REPORT

Tonkin+Taylor

Geotechnical and Contaminated Land Desktop Assessments

121 Murphys Road, Flat Bush, Auckland

Prepared for
Ministry of Education
Prepared by
Tonkin & Taylor Ltd
Date
November 2022
Job Number
1018471.1000 v1

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Document control

Title: Geotechnical and Contaminated Land Desktop Assessments					
Date	Version	Description	Prepared by:	Reviewed by:	Authorised by:
27/10/2022	DRAFT	To support Notice of Requirement submission -draft	V. Lancaster R. Pickett	K. Speight N. O'Rourke	K. Speight
11/11/2022	1	To support Notice of Requirement submission - final	V. Lancaster R. Pickett	K. Speight N. O'Rourke	K. Speight

Distribution:

Ministry of Education	1 PDF copy
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1 Introduction

The Ministry of Education (MoE) has engaged Tonkin & Taylor Ltd (T+T) to carry out a geotechnical and contamination desktop assessment to support a Notice of Requirement (NoR) application at 121 Murphys Road, Flat Bush. MoE proposes to designate the site for educational purposes and construct a new primary school (Years 0-6) with a master planning roll of 1,250 students.

We understand that MoE is planning to undertake the following proposed development at the site:

1 Demolition of the existing residential building.

2 A primary school, likely comprising 3 No. three-storey teaching blocks.

3 A multi-purpose hall.

4 Sports fields, hard courts, outdoor play areas and car parking spaces.

To support the NoR application for the proposed school, the following scope of works has been completed:

a Review of existing geotechnical and contaminated land reports provided by MoE;

b Liaison and workshops with the design team to assess opportunities and constraints;

c High-level assessment of geotechnical and contaminated land considerations for the proposed development. These are presented in Tables 4.1 and 5.1; and

d Preparation of this report.

This report presents our findings from the geotechnical and contaminated land desktop assessment[1] in September 2022. T+T also carried out pre-purchase assessments[2] for the site in November 2021.

Our overall conclusion is that the site is generally suitable for the proposed school development provided that earthworks and design accommodate the considerations detailed in this report. Further investigations outlined in Sections 4.4 and 5.5 can be carried out at the preliminary or detailed design stage.

[1] T+T, Contamination Land, Geotechnical & Infrastructure desktop assessments. Ref: 1018471.1000. 14 September 2022

[2] T+T, Pre-Purchase Assessment Report. Ref. 1018471.0000v.1. 25 August 2022

2 Site description

The site located at 121 Murphys Road, Flat Bush in Auckland is legally described as Lot 3 DP 515396. The site covers an overall area of approximately 3 ha, as shown on Figure 2.1.

The site comprises a residential building and pastoral land. The dwelling is located on generally flat (< 5°) land lying at approx. 65 m RL in the north of the site. The slope steepens to the south of the dwelling and becomes moderately inclined (approx. 10 to 30°), as the land falls to the south and southeast towards a tree-lined stream. The stream is located at approx. 53 to 55 m RL and flows along the southern boundary of the site in a west-east direction.

Construction for subdivision lots is currently in progress to the north of the site at 125 Murphys Road.

Figure 2.1: Site location (Auckland Geomaps, accessed 21/10/2022)

3 Proposed development

The current proposed development comprises demolition of the existing residential dwelling and construction of 3 No. teaching blocks and 1 No. multi-purpose hall. These structures are planned to be up to three stories in height.

The location of these proposed buildings is not yet confirmed. Current proposals[3], shown on Figure 3.1, indicate that the buildings will be located on gently sloping land in the northern and central areas of the site.

A sports field and hard courts are currently proposed to the west of the buildings. Car parking spaces are proposed to the east of the buildings.

The site levels will generally tie in with the recently formed road along the northern site boundary.

No development is planned within a 20 m riparian margin of the stream. We note that buildings can be placed closer to the slope if specific design, such as piles or buttressing, is implemented.

Figure 3.1. Proposed Bulk & Location study by Jasmax Architects[3].

[3] Jasmax Architects: "121 Murphys Road, Flat Bush Primary School – Feasibility Study for NoR, 3 November 2022, project number 221156.100

4 Contaminated land

4.1 Source Material

In total three contaminated land investigations and assessments have been undertaken on the site including adjacent land between 2016 and 2021. The investigations are documented in the following reports:

- Focus, December 2016. Detailed Site Investigation, Remediation Action Plan & Assessment of Environmental Effects – 125 Murphys Road, Flat Bush, Auckland. Prepared for Green City Developments. Ref: FES 0749.002.
- Tonkin + Taylor, August 2021. Pre-purchase Assessment Report 121 Murphys Road, Flat Bush. Prepared for Ministry of Education. Ref 1018471 V1
- Babingtons, November 2021. Detailed Site Investigation, Site Management Plan & Remediation Action Plan – 121 Murphys Road, Flatbush. Prepared for Murphys Jixiang Development Limited

A summary of the information contained in reports is presented in the following sections. Figure 0.1 also shows the general location of existing site investigations.

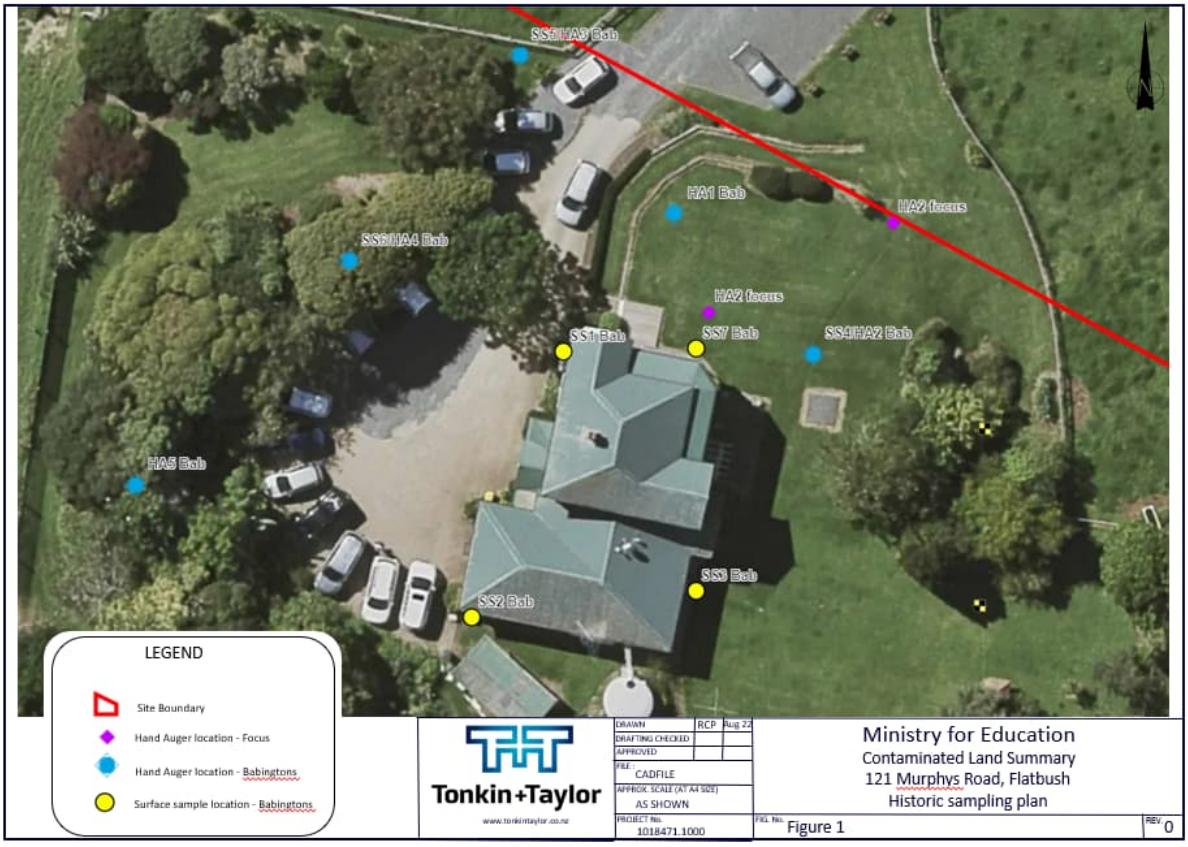

Figure 0.1: Summary of existing site investigations.

4.2 Review and Assessment

4.2.1 Focus, December 2016

Focus undertook a Detailed Site Investigation (DSI) in 2016 covering an area of approximately 12.2 hectares (ha). This DSI included properties at 121 Murphys Road, 125 Murphys Road and 127 Murphys Road. For the purposes of this summary, we have only looked at the information relating to 121 Murphys Road.

The DSI indicates that potential asbestos contaminated material was observed in the soffits of the remaining dwelling on 121 Murphys Road but they were in good condition with no breakages noted. A small domestic garden was observed south of the dwelling.

The DSI also showed an area of potential filling adjacent north of the dwelling on 121 Murphys Road. Focus undertook contamination investigations from two locations (HA01 and HA02) within the potentially filled area on 121 Murphys Road, testing samples from the surface and at approximately one metre below ground level (bgl) for heavy metals, organochlorine pesticides (OCPs) and polycyclic aromatic hydrocarbons (PAHs). Sample results indicated metals concentrations were within published Auckland background range concentrations. OCPs and PAHs were not detected.

4.2.2 Tonkin + Taylor, August 2021

T+T undertook a desktop assessment of the site in August 2021 as part of a pre-purchase assessment reviewing the site history and assessing the potential for historical activities to have resulted in ground contamination on the site.

The site history was established by reviewing the Auckland Council property file and contamination records, as well as a review of historical aerial photographs. A summary of the site history is provided below:

1 The site has remained in a rural setting from at least 1939 (earliest available aerial photograph) to present like much of the surrounding area.

2 Three structures were identified, one to the west (an inferred dwelling) and two to the east (inferred sheds) were observed in the earliest aerials. The structures to the east were amalgamated between 1939 and 1960. This building was further redeveloped between 1960 and 1975 and eventually removed between 1988 and 1996. The western building (the dwelling) was redeveloped between 1996 and 2006.

3 Some potential vegetation maintenance activity was noted on the north-western portion of the site and the property adjacent north (125 Murphys Road) in the 1988 aerial that was suggestive of a potential horticultural activity (e.g. cropping). However, horticultural use at the site, was not observed in any other aerial photographs reviewed, or noted by Auckland Council in their records.

4 The property files indicate that the site was part of the subdivision of the wider 125 Murphys Road property which occurred in the late 2000s to early 2010s and was designated as “Lot 3” of the subdivision.

5 The site contamination enquiry provided by Auckland Council indicated that the site was found to have fill present which has been deemed a HAIL activity (Activity G.5).

The desktop assessment identified a number of historic activities that have the potential to result in ground contamination, further testing would be required to establish the impact of these activities.

Historic activities with the potential to cause ground contamination include:

a Potential for uncontrolled fill (HAIL Activity I).

b Buildings constructed (and subsequently demolished) with ACM or lead paint (Activity I).

c Potential for farm dumps / unconsented landfills (Activity I or G.5).

d Potential horticultural activity including persistent pesticide storage use (Activity A.10).

The report identified that further soil testing was required to understand their extent in the context of future development works around the site and would be required to support any consents require for the proposed development.

4.2.3 Babingtons, November 2021

An investigation was undertaken by Babingtons, on behalf of the current site owner, to assess the potential soil contamination risk and support a residential subdivision development.

The desktop study confirmed HAIL activities had likely occurred on the site – in particular asbestos and lead paint in buildings, and filling.

The investigation comprised the following:

1 Collection of three surface soil samples in the perimeter of the dwelling and two paint flake samples to characterise the risk of lead and arsenic. Analytical results from this sampling confirmed elevated levels of metals in the vicinity of the dwelling above both the human health and environmental discharge criteria.

2 Three surface samples and five hand auger samples were collected from the area of suspected fill material. Fill material up to one metre thick was confirmed in all of the samples locations. Analytical results from this sampling confirmed elevated levels of metals in particular arsenic and lead

3 A visual inspection of the site including the gully along the southern portion of the site showed no obvious signs of dumping had occurred there in the past.

4 Asbestos fibres were detected in two sample locations (SS5 – 0.3 m and HA5 – 0.5 m), both within the fill material located to the west of the house. Semi quantitative analysis was not undertaken to allow for assessment against human health criteria and consideration of health and safety controls for construction.

The report concluded that due the presence of elevated metals concentrations above the natural background, AUP criteria and NESCS soil contaminant standards, resource consent will be required for both landuse change and soil disturbance at the site.

4.3 Summary and Recommendations

The investigations undertaken to date focussed on soil around the existing buildings (refer Figure 4.1). Testing to date has confirmed that elevated lead concentrations around the dwelling and fill material containing elevated metals and asbestos. The proposed development will require the following consents unless permitted activity requirements can be met:

- A restricted discretionary consent under the NESCS[4] Regulations; and
- A controlled consent under the AUP for the disturbance of contaminated soil.

The identification of the confirmed HAIL activities indicates that development of the site for a school (comprising both soil disturbance and change in land use) will be subject to the requirements of the NESCS and the Auckland Unitary Plan. Accordingly, further testing is not required to support the NoR application as the findings of the previous investigations are considered sufficient to conclude the NESCS applies to the site.

[4] Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011

Geotechnical investigations[5] have confirmed the fill material extends further than initially anticipated and investigations should be undertaken to characterise this material prior to its disturbance to inform both consenting and potential disposal requirements. Proposed scope of investigations is outlined in Section 4.4 and may be carried out during the design phase or just before construction.

A summary of the opportunities and constraints is provided in Table 4.1 below.

Table 4.1: Summary of ground contamination opportunities and constraints

	Issue / constraint	Impact*	Comments / opportunities
Building demolition	Buildings with asbestos-containing materials are present at the site, and buildings were constructed within the time period when lead paint was in use. Residual contamination may have been caused by construction, maintenance or historical demolition of buildings that may have used asbestos or lead based paint	Low to medium	• Asbestos building surveys will be required prior to demolition of any building constructed before January 2000. • Elevated concentrations of lead have been identified in soil in the vicinity of the dwelling (refer soil contamination below). • Validation soil sampling is expected to be required in the construction phase as part of the RAP/SMP
Soil contamination	HAIL activities have been identified on the site and soil testing has confirmed that soil concentrations are elevated above human health and/or environmental discharge criteria.	Medium to high	• The 2021 DSI by Babingtons identified concentrations of metals above human health and environmental discharge criteria in the vicinity of the dwelling (this is also relevant for the consent requirements, see below). • Further soil investigation is recommended to assess the extent of contamination at the site. This sampling could be undertaken as a supplementary site investigation either prior to consenting or as a condition of the consent prior to the commencement of construction.
Regulatory considerations	Consent requirements	Low to medium	• The findings of the 2021 DSI indicate the future development of a school will be subject to the requirements of the NESCS and the contaminated land rules of the AUP, and it is likely that consent will be required. This would need to be confirmed based on the development design. • Supplementary soil investigation and preparation of a Remediation Action Plan (RAP) or Site Management Plan (SMP) is expected to be required as part of the consenting process.

[5] Lander Geotechnical, April 2018. Geotechnical Investigation Report 125 Murphys Road (Stage 2), Flatbush. Prepared for Green City Developments Limited

	Issue / constraint	Impact*	Comments / opportunities
Soil re-use / disposal	Potential for excess spoil to be re-used onsite or disposed of offsite	Low to medium	• Testing of the fill material to date has generally detected contaminants below the NESCS and therefore depending on the results of the supplementary investigation and if it is geotechnically suitable then this material maybe suitable for reuse onsite.

** The impact rating is intended as a guide in terms of perceived importance to the project. Low impact does not mean low risk or low cost.*

4.4 Further Work

Geotechnical investigations indicate that the site is underlain by varying thicknesses of non-engineered fill. We recommend that further testing be undertaken to assess the extent of contamination. The contaminated land investigations are to further:

1 Characterise soil across the proposed building platforms;

2 Investigate the extent of the fill material; and

3 Assess if contaminants are present in the area of potential former horticultural use.

This sampling could be undertaken as a supplementary site investigation either prior to consenting or as a condition of the consent before construction commences. The sampling locations will need to be tailored to the proposed design of the school.

A Remedial Action Plan (RAP) and a Soil Management Plan (SMP) are also required to support a resource consent application for the proposed development.

5 Geotechnical

5.1 Source Material

Geotechnical investigation and assessments have been carried out by Lander Geotechnical at the site. Subsequently, Frederick Wentz of Wentz-Pacific Ltd has carried out a peer review of that report for MoE. The investigations and review comments are summarised in the following documents:

- Lander Geotechnical, Geotechnical Investigation Report. J00862. 6 April 2018;
- Email from Frederick Wentz (Wentz-Pacific Ltd) to Bronte Pierson (Ministry of Education), titled "RE: 121 Murphys Road, Flat Bush". 23/08/2021, 11:43AM, and
- Published Geological Map (see Section 5.2.1).

5.2 Geological model

5.2.1 Published Geology

A published geological map[6] of Auckland indicates that the site is underlain by Takanini Formation belonging to the Tauranga Group (TG), as shown on Figure 0.1. The Takanini Formation is described as comprising pumiceous mud, sand and gravel with muddy peat and lignite.

East Coast Bays Formation (ECBF) is located to the south of the site, which consist of alternating sandstone, siltstone and mudstone.

