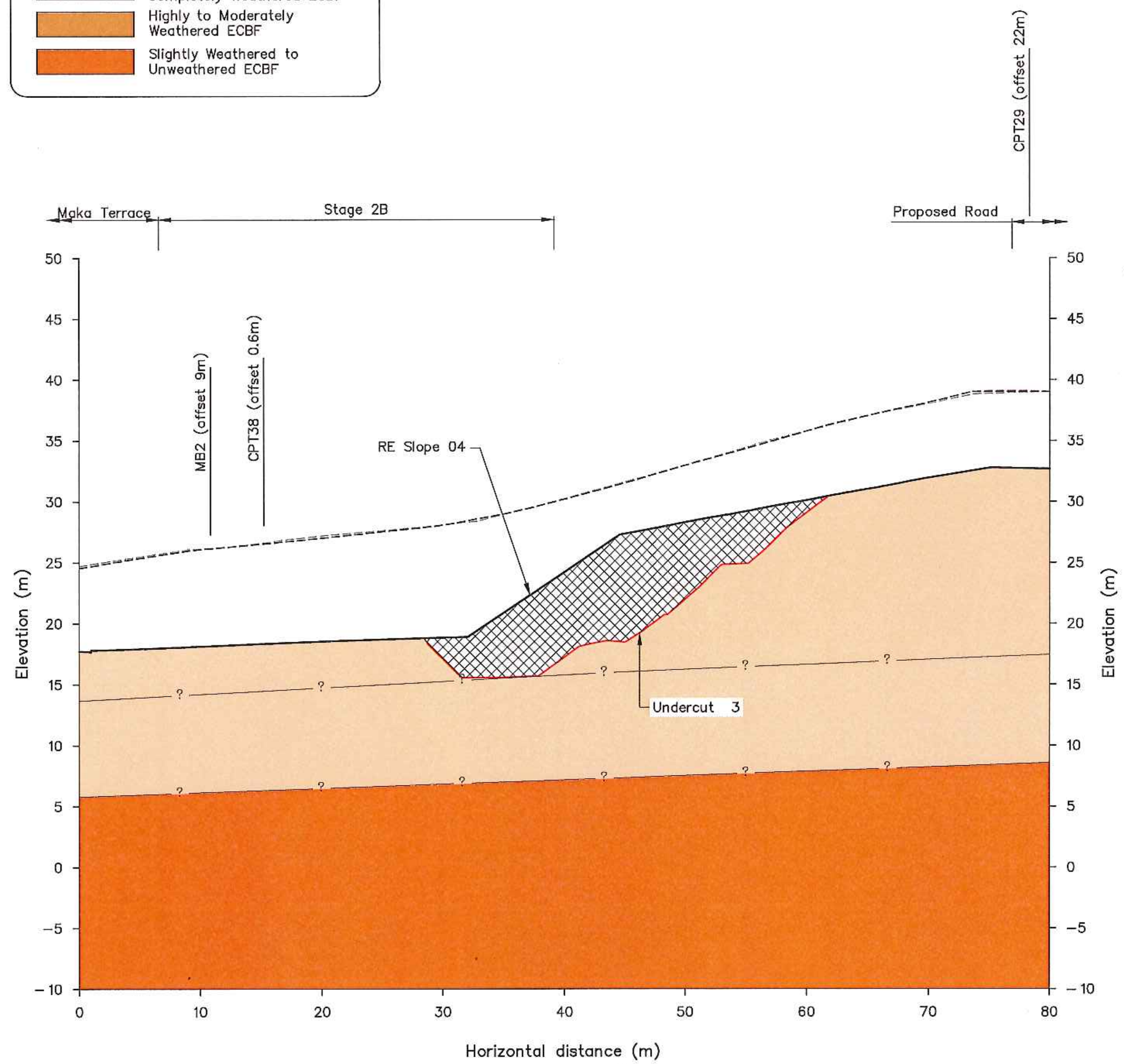
TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Geotechnical Works Subsoil Drain Plan

SCALES (AT A3 SIZE) 1: 1250
DWG. No. 21854.0037-APP7S2B-102
REV. 1

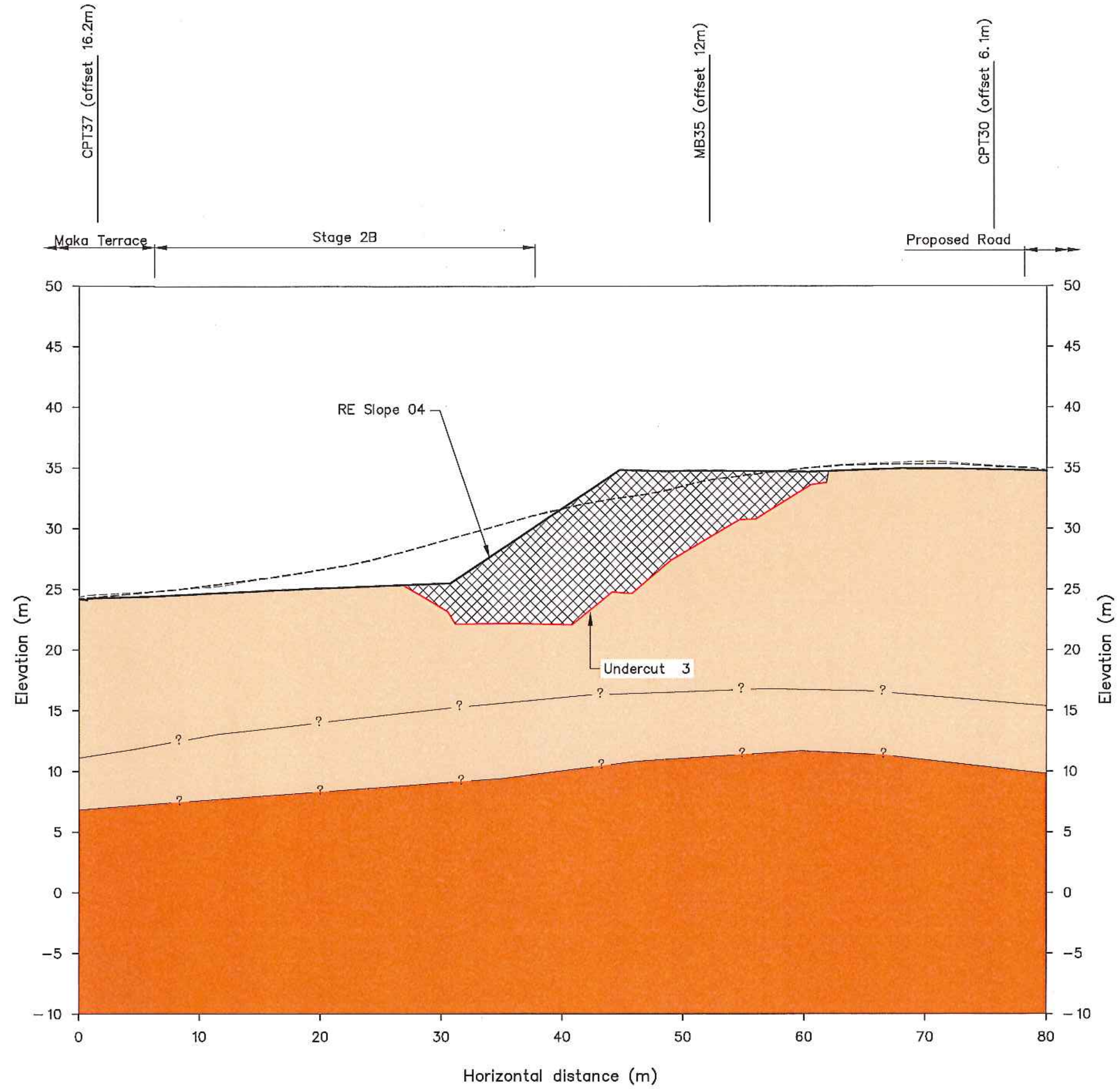
LEGEND

- - - - - - -	Original 2009 Ground profile
———	Stage 2B Finished Ground level
—— ? ——	Inferred geological boundary
—— (red)	Undercuts Level
(cross-hatched)	Engineered Fill
(light)	Residual Soils/ Completely Weathered ECBF
(medium)	Highly to Moderately Weathered ECBF
(dark)	Slightly Weathered to Unweathered ECBF

Geological sections are an interpretation of the investigation data which is available only at discrete locations. Additional Paleo–valleys and variability in soil layers and ECBF Rock interface may be present in areas between test locations.



