APPENDIX 6 – '*Land Stability Assessment Areas – Ikitara Road, Bastia Hill & Durie Hill – Risk Study Report*'

by Opus International Consultants Ltd, 2014

PC38 Hearing Report

Wanganui District Council

Land Stability Assessment Areas
Ikitara Road, Bastia Hill & Durie Hill

Risk Study Report

Wanganui District Council

Land Stability Assessment Areas

Ikitara Road, Bastia Hill & Durie Hill

Risk Study Report

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Project No: 5W1100.12

Contents

Appendices

Executive Summary

Wanganui District Council is currently undertaking a review of its District Plan, and has identified the need to manage risks from land instability. Consideration of the extent of land within Wanganui at risk of land slip has identified a list of areas which are priorities for further study. The Council has commissioned Opus International Consultants to carry out an assessment of the stability issues on hillslopes to the east of the Wanganui city centre, south of Ikitara Road and in the Bastia Hill and Durie Hill suburbs.

Mapping of the distribution and characteristics of slope instability hazards was carried out within those areas. Instability features observed during the mapping include shallow seated topsoil and regolith slides, shallow seated slumps and slides on steep slopes, creep failures of soil and vegetation, earthflow-type failures of surficial soils, and larger deep seated landslide features in the underlying siltstone bedrock.

Qualitative assessment of risks to people and property were used to define two levels of landslide hazard. Areas classified as type A comprise land that is steep and shows evidence of instability, with a high risk of further instability and damage to property or life. Council should discourage subdivision and new dwellings in these high risk areas. Areas classified as type B are marginal slopes, which have shallower slope angles but are still prone to instability. Geotechnical investigations should be carried out prior to any development proposal being submitted for resource consent. The investigations are required for detailed assessment of the slope stability hazards. The investigations and assessment will determine the risk to property from landsliding, and therefore whether the land is suitable for development, with mitigation measures implemented, or whether it is unsuitable for further development.

It is recommended that the results of the mapping are incorporated into the District Plan through overlay maps and by introducing objectives, policies and rules that apply additional considerations and restrictions specific to the land instability issues present in each area. This will help achieve greater resilience of the community to natural hazards through a proactive approach to land use and development in hazard prone areas.

1 Introduction

Experience from natural hazard events highlights the importance of hazard, vulnerability and risk assessments in land use planning and development, to ensure the future resilience of communities. Wanganui District Council is currently undertaking a staged review of its District Plan, which includes investigating ways to manage natural hazards.

Wanganui District is affected by a number of natural hazards; in particular, parts of the urban area are susceptible to slope instability and erosion. Consideration of the extent of the land within the Wanganui District at risk of land slip has identified a list of Land Stability Assessment Areas which are priorities for further study. These areas are being examined in a staged approach to identify the extent of susceptibility to land instability hazards.

Opus International Consultants (Opus) has been commissioned to undertake the assessment of slope stability issues within the study areas. Two areas have been investigated and the following reports prepared:

- ANZAC Parade / Putiki Drive (Opus, 2011);
- Shakespeare Cliff (Opus, 2012).

This report represents the second stage in this process, and summarises the study results for the following study areas:

- **Ikitara Road**: Wairere Road, Mount View Road, slopes above Ikitara Road and Turoa Road;
- **Bastia Hill**: Bastia Hill area including Shakespeare Road, Georgetti Road, Darcy Road, Mount View Road;
- **Durie Hill**: Durie Hill area including Durie Vale Road, Portal Street, Forres Street, and southern slopes.

The study areas are shown on Illustration 1. This report details our investigations which included a desk study and reconnaissance level engineering geological mapping of the study area. It provides an appraisal of the stability issues in the area, landslide susceptibility mapping process, and recommendations for measures to manage the effects of land instability hazards for any future developments.

2 Study Methodology

The following points describe the approach taken in carrying out this study:

1. Identify areas with potential for land instability issues for further study.

   Wanganui District Council has identified 12 urban areas within the district with potential for land instability issues, which are being investigated in a staged approach. This study forms the second stage in that process.

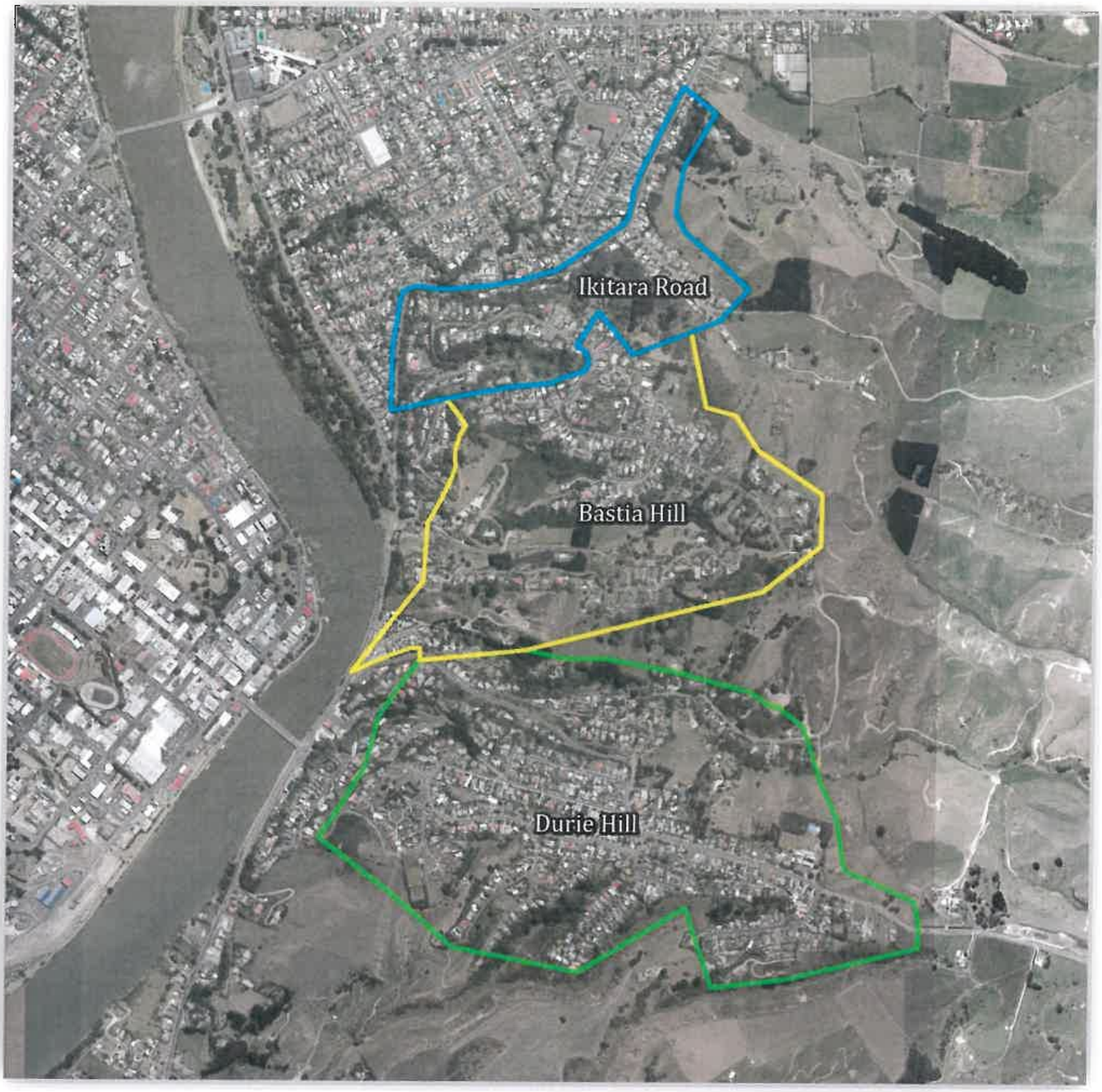

Illustration 1 Study area locations

2. Identify the geology and geomorphology of the study areas.

   This process involves examination of stereo aerial photographs, a desk study of geology maps and other available information, and reconnaissance-level engineering geological mapping to observe and describe the geology and geomorphology of the study areas, and in particular to identify areas of instability and other hillslope features.

3. Identify past slope instability and areas of known slope instability.

   Instability features were identified during the examination of historical aerial photos, and areas of recent or active instability were noted during the reconnaissance mapping.

4. Characterise the slope angle of hillslopes and the hillside slope angles generally susceptible to instability.

   Hillslope characteristics that influence the location and nature of instability features were identified during the desk study and mapping phases and captured onto a GIS platform. The GIS database allows the distribution and extent of instability hazards and affected areas to be mapped spatially.

