25 March 2024

SILVERDALE WEST

DAIRY FLAT HIGHWAY, SILVERDALE

GEOTECHNICAL ASSESSMENT REPORT

Fletcher Development Limited

AKL2022-0152 AB Rev3

AKL2022-0152 AB		
Date	**Revision**	**Comments**
18 October 2022	A	Initial draft for initial review
21 October 2022	0	Final draft for client review
14 December 2022	1	Final issue to client
11 August 2023	2	Revised issue to consider alternative plan change area

	Name	Signature	Position
Prepared by	Andrew Gordon		Project Engineering Geologist
Reviewed by	Chris Ritchie		Principal Engineering Geologist CMEngNZ, PEngGeol
Authorised by	Richard Knowles		Principal Geotechnical Engineer CMEngNZ, CPEng

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1 INTRODUCTION

CMW Geosciences (CMW) was engaged by Fletcher Development Limited to carry out a geotechnical investigation of a site located at Dairy Flat Highway, Silverdale, which is being considered for the construction of an industrial subdivision. This report is to provide geotechnical input to support a Plan Change Application to urbanise current Future Urban zoned land.

This report is to support a plan change application to Auckland Council.

The purpose of this report is to summarise the existing information, preliminary ground conditions expected, identify and quantify geotechnical risks to the proposed subdivision development.

1.1 Scope of work

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced AKL2022-0152AA, Rev 0 dated 23 August 2022, and is defined as follows:

- Desktop analysis of the site, including review of available existing reports, historic aerial photographs, and published geology.
- Site walkover and geomorphological mapping.
- Provision of plans showing anticipated geology, geomorphology, and geotechnical hazard / constraint zones.
- A Geotechnical Assessment Report summarising the above, which will include any areas of historic filling identified and discuss potential constraints to future urban development.

2 SITE LOCATION AND LANDFORM

- The site comprises an area of approximately 107.35 hectares and is located immediately west of the Northern Motorway, bound to the northwest by Dairy Flat Highway, as shown on **Error! Reference source not found.**.
- The current general landform is presented on the attached Site Plan ***(Appendix A)*** and in Figures 1 & 2.
- The subject area comprises 14 parcels of land.
- Current land use is predominantly pasture, with scattered trees and shelter belts. The northern portion of the site south of Dairy Flat Highway is more densely covered in scrub and trees. Stand-alone rural-residential dwellings are scattered across the western portion of the site, together with assorted farm buildings. Due to the historical farming land use, rubbish fills, offal pits and uncontrolled fills may exist. Where these were observed during our site walkover, they have been noted on the Geomorphology Plan (Figure 6).
- Topography of the site is dominated by an easterly to north-easterly trending ridge, along which lies Dairy Flat Highway. The ridgeline climbs from approximately 32mRL in the north-east, to approximately 70mRL in the south-west. The eastly flank of the ridgeline falls gently towards John Creek, meeting the alluvial terrace at approximately 25mRL, forming a gently sloping wide alluvial valley, with multiple east-west orientated tributaries extending below the Northern Motorway via culverts.
- Under the Auckland Council Unitary Plan, the land is currently zoned Future Urban.

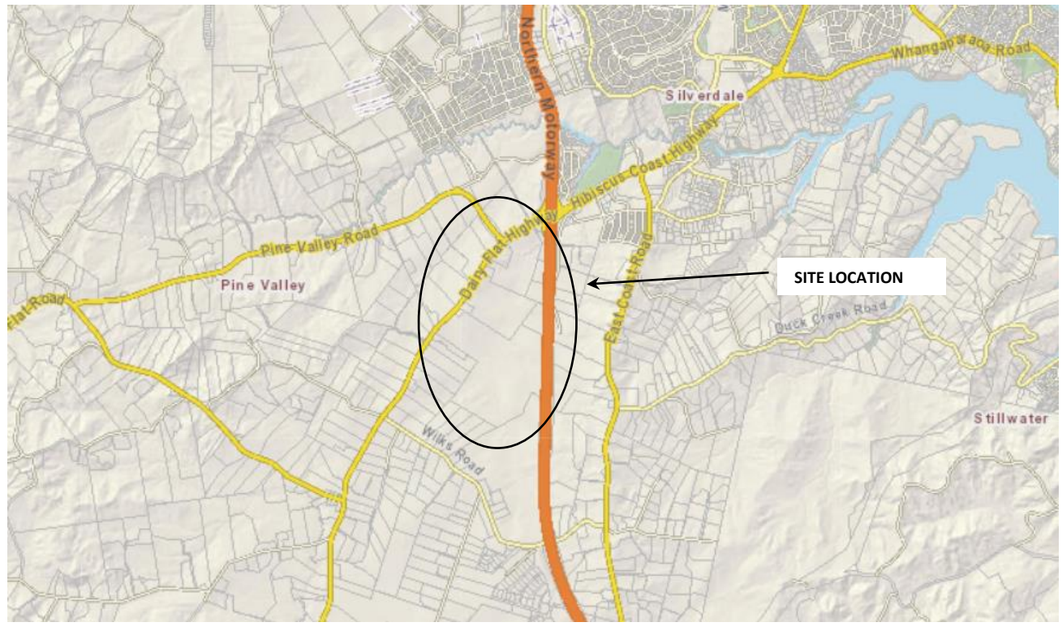


Figure 1: Site Location Plan (Auckland Council Geomaps)

