Perpendicular Point

Natural Hazard Desktop Assessment

Version 2

24 March 2025

ACG Properties Limited

Tonkin+Taylor

Sheet 1: Executive summary and applicability

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Table of Contents

Background

We understand that you plan to develop the property 4663 State Highway 6, Te Miko, Punakaiki (Valuation Ref: 18860/28400). The site is located on a west-facing, gently to moderately sloping hillside perched above near-vertical sandstone cliffs. The hillside has been incised by several 3 – 10 m deep channel features which connect to the coast. We understand at this stage the proposed development currently includes 15 lightweight cabins, a lodge, a main access track, and access tracks to each of the cabins.

Scope of work

This report provides preliminary guidance on the critical geotechnical and natural hazard constraints likely to have an impact on the master planning and options assessment. This assessment includes the following:

- Review of readily available information, including topographic data from 2022 LiDAR survey and 2024 UAV survey, historic aerial imagery, published geological / council maps, and our knowledge from nearby sites that T+T has worked on.
- Site mapping of the natural hazards within the site constraints, including any geological exposures.
- This report, which includes an annotated natural hazards constraint map, concept-level geotechnical implications table, and recommendations for master planning.
- A follow-up videoconference to discuss the outcomes of our report.

Executive Summary

This geotechnical and natural hazards desktop assessment has been prepared to provide concept level geotechnical considerations and recommendations to support master planning of the proposed development at Perpendicular Point, north of Punakaiki.

Our initial desktop assessment (v1) identified four key hazard areas across the site, including:

- Falling debris hazards
- Gully hazards
- Undermined cliff hazard
- Cliff erosion hazards

Subsequent on-site mapping by a T+T geologist on 28 August 2024 confirmed these preliminary hazard areas to be suitable for assessing appropriate building locations at the site for master planning purposes.

Before locating buildings, infrastructure, or access routes within these hazard areas, a more detailed assessment of life safety and property risk would be required. It is important to note that these hazard areas are not necessarily “no build zones.” Various risk management strategies are likely available, including avoidance, site-specific foundation design, or engineered ground structures such as debris flow / rockfall protection barriers. In locations where potential damage to property is limited, a “do nothing” approach could be considered, with repairs made as necessary.

Following our v1 assessment and discussions with the project team an updated site layout was provided for review (13 January 2025). In this layout buildings and access routes generally avoid the hazard areas where feasible. However, three cabin locations overlap with gully hazard areas. These cabins will require specific foundation design to accommodate localised shallow failure of the gully slopes (e.g. deeper piles may be necessary). One of these cabins also appears to be positioned in close proximity to, or potentially overlapping the TTPP coastal setback boundary. The actual location relative to this setback should be confirmed.

Applicability

T+T Reference: 1095111 **Version:** v2, 24-March-2025

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

Cole Brown
Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

Mike Jacka
Project Director

Sheet 2: Geotechnical constraints

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T:\Christchurch\TT Projects\1095111\WorkingMaterial\GIS Layout: Sheet 2 - Overall Constraints Map 2024-Aug-29 4:26 pm Drawn by CRB

Hazard areas

What do these hazard areas mean?

These hazard areas indicate that more detailed assessment would be needed to better understand and design for the hazard before locating buildings, infrastructure or access in these areas. It's important to emphasise that these are not "no build zones". The areas have been drawn with a moderate degree of conservatism, so more detailed assessment may indicate the extent of the hazard is less than currently shown.

Falling debris hazard

The steep hillside and escarpment east of the site presents several significant falling debris hazards. There is evidence of historic instability of this slope affecting the site, including:

- Rockfall (extending approximately 100m west of SH6).
- Channelised flows.
- Rock avalanche.

Gully hazards

Several gullies are present across the site, comprising two major gulley systems. These gulley systems contain large upslope catchments connecting to areas of historic debris deposits. Following large rainfall events, these gullies may present a debris flow / flood hazard. These gully systems also show signs of localised slope instability.

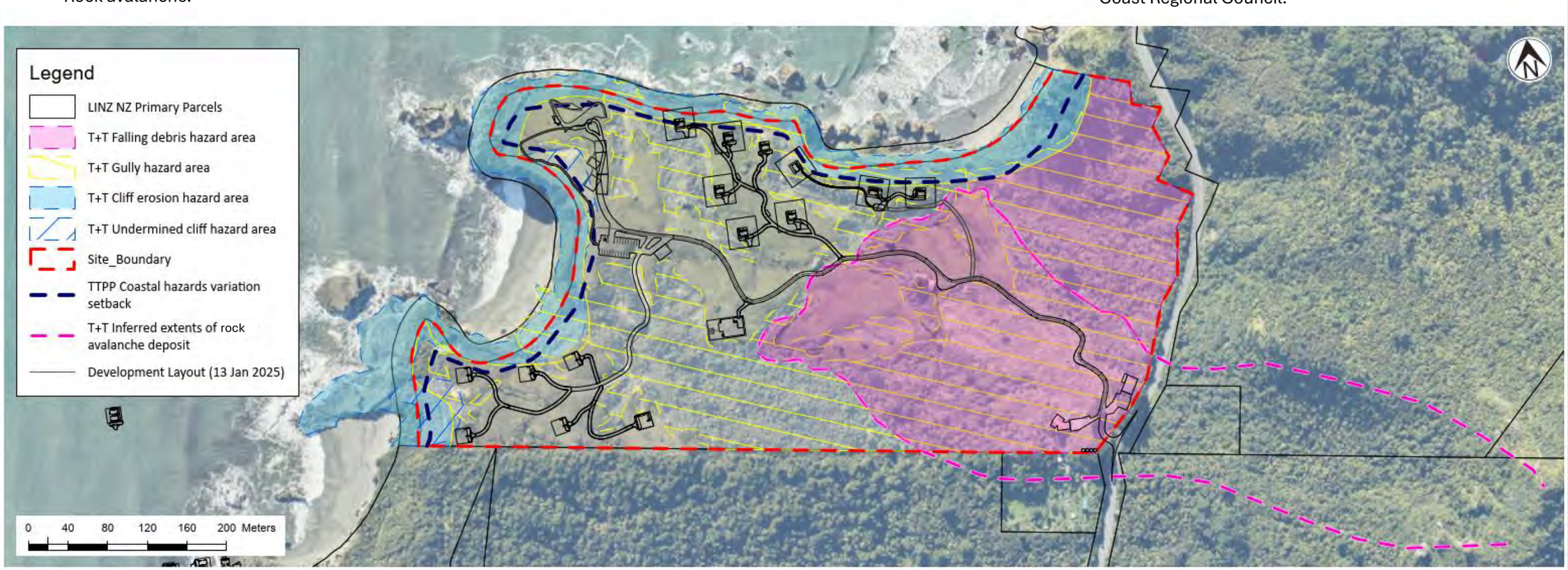
Undermined cliff hazard

Two arc-shaped caves have been identified along beaches at the west edge of the site. The ground overlying these caves systems is potentially susceptible to future subsidence or collapse.