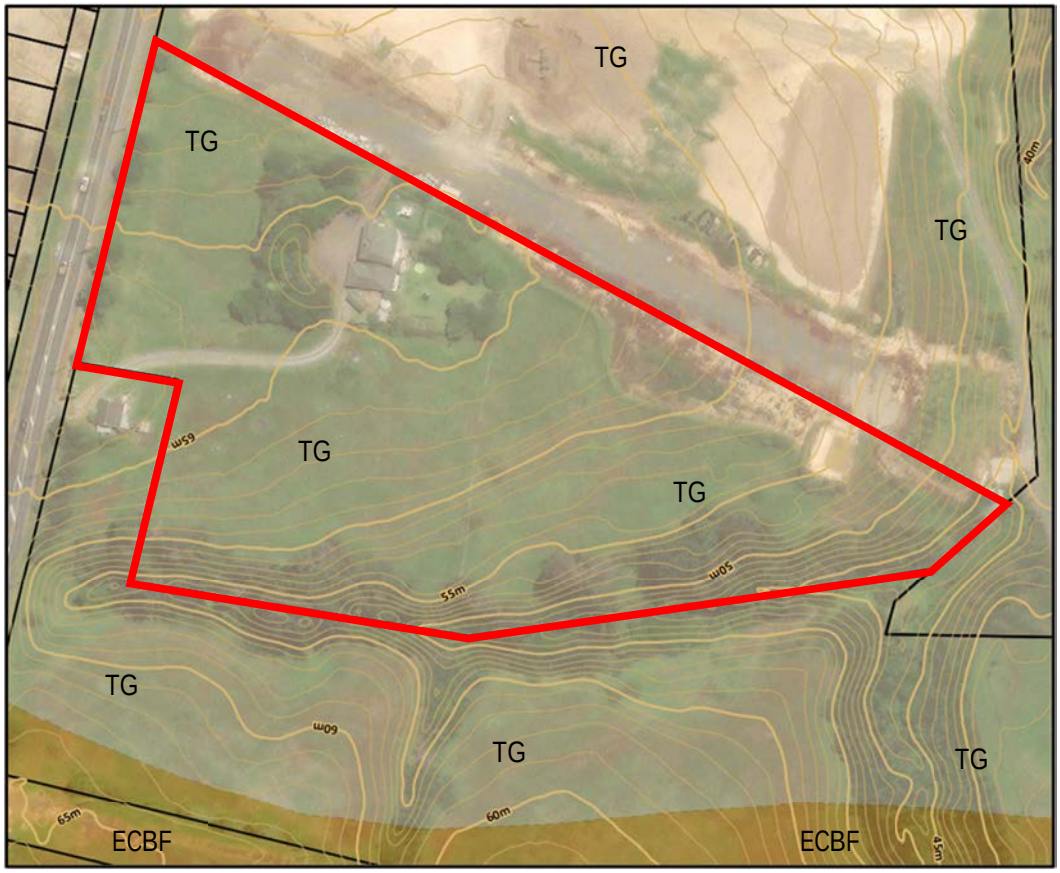

Figure 0.1: Extract of the published geological information for the site.

[6] Edbrooke, S.W., 2001. Geology of the Auckland area. Institute of Geological and Nuclear Sciences 1:250 000 Geological Map 3.3.

5.2.2 Geological Model

The geotechnical investigation was carried out on the site between 12 February 2018 and 18 February 2018.

Figure 0.2 shows an extract of the Site Investigation plan prepared by Lander Geotechnical. The investigations comprised:

- 14 No. hand augers to depths of up to 5 m.
- 6 No. trial pits to depths of up to 5.4 m.
- 2 No. machine boreholes to depths of up to 15.5 m.

The investigation generally indicates that the site is underlain by:

- Up to 1.9 m of topsoil and/or Fill (re-worked Tauranga Group Formation soils); over
- Tauranga Group Formation soils (firm to hard, silty clays and clayey silts with minor layers of sandy silt) – likely to range between 0 and 6 m in thickness; over
- Residual and Highly Weathered East Coast Bays Formation soils (very stiff to hard, silty clays, clayey silts and clayey sands) – likely to range between 1 and 5 m in thickness; over
- East Coast Bays Formation rock (very weak, interbedded siltstone and sandstone, SPT N>50) was encountered at 8.5 m and 3.9 m depth respectively in MH01 and MH02.

Lander Geotechnical has logged up to 3 m of slope debris along the stream edge. The inferred extent of the slope debris appears to extend some 30 m from the edge of the stream into the site.

The geotechnical investigation indicate that perched groundwater is situated at approximately 1.5 m and 3 m depth beneath the higher part of the site (i.e. away from the crest of the slope). Groundwater is also present at a deeper level within the ECBF, lying at approximately 6 to 8 m below existing ground level.

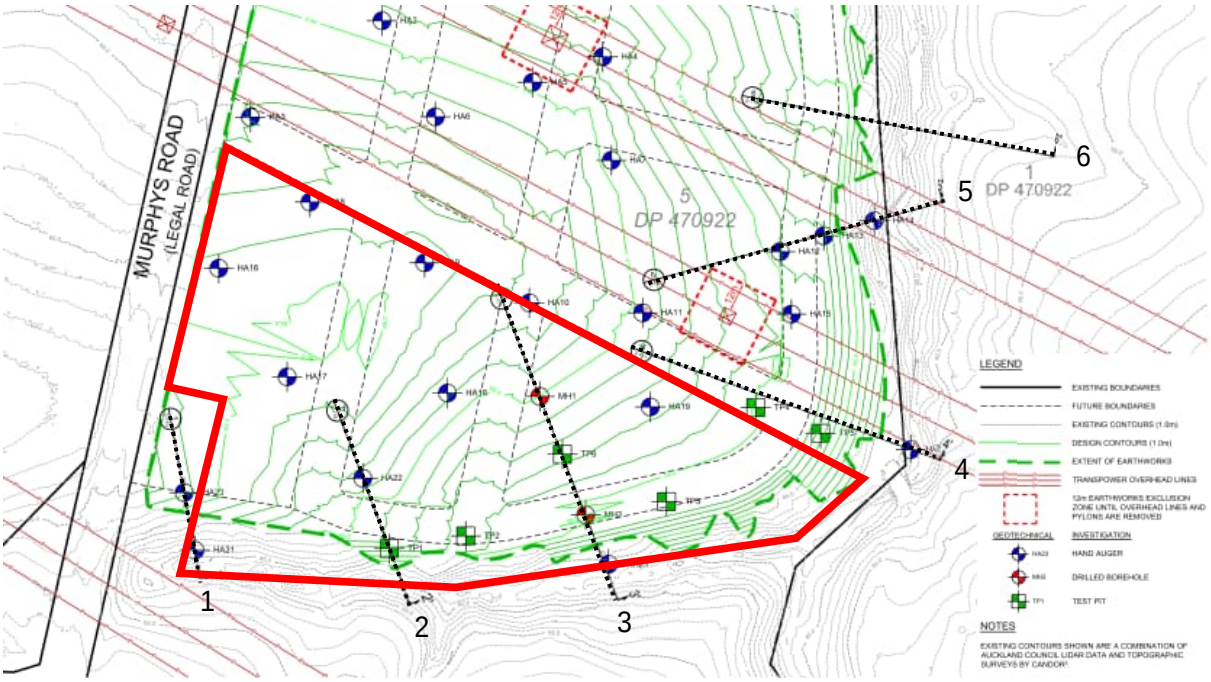

Figure 0.2: Geotechnical site investigation plan extracted from the Lander Geotechnical report.

5.3 Review and Assessment

Lander Geotechnical and Wentz-Pacific have carried out geotechnical assessments for the site. We have reviewed those documents and provide a high-level summary of the key geotechnical constraints below:

1 Slope stability: Sections 1, 2 and 3 as shown on Figure 5.2 are located with the site. Modelling by Lander Geotechnical found that the Factor of Safety for those slopes generally met the criteria set out by Auckland Council[7].

2 Assessment of Section 4 and 7 as shown on Figure 5.2 are located within the neighbouring site at 125 Murphys Road. The assessment found slip circles with unsatisfactory Factors of Safety. Remediated slopes were modelled with shear key, geogrid reinforced shear key and counterfort drains.

3 Non-engineered fill: There is non-engineered fill present across the site, which was generally proposed to be undercut. However, it was recommended that the existing fill material is inspected during earthworks operations. If considered suitable for re-use during the inspection, the fill material may be re-conditioned and prior to re-use.

4 Earthworks: Land Use consent drawings in 2018 included cuts of up to 4 m and fill of up to 3 m (see Figure 5.3). The Lander Geotechnical report provides recommendations to earthwork the site.

5 Expansive soils: Based on limited testing, the development should be built in accord with AS 2879 expansive Site Class M (moderate) provisions based. No minimum foundation embedment depth was provided.

6 Liquefaction: The slope stability assessment has included an allowance for seismic loading with accelerations determined in accordance with NZS1170.5:2004. However, no liquefaction assessment has been undertaken.

7 Foundations: The site is likely able to support 3-5 storey structures, with 3 storey structures likely supported by shallow foundations. Higher storey structures may require piling.

8 Stormwater disposal through infiltration: Groundwater varies across the site and have been measured between 1.5 and 3 m depth. Cut and fill levels are not yet confirmed for the site. Once determined, we recommend that infiltration testing is done to assess the permeability of soils and the opportunity to infiltrate stormwater to the ground.

[7] Code of practice for and development and subdivision, part 2: earthworks and geotechnical (aucklanddesignmanual.co.nz)

Figure 0.3: Proposed cut fill contours extracted from the Lander Geotechnical report.

5.4 Summary and Recommendations

Our preliminary conclusion is that the site is generally suitable for the proposed new development from a geotechnical perspective. The key geotechnical constraints are summarised below:

1 Non-engineered fill is likely to require removal and replacement by engineered fill below proposed building platforms and pavements.

2 A 20 m set-back distance is recommended between the crest of the slope and the proposed buildings, unless specific design, such as piles or buttresses, is implemented.

3 Shallow foundations are considered feasible for up to three-level buildings provided that filling is limited to about 0.5 m thickness under the building platform - unless the filling is staged and allows for settlement to occur prior to construction of the buildings. Differential settlement will also need to be checked where cut and fill levels vary significantly under the building platform.

4 Minimum embedment of foundations bearing within natural soils should be at least 750 mm below the ground level.

A summary of the opportunities and constraints is provided in Table 5.1 below.

Table 5.1. Summary of geotechnical engineering opportunities and constraints

	Issue / constraint	Impact*	Comments / opportunities
Earthworks	Earthworks currently involves cuts of up to 4 m and fills up to 2 m to level the site.	Medium	• There is up to around 1.9 m of non-engineered fill in the north-western area of the site. This fill is likely to require removal and replacement by engineered fill prior to filling to the required site levels.

	Issue / constraint	Impact*	Comments / opportunities
			• The non-engineered fill can likely remain in place beneath proposed playing fields [subject to contaminated land assessment findings. • An earthworks specification and laboratory testing will need to be prepared as part of detailed design. • The natural soils may be suitable for re-use as engineered fill provided that an experienced contractor carries out earthworks during the summer months.
Slope stability	The site is steeply sloping near the southern boundary.	Low	• Proposed buildings are likely to be located away from the moderately sloping ground near the stream due to requirements outlined in the Stormwater Management Plan (SMP) for the area. • Slope stability is not considered a concern at the proposed location of the buildings provided there is a 20 m set-back from the crest of the slope. This can be refined by an assessment by a senior Engineering Geologist. Alternatively, specific design such as piles or buttressing can be implemented. • Playing fields may be located closer to the crest of the slope if slope risk is mitigated or if risk of slope instability is accepted. • The Lander Geotechnical Report refers to slump debris at the site and signs of relic slope instability. However, no large-scale of deep instability was identified.
Foundation selection	Shallow foundations	Low to medium (increasing with number of storeys)	• Shallow foundations are considered feasible for up to three-level buildings if filling is limited to about 0.5 m thickness under the building platform - unless the filling is staged and allows for settlement to occur prior to construction of the buildings. • Differential settlement will also need to be checked where cut and fill levels vary significantly under the building platform. • This will need to be verified by the Structural Engineer during the preliminary design stage.
	Pile foundations	Low	• Proposed structures >3 storeys in height are likely to require pile foundations. • Bored piles may be embedded into East Coast Bays Formation (ECBF) rock. • The proposed earthworks at the site indicate that the rock level will likely be present between 4 and 8 m below existing ground level.

	Issue / constraint	Impact*	Comments / opportunities
Settlement	Consolidation	Low to medium	• Settlement of shallow foundations may be expected due to the presence of Tauranga Group Formation clay soils beneath the site. However, the clay soils are generally stiff and do not to appear to contain compressible organic soils. • A settlement analysis will need to be undertaken. The analysis will need to also consider consolidation settlement induced by placement of fill beneath proposed buildings.
	Liquefaction	Low to medium (increasing with number of storeys)	• The underlying Tauranga Group Formation soils generally comprise clay soils that are considered to not be susceptible to seismic liquefaction when saturated. • Few layers of loose sandy silt were encountered (that may potentially be susceptible to liquefaction) during the geotechnical investigations. It is considered that the effects of liquefaction on the proposed structures is low. • Cone Penetrometer Tests (CPTs) should be carried out during preliminary design to better assess liquefaction risk.
Expansive soils	Expansive soils susceptible to shrink/swell.	Medium	• The underlying natural soils generally comprise medium to highly plastic clays and clayey silts, which indicate that they are susceptible to shrink/swell. It is likely the soils will require design for highly expansive soils (i.e. AS 2870 Class H). • Minimum embedment of foundations bearing within natural soils should be at least 750 mm below the ground level.
Groundwater	Perched groundwater levels	Medium	• The geotechnical investigation indicate that perched groundwater is situated at approximately 1.5 m and 3 m depth beneath the higher part of the site (i.e. away from the crest of the slope). • These perched groundwater levels were measured in the summer and will likely be higher during winter months. • Perched groundwater will likely be encountered within excavations (particularly in areas where the site will be cut). • There are proposed neighbouring structures within 125 Murphys Road, on the site boundary. An assessment of the impact of localised groundwater drawdown on the neighbouring properties will need to be undertaken.

	Issue / constraint	Impact*	Comments / opportunities
			• Surface and subsurface drainage measures may be required to locally control groundwater levels, particularly in areas of cut. • Cut and fill levels are not yet confirmed for the site. Once determined, we recommend that infiltration testing is done to assess the permeability of soils and opportunity for stormwater disposal to the ground.

** The impact rating is intended as a guide in terms of perceived importance to the project. Low impact does not mean low risk or low cost.*

5.5 Further Work

We do not expect that additional geotechnical investigations are required to support the Notice of Requirement application. However, the following investigations are recommended during the preliminary design phase for the development:

1 Hand auger boreholes or test pits to assess the extent of existing non-engineered fill across the proposed building platforms. Contaminated sampling can be carried out in conjunction with the geotechnical investigations.

2 A site walkover by a senior Engineering Geologist is done to map the extent of inferred slope instability along the stream bank.

3 Cone Penetrometer Tests (CPTs) and machine boreholes should be carried out during preliminary design to better assess the liquefaction and consolidation settlement risks.

4 Infiltration testing to assess the permeability of soils and opportunity for stormwater disposal to the ground.

5 Laboratory testing to assess re-use of site-won soils and to prepare an earthworks specification for the works.

6 Geotechnical assessments and reporting to support the preliminary design of the proposed development

6 Applicability

This report has been prepared for the exclusive use of our client Ministry of Education, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for Notice of Requirement and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Recommendations and opinions in this report are based on data from discrete investigation locations. The nature and continuity of subsoil away from these locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

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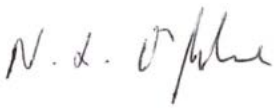
Verone Lancaster
Geotechnical Engineer

pp 

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Rachel Pickett
Senior Contaminated Land Specialist

Authorised for Tonkin & Taylor Ltd by:

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Karin Speight
Project Director

Report has been reviewed by Natalie O'Rourke, senior contaminated land specialist and Karin Speight, senior geotechnical engineer

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Appendix A Lander Geotechnical Report

Geotechnical Investigation Report

125 MURPHYS ROAD (STAGE 2), FLAT BUSH

For

GREEN CITY DEVELOPMENTS LIMITED

J00862 | Lander Geotechnical Consultants Limited | 6 April 2018

6 April 2018 Ref No: J00862

Green City Developments Limited
C/- Candor3 Limited

Attention: Mr A Turnbull

Dear Alistair

RE: Geotechnical Investigation for Proposed Residential Subdivision at 125 Murphys Road (stage 2), Flat Bush

This report represents the results of the geotechnical investigations carried out by Lander Geotechnical Consultants Limited for Green City Developments Limited for a proposed residential subdivision at 125 Murphys Road, Flat Bush.

If you have any queries or you require any further clarification on any aspects of this report, please do not hesitate to contact the undersigned.

For and on behalf of Lander Geotechnical Consultants Limited

S.G. Lander

Principal Geotechnical Engineer

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1 PROJECT BRIEF

This report has been prepared for Green City Development Limited in support of an application to the Auckland Council for Resource and Earthworks Consent in accordance with the requirements of the Resource Management Act 1991.

Where appropriate, it is in accordance with the recommendations of NZS 4404, Land Development and Subdivision Engineering; Auckland Council Code of Practice for Land development and Subdivision, Section 2 Earthworks and Geotechnical Requirements (version 1.6); and related documents.

2 SCOPE AND OBJECTIVES

The scope of this report encompasses the geotechnical suitability and stability of the land having regard for the nature of the development proposals.

