



INITIA

GEOTECHNICAL SPECIALISTS

GREENSTONE LAND DEVELOPMENTS LIMITED

STAGE 11, LYNDHURST SUBDIVISION,
HASTINGS

GEOTECHNICAL COMPLETION REPORT

INITIA REF P-000828 REV 2

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1. Introduction

Initia Limited (Initia) was engaged by Greenstone Land Developments Limited (Greenstone) to provide geotechnical consultancy services in relation to the Stage 11 of proposed Lyndhurst Subdivision at 574 Lyndhurst Road, Frimley, Hastings¹. The legal description of the site is LOT 400 DP 541537.

As shown on the Zorn Surveying fill depth plan² attached in Appendix A, earthworks including the placement of engineered fill up to 1.5 m depth has been completed for most of the site. Initia has recently carried out a geotechnical site investigation for the Stage 11 area (refer the investigation plan attached in Appendix B).

This report summarises and collates the results of all the investigations and testing associated with the bulk earthworks that have been undertaken to prepare the Stage 11 site for the residential subdivision.

The scope of this report is limited to the following:

- Bulk earthworks for the Stage 11 Lots (Lots 69 and 92 – 103), and
- Geotechnical investigations, assessment, and recommendations for future building design.

This geotechnical completion report has been prepared to accompany a “Statement of Professional Opinion on Suitability of Land for Construction” This is provided in Section 6.

¹ Initia Ltd (28 May 2020). *Proposal for Geotechnical Consultancy Services – Stage 11 & 12, Lyndhurst Subdivision, Hastings*. Ref P-000829.

² Zorn Surveying (25 March 2020). *Engineered Fill Survey Depths*. Ref J001255.



2. Background

2.1 General

The site at Lyndhurst has previously been used for as agricultural land with a shed located in the eastern area of Stage 11. The Hawkes Bay expressway is present to the north of Stage 12. A farming block is located on the southern boundary and is occupied by a residential dwelling and sheds.

2.2 Resource Consent

A Resource Consent for the subdivision has been granted. All the previous geotechnical work carried out at the site was undertaken by Resource Development Consultants Limited (RDCL).

RDCL are no longer involved with the project and Initia were engaged by Greenstone to provide on-going geotechnical support and certification for the Stages 11 and 12.

2.3 Previous Geotechnical Reporting

Geotechnical Investigations (5 No. Cone Penetration Tests – CPTs) within the Stage 11 and 12 areas have been previously undertaken by RDCL³. Particularly, two of the CPTs were undertaken within the Stage 11 area.

The existing investigation data indicates that the site is typically underlain by interbedded alluvial deposits comprising clays, silts and sands. A shallow dense gravel layer has been identified in certain location across the Lyndhurst subdivision. The CPTs have been unable to penetrate this layer.

2.4 Recent Investigations

On 10 and 11 June 2020, Initia carried out 25 No. CPTs and 13 No. hand auger boreholes within the Stage 11 area to provide Greenstone with a geotechnical completion report for subdivision. This document will provide potential purchasers of each lot with the required geotechnical information to enable a Building Consent Application to be submitted to Hastings District Council.

7 No. of the Initia CPTs were pushed down to the target depth of 15 m below ground level and the other 18 No. CPTs reached refusal due to high cone resistance q_c (greater than 20 MPa) at variable depths of 3 to 9.6 m below ground level.

The Initia test locations are shown on the investigation plan attached in Appendix B and the investigation logs are attached in Appendix C and D. This data combined with the original RDCL investigations forms the basis of this report.

During the recent investigation, the groundwater levels were measured in the CPTs and were generally at approximately 3 m below the surface. We have adopted a design groundwater level of 2.5 m for the purpose of liquefaction analysis.

³ Resource Development Consultants Limited (12 December 2019). Report on: *Stage 10, Lyndhurst Road Subdivision, Frimley, Hastings – Lots 163 to 178 (Excluding Lot 171)*. Project: *Geotechnical Assessment*. Ref R_183970602C_01.



3. Earthworks

The earthworks were undertaken by Santo Drainage & Contracting Ltd and compaction testing was carried out by WSP OPUS (WSP).

