Prestons Park Subdivision

Stages F1, F2 and F3 Geotechnical Completion Report

CDL Land New Zealand Ltd

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Contents

Executive Summary

CDL Land New Zealand Limited is developing Stages F1, F2 and F3 of the Prestons Park Subdivision, located on Prestons Road, Christchurch. As part of the work, a geotechnical completion report is required to confirm that the site works have been carried out to the required standard and provide recommendations for building developments. This report describes the earthworks and ground improvement involved with Stages F1, F2 and F3 of the Prestons Park Subdivision.

Based on Aurecon's historical geotechnical assessment, Stages F1, F2 and F3 comprised sixteen lots classified as Technical Category TC2 and twenty-four lots classified as Technical Category TC1 equivalent prior to earthworks commencing.

Aurecon's role was to monitor the earthworks and fill compaction testing.

Earthworks predominantly comprising filling have occurred on the site. The quality assurance testing of the engineered earth fill indicates that the earth fill placed within the Stages F1, F2, and F3 area has achieved the required compaction levels as per NZS4431:1989 (since superseded by the NZS 4431:2022 '*Engineered fill construction for lightweight structures'*).

From the monitoring and testing undertaken as part of the development of Stages F1, F2 and F3 the following is concluded:

Certificate of Compliance

The standard of bulk earthworks generally meets the earthworks specification and the applicable codes, including NZS4431:1989 (since superseded by the NZS 4431:2022 '*Engineered fill construction for lightweight structures'*).

Building Considerations

General

This report shall not be used for building consent application for buildings on individual lots. Site specific geotechnical investigations, in-line with NZS3604:2011, shall be undertaken at building consent application stage.

TC1 Foundations

For lots identified as TC1, NZS 3604:2011 type foundations are considered suitable. At the time of writing this report, the location and structural form of the future dwelling on the lots are unknown and this recommendation relates to NZS3604:2011 type lightweight timber or steel framed residential buildings only.

TC2 Foundations

For lots identified as TC2, dwellings shall be founded on TC2 type 'enhanced foundation slabs' as per Options 2, 3 or 4 from the MBIE Guidelines (2012) Section 5.3 to mitigate the effects of liquefaction induced vertical settlement. Alternatively, a specific design in accordance with MBIE Guidelines Section 5.4 could be undertaken by a suitably qualified chartered professional engineer.

Explanatory Statement

This report shall be read as a whole and our Explanatory Statement is presented in Section 7.

1 Introduction

1.1 Geotechnical Completion

CDL Land New Zealand Limited is developing Stages F1, F2 and F3 of the Prestons Park Subdivision, located on Prestons Road, Christchurch. Stages F1, F2 and F3 are sub-stages within the wider Stage Five of the subdivision. The site works in Stages F1, F2 and F3 included bulk earthworks for the development of the lots. As part of this work, a geotechnical completion report is required to certify the site works have been carried out to the required standard and provide recommendations for building developments.

This report has been prepared for CDL Land New Zealand Limited and issued to Christchurch City Council (CCC). It describes the earthworks involved within Stages F1, F2 and F3 of the Prestons Park Subdivision (see Figure 1 in Appendix A).

The purpose of this geotechnical completion report is to present the following:

- Summarised information from previous investigations carried out as part of the subdivision consent and detailed design;
- Summarised information on the ground conditions and liquefaction risk;
- Extent of earthworks on the lots and compliance testing of bulk earthworks;
- A summary of the findings, land technical category, and recommendations for building development.

This report has been prepared based on geotechnical data from site observations and compaction testing during and after earthworks construction. All references to cut-fill depths are based on subgrade levels.

This report shall be read as a whole and our explanatory statement is presented in Section 7.

1.2 Site Description

The Prestons Road subdivision is located on the northern fringes of Christchurch City. The site is made up of a series of adjacent properties forming an irregular and elongated rectangle shape, orientated approximately north to south. The total area of the overall Prestons Subdivision site is approximately 190ha. The site can be separated into two distinct blocks. Prestons North runs from the Lower Styx Road in the north through to Prestons Road in the south. Prestons Park continues from Prestons Road, through to Mairehau Road to the south.