Cliff erosion hazard

The erosion of the coastline appears to be primarily due to topple failures or block 'drop-outs' enabled by undermining of the cliffs along preferential bedding planes with the very widely spaced vertical joints providing side releases. Dozens of these large blocks are strewn across the beach and are consistently about 10 to 15m wide and 10 m in height. There is limited observations of block failures occurring between 1951 and present.

The coastal hazards in the Te Tai o Poutini Plan (TTPP) have recently been mapped and are in the process of being updated to become operative. Submissions close on 30 August 2024. Development coastward of this line will likely require detailed assessment and interaction with West Coast Regional Council.



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TITLE GEOTECHNICAL CONSTRAINTS OVERALL SITE PLAN
FIG No. SHEET 2. REV 0

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Sheet 3: Geotechnical constraints map – zoomed view [1 of 2]

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T:\Christchurch\TT Projects\1095111\WorkingMaterial\GIS Layout: Sheet 3&4 - Constraints Map [1of 3] 2024-Aug-29 4:26 pm Drawn by <ACP>crb</ACP>

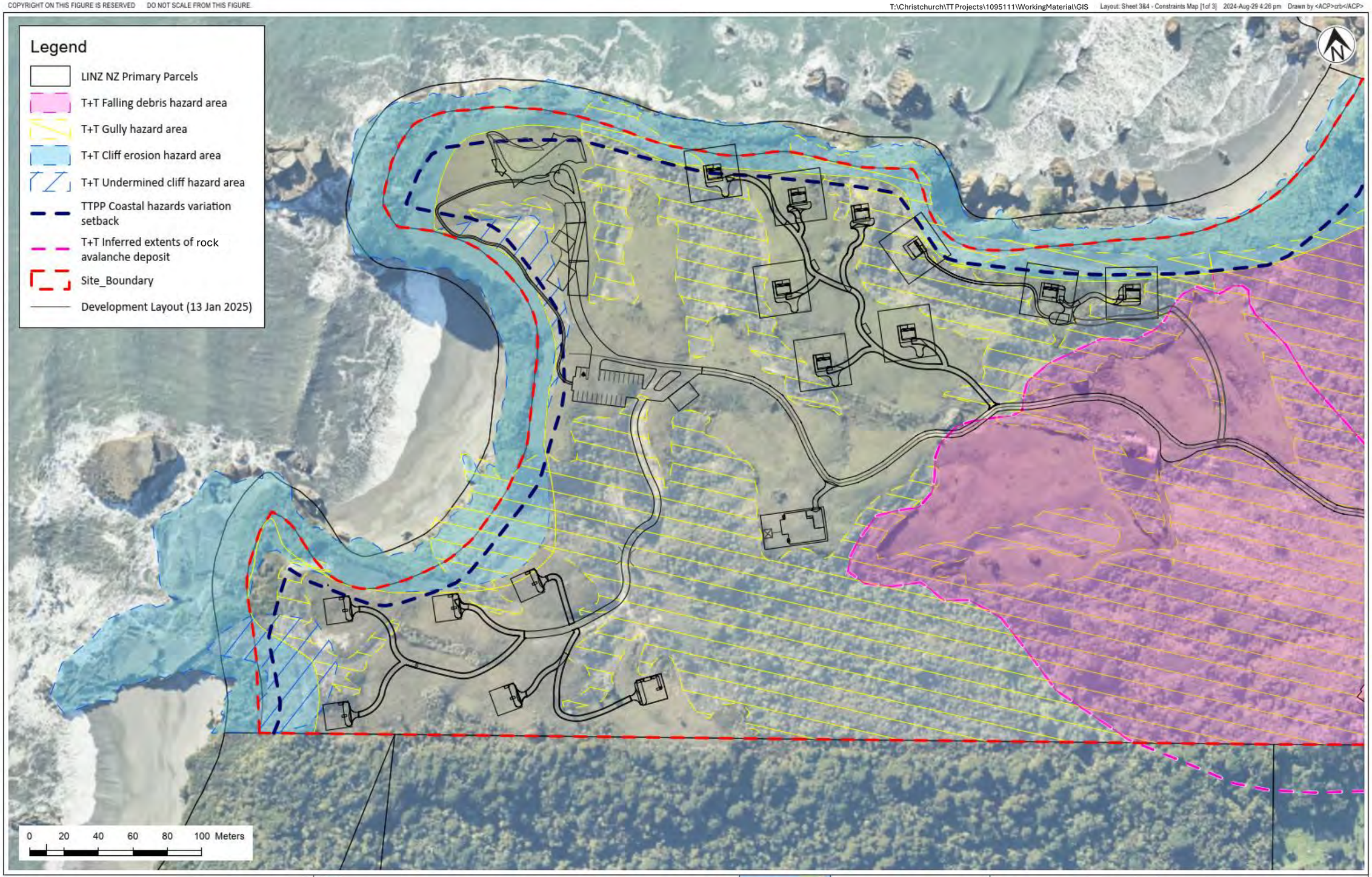

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FIG No. SHEET 3. REV 0

Sheet 4: Geotechnical constraints map – zoomed view [2 of 2]