5. Carry out a qualitative assessment of the instability risks.

   A simple qualitative risk assessment was carried out to assist in differentiating areas of hillslope based on the slope instability risks.

6. Develop Land Stability Assessment (LSA) Area classifications.

   A classification scheme was developed for the slope hazards, to enable areas of slope to be mapped based on their level of susceptibility to the hazards and the potential for consequent risks.

7. Produce LSA maps.

   Maps of the slopes classified as LSA Areas were produced at 1:5,000 scale (Figures 2 and 2).

8. Recommend planning policies and rules to ensure development avoids or mitigates the instability hazard potential.

   This report makes recommendations for incorporating the results of this study into its District Plan.

3 Site Description

3.1 Geomorphology

The study area consists of flat-topped hills in eastern Wanganui, that rise to c. 100 m above Whanganui River. The hills are remnants of uplifted Quaternary marine terraces, and consist of broad, flat to gently sloping hilltops flanked by moderately steep to very steep hillsides.

The terraces have been incised since their uplift, resulting in steep gullies and side slopes. Slope angles generally range between 25° to 55°, with localised near-vertical sections of slope (cliffs and bluffs).

Land use in the study area is predominantly residential, with limited commercial development and an area of rural pasture land in the northern part of the study area. Vegetation cover varies from grass and low scrub to mature exotic forest. Residential development of the hillsides and crests began in the early 1900s.

3.2 Geology

The Wanganui area has been mapped by the New Zealand Geological Survey (1959) and GNS Science (2008). The mapping indicates the sites are underlain by rocks belonging to the Shakespeare Group, comprising sandstone, siltstone, bioclastic limestone and conglomerate, and locally overlain by marine terrace deposits of marine sand, dune sand, volcanic sand and lignite bands with basal conglomerate. These rocks are of Pleistocene age (2.5 million – 12,000 years old).

Observations made during the engineering geological mapping were that the siltstone and sandstone materials are exposed within the study areas. These rocks are overlain on the hillslopes by variable thicknesses of colluvium and topsoil. In areas where outcrop exposures of the soils were observed, these slope-derived deposits are generally less than 2 m thick, although this thickness will increase down-slope and in gullies where more extensive fan and slip deposits can accumulate.

4 Investigations

4.1 Desk Study

The desk study consisted of a review of available geological maps and reports, and detailed examination of aerial photograph stereopairs from 1942, 1993 and 2011. Archival photographs were also obtained from both the Wanganui Regional Museum and from books. These commonly show the hillsides above the Whanganui River before they were heavily developed with housing, and therefore enable mapping of landslide and slope instability features which are often now obscured by housing and vegetation.

4.2 Engineering Geology Mapping

Site reconnaissance mapping of the hillslopes within the study area was carried out by an Opus engineering geologist. Areas of recent or active instability were noted during the mapping, as well as from examination for present-day evidence of the key instability features observed from the historical aerial photos. This study comprised an appraisal of an area-wide understanding of the geology and geomorphology. No intrusive investigations or testing were therefore undertaken as part of this study, as to provide information of significant value these would need to be extensive and costly, given the size of the study area and the range of slope issues. Similarly, the mapping was carried out along publicly-accessible roads and footpaths; individual site or property inspections were not carried out, as this was an area-wide study into the general stability issues.

The mapping involved identification of areas of slope instability, typically from landslide scarps, hummocky ground or exposed soil. Some older landslide features were also identified, from degraded scarps and evacuated slopes.

Existing slope mitigation measures, such as retaining walls, were also mapped as they indicate a precedent for past slope instability or show where the natural slopes have been modified. The engineering geological maps, which include maps of the slope angles across the study areas, are given in Appendix A.

5 Slope Hazard Characterisation

5.1 Factors Influencing Instability

5.1.1 Slope Materials

The slope materials in the eastern Wanganui urban area are predominantly siltstone, sandstone and conglomerate of Quaternary age. These are overlain by a surficial zone of soil comprised of highly weathered rock, colluvium, loess and topsoil. These materials are susceptible to failure, particularly on sparsely vegetated slopes following prolonged or intense rainfall.

The siltstone materials are described as soft rock. These soft rocks typically fail by three progressive failure modes:

1. Slabbing, where slabs 300 mm – 400 mm thick fail along planes subparallel to the slope. Slabbing is typically observed on siltstone slopes of angles greater than 45°.
2. Slaking, where the surface disaggregates, or frets, to form fragments ranging from silt to gravel sized. Slaking is more common in finer-grained rocks (Read and Millar, 1990).
3. Deeper seated instability particularly where there are other unfavourable factors such as high groundwater pressures or undermining of the slope by river erosion.

Sand and gravel materials were observed in parts of the study area, and failure of the surficial materials by translational sliding was mapped within the study areas.

5.1.2 Slope Angle

Engineering geological mapping of landslides within the study areas has shown instability is apparent on hillsides with slope angles of greater than 40°, and is common on slopes of greater than 50°, and particularly more deeper seated failures. Mapped instability features and slope angles are shown on the engineering geology maps in Appendix A.

In some localised areas, slopes of less than 40° also showed instability features, however this was generally restricted to shallow translational failures of topsoil/regolith, such as the hillslopes to the north of Turoa Road. Slopes with angles of 30° to 40° are marginally stable and may pose a risk to development.

5.1.3 Storm and Earthquake Events

The hillslopes are susceptible to instability following periods of prolonged or intense rainfall, due to rising groundwater levels and a consequent increase in pore water pressure within the slope. Similarly, strong ground shaking during earthquakes could trigger slope instability, and there is evidence for earthquake-induced landslides recorded at Shakespeare Cliff to the west of the Bastia Hill study area.

5.1.4 Modification of Natural Slopes for Housing and Infrastructure

Excavation into natural slopes may cause instability by oversteepening of the slope, particularly if the excavation is into the toe of a slope. The formation of fill embankments may also contribute to landsliding, due to the increased load on slope crests. Evidence of deformation of the road pavement was recorded at several positions along Wairere Road, and discussions with local residents suggest the northern part of the road has been formed on sections of un-engineered fill, which has been prone to consolidation and creep-type movement down the adjacent hillslope.

5.2 Observed Instability Features

A range of instability features were recorded during the engineering geological mapping. These include:

- Topsoil and regolith slides, with areas of deflated[1]/evacuated hillslopes showing evidence of previous failures (e.g. Illustration 2)
- Shallow seated slumps and slides on steep slopes (e.g. Illustration 3)
- Creep failures of soil and vegetation
- Cracking and rotation of footpaths at slope crests (e.g. Illustration 4)
- Earthflow-type failures of surficial soils (e.g. Illustration 5)
- Larger landslide features observed on historic aerial photos (Appendix A)

Illustration 2 Deflated/evacuated hillslope to the north of Turoa Road.

[1] Deflation of hillslopes is the progressive erosion and removal of loose, finer-grained soils

Illustration 3 Shallow seated slips on steep hillslopes below Portal Street.

Illustration 4 Progressive failure/rotation of the footpath along Wairere Road.

Illustration 5 Earthflow-type failure of hillslopes to the southeast of Turoa Road.

The majority of recent instability features observed during the mapping were shallow seated failures of topsoil, regolith and shallow soft rock materials. Evidence for deep-seated failures in the underlying siltstone was rare; however a possible deep-seated rotational landslide was observed from the aerial photo mapping of the hillslopes to the east of No's 114 to 124 Ikitara Road.

Instability features such as translational landslides and slumps were commonly observed on slopes steeper than 40° to 45°. Shallower failures of surficial materials were observed on flatter slopes, with angles typically steeper than 30° to 40°.

5.3 Qualitative Risk Assessment

A qualitative risk assessment to property from failure of the hillslopes has been undertaken with reference to the guidelines for landslide susceptibility, hazard and risk zoning (AGS, 2007a) and landslide risk management (AGS, 2007b) published by the Australian Geomechanics Society. A summary of the qualitative risk assessment is presented in Table 1. Explanation of the risk assessment tables and terminology is given in Appendix B.