Its principal objectives were to assess:

- existing geomorphological features and their effects on existing site stability
- the nature, bearing qualities and relative uniformity of the subsoils to the depths likely to be affected by proposed land development works and future building loads
- soil strength and classification as considered relevant to the design issues of this development
- engineering works required to remediate areas having identified poor bearing capacity, high settlement potential, slope stability or groundwater problems

3 SITE DESCRIPTIONS

The study area is located at 125 Murphys Road, Flat Bush, being 4 kilometres to the south east of Botany Junction on the western side (foothills) of the Redoubt Road ridgeline. The site is legally described as Lot 5 DP 470922, comprising an area of approximately 12.2 Hectares. The site is also zoned Residential – Mixed Housing Suburban Zone under the Auckland Unitary Plan.

The study area (i.e. 125 Murphys Road -stage 2) is bound by Murphys Road to the west, newly subdivided residential site to the north and an existing gully line / watercourse to the south and east. It accessed from a sheared driveway that services a residential dwelling and a large pastured area. The landform of the study area is generally flat and sloping downwards from the central portion to the east and south to form the western gully flank. Two existing Transpower corridors running across our study area as depicted on the attached drawings.

4 RELATED REPORTS

Lander Geotechnical have reviewed the following existing reports from neighbouring developments within 125 Murphys Road:

- Coffey, Geotechnical Investigation report, 125 Murphys Road, Flat Bush, ref no. GENZAUCK15979AB, dated: 19 January 2015.
- Lander Geotechnical Consultants Limited, Geotechnical Investigation report, First Stage Qualifying Development 125 Murphys Road, Flat Bush, ref no. J00016, dated: 6 May 2015.

- Lander Geotechnical Consultants Limited, Geotechnical Investigation Report, 125C Murphys Road, Flat Bush, ref no. J00561, dated: 7 September 2017.
- Lander Geotechnical Consultants Limited, Geotechnical Assessment Report Transpower Flat Bush Stage 2 Undergrounding Option, ref no. J00552, dated 25 May 2017.
- Lander Geotechnical Consultants Limited, Geotechnical Design Report for Mechanically Stabilised Earth (MSE) Slopes and Timber Cantilever Retaining Walls (Walls 1 and 2) at 125B Murphys Road (Stage 1), Flat Bush, ref no. J00463, dated 19 February 2018,
- Lander Geotechnical Consultants Limited, Geotechnical Investigation Report, 125B Murphys Road (Stage 2), Flat Bush, ref no. J00765, dated 12 March 2018.

5 DEVELOPMENT PROPOSALS

Based on the Candor3's drawings, we understand it is proposed to subdivide the site into 8 new super lots with associated roads. The existing dwelling will be removed to clear a way for the proposed subdivision.

From the Cut and Fill Plan reviewed, earthworks for this subdivision will involve cuts up to 4m and fills up to 3m to level the site.

The purpose of this subdivision is mainly for residential building development and therefore it is anticipated that future residential building development construction within the proposed lots will take place mainly in accordance with NZS3604.

6 GEOLOGY / GEOMORPHOLOGY

Geological records (i.e. online GNS geology maps) indicate that the site is underlain by the Puketoka Formation of the Tauranga Group sedimentary lithology (i.e. Late Pliocene – early Pleistocene epoch). In summary, these deposits comprise terrace alluvium (clays, silts, sands, pumiceous silts and organic deposits) underlain by Waitemata Group Bedrock.

Geomorphically there is evidence of relict slope instability upon the flanks of the incised watercourses at the southern and eastern edges of the development area. These appear as arcuate hummocky features, mid-slope benches, and soil creep. The most prominent feature is at the southern edge of the development. All features have been a focus for this investigation.

There also appears to be localised filling associated with the existing dwelling to form a level building platform/lawn, and cuts/fills associated with a farm track entering the site from the south-eastern corner of the site traversing the hillside here.

7 FIELDWORK

Our fieldwork was undertaken between 12 February and 16 February 2018 and involved the drilling of twenty-four hand auger boreholes to depths of up to 5.0m, six trail pits to depths of up to 5.4m and two machine boreholes to depths of up to 15.5m in location indicated on the appended Geotechnical Engineering Plan (Appendix 2, Figure 01), and also as depicted on the Candor 3 plan set (Appendix 1).

Shear vane tests were taken at 0.5m intervals in hand auger boreholes and wherever was practical in machine boreholes and trial pits to assess the in-situ shear strengths of the underlying soil.

Detailed description and depth of strata encountered during the drilling of hand auger boreholes, machine boreholes and trial pits are appended.

8 FINDINGS

8.1 Topsoil

Apart from HA14 where topsoil was not encountered, topsoil was encountered in all other borehole locations and ranged between 100mm and 300mm in thickness.

8.2 Pre-existing Filling

Below the surficial topsoil, pre-existing filling was encountered to depths of up to 1.9m. these materials are generally comprised of topsoil (organic silt) intermixed clayey silts with occasional rootlet inclusions. Vane shear strengths in these materials ranged from 47kPa to 165kPa indicating they were highly variable in strength (i.e. firm to very stiff). However, it is expected these materials will be reworked during the bulk earthworks process. Depths of fill at our borehole locations are summarised in Table 1.

Table 1: Depth of Pre-Existing Filling

Borehole No.	Fill Depth (m)
HA02	1.1
HA03	0.9
HA08	1.3
HA09	≥1.3*
HA11	1.2
HA16	1.9
HA22	0.8
HA24	1.4

*The pre-existing fill depth in HA09 was not proven due to an obstruction that inhibited the hand auger.

8.3 Natural Ground

Slump debris (colluvium) were encountered in boreholes along the southern and eastern edge of the site to depths of up to 3.4m. In-situ vane shear strengths in these deposits were ranged from 66kPa to 113kPa indicating they were stiff to very stiff. These deposits are associated with the relict slope instability geomorphology.

Below the aforementioned fill ground and slump debris, all boreholes encountered Puketoka Formation soils which generally comprised orange, brown and light grey silty clays and clayey silts. In-situ vane

shear strength ranged from 40 kPa to UTP indicating they were firm to hard. Sensitivities to disturbance were typically insensitive to moderately sensitive.

Transitional Waitemata Group soils were encountered in most of the boreholes right beneath the aforementioned Puketoka Formation. These soils comprised typically dark grey, very stiff to hard silts, clays and sands. Vane shear strengths were typically very high (i.e. mostly UTP or above 200kPa).

Beneath this competent Waitemata Group Bedrock was encountered in all machine boreholes and comprised interbedded layers of slightly weathered to unweathered, very weak to weak, dark grey, siltstone and sandstone. The depths to bedrock in each machine boreholes are summarised in Table 2.

There was no evidence of slickensides or parallel bedded (pre-sheared) clay seams within the rockmass that would indicate historic deep-seated slope movements.

Table 2: Depth to Bedrock from Existing Ground Level

Machine Borehole No.	Depth to Bedrock (m below ground level)
MH01	8.5
MH02	3.9

8.4 Groundwater Levels

8.4.1 Hand Auger Boreholes

Groundwater was encountered in hand auger borehole Except hand auger borehole HA04, 09, 19 and 23, Groundwater was encountered in all borehole locations during the time of our investigation. Details in relation to the groundwater levels in hand auger boreholes are depicted on the attached borehole records.

8.4.2 Machine Boreholes

We returned to site a week after the completion of site investigation works and measured standing groundwater levels in the machine boreholes as presented in following table.

Table 3: Machine Borehole Groundwater Levels as Measured on 19 February 2018

Borehole No.	Depth (m)
MH01	6.81
MH02	8.01

9 LABORATORY

Three sets of Atterberg Limits tests were carried out on samples taken from around the site, generally within the zone of li9kely influence of shallow building foundations.

The tests were in accordance with NZS 4402, “Methods of Testing Soils for Civil Engineering Purposes” test section 2 and were primarily intended to assess the Casagrande Classifications and Expansive Classes of the site materials.

All results are IANZ (International Accreditation New Zealand) endorsed and full details are appended.

The following table summarises the results of the laboratory test programme undertaken to establish plasticity index properties:

Table 4: Results of Laboratory Plasticity Tests

Borehole No.	Avg. Depth (m)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Linear Shrinkage	Casagrande Classification
HA05	**0.75**	**29.5**	**74**	**29**	**45**	**0.0**	**14**	**CH**
HA15	**0.75**	**25.8**	**62**	**28**	**34**	**-0.1**	**15**	**CH**
HA17	**0.75**	**56.5**	**108**	**56**	**52**	**0.0**	**27**	**MH**

9.1 Water Content and Plastic Limit

Water contents for all samples tested lay within the range 25.8% to 56.5%, the average of all measured values being 37.3%. These are considered to be typical values given the usual variations between clayey silts and silty clays.

The plastic limit is sometimes approximated to the optimum moisture content to achieve maximum compaction for an engineered fill. It is noted there is only slight variation between plastic limit and the corresponding in-situ moisture content, meaning that conditioning of near surface borrow materials is unlikely to be required a major requirement during the fill placement process. The need for conditioning will become more pressing within the deeper cuts, where the materials are anticipated to be wet of optimum moisture content.

9.2 Atterberg Limits

The liquid or cone penetration limit is the minimum water content at which the soil will flow as a liquid, while plastic limit is the minimum water content at which the soils remain plastic. The difference is the plasticity index, being the range of water contents over which the soil remains in plastic state.

A plot of plasticity index versus liquid limit is called plasticity chart and on has been prepared for each sample tested to determine its Casagrande Classification (see appendices).

The A-line on the plasticity chart is the arbitrary boundary between inorganic clays (CL and CH), which are above this line and the inorganic silts, and organic clays (ML, MH, OL and OH), which are below.

The Casagrande Classification test confirmed moderately to highly plastic site materials, classifications being CH.

9.3 Liquidity Index

The liquidity index is a measure of the proximity of the natural water content to their liquid and plastic limit. Values near to or greater than 1 indicate highly compressible sensitive materials with natural water contents near the liquid limit, while values near zero indicate heavily over-consolidated soils with natural water contents near the plastic limit. In this case, all samples returned liquidity index of zero or less than zero. This indicates that greater over-consolidation of the near surface materials has occurred because of desiccation rather than surcharge.

9.4 Linear Shrinkage

The linear shrinkage value is an indication of the shrinkage of a soil from a water content near the liquid limit, to its oven dried state. High values generally indicate highly expansive soils. Here, linear shrinkages were in the range 14 to 27, averaging around 18, pointing to medium shrinkage potential throughout the subsoils on this site. This is a common feature of the materials in the regio0n and is best addressed by specifying appropriate minimum foundation depths or specifically designed foundations.

10 SLOPE STABILITY

10.1 Methods

A total of seven cross sections were provided to us by Candor3 (as appended).

However, among those two cross-sections mentioned above, we have modelled and remodelled Cross sections 2-2’ to 7-7’ as part of this report by using the Morgenstern/Price method for circular slips. Planar slips have been dismissed as a failure mode based on geomorphic observations and the site investigation findings.

The degree of stability of a slope is expressed as the factor of safety, which is the ratio of the forces resisting failure to the driving forces causing instability. Theoretical failure of a slope is possible when the factor is 1.0, while increasing values above 1.0 indicate improving stability.

Auckland Council Code of Practice (ACCoP) for Land Development and Subdivision require slopes within residential subdivisions to have minimum factors of safety of 1.5 and 1.3 under Long Term (existing groundwater) and Short Term (worst credible groundwater conditions) respectively, and to demonstrate any adverse effects of proposed land modifications on slope stability. If these fail below the minimum criteria, then demonstration of engineering measures is required to achieve the criteria.

For the analysis of the cross sections, the effective stress soil parameters presented in following table were selected based on our experience in similar geology in vicinity of the site and the field test results, and which are also conservative than suggested parameters outlined in Schedule 2E of ACCoP.

Table 5: Soil Properties

Description	C' (kPa)	Ø' (degrees)
Colluvium (relict)	**3**	**26**
Recent Alluvium	**2**	**24**
Existing Fill	**3**	**28**
Engineer Certified Fill	**5**	**32**
Puketoka Formation	**4**	**28**
Transitional ECBF	**10**	**34**
Waitemata Group Bedrock	**50**	**40**

10.1.1 Seismic Analysis – ACCoP Residential Requirements

Seismic analyses were also undertaken with a 1 in 150-year seismic event under effective stress (pseudostatic) conditions with a minimum factor of safety of 1.2 required by Auckland Council in this scenario. The stability assessment has included an allowance for seismic loading with accelerations determined in accordance with NZS1170.5:2004. The Peak Ground Acceleration is calculated using the following formula from NZS1170.5:2004 Section 3.1: C(T) = Ch(T) x Z x Ru x N(T,D).

Table 6: Peak Ground Acceleration Parameters

Parameters	Standard	Description
Spectral Shape Factor (Ch(T)): **1.33**	NZS1170.5:2004 Table 3.1	Shallow soil site (Site Class C) – very stiff or hard materials under 60m
Hazard Factor (Z): 0.13	NZS1170.5:2004 Table 3.3	Auckland/Manukau City
Return Period Factor (Ru): 0.65	NZS1170.5:2004 Table 3.5	Conservative estimate between 1/100 and 1/250, as Auckland Council require 1/150 return period
Near Fault Factor (N(T,D)): 1	NZS1170.5:2004 Section 3.1.6	No near faults to site

The Peak Ground Acceleration (PGA) for this site and proposed development is 0.11g, after applying a seismic reduction factor of 65% (i.e. reduced by a factor of 0.65 as it is generally accepted that the lower value of PGA may be adopted on account of the very short duration of the acceleration above this) It is calculated as 0.07g has been used in the seismic stability assessment.

10.1.2 Seismic Analysis – Transpower Specification

For sections within the vicinity of the proposed Transpower (cross section 4-4' and 5-5') seismic design should be carried out in accordance with the recommendations of NZGS Earthquake Geotechnical Engineering Practice Module 1 (Version 0). The following assumptions has been used to calculate the peak ground acceleration for the geotechnical design:

- The Transpower has been assumed to be Importance Level 4;
- Based on Importance Level 4 a return period of 1 in 2,500 years and a return period factor (R) of 1.8 have been adopted from Table 3.3 of NZS1170.0 and Table 3.5 of NZS1170.5 respectively;
- A C0,1000 value of 0.1 and an effective magnitude of 5.75 have been adopted from Figures A.1 and A.3 of NZGS Module 1 respectively;

Based on the above an Ultimate Limit State (ULS – minimum acceptable Factor of Safety of 1.0) Peak Ground Acceleration (PGA) of 0.28g has been determined for geotechnical design with associated Serviceability Limit State (SLS – minimum acceptable Factor of Safety of 1.1) PGA of 0.07g. As applied to the calculation above, aseismic reduction factor of 0.65 has been applied and is calculated as 0.19g and 0.05g for ULS and SLS respectively.

10.2 Results and Discussion

Results of our slope stability analysis for each section and scenario are given in Appendix 8.

The proposed slope profile for Section 5-5' and 7-7' found slip circles with unsatisfactory factors of safety encroaching into the proposed development. Remediated slopes were modelled with shear key, geogrid reinforced shear key and counterfort drain recommended as appropriate.

The rest slopes found no unsatisfactory slip circles within the proposed earthworks area.

Remediation concepts are illustrated on the attached Geotechnical Engineering Plan (Figure 01) and detailed discussion for remediation details on each of Cross Section 5-5' and 7-7' is as follows:

Cross Section 5-5'

Under circular analysis for residential subdivision specifications unsatisfactory slip circles are found to encroach into the proposed development under all kind of scenarios as depicted on the appended slope stability output.

Remediation to achieve satisfactory factors of safety involves a 8m wide geogrid reinforced shear key below the toe of the proposed fill, to be formed from engineer certified clay fill with Tensar RE 520 geogrid at 0.5m vertical spacings to span the width of the shear key.

Cross Section 7-7'

Unsatisfactory slip circles were found to encroach into the proposed development under extreme groundwater condition.

Remediation to achieve satisfactory factors of safety involves counterfort drainage to a depth of up to 4m with 12m spacings.

11 PROJECT EVALUATION AND RECOMMENDATIONS

11.1 General

The undertaking of earthworks construction and drainage works in accordance with the following specific subdivision and building development recommendations, NZS 4404, "Code of Practice for Urban Land Subdivision" and related documents and Auckland Council's Code of Practice standard specifications where appropriate should ensure that the completed development is generally suitable for conventional timber framed dwellings constructed in accordance with the requirements of NZS 3604, and with AS 2870 expansive Site Class provisions.

However, there are two areas requiring engineering intervention to achieve minimum factors of safety against slope instability.

Specific comments and recommendations are as follow:

11.2 Slope Stability

11.2.1 General

The appended Geotechnical Engineering Plan (Appendix 2, Figures 01 to 03) presents an overview of the approximate location and extent of the geotechnical stabilisation concepts outlined in Section 10.2 of this report and on the slope stability analysis outputs.

These are discussed generally below:

11.2.2 Shear Key with Reinforced Geogrid

A geotechnical shear key is a method of improving the overall ground conditions by excavating the natural ground and replacing it with fill of a higher strength, together with underfill drainage. This concept has been determined as a solution in the vicinity of Section 5-5', to support the path edge road.

The location, dimensions and overall depth of the shear key has been determined through detailed slope stability analysis based on the geotechnical site model and our understanding of the earthworks proposals

Geogrid reinforcement of shear key is required, and our preliminary analyses indicate that the geogrid will need to comprise of 4m width Tensar RE520 geogrid at 0.5m vertical spacings. This will be subject to detailed design verification to check internal stability.

Shear Key construction also includes the installation of subsoil drainage to suppress and control groundwater levels, as groundwater generally has a significant influence on slope stability processes.