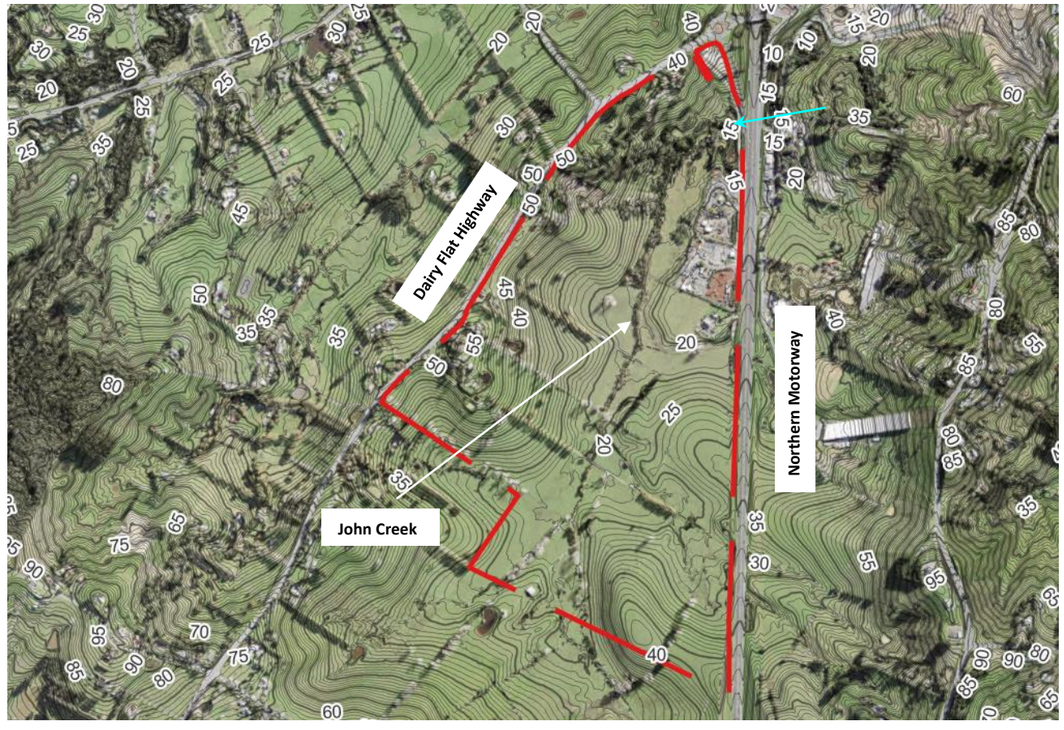


Figure 2: Site Contour Plan (Auckland Council Geomaps)

FACTUAL

3 DESKTOP STUDY

Related Documents
Auckland Council Silverdale West Dairy Flat Business Area Structure Plan, Geotechnical Topic Report, December 2017.
Auckland Council Silverdale West Dairy Flat Industrial Area Structure Plan, Geotechnical Topic Report, April 2020.
CMW Geosciences 1660 Dairy Flat Highway, Dairy Flat, Geotechnical Investigation Report, Ref AKL2020-0122AB Rev.0, 31 July 2020.
CMW Geosciences Silverdale West. Dairy Flat Highway, Silverdale, Geotechnical Comment on RTN Alignment Options, Ref AKL2020-0122AE Rev.0, 20 July 2021.
CMW Geosciences Onion patch LOT 2 DP 480626, Dairy Flat Highway, Silverdale, Geotechnical Investigation Report, Ref AKL2019-0198AB Rev.0, 25 November 2019.

Historical Aerial Photographs		
Source	**Photograph Set**	**Notes/Observations**
Retrolens	S/N 143, North Auckland, Run 84, Photo 30, Scale 1:16000, 24/04/1940;	Earliest known Aerial Photograph
	S/N 1052, North Auckland, Run C, Photo 6, 7, 8 and 9, Scale 1:12700, 14/04/1958;	Minor filling east of John Creek
	S/N 5783, North Auckland, Run G, Photo 17, Scale 1:25000, 29/03/1981.	Cut and fill of platform at northern end of the site and infilling/realignment of farm drains
Auckland Council Geomaps	Aerial Photography Set – 1999 Rodney	Construction of Northern Motorway, placement of fill within north-eastern corner of the site.
	Aerial Photography Set - 2017	Development of industrial area in northern area of the site

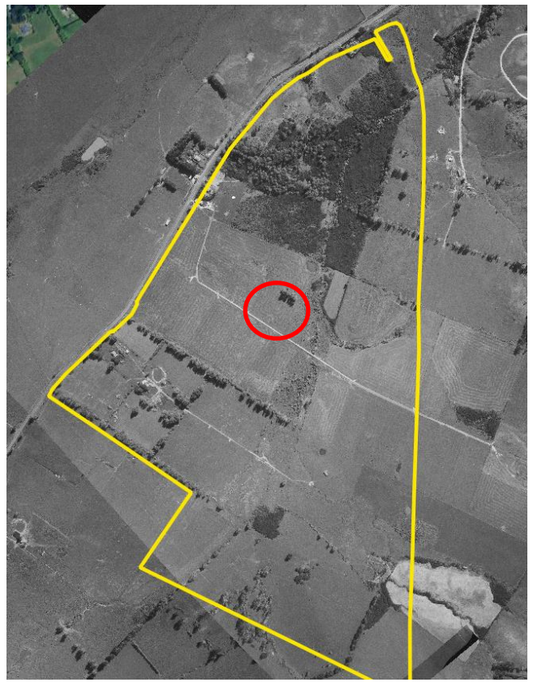


Figure 3: 1958 (Retrolens)

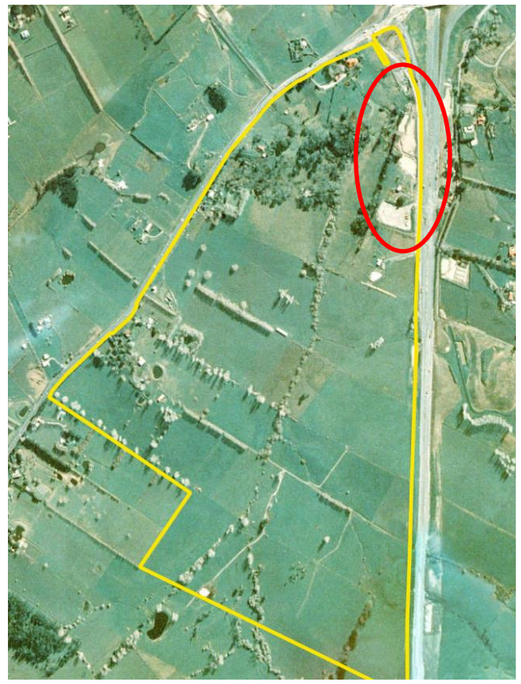


Figure 5: 1999 (Auckland Council GeoMaps)