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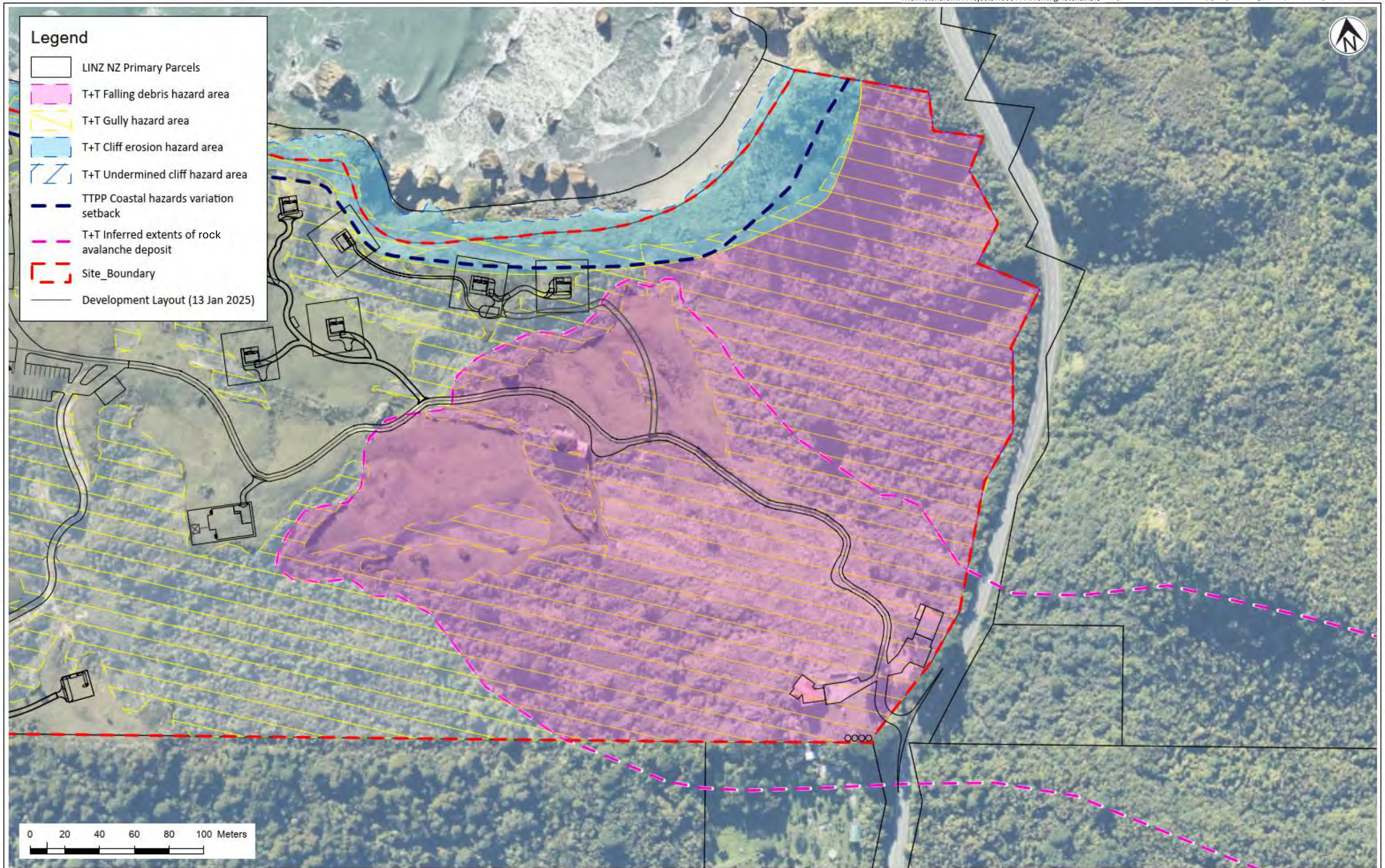

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TITLE GEOTECHNICAL CONSTRAINTS ZOOMED EXTENT: 2 OF 2
FIG No. SHEET 4. REV 0

Sheet 5: Geotechnical considerations [1 of 3]

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Hazard area	Geotechnical consideration	Implications	Comments	Triggering events	Interim qualitative risk – without management measures using AGS 2007 [1] (Refer to Sheet 18 and 19)			Concept-Level Management Measures and general geotechnical development advice
					Likelihood	Consequence	Risk level	
Falling debris hazard	Rockfall (up to approx.100m west of road)	Rockfall impacting building likely to cause extensive damage to most of structure / completely destroy the structure.	Numerous boulders located along slope. Potential new boulders identified in 1976 aerial photograph, following the Inangahua Earthquake.	No trigger / Earthquake	Possible	Major to catastrophic	High to very high	• Refine the hazard area by conducting a boulder mapping assessment during the proposed site visit to identify the locations, diameters, shapes, and distribution of boulders, and use the results to refine the current 100m runout distance estimate through a rockfall analysis. A boulder mapping assessment would require permission to access the property east of the road. • Quantitatively estimate and evaluate life safety risk of hazard versus tolerance criteria to identify if risk level of building within the hazard zone is acceptable. • Potential for specific engineering design of passive protection structures, such as a soil rockfall bund to mitigate rockfall impacting structures.
	Channelised flow	Mobilised flow of debris deposits and rocks impacting building causing moderate to extensive damage to most of structure.	No current observations, although debris material identified along upper slopes in 1976 aerial photograph, following the Inangahua Earthquake.	Heavy rainfall event/ Post-earthquake rainfall	Unlikely to possible	Medium to major	High	• Quantitatively estimate and evaluate life safety risk of hazard versus tolerance criteria to identify if risk level of building within the hazard zone is acceptable. • As above for rockfall, potential for specific engineering design of passive protection structures to mitigate debris flows from impacting structures, such as debris barrier or a diversion structure.
	Rock avalanche	Significant portion of upslope escarpment mobilising rapidly downslope and burying large portion of the site in metres of rock and debris.	There are two inferred rock avalanche deposits present on the escarpment on and within 400m of the site. The rock avalanche deposits are overlying a raised sea platform, which could be used to infer the age.	Earthquake	Unlikely	Catastrophic	High	• Refine lower zone of hazard by mapping during site visit. • Quantitatively estimate and evaluate life safety risk of hazard versus tolerance criteria to identify if risk level of building within the hazard zone is acceptable. • Potential for specific engineering design to build cabins on lower zone of hazard, such as using elevated pile foundation.
Cliff erosion Hazard	Block 'drop-out' / Topple	Single or a few blocks falling from slope likely resulting in a 10 – 20m wide area that regresses by about 10 – 15m in a single event. Any structures and infrastructure located within this zone could be undermined. Adjacent land could be impacted by progressive instability of the soil mantle over time.	Significant observations of this failure mechanism and block size along the coastline. Limited observations of blocks dropping out between 1951 and present. Sea level rise will likely increase the rate this process occurs.	No trigger / Storm event	Possible	Medium to major	Moderate to high	• Cabin structures could be located within some areas of this zone through specific engineering design, such as a piled foundation system to mitigate the effects of cliff erosion. The structure can then be relocated if a significant block 'drop-out' or topple of the cliff occurs in front of the structure. • Any proposed development within the TTPP coastal setback area will likely require detailed assessment and interaction with West Coast Regional Council.
	Cliff collapse	Significant length of the coastline collapses resulting in a 10 to 20m wide regression in a single event.	No evidence of this failure mechanism and generally not expected given the massive structure and defect orientations.	Earthquake	Rare	Major	Low	
Undermined cliff hazard	Collapse of cave	Collapse of cave structure, resulting in subsidence and significant tilting of the ground profile and building structure.	Collapsed cave features present across the wider coastline. Also poses risk to any people inside cave.	Earthquake / Storm event	Possible	Medium to major	Moderate to High	• Map extents of each cave to refine hazard area and potentially allow development closer to underlying caves.

