REPORT

WHANGAREI DISTRICT COUNCIL

Land Zonation Mapping Stability hazard mapping/geotechnical assessment level and effluent disposal potential for Kamo, Maunu, Onerahi, Otaika and Tikipunga.

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1 Introduction

1.1 General

Tonkin and Taylor Ltd (T&T) were engaged by Whangarei District Council (WDC) to undertake an assessment of land stability and the potential for disposing of effluent waste water in areas that were under development pressure within the Whangarei District. The purpose of the assessment in all areas is to;

- Inform Council of the level of slope instability hazard
- Inform the Council of the suitability of the ground for the disposal of effluent waste water
- Inform Council of the suitability of the land for residential development
- Alert Council of the areas that are considered to have a high probability of slope instability
- Alert the Council to the areas that have soil types with characteristics that render them unsuitable for disposal of significant amounts of effluent
- Provide Council with a basis for determining the geotechnical assessment requirements to support applications for subdivision and building consent in these areas
- Assist Council with future planning of the areas.

This report presents our Slope Instability Hazard and Effluent Disposal Potential assessments for five large areas on the outskirts of Whangarei City. In particular the areas that have been mapped are;

- Kamo
- Tikipunga
- Onerahi
- Maunu
- Otaika.

Definitions of each zone are given, as are recommendations for the levels of geotechnical investigation that should be considered for each zone. General engineering geological characteristics of the areas are also described, as the behaviour of the slopes is very closely related to the underlying geology. Soil types are also presented, since soil type bears a close relationship with the potential for effluent disposal.

1.2 Limitations

The information contained in this document and on the accompanying plans has been carried out specifically for the Council for the purposes listed above only. The land instability work has been carried out at a sub-regional scale and is not to be viewed at scales more detailed than 1:5000. Zonation plans have been developed primarily on information obtained from aerial photograph analysis and mapped onto a digital aerial photograph base. No liability is accepted for any of the information presented, as the information is only an indication of what we consider to be the general current level of stability of the land. Land at a section-scale could, in fact, be classified differently from that shown on the plans. It also must be appreciated that slope behaviour is "gradational" in many cases, ranging from very low risk land though to very high-risk. Properties that straddle two zones should be assessed based on the higher risk category. The hazard plans have been checked against WDC's cadastral data, and are considered to generally lie within the lateral error that exists between the geo-referenced digital photo base and the cadastral, when viewed at 1:5000. However, the plans should not be used as a replacement for site specific assessments.

It should be noted that the effluent disposal potential zones are based purely on soil and rock types. These zones have been produced primarily from maps at 1:100,000 and 1:63,360 scales, and therefore represent the general picture at a regional scale. Accordingly, the scale of mapping means that it cannot show local variations at a scale of individual sites. No liability is accepted for any of the information presented, as the information is only a classification of what *most* of the soils in the area are likely to be. Soils at a section-scale could, again, be classified differently from those shown on the plans. Many other factors are involved in dictating whether or not a given site is suitable for effluent disposal. For example, site specific landforms are also critical - especially since adding effluent to the ground can induce movement in otherwise stable ground. In other words, even if an area is zoned as having high effluent disposal potential, and even where the soils on the ground match those on the map, individual sites within that area may still be unsuitable to accept effluent. The zones are produced to help Council with planning at the scale indicated and should again not be used to replace site specific assessments, which should be carried out as a matter of course.

1.3 Scope of work and methodology

The assessments were carried out by engineering geologists from Tonkin & Taylor Ltd, and included;

1.3.1 Slope stability hazard potential

- A desktop study of the area: This included a review of existing geological and soil type publications for the area, and our T&T database, which includes a wide variety of geotechnical investigations that we have carried out in the area, ranging from Earthquake Commission (EQC) landslip claim assessments through to detailed slope instability and stabilisation work. WDC provided information, including ArcView compatible shape files, from their database on known areas of slippage.
- Field reconnaissance. Each area was broadly visited and assessed. Attention focussed on existing geomorphology (i.e. locations of active landsliding and erosion, landslide morphology, slope gradients), rock and soil types based on exposures of the underlying geology and comparison to the soil-types presented on existing soil-type and geological maps, the locations of seepage lines (to provide an indication of groundwater conditions), and the locations of residential dwellings in each of the areas.
- Aerial photograph analysis: This was the main method used to zone the land. Stereographic aerial photographs taken in March 1998 at a scale of 1:10,000 were primarily used, because of their high degree of observable detail. Analysis of more recent photographs (July 2002/ Jan 2004, 1:30,000 colour photographs) was also undertaken as a check, and to identify any new areas of land that have been subject to instability. These were also used to zone the

land in areas the 1998 series did not cover. The difference in scale of the two series results in those areas zoned using the 2002/2004 colour photographs having a lower degree of accuracy than those zoned using the 1998 black and white photographs. Three classes of hazard were used to zone the land, based on specific characteristics described below. The information was digitised into a GIS database using a high-resolution aerial photo-base overlain by 2 m topographic contours of the area (both supplied by WDC).

