Geotechnical and coastal hazards assessment

Warkworth Structure Plan

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Te Kaunihera o Tāmaki Makaurau

Table of Contents

1 Executive Summary

The Warkworth Future Urban Zone is located upstream of the Mahurangi River, approximately 14 km from the open coast. The boundaries of the future urban zone are adjacent to the Mean High Water Springs (MHWS) boundary, extending further landward in northerly, southerly and westerly directions as demonstrated on Figure . As a result, the extent of tidal influence and coastal processes on the future urban zone is limited and there are no identified coastal hazard constraints.

Most of the study area is underlain by rocks of the Waitemata Group, with smaller areas of the Northland Allochthon. The result is a complex combination of weak to moderately strong sandstones and mudstones (the Waitemata Group), with large lenses or disrupted slices of significantly weaker and highly sheared mudstones, siltstones, sandstones and limestones of the Northland Allochthon. These rock types are often associated with large landslides.

Although ancient landslides are observed in some slopes, no areas in the study area have been deemed unsuitable for development because of slope instability. Areas where stability is likely to be more challenging have been zoned for lower density development. This development style can be more flexible, with less need for significant earthworks which could compound existing instability.

Sea level rises since the last ice age ‘drowned’ the Puhoi and Mahurangi valleys. These valleys are infilled with deep, soft estuarine and alluvial sediments. These sedimentary deposits are often very weak, resulting in the need for more ground preparation (such as pre-loading to reduce settlement) or for deep foundations. They may also include areas locally prone to liquefaction.

These soft areas have been mostly left as open space or zoned for industrial uses which tend to either be light weight structures (so settlement is a relatively minor issue) or very heavy, in which case the structures would be built on piled foundations.

Overall it is considered that the Warkworth Structure Plan is appropriate from a geotechnical and coastal hazards perspective. The hazards identified should be practical to address with engineering controls. Further investigation and assessment will be needed as the land is developed to manage the risk posed by these hazards.

2 Introduction

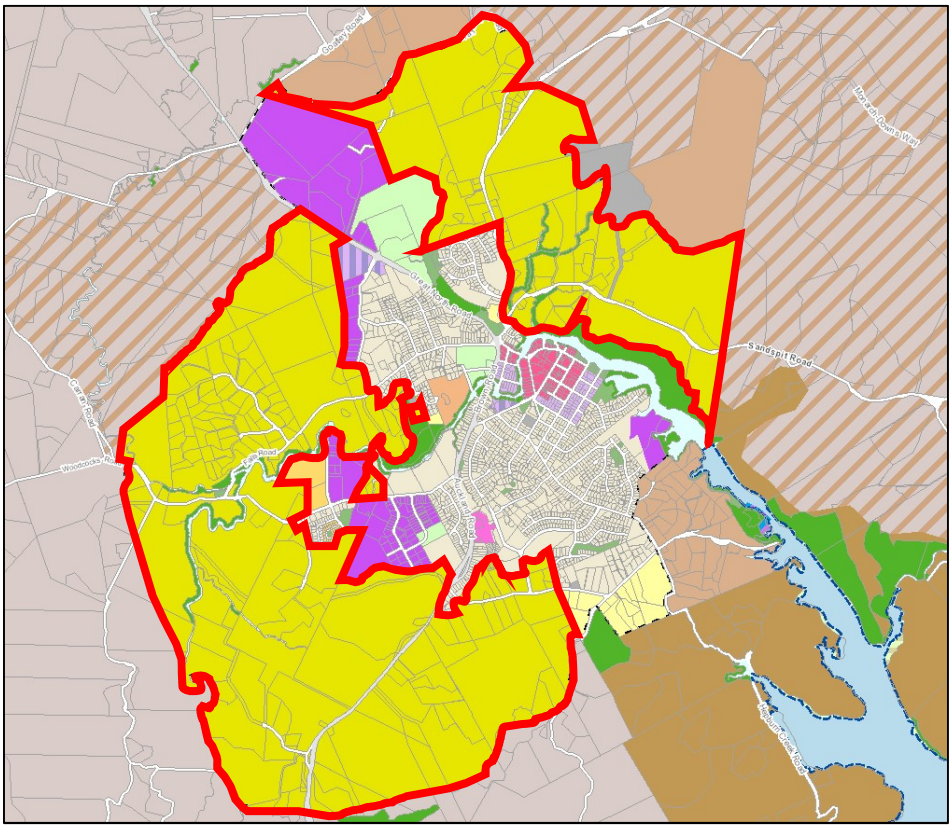
2.1 Purpose and scope of the report

This is one of a number of reports that have been prepared for the Warkworth Structure Plan as part of the supporting information behind the structure plan document. This report outlines the existing environment in the study area with regards to geotechnical and coastal hazards and assesses the Warkworth Structure Plan in relation to these topics.