The focus of this geotechnical completion report is on Stages F1, F2 and F3 of the Prestons Park Subdivision. Stages F1, F2 and F3 incorporates a block in the southeast part of the Prestons Park Subdivision (see Figure 1 in Appendix A).

2 Pre-Development Geotechnical Work

2.1 Geotechnical Testing

The subdivision consent and detailed geotechnical design for the subdivision included an extensive series of geotechnical investigations. These comprised Cone Penetration Tests (CPT), test pits, groundwater measurements and laboratory testing.

The details of these investigations are presented in the following Aurecon reports:

- *Caldwell Block Subdivision Resource Consent Geotechnical Report,* Revision 0 dated 11 July 2018.
- *Prestons Park Stage Five Gravel Embankment Design*, Revision 0 dated 9 October 2019.

The geotechnical investigations carried out within Stages F1, F2 and F3 of the Prestons Park area are presented in Figure 2 in Appendix A.

2.2 Ground Conditions

From the extensive geotechnical investigations, the ground conditions within the Prestons Park Subdivision were divided into various geological areas. The typical ground conditions in the area are presented in Table 1.

Table 1: Typical ground conditions within Stages F1, F2 and F3.

Depth to Top of Unit (m)	Depth to Base of Unit (m)	Soil Unit
0	0.3 to 0.4	TOPSOIL.
0.3 to 0.4	3	SAND with minor silt, loose to medium dense.
3	12	SAND with minor silt, medium dense to dense.
12	Not determined	SAND, dense to very dense.

Groundwater levels ranged from 1m to 2.5m below ground level. During the site earthworks the above soil profile and groundwater levels were typically encountered within the area of interest.

2.3 Liquefaction Potential

As part of the geotechnical assessment and detailed design, a liquefaction assessment was carried out. The details of the liquefaction assessments are presented in the above reports listed in section 2.1. The land categorisation was based on the criteria of Ministry of Business, Innovation and Development (MBIE), Technical Category deformation performance limits are set out in Table 2.

Table 2: Technical category definitions and foundation implications (MBIE, 2012).

Technical Category	Liquefaction Deformation Limits				Likely Implications for House Foundations (Subject to individual assessment)
	Vertical		Lateral Spread		
	SLS	ULS	SLS	ULS	
TC1	15mm	25mm	nil	nil	Standard 3604-like foundation with tied slabs
TC2	50mm	100mm	50mm	100mm	MBIE Enhanced Foundation Solutions
TC3	>50mm	>100mm	>50mm	>100mm	Site Specific Measures – Piles or Ground Improvement

The results from the liquefaction assessment, detailed in the geotechnical report dated 11 July 2018, indicated that the Stage Five of Prestons Park Subdivision can be classified as Technical Category 1 (TC1) and Technical Category 2 (TC2).

3 Subdivision Earthworks

3.1 General

Bulk earthworks for Stages F1, F2 and F3 of Prestons were carried out in accordance with the requirements of NZS 4404:2010, "*Code of Practice for Urban Subdivision*" and NZS4431:1989 "*Code of Practice for Earthfill for Residential Development*" (since superseded by the NZS 4431:2022 "*Engineered fill construction for lightweight structures"*). The earthworks typically comprised stripping the site of topsoil, filling using imported pit run gravel or site-won sand, and then replacing topsoil. No excavation to remove in-situ organic material was undertaken as organics were infrequent, typically thin seams if encountered and at depths of greater than 2m.

3.2 Areas of Cut and Fill

Site earthworks within Stages F1, F2 and F3 have included predominantly filling with only localised minor cutting. The fill material comprises site-won sand and pit run gravel overlying a natural sand subgrade. A layer of topsoil overlies the fill material. The extent of filling and cuttings is shown in Figure 5 (AB-PS-S5-EW-04) in Appendix A.