Table 1 Qualitative risk assessment table (AGS, 2007a)

Likelihood[1]	Consequences to property[2]				
	1 Catastrophic (200%)	**2 Major** (60%)	**3 Medium** (20%)	**4 Minor** (5%)	**5 Insignificant** (0.5%)
A: Almost certain (10^{-1})	Very high	Very high	Very high	High	Moderate[3]
B: Likely (10^{-2})	Very high	Very high	High	Moderate	Low
C: Possible (10^{-3})	Very high	High	Moderate	Moderate	Very low
D: Unlikely (10^{-4})	High	Moderate	Low	Low	Very low
E: Rare (10^{-5})	Moderate	Low	Low	Very low	Very low
F: Barely Credible (10^{-6})	Low	Very low	Very low	Very low	Very low

Notes: [1] Indicative approximate annual probability

[2] Indicative approximate cost of damage as a percentage of the value of the property

[3] For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk

For areas showing precedent for instability and having steep slope angles of greater than 40°, the recurrence interval for failure is expected to be approximately 10 to 50 years, giving a likelihood of failure of almost certain to likely during the design life of buildings. Such failures have the potential to cause extensive property damage and would likely require major engineering works for stabilisation, giving a consequence of failure of major to catastrophic. The risk rating for such areas is therefore very high, and is unacceptable.

Some areas have shallower slope angles of 30° to 40° but still show some evidence of instability. Failures may occur less frequently on these marginal slopes or may be smaller in extent, depending on site-specific conditions, such as the type and thickness of colluvium and the prevailing groundwater conditions. Therefore the recurrence interval will be variable for marginal slopes – perhaps 50 to 1000 years, giving a likelihood of failure of likely to possible. Property damage is likely to be less severe, and the structures may not be completely destroyed, giving a consequence to property of medium to major. The level of risk to property is therefore moderate to high.

6 Land Stability Assessment Areas

Based on the risk assessment above, two Land Stability Assessment (LSA) areas are proposed to assist the Council in its objective to manage the risks from instability hazards. These areas are:

Area A: Areas of high to very high landslide hazard risk

The area comprises three parts, which are shown in Illustration 6:

1. A setback zone at the crest of the cliff, where failure of the slope below will undermine, or to allow for natural regression of the cliff to a more stable slope angle. For the purposes of this assessment we have assumed a characteristic angle of 45° from the toe of the slope for defining the boundary between the setback zone and landsliding zone.
2. The landsliding zone – the steep section of the cliff, where landsliding occurs, or has occurred in the past.
3. The run-out zone, where landslide debris collects at the toe of the slope.

It is recommended that subdivision and new dwellings are actively discouraged within Area A, as the risk of further instability and damage to property or life is very high.

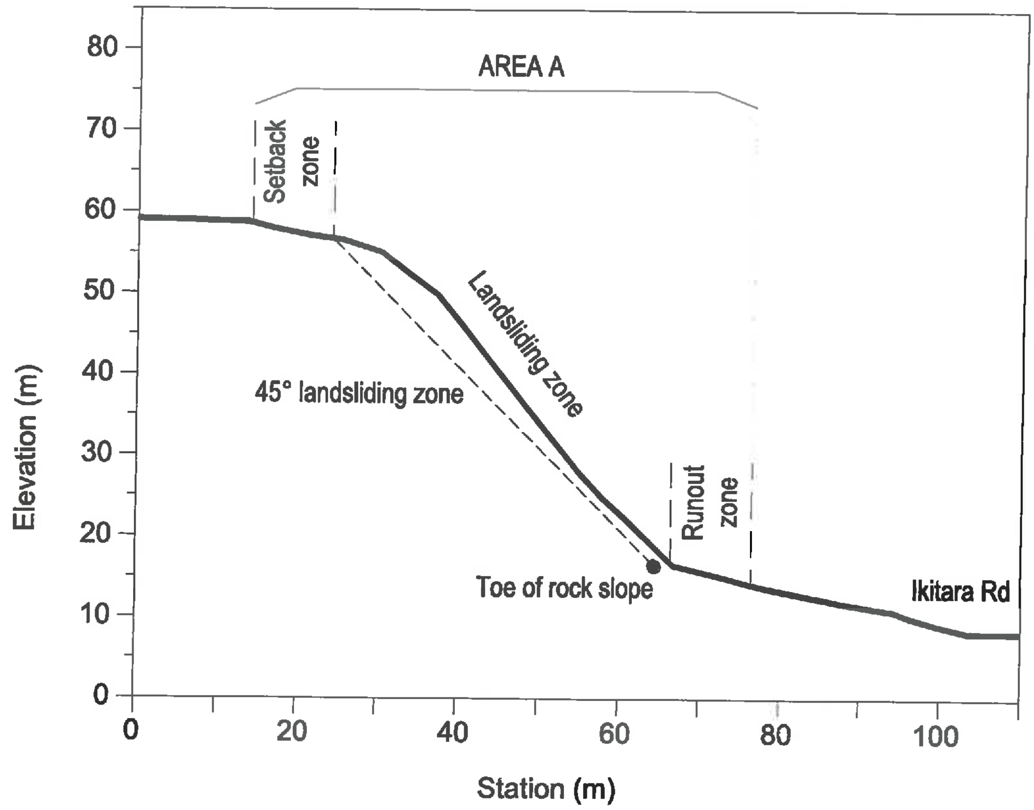

Illustration 6 Typical cross-section through an Area A hillslope section

Area B: Areas of moderate landslide hazard risk

This area consists of marginal land, with a significant landslide hazard, requiring prior geotechnical investigation to confirm its suitability for development. Assessment of the landslide hazard and risk to development should be carried out prior to consideration of any development as part of the consenting process. It is recommended that building consents not be issued unless prior resource consents are obtained for development including geotechnical investigations and assessment that prove their suitability for development with a low risk to the properties and life.

The outcome of geotechnical investigations will determine if the risk to property is moderate, high or very high, depending on factors such as the thickness and type of colluvium and groundwater levels. An outcome of very high risk may mean the land will be unsuitable for development (Area A), whereas moderate risk may mean the land can be developed, with mitigation measures designed and implemented to reduce the risk to low. The geotechnical assessment needs to demonstrate that a low risk can be achieved with mitigation.

LSA Area Maps

The zonation of the hillslopes in the study areas are given on Figures 2 and 3. The engineering geological mapping was carried out at approximately 1:2,500 scale, and consequently the area boundaries are approximate only. The LSA maps should be used only at the scale provided.

7 Recommendations

We recommend:

1. Subdivision and new dwellings be actively discouraged within the area of very high landslide risk (Area A).
2. Activities on marginal slopes (Area B) be preceded by site-specific geotechnical investigation and assessment prior to consideration of any development as part of the consenting process, to determine the risk of instability and identify treatment measures.
3. The landslide hazard maps be incorporated into Wanganui District Council's District Plan by way of a Land Stability Assessment overlay on the district planning maps.
4. The areas surrounding current study areas and other areas in the city where slope instability has caused issues in the past be assessed in a similar way as this study to provide uniformity in how these areas are treated in the District Plan.

8 Limitations of the Assessment

The slope stability assessment for this study covers only the area shown in Figures 2 and 3. No assessment of hillside stability has been made for properties outside this area.

Engineering geological mapping within the study area was carried out from examination of aerial photographs and observations from roads within the study areas. No access was gained to properties, and therefore individual property stability assessments have not been made. This is not a property specific assessment, but an area-wide qualitative appraisal to assist with development of land development controls.