2.2 Study Area

The study area for the Warkworth Structure Plan is the Future Urban zone around Warkworth. It comprises around 1,000ha of land. The study area is shown outlined in red on Figure 1 below.

Figure 1: Warkworth structure plan study area (outlined in red)



3 Existing environment

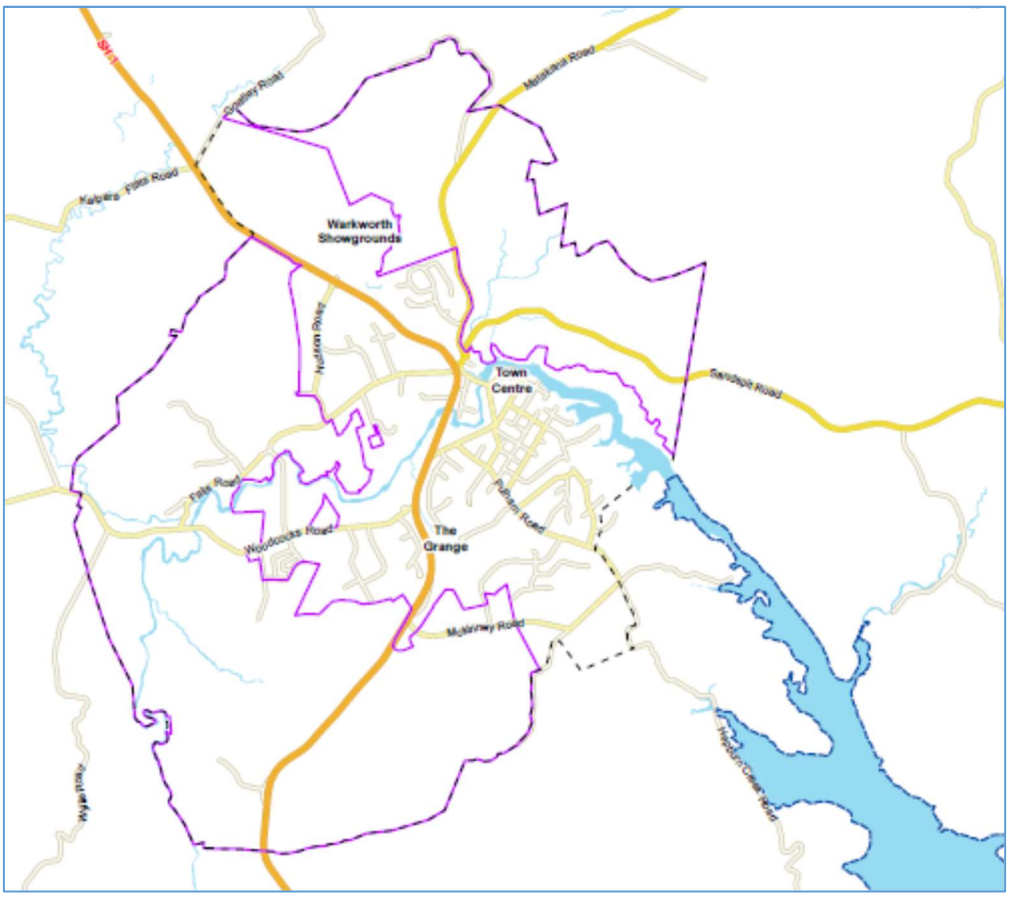
This section presents a brief introduction to the geotechnical and coastal environment. Further details are available in the Geotechnical and Coastal Hazards Topic Report (document reference AKLC-1201561183-276).

3.1 Description of study area

The Warkworth Future Urban Zone is located upstream of the Mahurangi River, approximately 14 km from the open coast. The boundaries of the future urban zone are adjacent to the Mean High Water Springs (MHWS) boundary, extending further landward in northerly, southerly and westerly directions as demonstrated on **Figure** . As a result the extent of tidal influence and coastal processes on the future urban zone is limited.

The topography of the area is shown in more detail in Map 1(attached)

Figure 2: Warkworth Future Urban zone demonstrating distance from MHWS (blue dashed line) and the open coast



3.2 Geology

3.2.1 Summary

The 2001 QMap at 1:250,000 scale (Edbrooke S. W., 2001) is the most recent published geological map covering the study area. This shows the following main geological units present in the Warkworth Structure Plan study area:

- Northland Allochthon:
  - Motatau Complex – closely fractured limestone (Mahurangi Limestone) and calcareous mudstone
  - Mangakahia Complex – closely fractured to sheared mudstone, limestone and sandstone
- Waitemata Group:
  - Pakiri Formation – volcanic rich interbedded sandstone and siltstone with thick beds or lenses of coarse conglomerate-breccia (Parnell Grit)
- Tauranga Group Alluvium:
  - Holocene floodplain and alluvial fan deposits consisting of unconsolidated to very soft clay, sand and gravel with thin peat or organic lenses
  - Colluvium – gravity driven and mass movement (e.g. landslide) deposits derived from parent Waitemata Group and Northland Allochthon rocks (not separately identified on geological maps)

Maps 2a and 2b (attached) provide the extent of these geological units taken from the most recent published geological mapping (Edbrooke S. W., 2001). There is existing information available in the public domain from previous ground investigations, as shown on Map 2a, and numerous geotechnical reports held on property files as shown in Map 2b.