- Calibration: The digital map was then calibrated in the field to check the map accuracy of the digitisation and the aerial photograph interpretation.
- Checking: A further field check was made by a senior geotechnical specialist from T&T.

1.3.2 Effluent disposal potential

- A desktop study of the area. In addition to existing publications on soil types for the area, and our T&T database, this included the Australian and New Zealand Standard for on-site domestic wastewater management.
- Field reconnaissance. Each area was broadly visited and assessed. Attention focussed on existing rock and soil types based on exposures of the underlying geology, and comparison to the soil-types presented on existing soil-type and geological maps.
- Aerial photograph analysis. This was used to correlate particular landforms with rock and soil type.
- Calibration. The digital map was then calibrated in the field to check the map accuracy of the digitisation.
- Checking. A further field check was made by a senior geotechnical specialist from T&T.

1.4 Previous work

Tonkin & Taylor have previously carried out similar slope instability hazard mapping of Whangarei Heads and Langs Beach, Whangarei Heads, the area from Waipu Cove to Langs Beach and Bland Bay to Taiharuru in 2000, 2001, 2002 and 2004 respectively (T&T report reference 18028; Whangarei District Council; Landslip hazards, Whangarei Heads and Langs Beach, November 2000; T&T report reference 18517; Whangarei District Council; Land Slope Stability Hazard Zonation, Waikaraka to Ocean Beach; August 2001; T&T report reference 18517; Whangarei District Council; Land Slope Stability Hazard Zonation, Langs Beach to Waipu; July 2002 and T&T report reference 18517; Whangarei District Council; Slope Instability Hazard potential, Bland Bay to Taiharuru, June 2004).

Effluent Disposal Potential mapping has been produced by Tonkin and Taylor in the coastal areas between Oakura and Langs Beach in August 2005 (T&T report reference 22705: Whangarei District Council; Coastal Structure Plan; Slope instability hazard potential and effluent disposal potential, Oakura to Langs Beach, August 2005).

2 Engineering geology

2.1 General

The engineering behaviour of the areas surrounding Whangarei varies along with the geology.

This section summarises the engineering geological and soil type characteristics of the study areas, and their relationship to slope stability. The sources of geological information are described first, followed by a description of the main geological groups and their particular engineering geological characteristics.

The geological characteristics are also among the factors used in producing effluent disposal potential zones and, along with soil type, will be discussed further in the related subsections.

2.2 Sources of geological information

Much of the study area is covered by the 2003 IGNS 1:25,000 map, "The Geology of the Whangarei Urban Area" (White and Perrin, 2003).

For the areas not covered by the 1:25,000 map, the NZ Geological Survey Map 1:250,000, Sheet 2A Whangarei by Thompson (1961) is currently the most widely used publication of geological information in the Whangarei District. Although the publication is now more than 40 years old, the information provided in it is generally suitable for engineering purposes due to the overall lithological simplicity of the underlying geology.

It should be appreciated that information from any map produced at either of these scales should not be relied upon for site specific investigations.

Unfortunately modern published information showing the distribution of the geology, and summarising the stratigraphy and structure of the outskirts of the mapping areas is relatively sparse. The NZ Geological Survey Maps 1:250,000, Sheet 2A Whangarei by Thompson (1961) is limited in that the understanding of the geology of Northland has changed significantly since its publication, and the map can really only be used as a very broad indication of the underlying geology. For example the distribution of Northland Allochthon geology (described below) is far more widespread in some areas than is shown on the map. That map therefore should not be relied upon for site specific investigations. The IGNS is due to publish a new 1:250,000 "Q-Map" of the geology of the Whangarei District within the next 2 years. However information from any map produced at that scale should not be relied upon for site specific investigations.

There are some published papers describing localised geology of the Whangarei area, although these have tended to focus on specific localised geological units or structure, with little information showing the distribution of the units. Perhaps the most useful and up to date publication describing Northland Geology is "Cretaceous and Cenozoic Sedimentary Basins of Northland, New Zealand", by Isaac et al. (1994). This Monograph summarises the stratigraphy and structure of the Northland region, with a good summary of the formation of the Northland Allochthon, regional engineering geology and material characteristics.

There are significant differences in the geology of each of the study areas. The lithological units represented in each area are identified first, then each unit described in more detail.

2.2.1 Geological distribution

2.2.1.1 Kamo

The geology of the Kamo area is relatively simple

- *Waipapa Group* : Strong shattered greywacke and argillites outcropping in the south of the area.
- *Northland allochthon:* Typically comprise highly sheared and crushed sedimentary rocks. They are present at surface in the far west and far east of the Kamo area.
- *Te Kuiti Group* : Eocene age rocks comprising *Ruatangata Sandstone, Kamo Coal Measures* and *Whangarei Limestone*-flaggy, white to cream locally pebbly limestone, underlies the Kerikeri Group, and generally outcrops in fairly small pockets around its edges.
- *Kerikeri Volcanic Group* : Plio-Pleistocene age rocks. Basalt lavas and scoria cones cover approximately half the area and altered and weathered dacite covers a further quarter.
- *Holocene sediments*: Generally cover low lying ground, typically comprising soft to firm alluvial sediments or swamp deposits.