3.3 Compaction Quality Control Testing

Independent testing of earthfill compaction completed using conventional earthworks techniques was carried out using a Nuclear Densometer (NDM). The acceptance criterion was based on the Prestons Park Subdivision earthworks specification as follows:

- Compaction of fill is to be in accordance with NZS 4431: 1989 (since superseded by the NZS 4431:2022 '*Engineered fill construction for lightweight structures'*).
- Compaction standard is 95% Maximum Dry Density (MDD) for all areas of bulk filling, per NZS4402 Test 4.1.3.

Fill materials comprised of site-won sand and imported pit run gravel. Compaction curves for each of the fill materials are presented in Appendix B.

The MDD from the compaction curves were used to determine the level of compaction required for the fill material. A summary of these NDM results is presented in Appendix C and the NDM testing locations are presented in Figure 3 in Appendix A.

On those occasions where quality control testing did not meet the specification, the Contractor was required to rework the fill to achieve the required compaction.

3.4 Compaction Results

The results presented in Appendix C indicate that 95% MDD or greater compaction has been consistently achieved in the areas of bulk fill. Where NDM results indicated the required compaction had not been achieved, the Contractor completed additional compaction effort and conforming NDM results were achieved. From these results and our site observations, we confirm that the earthfill placed within Stages F1, F2 and F3 have achieved the required compaction.

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4 Gravel Embankments

4.1 Introduction

The construction of the stormwater infrastructure within Stage Five comprised a large stormwater pond to south of Stage F3 which was identified as being a potential cause of liquefaction induced lateral spreading in a large seismic event. In addition to this stormwater pond, the existing Snellings Drain runs along the eastern boundary of Stage 5 adjacent to Stage F1.

Liquefaction induced lateral spreading requires a continuous liquefiable layer through to the free face. As the liquefiable layers are typically in the upper 2.5m to 3m depth of the soil profile, it was considered more feasible to remove the liquefiable layers and form a compacted gravel embankment to limit the potential hazard. By removing this continuous liquefiable layer and reinstating with compacted gravel, lateral spreading can be limited or eliminated.

4.2 Gravel Embankment Details

The design of the gravel embankments within Stage Five of Prestons Park Subdivision was undertaken by Aurecon and is presented in *"Prestons Park Stage Five Gravel Embankment Design"*, Revision 0 dated 9 October 2019. The gravel embankments were designed to limit liquefaction induced lateral spreading displacements within the residential lot to within TC2 acceptable limits, which are given in Table 2.

Depending on the depth and the extent of liquefiable layers near the free face, the gravel embankment size and depth varied. The gravel embankment design comprised compacted AP65 or pit run gravel with a layer of overlying topsoil.

4.3 Gravel Embankment Construction

The gravel embankment design required that a well graded sandy gravel material (such as AP65 or approved pit run) was used for the embankment construction. Material used on site comprised of imported, well graded pit run sandy gravel (AP100). The gravel was topped with approximately 300mm of topsoil.

Site observations by Aurecon Geotechnical and Civil Engineers confirm the gravel embankments have been constructed with imported well graded pit run gravel. The design documentation specifies compaction is undertaken to 98% of maximum dry density, however after site observations of compaction effort by Aurecon Geotechnical Engineers it was agreed that this could be lowered to 95% based on the observed material and compaction. As noted in Section 3, the compaction quality testing indicates that compaction of at least 95% of MDD has been achieved for the sandy gravel embankment fill material.

A review of as-built earthworks information provided by the civil engineers indicates that the required toe width and depth of the gravel embankment profile has been achieved in accordance with the design documentation. The cut slope angle of the gravel embankment sides was not specified, and the contractor was only required to construct the correct toe width and depth. As-built plans for the gravel embankments are provided in Appendix D.

Based on the intended design and the gravel embankment construction, Aurecon considers that the gravel embankments have been constructed appropriately and lateral spreading exceeding TC2 limits adjacent to the pond and along the waterway is unlikely. From a lateral spreading perspective, the lots adjacent to pond and water way are likely to perform to the level of TC2 equivalent.