Most of the study area is underlain by rocks of the Waitemata Group, which were deposited in-situ, and rocks of the Northland Allochthon[1] which were scraped off the Pacific plate as it was subducted beneath New Zealand approximately 15 million years ago.

The result is a complex combination of weak to moderately strong sandstones and mudstones (the Waitemata Group), with large lenses or disrupted slices of significantly weaker and highly sheared mudstones, siltstones, sandstones and limestones of the Northland Allochthon. These rock types are often associated with large landslides.

Since deposition and emplacement of these rocks the study area has been uplifted. It is thought that this ongoing regional uplift may have been in large part responsible for maintaining a relatively rugged relief, despite ongoing deep and rapid chemical weathering of the rocks and an otherwise stable tectonic situation for the last 10-15 million years.

About 20,000 years ago, during a period of glaciation, sea levels reached a low of about 100 m below current sea level resulting in rivers cutting deep valleys into the landscape. Subsequent sea level rises 'drowned' and infilled many of the deep valleys with sediments. These drowned valleys dominate the east coast of Northland, including the Puhoi and Mahurangi valleys. These valleys are infilled with deep, soft estuarine and alluvial sediments, often with terrace levels representing

[1] Allochthon: a large block of rock which has been moved from its original site of formation, usually by low angle thrust faulting.

previous, higher sea levels or lower land levels (Ballance & Williams, 1992). These sedimentary deposits are often very weak, resulting in the need for more ground preparation (such as pre-loading to reduce settlement) or for deep foundations. They may also include areas locally prone to liquefaction.

Colluvium is present on many slopes, typically resulting from translational sliding of residual soils. Colluvium is a general term for the material transported by slope movement. This slope movement has been exacerbated as a result of human impacts on the landscape since the 1820s, including the changing land use from kauri forest to scrub, pasture, or urban land (Ballance & Williams, 1992). Deforestation also alters hydrology, which may result in channel enlargement and migration.

3.3 Regional hydrogeology

Subsurface groundwater conditions are an important consideration for any development, and may have a major impact on foundations, services (excavations), earthworks, slope stability and liquefaction potential.

The hydrogeological regimes of the main geological groups encountered in the Warkworth Structure Plan study area (the Waitemata Group, Northern Allochthon and Tauranga Group) are fundamentally different.

Northland Allochthon rocks can display highly variable and complex hydrogeological conditions relative to various response zone depths. Northland Allochthon rocks typically comprise low to very low permeability rocks. Both matrix and secondary permeability along bedding planes is typically low due to secondary infill through either weathering products (clay) or precipitation (limonite or calcite). However, localised zones of high tertiary (conduit) permeability have been experienced in water supply boreholes in the Warkworth area as a result of the presence of fault induced shattering of the rock.

Drainage from the Northland Allochthon rocks is typically observed as a line of seepage or minor springs at geological boundaries between units within the Northland Allochthon rocks.

Waitemata Group Rocks typically have slightly higher hydraulic conductivity values. Perched and leaky water tables may be present and reflect the interbedded nature of the sandstones and siltstones of varying permeability. Groundwater from the Waitemata Group rocks is used as a resource for stock and domestic water supplies, but generally the yields are low for boreholes less than 100 m deep, and the aquifers are not generally conducive within reasonable economic consideration for the higher flows required for broad water supply or irrigation purposes.

The geology and geological structure in the area lends itself to poorly yielding aquifers, with the exception being localised zones of better yields associated with faulting and shallow alluvial deposits infilling valleys. Groundwater use in the Puhoi to Warkworth area is generally low with the bore database only providing information on private seven bores. These are typically for stock and domestic purposes. Deeper bores (such as those at Sanderson Road) have encountered higher yielding zones.

3.4 Coastal setting

The proposed Warkworth Future Urban Zone is 14 km inland from the open coast and extends landward in a northerly, westerly and southerly direction from the upper limit of Mean High-Water

Springs. The site is outside of the activity controls identified in the Auckland Unitary Plan for coastal erosion, coastal inundation and the future effects of sea-level rise. As a result, there are no identified coastal hazard constraints.