9 References

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Figures

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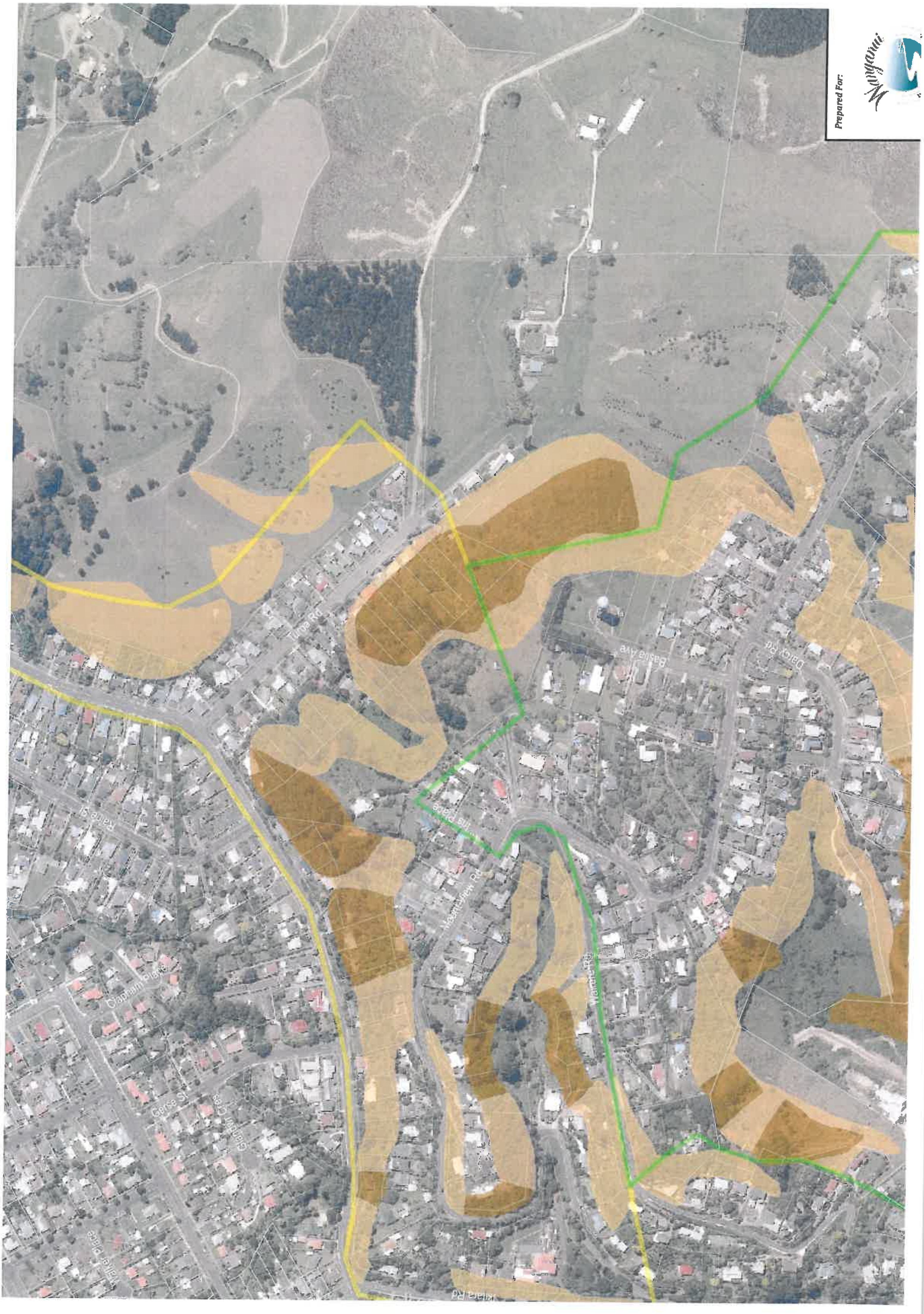
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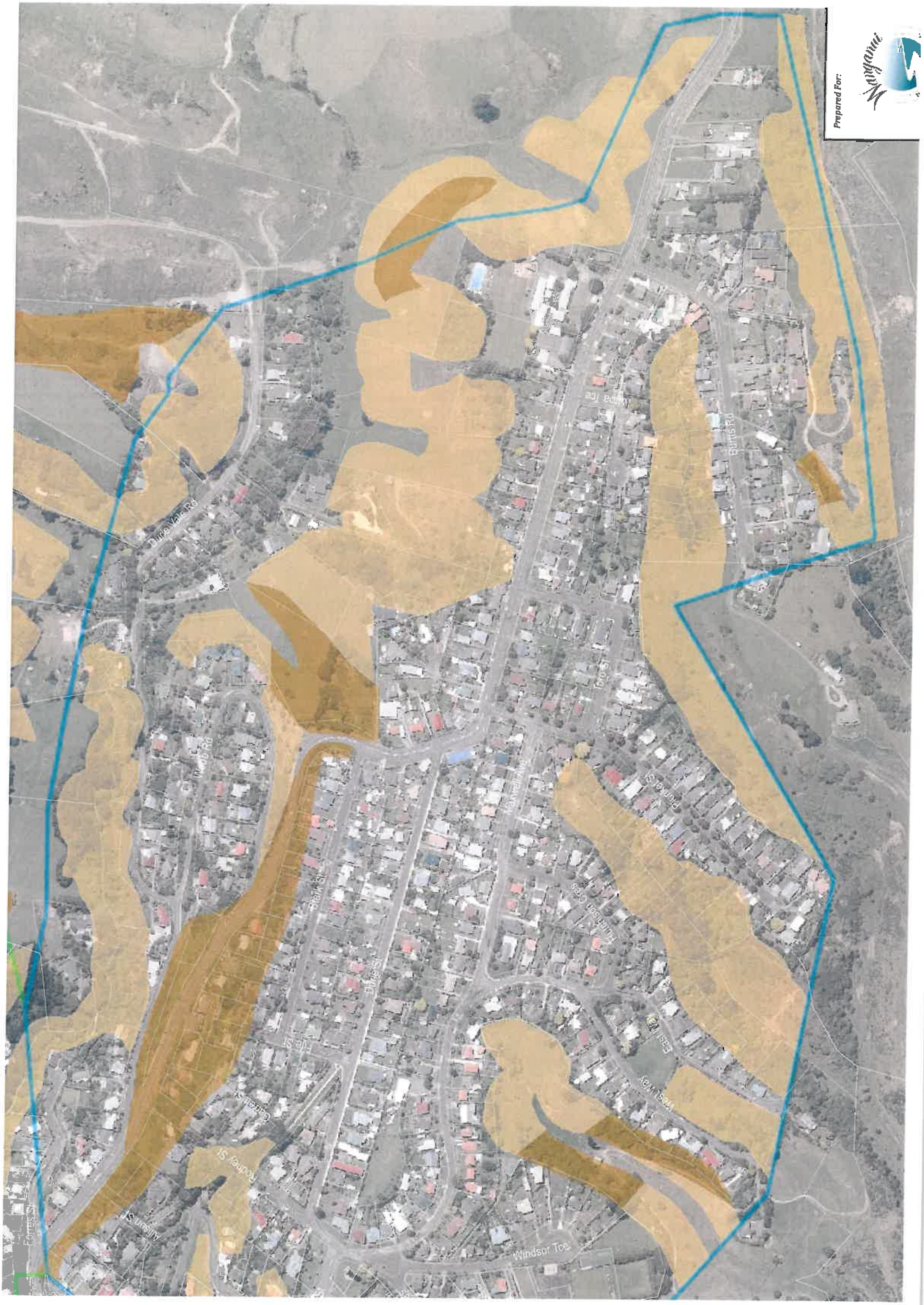
Turoa Rd
Clapham Place



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Blair St
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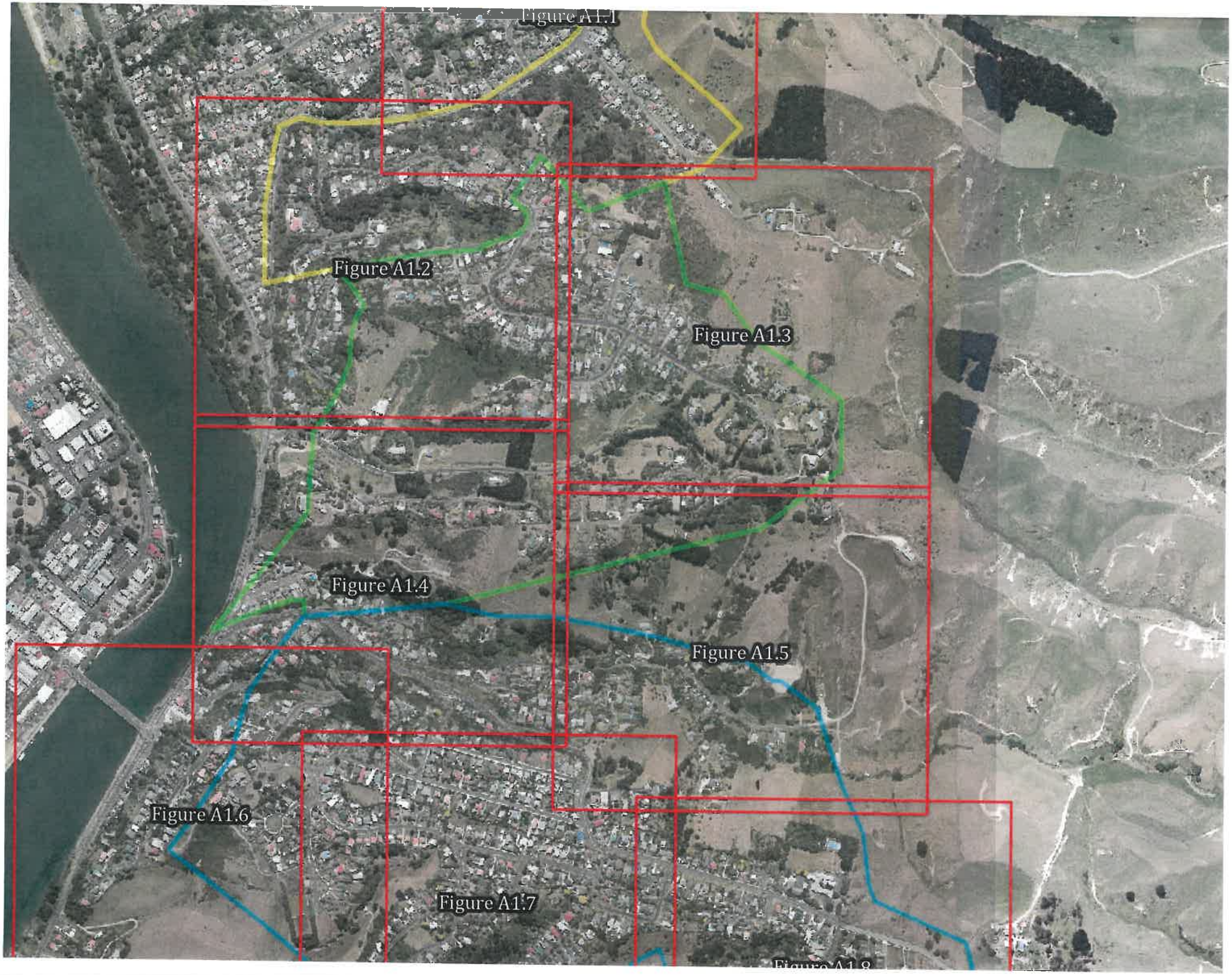
Appendix A
Engineering geology maps