5 Building Development

5.1 Technical Category

Geotechnical testing has been carried out as part of the subdivision development. The testing indicates the lots within Stages F1, F2 and F3 are likely to perform to TC1 and TC2 equivalent. The technical category classification of the lots is provided in Figure 4 in Appendix A.

5.2 Earthworks on Building Lots

The extent of earthfill on the lots in Stages F1, F2 and F3 is shown in Figure 5 (AB-PS-S5-EW-04) in Appendix A.

The fill areas have been constructed using materials and processes that have been randomly measured by independent testing. The testing shows that the placement of filling is generally in accordance with the specification and relevant standards.

5.3 Soil Suitability Criteria

Section 3 of New Zealand Standard NZS 3604:2011 "*Timber Framed Buildings not requiring specific Engineering Design*" provides several criteria for defining foundation soil suitability for lightweight timber or steel framed residential buildings.

Clauses 3.1.3 and 3.3 of NZS 3604:2011 provide criteria for determining strength and suitability of founding soils. Clauses 3.4.1 and 3.4.2 of NZS 3604:2011 discuss depths to competent founding. For purposes of this report, we have interpreted these clauses as meaning that for sound bearing at depths of 200mm to 600mm, standard shallow type foundations can be used.

For depths greater than this, specific foundation designs could be used or alternatively excavations can be backfilled to the required level with 10MPa site concrete or compacted hardfill. In line with the Client's brief, Aurecon will be undertaking site specific investigations on each residential lot. We will prepare site specific geotechnical reports addressing the foundation requirements on individual building lots. The testing data for the lot specific investigations will be uploaded to the New Zealand Geotechnical Database. For building consent purposes reports prepared for individual lots shall be used.

5.4 Building Considerations

The recommendations in this report shall not be used for individual building consent applications. Site specific investigations in accordance with NZS 3604:2011 are required.

TC1 Foundations

For lots identified as TC1 we consider NZS 3604:2011 type foundations are suitable. We note that at the time of writing this report, the location and structural form of the future dwelling on the lots are unknown and our recommendations relate to NZS3604:2011 type lightweight timber or steel framed residential buildings only.

TC2 Foundations

For lots identified as TC2 we recommend founding dwellings on TC2 type 'enhanced foundation slabs' as per Option 3 or 4 from the MBIE Guidelines (2012) Section 5.1.3 to mitigate the effects of liquefaction induced vertical settlement. Alternatively, in accordance with MBIE Guidelines Section 5.4 a specific design could be undertaken by a suitably qualified chartered professional engineer.

5.5 Future Earthworks

We do not anticipate that future earthworks will be required on the majority of the lots, however should such work be required the following should be noted.

- All earthworks should be carried out in accordance with the Health and Safety at Work Act 2015 and the Worksafe New Zealand Excavation Safety Good Practice Guidelines, 2016.
- Cuts that exceed 0.6m high around any of the house sites must be retained by a suitable retaining wall designed by a Chartered Professional Engineer.
- We recommend that no more than 450mm of fill is placed on the allotment without detailed engineering design.
- Earthworks (cut and fill) should not be undertaken adjacent to any timber retaining wall if present.
- Any development where excavations greater than 1.2m in depth are proposed, must be subject to specific investigation and design to confirm these works will have no adverse effect on land stability, infrastructure and/or structures on adjacent lots. Excavations near sensitive structures or near boundaries may require geotechnical engineering input even if shallower than 1.2m.

5.6 Construction Observations

The suitability of foundation conditions must be verified at the time of construction. Foundation inspections by a Building Inspector or a Chartered Professional Engineer who are familiar with this report must be carried out to ensure the adequacy of the foundation subgrade prior to the placement of granular hardfill or the construction of foundations.

6 References

Aurecon New Zealand Limited, 2018. *Caldwell Block Subdivision Resource Consent Geotechnical Report,* Rev 0. Christchurch, New Zealand.