4 Warkworth Structure Plan

4.1 Overview of Warkworth Structure Plan

The Warkworth Structure Plan sets out the pattern of land uses and the supporting infrastructure networks for the Future Urban zoned land around Warkworth. In preparing the Warkworth Structure Plan, the following were considered:

- the context of the existing town in Warkworth
- the opportunities and constraints of the structure plan area as identified in 16 technical papers[2]
- the feedback received from various stakeholders and public engagement events[3].

The structure plan is show in **Figure 3**.

Some of the key high-level features of the Warkworth Structure Plan include:

- Ecological and stormwater areas are set aside from any built urban development.
- The new residential areas across the Future Urban zone enable around 7,500 dwellings and offer a range of living types from spacious sections around the fringe to more intensive dwellings such as town houses and apartments around the new small centres and along public transport routes.
- Warkworth's local and rural character is protected through various measures including provisions to protect the bush-clad town centre backdrop by the Mahurangi River and retaining the Morrison's Heritage Orchard as a rural feature of the town.
- New employment areas are identified, comprising land for new industry (e.g. warehousing, manufacturing, wholesalers, repair services) and land for small centres (e.g. convenience retail, local offices, restaurants/cafés). The existing Warkworth town centre by the Mahurangi River will remain as the focal point of the town.

The land uses are supported by infrastructure including:

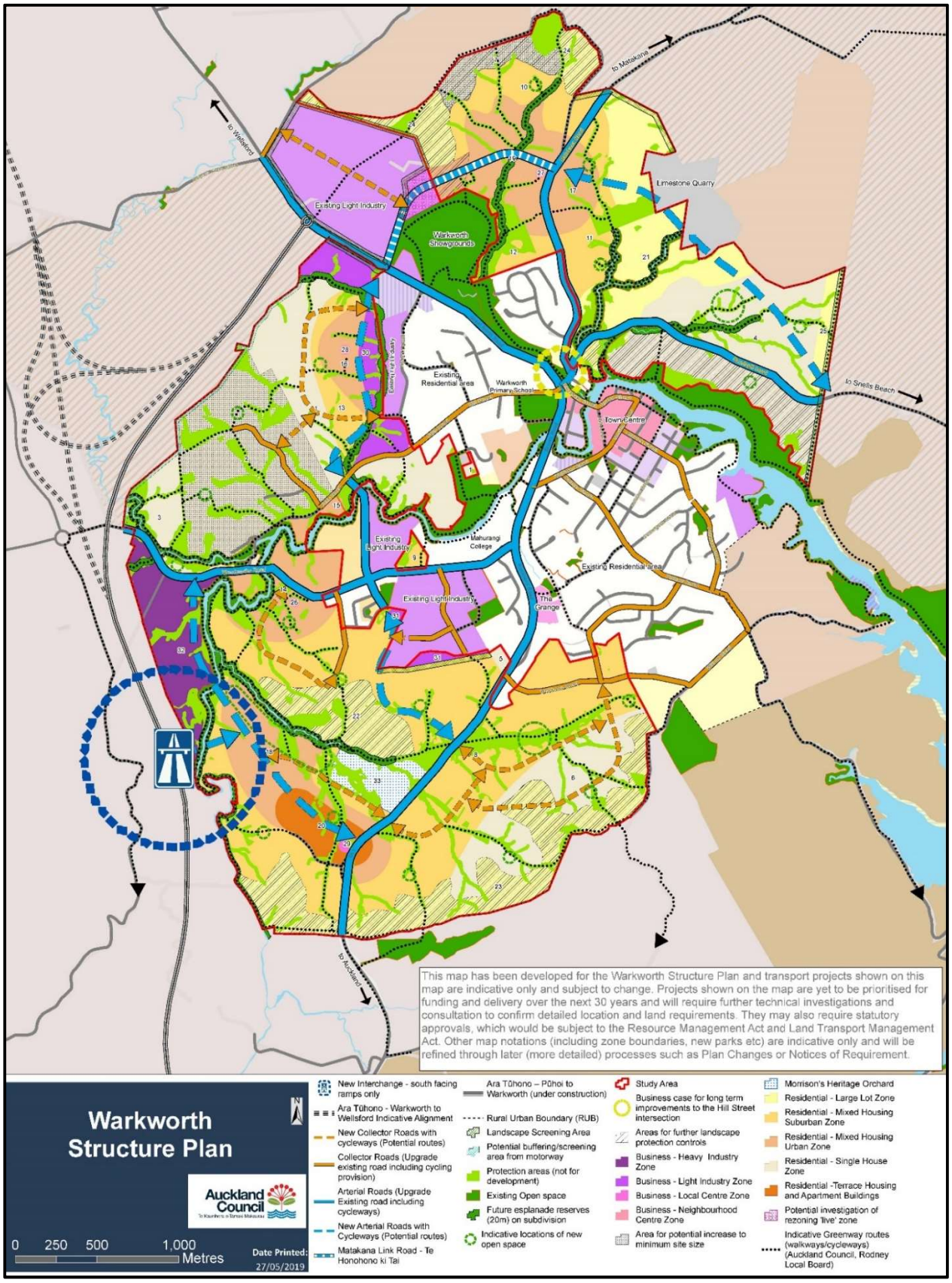
- Prioritising active transport in Warkworth through a separated walking and cycling network providing connectivity to new and existing centres, employment areas, schools and public transport stations.
- A roading network including a potential southern interchange on Ara Tūhono – Pūhoi to Warkworth (south facing ramps only).
- A public transport network built upon the recently introduced 'New Network for Warkworth' and in the long term has a bus station/interchange in Warkworth's southern Local Centre and a Park and Ride near the potential Ara Tūhono – Pūhoi to Warkworth southern interchange.