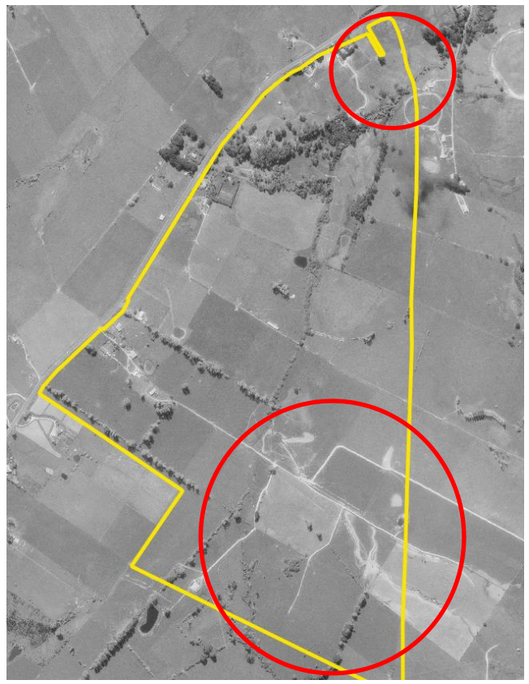


Figure 4: 1981 (Retrolens)

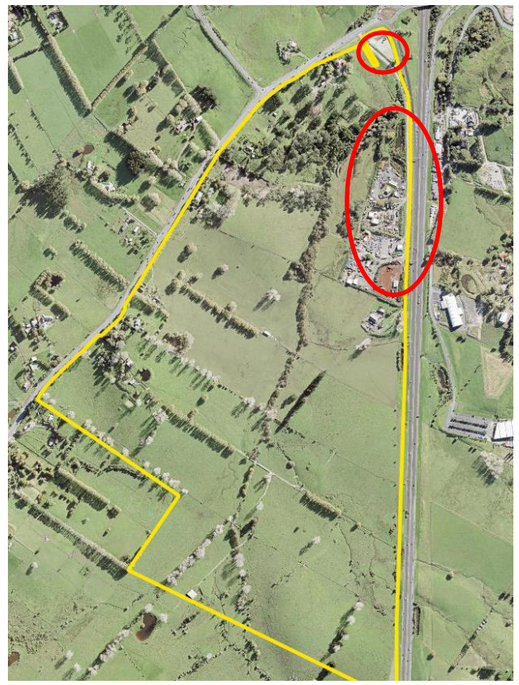


Figure 6: 2017 (Auckland Council GeoMaps)