The attached Typical Shear Key Detail (Appendix 2, Figure 02) depicts a conceptual shear key design, with a buttress fill upslope and associated geotechnical drainage. The geotechnical drainage requirements for a buttress fill with a toe key, while similar in concept, are generally less rigorous than depicted on this schematic. The locations of shear keys and their indicative widths required is shown in Appendix 2, Figure 01.

During construction shear key concepts are refined through iterative slope stability analyses as they advance, reacting to ground conditions as they are revealed. Stability and appropriateness of the final as-built construction is proven in the Geotechnical Completion Report.

11.2.3 Counterfort Drainage

Geotechnical 'counterfort' drainage improves ground conditions by lowering groundwater levels through drains constructed from a perforated drain coil within self-filtering material such as SAP50, or alternative approved drainage media that is compatible with the self-filtering criteria for subsoil drainage. This concept has been determined as a solution in the vicinity of Section 7-7', to support the park edge road.

Groundwater drawdown was modelled in accordance with Price and Fitch (2017) 1, and spacing was chosen appropriately (12m in this case) to ensure adequate drawdown. The attached Typical Drainage Detail (Appendix 2, Figure 3), depicts conceptual drainage design and locations of counterfort drains are depicted in dark blue in Figure 01. If drainage outlets are restricted by covenant bush areas, collector drains can be employed, and outlets thrusted to natural drainage channels, locations to be confirmed during construction and depicted on the final as-built plans.

11.2.4 Toe Keys

These are nominal undercuts and benching of the ground at the toe of fill batters, to key the filling into the natural ground in a stable fashion. Minor under fill drainage may also be specified if seepages are identified. The extent of areas requiring Toe Keys is given in Appendix 2, Figure 01. Refer Section 11.5.4 also.

11.3 Foundations for Buildings

11.3.1 Bearing Capacity and Settlement Potential

A geotechnical ultimate bearing capacity of 300 kPa should generally be available for all shallow strip and pad foundations constructed on the natural ground and/ or on the engineer certified filling.

Further specific site investigation and design modification as necessary should be carried out for all building having loads greater than these.

This assessment of bearing capacity will be re-addressed in our Geotechnical Completion Report at the completion of the subdivision.

11.3.2 Expansive Site Class

Based on our visual-tactile and laboratory assessment, we consider the preliminary AS 2870 expansive Site Class is M (moderate) and the characteristic surface ground movement is up to 40mm.

This preliminary assessment of the Site Class will be re-addressed and finalised in our Geotechnical Completion Report in conjunction with additional laboratory testing.

11.4 Roading and Services

11.4.1 CBR's

No significant problems are anticipated in relation to road construction. Following earthworks and subgrade trimming, a minimum CBR of 4% and 6% can be expected.

However, we recommend that a programme of Scala penetrometer testing is carried out when the roads are being formed to their final levels to confirm actual CBR values.

Lime stabilisation of subgrade may be an economical alternative to undercutting in areas where low CBR's are recorded. Appropriate response and strength testing should be carried out before earthworks commence if this option is to be adopted.

11.4.2 Groundwater Problems

Construction of the stormwater and sanitary sewage reticulation during the winter months could involve raised groundwater levels and could cause problems with the stability of trench sides, leading to a need for additional subsoil drainage and/or dewatering, especially in areas where deep lines are required.

On this site, groundwater levels were relatively high in some locations when measured, in any event in the long term the network of subsoil, sanitary and stormwater drains to be installed as part of the normal land development process should help to regulate groundwater levels throughout the subdivision and it is not anticipated that trench excavations will be unduly troublesome on account of groundwater.

11.5 Earthworks Operations

11.5.1 General

Earthworks for this development will involve cuts up to 4m and fills up to 3m to produce desired level, for the residential subdivision.

Earthworks should be undertaken in accordance with NZS 4431 with conventional plant and under engineering control. Fill testing should be carried out to verify compaction to engineer certified standards.

11.5.2 Site Preparation

All building debris, existing gravel tracks and bulk excavation which is surplus to requirements should be removed from site along with all trees and vegetation that is proposed to be removed on the site Clearance Plan. Prior to fill being placed vegetation and topsoil should be stripped and stockpiled well clear of fill areas.

Based on the supplied drawings, it is important that the existing dwelling and surrounding trees are completely removed and any excavations backfilled with approved hardfill materials or clay fills compacted in 0.3m layers to ensure a consistent subgrade.

11.5.3 Material Suitability

Fill materials, should consist of clean, inorganic clays and silts or approved hardfill (i.e. GAP 40). During the winter months, the rising groundwater table may cause problems for earthmoving plant but usually the materials become suitable for inclusions in the earthworks after drying and / or mixing.

Any stability problems such as pumping of the subgrade under heavy machinery trafficking that occur during earthworks will probably be associated with localised high groundwater levels (i.e. resulting from storm events or perching). Solutions to this problem are generally centred on the installation of appropriate subsoil drainage if required.

However, based on our experience with nearby subdivisional works, it is anticipated that optimum water contents will most likely be lower than the range of natural water contents (particularly in deeper cuts), and accordingly it will probably be necessary for some drying to take place before compaction, by taking thin cuts over broad areas, or by discing in-situ before transportation, or by carrying out the earthworks at a relatively slow and controlled rate with minimal plant.

11.5.4 Benching of Slopes

All benching of slopes prior to the placement and compaction of filling should be carried out in accordance with the normal requirements of NZS 4404 and related documents as mentioned above, especially on the steeper areas of the site, to ensure that the filling placed is keyed into the underlying natural ground. This would involve the cutting of benches approximately the width of a bulldozer, with a slight reverse gradient back into the slope. The optimum depth of each bench is best confirmed by careful Engineering inspections during construction, particularly where Toe Key have been identified.

11.5.5 Pre-Existing Filling

Pre-existing filling was encountered across the site in several borehole locations (as mentioned in Section 8.2). Some of these fills are not considered to meet the engineer certified filling standards and therefore will require to be fully undercut prior to the placement of further filling. However, it is recommended that it should be inspected by us to confirm its quality / suitability during the earthworks operations prior to the placement of further filling. If suitable, the pre-existing filling can be leave in place and its surface should be reworked in accordance with good engineering practice to ensure that it binds with the new filling.

11.6 Land Drainage

11.6.1 Subsoil Drainage

Counterfort, subsoil and underfill drainage will be required as shown on the attached plans (Appendix 2, Figures 01 to 03) and will comprise of underfill drainage below fill areas as considered appropriate on site to tap any springs and within existing gullies, subsoil/ bench drainage associated with the proposed stability shear keys / toe keys, and counterfort drainage constructed within natural soils. Details of the construction of these drains are also shown on Figure 02 to 03. These drains are designed to be robust and maintenance free with design redundancy via multiple outlets / water pathways and use of geotextile (i.e. Bidim A19) filter cloth where practical to install, to provide a barrier to prevent ingress of sediment into the drainage medium. Otherwise, the drainage medium is graded to provide self-filtering and prevent long term internal erosion of the native soils.

With regards to the Auckland Council's Unitary Plan E7 groundwater guidelines, we have assessed the compliance to E7.6.1.6 and E7.6.1.10 of the proposed geotechnical drainage as follows:

Table 7: E7.6.1.6 and E7.6.1.10 Assessment

Rule	Activity	Applicability to Site
E7.6.1.6 (1)	The water take must not be geothermal water.	**Complies**: We confirm no signs of geothermal water on site.
E7.6.1.6 (2)	The water take must not be for a period of more than 10 days where it occurs in peat soils, or 30 days in other types of soil or rock.	**Does not comply:** The water take from the geotechnical drainage will be permanent, only during elevated groundwater events.
E7.6.1.6 (3)	The water take must only occur during construction.	**Does not comply:** The water take from the geotechnical drainage will be permanent, only during elevated groundwater events.
E7.6.1.10 (2)	Any excavation that extends below natural groundwater level must not exceed: a) 1ha in total area; and b) 6m depth below the natural ground level	**Complies**: The proposed shear key and geotechnical drainage excavations should not exceed greater than 6m below ground level or be greater than 1ha.
E7.6.1.10 (3)	The natural groundwater level must not be reduced by more than 2m on the boundary of any adjoining site.	**Complies:** Geotechnical drainage is offset at least 10m from site boundaries and therefore groundwater drawdown beyond the site boundaries is not anticipated.
E7.6.1.10 (4)	Any structure, excluding sheet piling that remains in place no more than 30 days, that physically impedes the flow of groundwater through the site must not: a) Impeded the flow of groundwater over a length of more than 20m; and b) Extend more than 2m below the natural groundwater level	**Complies:** No structures are proposed that will impede the flow of groundwater.

Rule	Activity	Applicability to Site
E7.6.1.10 (5a)	The distance to any existing building or structure (excluding timber fences and small structures on the boundary) on an adjoining site form the edge of any trench or open excavation that extends below natural groundwater level must be at least equal to the depth of the excavation	**Complies:** The nearest house on an adjoining site is greater than 100m away from any proposed geotechnical drainage for Stage 2.

As presented above, the proposed geotechnical drainage does not comply with rules E7.6.1.6(2) and E7.6.1.6(3). However, the proposed drainage is located more than 10m away from any neighbouring property boundary (per E7.6.1.10(3)). Therefore, it can be assumed that there will be negligible effect (i.e. from groundwater drawdown induced settlement of groundwater take) on any neighbouring property. Moreover, the geology here is generally over consolidated and consolidation settlement is generally surpassed by prevailing slope stability issues which generally dictate the geotechnical engineering in this locality. Moreover, the groundwater table should only occur during elevated groundwater conditions.

11.6.2 Groundwater Disposal

All groundwater from subsoil/underfill drains should be collected by means of sealed pipes and discharged into properly designed outfall structures (refer to Appendix 2). In addition, regular inspections of all accessible subfill drain sumps and outfalls should be carried out during subdivision construction to ensure no damage occurs as a result of earthworks operations.

All subsoil/underfill drains, should be carefully recorded on as-built plans by a Registered Surveyor and the details forwarded to us for inclusion in our Geotechnical Completion Report.

11.7 Compaction Control

Laboratory testing should be undertaken in the near future to establish specific compaction control criteria, but at this stage it is envisaged that earthworks control will be in terms of maximum allowable air voids / minimum allowable shear strengths for the general subdivisional work. However, the criteria of 95% of the maximum dry density within the appropriate water content range could also have some relevance and most likely we would control the works using a combination of both methods.

Upon instruction we will undertake compaction control testing prior to commencement of the earthworks.

11.8 Imported Filling

If imported filling is to be used in conjunction with the in-situ materials, it is essential that we are given the opportunity of examining its source or sources and determining its suitability for inclusion in the earthworks on the basis of observation, investigation and testing as considered necessary.

It will also be necessary for all truckloads of imported material to be inspected for contaminants prior to dumping to facilitate certification of the completed works.

11.9 Erosion and Sediment Control

All erosion and sediment control should be undertaken in accordance with the Auckland Council Guideline Document (dated June 2016, reference 2016/005, titled 'Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region) and/or any Land Use Consent required to be obtained prior to commencing any site works. Other requirements may be imposed in the Earthworks Consent. Cut-off drains should be installed as specified in the above documents as should all other appropriate doubtful weather measures.

12 PLAN REVIEW AND FURTHER WORK

If significant changes are proposed to be made to the earthworks plans reviewed to date, we reserve the right to revisit our evaluations and recommendations when they come to hand.

In addition, our input into the civil works / engineering drawings and scheme plans for the subdivision is highly recommended, especially where slope stabilisation concepts are required.

It should be noted that it was not possible to cover all proposed building lots during the site investigation work carried out for this report. Accordingly, it may be necessary at the time of preparation of our Geotechnical Completion report to undertake specific site investigation work on any previously uninvestigated lots that have either been cut or not affected by the earthworks.

13 LIMITATIONS

This report has been prepared solely for the use of our client, Green City Developments Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specific project described herein. No liability is accepted in respect of its use for any other purpose or by any other person or entity. All future owners of this property should seek professional geotechnical advice to satisfy themselves as to its ongoing suitability for their intended use.

The opinions, recommendations and comments given in this report result from the application of normal methods of site investigation. As factual evidence has been obtained solely from boreholes and trial pits which by their nature only provide information about a relatively small volume of subsoils, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in the report.

If variations in the subsoils occur from those described or assumed to exist then the matter should be referred back to us immediately.

For and on behalf of Lander Geotechnical Consultants Limited

Prepared By:

Alex Bu
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NZDE(Civil)

Reviewed and Authorised By:

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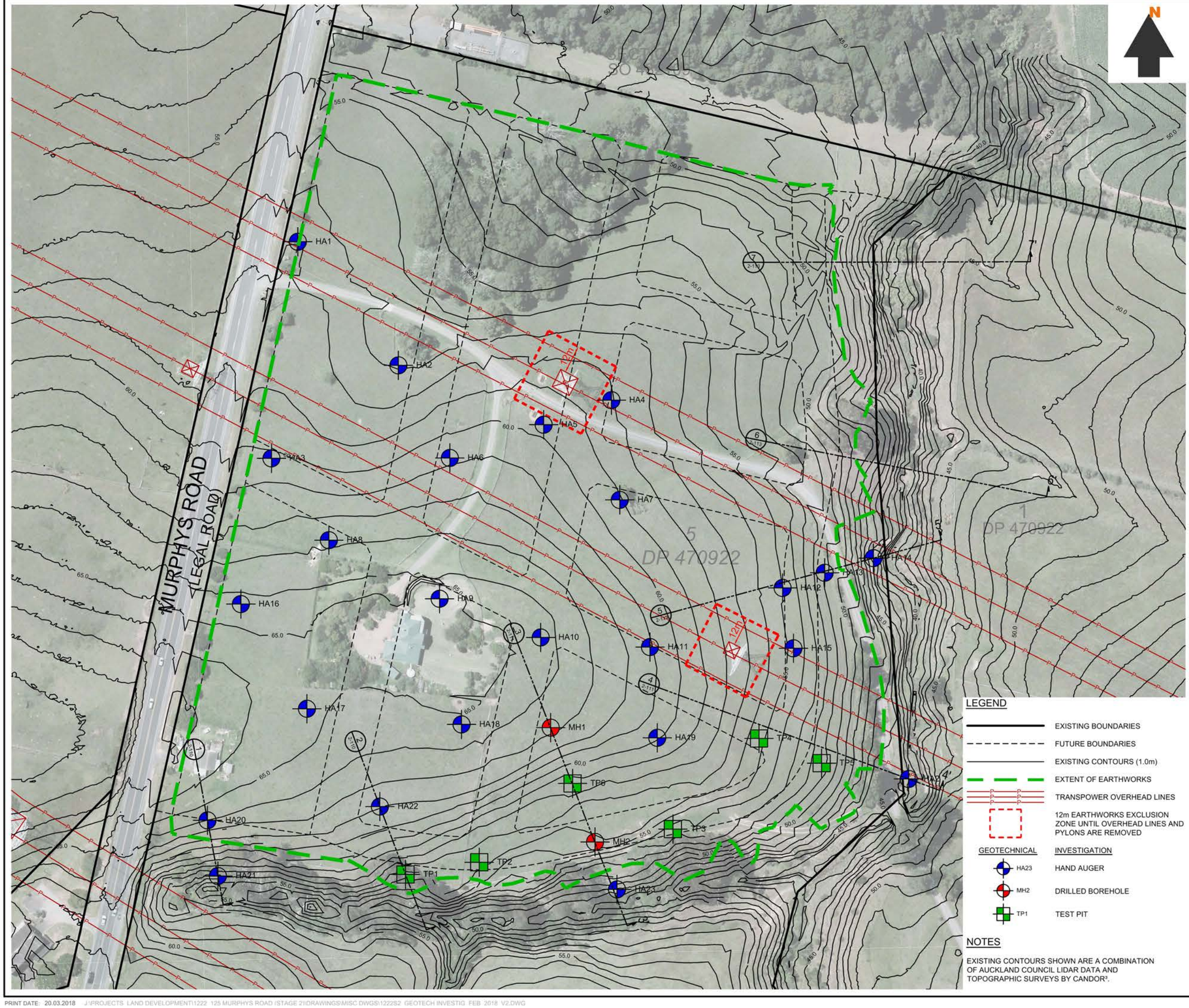
CMEngNZ, CPEng, IntPE(NZ)

Appendix 1

Candor3 Limited
Drawings

REV	DESCRIPTION	BY	APPVD	DATE
A	SECTIONS 6 & 7 ADDED		JFG	08-03-18



NOTES

EXISTING CONTOURS SHOWN ARE A COMBINATION OF AUCKLAND COUNCIL LIDAR DATA AND TOPOGRAPHIC SURVEYS BY CANDOR³.