[2] 16 topic papers that were prepared in February 2018 as part of initial consultation on the structure plan
[3] This includes feedback from mana whenua, business, resident and community groups, engagement survey findings and community workshops held to generate land use ideas for the Warkworth area.

- Other infrastructure providers for utilities such as wastewater, water, power supply, telephone, broadband, community facilities, schools, and healthcare have plans underway to service the planned growth of Warkworth.

Further details on the Warkworth Structure Plan can be found in the structure plan document on the project website.

Figure 3: Warkworth Structure Plan



4.2 Assessment of the Warkworth Structure Plan

4.2.1 Land use plan

4.2.1.1 Industry

In order to accommodate large footprint buildings, industrial land has been concentrated on in flatter, low-lying areas. These tend to coincide with soft ground and relatively poor geotechnical conditions. This is considered appropriate for industrial land use because:

- Warehouse structures tend to impose relatively low loads and are therefore not likely to suffer significant settlement.
- Structures that are sensitive to differential settlement (such as storage facilities with automated racking systems) are likely to need to be piled regardless of the geotechnical constraints, and so the soft soils would not pose a significant additional cost.

4.2.1.2 Small centres

The proposed locations for the Local Centres and Neighbourhood centres are not constrained by any particular geotechnical issues.

4.2.1.3 Low density residential (LL, SH)

The low-density residential housing has been partially selected in response to the presence of geotechnical stability issues. Where instability may be exacerbated by large earthworks, the selection of lower density development is appropriate to minimise earthworks volumes and therefore reduce these impacts.

4.2.1.4 High density residential (MHS/MHU/THAB)

Higher density residential areas are concentrated in flatter and more stable land. The selection of flatter land reduces the volume of earthworks required, which should enable more cost-effective development.

4.2.2 The Auckland Plan (2018)

The Auckland Plan recognises that Auckland is exposed to a broad and dynamic range of natural hazards and that they are a significant part of our natural environment. The plan states that part of the definition of a healthy home is that it is safe and potential hazards are minimised and/or isolated and/or eliminated. The plan also recognises that Auckland's infrastructure systems need to be resilient to the risk from natural hazards.

Commentary on the Warkworth Structure Plan in relation to these hazards is presented in the following Auckland Unitary Plan section.

4.2.3 The Auckland Unitary Plan (Operative in Part) (2016)

The Auckland Unitary Plan recognises that Auckland is affected by a range of hazards including land instability, coastal erosion and coastal inundation. In addition, it considers the effects of climate change and sea-level rise. These matters are predominantly addressed in the Auckland Wide rules of Chapter E.36 Natural Hazards and Flooding. The overarching objectives of which are to ensure that the risks of adverse effects from natural hazards in rural areas are not increased and, where practicable, are reduced.

Policy 1 requires land that may be subject to natural hazards (including land instability, coastal hazards and the likely effect of climate change) to be identified. The Geotechnical and Coastal Topic Report has assessed these factors at a level appropriate for structure planning. More detailed assessments will be required on a site by site basis as more detailed investigations are undertaken.

Policies 5 to 9 specifically relate to coastal hazards to avoid and not increase the risk through subdivision and development. Given the distance of the study area from the coastal hazards, these are not considered a constraint for the area.

Policies 10 to 12 consider coastal defences and seek to encourage natural systems as defences against coastal hazards over hard protection structures. Given the distance of the study area from the coastal hazards, these are not considered relevant for the area.

Policies 31 to 33 specifically relate to land instability. The policies highlight that land potentially exposed to instability must be identified taking into account; proximity to cliffs, steepness of land, geological characteristics and uncontrolled fill. As a result, risk assessment prior to subdivision, use and development of land is required, and results should ensure potential adverse effects are primarily avoided. Where not practicable, effects should be remedied or mitigated. The Topic Report has shown that slope stability can be an issue in the study area. Slope instability is a problem encountered in several areas of Auckland and can usually be addressed with careful engineering. This increases the cost of development, but often does not preclude it. No areas in the study area have been deemed unsuitable for development because of slope instability. Areas where stability is likely to be more challenging have been zoned for lower density development. This development style can be more flexible, with less need for significant earthworks which could compound existing instability.