FACTUAL

4 GROUND MODEL

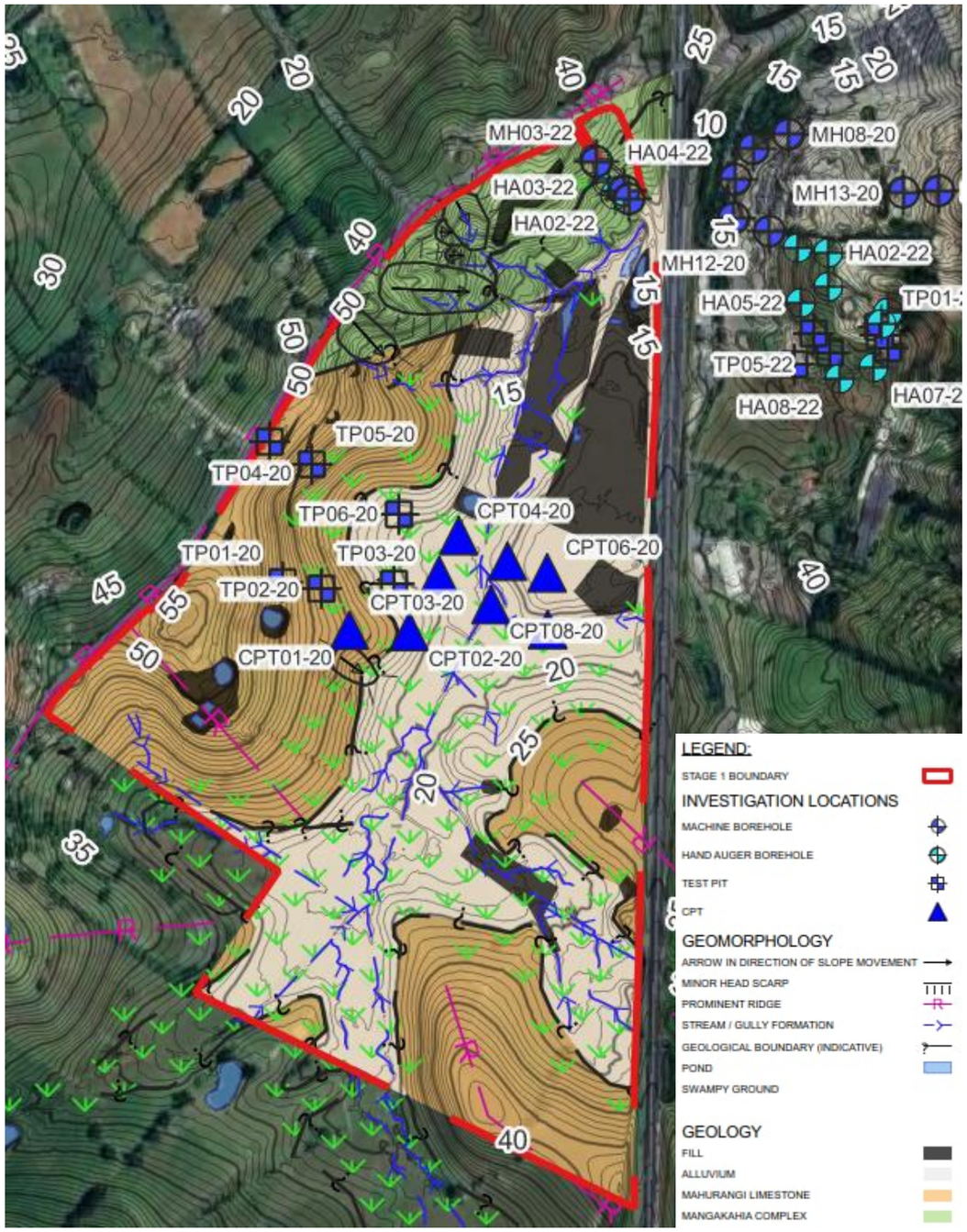
4.1 Geomorphology

- The geomorphology of the site was mapped by examination of aerial photography stereo pairs, and during a site walkover, and is shown in the Geomorphology Plan (Figure 7 and Appendix A).
- The geomorphology reflects the underlying geology and associated slope processes. There are three distinct landforms which likely reflect different geological units.
- The Dairy Flat Highway ridgeline and elevated areas between John Creek and the Northern Motorway are characterised by gentle to moderate slopes with small scale slope instability in the form of creep. Mid-slope water seepages and swampy ground are common, indicating elevated (likely perched) groundwater conditions. These areas are expected to be underlain by Northland Allochthon units, predominantly Mangakahia Complex.
- The western slopes between John Creek and Dairy Flat Highway are typically characterised by gentle slopes, expected to be underlain by Mahurangi Limestone. Localised areas of steeper gradients in the northern corner– are likely underlain by Mangakahia Complex.
- The lower lying, gently sloping to flat areas contain drainage channels and tributary streams flowing to the John Creek. These gently sloping areas likely indicate the extent of the alluvium where it meets the underlying Northland Allochthon, often a line of seepages is observed along this boundary. Small rotational failures are common along the bank of watercourses and farm drains.
- Minor earthworks and fills have been carried out in the past across the site to form farm ponds, farm races, drainage channels and to level building platforms.

4.2 Geology

The geology of the subject area has been assessed from a combination of published geological maps and the topography, geomorphology, and previous geotechnical investigations. A Geology and Geomorphology plan is provided in ***Appendix A.***

A summary of the geohazards associated with each geology were identified through the Preliminary Natural Hazard Risk Assessment for this site attached as ***Appendix B,*** a summary can be found overleaf.



INTERPRETIVE

Geotechnical Hazards			
Geological Unit	**Location**	**Description**	**Behaviour**
Mahurangi Limestone **(of the Northland Allochthon)**	Published maps indicate this is the prominent geologic unit underlying the site, predominately found on the eastern side of the Dairy Flat Highway Ridge	Typically, blue grey to white, muddy limestone, with some serpentinite deposits, which forms gently rolling slopes, which weathered to low-permeability clay, typically several meters thick. A shattered rock zone is present at the weathering interface. Both the intact strength and degree of shattering of the rock mass are variable Groundwater levels are expected to be near the existing ground surface across most of the site, as indicated by the extensive covering of rushes over gentle to moderate slopes, with springs likely feeding the various ponds and ephemeral watercourses. Within zones of high elevations, close to ridgelines groundwater is anticipated to be encountered between 2m and 5m depth, generally above the soil-rock interface.	Typical failure mechanisms for this geology will generally comprise shallow translational sliding, even on gentle to moderate gradients, at transition to rock and within the upper profile of the rock mass and is most significantly impacted by either cutting on/below a slope. ***Landslip*** is the predominate geohazard in this geology.
Mangakahia Complex **(of the Northland Allochthon)**	Mapped within the northern corner of the site, extending along the north-facing slopes underlying Dairy Flat Highway.	Typically, highly fractured or even shattered and variably weathered, soft, red, brown, grey and green, commonly highly sheared, clay-rich mudstone with rare interbeds of glauconitic greensand and micaceous sandstone, which weathers to low shear-strength, high plasticity clays. Many small serpentinite bodies are enclosed within this unit. Groundwater seepages are common from mid-slope.	High plasticity clays are prone to debris sliding and deep-seated creep, even on gentle (<10°) slopes. Weathering generally extends to depths of about 10 metres, however there is seldom a significant improvement in rock strength at this depth and a transitional zone between soil and rock is rarely observed, unlike other units of the Northland Allochthon. ***Landslip*** is the predominant geohazard in this geology.
Tauranga Group Alluvium/ Colluvium	Mapped in low-lying areas around the John Creek.	Late Pleistocene-aged (14,000 to 1.8Ma), up to 20m thick unconsolidated to very soft yellow grey to orange-brown mud, sand and gravel, with local muddy peat and pumice silt beds Upper few metres are commonly weathered to very soft clays. Groundwater is typically shallow in this geological unit, regularly 1 metre below ground level or less.	Susceptible to soil creep and shallow flows on gentle slopes, particularly when saturated. Will usually subside if unsupported or overloaded. ***Subsidence*** (load induced settlement) is the predominant geohazard in this geology, however ***Landslip*** can also be expected in the vicinity of incised watercourses. ***Liquefaction*** is unlikely to be a hazard in this geology, despite its saturated state. Susceptibility analysis of a soil also considers its age and plasticity. Pleistocene aged alluvium has a very low to low risk of liquefaction and deposits in this area are typically plastic.

5 GEOHAZARDS ASSESSMENT & MITIGATION

Commentary on the most significant hazards are listed overleaf. A preliminary risk assessment of these hazards is presented in ***Appendix B***.

Three Geohazard Zones have been identified within the subject site.

- Zones 1 & 2 are defined by the approximate extents of the Northland Allochthon slope areas and Alluvial terrace areas respectively.
- Zone 3 encompasses the stream-edge areas where instability may occur. This is defined by an indicative horizontal offset from the stream of four times the height from the alluvial terrace to the stream invert.

The extents of these areas are shown in the appended Geohazard Zone Plan ***(Appendix A)***.

The Northland Allochthon materials (Zone 1) can be highly variable over a limited spatial area and mitigation measures are largely dependent on the unit which is encountered. Three distinct units of the Mangakahia Complex have been observed during the previous works undertaken by CMW on adjacent sites, in addition to the mapped Mahurangi Limestone.

Without further site-specific investigation, the specific unit of Mangakahia Complex is underlying the northern section of the site or the spatial distribution of the material along west along the ridgeline is not fully understood at this stage. The description of the Mangakahia complex in Section 4.2 above reflects the Hukerenui Mudstone, which is typically considered to be the most challenging to mitigate and has been conservatively adopted for all Northland Allochthon materials identified and is considered likely that the ground conditions encountered will be better than those inferred in this due diligence assessment.

