26 February 2025

Milldale Temporary Wastewater Treatment Facility

Milldale Development

GEOTECHNICAL INVESTIGATION REPORT

Fulton Hogan Land Development Limited

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A	29 November 2024	Initial draft for internal review
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STATEMENT OF QUALIFICATIONS AND EXPERIENCE

Jenna Pallarca

I am a Geotechnical Engineer at CMW Geotechnical NZ Limited, trading as CMW Geosciences. CMW Geosciences is a specialist geotechnical engineering and geological services consultancy with offices in New Zealand and Australia. I have been employed at CMW Geosciences since January 2024.

I hold the qualifications of MS in Civil Engineering from the University of Santo Tomas (Manila), which I completed in 2019.

I have 10 years of professional experience in geotechnical engineering in the Philippines and Auckland region. My experience has been primarily in land development, infrastructure, and landslide mitigation, and for the last year have been focused in the North Auckland area.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Gaurav Mathur

I am a Principal Geotechnical Engineer at CMW Geotechnical NZ Limited, trading as CMW Geosciences. CMW Geosciences is a specialist geotechnical engineering and geological services consultancy with offices in New Zealand and Australia. I have been employed at CMW Geosciences since June 2024.

I hold the qualifications of Civil Engineer from Auckland University, which I completed in 2007, I am a MEngNZ member of the Engineering New Zealand.

With over 18 years of experience, I am a seasoned geotechnical engineer skilled in project management, design solutions, and team leadership. My background includes extensive work in infrastructure projects. My experience includes managing and participating in site investigations, instrumentation and monitoring, slopes and geotechnical hazard assessments, and slope stability design for major infrastructure projects.

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Chris Ritchie

I am a Principal Engineering Geologist at CMW Geotechnical NZ Limited, trading as CMW Geosciences. CMW Geosciences is a specialist geotechnical engineering and geological sciences services consultancy with offices in New Zealand and Australia. I have been employed at CMW Geosciences since July 2019.

I hold the qualifications of MSc (Engineering Geology) from The University of Auckland, which I completed in 2010. I am a Chartered Professional Engineering Geologist and Chartered Member of Engineering New Zealand.

I have 15 years of professional experience in engineering geology and geotechnical engineering in the Auckland region. My experience has been primarily in land and building development and linear infrastructure, the last 12 years has been focussed in the North Auckland area. Large portions of my work in this time have been focussed on development of land and the investigation and assessment of roading corridors in Northland Allochthon terrain.

I confirm that, in my capacity as CMW's internal reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

1.0 INTRODUCTION

CMW Geosciences (CMW) was engaged by Fulton Hogan Land Development Limited to carry out geotechnical investigation and assessment of a site located north of Milldale Development (Stage 8), which is being considered for the construction of a temporary wastewater treatment facility.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced AKL2024-0185AA, Rev 0 dated 6 September 2024.

This report has been prepared in support of the application by Fulton Hogan Land Development (FHLD) for a resource consent to the Environmental Protection Authority (EPA) under the Fast-Track Approvals Act 2024 (FTAA).

Resource consent is required for the construction and operation of a Wastewater Treatment Plant (WWTP) involving earthworks, wastewater discharges and vegetation removal.

The purpose of this report is to describe the investigation completed, the ground conditions encountered, identify and quantify geotechnical risks to the development and to provide recommendations with respect to geotechnical aspects of the proposed development including site preparation, earthworks, foundation and long-term settlements.

2.0 SITE DETAILS

The Wastewater Treatment Plan site (the Site) is located within Lot 4 DP 353309 which has a total area of 10.45 ha. The Site is on the northern side of Lysnar Road, Wainui and is located directly adjacent to the Milldale development and just outside the Wainui Precinct.

The parent site is characterised by undeveloped rural land that has historically been used for farming. The topography of the parent site generally slopes from north-west to south-east and has two stands of poplar trees. There is an unnamed tributary of the Waterloo stream that bisects the southern portion of the site.

The area subject to the works and enhancement planting covers a total land area of approximately 1.21 ha and has been positioned in the southern corner of the parent site, directly adjacent to Lysnar Road as illustrated in Figure 3.1. The works site is generally flat and has been utilised as a construction compound supporting the delivery of ongoing delivery of the Milldale development.

A full description of the Site and surrounds is provided in the application AEE.

3.0 PROPOSED DEVELOPMENT

FHLD is seeking approval to authorise the construction and operation of a Wastewater Treatment Plant (WWTP) on Lysnar Road, Wainui. The key elements of the proposal include:

- Site compound;
- Wastewater Treatment Plant;
- Site Establishment;
- Ownership & Operation; and
- Duration & Disestablishment.

A full description of the project is provided in the application AEE.

At the time of undertaking this investigation, detailed design of the plant including location of structures was ongoing and it was anticipated that the geotechnical investigation would inform the designers of potential geotechnical concerns that may influence the plant layout.

Brief details for the development are as follows:

- Consent drawings prepared by Woods (Reference: P24-189-2000-RD-WWTP Rev 1 dated February 2025) shows the indicative location of the proposed treatment plant and artificial wetland.
- The treatment plant would comprise a building and several liquid containing tanks. As of writing this report, detailed design is ongoing by others; as such, details of proposed structures have yet to be provided to CMW.
- The proposed structures are to be located outside of the 20 m offset from watercourse and wetland.

FACTUAL

Figure 3.1: Site Location Plan (Reference Auckland Council GeoMaps)

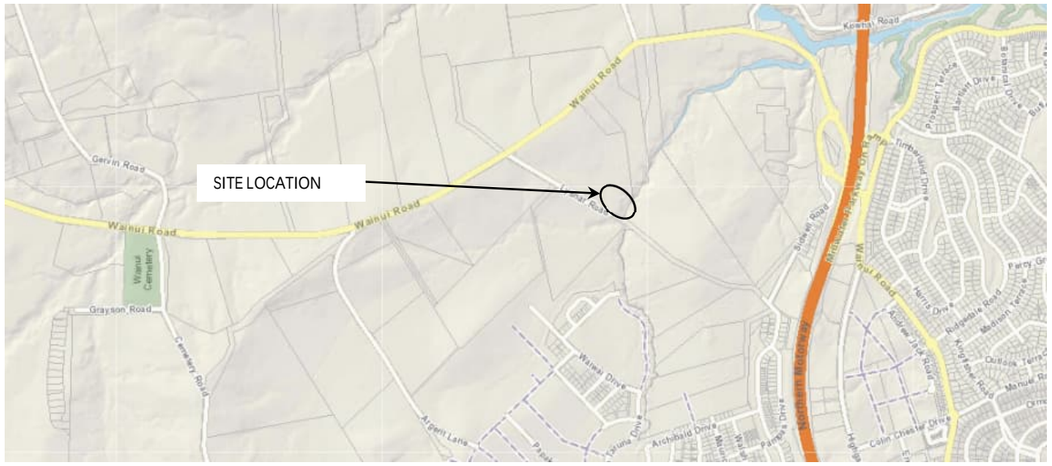
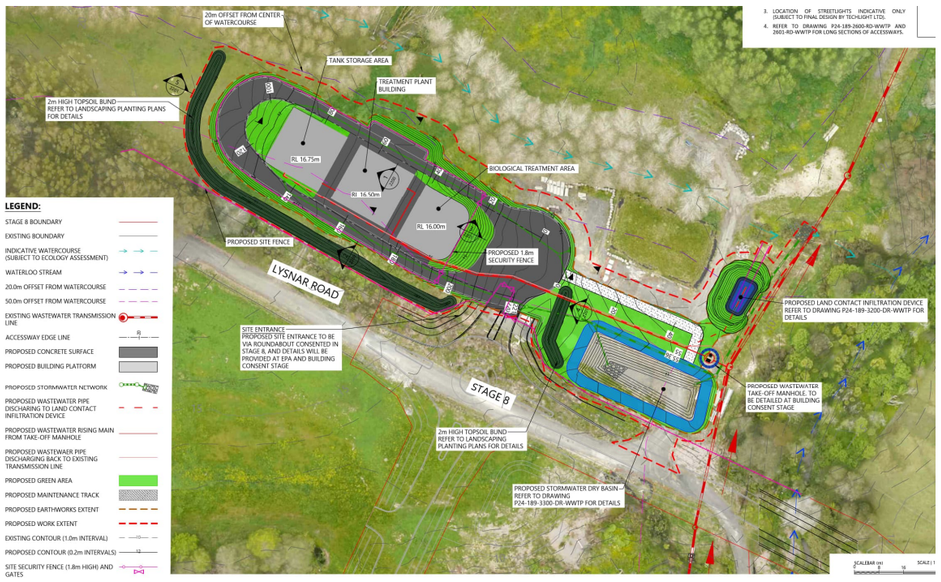


Figure 3.2: Overall Proposed Site Plan (Reference Woods P24-189-2000-RD-WWTP)



4.0 DESKTOP STUDY

4.1 Related Documents

The following documents were reviewed during preparation of this report:

- CMW Geosciences Geotechnical Investigation Report for Milldale Stage 8, Endsley Rise, Wainui, Ref AKL2022-0029AE Rev.3, 4 September 2024.
- Woods Overall Site Plan for Milldale Wastewater Treatment Plant, Ref P24-189-2000-EW-WWTP Rev 1 29 November 2024.

4.2 Site History

Historic aerial photographs were reviewed from the website Retrolens, Auckland Council GeoMaps and Google Earth.

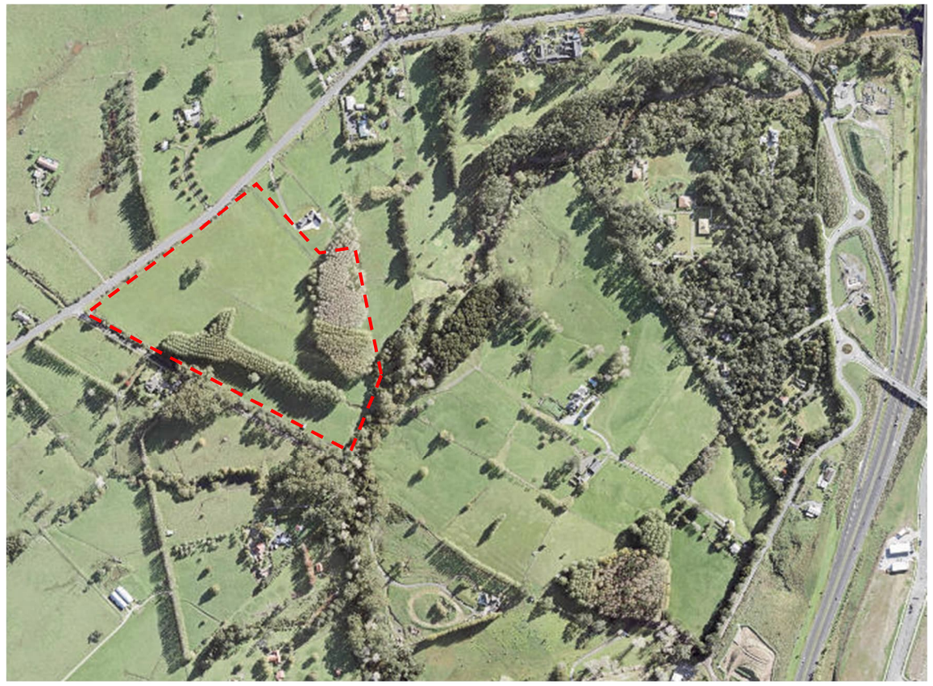
Changes are summarised below and depicted in *Figure 4.1* to *Figure 4.4*:

- The site has been used as farmland since the earliest available photographs were taken in 1940 (*Figure 4.1* and *Figure 4.2*).
- No development has been observed on the proposed plant location based on available photographs up to 2017. It is noted that two areas of wetland have been built within the property (*Figure 4.3*).
- Sometime in 2022, the eastern portion of the site near Waterloo Creek has been filled with hardfill to be used as laydown area for Milldale construction (*Figure 4.4*).

Figure 4.1: Aerial Photograph from April 1940 (Retrolens)

Figure 4.2: Aerial Photograph from March 1988 (Retrolens)

Figure 4.3: Aerial Photograph from 2017 (GeoMaps)



FACTUAL

Figure 4.4: Aerial Photograph from February 2022 (Google Earth)

5.0 INVESTIGATION

5.1 Previous Investigations

Existing field data from previous reporting for this and adjacent sites by CMW was reviewed in the preparation of this report. This data comprised:

- CMW Machine Borehole MH07-18, MH01-20 (Wainui to Lysnar Road) and MH04-23 (Waterloo Creek)
- CMW Hand Augers HA19 and 20-20 (Milldale Stage 7 Wastewater Investigation)
- CMW Cone Penetrometer Test CPT02-23 (Waterloo Creek)

The approximate locations of the respective investigation sites referred to above are shown on the Site Investigation Plan as *Drawing 01*.

5.2 Field Investigation

Following a dial before you dig search, the field investigation was carried out in October 2024. The scope of fieldwork completed is shown below:

Table 5.1: Investigation Summary

Test ID	Test Type	Ground Surface Elevation (RL m)	Depth (m)
HA01-24	Hand Auger	18.1	5.0
HA02-24		17.9	2.5
HA03-24		17.6	5.0
HA04-24		17.0	5.0
HA05-24		16.9	5.0
HA06-24		12.1	5.0

Engineering logs of the relevant investigations are presented in *Appendix C*.

The approximate locations of the respective investigation sites referred to above are shown on the Geotechnical Investigation Plan as *Drawing 01*.

5.3 Groundwater

During the investigation, completed in spring, groundwater was encountered in boreholes HA04 to HA06-24 at depths ranging from 2.5 to 3.0 m below existing ground levels.

Groundwater level measurement was also taken from a piezometer previously installed in MH04-23 at 2.0 m below existing ground level.

6.0 GEOLOGY

6.1 Published Geology

Published geological maps[1] for the area depict the regional geology as comprising Mangakahia Complex (Kk) of the Northland Allochthon as illustrated in Figure 6.1. These strata are part of an allochthonous (meaning removed from its formation location) mass of continental crust that was peeled from the subduction zone north of New Zealand and emplaced through low angle thrust faulting onto areas of Northland and the Silverdale area. Due to the nature of emplacement, materials are typically highly fractured or even shattered and variably weathered.

Hukerenui Mudstone (Kkh, a unit of the Mangakahia Complex) is mapped to the west in the areas of higher elevation. This unit typically comprises deeply weathered clays in green, black, brown and purple.

The low-lying areas around Waterloo Creek, its tributaries and the broad valley in the northern portion of Argent Lane are mapped as Tauranga Group Alluvium/ Colluvium (IQa). These are Pleistocene-aged clays and silts and include swamp and colluvium deposits.

The main geohazards associated with these geological units are presented below:

Table 6.1: Published Geology Summary

Geological Unit	Location	Behaviour	Principal Potential Geohazards
Hukerenui Mudstone (part of the Mangakahia Complex of the Northland Allochthon)	Slopes and elevated portions of site toward the west	Typically weathers to low shear-strength, high plasticity clays which are prone to debris sliding and deep-seated creep, even on gentle (<10°) slopes.	Slope Instability / Landslide

[1] Edbrooke, S. W. (compiler) 2001: Geology of the Auckland area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 3. 1 sheet +74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences.