Candor³ ENGINEERING FOR LIFE

PROJECT

125 MURPHYS ROAD, FLAT BUSH GEOTECHNICAL INVESTIGATION FEBRUARY 2018

EXISTING CONTOURS

CLIENT

GREEN CITY DEVELOPMENTS LIMITED

PURPOSE

FOR INFORMATION ONLY

DESIGN AGT	APPROVED	SCALE
DRAWN AGT	BY JFG	1:1500 @ A3
CHECK AVS	DATE MAR 2018	

PROJECT NO.	DRAWING NO.	REV.
1222s2	2-100	A

REV	DESCRIPTION	BY	APPVD	DATE
A	SECTIONS 6 & 7 ADDED		JFG	08-03-18
B	DESIGN CONTOURS ADJUSTED		JFG	20-03-18

SECTION 4
SO 482109

5
DP 470922

1
DP 470922

MURPHYS ROAD
(LEGAL ROAD)

HA1 HA2 HA3 HA4 HA5 HA6 HA7 HA8 HA9 HA10 HA11 HA12 HA13 HA14 HA15 HA16 HA17 HA18 HA19 HA20 HA21 HA22 HA23

MH1 MH2

TP1 TP2 TP3 TP4 TP5 TP6

12m

7' 6' 5' 4'

LEGEND

- EXISTING BOUNDARIES
- FUTURE BOUNDARIES
- EXISTING CONTOURS (1.0m)
- DESIGN CONTOURS (1.0m)
- EXTENT OF EARTHWORKS
- TRANSPOWER OVERHEAD LINES
- 12m EARTHWORKS EXCLUSION ZONE UNTIL OVERHEAD LINES AND PYLONS ARE REMOVED

GEOTECHNICAL INVESTIGATION

- HA23 HAND AUGER
- MH2 DRILLED BOREHOLE
- TP1 TEST PIT

NOTES

EXISTING CONTOURS SHOWN ARE A COMBINATION OF AUCKLAND COUNCIL LIDAR DATA AND TOPOGRAPHIC SURVEYS BY CANDOR³.

Candor³
ENGINEERING FOR LIFE

PROJECT

125 MURPHYS ROAD, FLAT BUSH GEOTECHNICAL INVESTIGATION FEBRUARY 2018

DESIGN CONTOURS

CLIENT

GREEN CITY DEVELOPMENTS LIMITED

PURPOSE
FOR INFORMATION ONLY

DESIGN AGT DRAWN AGT CHECK AVS	APPROVED BY JFG DATE MAR 2018	SCALE 1:1500 @ A3	
PROJECT NO. 1222s2	DRAWING NO. 2-101	REV. B	

SECTION 4
SO 482109

MURPHYS ROAD
(LEGAL ROAD)

5
DP 470922

1
DP 470922

HA1 HA2 HA3 HA4 HA5 HA6 HA7 HA8 HA9 HA10 HA11 HA12 HA13 HA14 HA15 HA16 HA17 HA18 HA19 HA20 HA21 HA22 HA23

MH1 MH2

TP1 TP2 TP3 TP4 TP5 TP6

12m

7' 6' 5' 4' 3' 2' 1'

LEGEND

- EXISTING BOUNDARIES
- FUTURE BOUNDARIES
- CUT DEPTH CONTOURS INTERVAL (1.0m) (-1.0)
- FILL DEPTH CONTOURS INTERVAL (1.0m) (1.0)
- EXTENT OF EARTHWORKS
- TRANSPOWER OVERHEAD LINES
- 12m EARTHWORKS EXCLUSION ZONE UNTIL OVERHEAD LINES AND PYLONS ARE REMOVED

GEOTECHNICAL INVESTIGATION

- HA23 HAND AUGER
- MH2 DRILLED BOREHOLE
- TP1 TEST PIT

REV	DESCRIPTION	BY	APPVD	DATE
A	SECTIONS 6 & 7 ADDED		JFG	08-03-18
B	DESIGN CONTOURS ADJUSTED		JFG	20-03-18

Candor3 ENGINEERING FOR LIFE

PROJECT

125 MURPHYS ROAD, FLAT BUSH GEOTECHNICAL INVESTIGATION FEBRUARY 2018

CUT / FILL CONTOURS

CLIENT

GREEN CITY DEVELOPMENTS LIMITED

PURPOSE
FOR INFORMATION ONLY

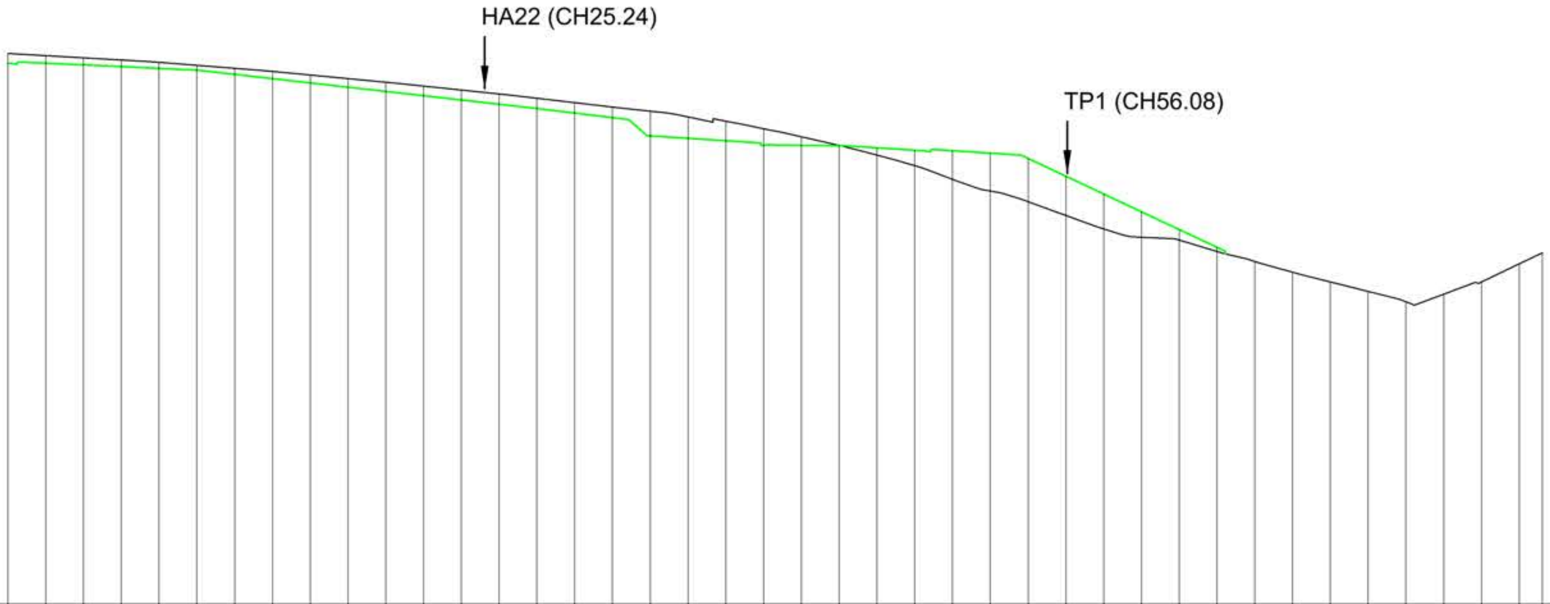
DESIGN	AGT	APPROVED		SCALE	
DRAWN	AGT	BY	JFG	1:1500 @ A3	
CHECK	AVS	DATE	MAR 2018		

PROJECT NO.	DRAWING NO.	REV.
1222s2	2-102	B

DATUM RL = 38.00

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	CUT / FILL DEPTH
0.00	66.28	66.77	-0.50
2.00	66.28	66.67	-0.39
4.00	66.28	66.79	-0.50
6.00	66.29	66.52	-0.23
8.00	66.29	66.29	-0.01
10.00	66.29	65.97	0.32
12.00	66.29	65.82	0.47
14.00	66.29	65.61	0.68
16.00	66.30	65.41	0.89
18.00	66.30	65.21	1.09
20.00	66.30	64.93	1.37
22.00	66.30	64.65	1.65
24.00	66.30	64.38	1.92
26.00	66.28	64.06	2.22
28.00	65.88	63.59	2.29
30.00	65.48	63.12	2.35
32.00	65.08	62.67	2.41
34.00	64.68	62.10	2.58
36.00		61.62	0.00
38.00		60.98	0.00
40.00		60.31	0.00
42.00		59.58	0.00
44.00		58.77	0.00
46.00		57.95	0.00
48.00		57.14	0.00
50.00		55.96	0.00
52.00		54.87	0.00
54.00		54.29	0.00
56.00		53.70	0.00
58.00		53.65	0.00
60.00		54.65	0.00
62.00		55.52	0.00
62.68		55.87	0.00

SECTION 1 - 1'



DATUM RL = 35.00

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	CUT / FILL DEPTH
0.00	63.64	64.15	-0.51
2.00	63.63	64.03	-0.40
4.00	63.54	63.91	-0.37
6.00	63.45	63.80	-0.35
8.00	63.35	63.68	-0.32
10.00	63.26	63.52	-0.26
12.00	63.04	63.36	-0.32
14.00	62.81	63.19	-0.38
16.00	62.59	63.00	-0.42
18.00	62.36	62.81	-0.45
20.00	62.13	62.62	-0.49
22.00	61.91	62.42	-0.51
24.00	61.68	62.21	-0.53
26.00	61.46	62.00	-0.54
28.00	61.23	61.77	-0.54
30.00	60.99	61.54	-0.55
32.00	60.75	61.31	-0.56
34.00	59.78	61.09	-1.31
36.00	59.65	60.78	-1.13
38.00	59.52	60.56	-1.03
40.00	59.29	60.16	-0.87
42.00	59.28	59.73	-0.45
44.00	59.26	59.27	-0.02
46.00	59.15	58.76	0.38
48.00	59.02	58.20	0.82
50.00	58.99	57.48	1.52
52.00	58.87	56.86	2.01
54.00	58.59	56.29	2.29
56.00	57.64	55.57	2.08
58.00	56.70	54.85	1.85
60.00	55.76	54.41	1.35
62.00	54.82	54.26	0.56
64.00	53.88	53.66	0.22
66.00		53.13	0.00
68.00		52.56	0.00
70.00		52.05	0.00
72.00		51.54	0.00
74.00		51.00	0.00
76.00		51.40	0.00
78.00		52.05	0.00
80.00		53.01	0.00
81.22		53.59	0.00

SECTION 2 - 2'

REV	DESCRIPTION	BY	APPVD	DATE
A	DESIGN LEVELS UPDATED		JFG	20-03-18

Candor[3] ENGINEERING FOR LIFE

PROJECT
125 MURPHYS ROAD, FLAT BUSH
GEOTECHNICAL INVESTIGATION
FEB 2018 - LONG SECTION (SHEET 1 OF 4)

CLIENT
GREEN CITY DEVELOPMENTS LIMITED

PURPOSE
FOR INFORMATION ONLY

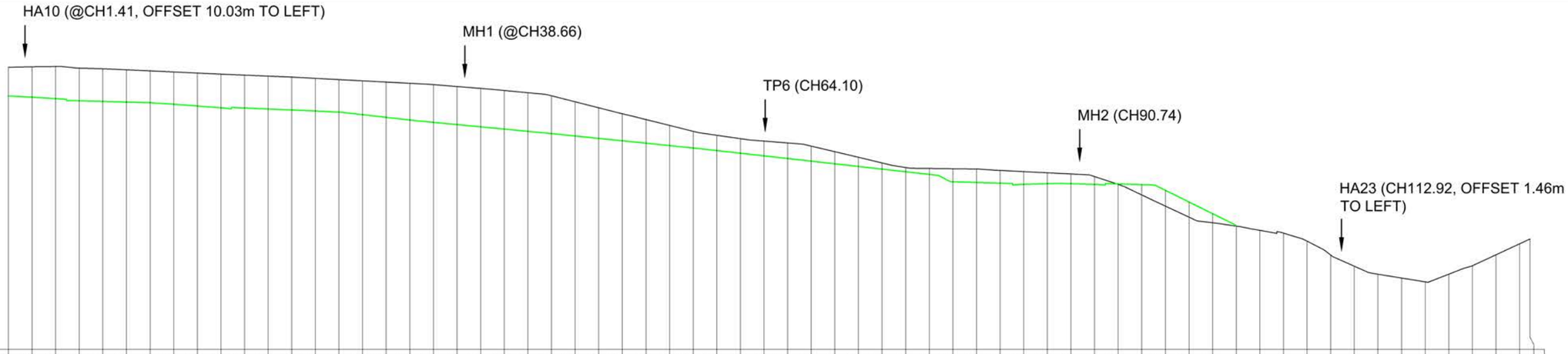
DESIGN AGT
DRAWN RS
CHECK AVS

APPROVED
BY JFG
DATE MAR 2018

SCALE
1:400 @ A3

PROJECT NO. 1222s2
DRAWING NO. 2-110
REV. A

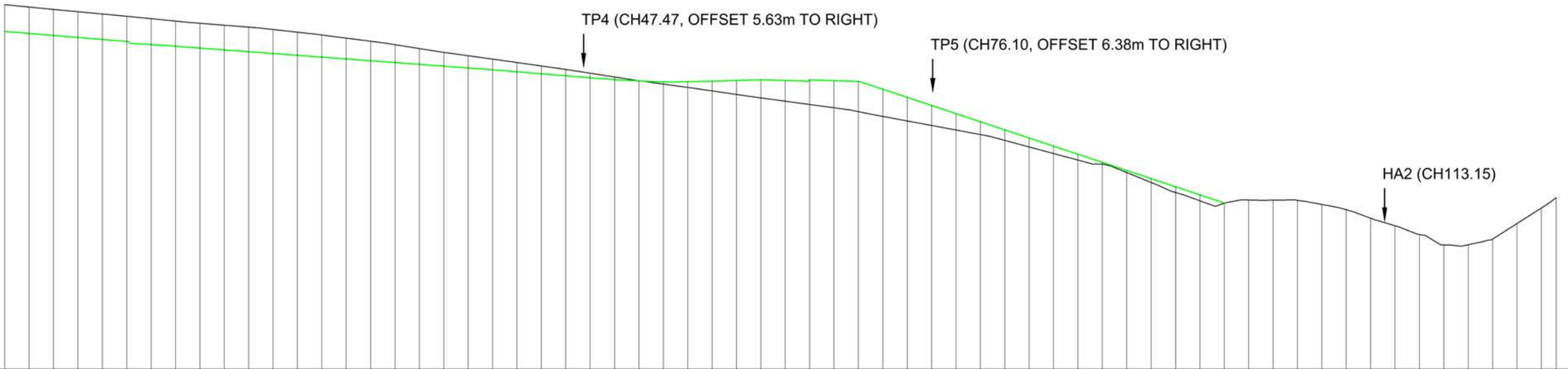
PRINT DATE: 21.03.2018 J:\PROJECTS\LAND DEVELOPMENT\1222 125 MURPHYS ROAD\STAGE 2\DRAWINGS\MISC DWGS\1222S2 GEOTECH INVESTIG FEB 2018 V2.DWG



DATUM RL = 41.00

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	CUT / FILL DEPTH
0.00	62.46	64.89	-2.43
2.00	62.35	64.93	-2.58
4.00	62.23	64.95	-2.72
6.00	62.05	64.82	-2.76
8.00	62.00	64.76	-2.77
10.00	61.94	64.67	-2.73
12.00	61.88	64.58	-2.70
14.00	61.76	64.49	-2.73
16.00	61.61	64.40	-2.79
18.00	61.46	64.30	-2.85
20.00	61.44	64.22	-2.78
22.00	61.35	64.14	-2.79
24.00	61.27	64.05	-2.78
26.00	61.19	63.95	-2.76
28.00	61.09	63.84	-2.76
30.00	60.87	63.74	-2.87
32.00	60.65	63.63	-2.99
34.00	60.42	63.53	-3.11
36.00	60.22	63.42	-3.20
38.00	60.03	63.26	-3.23
40.00	59.84	63.10	-3.26
42.00	59.65	62.92	-3.27
44.00	59.46	62.73	-3.27
46.00	59.27	62.47	-3.20
48.00	59.07	61.96	-2.90
50.00	58.86	61.46	-2.59
52.00	58.66	60.95	-2.29
54.00	58.46	60.46	-2.00
56.00	58.25	59.96	-1.71
58.00	58.05	59.46	-1.41
60.00	57.83	59.13	-1.30
62.00	57.61	58.84	-1.23
64.00	57.38	58.63	-1.25
66.00	57.16	58.48	-1.32
68.00	56.94	58.21	-1.27
70.00	56.71	57.74	-1.03
72.00	56.49	57.26	-0.78
74.00	56.26	56.78	-0.52
76.00	56.04	56.40	-0.36
78.00	55.81	56.31	-0.50
80.00	55.19	56.29	-1.10
82.00	55.13	56.27	-1.14
84.00	55.07	56.15	-1.08
86.00	54.97	56.05	-1.08
88.00	55.03	55.95	-0.92
90.00	55.03	55.85	-0.82
92.00	54.97	55.63	-0.66
94.00	55.01	54.97	0.04
96.00	54.95	54.07	0.88
98.00	54.46	53.13	1.34
100.00	53.47	52.19	1.28
102.00	52.48	51.72	0.77
104.00		51.43	0.00
106.00		51.08	0.00
108.00		50.84	0.00
110.00		50.16	0.00
112.00		48.98	0.00
114.00		48.04	0.00
116.00		47.36	0.00
118.00		47.03	0.00
120.00		46.71	0.00
122.00		47.36	0.00
124.00		48.07	0.00
126.00		49.00	0.00
128.00		49.93	0.00
128.89		50.35	0.00

SECTION 3 - 3'