Geotechnical Assessment and Mitigation			
Geotechnical Hazard	**Description**	**Area Affected**	**Comments and Geotechnical Control / Mitigation Measures**
Water/Groundwater	Surface Water	Alluvial terrace (Geohazard Zone 2)	A significant number of watercourses, some ephemeral, some permanent, exist within the subject area. Many have been altered to form farm drains. For the purposes of this report, we have assumed that these can be filled, except for John Creek and its major tributaries. It can be assumed that any filling will have underfill drainage placed beneath it to allow the flow of water to continue and to prevent the build-up of groundwater pressures from developing beneath the fill.
	Shallow Groundwater	Entire Site	During the site walkover large areas of swampy ground and/or ponding were observed. Mitigated by the installation for subsoil drainage is expected to be required to control water within the natural soils, additionally groundwater take and diversion consents for areas of long-term construction and/or permanent water table lowering will be required. Given the elevation of Dairy Flat Highway, it is likely that the greatest cuts will be undertaken near this boundary. Whilst likely to be considered a restriction discretionary activity (AUP OP E7), the underlying Northland Allochthon soils have extremely low permeability. Experience from earthworks projects in the region are that groundwater drawdowns do not typically extend far beyond the excavation and effects on neighbouring properties from the effect of drawdown are minor. It is expected that this will be investigated with a groundwater monitoring regime carried out prior to any resource consent application along this boundary. Stormwater soakage to ground is typically not feasible.
Erosion	Cut Batters	Unknown (future cut areas)	Mitigated by designing for maximum 1V:5H gradient, or steeper with surface stabilisation / treatment included in design (such as shear keys by over excavation and replacement, soil nails, retaining walls).
	Fill Batters	Unknown (future fill areas)	Mitigated by designing for maximum 1V:3H gradient, stormwater control and/ or steeper with surface stabilisation / treatment in design (such as reinforced earth slopes / walls).
Landslip	Global Slope Instability	Elevated areas and slopes. (Geohazard Zones 1 and 3)	The primary geotechnical hazard in Northland Allochthon terrain is slope instability. Slope stability remedial works in this geology typically include undercutting of transition zone deposits and/ or keying fills into the less weathered rock mass, the installation of extensive networks of subsoil drainage, including underfill drains in mucked-out gully alignments, and placement of engineered fills. In addition, excavations that daylight the transition between soil and rock or expose the rock mass will require careful engineering to prevent surface water ingress that can lead to slope instability. The highly fractured rock mass where it is exposed at finished levels is susceptible to rapid weathering and infiltration of surface water that will compromise stability conditions. Remedial works incorporating over-excavation and capping with engineered filling can be expected. No water should be added to these deposits from external sources such as raingarden soakage. It is likely that a series of shear keys or inground walls will be required throughout the development to produce suitably graded lot platforms. Where favourable materials allow earthwork solutions i.e. shear keys and undercuts can be a suitable remediation option
	Soil Creep	Elevated areas and slopes. (Geohazard Zones 1 and 3)	A function of slope gradient and the expansive nature of the materials, movement is typically along the soil/rock interface. Creep is limited to the sloped areas partially along ridge flanks. To be mitigated by design of slope gradients, including use of retaining walls, subsoil drainage and by design of footings.
	Bearing Capacity Failure	Alluvial terrace areas (Geohazard Zones 2 and 3)	A consideration for large buildings and rapid loading on alluvial soils. Will require specific design of foundations for highly loaded structures (i.e. ground improvement or piled foundations).
	Cut & Fill Batter Instability	Dairy Flat Ridgeline, future cut, and fill areas	Mitigated by stormwater control and surface stabilisation, smart construction staging and temporary and permanent retaining.
Expansive Soils	Expansive Soils	Entire site	Expansive soils are classified in NZS 3604 as those soils having a liquid limit of more than 50% and linear shrinkage of more than 15%. Northland Allochthon residual overburden soils and clay alluvial soils are typically highly expansive. Mitigation of the expansive soil hazard is by foundation design at Building Consent stage and will be addressed on a lot-by-lot basis in the Geotechnical Completion Report(s) at the conclusion of the development works.
Subsidence	Soft Soils/ Load Induced Settlement	Alluvial terrace areas (Geohazard Zones 2 and 3)	In areas where fills and/ or significant building construction or storage loads are placed over soft deposits, allowance needs to be made for post-construction settlement of the fills and the underlying ground that could cause damage to structures.

Geotechnical Assessment and Mitigation			
Geotechnical Hazard	**Description**	**Area Affected**	**Comments and Geotechnical Control / Mitigation Measures**
			Consideration in the design needs to be given to the quantum of settlement that is likely to occur (i.e. ensuring it is insufficient to influence the cut/ fill volumes and balance during earthworks and/ or damage structures) and the time taken for the settlement to occur (i.e. ensuring it will be largely completed by the time a normal civil works programme would likely be commencing). The topography and existing information indicate that the paleo-channel alignment (and therefore the greatest alluvium depth) is located within the vicinity of current John Creek, and eastern tributary alignments. The most appropriate mitigation is to avoid the potential for highly loaded structures in these areas during Master Planning. Remedial options for accelerating settlements in areas of deep alluvium include preloading and installation of wick drains but based on our experience in the Milldale development to the north, pre-loading without wick drains is able to provide good results. Locations and heights of surcharge must be subject to geotechnical review to avoid causing bearing capacity failure in the underlying alluvium.
Existing Fill	Uncertified Fill	Entire Site	Localised zones of existing uncertified fill area have been identified across the site. Re-engineering of existing fill maybe required in some areas. Following environmental testing (by others) material reworking is considered appropriate.
Seismicity	Liquefaction	Entire Site	Liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. Liquefaction potential will be largely dependent on material characteristics of the underlying soils. A region-wide liquefaction assessment has been undertaken by Auckland Council in accordance with MBIE document “Planning and engineering guidance for potential liquefaction-prone land Resource Management Act and Building Act aspects” (2017). The liquefaction potential for the Northland Allochthon slope (Geohazard Zone 1) has been assessed to be very low. The alluvial valley (Geohazard Zones 2 and 3) has been assessed to be unlikely.