Geological Unit	Location	Behaviour	Principal Potential Geohazards
Tauranga Group Alluvium / Colluvium	Mapped in low-lying areas around streams	Unconsolidated peats and clays will usually subside if unsupported or overloaded. Susceptible to soil creep and shallow flows on gentle slopes, particularly when saturated.	Load-induced settlement Liquefaction (if sandy lenses are present)

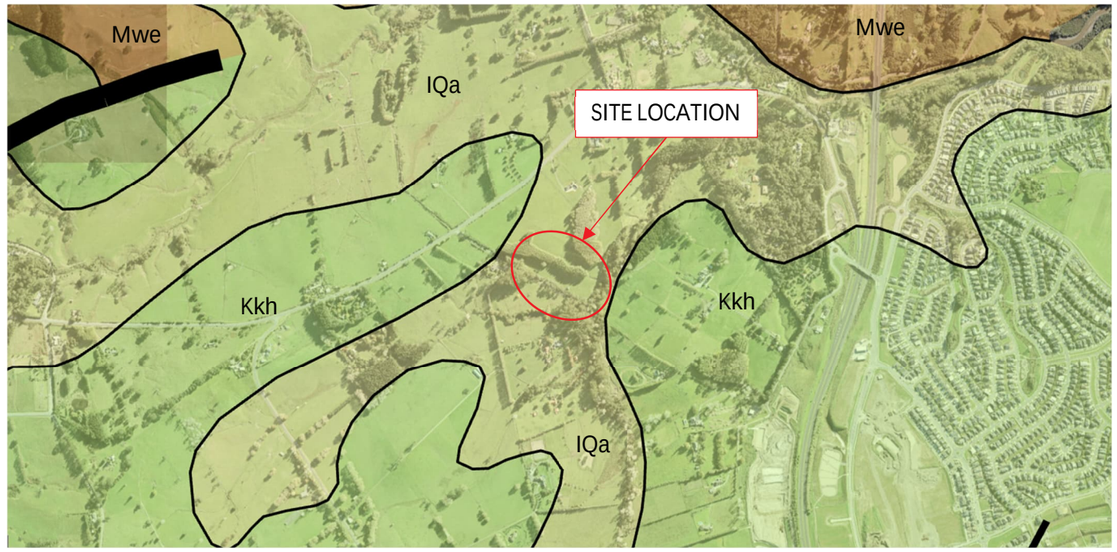
6.2 Geomorphology

Geomorphology of the site was mapped during a site walkover and in conjunction with examination of aerial photographs, digital elevation models, and hill-shades.

Key notes for this site include:

- Gentle slopes averaging 5 degrees.
- The site contains overland flow paths flowing northwest to southeast into Waterloo Creek. The overland flow paths in the lower slopes contain areas of swampy ground.
- The gentle slopes are vegetated with short grass, whereas the portion near the creek has been filled with hardfill.
- An existing wetland area is located north of the proposed location of the wastewater treatment plant.

Figure 6.1: Regional Geology (GNS Science Web Geology Map[2])



7.0 GROUND MODEL

7.1 Stratigraphic Units

Our assessment of the distribution of the stratigraphic layers is illustrated on the appended Geological Section A (*Drawing 02*) and presented below.

Table 7.1: Ground Model

Geological Unit	Description
Topsoil/Fill	Topsoil layer encountered in natural ground at elevated areas up to 0.2 m thick. Topsoil typically described as dark brown organic SILT. Hardfill layer encountered at the recently constructed laydown area. Hardfill found up to 1 m thick. The layer comprises well-compacted coarse to cobble sized hardfill.
Middle Pleistocene to Late Pleistocene Alluvium	Encountered in lower lying areas of the eastern side of the facility (adjacent to Waterloo Creek). Alluvium found extending to 12.5 m on MH01-20. Alluvium typically described as a light grey mottled yellow and dark brown Silty CLAY and Clayey SILT.
Hukerenui Mudstone (Northland Allochton) Residual Soil	Encountered in all boreholes except HA07-24 to depths up to 5.0 m below ground level. Typically described as yellowish brown to grey clays and silty clays, firm to very stiff, moist and highly plastic.
Hukerenui Mudstone (Northland Allochton) Transitional Zone	Encountered below the residual Hukerenui soils to depths until refusal of investigations. Typically described as very stiff to hard, highly plastic clays, may be dark grey, brown, red, green or purple. May be intermixed with Undifferentiated Mangakahia Complex in a Melange.
Hukerenui Mudstone (Northland Allochton) Parent Rock	Inferred below transitional Hukerenui Mudstone. Not encountered in our investigations. Hard, highly plastic clays in dark grey, brown, red, green or purple. Frequently sheared surfaces within the clays. May be intermixed with Undifferentiated Mangakahia Complex in a Melange.

7.2 Recommended Geotechnical Parameters

Table 7.2: Geotechnical Design Parameters

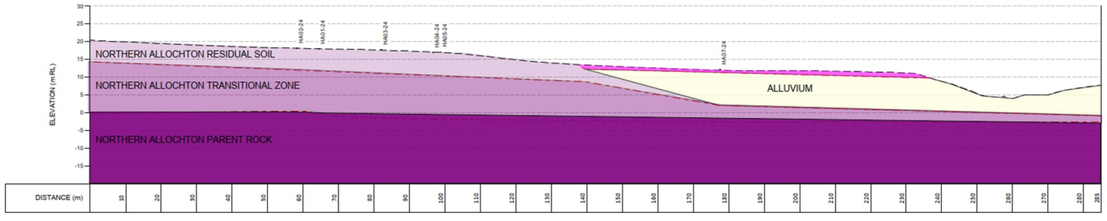
Unit Description	Typical Thickness (m)	Strength Range (kPa)	γ (kN/m3)	c´ (kPa)	Φ´ (deg)	Su (kPa)
Engineered Fill	1	100 – 200	17.5	8	28	100
Middle Pleistocene to Late Pleistocene Alluvium	10	35 – 145	18	5	26	50
Northland Allochthon - Hukerenui Residual Soils - Orange-brown to grey clays and silty clays which were firm to very stiff, moist and highly plastic.	6	89 – 200	17	5	28	60

[2] Edbrooke, S. W. (compiler) 2001: Geology of the Auckland area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 3. 1 sheet +74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences.

Unit Description	Typical Thickness (m)	Strength Range (kPa)	γ (kN/m3)	c´ (kPa)	ϕ´ (deg)	Su (kPa)
*Vane shear strengths range from isolated low values around 54kPa to 200kPa.						
Northland Allochthon - Hukerenui Transitional Zone - Grey, brown, red and green firm to very stiff, highly plastic clays, occasionally with fine gravel-sized angular inclusions of less weathered mudstone or siltstone. Sheared surfaces within the clays. *SPT N-values typically in the range of 20 to 40.	12	15 – 20 blows / mm	18	6	12	130
Northland Allochthon - Hukerenui Parent Rock - Grey, brown, red and green mudstone in the form of hard, highly plastic clays, occasionally with fine gravel-sized angular inclusions of less weathered mudstone or siltstone.		> 40 blows / mm	20.5	20	28	150
Sheared surfaces within the clays. Unable to be penetrated with a shear vane. *SPT N-values in excess of 40.						

Notes:
* Strata not encountered in HA01 to HA06
γ = soil unit weight (typical published values for similar soil types)
c´ = effective cohesion (conservative value determined from extensive laboratory testing and back analysis across the wider Milldale site)
ϕ´ = effective friction angle (conservative value determined from extensive laboratory testing and back analysis across the wider Milldale site)
Su = undrained shear strength (lower bound value determined from vane shear and laboratory testing)

Figure 7.1: Geological Section A



INTERPRETIVE

8.0 GEOHAZARDS ASSESSMENT

The table below is a summary of critical geohazards to this project and is based on information available to date.

Table 8.1: Geohazard Assessment Summary

Item	Geotechnical Hazard	Description	Area Affected	Assessment Outcome	Existing Risk of Damage to Land / Structures			Mitigation Measure	Residual Risk of Damage to Land / Structures		
					Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
1	Earthquake	Seismicity	Entire Site	Site subsoil class = Class C due to presence of shallow soils across the site ULS PGA = 0.19g	1	5	5	Not applicable	1	5	5
		Fault Rupture	Entire Site	Nearest active fault =Waikopua Fault, approximately 50km from the site. Recurrence interval unknown.	1	5	5	Not applicable	1	5	5
2	Slope Instability / Landslide	Global Instability	Entire Site	Due to the landform being generally gently sloping, slope instability is not anticipated.	1	5	5	Mitigation not required for global instability.	1	5	5
		Soil Creep	Entire Site	Soil creep anticipated within Northland Allochthon Residual Soils unit on slopes steeper than 1V:4H within upper 1 m of ground surface.	1	5	5	Limit cut slopes to 1V:5H in building platform. Specific design areas required on land adjacent to slopes steeper than 1V:5H (i.e. above the RE slopes).	1	4	4
		Cut / Fill Batter Stability	Entire Site	Refer to Global Instability.	1	5	5	Mitigation not required	1	4	4

Item	Geotechnical Hazard	Description	Area Affected	Assessment Outcome	Existing Risk of Damage to Land / Structures			Mitigation Measure	Residual Risk of Damage to Land / Structures		
					Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
		Stream bank instability and erosion	Slopes adjacent to Waterloo Creek on the western boundary of the site	Earthworks are set back at least 50m away from the creek, outside of erosion zone. Refer to Global Instability for risk assessment of fill embankment near creek edge.	1	5	5	Mitigation not required	1	5	5
3	Problematic Soils	Expansive Soils	Entire Site	Nearby Milldale stages have laboratory testing confirming AS2870:2011 expansive soil class between M-H.	4	5	20	Specific foundation design to be undertaken by structural engineer in accordance with NZBC B1/AS1 for Site Class M based on Stage 5A laboratory testing.	1	5	5
		Uncontrolled Fill	Area under pre-existing laydown area	Due to the site having been previously worked for the construction of a laydown area, uncontrolled fill may be discovered during earthworks. This uncontrolled fill may be prone to load induced settlement and/or poor bearing capacity.	4	4	16	Uncontrolled fill is to be excavated and replaced or if suitable reworked.	1	4	4
4	Settlement	Compressible Soils	Entire Site	Impact on infrastructure within and adjacent to site considered as well as impact on structures. Outcomes as follows: Primary (t90) settlements of 40mm to 75mm and post-construction settlements of 25mm max. predicted. These are considered within threshold for the development and therefore remediation is not required.	2	5	10	Refer to *Appendix D* - Settlement Design Memo	1	5	5
		Bearing Capacity	Entire Site	Bearing capacity assessment shows preliminary geotechnical ultimate bearing capacity (GUBC) of 300kPa is available with corresponding settlements of 50mm anticipated over design life.	1	5	5	A preliminary geotechnical ultimate bearing capacity (GUBC) of 300kPa should be available for shallow strip and pad foundations constructed within both the natural cut ground and engineered fill areas, subject to the short axis of those footings measuring no greater than 2.5m in plan.	1	5	5
		Settlement Behind Retaining Wall – Boundary Effects	Not applicable	No retaining walls on boundaries proposed.	1	5	5	Mitigation not required	1	5	5
5	Erosion	Cut Batters	Entire Site	Cut batters unlikely to be subject to erosion if topsoiled and vegetated.	1	3	3	Maximum cut batter gradient of 1V:5H. Surface protection comprising geogrid recommended. Temporary batters to be cut no steeper than 1V:5H and exposed for no longer than 48 hours unsupported.	1	3	3
		Fill Batters	Entire Site	Fill batters at 1V:2H or less are likely to be subject to erosion without further mitigation.	4	4	16	Maximum fill batter gradient of 1V:3H in engineered fill. Surface protection comprising geoweb recommended for planted batter gradients of 1V:2H.	1	4	4

9.0 RECOMMENDATIONS

9.1 Earthworks

All earthwork activities must be carried out in general accordance with the requirements of NZS 4431:2022[3] and the requirements of the Auckland Council Infrastructure Development Code under the guidance of a Chartered Professional Geotechnical Engineer. In addition, a Geotechnical Works Specification is provided as *Appendix E*. Between them, these documents provide the requirements for site preparation, fill placement, subsoil drainage, compaction requirements, quality assurance observations and testing and as-built requirements.

A summary of the key project specific construction risks, as presented in the Project Risk Register in Section 5, are as follows:

Table 9.1: Key Construction Risks

Item	Mitigation Measures
Subgrade Preparation	Topsoil needs to be stripped from entire site, uncontrolled fill areas to be certified prior to filling.
Uncontrolled Fills	Uncontrolled fills (including stockpile) are to be excavated and replaced.

The temporary stability of the works is the responsibility of the main contractor. All works are to be completed in accordance with the requirements of current safety legislation and WorkSafe NZ.

9.2 Settlement Mitigation

Preliminary settlement analysis has been undertaken and is appended to this report.(*Appendix D*).

Predicted post-construction settlements range from 5 to 25 mm and differential settlements from 10 to 25 mm based on a maximum structural bearing pressure of 100 kPa (see Table 2 of Appendix D for further information). Should these bearing pressures need to be exceeded, further settlement analysis must be undertaken during detailed design stage.

Settlement markers will need to be installed and regularly monitored; the certification of the building platforms will only take place once the settlement targets have been reached. Settlement marker locations will be provided once the finalised WWTP design has been completed (by others).

9.3 Civil Works

Table 9.2: Key Civil Inputs

Item	Value	Comment
Subgrade CBR	2 – 3 % 5 – 6 %	Within natural cut ground Within engineered fills Subgrade improvement with lime (if desired) is expected to provide better results than the use of cement due to the clayey nature of the soils.
Typical Topsoil Depths	Ranges 0.1 – 0.2 m	
Uncontrolled Fill Locations	Refer Drawing 01	Encountered to the east of the proposed facility location, used as laydown area for construction
Stormwater Soakage (permeability)	N/A	No soakage to ground available

9.4 Foundations

Table 9.3: Anticipated Foundation Details

Item	Methodology	Value	Comment
Preliminary Geotechnical Ultimate Bearing Capacity (GUBC) for shallow foundations	B1/VM4[4]	300 kPa	Available within natural cut / engineered fill areas. Short axis of footing measuring no greater than 2.5 m in plan
Expansive Soil Site Class	AS2870	M (moderate)	Anticipated characteristic surface movement of up to 40 mm (M)
Strength reduction factors	B1/VM4[5]	0.8 0.5	Load combinations involving earthquake overstrength All other load combinations
Seismic Site Class(es)	NZS1170	B and C	Depth to rock varies across the site

10.0 FURTHER WORK

The following further work is recommended as the project progresses:

- Plan review, further analysis once a scheme plan is finalised to confirm that the structural design complies with the recommendations of this report.
- Construction supervision, fill testing and settlement monitoring
- Foundation testing

During construction, regular inspections and testing will be required as outlined in the Geotechnical Works Specification.

11.0 CLOSURE

Additional important information regarding the use of your CMW report is provided in the *'Using your CMW Report'* document attached to this report.

This report has been prepared for use by Fulton Hogan Land Development Limited in relation to the Temporary Wastewater Treatment Plant at Milldale Development project in accordance with the scope, proposed uses and limitations described in the report. Should you have further questions relating to the use of your report please do not hesitate to contact us.

Where a party other than Fulton Hogan Land Development Limited seeks to rely upon or otherwise use this report, the consent of CMW should be sought prior to any such use. CMW can then advise whether the report and its contents are suitable for the intended use by the other party.

[3] Standards New Zealand (2022) Engineered fill construction for lightweight structures, NZS 4431:2022
[4] Ministry of Business, Innovation and Employment (2019) *Acceptable Solutions and Verification Methods for NZ Building Code Clause B1 Structure,* B1/VM4, Amendment 19
[5] Ministry of Business, Innovation and Employment (2019) *Acceptable Solutions and Verification Methods for NZ Building Code Clause B1 Structure,* B1/VM4, Amendment 19

USING YOUR CMW GEOTECHNICAL REPORT

Geotechnical reporting relies on interpretation of facts and collected information using experience, professional judgement, and opinion. As such it generally has a level of uncertainty attached to it, which is often far less exact than other engineering design disciplines. The notes below provide general advice on what can be reasonably expected from your report and the inherent limitations of a geotechnical report.