DATUM RL = 31.00

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	CUT / FILL DEPTH
0.00	58.67	60.86	-2.20
2.00	58.50	60.67	-2.16
4.00	58.34	60.47	-2.13
6.00	58.18	60.29	-2.11
8.00	58.01	60.10	-2.09
10.00	57.85	59.92	-2.06
12.00	57.60	59.72	-2.12
14.00	57.46	59.52	-2.06
16.00	57.31	59.34	-2.03
18.00	57.16	59.18	-2.02
20.00	57.01	59.02	-2.01
22.00	56.86	58.83	-1.97
24.00	56.71	58.61	-1.90
26.00	56.57	58.38	-1.82
28.00	56.42	58.12	-1.71
30.00	56.27	57.87	-1.60
32.00	56.12	57.58	-1.46
34.00	55.97	57.27	-1.30
36.00	55.82	56.96	-1.13
38.00	55.68	56.68	-1.00
40.00	55.53	56.40	-0.88
42.00	55.36	56.13	-0.76
44.00	55.20	55.84	-0.64
46.00	55.04	55.55	-0.52
48.00	54.87	55.25	-0.38
50.00	54.72	54.94	-0.22
52.00	54.62	54.63	-0.01
54.00	54.54	54.36	0.18
56.00	54.55	54.08	0.47
58.00	54.59	53.80	0.80
60.00	54.65	53.51	1.14
62.00	54.71	53.22	1.49
64.00	54.65	52.95	1.70
66.00	54.69	52.68	2.01
68.00	54.64	52.41	2.22
70.00	54.58	52.09	2.48
72.00	53.93	51.71	2.23
74.00	53.27	51.33	1.93
76.00	52.60	50.96	1.64
78.00	51.94	50.59	1.35
80.00	51.27	50.22	1.05
82.00	50.60	49.74	0.86
84.00	49.94	49.20	0.74
86.00	49.27	48.66	0.61
88.00	48.61	48.13	0.48
90.00	47.94	47.79	0.15
92.00	47.27	47.10	0.17
94.00	46.61	46.29	0.32
96.00	45.94	45.47	0.47
98.00	45.28	44.79	0.49
100.00	44.61	44.59	0.01
102.00		44.85	0.00
104.00		44.84	0.00
106.00		44.83	0.00
108.00		44.49	0.00
110.00		44.06	0.00
112.00		43.36	0.00
114.00		42.74	0.00
116.00		42.03	0.00
118.00		41.18	0.00
120.00		41.19	0.00
122.00		41.65	0.00
124.00		42.92	0.00
126.00		44.20	0.00
127.22		45.03	0.00

SECTION 4 - 4'

REV	DESCRIPTION	BY	APPVD	DATE
A	DESIGN LEVELS UPDATED		JFG	20-03-18

Candor3 ENGINEERING FOR LIFE

PROJECT

125 MURPHYS ROAD, FLAT BUSH
GEOTECHNICAL INVESTIGATION
FEB 2018 - LONG SECTION (SHEET 2 OF 4)

CLIENT

GREEN CITY
DEVELOPMENTS LIMITED

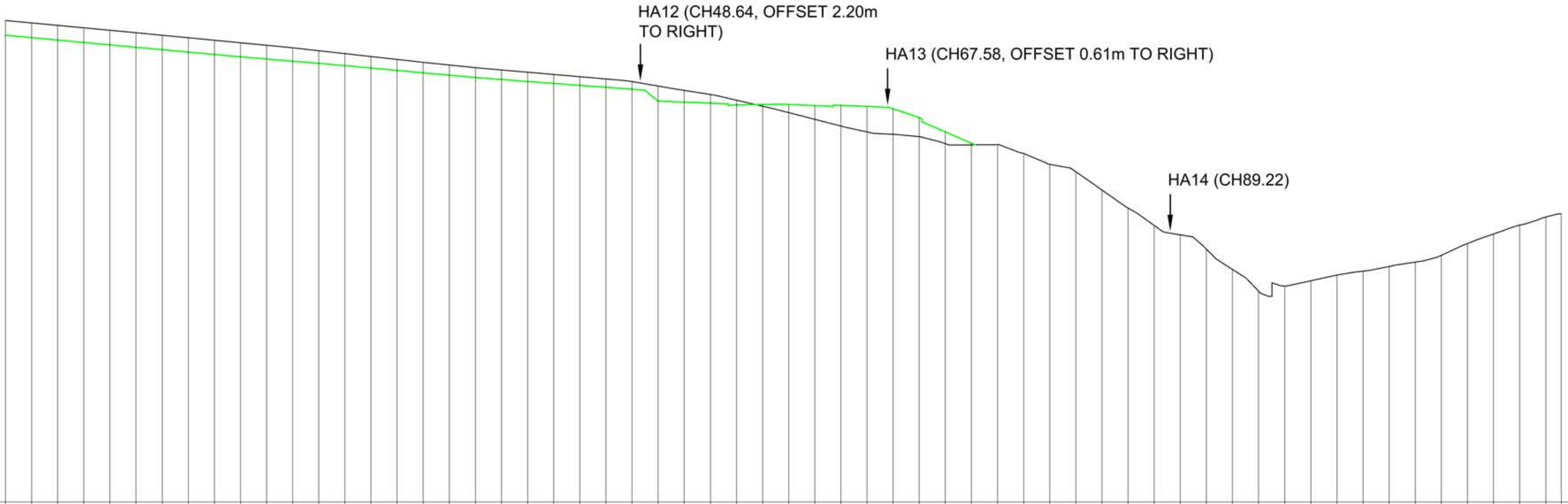
PURPOSE
FOR INFORMATION ONLY

DESIGN	AGT	APPROVED BY	JFG
DRAWN	RS	DATE	MAR 2018
CHECK	AVS		

SCALE 1:400 @ A3

PROJECT NO.	DRAWING NO.	REV.
1222s2	2-111	A

PRINT DATE: 21.03.2018 J:\PROJECTS\LAND DEVELOPMENT\1222 125 MURPHYS ROAD ISTAGE 2\\DRAWINGS\MISC DWGS\1222S2 GEOTECH INVESTIG FEB 2018 V2.DWG



DATUM RL = 23.00

CHAINAGE	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
DESIGN LEVELS	58.71	58.53	58.34	58.16	57.98	57.79	57.61	57.42	57.24	57.07	56.90	56.73	56.56
EXISTING LEVELS	59.84	59.66	59.47	59.28	59.09	58.91	58.72	58.52	58.33	58.14	57.95	57.75	57.53
CUT / FILL DEPTH	-1.13	-1.13	-1.13	-1.12	-1.12	-1.12	-1.11	-1.10	-1.09	-1.07	-1.05	-1.02	-0.97

CHAINAGE	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00	48.00	50.00
DESIGN LEVELS	56.39	56.21	56.02	55.84	55.66	55.48	55.33	55.17	55.03	54.88	54.73	54.59	53.68
EXISTING LEVELS	57.31	57.09	56.86	56.64	56.43	56.24	56.06	55.89	55.71	55.54	55.37	55.17	54.82
CUT / FILL DEPTH	-0.92	-0.88	-0.84	-0.80	-0.78	-0.76	-0.73	-0.71	-0.69	-0.66	-0.64	-0.58	-1.15

CHAINAGE	52.00	54.00	56.00	58.00	60.00	62.00	64.00	66.00	68.00	70.00	72.00	74.00	76.00
DESIGN LEVELS	53.60	53.52	53.38	53.41	53.41	53.33	53.35	53.27	53.09	52.41	51.32	50.45	
EXISTING LEVELS	54.50	54.18	53.75	53.28	52.79	52.28	51.77	51.32	51.13	50.95	50.42	50.32	50.34
CUT / FILL DEPTH	-0.90	-0.66	-0.37	0.13	0.62	1.05	1.59	1.95	1.95	1.46	0.90	0.12	0.00

CHAINAGE	78.00	80.00	82.00	84.00	86.00	88.00	90.00	92.00	94.00	96.00	98.00	100.00	102.00
DESIGN LEVELS													
EXISTING LEVELS	49.67	48.83	48.27	46.87	45.49	44.16	43.44	42.35	40.79	39.13	39.52	39.93	40.36
CUT / FILL DEPTH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CHAINAGE	104.00	106.00	108.00	110.00	112.00	114.00	116.00	118.00	119.17
DESIGN LEVELS									
EXISTING LEVELS	40.66	41.02	41.35	41.88	42.77	43.51	44.18	44.80	45.07
CUT / FILL DEPTH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SECTION 5 - 5'

REV	DESCRIPTION	BY	APPVD	DATE
A	DESIGN LEVELS UPDATED		JFG	20-03-18

Candor³ ENGINEERING FOR LIFE

PROJECT
125 MURPHYS ROAD, FLAT BUSH
GEOTECHNICAL INVESTIGATION
FEB 2018 - LONG SECTION (SHEET 3 OF 4)

CLIENT
GREEN CITY DEVELOPMENTS LIMITED

PURPOSE
FOR INFORMATION ONLY

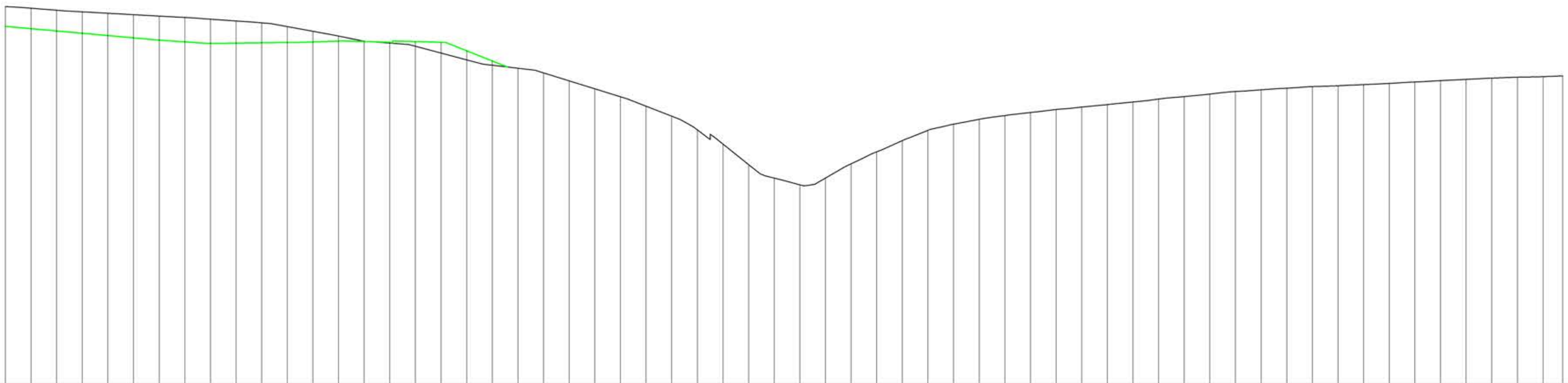
DESIGN AGT
DRAWN RS
CHECK AVS

APPROVED
BY JFG
DATE MAR 2018

SCALE
1:400 @ A3

PROJECT NO. 1222s2
DRAWING NO. 2-112
REV. A

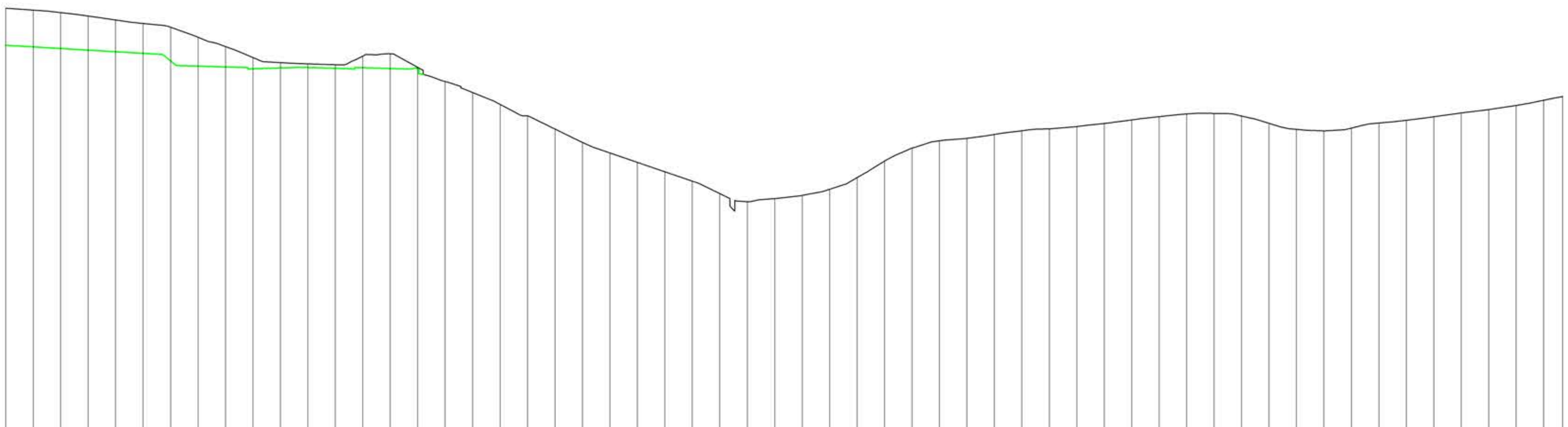
PRINT DATE: 21.03.2018 J:\PROJECTS\LAND DEVELOPMENT\1222 125 MURPHYS ROAD (STAGE 2)\DRAWINGS\MISC DWGS\1222S2 GEOTECH INVESTIG FEB 2018 V2.DWG



DATUM RL = 24.00

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	CUT / FILL DEPTH
0.00	51.82	53.37	-1.54
2.00	51.64	53.24	-1.59
4.00	51.47	53.08	-1.62
6.00	51.29	52.95	-1.67
8.00	51.11	52.84	-1.74
10.00	50.93	52.73	-1.80
12.00	50.75	52.62	-1.87
14.00	50.62	52.52	-1.90
16.00	50.49	52.38	-1.89
18.00	50.52	52.24	-1.73
20.00	50.55	52.10	-1.55
22.00	50.57	51.80	-1.23
24.00	50.61	51.44	-0.83
26.00	50.68	51.07	-0.39
28.00	50.64	50.67	-0.02
30.00	50.58	50.52	0.06
32.00	50.64	50.27	0.36
34.00	50.58	49.74	0.84
36.00	49.92	49.21	0.71
38.00	49.13	48.80	0.33
40.00		48.56	0.00
42.00		48.20	0.00
44.00		47.58	0.00
46.00		46.96	0.00
48.00		46.34	0.00
50.00		45.61	0.00
52.00		44.83	0.00
54.00		43.77	0.00
56.00		42.66	0.00
58.00		41.06	0.00
60.00		40.02	0.00
62.00		39.49	0.00
64.00		40.01	0.00
66.00		41.12	0.00
68.00		42.06	0.00
70.00		42.93	0.00
72.00		43.73	0.00
74.00		44.21	0.00
76.00		44.59	0.00
78.00		44.88	0.00
80.00		45.12	0.00
82.00		45.36	0.00
84.00		45.54	0.00
86.00		45.74	0.00
88.00		45.93	0.00
90.00		46.17	0.00
92.00		46.36	0.00
94.00		46.55	0.00
96.00		46.75	0.00
98.00		46.88	0.00
100.00		47.01	0.00
102.00		47.14	0.00
104.00		47.20	0.00
106.00		47.29	0.00
108.00		47.38	0.00
110.00		47.50	0.00
112.00		47.60	0.00
114.00		47.70	0.00
116.00		47.79	0.00
118.00		47.87	0.00
120.00		47.91	0.00
121.53		47.97	0.00

SECTION 6 - 6'



DATUM RL = 22.00

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	CUT / FILL DEPTH
0.00	50.00	52.69	-2.69
2.00	49.88	52.55	-2.67
4.00	49.76	52.37	-2.61
6.00	49.64	52.12	-2.48
8.00	49.53	51.84	-2.31
10.00	49.41	51.58	-2.17
12.00	48.87	51.31	-2.45
14.00	48.48	50.58	-2.10
16.00	48.42	49.90	-1.48
18.00	48.29	49.10	-0.81
20.00	48.35	48.74	-0.39
22.00	48.38	48.64	-0.26
24.00	48.32	48.58	-0.26
26.00	48.37	49.21	-0.84
28.00	48.31	49.38	-1.07
30.00	48.29	48.39	-0.10
32.00		47.36	0.00
34.00		46.56	0.00
36.00		45.70	0.00
38.00		44.86	0.00
40.00		43.90	0.00
42.00		42.93	0.00
44.00		42.16	0.00
46.00		41.48	0.00
48.00		40.79	0.00
50.00		40.11	0.00
52.00		39.21	0.00
54.00		38.62	0.00
56.00		38.85	0.00
58.00		39.08	0.00
60.00		39.52	0.00
62.00		40.37	0.00
64.00		41.57	0.00
66.00		42.52	0.00
68.00		43.05	0.00
70.00		43.23	0.00
72.00		43.51	0.00
74.00		43.78	0.00
76.00		43.92	0.00
78.00		44.09	0.00
80.00		44.31	0.00
82.00		44.57	0.00
84.00		44.80	0.00
86.00		45.00	0.00
88.00		45.04	0.00
90.00		44.85	0.00
92.00		44.32	0.00
94.00		43.88	0.00
96.00		43.77	0.00
98.00		43.97	0.00
100.00		44.34	0.00
102.00		44.54	0.00
104.00		44.80	0.00
106.00		45.07	0.00
108.00		45.32	0.00
110.00		45.62	0.00
112.00		46.00	0.00
113.39		46.27	0.00

SECTION 7 - 7'

REV	DESCRIPTION	BY	APPVD	DATE
A	DESIGN LEVELS UPDATED		JFG	20-03-18

Candor³ ENGINEERING FOR LIFE

PROJECT
125 MURPHYS ROAD, FLAT BUSH
GEOTECHNICAL INVESTIGATION
FEB 2018 - LONG SECTION (SHEET 4 OF 4)

CLIENT
GREEN CITY DEVELOPMENTS LIMITED

PURPOSE
FOR INFORMATION ONLY

DESIGN AGT
DRAWN RS
CHECK AVS

APPROVED
BY JFG
DATE MAR 2018

SCALE
1:400 @ A3

PROJECT NO. 1222s2
DRAWING NO. 2-113
REV. A

Appendix 2

Lander Geotechnical Consultants Limited
Drawings

Legend and/or Notes:

Indicative area of geogrid reinforced shear key (2m depth, 8m width and approximately 40m length). It will require undercut and benching into identified competent materials, placement of underfill drainage network. Undercut to be backfilled with engineer certified fill with 4m width Tensar RE520 geogrid at 0.5m vertical spacings reinforcing.