6 CONCLUSION

Based on our hazard assessment, we consider that the land is suitable for creating stable building platforms and infrastructure, having acceptable levels of post-development residual risk from natural hazards. Consideration of the key geotechnical hazards for each zone should be incorporated into Master Planning. These include:

- Due to the presence of soft soils underlying Zones 2 and 3 (Alluvial Terraces) these areas are considered highly likely to be subject to load induced settlements. Therefore, will require ground improvement beneath building platforms and/or specific foundation design.
- Due to the unstable nature of the slopes within Zone 1 (Elevated Areas and Slopes) slope remediation will be required across these sections of the site, particularly beneath areas of large fills on the existing sloping areas. Shear keys and/or palisade walls will need to be considered following the confirmation of the proposed landform.

Development will require earthworks and drainage to provide adequate stability. This is achievable given appropriate design, and construction. Any proposed earthworks are to be undertaken in accordance with all relevant standards and documents. The engineering controls required to control existing, latent risks are commonplace works in this terrain that are consistent with those being adopted on adjacent land. Further site investigation and design will need to be undertaken to quantify the geotechnical controls prior to resource consent application and the commencement of any works.

7 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 Fletcher Development Limited in relation to the Silverdale West 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 Fletcher 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.

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.

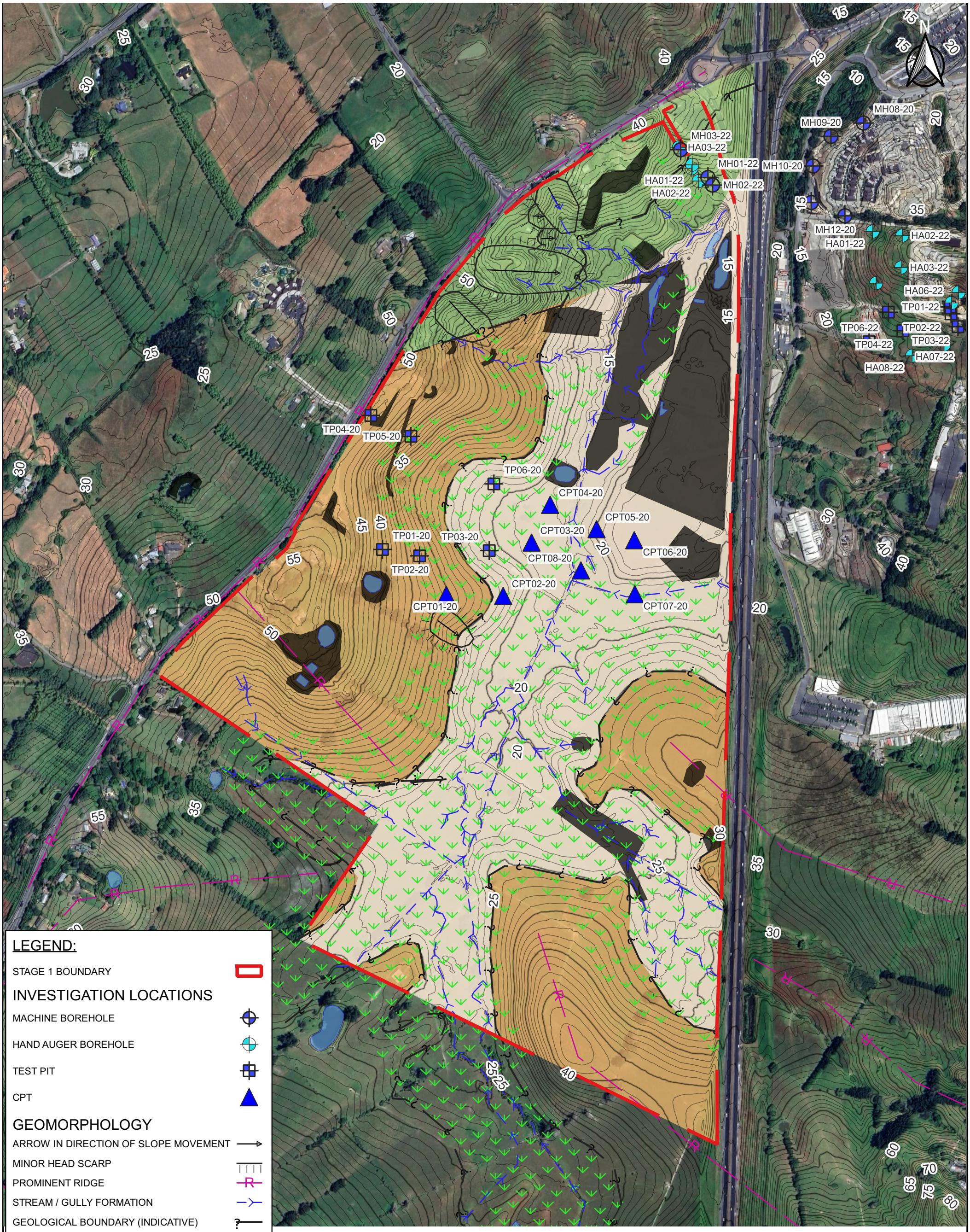
Environmental Matters Are Not Covered

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

Title	Reference No.	Date	Revision
Geology and Geomorphology Pan	AKL2022-0152 DWG 01	7/08/2023	2
Geohazard Zone Plan	AKL2022-0152 DWG 02	7/08/2023	3