SECTION 1/103
SCALE 1:500



SECTION 2/103
SCALE 1:500

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

ORIGINAL IN COLOUR

DRAWING STATUS: COMPLETION REPORT

DESIGNED :	AJL	May. 17
DRAWN :	JC	May. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.0037–APP7S2B–103.dwg		
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TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Geolgical Cross Sections 1 & 2

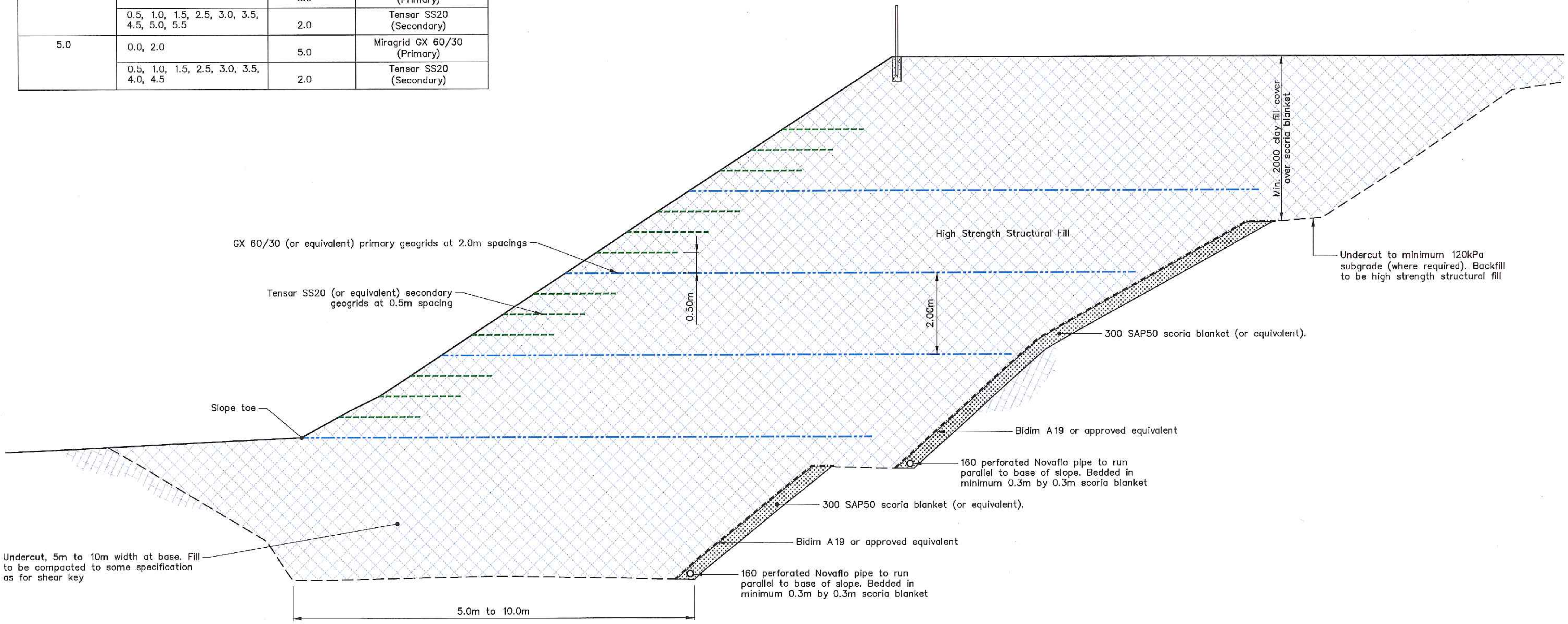
SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1000	21854.0037–APP7S2B–103	1

GEOGRIDS REQUIREMENTS FOR A 1: 1 (V:H) REINFORCED EARTH SLOPE

SLOPE HEIGHTS (m)	GEOGRID REQUIREMENTS		
	Height above slope toe (m)	Geogrid Length (m)	Geogrid Type
9.0	0.0, 2.0, 4.0, 6.0	14.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5, 6.5, 7.0, 7.5, 8.0, 8.5	2.0	Tensar SS20 (Secondary)
8.0	0.0, 2.0, 4.0, 6.0	12.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5, 6.5, 7.0, 7.5	2.0	Tensar SS20 (Secondary)
7.0	0.0, 2.0, 4.0	7.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5, 6.0, 6.5	2.0	Tensar SS20 (Secondary)
6.0	0.0, 2.0, 4.0	5.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5	2.0	Tensar SS20 (Secondary)
5.0	0.0, 2.0	5.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.0, 4.5	2.0	Tensar SS20 (Secondary)

LEGEND

- Miragrid GX60/30 (Primary Geogrid)
- Tensar SS20 (Secondary)
- Bidim A19 Geotextile
- High Strength Structural Fill
- Natural soil/rock
- SAP50 Scoria



1(V): 1(H) RE SLOPE 4 TYPICAL DETAILS (LOT 101 TO 104 & LOT 108 TO 119)

SCALE 1: 100

A3 SCALE 1: 100

0 1 2 3 4 5 (m)

DRAWING STATUS: COMPLETION REPORT

DESIGNED :	AJL	May.17	NOTES :			
DRAWN :	JC	May.17				
DESIGN CHECKED :	AJL	Feb.15				
DRAFTING CHECKED :	AMM	Feb.15				
CADFILE : \\21854.0037-APP7S2B-104-105.dwg						
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TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
1(V): 1(H) RE Slope Typical Details (Sheet 1 of 2)

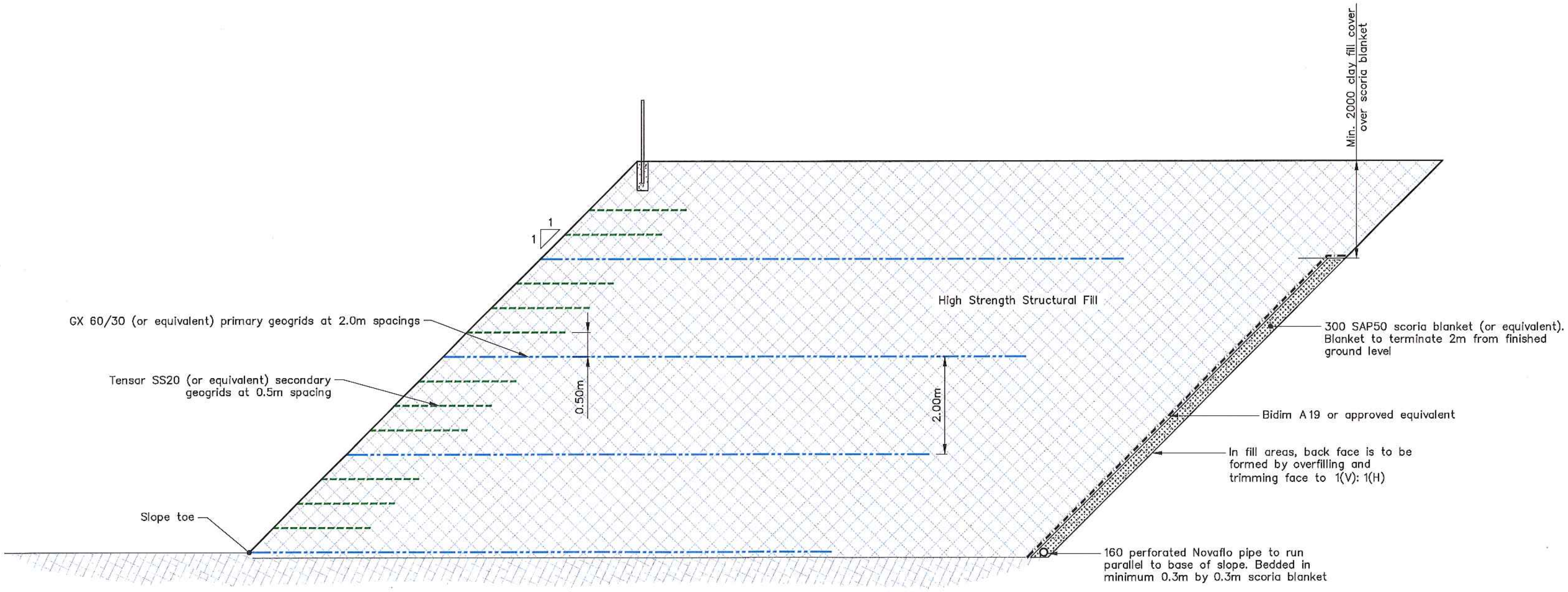
SCALES (AT A3 SIZE): AS SHOWN
DWG. No.: 21854.0037-APP7S2B-104
REV.: 1

GEOGRIDS REQUIREMENTS FOR A 1: 1 (V:H) REINFORCED EARTH SLOPE

SLOPE HEIGHTS (m)	GEOGRID REQUIREMENTS		
	Height above slope toe (m)	Geogrid Length (m)	Geogrid Type
8.0	0.0, 2.0, 4.0, 6.0	12.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5, 6.5, 7.0, 7.5	2.0	Tensar SS20 (Secondary)
7.0	0.0, 2.0, 4.0	7.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5, 6.0, 6.5	2.0	Tensar SS20 (Secondary)
6.0	0.0, 2.0, 4.0	5.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.5, 5.0, 5.5	2.0	Tensar SS20 (Secondary)
5.0	0.0, 2.0	5.0	Miragrid GX 60/30 (Primary)
	0.5, 1.0, 1.5, 2.5, 3.0, 3.5, 4.0, 4.5	2.0	Tensar SS20 (Secondary)

LEGEND

- Miragrid GX60/30 (Primary Geogrid)
- Tensar SS20 (Secondary)
- Bidim A19 Geotextile
- High Strength Structural Fill
- Natural soil/rock
- SAP50 Scoria



1(V): 1(H) RE SLOPE 4 TYPICAL DETAILS (LOT 105 TO 108)

SCALE 1: 100

A3 SCALE 1: 100

0 1 2 3 4 5 (m)

DRAWING STATUS: COMPLETION REPORT

DESIGNED :	AJL	May.17		
DRAWN :	JC	May.17		
DESIGN CHECKED :	AJL	Feb.15		
DRAFTING CHECKED :	AMM	Feb.15		

CADFILE : \\21854.0037–APP7S2B–104–105.dwg

APPROVED :