20m spacings of collector drain trenched to outlet

Counterfort Drain (4m depth, 12m Spacings) & trenched to outlet

Toe keys are required subject to further geotechnical investigations during earthworks operations

LEGEND

- EXISTING BOUNDARIES
- FUTURE BOUNDARIES
- EXISTING CONTOURS (1.0m)
- EXTENT OF EARTHWORKS
- TRANSPOWER OVERHEAD LINES
- 12m EARTHWORKS EXCLUSION ZONE UNTIL OVERHEAD LINES AND PYLONS ARE REMOVED

GEOTECHNICAL INVESTIGATION

- HA23 HAND AUGER
- MH2 DRILLED BOREHOLE
- TP1 TEST PIT

revision	description	drawn	approved	date

0 30.0 60.0 90.0
Horizontal Scale (metres)
0 30.0 60.0 90.0
Vertical Scale (metres)

drawn	AB
approved	MPC
date	05.04.18
scale	1:1500
original size	A3

LANDER geotechnical

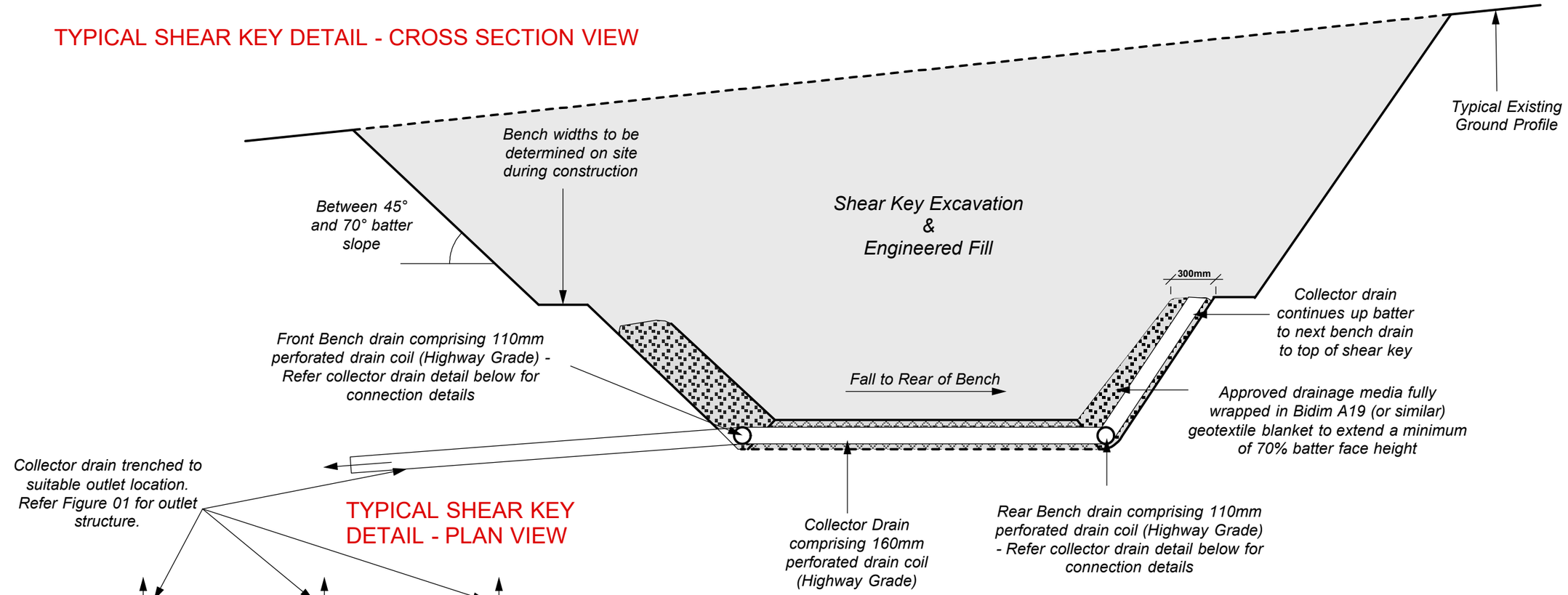
client: GREEN CITY DEVELOPMENTS LIMITED

project: 125 MURPHYS ROAD (STAGE 2), FLAT BUSH

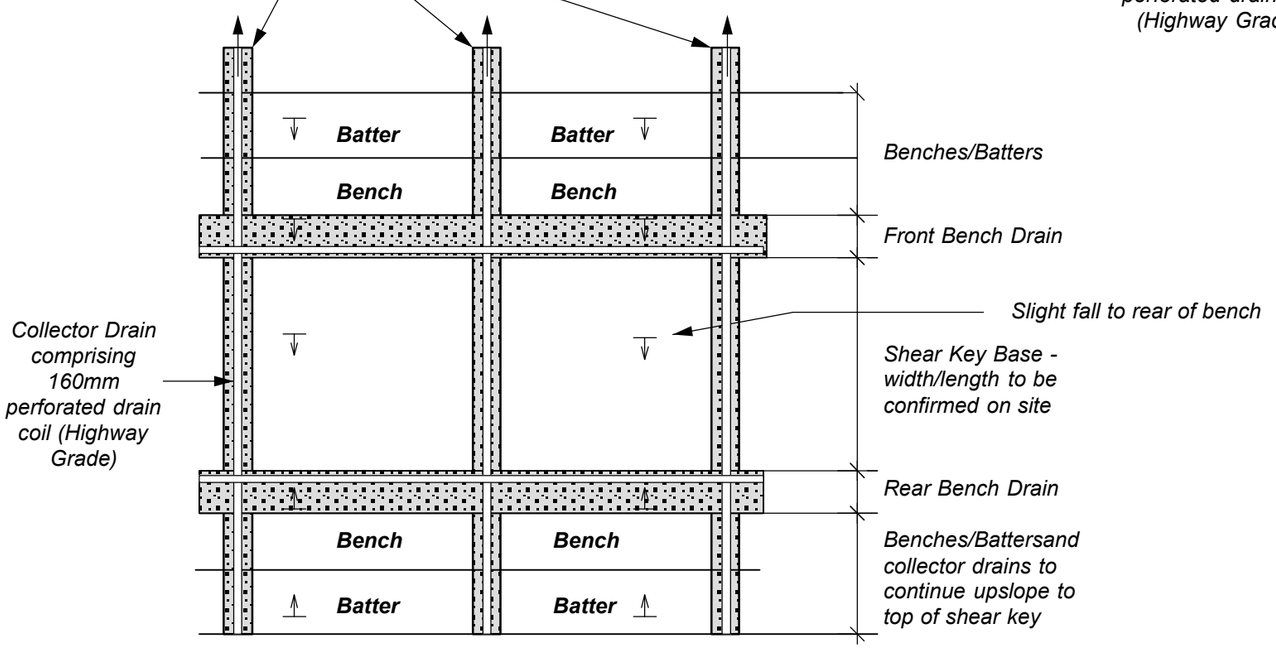
title: GEOTECHNICAL ENGINEERING PLAN

project no: J 00862 figure no: 01

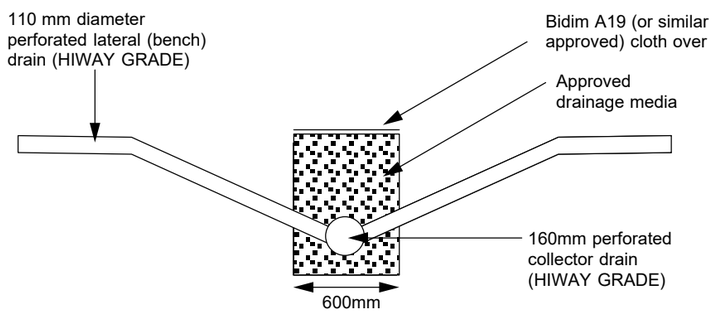
TYPICAL SHEAR KEY DETAIL - CROSS SECTION VIEW



TYPICAL SHEAR KEY DETAIL - PLAN VIEW



TYPICAL SHEAR KEY COLLECTOR DRAIN CONNECTION DETAIL - END VIEW



Positive coupling to connect all drainage pipes

revision	description	drawn	approved	date

drawn	AB
approved	MPC
date	05.04.18
scale	NTS
original size	A3

LANDER geotechnical

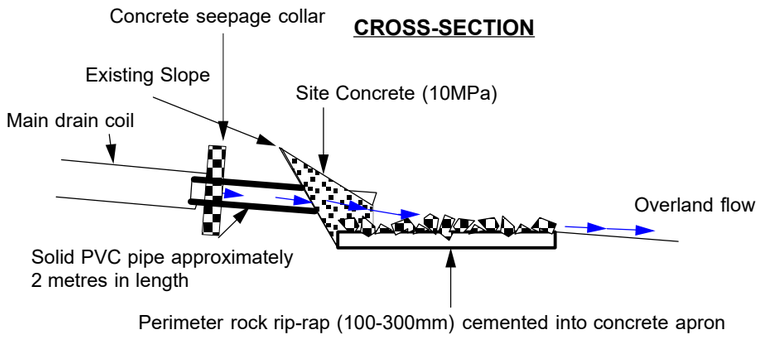
client: GREEN CITY DEVELOPMENTS LIMITED

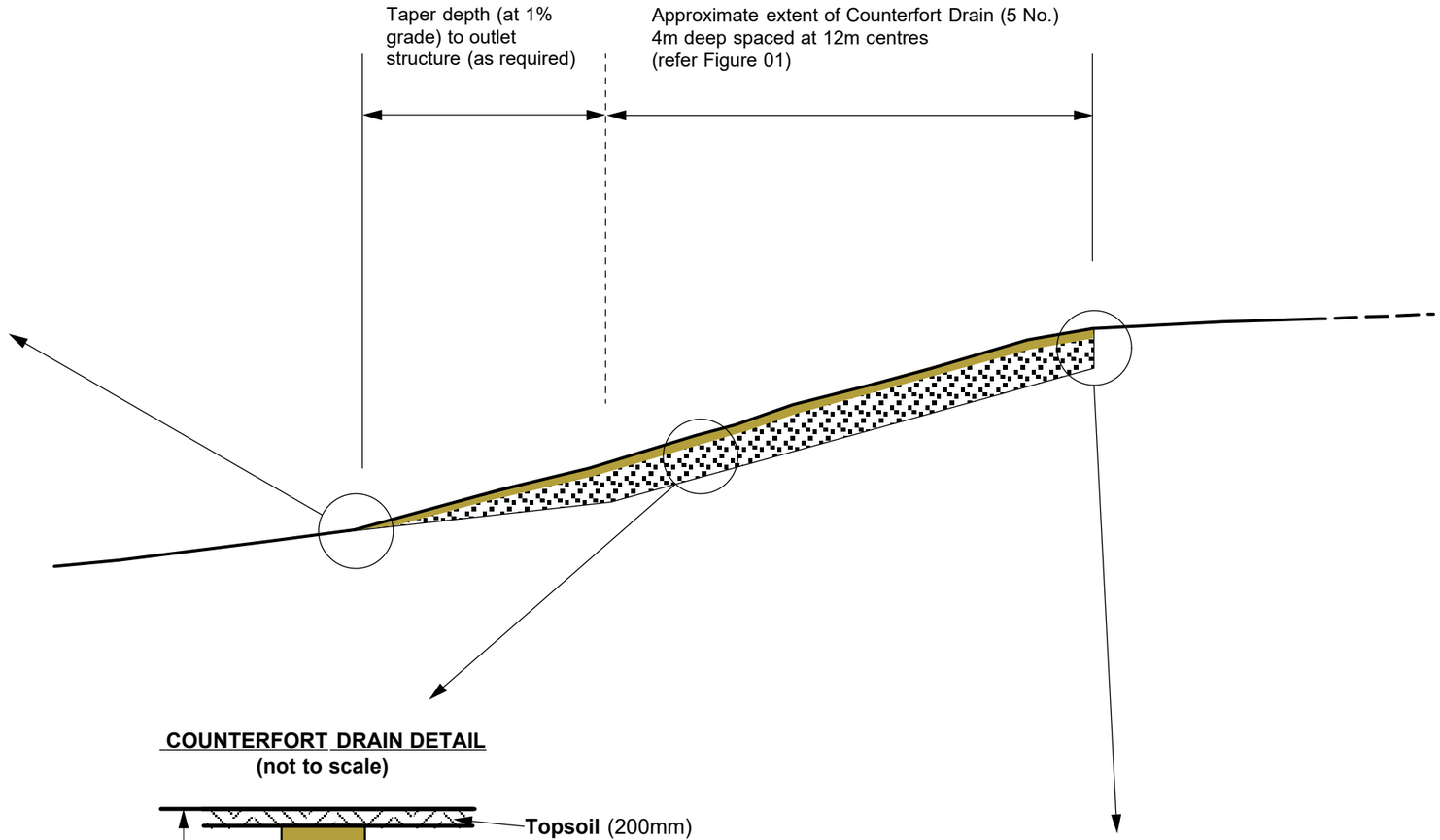
project: 125 MURPHYS ROAD (STAGE 2), FLAT BUSH

title: TYPICAL SHEAR KEY DETAIL

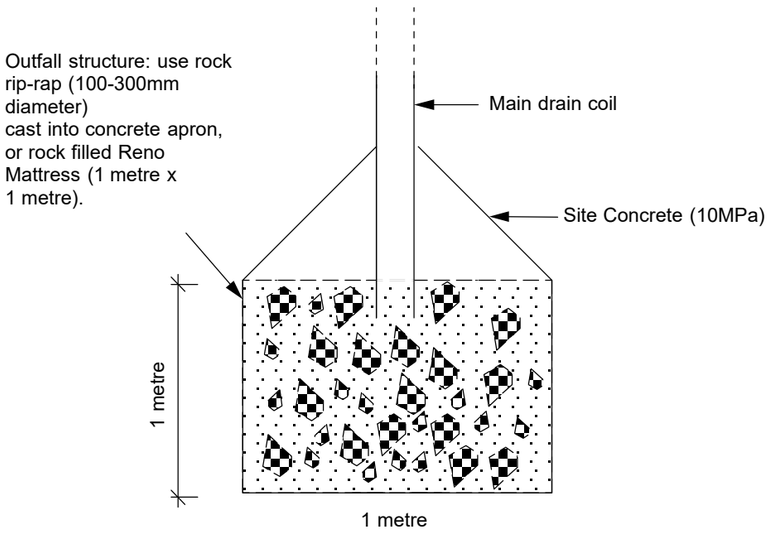
project no: J00862 | figure no: 02

SCHEMATIC DETAILS OF COUNTERFORT DRAIN OUTFALL STRUCTURE
(not to scale)

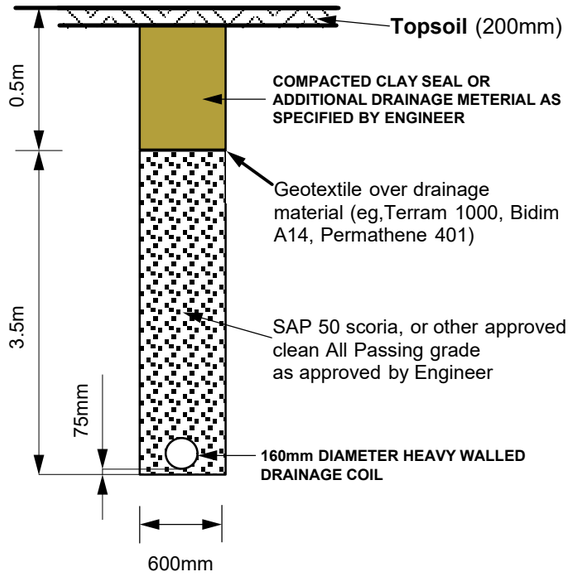


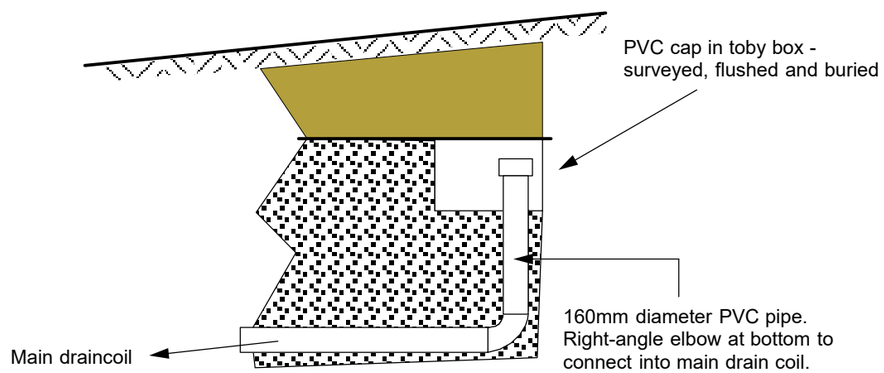


PLAN VIEW



COUNTERFORT DRAIN DETAIL
(not to scale)