3.1 Granular Fill Area

We have been informed from the client that granular materials (“red metal”) were used for filling in an area including Lots 69, 94 and 95 within Stage 11. However, we have not been provided with a detailed construction record of filling, but the investigation did record some high ground strengths, and these are discussed below.

3.1.1 Lot 69

The hand auger borehole at Lot 69 encountered TOPSOIL overlying very stiff gravelly SILT before the refusal was reached at 0.5 m below ground level.

Initia CPT11 and CPT12 were undertaken within Lot 69. Both CPTs indicated a dense layer of coarse-grained material from 0.5 to 1 m below ground level which is inferred to be the compacted red metal layer.

3.1.2 Lot 94

The hand auger borehole at Lot 94 encountered sandy SILT with trace pumice before the refusal was reached at 0.7 m below ground level.

Initia CPT13 and CPT14 were undertaken within Lot 94. CPT13 indicated a dense layer of coarse-grained material from 0.7 to 1.2 m below ground level which is inferred to be the red metal layer. However, this dense layer was not encountered by CPT14.

3.1.3 Lot 95

The hand auger borehole at Lot 95 encountered SILT with trace sand and gravel before refusal was reached at 0.6 m below ground level.

Initia CPT09 and CPT10 were undertaken within Lot 95. Both CPTs indicated a dense layer of coarse-grained material from approximately 0.5 to 1 m below ground level which is inferred to be the red metal layer.

3.2 Silt Fill Area

We understand that the fill materials placed in Lots 92, 93 and 96 – 103 were dominantly SILT from the Te Aute Road Havelock North Rymans site. The hand auger boreholes at these lots generally encountered stiff to very stiff SILT or sandy SILT beneath a thin layer of topsoil. The maximum depth of these hand auger boreholes was 3 m below ground level.

The Initia CPTs within these lots generally recorded an average q_c of approximately 5 MPa between depths of 0.3 to 1.5 m below ground level, indicating a good level of compaction.

3.3 Compaction Testing

A copy of the compaction test results was provided to Initia for review. We note that WSP did not provide oven dried moisture content for the Nuclear Densometer (NDM) testing. They have relied on the NDM alone. In addition, we have only been provided with a single point compaction result. Accordingly, it is difficult to fully assess the compaction of the engineered fill at the site.

4. Geotechnical Considerations

4.1 General

Recommendations and opinions contained in this report are based on the data provided by numerous sources including RDCL and Initia, using a variety of investigation techniques including:

- CPTs
- Hand auger boreholes

All the tests were undertaken at discrete point locations. Inferences about the nature and continuity of the subsoils away from the test locations are made however it must be appreciated that actual conditions could vary from the assumed model. It is important that Initia be informed immediately if differing ground conditions are encountered during the construction process.

4.2 Overall Site Stability

Due to the generally flat topography of the Stage 11 site, the overall stability of the site is not considered to be an issue. Seismic stability of the ground is addressed in the relevant building zone sections.

4.3 Site seismicity and subsoil class

Based on the previous and recent geotechnical investigations at the site and in the adjacent area, we consider that the site subsoil class should be classified as Class D – Deep or Soft Soil Site, in accordance with NZS1170.5 (2004)⁴.

For determination of the design Peak Ground Acceleration (PGA), we have assumed an Importance Level 2 and a 50-year design life for the future developments. These assumptions should be confirmed by the specific project Structural Engineer.

Based on the above assumptions and in accordance with NZS1170.0 (2002)⁵, the annual probabilities of exceedance for design earthquakes are 1/500 (500 years return period) and 1/25 (25 years return period) for Ultimate Limit States (ULS) and Serviceability Limit States (SLS) respectively.

Based on the assessment by GNS Science⁶, the PGAs and average magnitude of an earthquake contributing to PGA for ULS and SLS design are presented in Table 3-1 below.

Table 4-1 Design PGA and average magnitude of an earthquake contributing to PGA

Limit States	Return Period	PGA	Average Magnitude
ULS	500 years	0.42g	6.5
SLS	25 years	0.14g	6.2

Note: The design PGAs have been based on an Importance Level 2 structure and a 50-year design life.

4.4 Liquefaction susceptibility

The liquefaction susceptibility of the underlying material at the Stage 11 site has been assessed using the results of the Initia 2020 Investigations as well as considering the results and conclusions in RDCL 2019 report.