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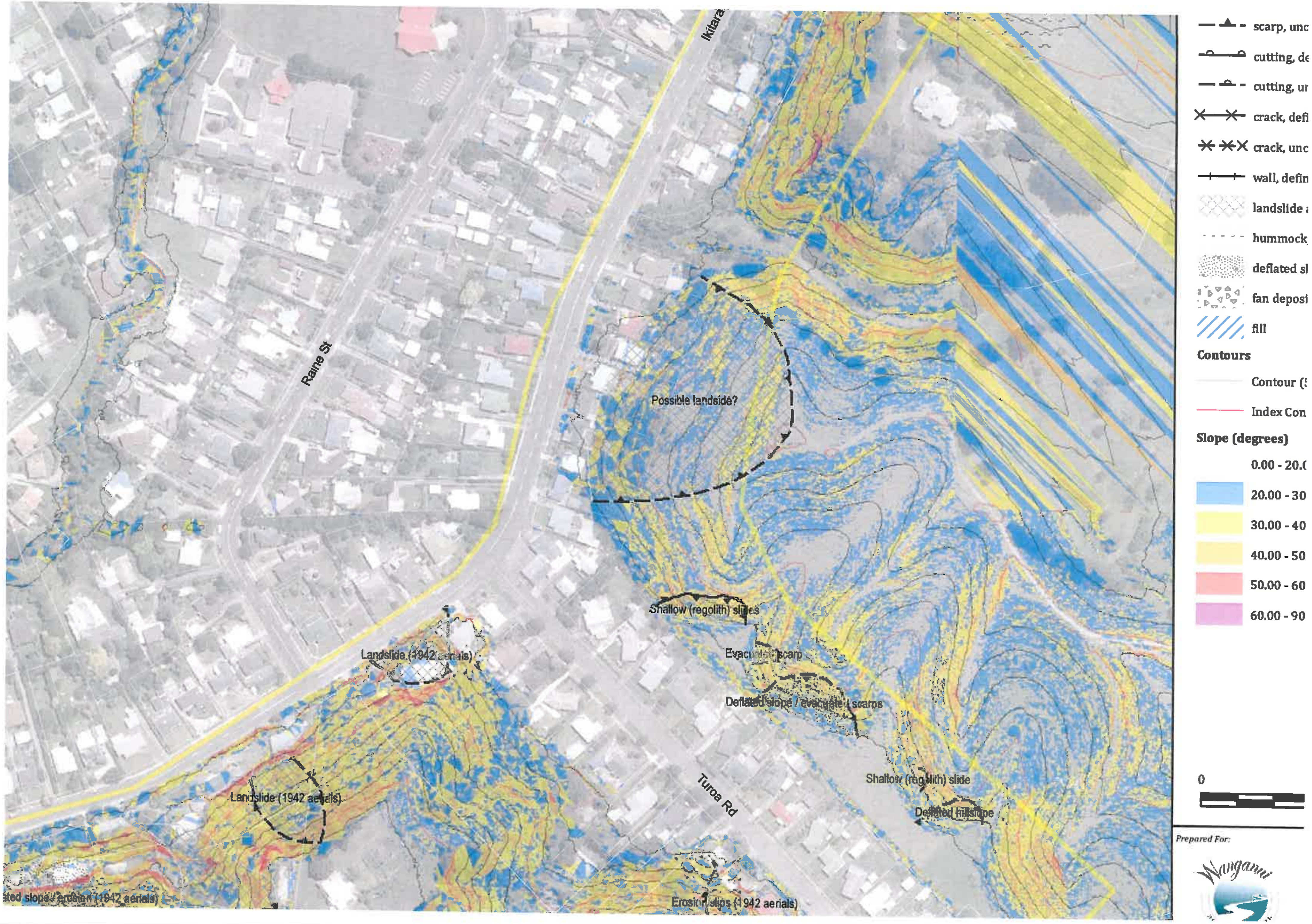

Ikitara
Raine St
Possible landside?
Shallow (regolith) slides
Evacuated scarp
Deflated slope / evacuated scarps
Shallow (regolith) slide
Deflated hillslope
Turoa Rd
Landslide (1942 aerials)
Landslide (1942 aerials)
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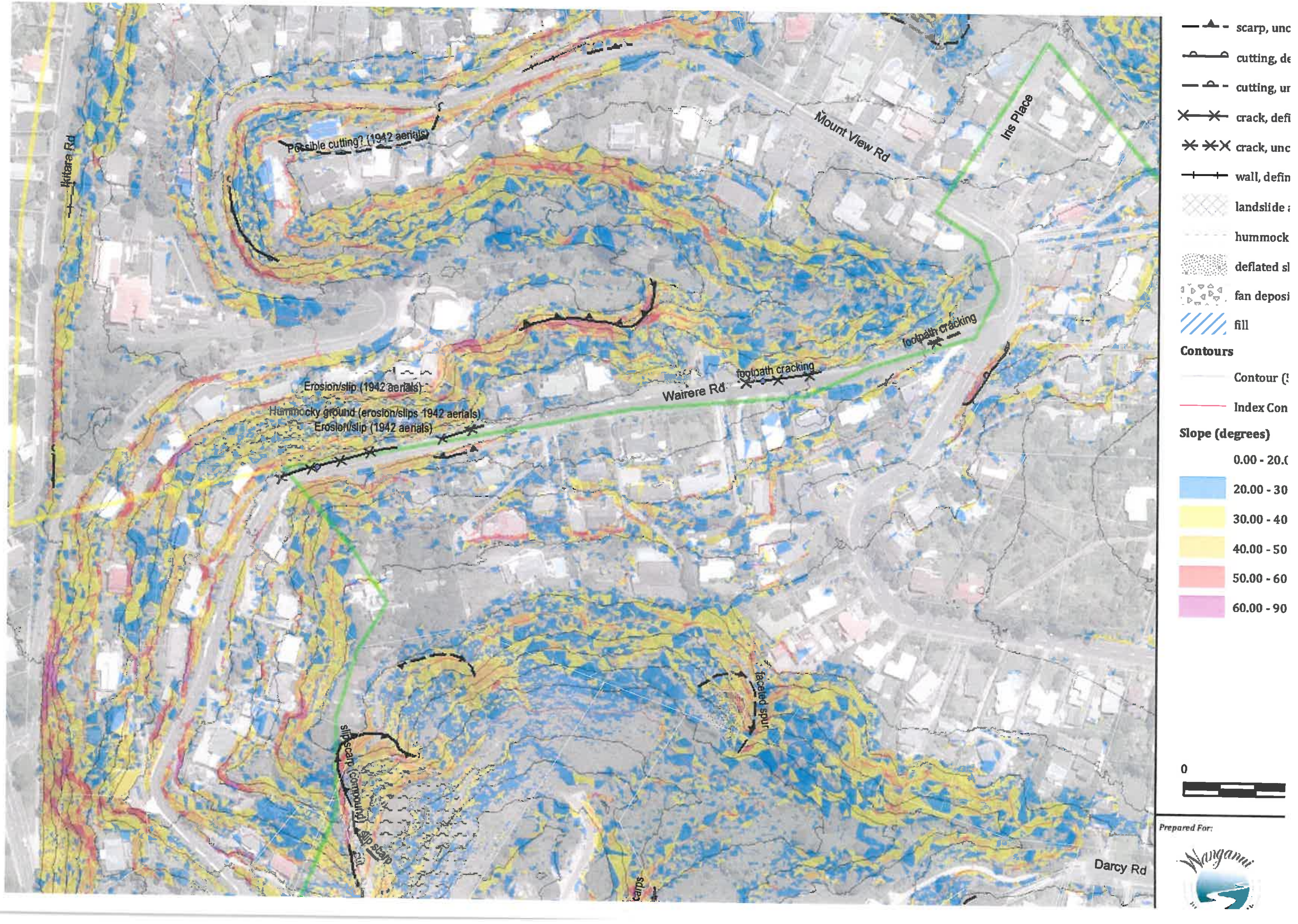