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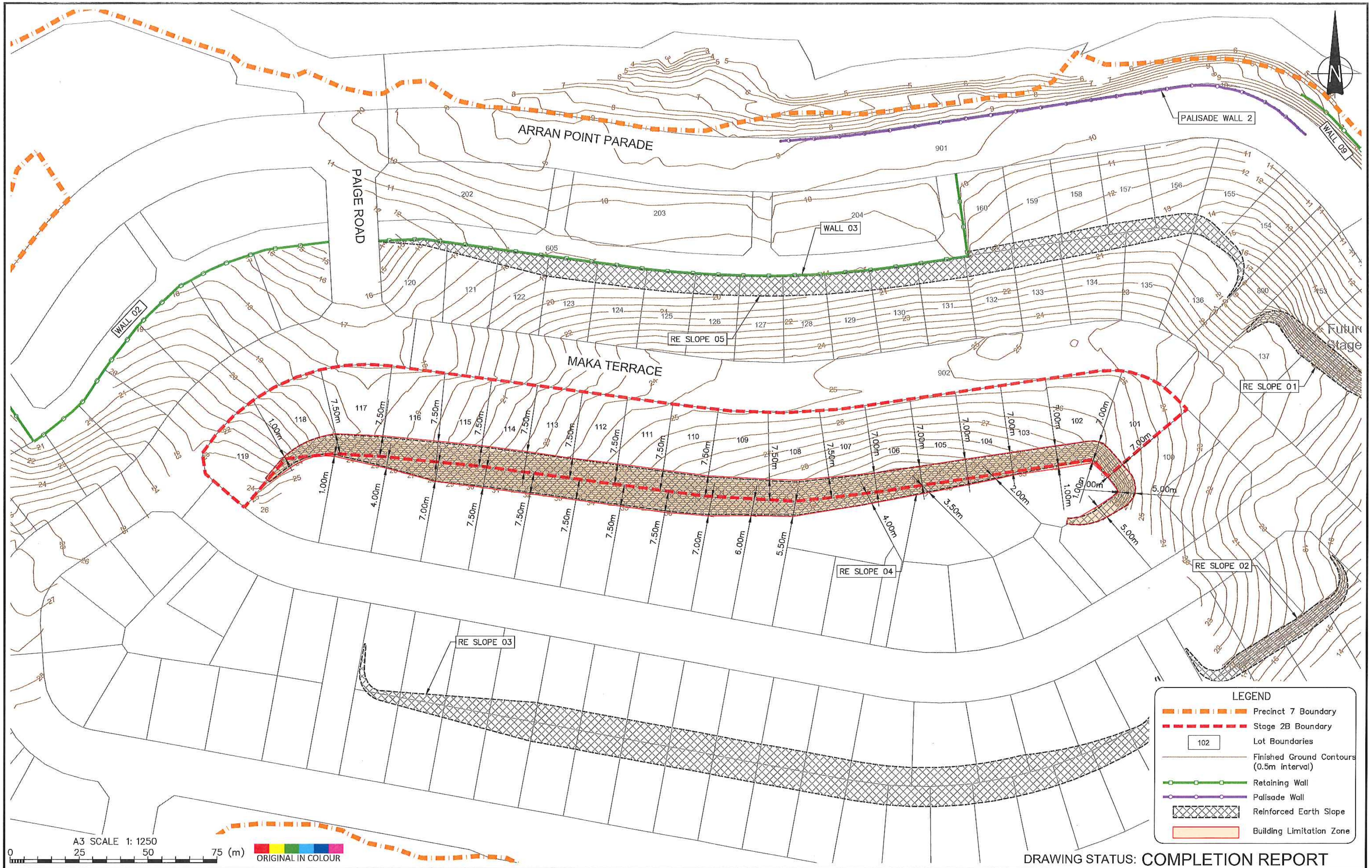
TITLE: MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)

1(V): 1(H) RE Slope Typical Details (Sheet 2 of 2)

SCALES (AT A3 SIZE): AS SHOWN

DWG. No.: 21854.0037–APP7S2B–105

REV.: 1



DRAWING STATUS: COMPLETION REPORT

REVISION	DESCRIPTION	BY	DATE
1	Completion Report Issue		

DESIGNED :	JXXL	May. 17
DRAWN :	JC	May. 17
DESIGN CHECKED :		
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CADFILE : \\21854.0037-APP7S1-00.dwg		
APPROVED : NOT FOR CONSTRUCTION		

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NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. Coordinate Datum: NZGD2000, Mt Eden Circuit Circuit Coordinates. Origin: Lat 36 52 47S Long 174 45 51E 800,000mN 400,000mE
3. Baseplan and final contour supplied by WOODS, reference data "37001-02B-AB-100-FINAL CONTOURS" dated May 2017.
4. Undercut and shearkey supplied by WOODS, reference data "37001-02B-AB-120 SK UC & SUBSOIL" dated May 2017.

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TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Building Limitation Plan

SCALES (AT A3 SIZE) 1: 1250
DWG. No. 21854.0037-APP7S2B-110
REV. 1

L:\21854\21854.0037 - Arrans Point Precinct 7\CAD\STAGE 2\GCR\STAGE 2B\21854.0037-APP7S2B-110.dwg, 110, 7/07/2017 11:24:04 a.m., JC

Appendix B: Contractors Certificates

- Hick Bros - Producer Statement PS3 – Contract 37000-02 (Stage 1 Bulk Earthworks)
- Hick Bros - Producer Statement PS3 – Contract 37001-02 (All Stage 2 Civil works)

PS3 - FORM OF PRODUCER STATEMENT- CONSTRUCTION

ISSUED BY: HICK BROS CIVIL CONSTRUCTION LIMITED

TO: WFH PROPERTIES

IN RESPECT OF: PRECINT 7 OREWA WEST BULK EARTHWORKS AND GEOTECHNICAL REMEDIATION
AT: PRECINCT 7 CONTRACT 37000-02

HICK BROS CIVIL CONSTRUCTION LTD has contracted to WFH PROPERTIES to carry out and complete certain building works in accordance with a contract, titled PRECINT 7 OREWA WEST BULK EARTHWORKS AND GEOTECHNICAL REMEDIATION ("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 all of the earthworks in Stage 2 as specified in the attached particulars of the contract works in in accordance with the contract.

Date: 4th August 2016

(Signature of Authorized Agent on behalf of)

HICK BROS CIVIL CONSTRUCTION LIMITED
(Contractor)

42 FORGE ROAD, SILVERDALE
(Address)

PS3 - FORM OF PRODUCER STATEMENT- CONSTRUCTION

ISSUED BY: HICK BROS CIVIL CONSTRUCTION LIMITED

TO: WFH PROPERTIES

IN RESPECT OF: PRECINT 7 OREWA WEST STAGE 1 & 2 CIVIL WORKS
AT: PRECINCT 7 CONTRACT 37001-02

HICK BROS CIVIL CONSTRUCTION LTD has contracted to WFH PROPERTIES to carry out and complete certain building works in accordance with a contract, titled PRECINT 7 OREWA WEST STAGE 1 & 2 CIVIL WORKS ("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 all of the works in Stage 2 as specified in the attached particulars of the contract works in in accordance with the contract.

Date: 10th January 2017

(Signature of Authorized Agent on behalf of)

HICK BROS CIVIL CONSTRUCTION LIMITED
(Contractor)

42 FORGE ROAD, SILVERDALE
(Address)

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 H2 as per the requirements of AS 2870:2011. Descriptions of the various site classes, together with characteristic surface ground movements are outlined below.

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

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

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

i. Building distress due to ground movement visible on adjacent structures,

ii. Known soil properties and site specific testing to determine the shrink / swell index of a soil (Test 7.1.1 in AS 1289 – Methods of Testing Soils for Engineering Purposes).

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

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

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

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

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

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

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

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

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

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

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

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

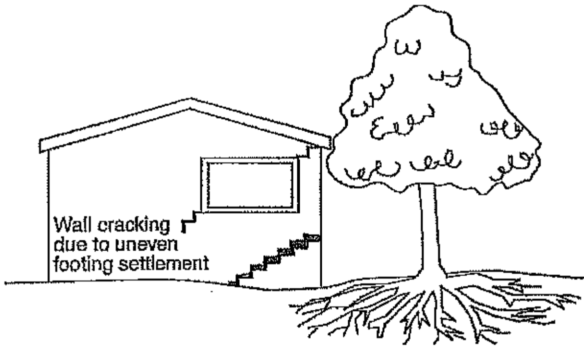
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

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

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

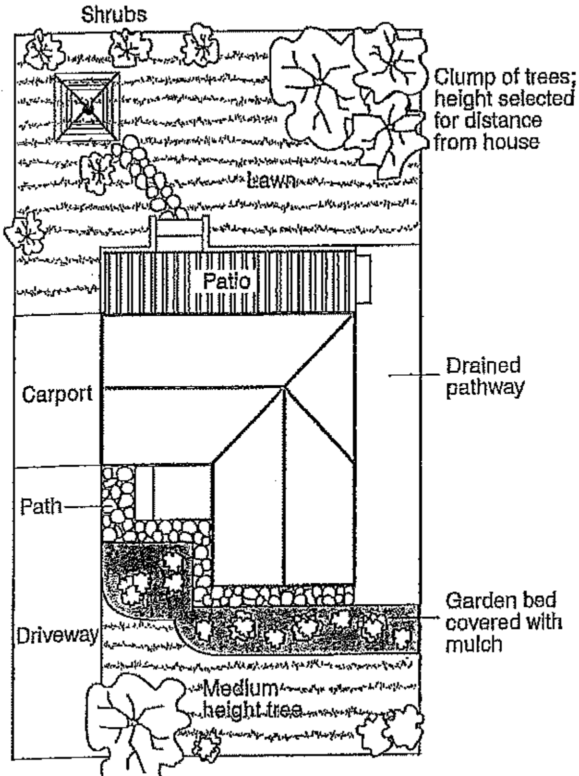
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