⁴ New Zealand Standard NZ 1170.5:2004 Structural Design Actions: Part 5: Earthquake actions – New Zealand.

⁵ New Zealand Standard NZ 1170.0:2002 Structural Design Actions: Part 0: General Principles.

⁶ GNS Science (October 2017), Consultancy Report 2015/186: *Assessment of liquefaction risk in the Hawke's Bay*.



A CPT-based liquefaction analysis has been carried out using the computer programme CLiq v.2.3⁷ on the recent Initia CPTs. The adopted analysis method is based on the study by Boulanger and Idriss (2014).

The analysis indicates that the liquefaction susceptibility during the SLS design event is low across the site. For the ULS design event, the liquefaction susceptibility is estimated to be moderate to high across the site. The analysis also indicates that up to 160 mm of liquefaction induced settlement may occur in a ULS design earthquake event. However, the 2.5 m crust above groundwater level will likely form a 'cap' to reduce the effects of liquefaction observed at the surface.

The main output from the ULS liquefaction analysis is attached in Appendix E.

4.5 Building Zones

Given the investigated engineered fill conditions with respect to the consequence of potential liquefaction, we have classified the site into two distinct areas based on the results of our geotechnical assessment of all the available data.

1. Building Zone, A
2. Building Zone B

We have provided recommendations for each building zone in the following sections. These recommendations are applicable to single level lightweight residential buildings.

4.5.1 Building Zone, A – Geotechnical Considerations

General

Building Zone, A only refers to the following Lots

- Lot 69
- Lot 95

In general, the recent investigation undertaken in these lots confirmed that a gravel layer was placed and compacted as part of the earthworks. This dense non-liquefiable layer will mitigate the effects of liquefaction withing these lots.

Foundations

Given the general high liquefaction risk at this site, in the event of a ULS earthquake event, we would recommend that a TC2 type structural raft foundation solution be adopted for Lots 69 and 95. This raft can be constructed directly on to the existing compacted gravel engineered fill for these two lots only.

The raft should be designed with the following bearing capacities:

- Geotechnical ultimate bearing capacity 300kPa
- ULS factored bearing capacity 150kPa
- Allowable bearing capacity 100kPa

As mentioned previously, we understand that raft foundations have been used extensively in other stages of the subdivision.

We have outlined the construction monitoring process that should be adopted for the foundation inspections in Section 7.

⁷ Geologismiki (2020), *CPeT-IT - detailed software package for the interpretation of Cone Penetration Test (CPTu) data*.



4.5.2 Building Zone B – Geotechnical Considerations

General

Building Zone B only refers to the following Lots (total 11 No. Lots)

- Lots 92 – 94
- Lots 96 – 103

In general, the recent hand auger boreholes undertaken in these lots encountered stiff to very stiff SILT or sandy SILT engineered fill beneath a thin layer of topsoil.

Gravel Raft

Given the absence of the compacted gravel fill within Building Zone B, we recommend that the existing ground be undercut by 600 mm and backfilled with imported hardfill and compacted to form a gravel raft beneath the building platform. The horizontal extent of gravel raft should be at least 1 m outside perimeter of the building.

The imported hardfill should be placed and compacted in maximum 200mm layers using a smooth drum roller. The supplier of the hardfill should provide a NZ Heavy Compaction curve for the material which indicates the Maximum Dry Density (MDD). The following testing should be carried out to ensure adequate compaction is being achieved:

- 95 % of MDD
- Clegg Impact values (CIV) greater than 20

Testing should be carried on a 5m grid on every 2nd lift and on the final surface.

Two layers of geogrid should be placed at the base of the excavation and at the mid-height of the gravel raft.

We have outlined the construction monitoring process that should be adopted for these gravel rafts in Section 7.

Foundations

Given the high liquefaction risk at this site, in the event of a ULS earthquake event, we recommend that all foundations (pads) are tied together to limit differential settlements. This also prevents the building from 'pulling apart' in a large earthquake.

A TC2 type structural raft foundation solution may then be adopted on the completed gravel raft for single level lightweight residential developments on Lots 92 – 94 and 96 – 103.