TYPICAL FLUSHING PORT DETAILS
(not to scale)

revision	description	drawn	approved	date

drawn	AB
approved	MPC
date	05.04.18
scale	NTS
original size	A3

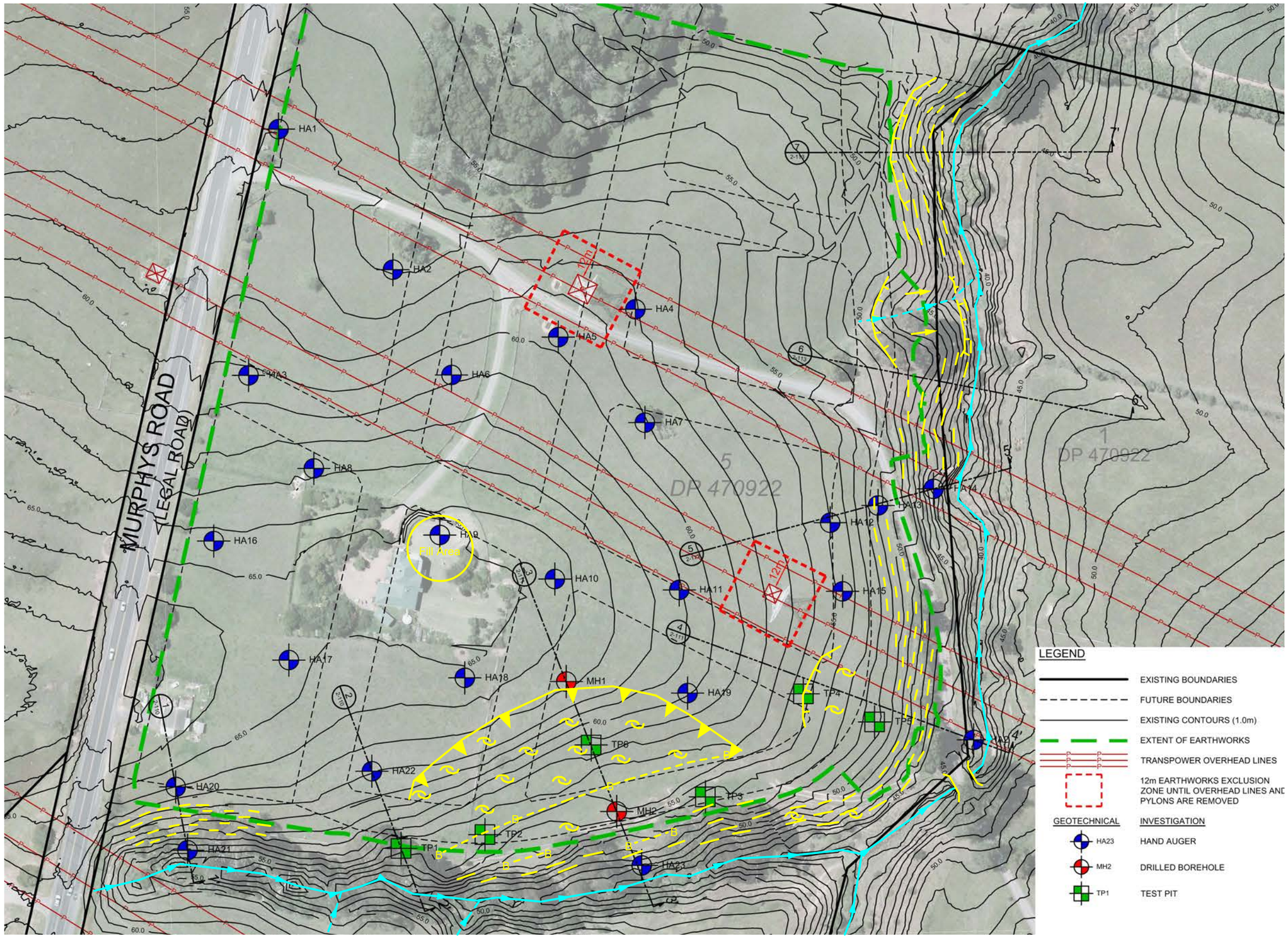
LANDER geotechnical

client: GREEN CITY DEVELOPMENTS LIMITED

project: 125 MURPHYS ROAD (STAGE 2), FLAT BUSH

title: COUNTERFORT DRAIN DETAIL

project no: J00862 | figure no: 03



Legend and/or Notes:

- Primary Head Scarp
- Secondary Head Scarp
- Debris Lobe
- Hummocky Ground
- Soil Creep
- Overland Flow Path

BASE PLAN SOURCE:
CANDOR3 LIMITED,
REFERENCE: 1222S2,
DRAWING NUMBER: 2-100,
DATED MARCH 2018

revision	description	drawn	approved	date

0 30.0 60.0 90.0
Horizontal Scale (metres)
0 30.0 60.0 90.0
Vertical Scale (metres)

drawn	JL
approved	MPC
date	06.04.18
scale	1:1500
original size	A3

LANDER geotechnical

client: **GREEN CITY DEVELOPMENTS LIMITED**

project: **125 MURPHYS ROAD (STAGE 2), FLAT BUSH**

title: **GEOMORPHIC MAP**

project no: **J00862** figure no: **04**

Template revision: 1:1000 (10/12/14)

Appendix 3

Laboratory Test Results

East Tamaki Laboratory

Coffey Services (NZ) Limited

144A Cryers Road, East Tamaki NZ 2013
PO Box 58877, Botany, Manukau NZ 2163

Phone: +64 9 272 3375
Fax: +64 9 272 3378

Report No: CLAS:ETAM18S-02052
Issue No:1
This report replaces all previous issues of Report No. CLAS:ETAM18S-02052

Atterberg Classification Test Report

Client:	Lander Geotechnical Consultants Limited PO Box 97385 Manukau City 2241
Principal:	Matt Charlesworth
Project No.:	773-ETAM00619AA
Project Name:	J00862 - 125 Murphys Road

Tests indicated as not accredited are outside the scope of the laboratory's accreditation.

{This document may not be altered or reproduced except in full. This report relates only to the positions tested.}

Approved Signatory: James McKelvey
Senior Technician
IANZ Accredited Laboratory Number: 105
Date of Issue: 12/03/2018

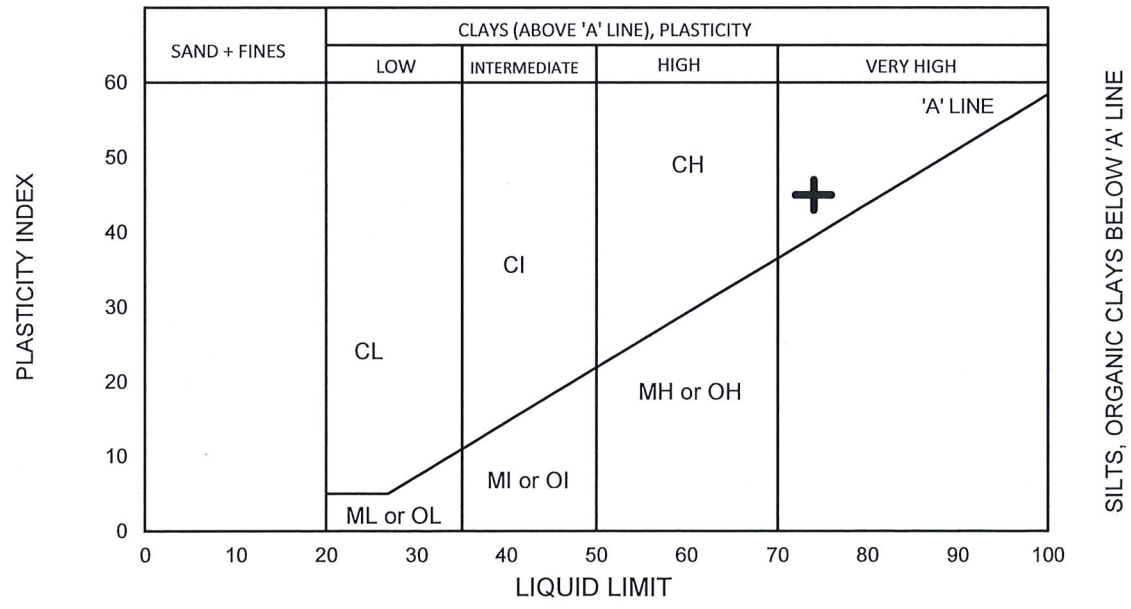
Sample Details

Sample Number:	ETAM18S-02052	**Date Sampled:**	12/02/2018
Project Location:	125 Murphys Road, Flat Bush	**Date Tested:**	09/03/2018
Sample Location:	HA5, 0.5 - 1.0 m	**Tested by:**	James McKelvey
Laboratory test Procedures:	*Atterberg Limits [NZS 4402 Test 2.2, 2.3, 2.4, 2.6], Moisture Content [NZS 4402:1986 Test 2.1]*		
Sampling Method:	*Unknown (Not IANZ Endorsed)*		

Laboratory Data

Liquid Limit	**74**	**Sample History:**	Natural state
Plastic Limit:	**29**	**Fraction Tested:**	Passing 425µm sieve
Plasticity Index:	**45**	**Material Description:**	Disturbed Soil
Linear Shrinkage:	**14**		
#Liquidity Index (w-PL)/PI	**0.0**	**Moisture Content (%)**	29.5

CASAGRANDE PLASTICITY CHART



Comments:

Form Number: R027A Issue Date: 19/09/2017

East Tamaki Laboratory

Coffey Services (NZ) Limited

144A Cryers Road, East Tamaki NZ 2013
PO Box 58877, Botany, Manukau NZ 2163

Phone: +64 9 272 3375
Fax: +64 9 272 3378

Report No: CLAS:ETAM18S-02051
Issue No:1
This report replaces all previous issues of Report No. CLAS:ETAM18S-02051

Atterberg Classification Test Report

Client:	Lander Geotechnical Consultants Limited PO Box 97385 Manukau City 2241
Principal:	Matt Charlesworth
Project No.:	773-ETAM00619AA
Project Name:	J00862 - 125 Murphys Road

Tests indicated as not accredited are outside the scope of the laboratory's accreditation.

{This document may not be altered or reproduced except in full. This report relates only to the positions tested.}

Approved Signatory: James McKelvey
Senior Technician
IANZ Accredited Laboratory Number: 105
Date of Issue: 12/03/2018

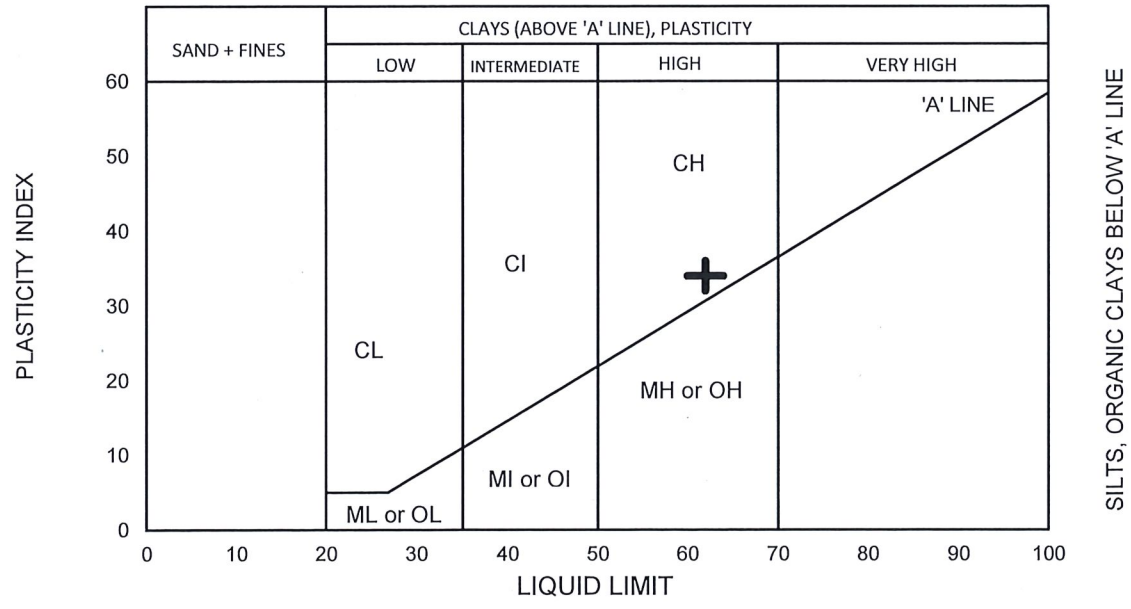
Sample Details

Sample Number:	ETAM18S-02051	**Date Sampled:**	12/02/2018
Project Location:	125 Murphys Road, Flat Bush	**Date Tested:**	02/03/2018
Sample Location:	HA15, 0.5 - 1.0 m	**Tested by:**	Fred Perese
Laboratory test Procedures:	*Atterberg Limits [NZS 4402 Test 2.2, 2.3, 2.4, 2.6], Moisture Content [NZS 4402:1986 Test 2.1]*		
Sampling Method:	*Unknown (Not IANZ Endorsed)*		

Laboratory Data

Liquid Limit	**62**	**Sample History:**	Natural state
Plastic Limit:	**28**	**Fraction Tested:**	Passing 425µm sieve
Plasticity Index:	**34**	**Material Description:**	Disturbed Soil
Linear Shrinkage:	**15**		
#Liquidity Index (w-PL)/PI	**-0.1**	**Moisture Content (%)**	25.8

CASAGRANDE PLASTICITY CHART



Comments:

Form Number: R027A Issue Date: 19/09/2017

East Tamaki Laboratory

Coffey Services (NZ) Limited

144A Cryers Road, East Tamaki NZ 2013
PO Box 58877, Botany, Manukau NZ 2163

Phone: +64 9 272 3375
Fax: +64 9 272 3378

Report No: CLAS:ETAM18S-02050
Issue No:1
This report replaces all previous issues of Report No. CLAS:ETAM18S-02050

Atterberg Classification Test Report

Client:	Lander Geotechnical Consultants Limited PO Box 97385 Manukau City 2241
Principal:	Matt Charlesworth
Project No.:	773-ETAM00619AA
Project Name:	J00862 - 125 Murphys Road

Tests indicated as not accredited are outside the scope of the laboratory's accreditation.

Approved Signatory: James McKelvey
Senior Technician
IANZ Accredited Laboratory Number: 105
Date of Issue: 12/03/2018

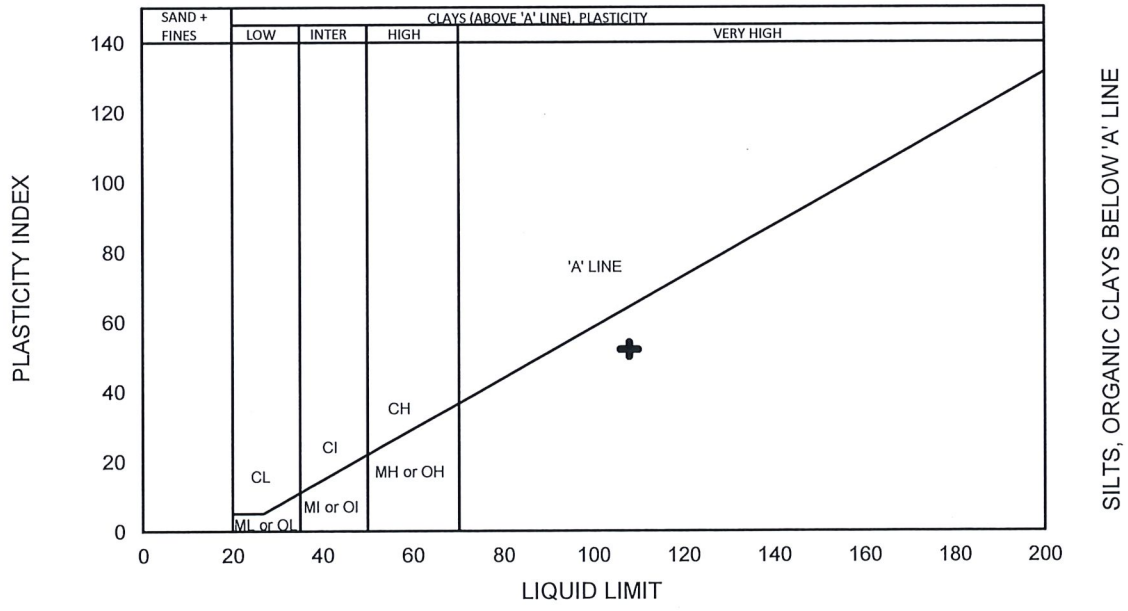
Sample Details

Sample Number:	ETAM18S-02050	**Date Sampled:**	12/02/2018
Project Location:	125 Murphys Road, Flat Bush	**Date Tested:**	03/03/2018
Sample Location:	HA17, 0.5 - 1.0 m	**Tested by:**	Fred Perese
Laboratory test Procedures:	*Atterberg Limits [NZS 4402 Test 2.2, 2.3, 2.4, 2.6], Moisture Content [NZS 4402:1986 Test 2.1]*		
Sampling Method:	*Unknown (Not IANZ Endorsed)*		

Laboratory Data

Liquid Limit	**108**	**Sample History:**	Natural state
Plastic Limit:	**56**	**Fraction Tested:**	Passing 425µm sieve
Plasticity Index:	**52**	**Material Description:**	Disturbed Soil
Linear Shrinkage:	**27**		
#Liquidity Index (w-PL)/PI	**0.0**	**Moisture Content (%)**	56.5

CASAGRANDE PLASTICITY CHART



Comments:

Form Number: R027A Issue Date: 19/09/2017