Preparation of your report

Your geotechnical report has been written for your use on your project. The contents of your report may not meet the needs of others who may have different objectives or requirements. The report has been prepared using generally accepted Geotechnical Engineering and Engineering Geology practices and procedures. The opinions and conclusions reached in your report are made in accordance with these accepted principles. Specific items of geotechnical or geological importance are highlighted in the report.

In producing your report, we have relied on the information which is referenced or summarised in the report. If further information becomes available or the nature of your project changes, then the findings in this report may no longer be appropriate. In such cases the report must be reviewed, and any necessary changes must be made by us.

Your geotechnical report is based on your project's requirements

Your geotechnical report has been developed based on your specific project requirements and only applies to the site in this report. Project requirements could include the type of works being undertaken; project locality, size and configuration; the location of any structures on or around the site; the presence of underground utilities; proposed design methodology; the duration or design life of the works; and construction method and/or sequencing.

The information or advice in your geotechnical report should not be applied to any other project given the intrinsic differences between different projects and site locations. Similarly geotechnical information, data and conclusions from other sites and projects may not be relevant or appropriate for your project.

Interpretation of geotechnical data

Site investigations identify subsurface conditions at discrete locations. Additional geotechnical information (e.g. literature and external data source review, laboratory testing etc) are interpreted by Geologists or Engineers to provide an opinion about a site specific ground models, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist due to the variability of geological environments. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. Interpretation of factual data can be influenced by design and/or construction methods. Where these methods change review of the interpretation in the report may be required.

Subsurface conditions can change

Subsurface conditions are created by natural processes and then can be altered anthropically or over time. For example, groundwater levels can vary with time or activities adjacent to your site, fill may be placed on a site, or the consistency of near surface conditions might be susceptible to seasonal changes. The report is based on conditions which existed at the time of investigation. It is important to confirm whether conditions may have changed, particularly when large periods of time have elapsed since the investigations were performed.

Interpretation and use by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical report. To help avoid misinterpretations, it is important to retain the assistance of CMW to work with other project design professionals who are affected by the contents of your report. CMW staff can explain the report implications to design professionals and then review design plans and specifications to see that they have correctly incorporated the findings of this report.

Your report's recommendations require confirmation during construction

Your report is based on site conditions as revealed through selective point sampling. Engineering judgement is then applied to assess how indicative of actual conditions throughout an area the point sampling might be. Any assumptions made cannot be substantiated until construction is complete. For this reason, you should retain geotechnical services throughout the construction stage, to identify variances from previous assumption, conduct additional tests if required and recommend solutions to problems encountered on site.

A Geotechnical Engineer, who is fully familiar with the site and the background information, can assess whether the report's recommendations remain valid and whether changes should be considered as the project develops. An unfamiliar party using this report increases the risk that the report will be misinterpreted.

Environmental matters are not covered

Unless specifically discussed in your report environmental matters are not covered by a CMW Geotechnical Report. Environmental matters might include the level of contaminants present of the site covered by this report, potential uses or treatment of contaminated materials or the disposal of contaminated materials. These matters can be complex and are often governed by specific legislation.

The personnel, equipment, and techniques used to perform an environmental study can differ significantly from those used in this report. For that reason, our report does not provide environmental recommendations. Unanticipated subsurface environmental problems can have large consequences for your site. If you have not obtained your own environmental information about the project site, ask your CMW contact about how to find environmental risk-management guidance.

APPENDIX A
Drawings

PRINT IN COLOUR

LEGEND:

- SITE BOUNDARY
- EXISTING GROUND CONTOUR (MAJOR)
- EXISTING GROUND CONTOUR (MINOR)
- HA01 HAND AUGER (HA) LOCATION

NOTES:

1. AERIAL IMAGE COURTESY OF GOOGLE EARTH.
2. BASE PLAN ADAPTED FROM DWG NO P2A-189-0101-WW-WWTP, DATED 03/10/2024.
3. EXISTING GROUND CONTOURS ADAPTED FROM TOPO LYSNAR DATA , SHOWN IN 0.5m INTERVALS.
4. CRS: NZGD2000 / MOUNT EDEN 2000. VERTICAL DATUM IN TERMS OF NZVD 2016.
5. TEST LOCATIONS ARE INDICATIVE ONLY.

CMW Geosciences
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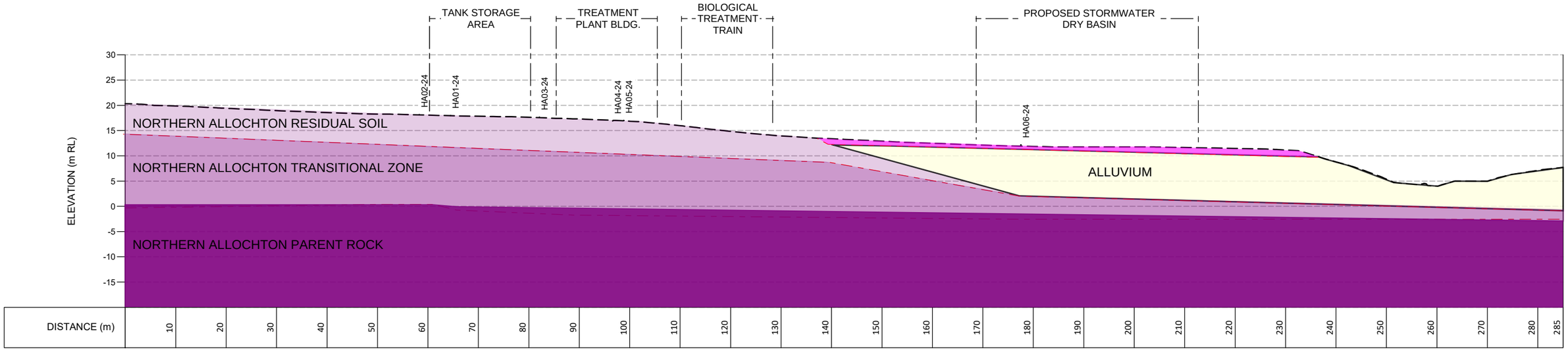
CLIENT: **FULTON HOGAN LAND DEVELOPMENT Ltd.**	DRAWN: JRAS	PROJECT: AKL2024-0185
PROJECT: **MILLDALE TEMPORARY WASTEWATER TREATMENT PLANT**	CHECKED: JP	DRAWING: 01
	REVISION: 0	SCALE: 1:800
TITLE: **GEOTECHNICAL INVESTIGATION PLAN**	DATE: 13/12/2024	SHEET: A3 L

\\cmwgeosciences.sharepoint.com@SSL\DavWWWRoot\sites\AucklandTeam\Shared Documents\Auckland Project Documents\2024\AKL2024-0185 Milldale Wastewater Treatment Plant\Drawings\AKL2024-0185-PLAN AND SECTIONS_01.11.24.dwg



CROSS SECTION A

LEGEND:

- EXISTING GROUND PROFILE
- DESIGN PROFILE
- INFERRED GEOLOGY BOUNDARY
- GROUND WATER LEVEL
- ENGINEERED FILL
- ALLUVIUM
- HUKERENUI MUDSTONE RESIDUAL SOIL
- HUKERENUI MUDSTONE TRANSITION ZONE
- HUKERENUI MUDSTONE PARENT ROCK

1:800 0 8 16 24 32 40 mm

PRINT IN COLOUR

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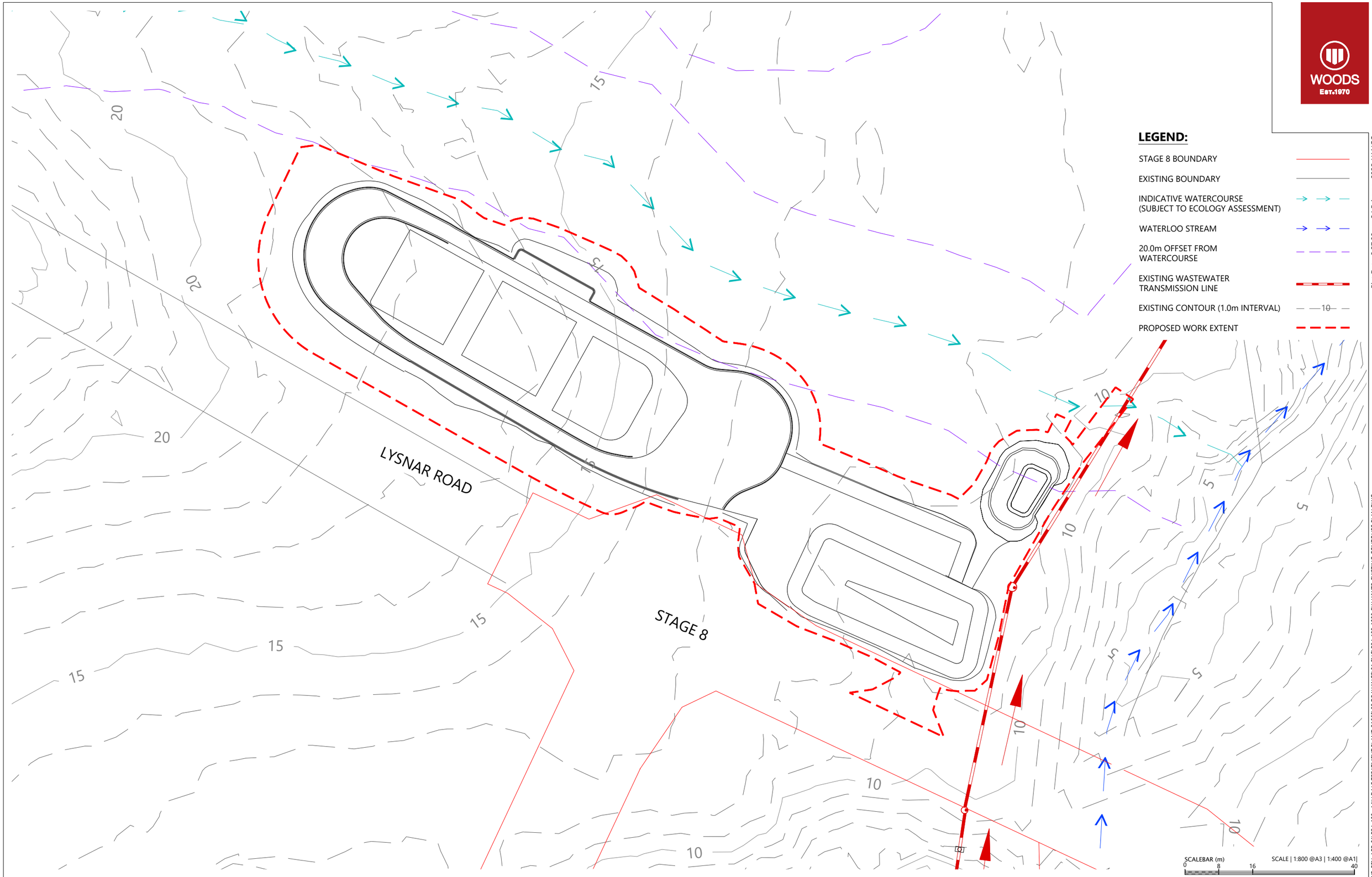
CLIENT: FULTON HOGAN LAND DEVELOPMENT Ltd.	DRAWN: JRAS	PROJECT: AKL2024-0185
PROJECT: MILLDALE TEMPORARY WASTEWATER TREATMENT PLANT	CHECKED: JP	DRAWING: 02
	REVISION: 0	SCALE: 1:800
TITLE: CROSS SECTION A	DATE: 13/12/2024	SHEET: A3 L

\\cmwgeosciences.sharepoint.com@SSL\DavWWWRoot\sites\AucklandTeam\Shared Documents\Auckland Project Documents\2024\AKL2024-0185 Milldale Wastewater Treatment Plant\Drawings\AKL2024-0185-PLAN AND SECTIONS_01.11.24.dwg

APPENDIX B
Woods Preliminary Plans



REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

BUILDING B, LEVEL 1
8 NUGENT ST, GRAFTON,
AUCKLAND 1023
+64 9 308 9229

WOODS.CO.NZ

MILLDALE
Connecting Lifestyles

MILLDALE WASTEWATER TREATMENT PLANT

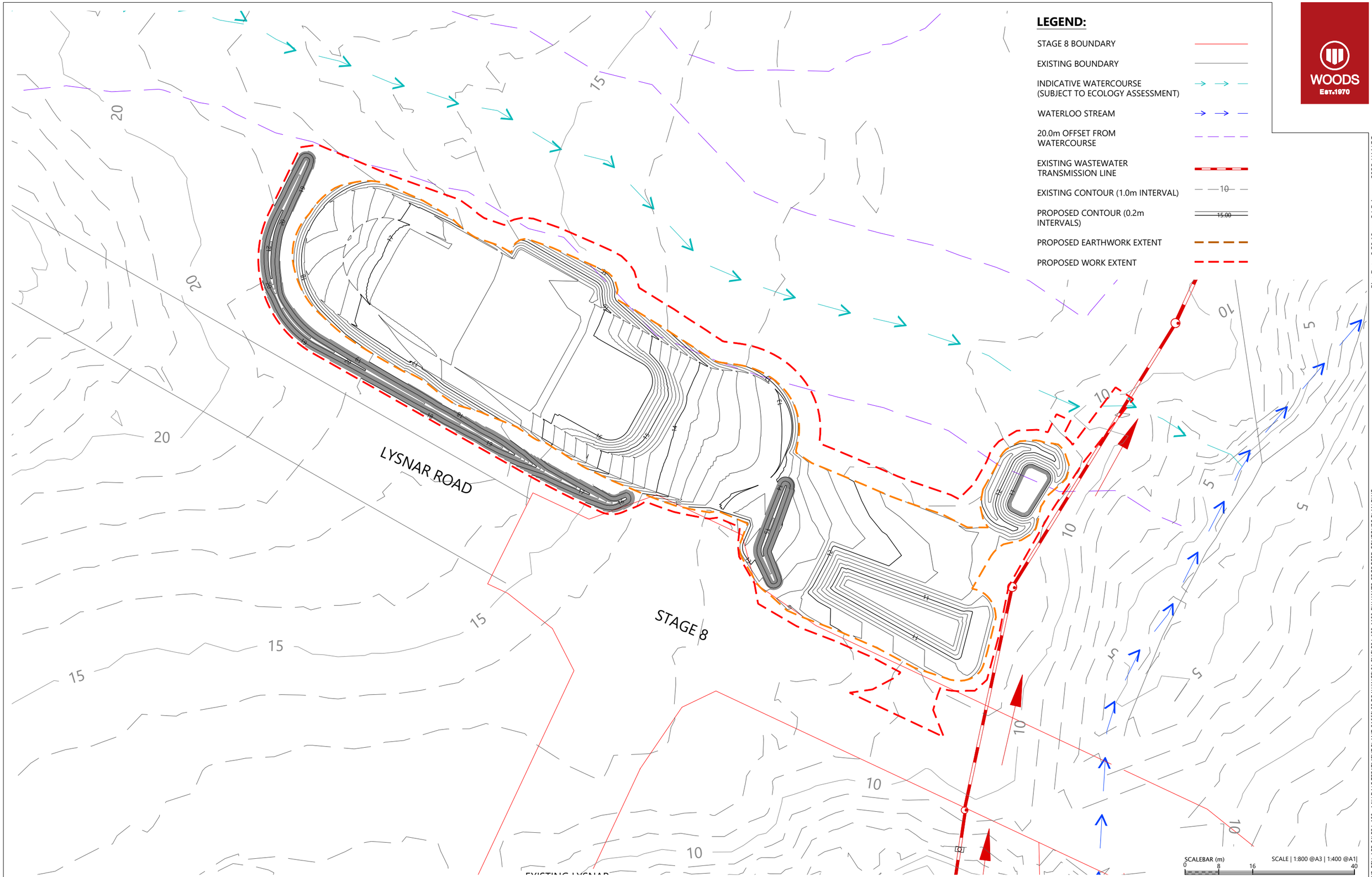
EXISTING CONTOURS PLAN

N

STATUS	ISSUED FOR CONSENT
SCALE	1:800 @ A3
COUNCIL	AUCKLAND COUNCIL
DWG NO	P24-189-1000-EW-WWTP
REV	1

Plot Date: 3:57:08 pm,24 February 2025, YANGC

File: C:\12DSYNERGY\DATA\WP-PEN-APP-01\P24-189 - MILLDALE TREATMENT PLANT_21668\02 DRAWINGS\01 ENG\P24-189-1000-EW-WWTP-EXISTING CONTOURS PLAN.DWG



REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

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MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED CONTOURS PLAN

N

STATUS	ISSUED FOR CONSENT	REV
SCALE	1:800 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-1100-EW-WWTP	

Plot Date: 3:58:18 pm,24 February 2025, YANGC

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EARTHWORK VOLUMES				
	AREA (m^2)	CUT (-) (m^3)	FILL (m^3)	BALANCE (m^3)
20m OFFSET FROM WATERCOURSE	175	-38	28	-10
50m OFFSET FROM WATERCOURSE	5,041	-1502	1503	1
TOTAL	7,498	-2,434	2348	-86

(NOTE: TOPSOILS ARE INCLUDED IN THE CALCULATION)

LEGEND:

- STAGE 8 BOUNDARY
- EXISTING BOUNDARY
- INDICATIVE WATERCOURSE (SUBJECT TO ECOLOGY ASSESSMENT)
- WATERLOO STREAM
- 20.0m OFFSET FROM WATERCOURSE
- 50.0m OFFSET FROM WATERCOURSE
- EXISTING WASTEWATER TRANSMISSION LINE
- CUT CONTOUR (0.25m INTERVALS)
- FILL CONTOUR (0.25m INTERVALS)
- ZERO CONTOUR
- CUT AREA
- FILL AREA

LYSNAR ROAD

STAGE 8

SCALEBAR (m) 0 8 16 40

SCALE | 1:800 @A3 | 1:400 @A1|

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

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MILLDALE WASTEWATER TREATMENT PLANT

CUT AND FILL CONTOURS PLAN

N

STATUS	ISSUED FOR CONSENT	REV
SCALE	1:800 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-1200-EW-WWTP	

Plot Date: 3:59:29 pm,24 February 2025, YANGC

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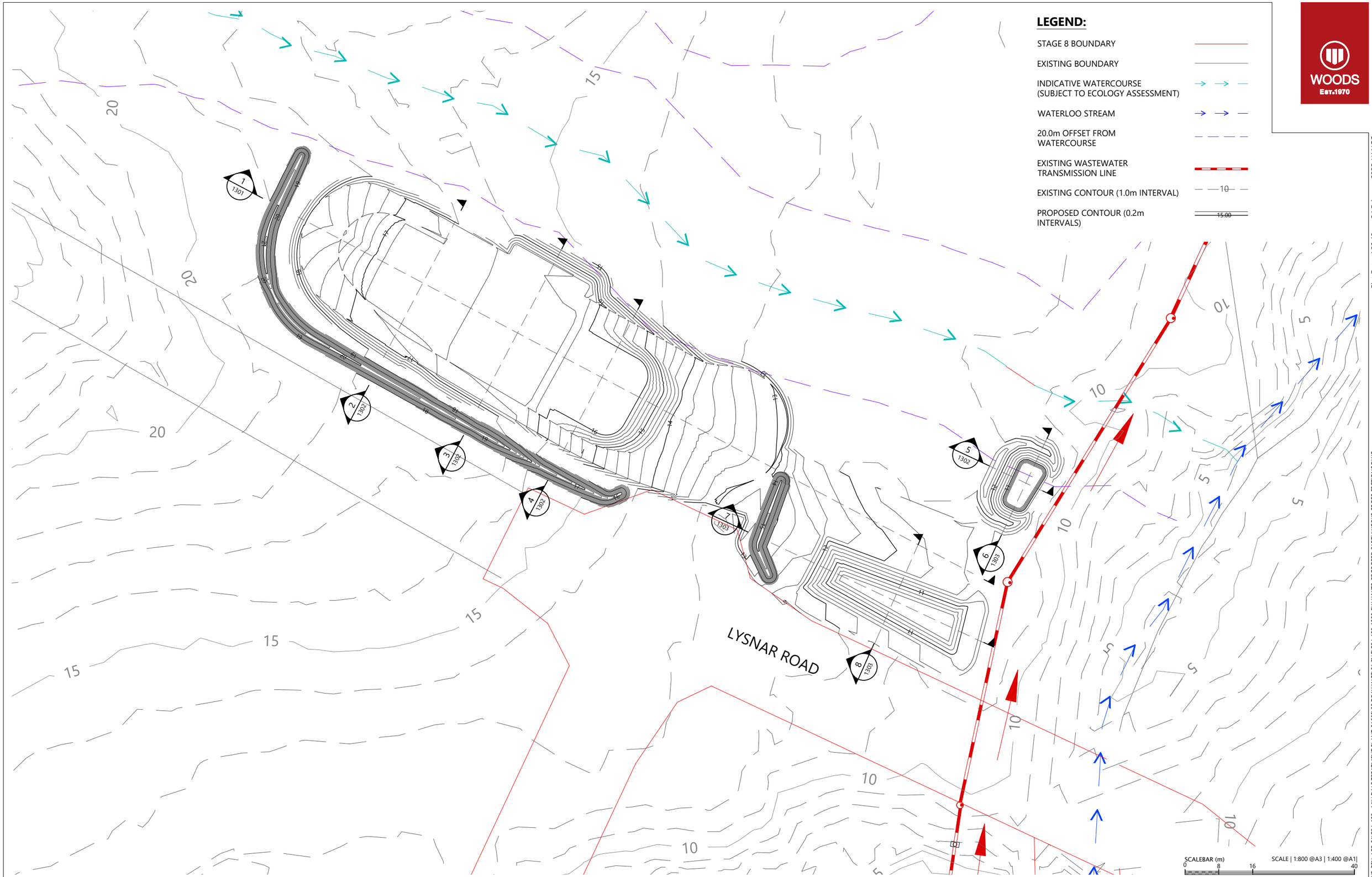

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

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MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED EARTHWORKS CROSS SECTIONS PLAN

N

STATUS	ISSUED FOR CONSENT
SCALE	1:800 @ A3
COUNCIL	AUCKLAND COUNCIL
DWG NO	P24-189-1300-EW-WWTP
REV	1

Plot Date: 4:00:40 pm,24 February 2025, YANGC

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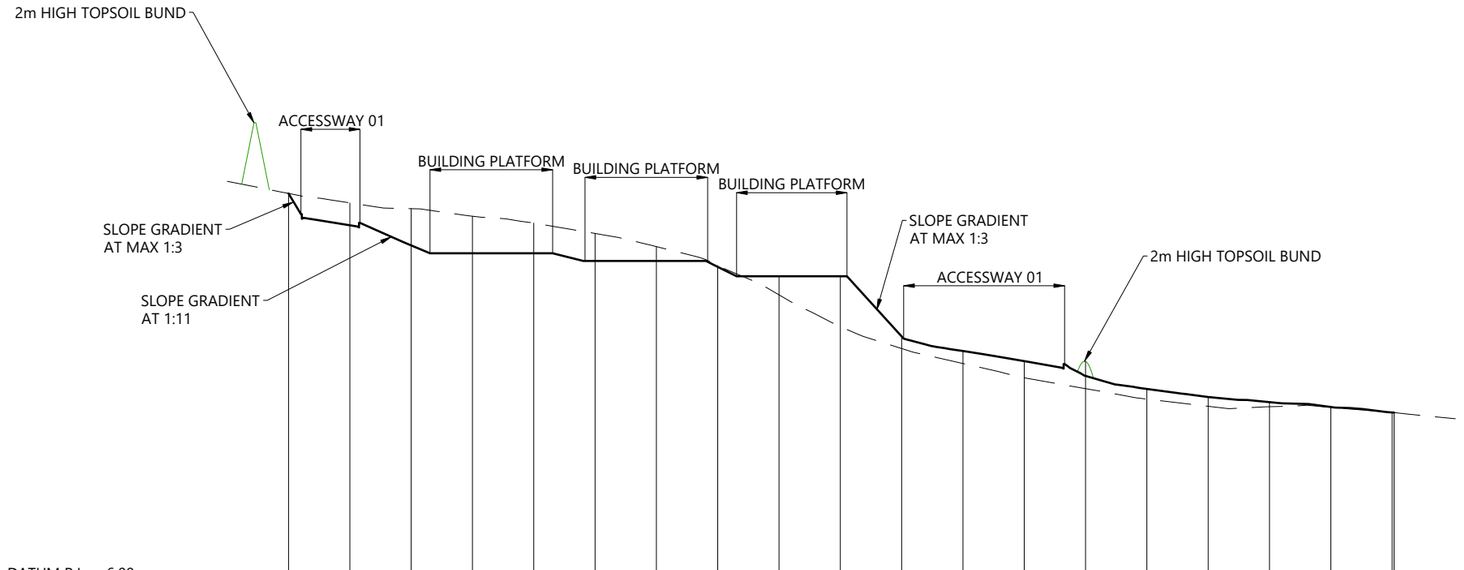

DATUM R.L. = 6.00

EXISTING SURFACE	18.70	18.40	18.21	17.96	17.74	17.40	16.97	16.35	15.40	14.36	13.65	13.16	12.69	12.34	12.00	11.76	11.75	11.73	11.57	11.56	
CUT / FILL DEPTH	-0.00	-0.73	-1.20	-1.21	-0.99	-0.90	-0.47	-0.04	0.61	1.64	0.39	0.41	0.54	0.42	0.33	0.30	0.15	0.02	-0.00	0.00	
CL DESIGN LEVELS	18.70	17.67	17.01	16.75	16.75	16.50	16.50	16.31	16.00	16.00	14.04	13.57	13.24	12.75	12.33	12.07	11.90	11.74	11.56	11.56	
CHAINAGE	0.01	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	180.32	

SECTION 1
HORZ 1:1000 @A3 VERT 1:200 @A3

SCALEBAR (m) 0 2 4 10 SCALE | 1:200 @A3 | 1:100 @A1|

SCALEBAR (m) 0 10 20 50 SCALE | 1:1000 @A3 | 1:500 @A1|

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

BUILDING B, LEVEL 1
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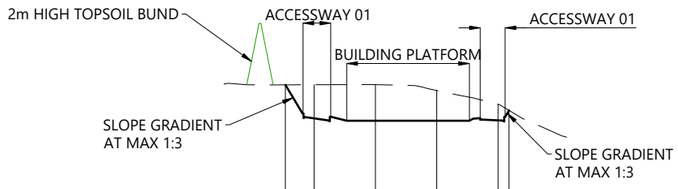
MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED EARTHWORKS CROSS SECTIONS - SHEET 1 OF 3

STATUS	ISSUED FOR CONSENT	REV
SCALE	AS SHOWN @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-1301-EW-WWTP	

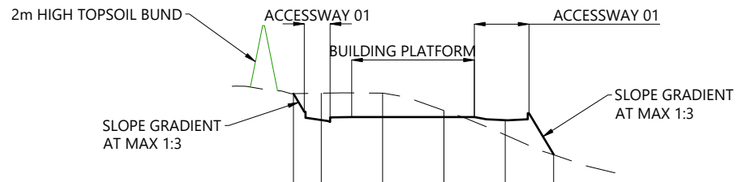
Plot Date: 4:01:28 pm,24 February 2025, YANGC
File: C:\12DSYNERGY\DATA\WP-PBN-APP-01\P24-189 - MILLDALE TREATMENT PLANT_21668\02 DRAWINGS\01 ENG\P24-189-1300-EW-WWTP-PROPOSED EARTHWORKS CROSS SECTIONS.DWG



DATUM R.L. = 12.00

EXISTING SURFACE	17.92	17.93	17.93	17.74	17.28	17.09	
CUT / FILL DEPTH	0.00	-1.10	-1.18	-0.99	-0.52	0.00	
CL DESIGN LEVELS	17.92	16.83	16.75	16.75	16.76	17.09	
CHAINAGE	5.31	10.00	20.00	30.00	40.00	41.80	

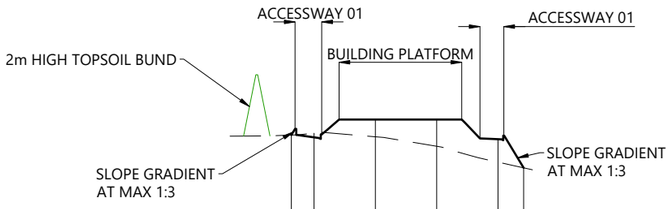
SECTION 2
HORZ 1:1000 @A3 VERT 1:200 @A3



DATUM R.L. = 10.00

EXISTING SURFACE	17.27	17.28	17.28	16.72	15.92	15.27
CUT / FILL DEPTH	0.00	-0.88	-0.78	-0.21	0.48	0.01
CL DESIGN LEVELS	17.27	16.40	16.50	16.50	16.40	15.29
CHAINAGE	5.45	10.00	20.00	30.00	40.00	47.89

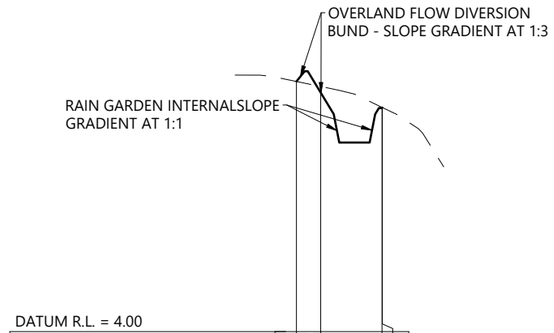
SECTION 3
HORZ 1:1000 @A3 VERT 1:200 @A3



DATUM R.L. = 10.00

EXISTING SURFACE	15.49	15.56	15.44	15.13	14.61	14.43	
CUT / FILL DEPTH	0.00	-0.14	0.56	0.87	0.75	0.00	
CL DESIGN LEVELS	15.49	15.42	16.00	16.00	15.36	14.43	
CHAINAGE	6.30	10.00	20.00	30.00	40.00	44.18	

SECTION 4
HORZ 1:1000 @A3 VERT 1:200 @A3



DATUM R.L. = 4.00

EXISTING SURFACE	12.16	11.99	11.31	11.30
CUT / FILL DEPTH	0.00	-0.20	-0.02	0.00
CL DESIGN LEVELS	12.16	11.79	11.29	11.30
CHAINAGE	6.04	10.00	20.00	20.06

SECTION 5
HORZ 1:1000 @A3 VERT 1:200 @A3

SCALEBAR (m) 0 2 4 10 SCALE | 1:200 @A3 | 1:100 @A1|

SCALEBAR (m) 0 10 20 50 SCALE | 1:1000 @A3 | 1:500 @A1|

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

BUILDING B, LEVEL 1
8 NUGENT ST, GRAFTON,
AUCKLAND 1023
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MILLDALE
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MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED EARTHWORKS CROSS SECTIONS - SHEET 2 OF 3