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Wanganui
Mount View Rd
Iris Place
Wairere Rd
footpath cracking
footpath cracking
Possible cutting? (1942 aerials)
Erosion/slip (1942 aerials)
Hummocky ground (erosion/slips 1942 aerials)
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faceted spur
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slip scarp
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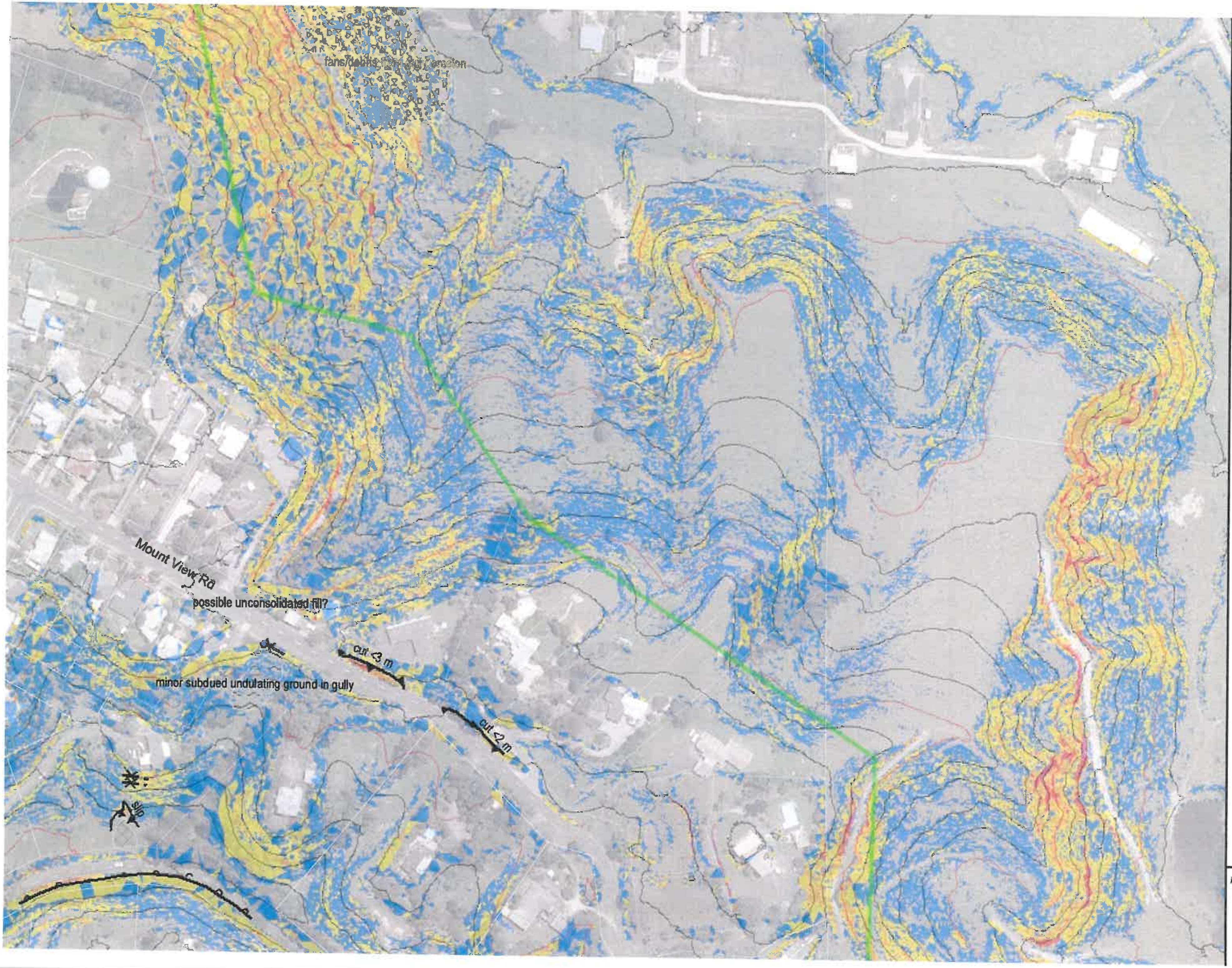
Darcy Rd
Ikitara Rd



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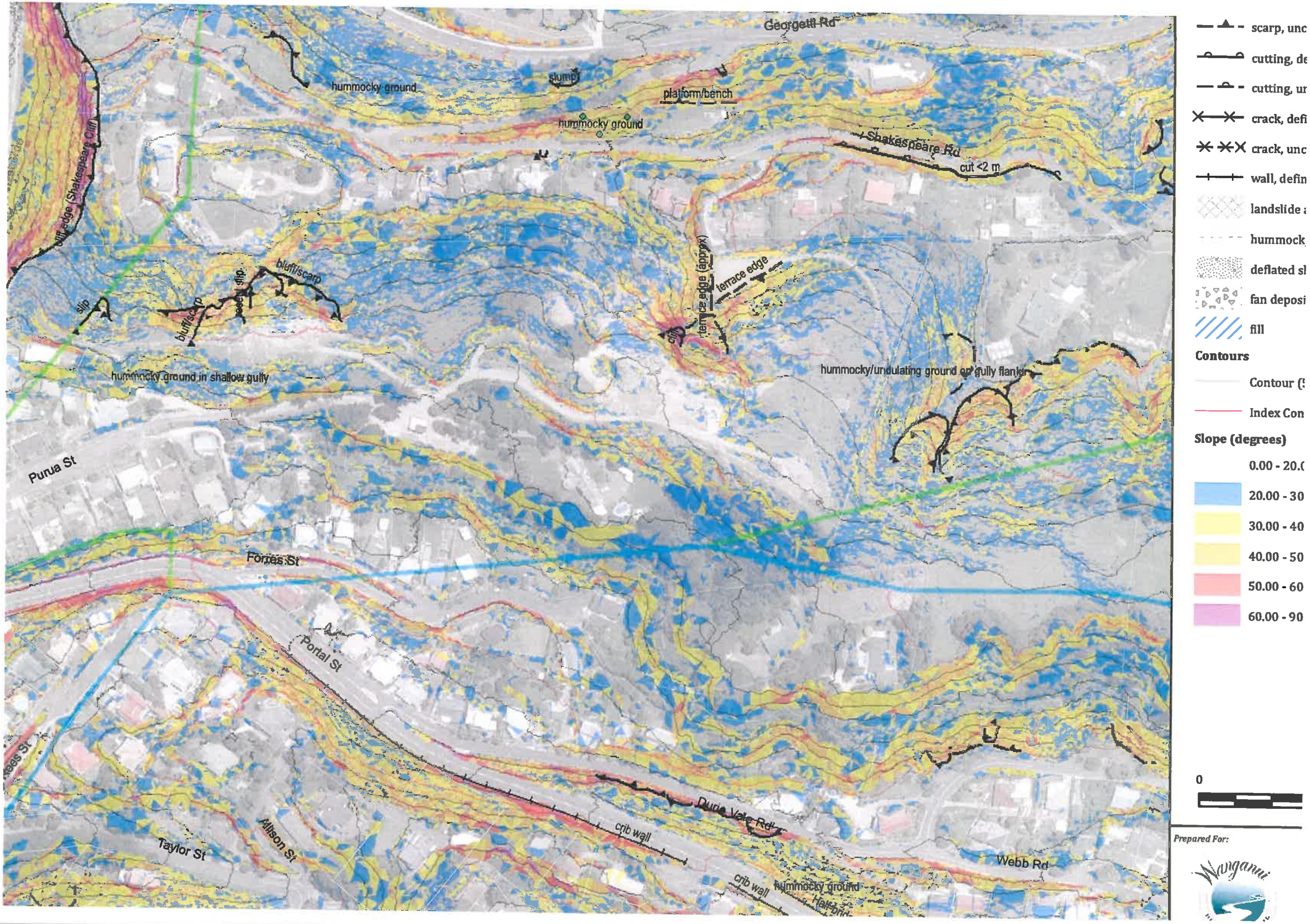