The raft should be designed with the following bearing capacities:

- Geotechnical ultimate bearing capacity 300kPa
- ULS factored bearing capacity 150kPa
- Allowable bearing capacity 100kPa

As mentioned previously, we understand that raft foundations have been used extensively in other stages of the subdivision.

5. Recommendations

The geotechnical investigations have established that the Stage 11 of Lyndhurst is suitable for residential development in accordance with the conclusions and recommendations outlined in this geotechnical completion report.

The main point is that certain Lots fall within building zones with different development recommendations in respect to foundation preparation and design. These lot categories are as follows:

- Building Zone, A - Lots 69 and 95;
- Building Zone B - Lots 92 - 94 and 96 - 103.

We recommend that the Hastings District Council adopt this classification when assessing individual Building Consent Applications for the site.

No further ground testing prior to the ground improvements being carried out is required for Stage 11 at Lyndhurst (see construction monitoring - section 7)



6. Statement of Professional Opinion as to the suitability of land for building development

6.1 Statement

I, Andy Pomfret of Initia Limited, 13/114 St Georges Bay Rd, Parnell, Auckland hereby confirm that:

I am a Professional Engineer experienced in the field of geotechnical engineering and was engaged by the developer, Greenstone Land Developments Limited as the Geotechnical Engineer on the “Stage 11 of Lyndhurst Subdivision, Hastings” project located on Lyndhurst Road, Frimley, Hastings. Refer to the plans contained within Appendix A and Appendix B for the extent of the works covered under this statement.

On the basis of our observations and inspections together with the information provided by others, it is my professional opinion, not to be construed as a guarantee that:

- The earth fill shown on the attached Zorn Surveying Plan (J001255) have been generally placed in compliance with the project specifications.
- The completed earthworks give due regard to land slope stability and foundation consideration providing the recommendations outlined in this Geotechnical Completion Report are followed.

6.2 Unexpected Ground Conditions

Our assessment is based on interpolation between site observations and periodic earthwork control visits by others. Local variations in ground conditions may occur leading to unfavourable ground conditions. It is important that we are contacted in this eventuality, or if any variation of subsoil conditions from those described in this report are found. Design assistance is available as required to accommodate any unforeseen ground conditions present.

We have set out the construction monitoring requirements for any structures that are to be constructed in this development.



7. Construction Monitoring

7.1 Construction Monitoring Zone A (Lots 69 and 95 only)

Given the presence of compacted gravel already placed within this area of the subdivision, a suitably qualified professional should ensure that all the topsoil has been removed from the site and that no soft spots are present within the compacted gravel fill prior to the foundation being poured.

Scala testing should be carried out in foundation trenches should ensure that the bearing capacities are as per the recommendation of the report.

A PS4 (geotechnical) should be provided on completion of the foundations

7.2 Construction Monitoring Zone B (all other lots in stage 11)

Given the requirement for a 600mm reinforced gravel raft to be installed beneath the building footprint, a suitably qualified geotechnical professional is required to observe the following stages:

- Inspect the base of the 600mm excavation prior to placement of the geogrid to check for presence of organics/soft zone
- Observe placement of the geogrid layers
- Review all the compaction data for the gravel layers to ensure it meets the specification and bearing capacity for foundations contained within the report.
- Provide a PS4 (geotechnical) on completion of the work and pouring of the foundation



8. Applicability

This report has been prepared for the exclusive use of our client, Greenstone Land Developments Limited and Hastings District Council, with respect to the brief provided to us and it may not be relied upon in any other contexts or for any other purpose, or by any person other than our client, without prior written agreement.

We note that only a representative sample of earthworks were reviewed by Initia and therefore we are relying on the contractor's PS3 for compliance with design. No liability is accepted for any omissions represented by those documents. The contractor's PS3 is presented in Appendix F. The advice and recommendations presented in this report should not be applied to any other project or used in any other context without prior written approval from Initia Limited.

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Appendix A: Earthworks Plan – As Built



Appendix B: Geotechnical Investigation Plan



Appendix C: Initia CPT Logs



Appendix D: Initia Hand Auger Borehole Logs



Appendix E: Liquefaction Summary



Appendix F: Earthworks Contractor's PS3