4.2.4 Warkworth Structure Plan principles

A number of planning principles have been developed for the Warkworth Structure Plan as outlined below. These planning principles are Warkworth specific and are intended to be considered in addition to (not replacing) existing objectives and policies guiding Warkworth's growth.

A number of information sources were used to develop the principles including public feedback on the structure plan project (April 2018), the Warkworth Community Aspirations document (2017), the Warkworth Spatial Plan consultation (2017), and feedback from iwi.

The planning principles have been used to help guide and assess the development of the Warkworth Structure Plan.

The Warkworth Structure Plan planning principles are grouped under seven headings:

- The Mahurangi River is Warkworth's taonga
- Character and identity
- A place to live and work
- Sustainability and natural heritage
- A well-connected town
- Quality built urban environment
- Infrastructure

The planning principles are covered in more detail in the Warkworth Structure Plan document.

4.2.5 Matters identified in the Structure Plan Guidelines

4.2.5.1 Natural resources

No significant effects are anticipated as a result of the structure plan on geotechnical or coastal natural resources.

4.2.5.2 Natural and built heritage

Only one area of geological significance is recorded in the area (Wilsons Cement Works). This is unlikely to be impacted by the proposed structure plan as it lies just outside the boundary adjacent to the Mahurangi River at the end of Wilson Road.

4.2.5.3 Geotechnical hazards

In addition to the slope stability hazards noted above, some areas of weak alluvium, which may be liquefiable, have been identified. As with slope stability, this is a problem encountered in several areas of Auckland and can usually be addressed with careful engineering.

5 Conclusion

Overall it is considered that the Warkworth Structure Plan is appropriate from a geotechnical and coastal hazards perspective. The hazards identified should be practical to address with engineering controls. Further investigation and assessment will be needed as the land is developed to manage the risk posed by these hazards.

6 References

Ballance, P. F., & Williams, P. W. (1992). The geomorphology of Auckland and Northland. In J. M. Soons, & M. J. Selby, *Landforms of New Zealand* (2nd ed., pp. 127-136).

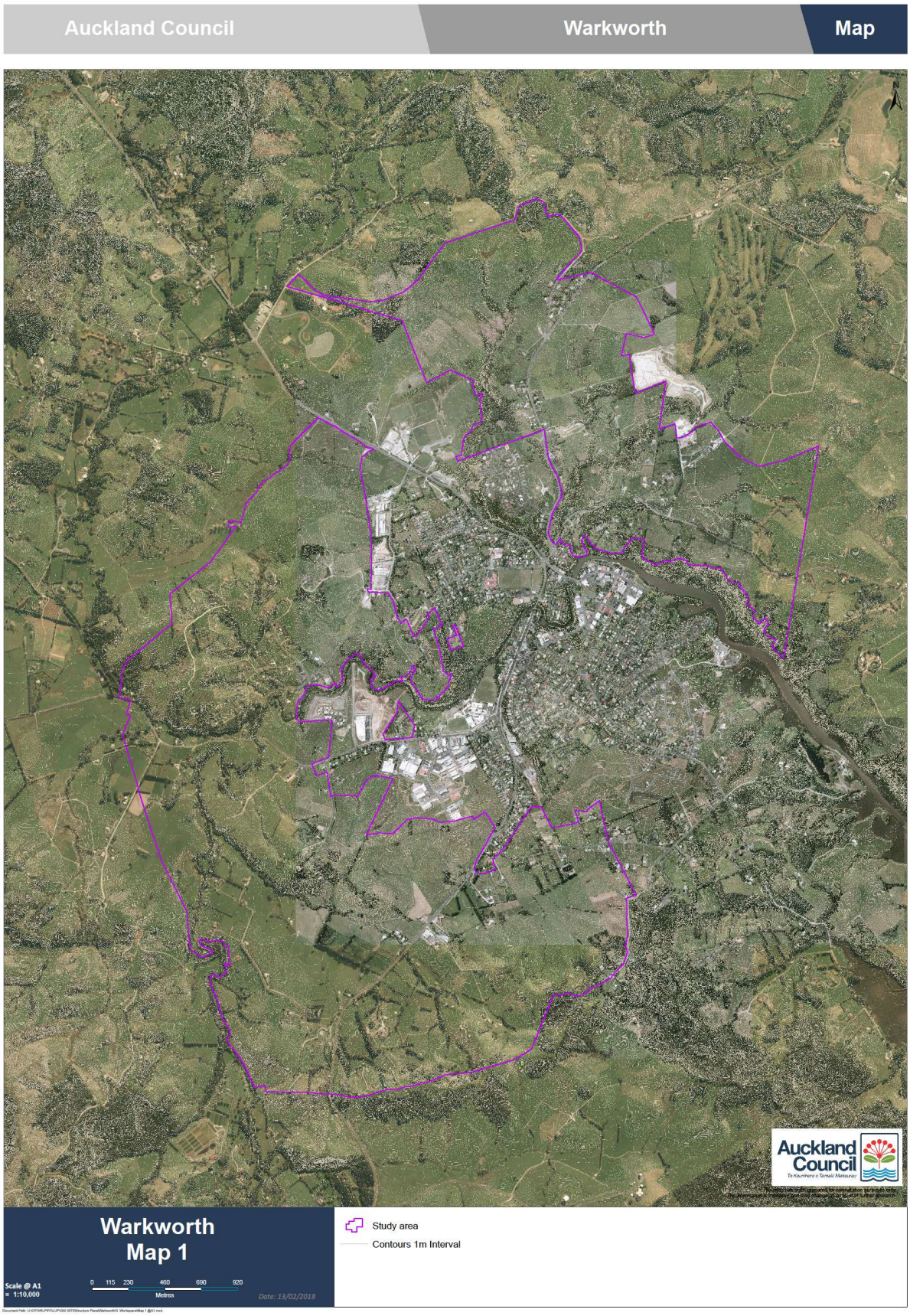
Edbrooke, S. W. (2001). *Geology of the Auckland Area.* Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences.