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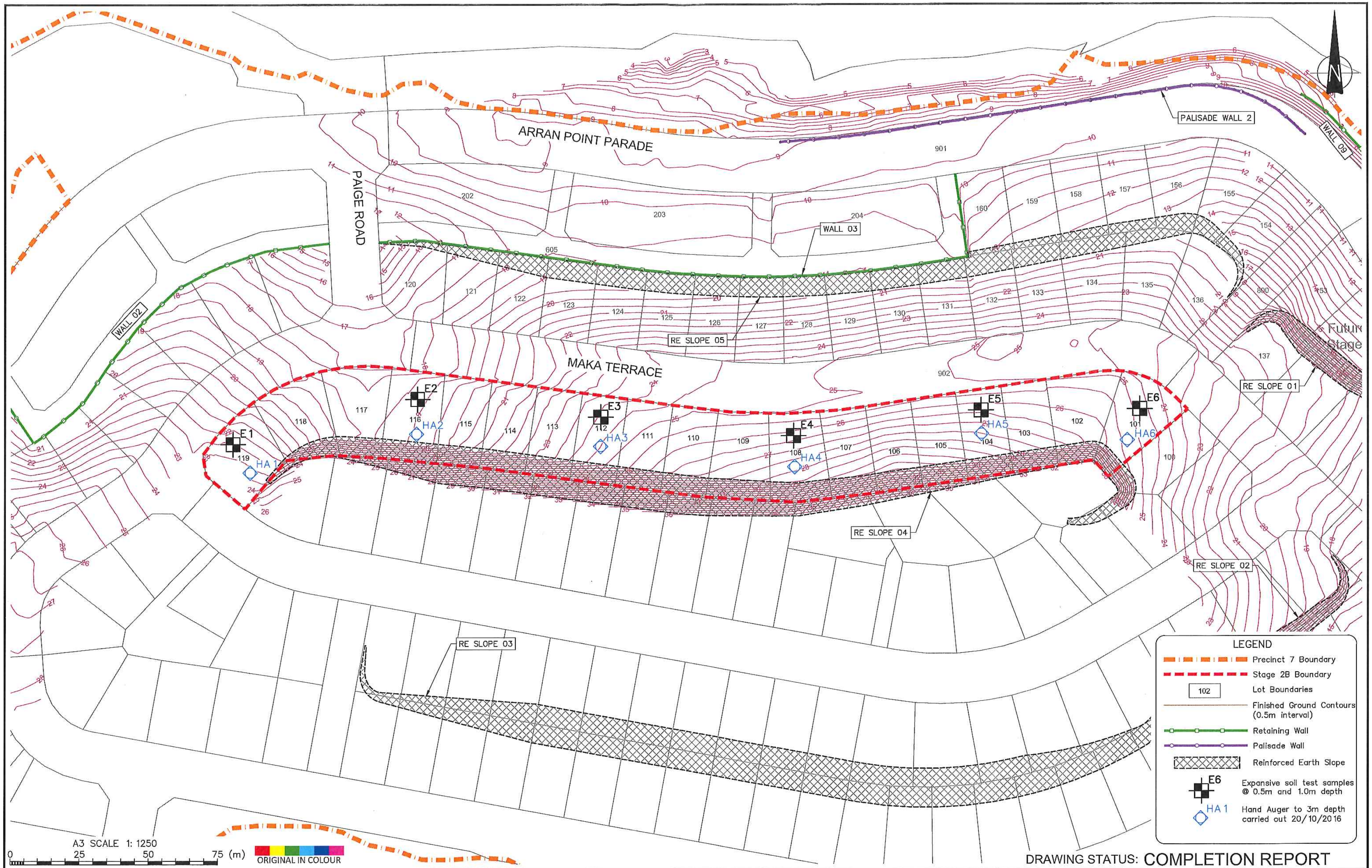
Appendix E: Test Results

- 21854.0037–APPP7S2B–111 Post Earthworks Investigation Plan
- 21854.0037–APPP7S2B–112 Earthworks Testing Location Plan
- Soil Expansion Test Results
- Post Earthworks Investigation Borehole Logs HA1 to HA6
- Earthworks Test Results



DRAWING STATUS: COMPLETION REPORT

REV.	REVISION DESCRIPTION	BY	DATE
1	Completion Report Issue		

DESIGNED :	JXXL	Mar. 17
DRAWN :	JC	Mar. 17
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.0037-APP7S1-00.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, Mt Eden Circuit Circuit Coordinates. Origin: Lat 36 52 47S Long 174 45 51E 800,000mN 400,000mE
3. Baseplan and final contour supplied by WOODS, reference data "37001-02B-AB-100-FINAL CONTOURS" dated May 2017.
4. Undercut and shearkey supplied by WOODS, reference data "37001-02B-AB-120 SK UC & SUBSOIL" dated May 2017.

REFERENCE :

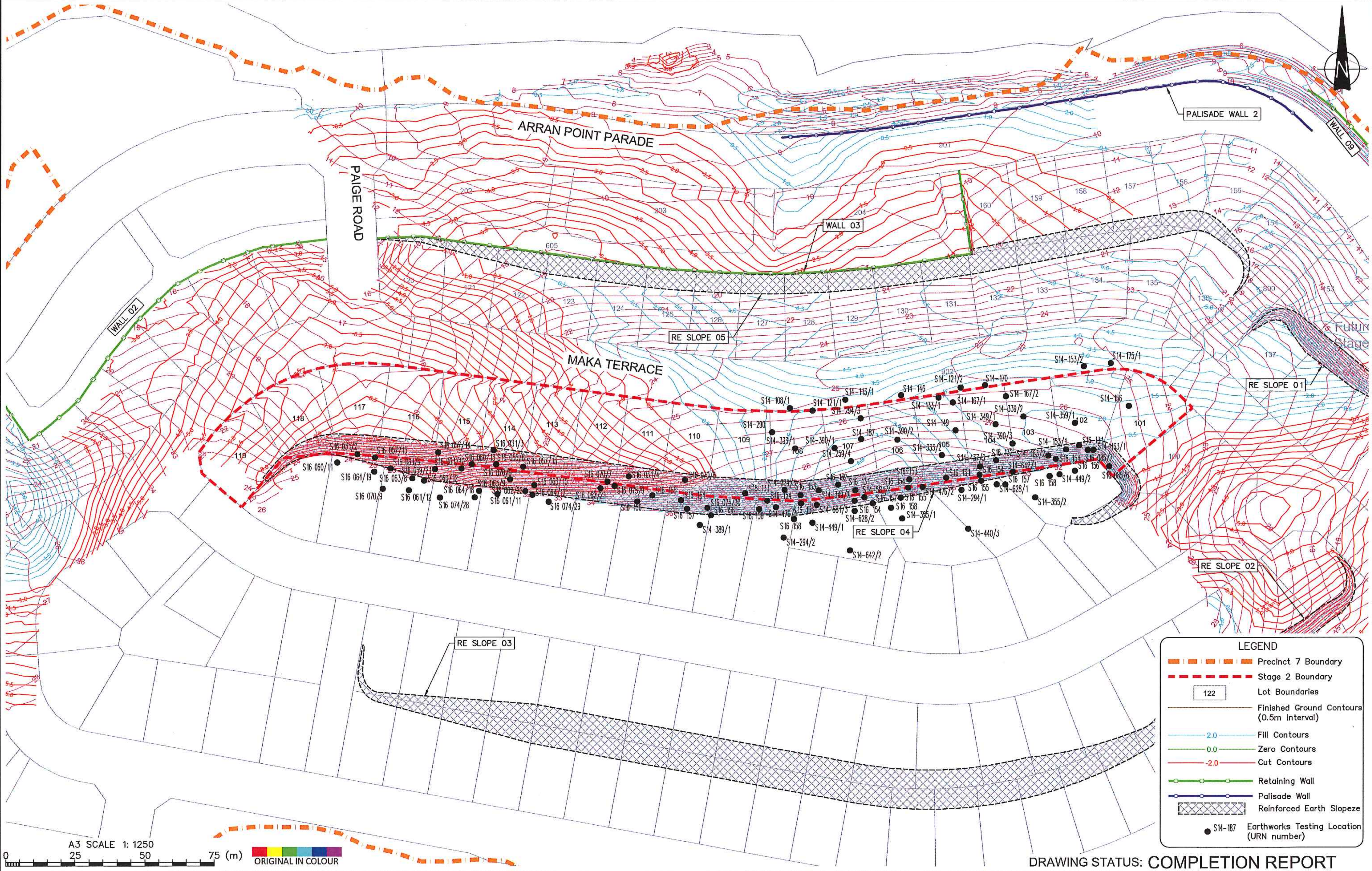
Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkintaylor.co.nz

CLIENT, PROJECT
WFH PROPERTIES LTD
RESIDENTIAL SUBDIVISION

TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Post Earthworks Investigation Plan

SCALES (AT A3 SIZE) 1: 1250
DWG. No. 21854.0037-APP7S2B-111
REV. 1

L:\21854\21854.0037 - Arrans Point Precinct 7\CAD\STAGE 2\GCR\STAGE 2B\21854.0037-APP7S2B-111.dwg, 111, 7/06/2017 4:23:31 p.m., JC



A3 SCALE 1: 1250

0 25 50 75 (m)

ORIGINAL IN COLOUR

DRAWING STATUS: COMPLETION REPORT

			DESIGNED :	JXXL	May.17	NOTES :
			DRAWN :	JC	May.17	
			DESIGN CHECKED :			
			DRAFTING CHECKED :			
			CADFILE : \\21854.0037-APP7S1-00.dwg			
			APPROVED : NOT FOR CONSTRUCTION			
1	Completion Report Issue		This drawing is not to be used for construction purposes unless signed as approved			
REVISION	DESCRIPTION	BY	DATE	COPYRIGHT ON THIS DRAWING IS RESERVED		REFERENCE :

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TITLE
MILLWATER – ARRANS POINT PRECINCT 7 (STAGE 2B)
Earthworks Testing Location Plan

SCALES (AT A3 SIZE): 1: 1250
DWG. No.: 21854.0037-APP7S2B-112
REV.: 1

GEOTECHNICS

Our Ref: 1003363.0000.0.0/Rep 1
Customer Ref: 21854.0037
10 July 2017

Tonkin & Taylor
PO Box 5271, Wellesley Street, Auckland 1141

Attention: Andrew Linton

Dear Andrew

Arran Point, Precinct 7, Stage 2B, Millwater

Laboratory Test Report

Samples from the above mentioned site have been tested as received and according to your instructions. Test results are included in this report.