Sheet 6: Geotechnical considerations [2 of 3]

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Hazard area	Geotechnical consideration	Implications	Comments	Triggering events	Interim qualitative risk – without management measures using AGS 2007 [1] (Refer to Sheet 18 and 19)			Concept-Level Management Measures and general geotechnical development advice
					Likelihood	Consequence	Risk level	
Gully hazards	Slope instability	Landslide movement resulting in undermining of building foundations and tilting of the structure.	Several circular landslide features identified along gully systems.	Rainfall	Possible	Medium	Moderate	• Specific engineering design of foundations to locate structures along the slope crests of this zone, such as using a piled foundation system to mitigate the slope instability. Direct drainage from dwellings away from any slopes, e.g. discharge at base of slope.
	Debris flow	Upslope landslide movement resulting in mobilisation of debris impacting structures or infrastructure such as roads or access routes within gullies downslope.	Significant debris was present In upper gully system in the 1976 aerial photography following the Inangahua Earthquake.	Heavy rainfall event / Post-earthquake rainfall	Likely	Major to catastrophic	Very high	• Avoid building structures within gullies. • Clear and if required repair roads / access tracks and infrastructure following debris flow event. • Specific engineering design of passive protection structures could be undertaken to mitigate effects of debris flows on tracks and infrastructure, such as debris barrier or a diversion structure. These may require post-event maintenance, e.g. clearing of debris, potentially repairing structure.
	Flooding	Flooding of gullies resulting in inundation of structures or infrastructure such as roads or access routes.	Appears to be constant water discharge along main gully systems. Credible that flooding occurs during heavy rainfall.	Heavy rainfall event	Likely	Major	Very high	• Avoid building structures within gullies / within catchment areas. • Potential for temporary access issues during adverse rainfall events. • Clear and if required repair roads / access tracks and infrastructure following debris flow event.
General	Health & Safety	Visitors to the site are exposed to various safety hazards. Various parties have a duty of care as PCBUs under health & safety legislation.	This includes during design, construction and operation phases of the development. Some of these hazards may not be obvious, so visitors to site should be made aware.	Some hazards are present at all times (e.g. fall from cliffs or into voids), some triggered by storm or earthquake event (e.g. cave collapse).	Likely [2]	Major [2]	High [2]	• Job Safety & Environmental Analysis(JSEA) document distributed to all parties who work on site during design, as well as site induction process in construction. This JSEA document should be kept up-to-date throughout the design and construction process. • Consider safety hazards during design of the layout of the structures and infrastructure, such as setback cabins from potential fall hazards or installation of physical barriers. • Appropriate safety briefing and clear information for visitors to the site so they are aware of the hazards.
	Tomo	Subsidence / collapse of ground due to erosion along joints / geological structures.	Limited observations of tomos on rock outcrops at the coastline.	Heavy rainfall event	Rare	Minor to moderate	Very low to low	• Onsite walkover of each proposed building locations during our site visit. This may need to be undertaken again if the locations are moved significantly.

Sheet 7: Geotechnical considerations [3 of 3]

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Hazard area	Geotechnical consideration	Implications	Comments	Triggering events	Interim qualitative risk – without management measures using AGS 2007 (1) (Refer to Sheet 18 and 19)			Concept-Level Management Measures and general geotechnical development advice
					Likelihood	Consequence	Risk level	
General	Earthquakes and faulting	Site is susceptible to large ground motions from known faults that are distant from the site.	No evidence of active faults within or near the site has been observed.	-	-	-	-	• Design level ground shaking at the site and on engineered structures is typically managed by existing national guidance and standards to meet requirements of the Building Act and Code.
	Bearing capacity for building foundations	Potential for unacceptable deformation of key buildings or infrastructure due to sharp changes in ground conditions and strength and compressibility.	This is particularly notable when building structures or infrastructure, such as roads, on landslide materials such as the rock avalanche deposit.	-	Possible to likely	Medium	Moderate to high	• Site investigations, such as trial pits, at the preferred areas for key buildings. In areas where the ground conditions are problematic, specific engineering design such as a piled or lightweight foundation system could be used.
	Stormwater / wastewater disposal	Potential for erosion / scour issues along structures and access routes due to inadequate disposal stormwater / wastewater management, thereby requiring continued maintenance and repairs.	Many of the structures are located near to the crests of slopes, with many crossings across the gullies. Concentrated surface water flows could be problematic if not appropriately managed.	-	Possible to likely	Minor	Moderate	• We recommend that you engage a suitably qualified stormwater engineer for input into the design, in particular the management of surface / standing water.
	Pavement subgrade	Potentially inadequate pavement subgrade resulting in premature pavement failure and uneven roads, resulting in increased maintenance costs.	This is more likely to be an issue where roads / access routes cross gullies that are filled with loose alluvial material. It may also be problematic along the rock avalanche deposit.	-	Possible	Minor	Low	• Site investigations, such as trial pits, at the preferred location for key infrastructure such as parking areas to assess ground conditions and support any pavement design requirements.

Notes:

(1) The interim qualitative risk analysis has been completed for selected geotechnical hazards and considerations only and assumes no management measures are in place. This is a high-level risk analysis intended primarily to assist identification of potential priority geotechnical risks to the development.
(2) The qualitative risk assessment health and safety geotechnical consideration uses the health and safety risk matrix from ISO 45001. High = Risk undesirable: Risks must be reduced so far as practicable. Requires management oversight.