STATUS	ISSUED FOR CONSENT	REV
SCALE	AS SHOWN @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-1302-EW-WWTP	

Plot Date: 4:01:48 pm,24 February 2025, YANGC
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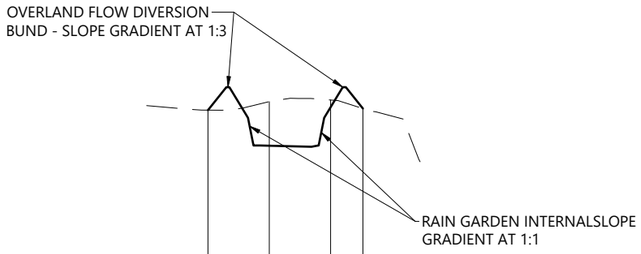
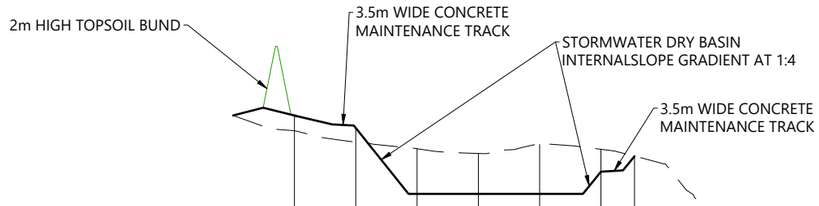


DATUM R.L. = 4.00

EXISTING SURFACE	11.34	11.62	11.67	11.39		
CUT / FILL DEPTH	0.00	-1.44	-0.24	0.00		
CL DESIGN LEVELS	11.34	10.18	11.44	11.39		
CHAINAGE	0.00	10.00	20.00	25.27		

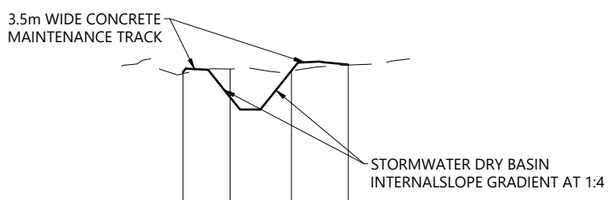
SECTION 6
HORZ 1:1000 @A3 VERT 1:200 @A3



DATUM R.L. = 6.00

EXISTING SURFACE	12.41	12.04	11.82	11.67	11.96	11.80	11.58	
CUT / FILL DEPTH	0.50	0.46	-1.47	-1.32	-1.61	-0.73	-0.00	
CL DESIGN LEVELS	12.91	12.50	10.35	10.35	10.35	11.07	11.58	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	55.46	

SECTION 7
HORZ 1:1000 @A3 VERT 1:200 @A3



DATUM R.L. = 6.00

EXISTING SURFACE	11.52	11.67	11.61	11.80	
CUT / FILL DEPTH	0.05	-0.92	0.01	0.01	
CL DESIGN LEVELS	11.57	10.75	11.62	11.82	
CHAINAGE	2.31	10.00	20.00	29.26	

SECTION 8
HORZ 1:1000 @A3 VERT 1:200 @A3

SCALEBAR (m) 0 2 4 10 SCALE | 1:200 @A3 | 1:100 @A1|

SCALEBAR (m) 0 10 20 50 SCALE | 1:1000 @A3 | 1:500 @A1|

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

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MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED EARTHWORKS CROSS SECTIONS - SHEET 3 OF 3

STATUS	ISSUED FOR CONSENT	REV
SCALE	AS SHOWN @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-1303-EW-WWTP	

Plot Date: 4:02:05 pm,24 February 2025, YANGC

File: C:\12DSYNERGY\DATA\WP-PBN-APP-01\P24-189 - MILLDALE TREATMENT PLANT_21668\02 DRAWINGS\01 ENG\P24-189-1300-EW-WWTP-PROPOSED EARTHWORKS CROSS SECTIONS.DWG

NOTES:

1. ALL WORK AND MATERIALS TO COMPLY WITH AUCKLAND COUNCIL STANDARDS. ANY AMBIGUITY BETWEEN DRAWINGS AND COUNCIL STANDARDS TO BE REPORTED TO THE ENGINEER FOR CLARIFICATION.
2. FOR ACCESSWAY DETAILS REFER TO WOODS TYPICAL CROSS SECTIONS DRAWINGS P24-189-2200-RD-WWTP TO 2201-RD-WWTP.
3. LOCATION OF STREETLIGHTS INDICATIVE ONLY (SUBJECT TO FINAL DESIGN BY TECHLIGHT LTD).
4. REFER TO DRAWING P24-189-2600-RD-WWTP AND 2601-RD-WWTP FOR LONG SECTIONS OF ACCESSWAYS.

WOODS
Est.1970

20m OFFSET FROM CENTER OF WATERCOURSE

TANK STORAGE AREA

TREATMENT PLANT BUILDING

2m HIGH TOPSOIL BUND
REFER TO LANDSCAPING PLANTING PLANS FOR DETAILS

RL 16.75m

RL 16.50m

RL 16.00m

BIOLOGICAL TREATMENT AREA

PROPOSED SITE FENCE

PROPOSED 1.8m SECURITY FENCE

LYSNAR ROAD

SITE ENTRANCE
PROPOSED SITE ENTRANCE TO BE VIA ROUNDABOUT CONSENTED IN STAGE 8, AND DETAILS WILL BE PROVIDED AT EPA AND BUILDING CONSENT STAGE

STAGE 8

PROPOSED LAND CONTACT INFILTRATION DEVICE
REFER TO DRAWING P24-189-3200-DR-WWTP FOR DETAILS

PROPOSED WASTEWATER TAKE-OFF MANHOLE. TO BE DETAILED AT BUILDING CONSENT STAGE

2m HIGH TOPSOIL BUND
REFER TO LANDSCAPING PLANTING PLANS FOR DETAILS

PROPOSED STORMWATER DRY BASIN
REFER TO DRAWING
P24-189-3300-DR-WWTP FOR DETAILS

LEGEND:

- STAGE 8 BOUNDARY
- EXISTING BOUNDARY
- INDICATIVE WATERCOURSE (SUBJECT TO ECOLOGY ASSESSMENT)
- WATERLOO STREAM
- 20.0m OFFSET FROM WATERCOURSE
- 50.0m OFFSET FROM WATERCOURSE
- EXISTING WASTEWATER TRANSMISSION LINE
- ACCESSWAY EDGE LINE
- PROPOSED CONCRETE SURFACE
- PROPOSED BUILDING PLATFORM
- PROPOSED STORMWATER NETWORK
- PROPOSED WASTEWATER PIPE DISCHARING TO LAND CONTACT INFILTRATION DEVICE
- PROPOSED WASTEWATER RISING MAIN FROM TAKE-OFF MANHOLE
- PROPOSED WASTEWAER PIPE DISCHARGING BACK TO EXISTING TRANSMISSION LINE
- PROPOSED GREEN AREA
- PROPOSED MAINTENANCE TRACK
- PROPOSED EARTHWORKS EXTENT
- PROPOSED WORK EXTENT
- EXISTING CONTOUR (1.0m INTERVAL)
- PROPOSED CONTOUR (0.2m INTERVALS)
- SITE SECURITY FENCE (1.8m HIGH) AND GATES

SCALEBAR (m) 0 8 16 40
SCALE | 1:800 @A3 | 1:400 @A1|

REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

BUILDING B, LEVEL 1
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AUCKLAND 1023
+64 9 308 9229
WOODS.CO.NZ

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MILLDALE WASTEWATER TREATMENT PLANT

OVERALL LAYOUT PLAN

N

		REV
STATUS	ISSUED FOR CONSENT	1
SCALE	1:800 @ A3	
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P24-189-2000-RD-WWTP	

Plot Date: 4:06:07 pm,24 February 2025, YANGC

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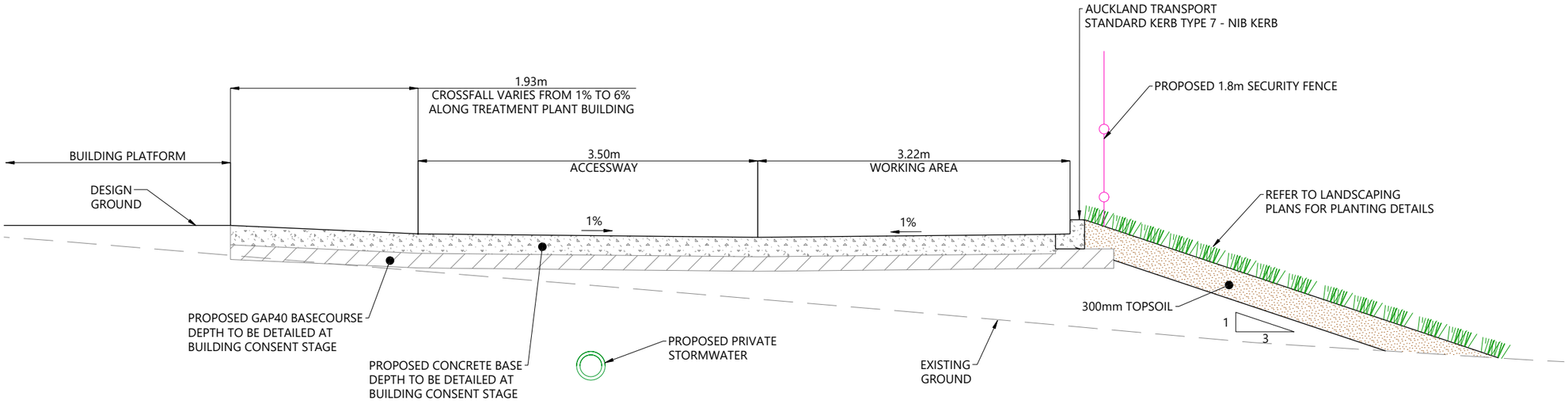

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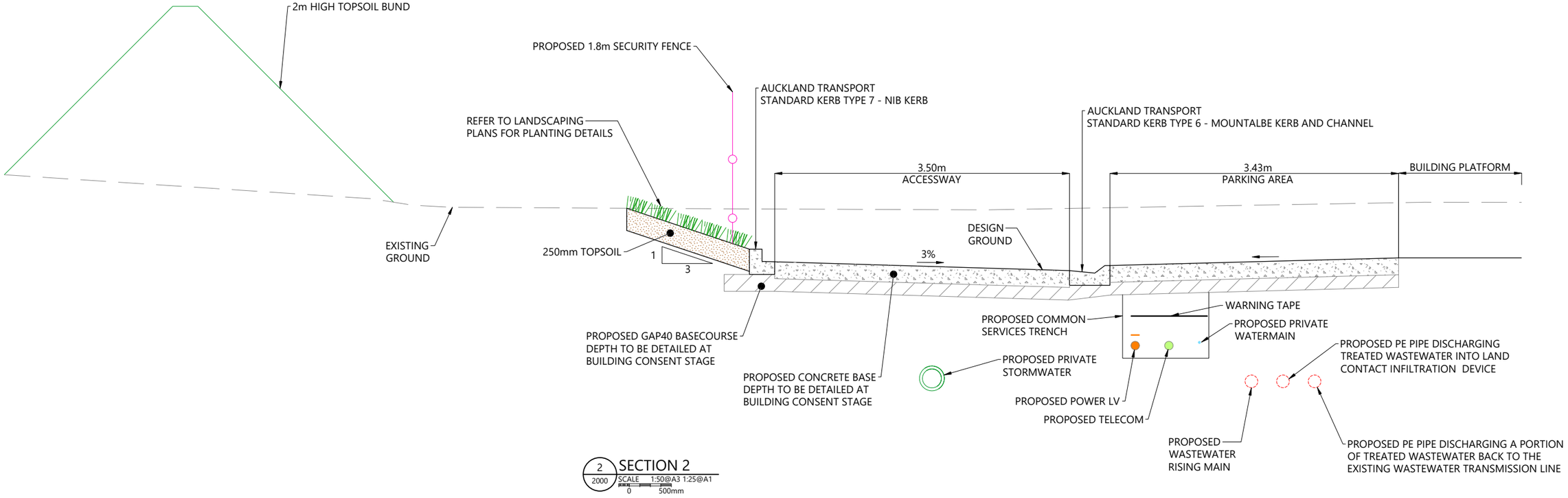

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REVISION DETAILS		INT	DATE	SURVEYED	WOODS
1	ISSUED FOR CONSENT	YC	FEB 2025	DESIGNED	YC
				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

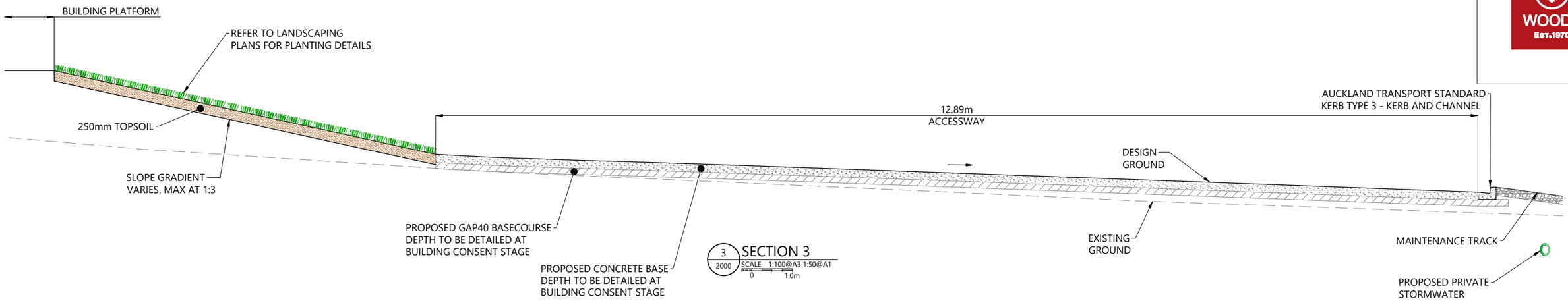
BUILDING B, LEVEL 1
8 NUGENT ST, GRAFTON,
AUCKLAND 1023
+64 9 308 9229
WOODS.CO.NZ

MILLDALE
Connecting Lifestyles

MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED TYPICAL CROSS SECTIONS - SHEET 1 OF 2

STATUS	ISSUED FOR CONSENT
SCALE	1:50 @ A3
COUNCIL	AUCKLAND COUNCIL
DWG NO	P24-189-2200-RD-WWTP
REV	1



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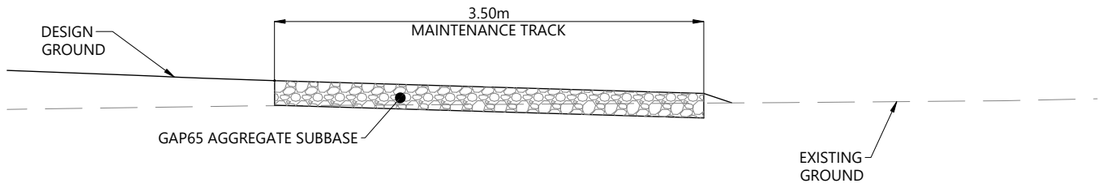