Georgetti Rd
hummocky ground
slump
platform/bench
hummocky ground
Shakespeare Rd
cut <2 m
cliff edge (Shakespeare Cliff)
bluff/scarp
slip
bluff/scarp
hummocky ground in shallow gully
terrace edge
terrace edge (approx)
slip
hummocky/undulating ground on gully flanks
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Forres St
Portal St
Durie Vale Rd
crib wall
crib wall
hummocky ground
Taylor St
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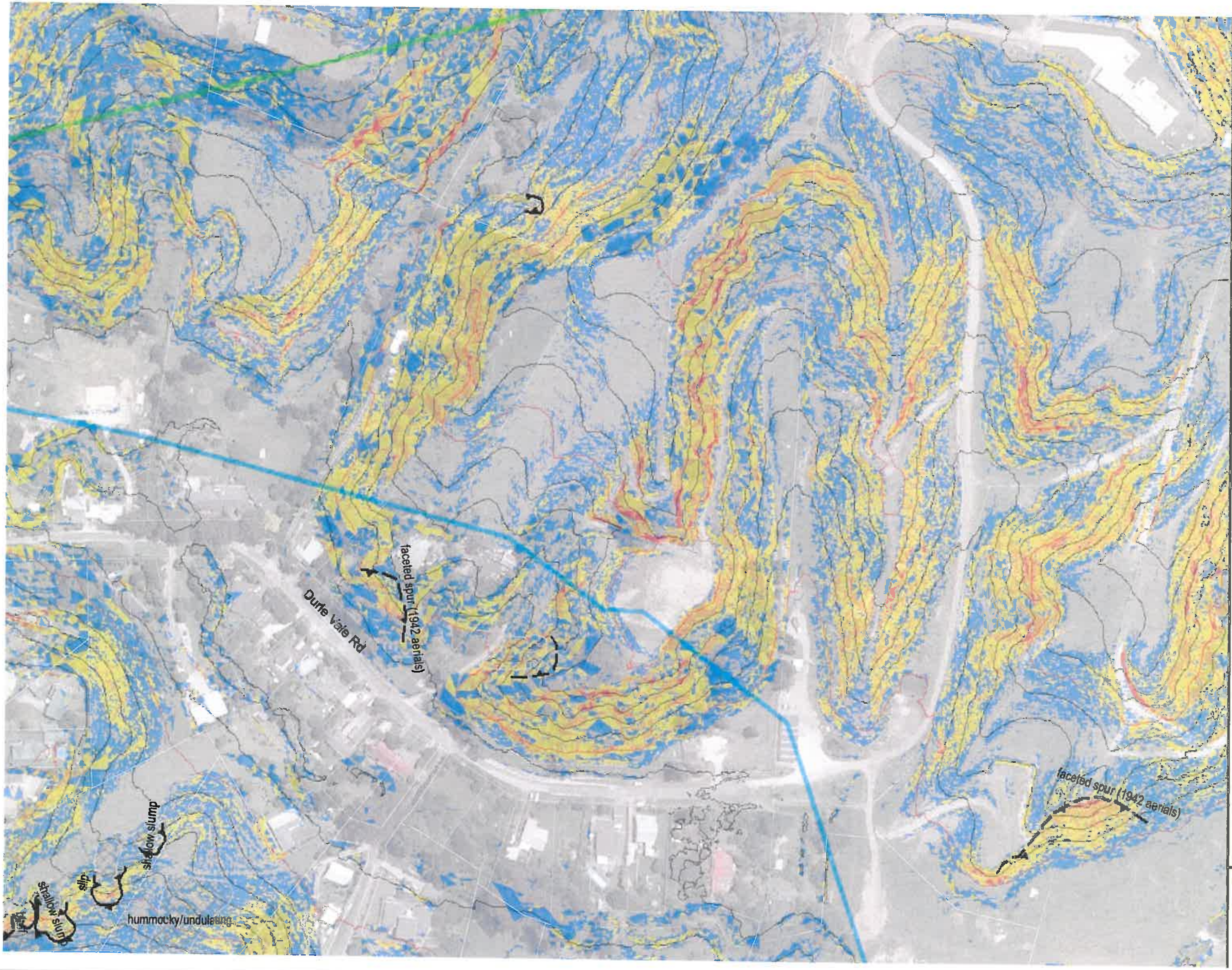

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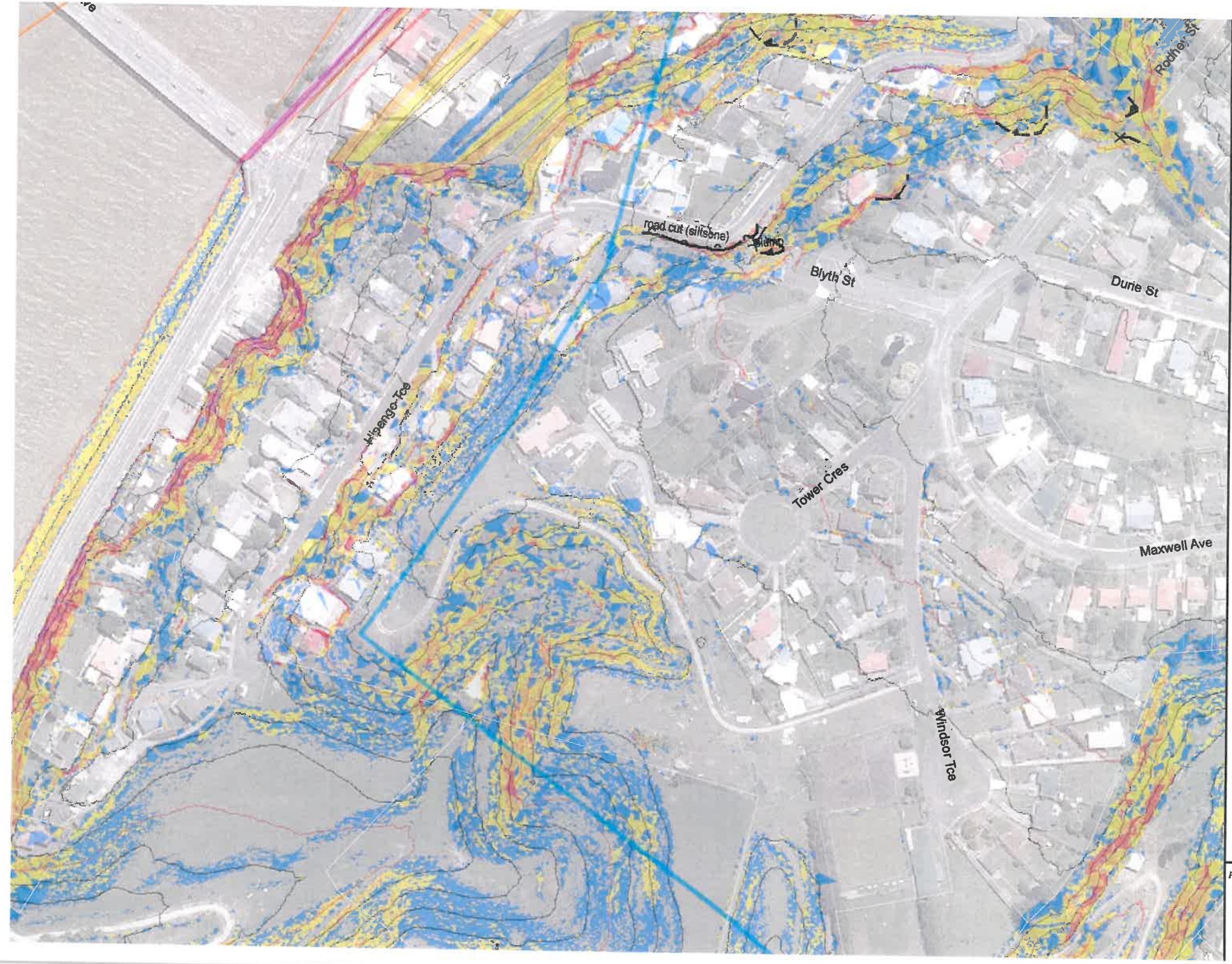