Samples destroyed during testing.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of this page.

GEOTECHNICS LTD

Report prepared by:

Sim Tirunahari
I am the author of this document
2017.07.10 14:26:50 +12'00'

Sim Tirunahari
Soils Laboratory Manager

Authorised for Geotechnics by:

Steven Anderson
I am approving this document
2017.07.10 17:02:21 +12'00'

Steven Anderson
Project Director
Approved Signatory

Report checked by:

Steven Anderson
I have reviewed this document
2017.07.10 17:02:33 +12'00'

Steven Anderson
Regional Manager
Approved Signatory

This document consists of 3 pages

10-Jul-17

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

Site: **Arran Point, Precinct 7, Stage 2B, Millwater**

Your Job No: 21854.0037
Our Job No: 1003363.0000.0.0

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

Sample No.:			**1**	**1**	**2**	**2**	**3**	**3**
DEPTH		(m)	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		(kPa)	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	32.9	31.3	33.9	31.9	53.0	54.2
	Bulk Density	(t/m^3)	1.81	1.82	1.81	1.87	1.68	1.66
	Dry Density	(t/m^3)	1.36	1.39	1.35	1.42	1.10	1.08
	Final Water Content	(%)	34.3	34.1	35.5	33.0	55.0	56.1
	Swelling Strain	(%)	0.14	0.09	0.03	0.04	0.31	0.26
SHRINKAGE TEST	Initial Water Content	(%)	30.4	32.4	34.8	32.3	53.5	52.0
	Estimated Shrinkage Limit	(%)	10.9	10.7	9.9	11.8	15.4	25.3
	Shrinkage Strain	(%)	2.8	5.3	5.6	6.2	10.6	10.2
	Inert Material Estimate in the Soil Specimen	(%)	0	0	0	0	0	0
	Soil Crumbling During Shrinkage		Nil	Nil	Nil	Nil	Nil	Nil
	Cracking of the Shrinkage Specimen		Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
SHRINK - SWELL INDEX		(%)	**1.6**	**3.0**	**3.1**	**3.4**	**6.0**	**5.8**

Remarks: The test results are IANZ accredited.

Entered by: JK Date: 10/07/2017 Checked by: ST Date: 10/07/2017

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w. www.geotechnics.co.nz

Site: **Arran Point, Precinct 7, Stage 2B, Millwater**

Your Job No: 21854.0037
Our Job No: 1003363.0000.0.0

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

			4	4	5	5*	6	6
Sample No.:			**4**	**4**	**5**	**5***	**6**	**6**
DEPTH		**(m)**	**0.5**	**1.0**	**0.5**	***1.0**	**0.5**	**1.0**
Applied Pressure		**(kPa)**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	30.6	12.8	35.8	41.0	29.4	33.7
	Bulk Density	(t/m³)	1.87	1.82	1.83	1.68	1.90	1.83
	Dry Density	(t/m³)	1.43	1.61	1.35	1.19	1.47	1.37
	Final Water Content	(%)	32.5	14.7	37.4	42.9	30.8	34.9
	Swelling Strain	(%)	0.46	0.18	0.36	-0.01	0.28	0.14
SHRINKAGE TEST	Initial Water Content	(%)	32.3	32.3	35.6	28.2	35.6	29.0
	Estimated Shrinkage Limit	(%)	11.8	15.8	24.1	17.2	24.5	19.5
	Shrinkage Strain	(%)	5.7	6.1	4.5	0.7	4.6	1.9
	Inert Material Estimate in the Soil Specimen	(%)	0	0	0	0	0	0
	Soil Crumbling During Shrinkage		Nil	Nil	Nil	Nil	Nil	Nil
	Cracking of the Shrinkage Specimen		Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
SHRINK - SWELL INDEX		**(%)**	**3.3**	**3.5**	**2.6**	***0.4**	**2.7**	**1.1**

Shrinkage Test: ***Sample No.5_1.0m:** Sample height to diameter ratio is less than the required 1.5. We have advised the engineer and it was decided to continue with the testing.

Therefore the test results reported are not IANZ accredited.

Remarks: The test results are IANZ accredited.

Entered by: JK Date: 10/07/2017 Checked by: ST Date: 10/07/2017

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **STG2B-HA01**

SHEET: 1 OF 1

PROJECT: Arran point stage 3	LOCATION: Arran Point, Millwater	JOB No.: 21854.0037/s3
CO-ORDINATES:	DRILL TYPE: 50mm Hand Auger	HOLE STARTED: 01/05/2017
R.L.:	DRILL METHOD: HA	HOLE FINISHED:
		DRILLED BY: Geotechnics
DATUM:	DRILL FLUID:	LOGGED BY: RBE CHECKED: AJL

GEOLOGICAL — ENGINEERING DESCRIPTION

Geological unit, generic name, origin, material composition	Water	Tests	Depth (m)	Graphic log	Moisture condition	Strength/density classification	Description and Additional Observations
Topsoil				TS	M	H	SILT, non plastic, moist, dark brown
Fill		● >211 kPa ● 193/93 kPa ● 154/89 kPa ● >211 kPa	1		M-W	VSt-H	clayey SILT, medium to low plasticity, wet, grey and yellowish brown, AND; SILT, non plastic, moist, greyish brown and yellowish brown
Residual Soil		● 124/- kPa ● 69/20 kPa ● 124/33 kPa ● 63/21 kPa	2			St-VSt	SILT, non plastic, moist, light brownish white *1.70m:* changes to SILT with some clay, moist to wet
Weathered East Coast Bays Formation	DRY 01/05/2017	● 69/24 kPa ● 89/29 kPa ● 89/30 kPa	3		M	St	SILT, some clay, low to no plasticity, moist, grey
							3.2m: Target depth

COMMENTS:

Hole Depth 3.2m

Scale 1:20

Rev.: A

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **STG2B-HA02**

SHEET: 1 OF 1

PROJECT: Arran point stage 3	LOCATION: Arran Point, Millwater		JOB No.: 21854.0037/s3
CO-ORDINATES:	DRILL TYPE: 50mm Hand Auger	HOLE STARTED: 01/05/2017	
R.L.:	DRILL METHOD: HA	HOLE FINISHED:	
		DRILLED BY: Geotechnics	
DATUM:	DRILL FLUID:	LOGGED BY: RBE	CHECKED: AJL

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	WATER	TESTS	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
Topsoil				TS	M	VSt	SILT, non plastic, moist, dark brown
Fill		● 140/36 kPa ● 89/45 kPa ● 83/35 kPa ● 96/38 kPa ● 99/63 kPa	1			St-VSt	SILT AND clayey SILT, low to no plasticity, moist, grey and yellowish brown, *1.30m:* inclusions of grey sandstone gravel
		● 92/30 kPa ● 107/48 kPa	2				clayey SILT, low to medium plasticity, moist, yellowish brown with grey inclusions, weak sandstone inclusions
Weathered East Coast Bays Formation		● 152/47 kPa				VSt	SILT, non plastic, moist, dark grey
		● 178/24 kPa ● >211 kPa	3		M-W	VSt-H	sandy SILT, non plastic, moist to wet, dark grey
	DRY 01/05/2017				M	H	SILT, non plastic, moist, dark grey
							3.2m: Target depth

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, 20, 50, 100, 250), DEFECT SPACING (cm) (20, 60, 200, 600, 2000).