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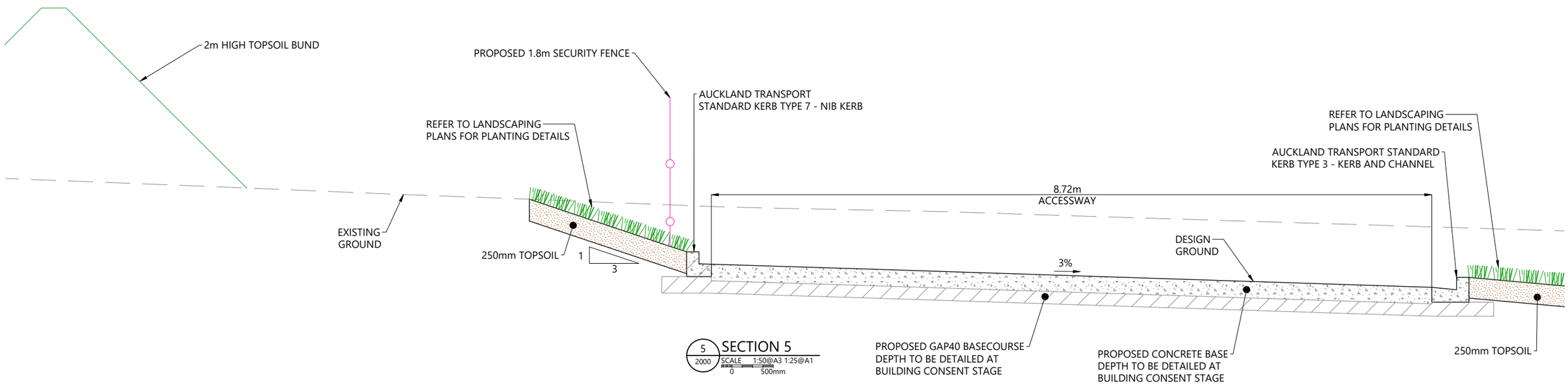

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REVISION DETAILS		INT	DATE	SURVEYED	WOODS
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				DRAWN	YC
				CHECKED	TR
				APPROVED	TR

BUILDING B, LEVEL 1
8 NUGENT ST, GRAFTON,
AUCKLAND 1023
+64 9 308 9229

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MILLDALE
Connecting Lifestyles

MILLDALE WASTEWATER TREATMENT PLANT

PROPOSED TYPICAL CROSS SECTIONS - SHEET 2 OF 2

STATUS	ISSUED FOR CONSENT
SCALE	1:50 @ A3
COUNCIL	AUCKLAND COUNCIL
DWG NO	P24-189-2201-RD-WWTP
REV	1

APPENDIX C
Investigation Logs / Results

HAND AUGER BOREHOLE LOG - HA01-24

Client: Fulton Hogan Land Development Ltd
Project: Milldale Wastewater Treatment Plant
Site Location: Milldale
Project No.: AKL2024-0185
Date: 30/10/2024
Borehole Location: Refer to Site Plan Logged by: JH Checked by: Scale: 1:25 Sheet 1 of 1

CMW Geosciences
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Position: 1747627.2mE; 5947814.1mN Projection: NZTM
Elevation: 18.10m Datum: NZVD2016 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			18.1			OL: Organic SILT: Dark brown. Low plasticity. Trace rootlets. (Topsoil)			
			18.0			CH: Silty CLAY: Yellowish brown mottled greyish brown. High plasticity. Moderately sensitive. (Hukerenui Mudstone)			
	0.4	Peak = 153kPa Residual = 65kPa							
						... at 0.60m, Becoming yellowish brown streaked orange and light grey.			
	0.8	Peak = 136kPa Residual = 59kPa							
						... at 0.90m, Minor limonite staining.			
				1					
	1.2	Peak = 124kPa Residual = 59kPa				*... at 1.20m, Becoming light whitish grey streaked light yellowish brown.*			
	1.6	Peak = 139kPa Residual = 91kPa							
	2.0	Peak = 139kPa Residual = 65kPa		2					
			15.9			ML: Clayey SILT: Yellowish brown. Low plasticity. Insensitive. (Hukerenui Mudstone)			
	2.4	Peak = 106kPa Residual = 65kPa					M	VSt	
	2.8	Peak = 106kPa Residual = 74kPa	15.3			ML: SILT: Bluish grey. Low plasticity. Moderately sensitive. (Hukerenui Mudstone)			
						... from 2.80m to 3.60m, Insensitive.			
				3					
	3.2	Peak = 124kPa Residual = 65kPa							
	3.6	Peak = 118kPa Residual = 65kPa							
	4.0	Peak = 148kPa Residual = 71kPa		4					
	4.4	Peak = 198kPa Residual = 77kPa							
	4.8	Peak = 192kPa Residual = 74kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 1603 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 4 - April 2023.

HAND AUGER BOREHOLE LOG - HA02-24

Client: Fulton Hogan Land Development Ltd
Project: Milldale Wastewater Treatment Plant
Site Location: Milldale
Project No.: AKL2024-0185
Date: 30/10/2024
Borehole Location: Refer to Site Plan

CMW Geosciences
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Scale: 1:25 Sheet 1 of 1

Position: 1747610.2mE; 5947795.5mN Projection: NZTM
Elevation: 17.90m Datum: NZVD2016 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			17.9			ML: Organic SILT: Dark brown. Low plasticity. Trace rootlets. (Topsoil)			
			17.7			ML: Clayey SILT: Greyish brown mottled orange. Low plasticity. Moderately sensitive. (Hukerenui Mudstone)			
	0.4	Peak = 148kPa Residual = 50kPa							
	0.8	Peak = 148kPa Residual = 47kPa		1				VSt	
	1.2	Peak = 136kPa Residual = 74kPa				*... from 1.20m to 1.60m, Insensitive.*	M		
	1.6	Peak = 136kPa Residual = 65kPa							
			16.1			ML: SILT with trace sand: Grey mottled trace light yellowish brown. Low plasticity. Moderately sensitive. Minor limonite staining. (Hukerenui Mudstone)			
	2.0	Peak = > 207 kPa		2				H	
	2.4	Peak = UTP							
						Borehole terminated at 2.5 m			15, 18, 20
				3					
				4					
				5					

Termination Reason: Refusal on Hard Ground

Shear Vane No: 1603 DCP No: 05

Remarks: Groundwater not encountered. DCP conducted from 2.5 to 2.7m. Refusal on hard ground at 2.7m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 4 - April 2023.

HAND AUGER BOREHOLE LOG - HA03-24

Client: Fulton Hogan Land Development Ltd
Project: Milldale Wastewater Treatment Plant
Site Location: Milldale
Project No.: AKL2024-0185
Date: 30/10/2024
Borehole Location: Refer to Site Plan Logged by: JH Checked by: Scale: 1:25 Sheet 1 of 1

CMW Geosciences
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Position: 1747637.4mE; 5947796.0mN Projection: NZTM
Elevation: 17.60m Datum: NZVD2016 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			17.6			OL: Organic SILT: Dark brown. Low plasticity. Trace rootlets.			
			17.5			(Topsoil)			
						CH: Silty CLAY: Yellowish brown streaked greyish brown. High plasticity. Insensitive. (Hukerenui Mudstone)			
	0.4	Peak = 171kPa Residual = 65kPa				... from 0.40m to 0.80m, Moderately sensitive.			
	0.8	Peak = 118kPa Residual = 65kPa		1					
	1.2	Peak = UTP	16.4			ML: Clayey SILT: Yellowish brown. Low plasticity. Insensitive. (Hukerenui Mudstone)	M		
						... at 1.20m, Thin lens of limonite nodules, medium gravel sized, angular.			
	1.6	Peak = 121kPa Residual = 74kPa	16.0			CH: Silty CLAY: Yellowish brown streaked light grey. High plasticity. Insensitive. (Hukerenui Mudstone)			
30-10-2024	2.0	Peak = 153kPa Residual = 89kPa		2				VSt	
			15.3			ML: SILT: Light bluish grey. Low plasticity. Insensitive. (Hukerenui Mudstone)			
	2.4	Peak = 150kPa Residual = 80kPa							
	2.8	Peak = 121kPa Residual = 71kPa				... at 2.80m, Becoming bluish grey.			
				3					
	3.2	Peak = 100kPa Residual = 71kPa							
	3.6	Peak = 103kPa Residual = 62kPa				... at 3.60m, With trace fine sand.	M to W		
	4.0	Peak = 89kPa Residual = 47kPa		4				St	
	4.4	Peak = > 207 kPa				... at 4.40m, Becoming hard.			
	4.8	Peak = > 207 kPa						H	
				5		Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 1603 DCP No:
Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 4 - April 2023.

HAND AUGER BOREHOLE LOG - HA04-24

Client: Fulton Hogan Land Development Ltd
Project: Milldale Wastewater Treatment Plant
Site Location: Milldale
Project No.: AKL2024-0185
Date: 31/10/2024
Borehole Location: Refer to Site Plan Logged by: JH Checked by: Scale: 1:25 Sheet 1 of 1

CMW Geosciences
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Position: 1747655.1mE; 5947798.4mN Projection: NZTM
Elevation: 17.00m Datum: NZVD2016 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			17.0			OL: Organic SILT: Dark brown. Low plasticity. Trace rootlets. (Topsoil)			
			16.8			CH: CLAY with minor silt: Greyish brown streaked yellowish brown. High plasticity. Moderately sensitive. (Hukerenui Mudstone)			
	0.4	Peak = 118kPa Residual = 30kPa							
	0.8	Peak = 121kPa Residual = 56kPa				... at 0.70m, Becoming light whitish grey streaked light yellowish brown. Trace limonite staining.			
				1			M	VSt	
	1.2	Peak = 118kPa Residual = 89kPa				... at 1.20m, Becoming insensitive.			
	1.6	Peak = 130kPa Residual = 86kPa							
31-10-2024	2.0	Peak = 124kPa Residual = 83kPa		2		... at 2.00m, Trace decomposing tree roots.			
	2.4	Peak = 80kPa Residual = 47kPa						St	
	2.8	Peak = 106kPa Residual = 56kPa							
				3			M to W		
	3.2	Peak = 62kPa Residual = 32kPa							
			13.5			MH: Clayey SILT: Light whitish grey streaked trace light yellowish brown. Low plasticity. Insensitive. (Hukerenui Mudstone)			
	3.6	Peak = 62kPa Residual = 38kPa						F	
	4.0	Peak = 47kPa Residual = 30kPa		4		... at 4.00m, Becoming light bluish grey.			
						... from 4.20m to 4.80m, Poor recovery.			
	4.4	Peak = 59kPa Residual = 30kPa					W to S	St	
	4.8	Peak = 89kPa Residual = 46kPa				... at 4.80m, With trace fine sand. Yellowish brown.			
				5		Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 1603 DCP No:
Remarks: Groundwater encountered at 2.4m. Poor recovery from 4.2 to 4.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 4 - April 2023.

HAND AUGER BOREHOLE LOG - HA05-24

Client: Fulton Hogan Land Development Ltd
Project: Milldale Wastewater Treatment Plant
Site Location: Milldale
Project No.: AKL2024-0185
Date: 30/10/2024
Borehole Location: Refer to Site Plan Logged by: JH Checked by: Scale: 1:25 Sheet 1 of 1

CMW Geosciences
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Position: 1747647.7mE; 5947779.7mN Projection: NZTM
Elevation: 16.90m Datum: NZVD2016 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			16.9			ML: Organic SILT: Dark brown. Low plasticity. Trace rootlets.			
			16.8			(Topsoil)			
						CH: Silty CLAY: Yellowish brown streaked greyish brown. High plasticity. Moderately sensitive. (Hukerenui Mudstone)			
	0.4	Peak = 106kPa Residual = 50kPa							
	0.8	Peak = 139kPa Residual = 59kPa				*... at 0.70m, Becoming light grey streaked light yellowish brown.*			
				1					
	1.2	Peak = 142kPa Residual = 77kPa				*... from 1.20m to 2.40m, Insensitive.*			
	1.6	Peak = 148kPa Residual = 89kPa					M		
	2.0	Peak = 159kPa Residual = 100kPa		2					
						... at 2.20m, Trace limonite staining.			
	2.4	Peak = 124kPa Residual = 83kPa						VSt	
30-10-2024	2.8	Peak = 133kPa Residual = 62kPa							
				3					
	3.2	Peak = 106kPa Residual = 62kPa	13.7			ML: SILT: Light whitish grey streaked pink. Low plasticity. Insensitive. (Hukerenui Mudstone)			
						... from 3.20m to 3.60m, Insensitive.			
	3.6	Peak = 112kPa Residual = 59kPa							
						... from 3.80m to 3.90m, Pink streaked light whitish grey.			
	4.0	Peak = 127kPa Residual = 56kPa		4			M to W		
			12.6			ML: SILT: Dark bluish grey. Low plasticity. Insensitive. (Hukerenui Mudstone)			
	4.4	Peak = 162kPa Residual = 89kPa							
	4.8	Peak = 150kPa Residual = 91kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 1603 DCP No:
Remarks: Groundwater encountered at 3.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 4 - April 2023.

HAND AUGER BOREHOLE LOG - HA06-24

Client: Fulton Hogan Land Development Ltd
Project: Milldale Wastewater Treatment Plant
Site Location: Milldale
Project No.: AKL2024-0185
Date: 01/11/2024
Borehole Location: Refer to Site Plan Logged by: JH Checked by: Scale: 1:25 Sheet 1 of 1

CMW Geosciences
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Position: 1747733.1mE; 5947772.8mN Projection: NZTM
Elevation: 12.10m Datum: NZVD2016 Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			12.1			Hardfill: Coarse to cobble sized hardfill, Subangulat to angular. Well compacted. (Fill)			
			11.6			CH: CLAY with minor silt: Brownish grey streaked yellowish brown. High plasticity. Insensitive. (Alluvium)		VSt	
	0.8	Peak = 108kPa Residual = 67kPa		1		... at 0.70m, Light grey streaked yellowish brown. Trace decomposing tree roots.			
	1.2	Peak = 48kPa Residual = 29kPa						St	
	1.6	Peak = 80kPa Residual = 48kPa				... at 1.70m, Becoming bluish grey.	M		
	2.0	Peak = 143kPa Residual = 64kPa		2		... from 2.00m to 2.80m, Moderately sensitive.			
	2.4	Peak = 130kPa Residual = 38kPa						VSt	
01-11-2024	2.8	Peak = 127kPa Residual = 32kPa	9.3			OH: Organic CLAY: Dark brown. High plasticity. Trace decomposing tree roots. (Alluvium)			
			9.2			SP: Silty SAND: Light grey. Poorly graded. Sand is medium grained. (Alluvium)			
			9.1	3		CH: Silty CLAY: Brown. High plasticity. Insensitive. Poor recovery. (Alluvium)			
	3.2	Peak = 35kPa Residual = 24kPa							
	3.6	Peak = 54kPa Residual = 29kPa						S to F	
	4.0	Peak = 64kPa Residual = 34kPa		4			S		
	4.4	Peak = 51kPa Residual = 32kPa							
	4.8	Peak = 45kPa Residual = 32kPa							
				5		Borehole terminated at 5.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 1620 DCP No:
Remarks: Groundwater encountered at 2.8m. Poor recovery from 3.0 to 5.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 4 - April 2023.

APPENDIX D
Static Settlement Design Memo

Static Settlement

Site Address	Milldale Temporary Wastewater Treatment Facility	Report Number	AKL2024-0185AB
Client	FHLDL	Date	11 December 2024
Prepared by	Jenna Pallarca		
Reviewed & Authorised by	Gaurav Mathur		

1.0 INTRODUCTION

The purpose of this design verification is to assess the anticipated construction and post-construction settlement magnitudes and rates at the site and to provide recommendations on any remedial works required to address static settlement issues.

The area(s) assessed herein are depicted on the plans prepared by Woods Limited (Reference P24-189-1200-EW-WWTP Rev. 1 dated 29 November 2024) and indicative structural loads provided by Apex Water on a meeting held on 21 November 2024.