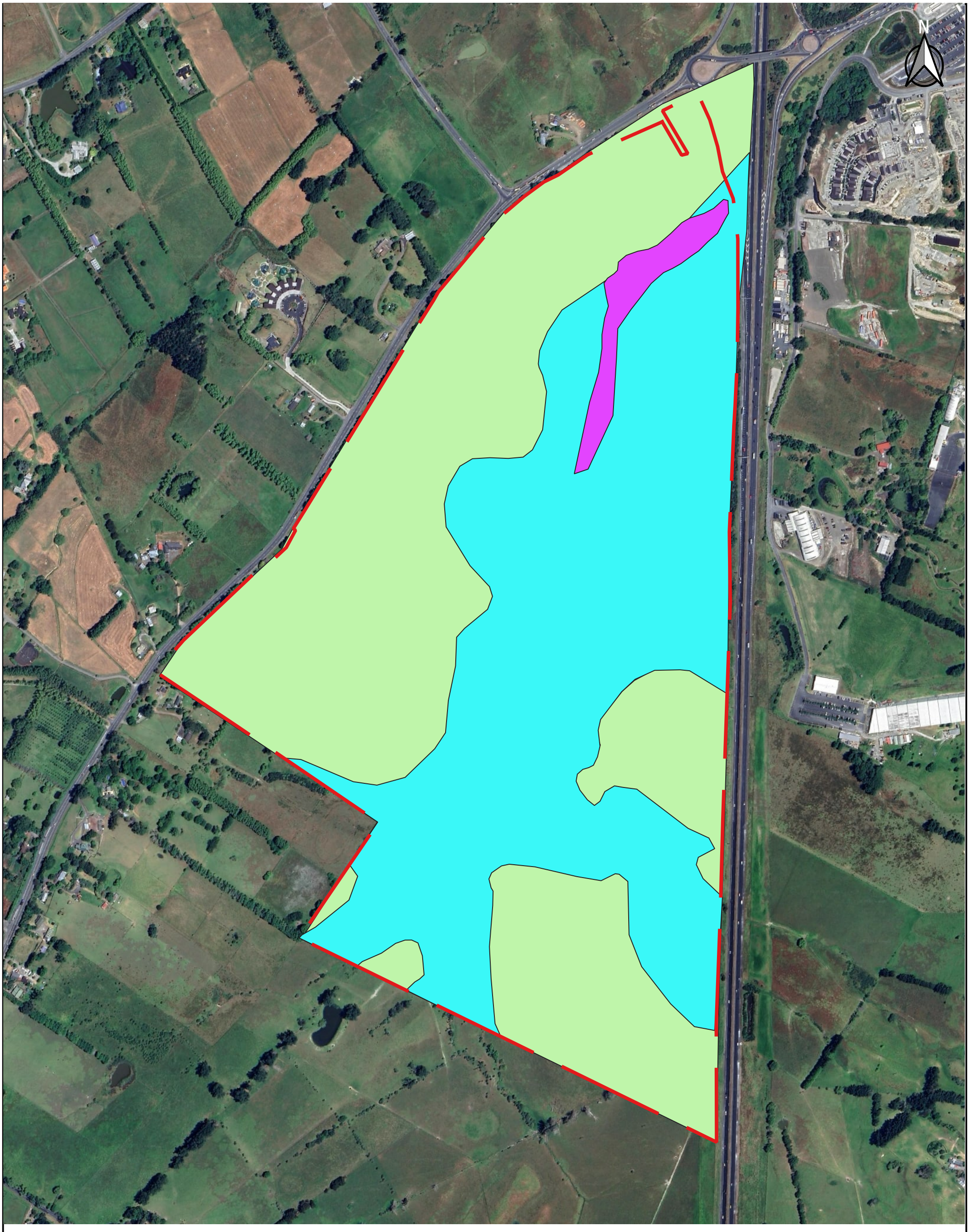
NOTES:

1. BASE MAP ADAPTED FROM LINZ OPEN DATA VIA QGIS
2. GEOLOGY ADAPTED FROM GNS SCIENCE OPEN DATA VIA QGIS

0 100 200 300 400 m

CMW Geosciences
Great People | Practical Solutions

CLIENT: FLETCHER DEVELOPMENTS LIMITED		DRAWN: AG	PROJECT: AKL2022-0152
PROJECT: SILVERDALE WEST - STAGE 1 DAIRY FLAT HIGHWAY, SILVERDALE		CHECKED: AG	DRAWING: 01
		REVISION: 2	SCALE: 1:6000
TITLE: GEOLOGY AND GEOMORPHOLOGY PLAN		DATE: 7/08/2023	SHEET: A3 P



LEGEND:

STAGE 1 BOUNDARY

GEOHAZARD ZONE

ZONE 1 - ELEVATED AREAS AND SLOPES

ZONE 2 - ALLUVIAL AREAS

ZONE 3 - STREAM EDGE AREAS

NOTES:

1. BASE MAP ADAPTED FROM LINZ OPEN DATA VIA QGIS
2. GEOLOGY ADAPTED FROM GNS SCIENCE OPEN DATA VIA QGIS

0 100 200 300 400 m

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CLIENT: FLETCHER DEVELOPMENTS LIMITED		DRAWN: AG	PROJECT: AKL2022-0152
PROJECT: SILVERDALE WEST - STAGE 1 DAIRY FLAT HIGHWAY, SILVERDALE		CHECKED: AG	DRAWING: 02
		REVISION: 3	SCALE: 1:6000
TITLE: GEOHAZARD ZONE PLAN		DATE: 7/08/2023	SHEET: A3 P

Appendix B: Preliminary Natural Hazards Risk Assessment

PRELIMINARY NATURAL HAZARDS RISK ASSESSMENT FOR LAND SUBDIVISION

SILVERDALE WEST, DAIRY FLAT HIGHWAY, SILVERDALE

A. CONTEXT

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land, other land or structures (consequence).

Section 2 of the RMA defines natural hazards as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

This appendix to CMW report reference AKL2022-0152AB Rev. 0 sets out the criteria for and presents the results of an assessment of the geotechnical-related natural hazards associated with this proposed subdivision development. The remaining hazards, i.e. tsunami, wind, drought, fire and flooding hazards are not covered by this assessment.

B. BASIS OF ASSESSMENT

For this project, this risk assessment has been carried out as a preliminary exercise to assist with identifying those natural hazards which may require addressing in any future development of the land. No development plans are available at the time of reporting, however bulk earthworks, which may include cutting of the Dairy Flat Road ridgeline and filling on the John Creek alluvial terrace to form large flat building platforms are envisaged. It is with reference to this type of development that the latent and residual risk ratings have been assessed.

B.1. Risk Classification

The occurrence of natural hazards and their potential impacts on the proposed subdivision development is assessed in terms of risk significance, which is based on likelihood and consequence factors. A risk table is used to help assess the likelihood and consequence factors, the form of which used by CMW for this project is presented in Table B1.