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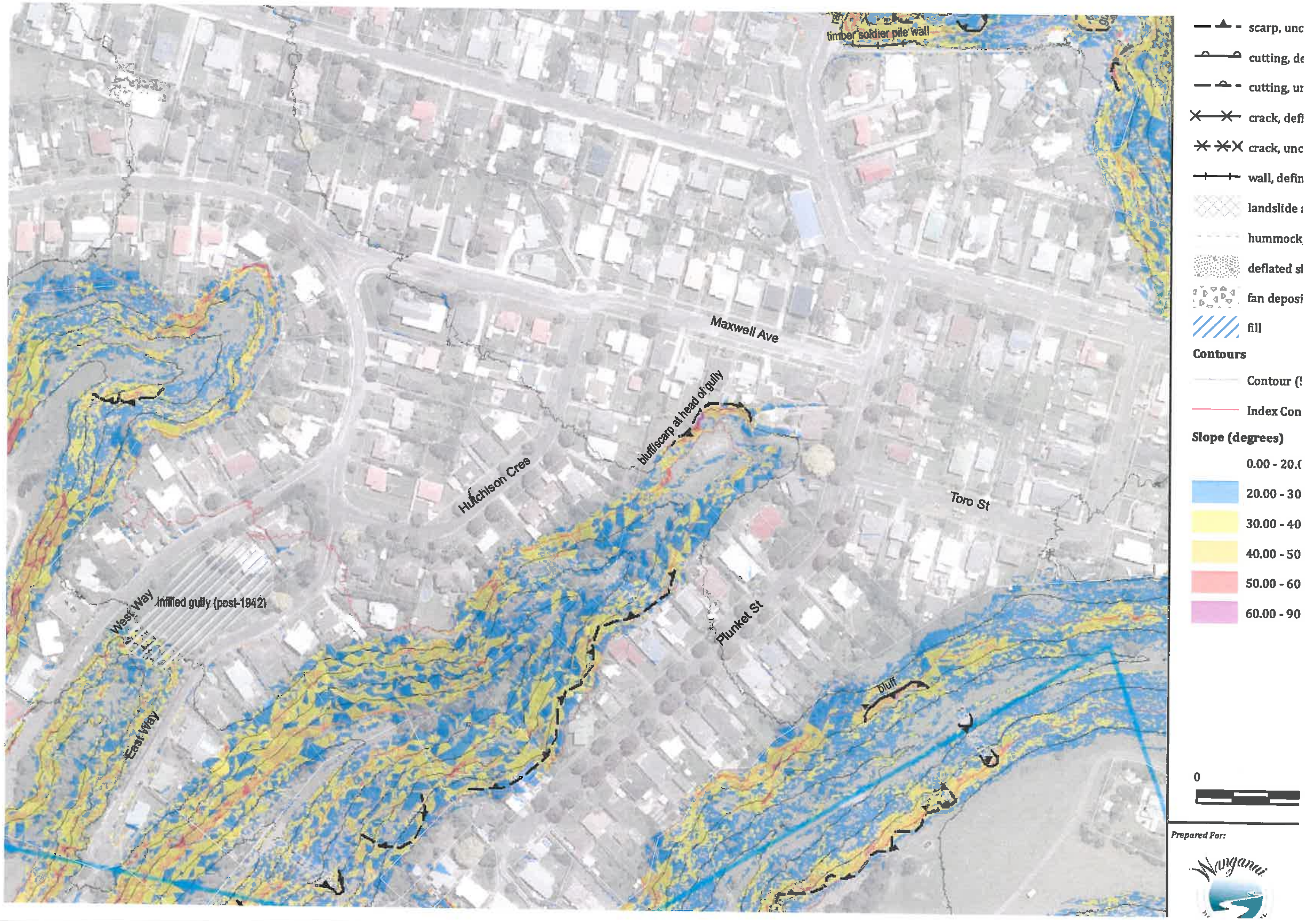
timber soldier pile wall
Maxwell Ave
bluffscarp at head of gully
Hutchison Cres
Toro St
Plunket St
infilled gully (post-1942)
West Way
East Way
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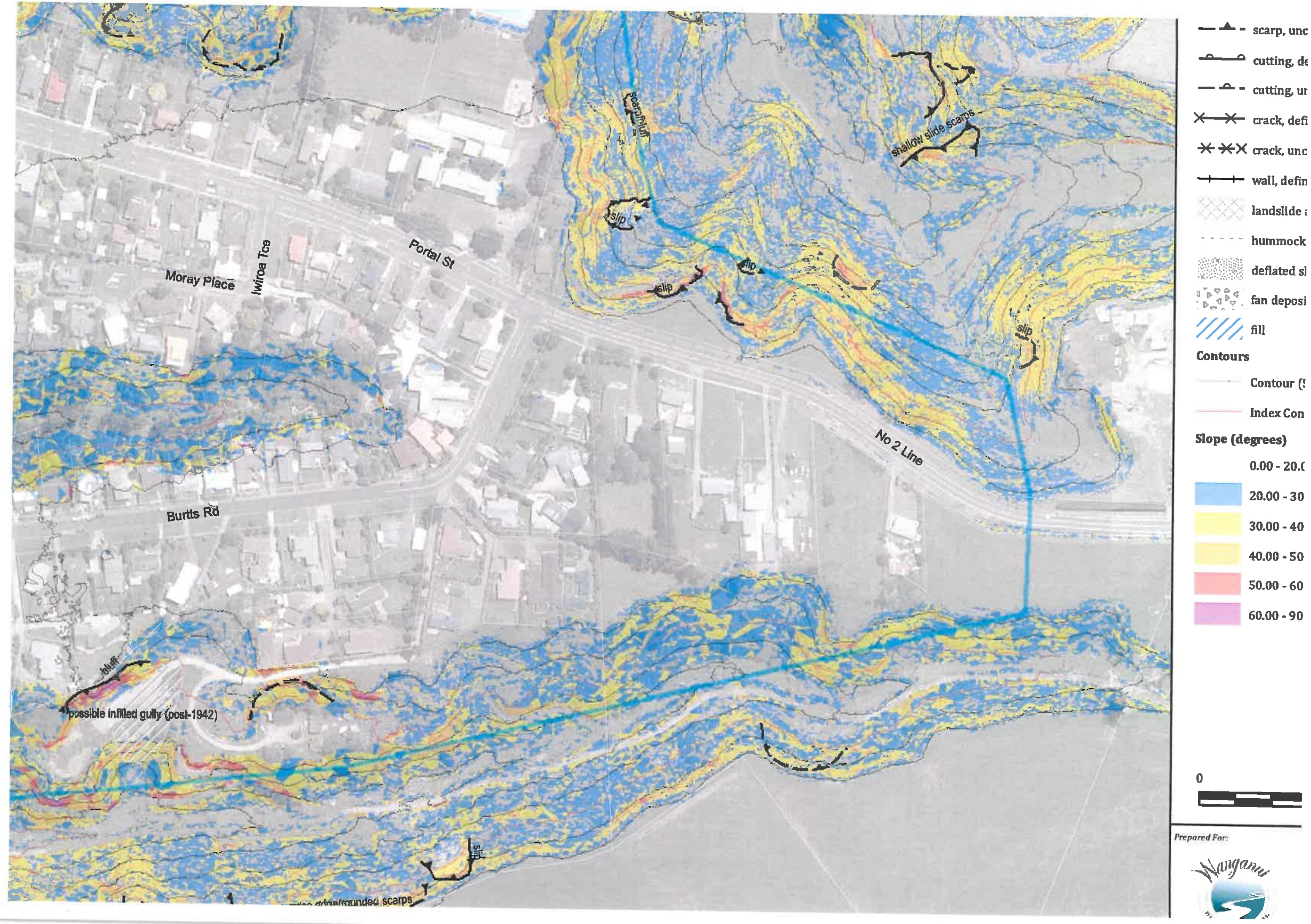

Portal St
Moray Place
Iwiroa Tce
Burtts Rd
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Slope (degrees)
0.00 - 20.0
20.00 - 30
30.00 - 40
40.00 - 50
50.00 - 60
60.00 - 90
0
Prepared For:
Wanganui

Appendix B
Risk assessment tables

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

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	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa.*

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

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

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}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

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.

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