Isaac, M. J., Herzer, R. H., Brook, F. J., & Haywood, B. W. (1994). *Cretaceous and Cenozoic sedimentary basins of Northland, New Zealand.* Institute of Geological & Nuclear Sciences.

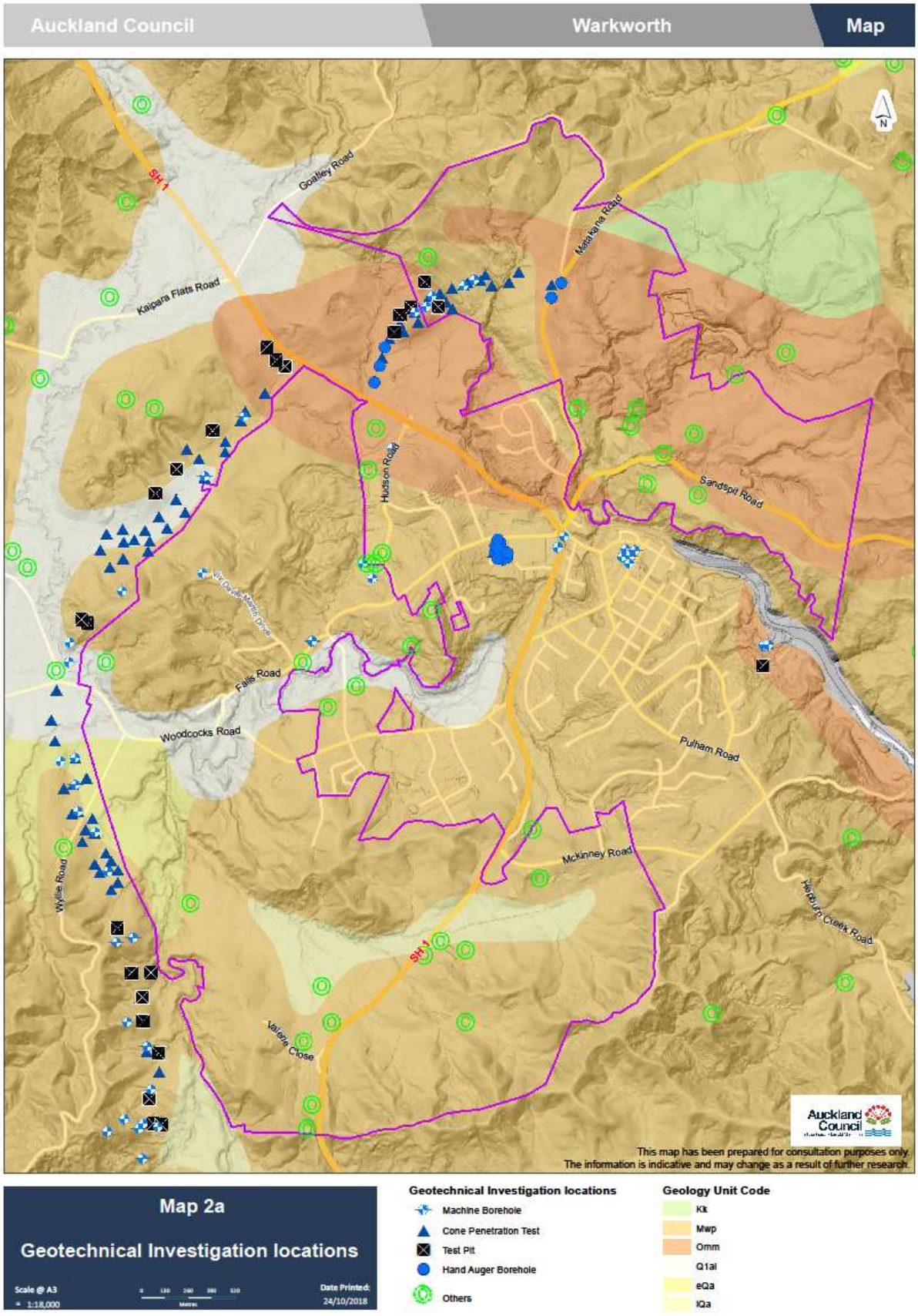
7 Map Sheets

Map 1	Warkworth Study Area