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Boulanger R.W. and Idriss, I.M., 2014. *CPT and SPT based Liquefaction Triggering Procedures.* Center for Geotechnical Modelling Report No. UCD/CGM-14/01, Department of civil and Environmental Engineering, College of Engineering, University of California at Davis.

Christchurch City Council, 2010. *Infrastructure Design Standards – Part 4: Geotechnical Requirements*.

Idriss and Boulanger, 2008. *Soil Liquefaction during Earthquakes*. EERI Monograph Series MNO-12 Ishihara, 1985. *Stability of natural deposits during earthquakes*. Proceedings, 11th International Conference on Soil Mechanics and Foundation engineering, Vol 1, pp. 321-376.

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NZS1170.0:2002. *Australia/New Zealand Standard, Structural Design Actions, Part 0: General Principals.* Standards New Zealand, Wellington, New Zealand.

NZS1170.5:2002. *Australia/New Zealand Standard, Structural Design Actions, Part 5: Earthquake Actions – New Zealand.* Standards New Zealand, Wellington, New Zealand.

NZS 3604:2011. *Timber Framed Buildings*. Standards New Zealand, Wellington, New Zealand.

NZS 4404:2010. *Land development and subdivision infrastructure*. Standards New Zealand, Wellington, New Zealand.

NZS 4431:1989. *Code of practice for earth fill for residential development*. Standards New Zealand, Wellington, New Zealand.

NZS 4431:2022 *Engineered Fill Construction for Lightweight Structures*. Standards New Zealand, Wellington, New Zealand.

Robertson and Wride, 1998. *Evaluating cyclic liquefaction potential using the cone penetration test*. Canadian Geotechnical Journal, Vol. 35, pp. 442 – 459.

Tonkin and Taylor (2013) *Liquefaction Vulnerability Study*, Tonkin and Taylor Report 52020.0200/v1.0. February 2013. 52 pages and 14 appendices.

Zhang, Robertson, and Brachman, 2002. *Estimating liquefaction-induced ground settlements from CPT for level ground.* Canadian Geotechnical Journal, Vol. 39, pp.1168 – 1180.

7 Explanatory Statement

This report has been prepared for CDL Land New Zealand Limited. It may be made available to others but only in full. As noted above, it shall not be used by any person as a substitute for specific field observations and testing once house sites are confirmed.

This report has been prepared as part of the development of the Prestons Park Stages F1, F2 and F3 Subdivision. It has been prepared to provide the following information:

- To report on the management of the earthworks during construction, including compaction standards of fills.
- To report on the extent of ground improvement and the resulting land technical category.