COMMENTS:

Hole Depth 3.2m

Scale 1:20

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: **STG2B-HA03**

SHEET: 1 OF 1

PROJECT: Arran point stage 3	LOCATION: Arran Point, Millwater	JOB No.: 21854.0037/s3
CO-ORDINATES:	DRILL TYPE: 50mm Hand Auger	HOLE STARTED: 10/05/2017
R.L.:	DRILL METHOD: HA	HOLE FINISHED:
		DRILLED BY: Geotechnics
DATUM:	DRILL FLUID:	LOGGED BY: AG CHECKED: AJL

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION	WATER	TESTS	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
Topsoil				TS	M	VSt	SILT, non plastic, moist, dark brown
Residual Soil		159/88 kPa				St-VSt	SILT minor clay, medium to low plasticity, moist, light grey mottled yellowish orange
		103/50 kPa					*0.60m:* changes to; low plasticity
		109/54 kPa	1				
		107/54 kPa					*1.40m:* changes to; low to no plasticity
		104/51 kPa					
		115/54 kPa					*1.90m:* changes to; light greyish white mottled yellowish brown and orangey red
		62/27 kPa	2				
		51/21 kPa				St	clayey SILT, low to medium plasticity, moist, light yellowish brown
						F-St	SILT some clay, low plasticity, moist, light yellowish brown mottled pink
		48/20 kPa					SILT trace clay, non plastic, moist, light yellowish brown mottled pink
	DRY 10/05/2017	56/24 kPa	3				
							3.1m: Target depth

COMMENTS:

Hole Depth 3.1m

Scale 1:20

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **STG2B-HA04**

SHEET: 1 OF 1

PROJECT: Arran point stage 3	LOCATION: Arran Point, Millwater	JOB No.: 21854.0037/s3
CO-ORDINATES:	DRILL TYPE: 50mm Hand Auger	HOLE STARTED: 10/05/2017
		HOLE FINISHED:
R.L.:	DRILL METHOD: HA	DRILLED BY: Geotechnics
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
Topsoil				TS	M	H	SILT, non plastic, moist, dark brown
Fill		● >211 kPa ● >211 kPa				VSt-H	SILT, non plastic, moist, yellow, AND; clayey SILT, low plasticity, light brown with grey inclusions, occasional sandstone inclusions
		● 152/96 kPa	1				clayey SILT, low plasticity, moist, yellowish brown, grey silt inclusions
		● UTP				VSt	SILT, non plastic, moist, grey, with pieces of sandstone gravel, AND; clayey SILT, medium to low plasticity, yellowish brown
	DRY 10/05/2017	● 131/84 kPa ● 152/84 kPa ● 167/87 kPa ● 169/59 kPa ● 160/92 kPa ● 184/102 kPa	2 3				clayey SILT, low plasticity, moist, yellowish brown, minor grey inclusions
							3.1m: Target depth

Other column headings: 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

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **STG2B-HA05**

SHEET: 1 OF 1

PROJECT: Arran point stage 3	LOCATION: Arran Point, Millwater	JOB No.: 21854.0037/s3
CO-ORDINATES:	DRILL TYPE: 50mm Hand Auger	HOLE STARTED: 10/05/2017
	DRILL METHOD: HA	HOLE FINISHED:
R.L.:		DRILLED BY: Geotechnics
DATUM:	DRILL FLUID:	LOGGED BY: AG CHECKED: AJL

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	WATER	TESTS	DEPTH (m)	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
Topsoil				M	H	SILT, non plastic, moist, dark brown
Fill		● >212 kPa ● 204/91 kPa ● >212 kPa ● >212 kPa ● 148/79 kPa ● 194/91 kPa	1		VSt-H	SILT some clay, non plastic, moist, yellowish brown mottled grey and brown, occasional gravel *0.50m:* changes to; moist to dry *0.80m:* changes to; moist
Residual Soil	DRY 10/05/2017	● >212 kPa ● 139/68 kPa ● 144/68 kPa ● 129/76 kPa	2 3			SILT minor clay, no to low plasticity, moist, orange, mottled light grey *2.70m:* changes to; light grey mottled yellowish brown
						3.1m: Target depth

Other column headings: FLUID LOSS (%) 25 50 75; CORE RECOVERY (%); METHOD; CASING; SAMPLES; RL (m); GRAPHIC LOG; WEATHERING; SHEAR STRENGTH (kPa) 10 25 50 100 200; COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 200; DEFECT SPACING (cm) 20 40 200 600 2000

COMMENTS:

Hole Depth 3.1m

Scale 1:20

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **STG2B-HA06**

SHEET: 1 OF 1

PROJECT: Arran point stage 3	LOCATION: Arran Point, Millwater
JOB No.: 21854.0037/s3	
CO-ORDINATES:	DRILL TYPE: 50mm Hand Auger
HOLE STARTED: 10/05/2017	HOLE FINISHED:
R.L.:	DRILL METHOD: HA
DRILLED BY: Geotechnics	
DATUM:	DRILL FLUID:
LOGGED BY: RBE	CHECKED: AJL

GEOLOGICAL (Geological unit, generic name, origin, material composition)	Water	Tests	Depth (m)	Moisture condition	Strength/density classification	Description and Additional Observations
Topsoil				M	VSt	SILT some clay, low plasticity, moist, dark brown
Fill		● 168/86 kPa ● >211 kPa			VSt-H	clayey SILT, low plasticity, moist, yellowish brown, AND; SILT, non plastic, moist, grey
		● >211 kPa	1			SILT, non plastic, moist, grey, minor inclusions of yellowish brown clayey SILT
		● 107/47 kPa ● 62/32 kPa			St-VSt	SILT, non plastic, moist, greyish white and yellowish brown *1.50m:* changes to; SILT some clay, grey and yellowish brown
		● 160/102 kPa ● 142/84 kPa	2	D-M	VSt	SILT, non plastic, dry to moist, yellowish brown *1.80m:* changes to; moist, yellowish brown with grey inclusions *2.20m:* changes to; inclusions of hard sandstone gravel
	DRY 10/05/2017	● 136/72 kPa ● 139/54 kPa ● 185/109 kPa	3	M		clayey SILT, low plasticity, moist, yellowish brown, inclusions of grey silt and sandstone gravel
						3.1m: Target depth

COMMENTS:

Hole Depth 3.1m

Scale 1:20

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Job: Arran's Point Stage 2B

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T&T Job #: 21854.0037

Job # 614089.032/1
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NZS 4407:1991 Field water content and field dry density using a nuclear densometer
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NZGS August 2001 Guidelines for hand held shear vane test.

URN	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m^3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate) Test 1	Test 2	Test 3	Test 4	Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
S14-108/1	2660285.59	6510675.844	23.22	Bulk Earthworks	YA	24/11/2014	1.79 1.79	1.33 1.33	34.7 34.7	2.7 2.7	4.5 4.9	137	154	171	205	167		P	
S14-113/1	2660315.478	6510678.445	23.79	Bulk Earthworks	HA	26/11/2014	1.83 1.83	1.38 1.39	32.0 32.0	2.7 2.7	4.4 4.3	137	154	154	205	163		P	
S14-121/1	2660303.673	6510674.832	24.09	Bulk Earthworks	HA	1/12/2014	1.79 1.79	1.23 1.23	44.9 44.9	2.7 2.7	0.0 0.0	120	137	171	171	150		P	
S14-121/2	2660356.9	6510681.931	25.68	Bulk Earthworks	HA	1/12/2014	1.77 1.76	1.31 1.31	34.8 34.8	2.7 2.7	5.8 6.2	154	154	171	205	171		P	
S14-133/1	2660348.865	6510678.549	24.78	Bulk Earthworks	HA	3/12/2014	- -	- -	- -	- -	- -	120	140	180	205	161		P	
S14-146	2660335.52	6510679.66	24.92	Bulk Earthworks	HA	5/12/2014	- -	- -	- -	- -	- -	145	160	170	188	166		P	
S14-149	-	-	-	Bulk Earthworks	YA	6/12/2014	- -	- -	- -	- -	- -	140	160	180	200	170		P	
S14-153/1	2660394.239	6510659.087	25.42	Bulk Earthworks	HA	8/12/2014	1.85 1.85	1.40 1.40	32.0 32.0	2.7 2.7	3.1 3.0	145	154	145	188	158		P	
S14-153/2	2660401.191	6510688.662	24.31	Bulk Earthworks	HA	8/12/2014	1.86 1.86	1.42 1.42	30.8 30.8	2.7 2.7	3.6 3.6	137	154	188	188	167		P	
S14-156	-	-	-	Bulk Earthworks	HA	8/12/2014	- -	- -	- -	- -	- -	154	175	195	205	182		P	
S14-163/1	2660404.052	6510658.774	26.48	Bulk Earthworks	HA	9/12/2014	1.84 1.83	1.36 1.36	35.3 35.3	2.7 2.7	1.8 1.9	154	154	188	205	175		P	
S14-163/2	2660387.846	6510657.062	27.27	Bulk Earthworks	HA	9/12/2014	1.83 1.83	1.41 1.41	30.0 30.0	2.7 2.7	5.5 5.4	205	205	205	197	203		P	
S14-167/1	2660354	6510676.675	26.08	Bulk Earthworks	HA	10/12/2014	1.90 1.89	1.45 1.45	30.3 30.3	2.7 2.7	2.1 2.6	205	UTP	205	UTP	205		P	
S14-167/2	2660373.112	6510678.516	25.26	Bulk Earthworks	HA	10/12/2014	1.84 1.84	1.37 1.37	33.8 33.8	2.7 2.7	2.9 2.9	154	188	171	UTP	171		P	
S14-175/1	2660410.857	6510689.568	24.15	Bulk Earthworks	HA	11/12/2014	1.89 1.88	1.42 1.42	32.7 32.7	2.7 2.7	0.9 1.2	154	171	180	188	173		P	
S14-187	2660320.933	6510664.278	27.33	Bulk Earthworks	YA	13/12/2014	- -	- -	- -	- -	- -	150	170	190	205	179		P	
S14-259/4	-	-	-	Bulk Earthworks	HA	14/01/2015	- -	- -	- -	- -	- -	120	120	86	103	107		P	
S14-290				Bulk Earthworks	HA	19/01/2015	1.86 1.85	1.38 1.37	35.3 35.3	2.7 2.7	0.4 1.0	154	154	188	154	163		P	
S14-294/1				Bulk Earthworks	HA	20/01/2015	1.86 1.86	1.41 1.41	31.7 31.7	2.7 2.7	3.1 3.2	137	154	154	188	158		P	
S14-294/2				Bulk Earthworks	HA	20/01/2015	1.86 1.86	1.41 1.41	32.0 32.0	2.7 2.7	3.0 2.9	154	154	171	188	167		P	
S14-294/3				Bulk Earthworks	HA	20/01/2015	1.83 1.83	1.36 1.36	34.8 34.8	2.7 2.7	2.3 2.4	128	137	154	154	143		P	
S14-333/1				Bulk Earthworks	HA	28/01/2015	1.89 1.88	1.52 1.51	24.1 24.1	2.7 2.7	7.1 7.6	205	205	205	205	205		P	
S14-333/2				Bulk Earthworks	HA	28/01/2015	1.86 1.85	1.43 1.43	29.5 29.5	2.7 2.7	4.5 4.8	154	205	205	205	192		P	