2.0 DESIGN PARAMETERS

Table 1: Summary of Consolidation Design Parameters

Parameter	Alluvium[1]	Residual Hukerenui Mudstone[2]
Compression Index (Cc)	0.52	0.10
Initial void ratio (e0)	1.2	1.2
Secondary / Primary Compression Index ratio (Cα/ Cc)	0.05	-
Note: 1. From laboratory testing completed for Stage 4A 2. From CPT analysis for Stage 8		

3.0 METHODOLOGY

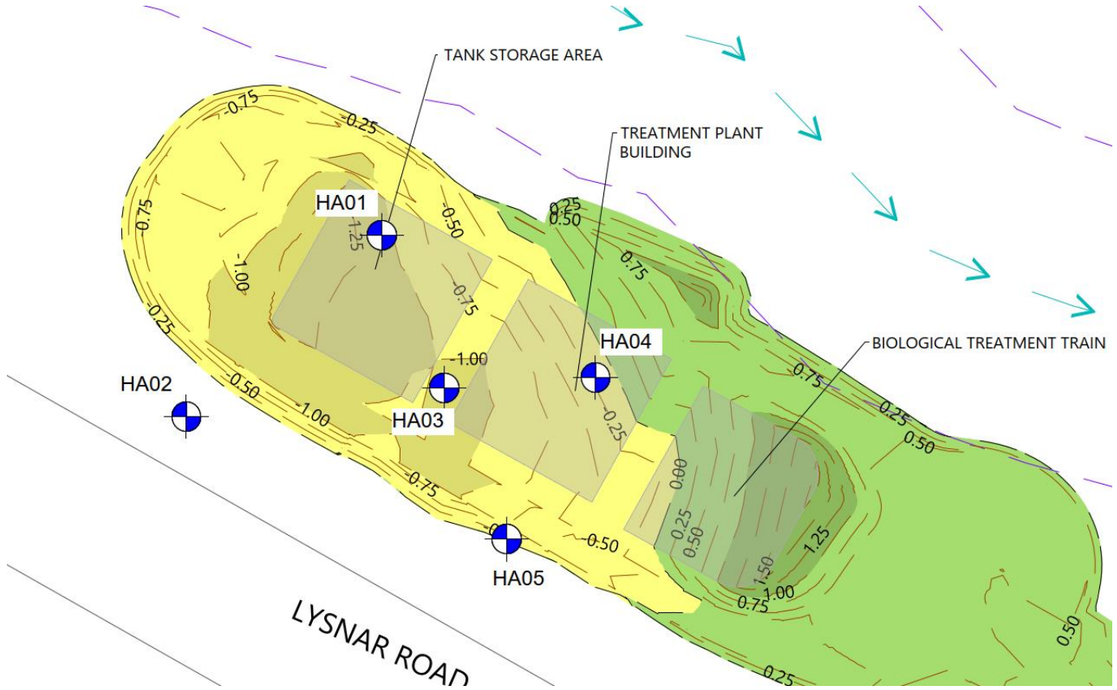
Settlement analyses were undertaken using the software Settle3, which is a three-dimensional program for the analysis of vertical consolidation and settlement under applied loads.

Based on preliminary building loads provided by Apex Water, the anticipated widespread floor loads are shown in Table 2.

Table 2: Summary of Preliminary Building Loads

Structure	Area	RL (m)	Distributed Loads (kPa)
Treatment Plant Building	400 m^2 (20 m by 20 m)	16.6 – 16.4	floor = 12 eastern exterior wall = 50* western exterior wall =100*
Biological Reactor	360 m^2 (18 m x 20 m)	16.0	40
Tank Storage Area	400 m^2 (20 m by 20 m)	16.8 – 16.6	20
Note: *Recommended maximum load based on analysis. See Section 4.0 for further details.			

Figure 1: Cut and Fill Plan



4.0 RESULTS

Estimated static settlements are summarised as follows:

Table 3: Estimated Fill Induced Static Settlements

Structure	Residual Soil Thickness (m)	Cut (-) / Fill (+) Height (m)	Max. Construction Settlement – 12 months (mm)	Max. Post Construction Settlement – 10 years (mm)	Differential Settlement Between Structures (mm)
Tank Storage Area	6.5	-0.5 to +1.25	40	10	25
Treatment Plant Building	4.7	-1.3 to -1	70	5	10
Biological Reactor	6 – 6.4	-1 to -0.5	75	25	

The structures are to be located on the firm to stiff soil of the Hukerenui Mudstone. Additional tests may be required to confirm the extent of this soil unit and avoid having the structures sitting on the softer alluvium clay layer found eastward approaching the stream.

The post-construction differential settlement estimated between the structures are within 25mm given the maximum bearing pressures in Table 2. It should be noted that the magnitude of the exterior wall loads have been back-analysed to achieve the 25mm maximum settlement threshold. If these bearing pressures were to be exceeded, CMW must be advised for further analysis.

Figure 2: Post-construction settlement contours at RL 16.5 m

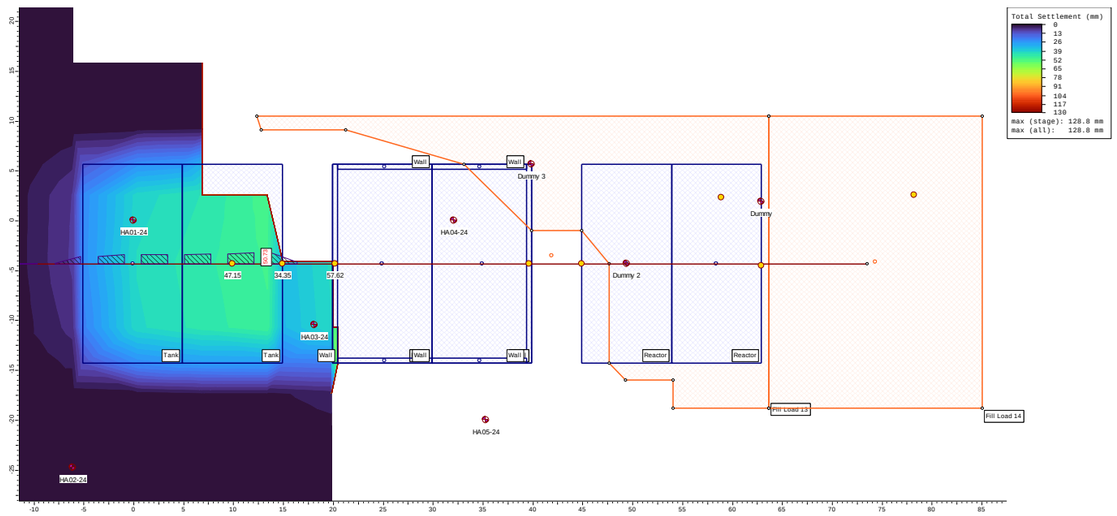


Figure 3: Post-construction settlement contours at RL 16 m

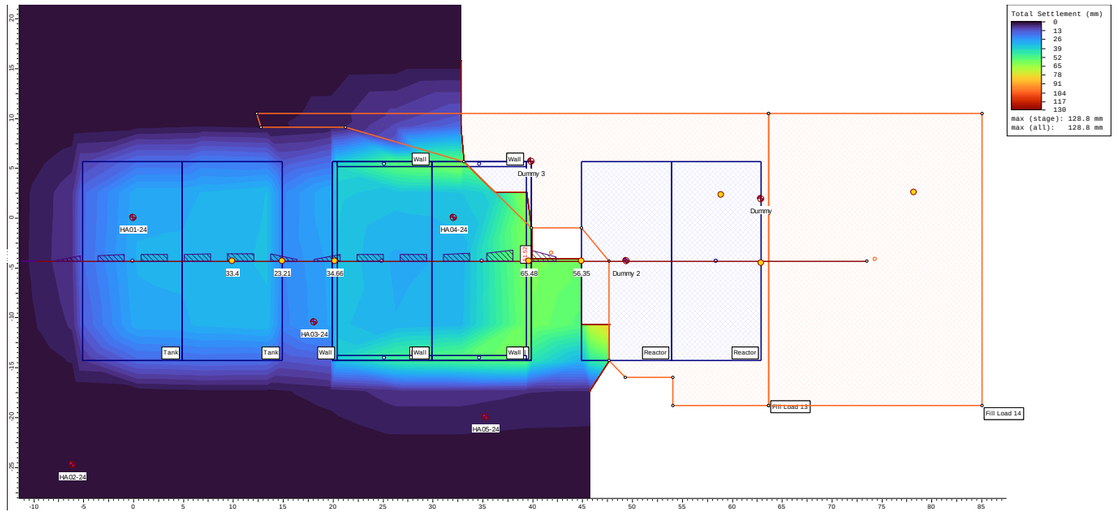
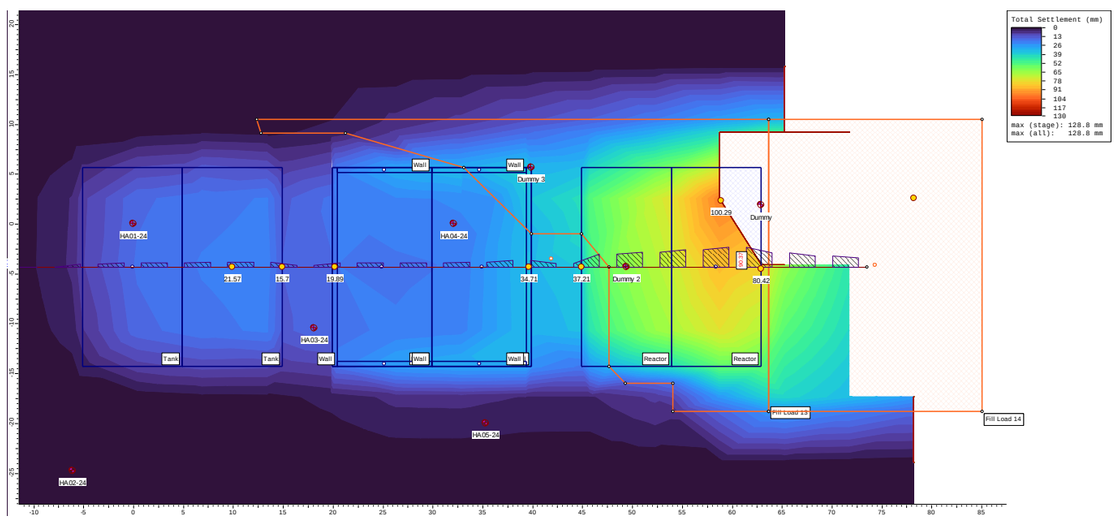


Figure 4: Post-construction settlement contours at RL 15.1 m



5.0 RECOMMENDATIONS

To avoid additional mitigating measures to address excessive differential settlements, it is recommended to undertake additional geotechnical investigation comprising deep CPT boreholes within the vicinity of the structures to provide a more detailed settlement assessment. CMW must also be advised should there be changes in the bearing pressures analysed in this report. These may be done in the detailed design stage.

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APPENDIX E
Geotechnical Works Specification

Auckland
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Rosedale 0632
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www.cmwgeosciences.com

Version control

Document version information	
Jon number	AKL2024-0185AC
Prepared by	Jenna Pallarca, Project Geotechnical Engineer
Reviewed by	Gaurav Mathur, Principal Geotechnical Engineer
Authorised by	Chris Ritchie, Principal Engineering Geologist CMEngNZ, PEngGeol

Review and update history

Version	Date	Comments
A	29 November 2024	Initial draft for internal review
0	11 December 2024	Final draft for client review
1	26 February 2025	Issued for Consent

CONTENTS

1.0 INTRODUCTION

CMW Geosciences (CMW) was engaged by FHLDL to prepare a Geotechnical Works Specification for a site located at Milldale Development, which is being considered for the construction of a temporary wastewater treatment facility.

This report is to support a resource consent application to Auckland Council.

This specification covers the geotechnical remediation works and associated earthworks outlined in the CMW Investigation Report (GIR), referenced AKL2024-0185AC Rev. 1 It supplements the information provided on the design drawings and GIR. It provides detail on the required specification for:

- Site clearance and preparation including topsoil stripping and stockpiling.
- Geotechnical stabilisation works such as shear keys, geotextile reinforced earth slopes (with 30-degree face angle or less) and stability undercuts.
- Subsoil drainage installation.
- Cut to fill earthworks operations.
- Fill materials and testing requirements.
- Earthworks finishing and respread of topsoil; and,
- As-built records.

Excluded from the scope are geotextile reinforced slopes with a face and steeper than 30 degrees or retaining structures covered by a building consent. Such works will be carried out in accordance with an independent structure specific specification.

Unless varied onsite by the Geotechnical Engineer, the following specification requirements must be met in order for CMW to provide a Geotechnical Completion Report (GCR) for the works.

2.0 RELEVANT DOCUMENTS

2.1 Standards, Guidelines and Consents

The works shall comply with the relevant sections of the following standards, guidelines, and consents:

- Health and Safety at Work Act 2015 and Regulations 2016.
- All Project Resource Consent Conditions and Engineering Works Approvals.
- The Auckland Council Code of Practice for Land Development and Subdivision Chapter 2 version 2, July 2022
- NZS 4431:2022 Engineered Fill Construction for Lightweight Structures.
- NZS 4402: 1986 Methods of Testing Soils for Civil Engineering Purposes; and,
- NZS 4404: 2010 Code of Practice for Urban Land Subdivision.
- WorkSafe NZ – Excavation Safety Good Practice Guidelines, July 2016.

2.2 Geotechnical Investigation / Design Report

Details of the geotechnical investigation, soil and rock conditions encountered, and the design of the geotechnical remedial works are contained in the CMW report AKL2024-0185AC Rev. 1. The contractor should be aware of the contents and comply with the recommendations contained in that report.

2.3 Construction Drawings

The works shall comply with the following geotechnical design drawings and standard details:

- Consent plans provided by Woods for Milldale Stage 8, referenced in Appendix B of the GIR

2.4 Conflicting Information

Where there is any conflict or discrepancy in the requirements of this specification and the documents listed above the matter shall be referred to the Geotechnical Engineer (CMW) for clarification.

3.0 GEOTECHNICAL OBSERVATIONS

The following items form hold points in the construction works that require observation, testing and approval by the Geotechnical Engineer (CMW):

- Foundations for filling once topsoil and unsuitable materials have been stripped prior to fill placement.
- Shear key excavations and undercuts to confirm depth and extents prior to backfilling.
- Subsoil drain excavations prior to placement of aggregate;
- Any imported soil fill materials prior to placement on site.
- Drainage aggregate quality prior to placement.
- Geotextile layers once in place and prior to backfilling.
- Filling placed at regular intervals to comply with the fill test frequency requirements below.
- Compaction of backfilling in critical service trenches.
- Flushing of the subsoil drainage system at the completion of earthworks.
- Any unforeseen ground conditions that may impact on the construction works or future land use; and,
- Installation of any settlement monitoring plates or points, application of pre-load and approval prior to its removal.

It is the contractor's responsibility to ensure that the Geotechnical Engineer is given reasonable notice (i.e., 24 hours) and opportunity to observe the above works and that the works do not proceed until approval has been gained from the Geotechnical Engineer.

4.0 CONSTRUCTION SPECIFICATION

4.1 Site Preparation

The Contractor shall remove all vegetation from the site of the earthworks except for trees indicated for preservation either by marking on the site or noted on the drawings and clear the remainder of the site.

Clearing shall mean the felling of all trees, except those indicated, removal of all growth other than grass and weeds, extraction of tree stumps, demolition of fences and other minor items remaining in the way of site stripping, and the complete disposal of all items. Stumping shall mean the removal of all roots greater than 25mm in diameter.

Cleared areas shall be stripped to remove all turf and organic topsoil to depths designated by the Engineer ahead of or during the stripping operations. Stripping shall also cover picking up any old topsoil stockpiles and any buried topsoil detected during the course of the works. The depth shall be sufficient to remove all materials considered unsuitable as fill or unsuitable to remain beneath fill but will not necessarily extend to the full limit of organic penetration.

4.2 Erosion and Sediment Control

The works shall be carried out in accordance with the project Erosion and Sediment Control Management Plan and associated drawings.

The contractor shall ensure good control of surface water runoff at all times by shaping of the surface in cut and fill areas to prevent ponding during rainfall events.