Sheet 8: Geomorphic mapping

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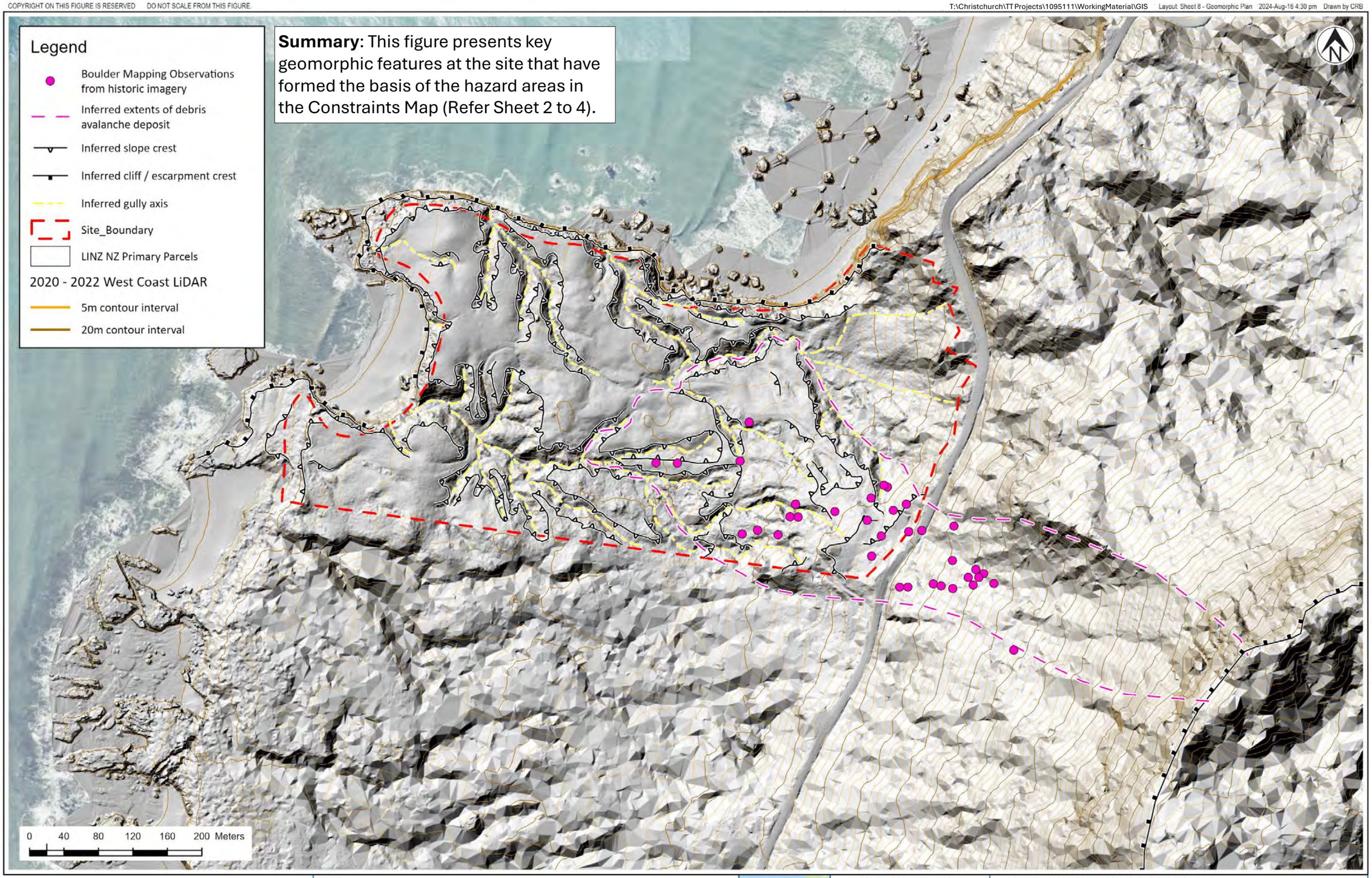
T:\Christchurch\TT Projects\1095111\WorkingMaterial\GIS Layout: Sheet 8 - Geomorphic Plan 2024-Aug-16 4:30 pm Drawn by CRB

Summary: This figure presents key geomorphic features at the site that have formed the basis of the hazard areas in the Constraints Map (Refer Sheet 2 to 4).



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TITLE GEOMORPHIC MAPPING
OVERALL SITE PLAN
FIG No. SHEET 8. REV 0

Sheet 9: Falling debris hazard [1 of 4]