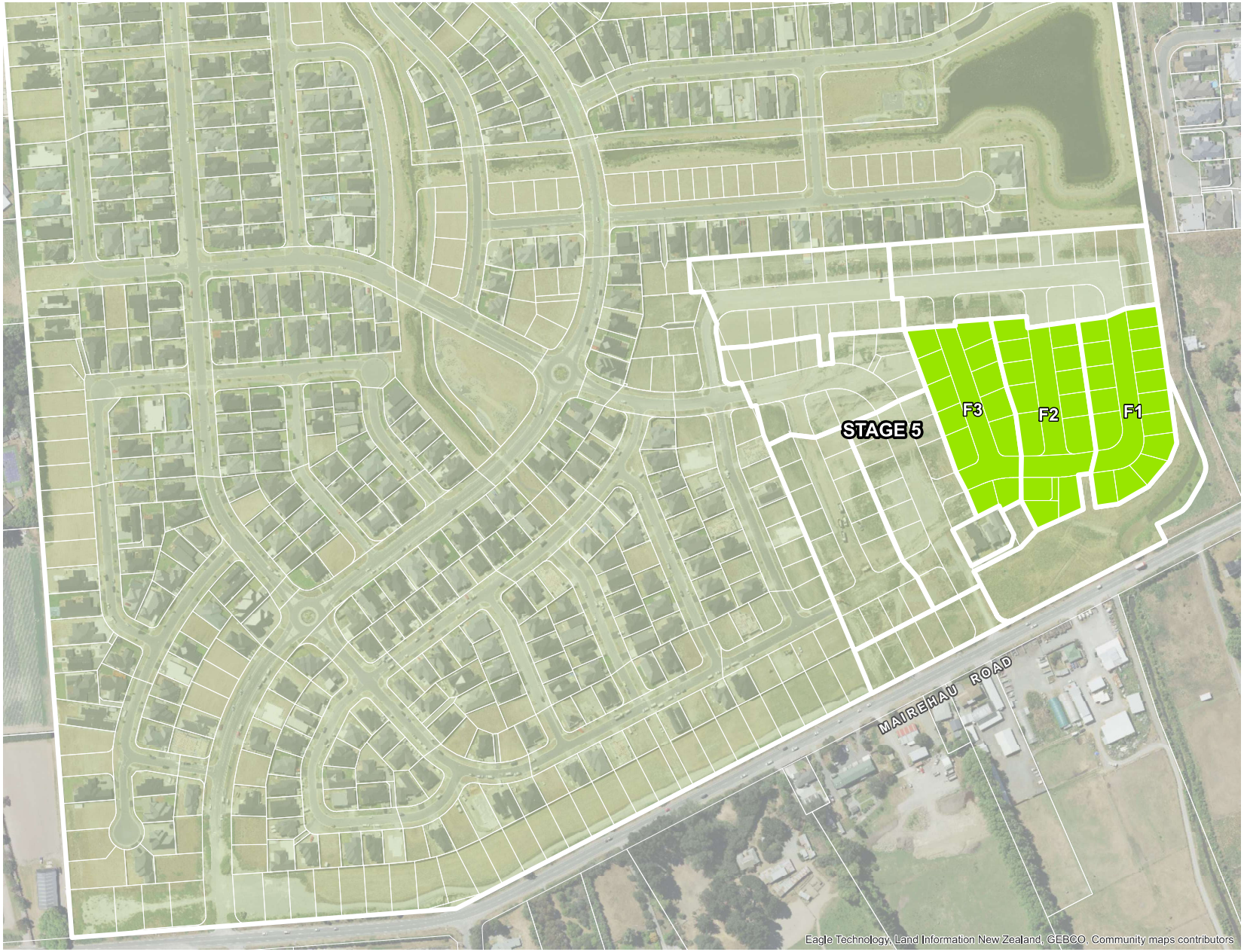
This report does not remove the responsibility of the Owner / Builder / Building Certifier to satisfy themselves of foundation depth and suitability at the finally selected house location.

Subsurface conditions relevant to construction works should be assessed by experienced Contractors and designers who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes. Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay or in wet weather.

It is strongly recommended that any plans and specifications prepared by others and relating to the content of this report, or amendments to the original plans and specifications, are reviewed by Aurecon to verify that the intent of our recommendations is properly reflected in the design. During construction we request the opportunity to review our interpretations if the exposed site conditions are significantly different from those inferred in this report.

This report is not to be reproduced either wholly or in part without our prior written permission.

Appendix A
Figures



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NOTES

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CDL LAND NEW ZEALAND LIMITED

REV	DATE	REVISION DETAILS	APPROVED
A	23/10/20	ISSUE FOR INFORMATION	J. Kupec

DRAWN	DESIGNED
R.Dawson	
CHECKED	
K. Foote	
APPROVED	DATE
J. Kupec	2023/10/20

PROJECT
PRESTONS PARK SUB-STAGES F1, F2 & F3

TITLE
SITE PLAN

PROJECT No.	
235361	
SCALE	SIZE
AS SHOWN	A3
DRAWING No.	REV
FIG 1	A

Path: C:\Users\Ros.Dawson\Desktop\prestons\GIS\SOUTH STAGE 5\F1-3\FIG 1 SITE PLAN.mxd