The location of temporary Sediment Retention Ponds (SRP) on sloping ground shall be decided upon with input from the Geotechnical Engineer. Where comment of SRP stability is sought by Council then all fill materials used to form batters, must be placed as engineered fill and tested accordingly unless advised otherwise by the Geotechnical Engineer.

When decommissioning temporary sediment ponds, all water softened material in the bases and sides of the ponds shall be removed and undercut to the satisfaction of the Geotechnical Engineer. Backfilling of temporary ponds shall be to the compaction standard for general filling unless otherwise specified.

4.3 Stockpiles

Topsoil stockpiles can add significant driving force for slope instability when placed at or near the crest of a slope. The location of all temporary stockpiles must be approved by the Geotechnical Engineer prior to placement. Where stockpiles cannot be avoided above sloping ground, they should be placed over a wide area with the height restricted under the direction of the Geotechnical Engineer.

4.4 Fill Foundations and Benching Slopes

The foundation on which filling is to be placed must be observed by the Geotechnical Engineer following clearing and prior to the placement of any filling to confirm the strength of the underlying soils is sufficient.

Where it is found, after clearing and stripping operations as specified, that the foundation on which filling is to be placed is unstable, or in cuttings if it is found after the excavation has been cut down to the levels shown in the drawings that unstable ground is encountered, then the Engineer may direct that the soft, yielding, or unstable materials causing such instability shall be removed to such depth as directed.

Benching of slopes prior to the placement and compaction of filling should be carried out in accordance with the normal requirements of NZS 4431 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.

4.5 Shear Key, Fill Drainage Key and Buttress Fill Excavations

All shear keys, fill drainage keys and buttress fills required to improve long term stability conditions are to be constructed in accordance with the design drawings and standard details. The key/buttress base width, lateral extent and benching requirements need to be confirmed on site by the Geotechnical Engineer during construction. In most cases this requires detailed logging of the excavation faces by a geo-professional and may require trial pits to be dug in the base of the excavation. The contractor should make allowance for the time and plant required for these inspections in their work programme.

4.6 Fill Materials and Conditioning

4.6.1 Material Types

Table 1: Material Types

Material Type	Description	Comments
T	Topsoil	Natural material at surface
F	Fine-grained	Based on more than 35% material passing the 63µm sieve
I	Intermediate-grained	Based on material that has between 15% to 35% passing the 63µm sieve
C	Coarse Grained or aggregate	Based on no more than 15% material passing the 63µm sieve
R	Rock	Material described as rock as per NZGS Field Description of Soil and Rock
M	Manufactured	Any manufactured material created or modified for the purpose of earthworks (such as crushed concrete, recycled asphalt, etc)

The soils at this site are predominantly classified as material type F

4.6.2 Blending of Unsuitables

The blending of ‘unsuitables’ into structural fills may be undertaken only at the discretion of the Geotechnical Engineer following a request by the contractor and with sufficient time for appropriate consideration. Approval for any such blending must be sought from and provided by the Geotechnical Engineer in writing prior to the commencement of any blending.

In consideration of any such requests, the Geotechnical Engineer will need to be able to assess, et. al., the composition of the materials requested to be blended, the location on the site for the proposed fills, the fill depths and the elevation of the blended materials within the fills and any environmental constraints.

As a minimum, it is expected that any blended fills will be directed to comply with the following conditions:

All significant, solid inorganics (such as roots and stumps) to be removed prior to blending; and,

All inclusions of suitable man-made materials (e.g. concrete) and any excavated rock must comply with the normal compaction requirements specified herein in terms of size and ability for appropriate compaction to be achieved in close vicinity to the inclusions.

All blended materials must be appropriately mixed/ blended normal fill materials to the specified ratio. Un-mixed interlayering of normal engineered filling with unsuitables will not be accepted.

As a preliminary indication, it is expected that the ratio of unsuitables to suitable fill will not exceed 1 in 10 by volume.

It is expected that the Geotechnical Engineer will also need to apply limits to the location/ depth of blended fills within any specified fill area.

4.6.3 Hardfill

Hardfill used as structural filling shall be a graded, unweathered, durable, crushed rock product approved by the Geotechnical Engineer, with a grading suitable for compaction.

4.6.4 Material Conditioning

The cut materials on site may require some drying prior to compaction to achieve the required specification. This may be done by harrowing (such as with discs) and air drying when conditions permit or by the addition of hydrated lime.

The addition of lime and/or cement to engineered filling in concentrations greater than 3% requires the approval of the Geotechnical Engineer.

All additives such as lime or cement proposed for use in backfill materials for Reinforced Earth Slopes or other materials in contact with geosynthetics must be approved and monitored by the Geotechnical Engineer.

4.7 Fill Placement, Compaction and Testing Requirements

4.7.1 Soil Fill

Soil placed in fills shall be conditioned and compacted until the following conditions are satisfied.

It should be noted that the surface of the fill area prior to placement of subsequent fill lifts should be in a state so as not to create a break in the consistency of the fill material between lifts. For example, if surfaces are left to dry out, or rolled to seal them from rainfall infiltration then the surface must be broken up and scarified with rippers or by other means to ensure a good bond between fill lifts.

The maximum lift of filling placed before compaction is dependent on the size and nature of the compaction equipment. Typically, 250mm to 300mm loose depth is considered the maximum for a Cat 815/820 type compactor. In any event the contractor must ensure that the fill is placed and compacted to achieve even and adequate compaction throughout each layer/lift.

The test criteria and frequency are set out below.

Table 2: Testing Requirements

Material Type	Test and Method	Acceptance Requirement	Minimum Frequency
F (Fine-grained)	Particle size distribution (NZS4407 test 3.8 or NZS4402.2.8.1)	100% passing 19mm sieve and min. 35% passing 0.075mm sieve	1 per source and 1 per change in material
	Dry density / water content relationship (NZS4402.4.1.1, NZS4402.4.1.2)	OMC and MDD determined	
	Water content (NZS4402.2.1)	Between OMC -2% and OMC +4%	
	Solid density (NZS4402.2.7.1 or 2.7.2)	Solid density determined	
	Liquid and plastic limits (NZS4402.2.2, NZS4402.2.3 and NZS4402.2.4)	PI < 25% and LL <50%	1 per source, 1 per change in material and 1 per 4,000m^3
	Field water content and density (NDM) (NZS4402.2.1 and NZS4407 test 4	>90% MDD and minimum <10% air voids over 10 tests. Maximum single value 12%	2 per 1,000m^3 (minimum 2 per lift)
	Shear strength (NZGS guideline for hand held shear vane)	Minimum average 140kPa over 10 tests. Minimum single value 120kPa	
C (Coarse-grained)	Particle size distribution (NZS4407 test 3.8 or NZS4402.2.8.1)	100% passing 75mm sieve and min 15% and max 35% passing 0.075mm sieve	1 per source and 1 per change in material
	Dry density / water content relationship (NZS4402.4.1.1, NZS4402.4.1.2)	OMC and MDD determined	
	Water content (NZS4402.2.1)	Between OMC -2% and OMC +4%	
	Solid density (NZS4402.2.7.1 or 2.7.2)	Solid density determined	
	Field water content and density (NDM) (NZS4402.2.1 AND NZS4407 test 4)	>90% MDD and minimum <15% air voids over 10 tests. Maximum single value 12%	1 per 1,000m^3 (min 2 per lift)
	Dynamic Cone Penetrometer	>5 blows per 100mm	2 per 1,000m^3 (min 2 per lift)
	Impact test – 4.5kg hammer (ASTM D 5874)	CIV > 25	1 per 50m^3 on each compacted layer (min 2 per lift)

The test criteria and/or frequency may be relaxed at the discretion of the Geotechnical Engineer (CMW) for the project or in a discrete fill area subject to the consistency of the results achieved being acceptable over a specified period of time.

4.7.2 Site Won Rock Fill

A compaction specification is to be determined by the Geotechnical Engineer based on site trials.

4.7.3 Hardfill

The test criteria and frequency are set out below for hardfill.

Table 3: Testing Requirements

Material Type	Test and Method	Acceptance Requirement	Min Frequency
GAP65	Particle size distribution (NZS4407 test 3.8 or NZS4402.2.8.1)	Refer GAP65 particle size criteria in NZS4431	1 per source and 1 per change in material
	Dry density / water content relationship (NZS4402.4.1.1, NZS4402.4.1.2)	OMC and MDD determined	
	Solid density (NZS4402.2.7.1 or 2.7.2)	Solid density determined	
	Weathering quality index	AA, AB, AC, BA, BB or CA	
	Field water content and density (NDM) (NZS4402.2.1 AND NZS4407 test 4)	>95% MDD and minimum <15% air voids over 10 tests. Maximum single value 12%	1 per 1,000m^3 (min 2 per lift)
	Dynamic Cone Penetrometer	>5 blows per 100mm	1 per 500m^3 (min 2 per lift)
	Impact test – 4.5kg hammer (ASTM D 5874)	CIV > 25	1 per 50m^3 on each compacted layer (min 2 per lift)
GAP40	Particle size distribution (NZS4407 test 3.8 or NZS4402.2.8.1)	Refer GAP40 particle size criteria in NZS4431	1 per source and 1 per change in material
	Dry density / water content relationship (NZS4402.4.1.1, NZS4402.4.1.2)	OMC and MDD determined	
	Solid density (NZS4402.2.7.1 or 2.7.2)	Solid density determined	
	Weathering quality index	AA, AB, AC, BA, BB or CA	
	Field water content and density (NDM) (NZS4402.2.1 AND NZS4407 test 4)	>95% MDD and minimum <15% air voids over 10 tests. Maximum single value 12%	1 per 1,000m^3 (min 2 per lift)
	Dynamic Cone Penetrometer	>5 blows per 100mm	1 per 500m^3 (min 2 per lift)
	Impact test – 4.5kg hammer (ASTM D 5874)	CIV > 25	1 per 50m^3 on each compacted layer (min 2 per lift)

4.7.4 Compaction Testing Reporting Requirements

All test location coordinates to be recorded by handheld GPS with reference to the NZTM projection. Test location coordinates, with date and test number reference are to be provided to the Geotechnical Engineer in electronic (excel) format on a weekly basis. Alternatively, the Geotechnical Engineer may approve the use of site plans to mark the location of tests in lieu of GPS location.

The volume of filling placed for each progress claim month (typically ending 20th of the month) including all filling placed (undercut and cut to fill) to be provided to the Geotechnical Engineer monthly by the contractor or Engineer to the Contract to allow assessment of test frequency adequacy.

Interim fill test summaries are to be provided to the Geotechnical Engineer for review on a regular basis.

4.8 Subsurface Drainage

4.8.1 General

Drainage for shear keys, fill drainage keys, buttress fills, underfill gully drains and counterfort drains shall be constructed in accordance with the design drawings and standard details.

4.8.2 Materials

Pipes

Drainage pipes used in subsoil drainage shall be 160mm diameter highway grade drain coil. Drain coil walls shall be perforated or solid as detailed in the design drawings or directed by the Geotechnical Engineer on site. Drain coils shall not have a geofabric filter sock unless requested by the Geotechnical Engineer on site.

Aggregate

Auckland Council now generally require that subsoil drainage has a 100-year design life and is essentially maintenance free, unless there is an entity such as body corporate or resident's association that maintenance responsibility can be transferred to. Maintenance by individual owners is not practical as the subsoil drainage systems usually cross over, and generally benefit, multiple lots.

This requires a high-quality drainage aggregate with the following properties:

Self-filters against the soils present on site preventing loss of permeability over time; or, able to be practically wrapped in a suitable geofabric filter.

High permeability, which translates to a low fines content; and

Stable and not subject to crushing, weathering, internal erosion or piping, or significant loss of volume (settlement) over time.

Ideally the drainage aggregate should be a well graded self-filtering material such as a clean (free of significant cohesive fines) scoria SAP50 product or Transit F/2 specification filter media.

Alternatively, for shear key drainage, blanket drains, underfill drainage and all applications where full encapsulation with a geofabric filter cloth can be relatively simply and safely achieved, an open graded product, preferably 27/7 Scoria may be used. Care will need to be taken to ensure that the cloth fully encapsulates the aggregate. Observation of the cloth wrap should form an inspection hold point prior to backfilling over the drain. Drain coils in this instance do not require a filter sock.

For counterfort trench drains and applications where a full filter cloth wrap is not practical to construct, and the performance of the drain is not critical to maintaining slope stability then a SAP20 or SAP50 may be used without a filter cloth wrap. Drains which fall into this category must be defined and confirmed as such by the Geotechnical Engineer. Additionally, where such materials are used, regular visual inspections and approval of the aggregate quality and laboratory grading curves is required. This is to comprise visual inspection of each site stockpile prior to material being placed in the trench. One wet sieve grading curve from each site stockpile per week is required while material is being imported to site to monitor the fines content. Drain coils in this instance do not require a filter sock.

For counterfort trench drains and applications where a full filter cloth wrap is not practical to construct, and the performance of the drain is critical to maintaining slope stability then a TNZ/F2 or (approved) modified F2 aggregate

must be used. In conjunction with this an approved high specification drainage pipe with filter cloth surround such as the Megaflo products may be specified.

Light compaction (i.e. tamping with back of excavator bucket) only is to be applied to drainage aggregates.

Filter Cloth

Any filter cloth surround specified on the drawings shall meet the requirements of Transit Specification TNZ/F7, Filtration Class 2 and Strength Class B unless otherwise specified on the drawings.

Trench Backfill in Service Trenches

It is important on all sloping land that service trenches running parallel to contours are avoided where possible as they can permit the ingress of surface water and/or lateral movement of trench sides that could lead to progressive land slippage, help develop tension cracks and possibly lead to slope and building instability.

Backfilling of all trenches should be to the general fill standard above unless specifically varied in writing by the Geotechnical Engineer and where possible the pipe bedding in all trenches on steep ground should contain a 50mm diameter perforated drain coil that is connected into each manhole on the line. This is to help prevent instability arising from the ingress of surface water and/or lateral movement of trench sides that could lead to progressive land slippage and is especially important where the lines are in close proximity to buildings.

The subdivision drain laying contractor must be made aware of these requirements and of the need to contact us when trench backfilling is to take place.

4.8.3 Depth and Extent

The location, extent and depth of the drainage shown on the design drawings may be varied on site by the Geotechnical Engineer in response to the ground conditions encountered.

4.8.4 Drainage Outlets and Inspection Points

Outlets for subsurface drainage shall be provided at regular intervals shown on the drawings or as determined on site by the Geotechnical Engineer. Pipe outlets shall be specifically formed structures with adequate protection such as a headwall and/or rock rip rap. The position of all outlets shall be recorded on the asbuilt drawings.

Where possible it is good practice to include additional inspection and/or flushing points in the subsoil drainage system in the event that their performance needs to be confirmed in the future.

In any event, at least one temporary flush point is required for each subsoil drainage system to enable flushing of the system once the earthworks are substantially complete.

The flushing of the subsoil drainage system must be witnessed by the Geotechnical Engineer.

4.9 Finishing Works and Topsoil Spread

4.9.1 Overcut

All areas cut to below finished level should be reinstated with engineered filling to the satisfaction of the Geotechnical Engineer.

4.9.2 Topsoil Depth

Topsoil respread depth should be between 100mm and 300mm, or as directed by the Engineer to the contract. On ground steeper than 1V:3H the surface should be roughened under the supervision of the Geotechnical Engineer prior to topsoil placement.

4.9.3 Unsuitable Materials

At the conclusion of earthworks all surplus unsuitable materials should be removed from site or placed in designated permanent stockpiles. The size and location of such stockpiles must be approved by the Geotechnical Engineer and recorded on the asbuilt drawings.

4.9.4 Road Subgrades

Testing and formation of road subgrades will be carried out as part of the subdivision civil works package.

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