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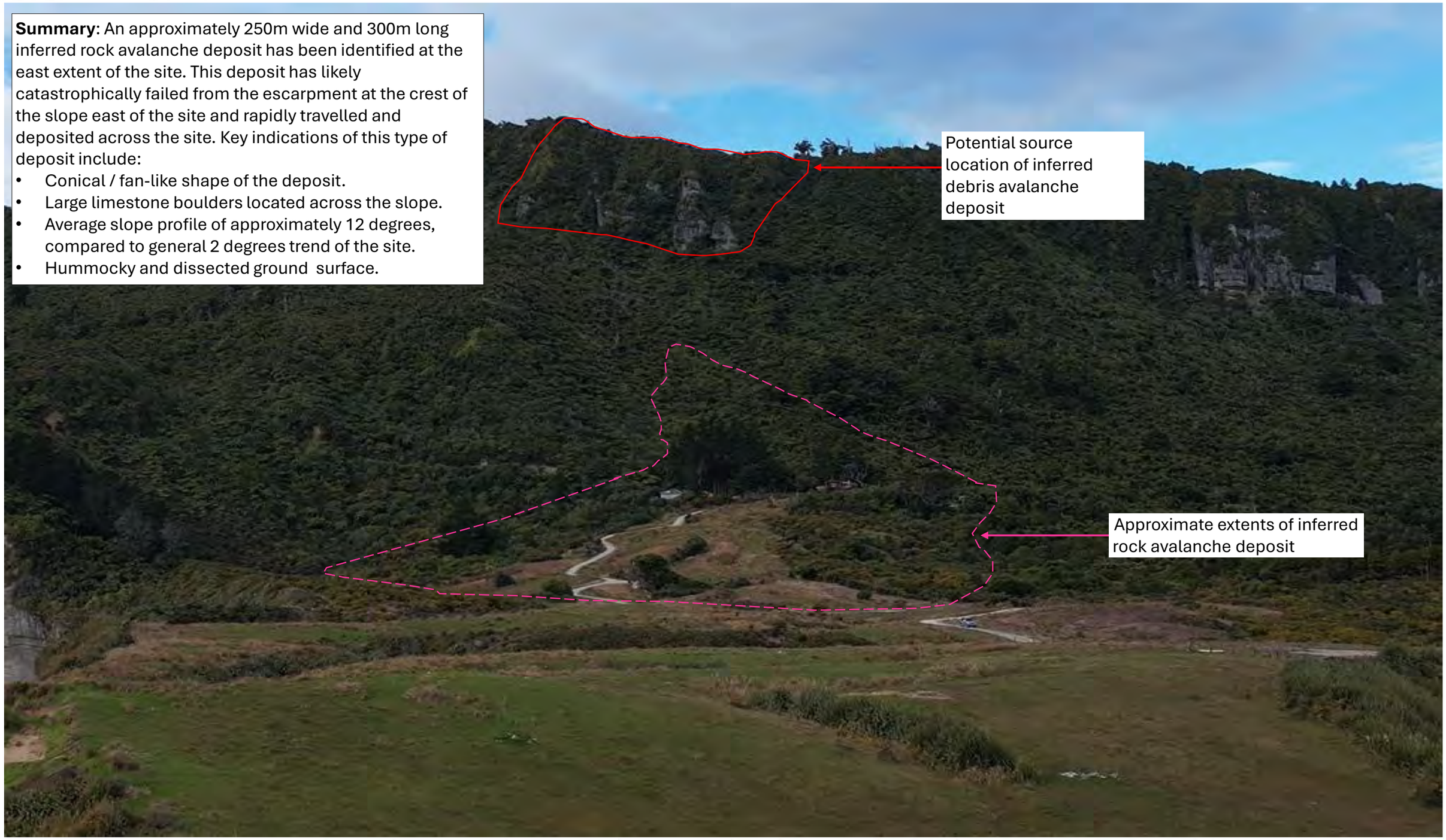
Summary: An approximately 250m wide and 300m long inferred rock avalanche deposit has been identified at the east extent of the site. This deposit has likely catastrophically failed from the escarpment at the crest of the slope east of the site and rapidly travelled and deposited across the site. Key indications of this type of deposit include:

- Conical / fan-like shape of the deposit.
- Large limestone boulders located across the slope.
- Average slope profile of approximately 12 degrees, compared to general 2 degrees trend of the site.
- Hummocky and dissected ground surface.



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TITLE FALLING DEBRIS HAZARD
INFERRED ROCK AVALANCHE DEPOSIT [1 OF 2]

FIG No. SHEET 9. REV 0

Sheet 10: Falling debris hazard [2 of 4]

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TITLE FALLING DEBRIS HAZARD
INFERRED ROCK AVALANCHE DEPOSIT [2 OF 2]

FIG No. SHEET 10. REV 0

Sheet 11: Falling debris hazard [3 of 4]

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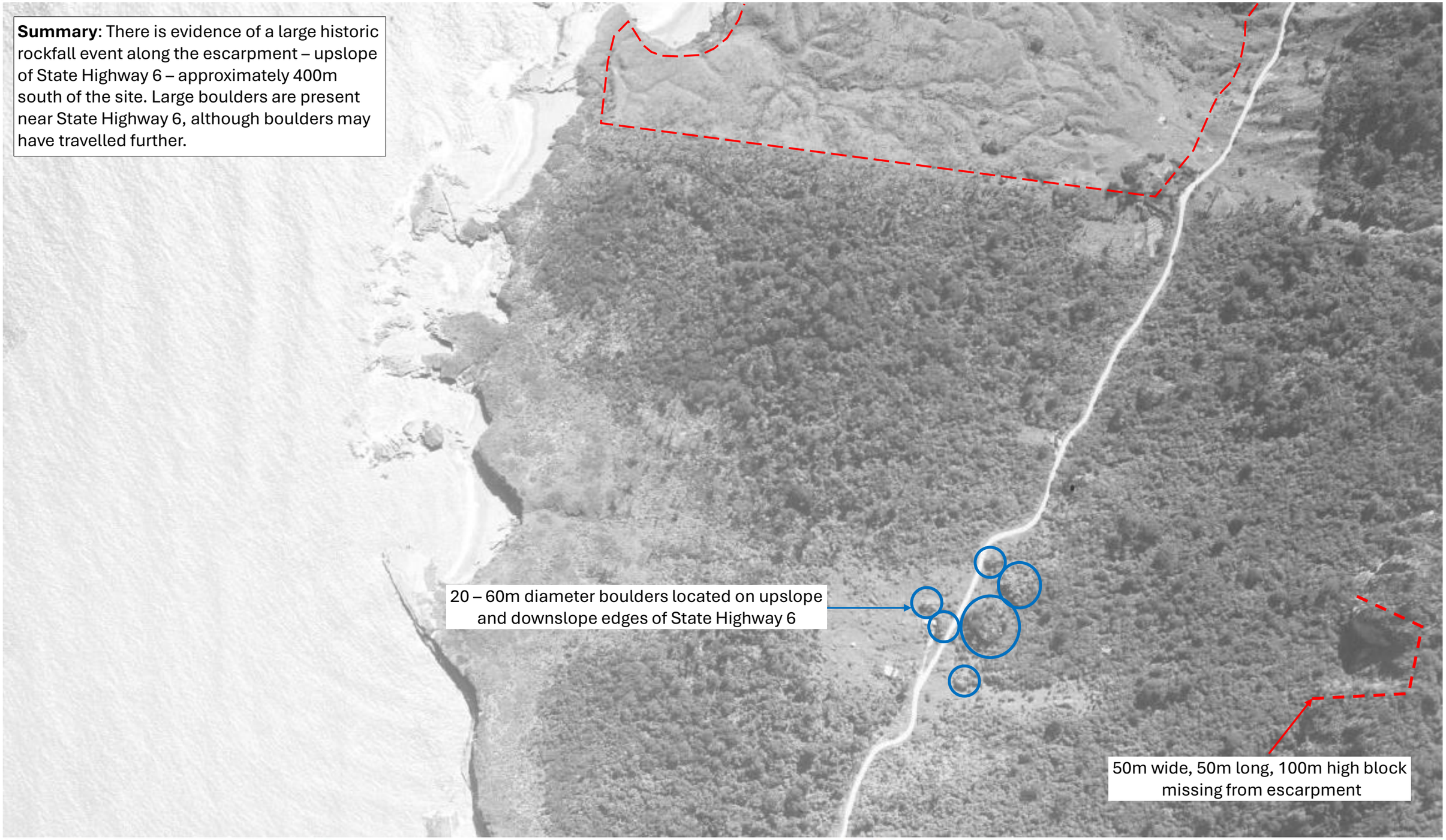
T:\Christchurch\TT Projects\1095111\WorkingMaterial\GIS Layout: Sheet 7 - 1976 Plan 2024-Aug-08 5:35 pm Drawn by CRB