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Job: Arran's Point Stage 2B

Client: Tonkin & Taylor
T&T Job #: 21854.0037

Job # 614089.032/1
Entered By: YA
Checked By:

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

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S14-339/1	-			Bulk Earthworks	HA	29/01/2015	1.87 1.87	1.40 1.39	33.8 33.8	2.7 2.7	0.9 1.3	137	188	171	205	175		P	
S14-339/2				Bulk Earthworks	HA	29/01/2015	1.87 1.86	1.43 1.41	31.5 31.5	2.7 2.7	2.3 3.2	205	205	205	205	205		P	
S14-349/1				Bulk Earthworks	HA	30/01/2015	1.80 1.79	1.26 1.26	42.5 42.5	2.7 2.7	0.0 0.1	171	154	137	154	154		P	
S14-349/2				Bulk Earthworks	HA	30/01/2015	1.83 1.83	1.42 1.42	28.9 28.9	2.7 2.7	6.5 6.4	145	128	145	154	143		P	
S14-355/1				Bulk Earthworks	HA	2/02/2015	1.84 1.83	1.32 1.31	39.5 39.5	2.7 2.7	0.0 0.0	120	133	137	171	140		P	
S14-355/2				Bulk Earthworks	HA	2/02/2015	1.77 1.78	1.38 1.38	28.8 28.8	2.7 2.7	9.3 9.1	120	137	154	188	150		P	
S14-359/1				Bulk Earthworks	HA	3/02/2015	1.93 1.92	1.47 1.47	30.7 30.7	2.7 2.7	0.1 0.7	171	154	205	205	184		P	
S14-389/1				Bulk Earthworks	HA	10/02/2015	1.81 1.81	1.32 1.32	37.2 37.2	2.7 2.7	2.0 2.3	120	137	154	205	154		P	
S14-390/1				Bulk Earthworks	HA	11/02/2015	- -	- -	- -	- -	- -	86	103	103	120	103		F	
S14-390/2				Bulk Earthworks	HA	11/02/2015	- -	- -	- -	- -	- -	103	103	120	154	120		F	
S14-390/3				Bulk Earthworks	HA	11/02/2015	1.80 1.93	1.34 1.43	34.8 34.8	2.7 2.7	3.9 0.0	154	137	154	188	158		P	
S14-407				Bulk Earthworks	HA	13/02/2015	- -	- -	- -	- -	- -	154	170	190	205	180	Y	P	Failed material from URN S14-390 removed and reworked. Underlying layer passing on SV.
S14-437/3				Bulk Earthworks	HA	18/02/2015	1.77 1.76	1.21 1.21	45.7 45.7	2.7 2.7	0.0 0.3	205	180	154	137	169		P	
S14-440/3				Bulk Earthworks	HA	19/02/2015	1.75 1.75	1.34 1.34	30.8 30.8	2.7 2.7	9.1 9.3	205	188	171	205	192		P	
S14-449/1				Bulk Earthworks	HA	20/02/2015	1.84 1.84	1.39 1.39	32.9 32.9	2.7 2.7	3.0 3.1	180	162	171	171	171		P	
S14-449/2				Bulk Earthworks	HA	20/02/2015	1.83 1.81	1.41 1.40	29.9 29.9	2.7 2.7	5.8 6.6	205	205	205	197	203		P	
S14-476/1				Bulk Earthworks	YA	25/02/2015	1.82 1.81	1.37 1.37	32.6 32.6	2.7 2.7	4.6 4.9	137	154	171	188	163		P	
S14-476/2				Bulk Earthworks	YA	25/02/2015	1.82 1.81	1.32 1.32	37.3 37.3	2.7 2.7	1.6 2.2	137	154	171	188	163		P	
S14-581/3	2660304.515	6510641.156	29.87	Bulk Fill	HA	11/03/2015	1.80 1.81	1.35 1.36	33.3 33.3	2.7 2.7	4.9 4.4	205	205	205	205	205	Y	P	
S14-581/4	2660321.715	6510643.529	29.76	Bulk Fill	HA	11/03/2015	1.86 1.84	1.42 1.41	30.5 30.5	2.7 2.7	3.8 4.7	154	154	154	188	163		P	
S14-628/1				Bulk Fill	HA	19/03/2015	1.93 1.91	1.45 1.43	33.2 33.2	2.7 2.7	0.0 0.0	205	154	145	154	165		P	
S14-628/2				Bulk Fill	HA	19/03/2015	1.87 1.81	1.37 1.33	36.7 36.7	2.7 2.7	0.0 2.2	154	154	188	137	158		P	
S14-642/1				Bulkfill	YA	21/03/2015	1.83 1.83	1.43 1.43	27.5 27.5	2.7 2.7	7.5 7.4	120	137	154	171	146		P	

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S14-642/2				Bulkfill	YA	21/03/2015	1.83	1.43	27.3	2.7	7.8	120	137	154	171	146		P	
							1.83	1.44	27.3	2.7	7.6								
S16 031/2	2660140.178	6510662.460	19.568	Shear Key	TAJ	13/02/2016	1.85	1.43	29.7	2.7	4.6	205	205	205	205	205		P	
							1.87	1.44	29.7	2.7	3.9								
S16 031/3	2660189.142	6510662.988	19.801	Shear Key	TAJ	13/02/2016	1.84	1.40	31.4	2.7	4.0	205	205	205	205	205		P	
							1.83	1.39	31.4	2.7	4.7								
S16 031/4	2660237.337	6510652.670	22.626	Shear Key	TAJ	13/02/2016	1.81	1.36	33.3	2.7	4.6	205	205	205	205	205		P	
							1.82	1.36	33.3	2.7	4.2								
S16 055/8	2660189.951	6510657.852	21.62	Wall4	TAJ	21/03/2016	1.89	1.44	31.8	2.7	1.2	196	196	196	196	196		P	
							1.89	1.44	31.8	2.7	1.2								
S16 057/13	2660199.537	6510656.857	22.42	P7 Shear key	TAJ	29/03/2016	1.84	1.36	34.9	2.7	2.1	160	196	140	154	163		P	
							1.84	1.36	34.9	2.7	2.0								
S16 057/14				P7 Shear key	TAJ	29/03/2016	1.85	1.37	35.3	2.7	1.0	143	196	168	196	176		P	
							1.84	1.36	35.3	2.7	1.7								
S16 057/15	2660146.52	6510661.182	22.51	P7 Shear key	TAJ	29/03/2016	1.85	1.39	33.3	2.7	2.3	150	167	154	175	162		P	
							1.85	1.39	33.3	2.7	2.3								
S16 059/21	2660168.003	6510656.595	23.12	P7 RE Wall	TA	31/03/2016	1.85	1.42	29.6	2.7	5.1	196	196	196	196	196		P	
							1.86	1.43	29.6	2.7	4.4								
S16 060/11	2660132.936	6510659.66	24.18	P7 RE Wall	TA	1/04/2016	1.85	1.35	37.4	2.7	0.0	196	196	196	196	196		P	
							1.85	1.34	37.4	2.7	0.0								
S16 060/12	2660164.024	6510652.566	24.19	P7 RE Wall	TA	1/04/2016	1.85	1.37	34.8	2.7	1.5	196	196	196	196	196		P	
							1.85	1.37	34.8	2.7	1.3								
S16 060/13	2660181.243	6510658.102	24.22	P7 RE Wall	TA	1/04/2016	1.82	1.34	35.9	2.7	2.2	196	196	196	196	196		P	
							1.82	1.34	35.9	2.7	2.2								
S16 061/9	2660152.064	6510657.176	24.72	P7 RE Wall	TA	4/04/2016	1.78	1.29	37.6	2.7	3.7	196	196	196	196	196		P	
							1.77	1.28	37.6	2.7	4.3								
S16 061/10	2660177.519	6510656.646	25.05	P7 RE Wall	TA	4/04/2016	1.76	1.27	38.1	2.7	4.5	196	196	196	196	196		P	
							1.77	1.28	38.1	2.7	4.0								
S16 061/11	2660190.183	6510647.301	24.28	P7 RE Wall	TA	4/04/2016	1.76	1.29	36.7	2.7	5.0	196	196	196	196	196		P	
							1.76	1.29	36.7	2.7	5.1								
S16 061/12	2660158.459	6510649.251	24.78	P7 RE Wall	TA	4/04/2016	1.74	1.27	36.8	2.7	6.1	196	196	196	196	196		P	
							1.75	1.28	36.8	2.7	5.5								
S16 063/8	2660159.786	6510653.497	24.61	P7 Re Wall	TA	6/04/2016	1.83	1.36	34.7	2.7	2.8	150	154	196	168	167		P	
							1.82	1.35	34.7	2.7	3.1								
S16 063/9	2660183.681	6510648.556	25.06	P7 Re Wall	TA	6/04/2016	1.87	1.39	34.0	2.7	1.1	154	182	168	196	175		P	
							1.84	1.37	34.0	2.7	2.4								
S16 063/10	2660203.408	6510650.193	24.91	P7 Re Wall	TA	6/04/2016	1.87	1.43	31.2	2.7	2.7	150	150	151	182	158		P	
							1.86	1.42	31.2	2.7	3.1								
S16 064/17	2660202.663	6510646.758	25.14	P7 RE Wall	TA	7/04/2016	1.79	1.29	38.2	2.7	2.7	168	155	196	196	179		P	
							1.78	1.29	38.2	2.7	3.0								
S16 064/18	2660182.097	6510646.26	25.43	P7 RE Wall	TA	7/04/2016	1.80	1.31	37.8	2.7	2.2	168	155	196	196	179		P	
							1.81	1.31	37.8	2.7	1.8								
S16 064/19	2660146.189	6510656.134	26.01	P7 RE Wall	TA	7/04/2016	1.75	1.31	33.8	2.7	7.1	168	155	196	196	179		P	
							1.77	1.33	33.8	2.7	6.1								
S16 070/6	2660194.789	6510652.437	27.40	P7 RE Wall	TA	14/04/2016	1.76	1.32	33.3	2.7	7.0	192	192	164	151	175		P	
							1.77	1.33	33.3	2.7	6.8								
S16 070/7	2660229.713	6510650.938	27.29	P7 RE Wall	TA	14/04/2016	1.89	1.44	31.5	2.7	1.3	151	151	164	192	165		P	
							1.91	1.45	31.5	2.7	0.3								
S16 070/8	2660257.449	6510650.993	27.17	P7 RE Wall	TA	14/04/2016	1.85	1.37	35.5	2.7	0.9	158	164	192	192	177		P	
							1.87	1.38	35.5	2.7	0.0								
S16 070/9	2660149.131	6510649.984	26.46	P7 RE Wall	TA	14/04/2016	1.82	1.37	32.7	2.7	4.1	164	151	192	181	172		P	
							1.82	1.37	32.7	2.7	4.4								