Map 2a	Geotecnical Investigation Locations
Map 2b	Geotechnical Reports Locations

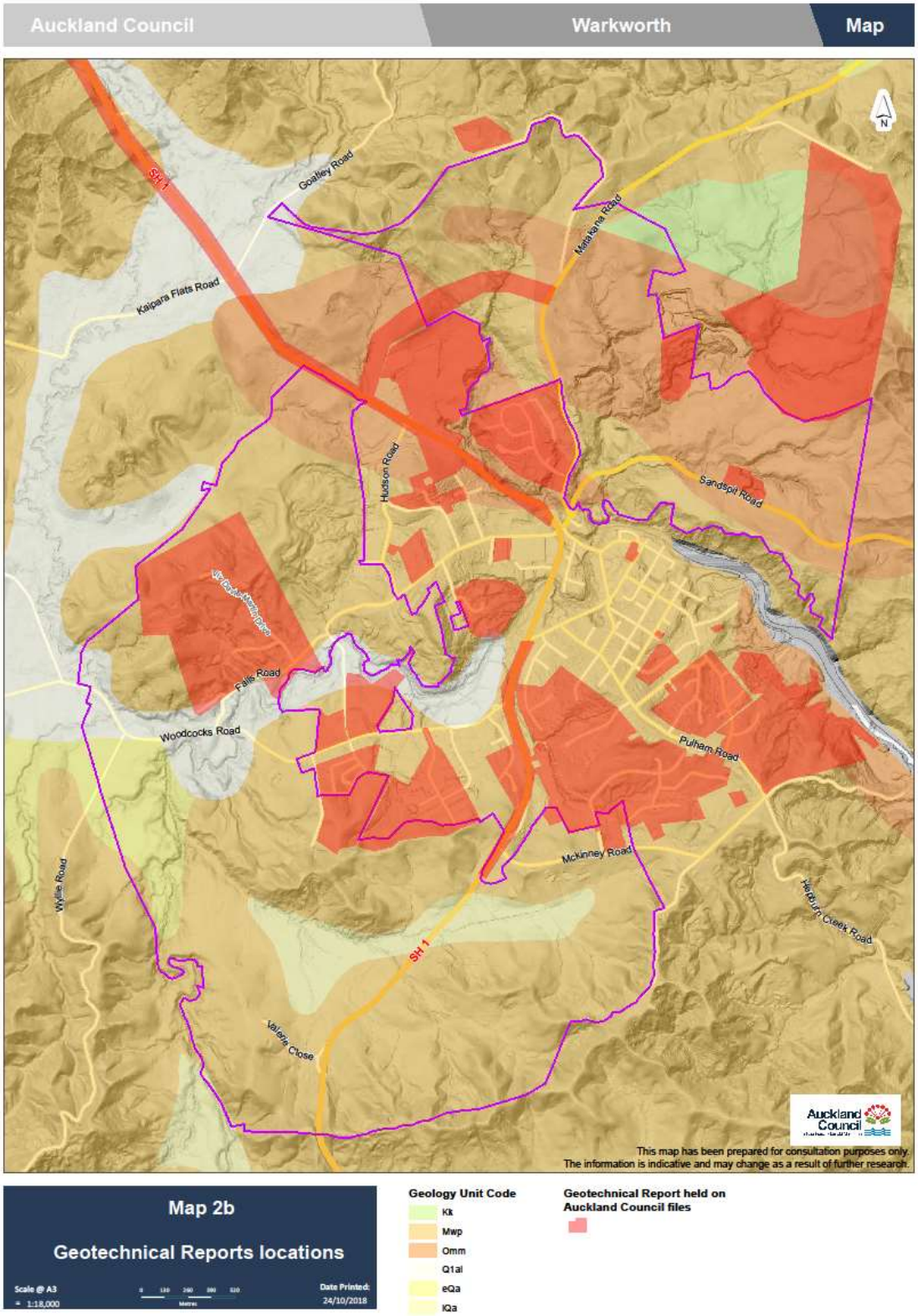
Map 1 Warkworth Study Area



Map 2a Geotechnical Investigation Locations



Map 2b Geotechnical Report Locations



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