Summary: There is evidence of a large historic rockfall event along the escarpment – upslope of State Highway 6 – approximately 400m south of the site. Large boulders are present near State Highway 6, although boulders may have travelled further.



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PROJECT **PERPENDICULAR POINT**

TITLE FALLING DEBRIS HAZARD
1951 AERIAL PHOTOGRAPH

FIG No. SHEET 11. REV 0

Sheet 12: Falling debris hazard [4 of 4]

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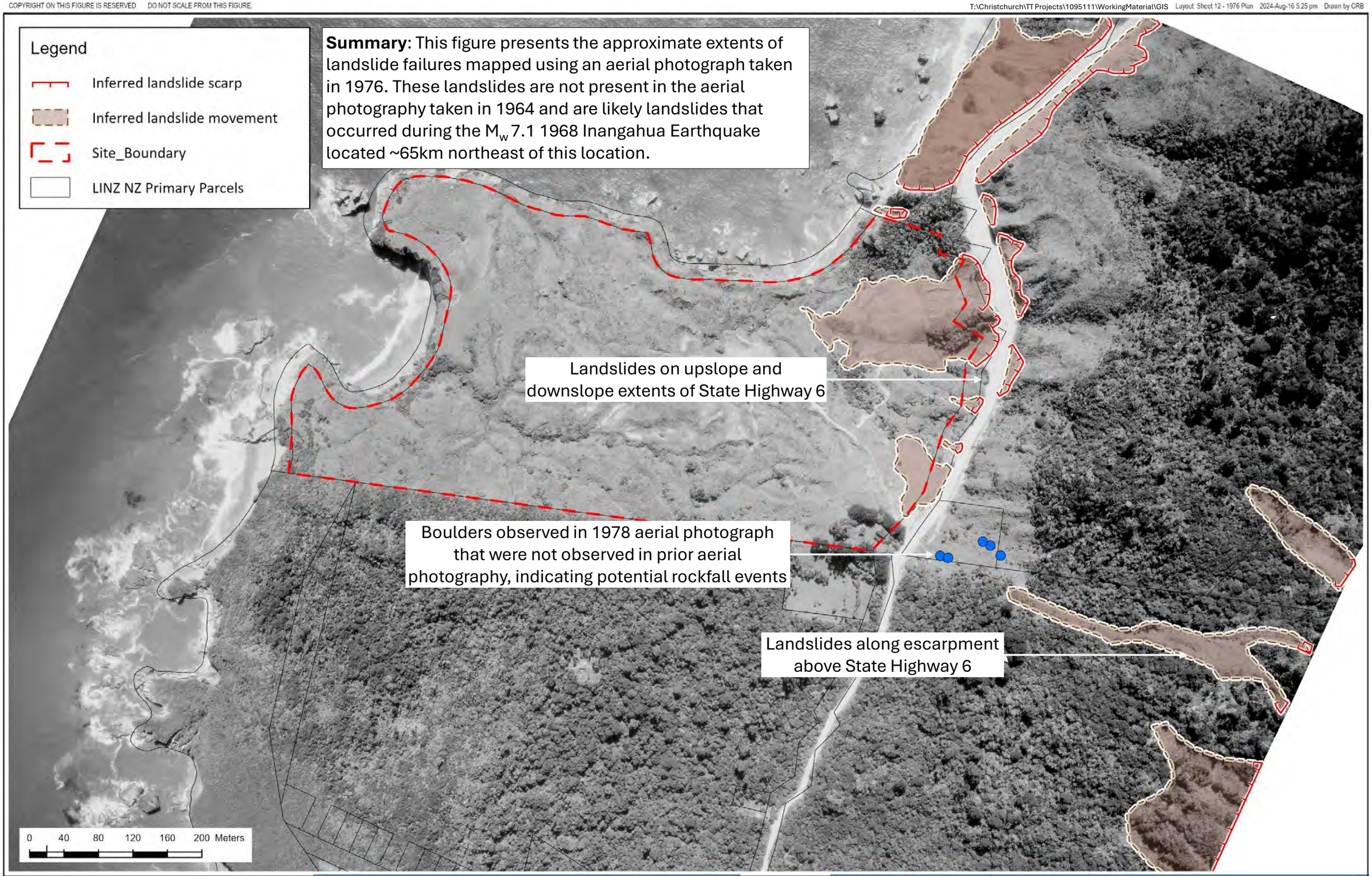

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PROJECT PERPENDICULAR POINT
TITLE FALLING DEBRIS HAZARD 1978 AERIAL PHOTOGRAPH
FIG No. SHEET 12. REV 0

Sheet 13: Coastal erosion hazard [1 of 2]