Table B1: Natural Hazard Risk Classification

Risk Matrix		Consequence				
		Insignificant 1	**Minor 2**	**Moderate 3**	**Major 4**	**Catastrophic 5**
Likelihood	**Almost Certain 5**	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extreme 20
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5

B.2. Likelihood

With respect to assessing the likelihood or chance of the risk occurring, the qualitative definitions used by CMW for this project are provided in Table B2 for each likelihood classification.

Table B2: Qualitative Natural Hazard Likelihood Definitions		
1	Rare	The natural hazard is not expected to occur during the design life of the project
2	Unlikely	The natural hazard is unlikely, but may occur during the design life
3	Moderate	The natural hazard will probably occur at some time during the life of the project
4	Likely	The natural hazard is expected to occur during the design life of the project
5	Almost Certain	The natural hazard will almost definitely occur during the design life of the project

B.3. Consequence

In terms of determining the consequence or severity of the natural hazard occurring, the qualitative definitions used by CMW for this project are provided in Table B3 for each consequence classification.

Table B3: Qualitative Natural Hazard Consequence Definitions		
1	Insignificant	Very minor to no damage, not requiring any repair, no people at risk, no economic effect to landowners.
2	Minor	Minor damage to land only, any repairs can be considered normal property maintenance no people at risk, very minor economic effect.
3	Moderate	Some damage to land requiring repair to reinstate within few months, minor cosmetic damage to buildings being within relevant code tolerances, does not require immediate repair, no people at risk, minor economic effect.
4	Major	Significant damage to land requiring immediate repair, damage to buildings beyond serviceable limits requiring repair, no collapse of structures, perceptible effect to people, no risk to life, considerable economic effect.
5	Catastrophic	Major damage to land and buildings, possible structure collapse requiring replacement, risk to life, major economic effect, or possible site abandonment.

B.4. Risk Acceptance

It is recognised that the natural hazard risk assessment provided herein is qualitative and, due to the wide range of possible geohazards that could occur, is somewhat subjective. Other methods are available to quantitatively assess an acceptable level of geotechnical related natural hazard risk, such as defining an acceptable factor of safety with respect to slope stability or acceptable differential ground settlements with respect to recommended building code limits.

Therefore, to give this qualitative natural hazard risk assessment some relevance to more commonly adopted numerical or quantitative geotechnical assessment techniques, a residual risk rating of very low to medium (risk value = 1 to 9 inclusive) is considered an acceptable result for the proposed subdivision development.

A risk rating of high to extreme (risk value ≥ 10) is considered an unacceptable result for the proposed subdivision development.

C. RISK ASSESSMENT

The natural hazards relevant to this proposed subdivision development and adjacent, potentially affected land have been assessed with respect to the criteria outlined above.

Assessment is based on proposed post development ground conditions with and without any geotechnical controls. The latent risk was first assessed with the site in its proposed developed state to consider the risks to the development and surrounding land, including assessment of land modifications from the pre-existing natural state, without any implemented geotechnical controls. The specific geotechnical mitigation measures and engineering design solutions outlined in the table below and CMW report, where relevant, were then considered to determine the natural hazard residual risk remaining after the proposed controls have been implemented.

Results of this assessment are presented in Table C1 below.

Table C1: Natural Hazard Risk Assessment Results

RMA S2 Hazard	Description	Proposed Site Latent Risk of Damage to Land / Structures			Comments and Geotechnical Control	Proposed Site Residual Risk of Damage to Land / Structures OR Acceleration/ Worsening of Hazard with Geotechnical Controls Implemented		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Earthquake	Fault Rupture	1	5	Medium 5	No active faults known within close proximity	1	5	Medium 5
	Liquefaction Induced Flooding and/ or Subsidence	1	4	Low 4	Highly plastic Pleistocene aged clays and silts unlikely to liquefy.	1	4	Low 4
	Lateral Spread	1	4	Low 4	Highly plastic clays and silts unlikely to liquefy and therefore unlikely to spread laterally.	1	4	Low 4
Volcanic Activity	Ash & Pyroclastic Falls	1	5	Medium 5	Proximity to active volcanic activity.	1	5	Medium 5
	Lava flows & Lahars	1	5	Medium 5	Proximity to active volcanic activity.	1	5	Medium 5
Geothermal Activity	Formation of geysers, hot springs, fumaroles, mud pools	1	5	Medium 5	Proximity to geothermal activity.	1	5	Medium 5
Erosion	Cut Batters	5	2	High 10	Max 1:5 gradient in this geology.	2	2	Low 4

	Fill Batters	4	2	Medium 8	Stormwater control / benches / geotextiles / gradient / revegetation etc	2	2	Low 4
Landslip	Global Slope Instability	5	4	Extreme 20	Slope gradient / fill buttress / shear key / drainage etc	2	4	Medium 8
	Soil Creep	5	4	Extreme 20	Slope gradient / footing depth / drainage / retaining wall etc	2	4	Medium 8
	Bearing Capacity Failure	5	4	Extreme 20	Consideration for large buildings and rapid loading on alluvial soils. Pre-load and/ or pile foundations.	2	4	Medium 8
	Cut & Fill Batter Instability	4	4	Very high 16	Surface water controls, re-grading, temporary support geogrids & subsoil drainage	1	4	Low 4
Subsidence	Expansive Soils	5	4	Extreme 20	Foundation design	1	4	Low 4
	Sinkholes	2	3	Medium 8	Undercut if encountered. Groundwater control.	1	3	Low 3
	Soft Soils	5	4	Extreme 20	Pre-load, ground improvement & pile foundations	2	4	Medium 8
	Effects of Dewatering (uncontrolled subsidence)	1	4	Low 4	Low compressibility soils in elevated areas are unlikely to settle due to dewatering.	1	4	Low 4
Sedimentation	Not applicable							

Notes:

- Assessments include the impact of the proposed subdivision works on adjacent properties.
- The following reference(s) contain information on the hazards contained in this assessment and the non-geotechnical hazards that have not been included:
  - **Auckland**
    https://aucklandcouncil.maps.arcgis.com/apps/MapSeries/index.html?appid=81aa3de13b114be9b529018ee3c649c8