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Job: Arran's Point Stage 2B

Client: Tonkin & Taylor
T&T Job #: 21854.0037

Job # 614089.032/1
Entered By: YA
Checked By:

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

URN	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m^3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate) Test 1	Test 2	Test 3	Test 4	Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
S16 074/28	2660169.603	6510646.433	29.30	P7 RE Wall	TA	21/04/2016	1.80	1.33	35.5	2.7	3.6	151	151	164	178	161		P	
							1.80	1.33	35.5	2.7	3.9								
S16 074/29	2660208.445	6510644.156	28.76	P7 RE Wall	TA	21/04/2016	1.78	1.30	36.4	2.7	4.3	151	151	164	178	161		P	
							1.80	1.32	36.4	2.7	3.3								
S16 074/30	2660265.266	6510640.869	28.61	P7 RE Wall	TA	21/04/2016	1.82	1.35	34.7	2.7	3.1	151	151	164	178	161		P	
							1.82	1.35	34.7	2.7	3.1								
S16 075/9	2660232.203	6510649.377	28.95	P7 Re Wall	TA	22/04/2016	1.83	1.38	32.7	2.7	3.7	192	192	192	192	192		P	
							1.85	1.39	32.7	2.7	3.0								
S16 085/6	2660409.538	6510652.796	27.479	P7 Re Wall	TA	9/05/2016	1.80	1.33	34.7	2.7	4.3	151	151	151	151	151		P	
							1.79	1.33	34.7	2.7	4.6								
S16 085/7	2660402.064	6510658.776	27.443	P7 Re Wall	TA	9/05/2016	1.83	1.36	34.5	2.7	2.6	151	151	151	151	151		P	
							1.83	1.36	34.5	2.7	2.6								
S16 131				Wall 4	TAJ	13/09/2016	1.83	1.36	34.4	2.7	2.7	214	214	214	214	214		P	
							1.81	1.35	34.4	2.7	3.7								
S16 131				Wall 4	TAJ	13/09/2016	1.89	1.43	32.0	2.7	1.2	214	214	214	214	214		P	
							1.88	1.43	32.0	2.7	1.6								
S16 131				Wall 4	TAJ	13/09/2016	1.89	1.41	33.8	2.7	0.2	214	214	214	214	214		P	
							1.89	1.41	33.8	2.7	0.0								
S16 131				Wall 4	TAJ	13/09/2016	1.84	1.37	34.1	2.7	2.6	214	214	214	214	214		P	
							1.82	1.36	34.1	2.7	3.3								
S16 132				Wall 4	TAJ	14/09/2016	1.85	1.36	36.0	2.7	0.8	153	160	153	168	159		P	
							1.84	1.35	36.0	2.7	1.3								
S16132				Wall 4	TAJ	14/09/2016	1.85	1.34	38.2	2.7	0.0	168	168	160	160	164		P	
							1.84	1.33	38.2	2.7	0.0								
S16 153				P7 Wall 4	TAJ	13/10/2016	1.85	1.37	35.1	2.7	1.1	214	214	214	214	214		P	
							1.86	1.38	35.1	2.7	0.6								
S16 153				P7 Wall 4	TAJ	13/10/2016	1.81	1.33	35.9	2.7	2.9	214	214	214	214	214		P	
							1.80	1.33	35.9	2.7	3.3								
S16 154				P7 Wall 4	TAJ	14/10/2016	1.88	1.40	34.0	2.7	0.5	214	214	214	214	214		P	
							1.81	1.35	34.0	2.7	4.3								
S16 154				P7 Wall 4	TAJ	14/10/2016	1.78	1.30	36.8	2.7	3.9	214	214	214	214	214		P	
							1.77	1.29	36.8	2.7	4.4								
S16 154				P7 Wall 4	TAJ	14/10/2016	1.88	1.38	35.9	2.7	0.0	214	214	214	214	214		P	
							1.87	1.37	35.9	2.7	0.0								
S16 154				P7 Wall 4	TAJ	14/10/2016	1.86	1.33	39.5	2.7	0.0	214	214	214	214	214		P	
							1.81	1.29	39.5	2.7	1.0								
S16 154				P7 Wall 4	TAJ	14/10/2016	1.74	1.27	36.7	2.7	6.2	214	214	214	214	214		P	
							1.74	1.28	36.7	2.7	6.0								
S16 154				P7 Wall 4	TAJ	14/10/2016	1.76	1.28	36.6	2.7	5.4	214	214	214	214	214		P	
							1.76	1.29	36.6	2.7	5.0								
S16 155				P7 Wall 4	TAJ	17/10/2016	1.83	1.34	36.6	2.7	1.6	214	214	214	214	214		P	
							1.83	1.34	36.6	2.7	1.3								
S16 155				P7 Wall 4	TAJ	17/10/2016	1.84	1.32	39.5	2.7	0.0	214	214	214	214	214		P	
							1.82	1.30	39.5	2.7	0.1								
S16 155				P7 Wall 4	TAJ	17/10/2016	1.82	1.34	36.1	2.7	2.4	214	214	214	214	214		P	
							1.83	1.34	36.1	2.7	1.8								
S16 155				P7 Wall 4	TAJ	17/10/2016	1.81	1.31	38.1	2.7	1.4	214	214	214	214	214		P	
							1.83	1.32	38.1	2.7	0.7								
S16 156				P7 Wall 4	TAJ	18/10/2016	1.79	1.29	39.1	2.7	1.8	168	183	165	153	167		P	
							1.79	1.29	39.1	2.7	2.0								
S16 156				P7 Wall 4	TAJ	18/10/2016	1.78	1.28	39.3	2.7	2.5	160	214	189	202	191		P	
							1.77	1.27	39.3	2.7	2.8								

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Job: Arran's Point Stage 2B

Client: Tonkin & Taylor
T&T Job #: 21854.0037

Job # 614089.032/1
Entered By: YA
Checked By:

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

URN	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m^3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate) Test 1	Test 2	Test 3	Test 4	Average Shear Strength (kPa)	Re-Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments
																			These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
S16 156				P7 Wall 4	TAJ	18/10/2016	1.78	1.31	35.8	2.7	4.3	176	202	196	159	183		P	
							1.80	1.32	35.8	2.7	3.5								
S16 156				P7 Wall 4	TAJ	18/10/2016	1.85	1.36	35.8	2.7	0.8	214	183	214	192	201		P	
							1.85	1.36	35.8	2.7	0.9								
S16 157				P7 Wall 4	TAJ	20/10/2016	1.82	1.33	36.9	2.7	1.7	214	214	214	214	214		P	
							1.82	1.33	36.9	2.7	1.7								
S16 157				P7 Wall 4	TAJ	20/10/2016	1.83	1.32	38.1	2.7	0.7	214	186	177	183	190		P	
							1.81	1.31	38.1	2.7	1.4								
S16 157				P7 Wall 4	TAJ	20/10/2016	1.83	1.33	37.6	2.7	0.7	214	214	214	214	214		P	
							1.84	1.34	37.6	2.7	0.1								
S16 158				P7 Wall 4	TAJ	21/10/2016	1.83	1.36	34.6	2.7	2.7	153	159	214	186	178		P	
							1.82	1.35	34.6	2.7	3.2								
S16 158				P7 Wall 4	TAJ	21/10/2016	1.79	1.32	35.6	2.7	4.0	214	174	141	147	169		P	
							1.79	1.32	35.6	2.7	4.0								
S16 158				P7 Wall 4	TAJ	21/10/2016	1.72	1.27	36.1	2.7	7.4	214	214	177	196	200		P	
							1.72	1.27	36.1	2.7	7.5								
S16 158				P7 Wall 4	TAJ	21/10/2016	1.80	1.30	38.3	2.7	1.9	160	214	214	214	201		P	
							1.79	1.29	38.3	2.7	2.5								