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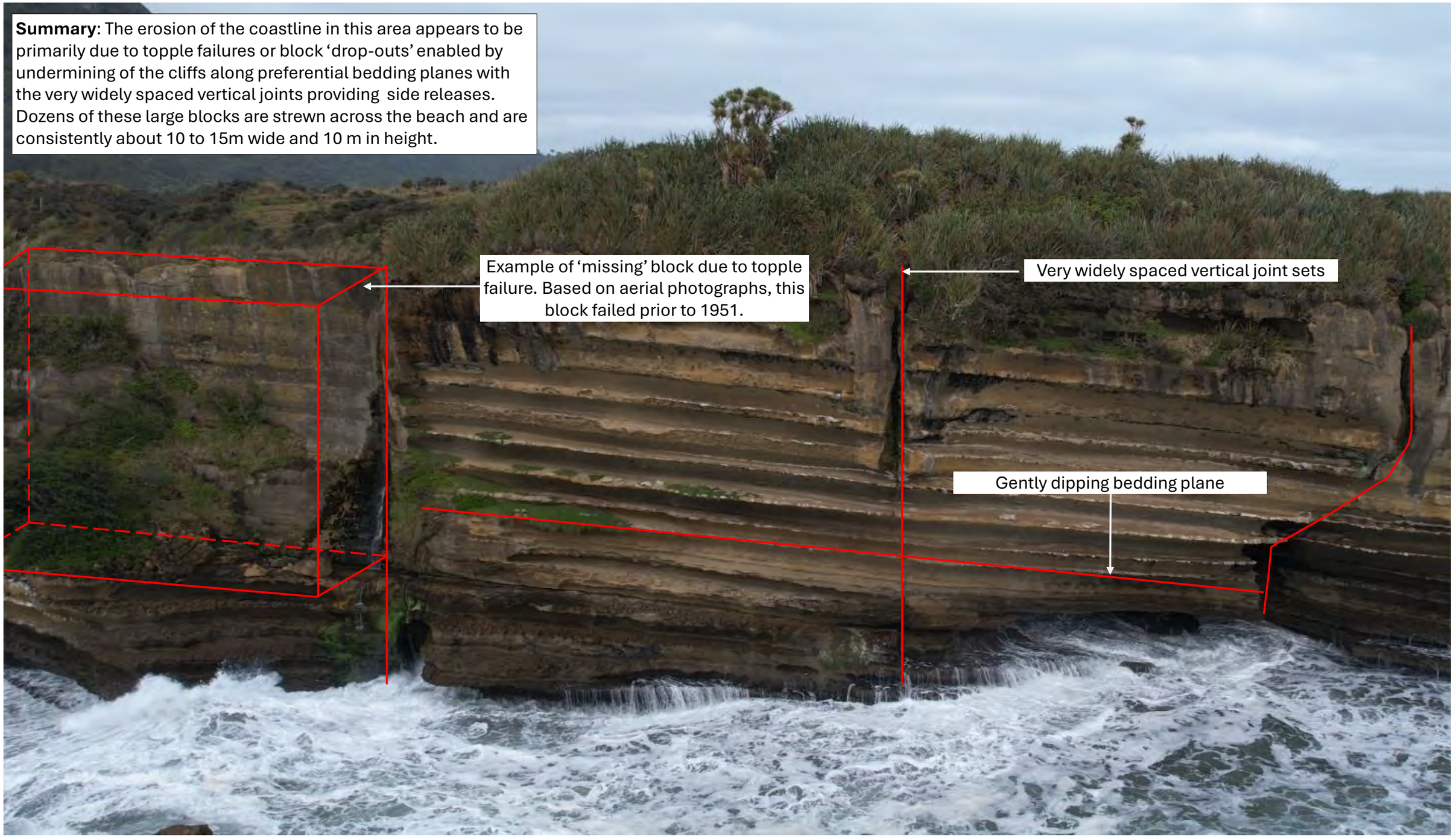
Summary: The erosion of the coastline in this area appears to be primarily due to topple failures or block 'drop-outs' enabled by undermining of the cliffs along preferential bedding planes with the very widely spaced vertical joints providing side releases. Dozens of these large blocks are strewn across the beach and are consistently about 10 to 15m wide and 10 m in height.



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PROJECT **PERPENDICULAR POINT**

TITLE COASTAL EROSION HAZARD
JULY 2024 DRONE FLYOVER [1 OF 2]

FIG No. SHEET 13. REV 0

Sheet 14: Coastal erosion hazard [2 of 2]

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PROJECT **PERPENDICULAR POINT**
TITLE COASTAL EROSION HAZARD
JULY 2024 DRONE FLYOVER [2 OF 2]
FIG No. SHEET 14. REV 0

Sheet 15: Gully hazards [1 of 2]

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Summary: Several gullies are present across the site and are generally made up of two major gulley systems. These gulley systems contain large upslope catchments that connect to areas where landslides have occurred in the past. These systems may present a debris flow / inundation hazard during large rainfall events.

These gully systems also show signs of localised slope instability.

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PROJECT **PERPENDICULAR POINT**

TITLE GULLY HAZARDS
JULY 2024 DRONE FLYOVER

FIG No. SHEET 15. REV 0

Sheet 16: Gully hazards [2 of 2]

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LOCATION PLAN

PROJECT No.	1095111.0000	
DESIGNED	CRB	AUG.24
DRAWN	CRB	AUG.24
CHECKED		
APPROVED		DATE

CLIENT **ACG PROPERTIES LIMITED**

PROJECT **PERPENDICULAR POINT**

TITLE GULLY HAZARDS
MAY 2024 DRONE FLYOVER

FIG No. SHEET 16. REV 0

Sheet 17: Undermined cliff hazard [1 of 2]

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Summary: Two arc-shaped caves have been identified along beaches at the west extent of the site. The ground overlying these caves systems is potentially susceptible to future subsidence or collapse.

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Exceptional thinking together www.tonkintaylor.co.nz

NOTES:

Basemap GNS New Zealand Geology: GNS Science. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	CRB	YYYY	D/M/Y

LOCATION PLAN

PROJECT No.	1095111.0000	
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CLIENT **ACG PROPERTIES LIMITED**

PROJECT **PERPENDICULAR POINT**

TITLE UNDERMINED CLIFF HAZARD
JULY 2024 DRONE FLYOVER [1 OF 2]

FIG No. SHEET 17. REV 0

Sheet 18: Undermined cliff hazard [2 of 2]

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NOTES:

Basemap GNS New Zealand Geology: GNS Science. NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	CRB	YYYY	D/M/Y

LOCATION PLAN

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CLIENT **ACG PROPERTIES LIMITED**

PROJECT **PERPENDICULAR POINT**

TITLE UNDERMINED CLIFF HAZARD
JULY 2024 DRONE FLYOVER [2 OF 2]

FIG No. SHEET 18. REV 0

Sheet 19: Qualitative risk matrix and risk level implications

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QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1} (10%)	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2} (1%)	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3} (0.1%)	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4} (0.01%)	H	M	**L**	**L**	**VL**
E - RARE	10^{-5} (0.001%)	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6} (0.0001%)	**L**	**VL**	**VL**	**VL**	**VL**

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Sheet 20: Qualitative measures of likelihood and consequence

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QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years		The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5