2.2.1.2 Tikipunga

In the Tikipunga area there are five dominant groups of geological materials. These are;

- *Waipapa Group*: Generally strong shattered greywacke and argillite outcropping from in the east of the area.
- *Te Kuiti Group*: Comprising *Kamo Coal Measures*- conglomerate, sandstone, mudstone, clay and coal, and *Ruatangata Sandstone,* blue to green-grey glauconitic, calcareous muddy sandstone.
- *Northland Allochthon*: Typically highly sheared and crushed mudstones, variably calcareous and siliceous mudstones, siltstones, sandstones, muddy limestones (marls), and limestones, and outcrop in the east of the area.
- *Kerikeri Volcanic Group*: Mostly basaltic lava with some scoria cones
- *Holocene Sediments*: Typically alluvium in low lying areas, valleys and paleovalleys.

2.2.1.3 Onerahi

The geology of this area is fairly complex but can be subdivided into six dominant geological groups. These each display different slope geomorphology and slope behavioural processes.

- *Waipapa Group*: Generally strong shattered greywacke and argillite forming the steep hill country to the east of the Onerahi area.
- *Te Kuiti Group*: Unconformably overlies the Waipapa Group, comprising *a) Ruatangata Sandstone,* blue to green-grey glauconitic, calcareous muddy

sandstone outcropping in the north eastern part of the area, and *b) Whangarei Limestone,* strong flaggy limestone outcropping on the western edge of the Ruatangata Sandstone.

- *Northland Allochthon*: The rocks in the area typically comprise highly sheared and crushed variably calcareous and siliceous mudstones. These rocks are typically chaotic in structure, and are generally prone to landslippage. They are also referred to as the "Onerahi Chaos".
- *Parahaki Rhyolite '(Coromandel Group)*: Outcrops in the north western part of the area, and comprises a biotite rhyolite extensively altered to halloysitic clay.
- *Kerikeri Volcanic Group*: Mostly basaltic lava with some scoria cones.
- *Holocene Sediments*: Typically alluvium adjacent to the inland coastline. In addition there are some reclaimed areas comprising man-made fill.

2.2.1.4 Maunu

The Maunu area has five main geological units.

- *Waipapa Group*: Again strong shattered greywacke and argillite forming the hill country in the north and south of the Maunu area.
- *Te Kuiti Group*: a) the calcareous muddy *Ruatangata Sandstone,* outcrops in the eastern part of the area, and b) strong, flaggy *Whangarei Limestone,* overlies Ruatangata Sandstone and again outcrops mostly on the eastern edge of the area.
- *Northland Allochthon*: The highly sheared and crushed rocks outcrop in the west, centre and east of the area. The central outcrop is of Omahuta sandstone, calcareous glauconitic sandstone/interbedded sandstone and mudstone.
- *Kerikeri Volcanic Group*: Mostly basaltic lava with some scoria cones
- *Holocene Sediments*: Typically alluvium in low lying areas, valleys and paleovalleys.

2.2.1.5 Otaika

The major part of the Otaika area is underlain by rocks of the problematic *Northland Allochthon*. These include highly sheared and crushed calcareous and siliceous mudstones, siltstones and sandstones, and interbedded sandstones and mudstones.

There are three other main groups of rocks in the area.

- *Waipapa Group* greywacke outcrop in the south.
- *Te Kuiti Group* sedimentary rocks (*Ruatangata Sandstone* and *Whangarei Limestone*) outcrop in the west.
- *Holocene* alluvial sediments cover the areas along the coast and in the low lying central area.

2.2.2 Engineering geology of the Lithological Groups

The engineering geological characteristics of the above geology are given in the following subsections. Description of the structural geology, however, is not given as it is outside the scope of this study. The unweathered intact rock types are described first, followed by information on the predominant rock mass characteristics, typical weathering profile groundwater.

2.2.2.1 Waipapa Group

The Waipapa Group of rocks predominantly comprises shattered Triassic to Jurassic age (140 to 200 million years old) greywacke and argillite. In their unweathered form these rocks are dark bluish grey, and strong (typically with unconfined compressive strength greater than 50 MPa), due to low-grade metamorphism of the sediments.

Waipapa Group rockmass generally comprises very closely to extremely closely spaced (<20 mm to 60 mm) joints, present in numerous joint sets at various orientations. The greywacke rockmass also tends to contain many sheared and crushed zones. However, despite the rock being very fractured, the high intact rock strength gives the Waipapa Group a relatively high overall rockmass shear strength.

The Waipapa Group usually has a deep weathering profile ranging from unweathered greywacke and argillite at 10 m to 20 m below the surface; through to highly weathered to completely weathered rock close to the surface. The latter materials typically form a soil mass (i.e. a regolith) of very stiff to hard light brown gravelly and clayey silts. Residual soil derived from these materials typically comprises very stiff silty clays and clayey silts, typically containing predominantly non-swelling kaolinitic clays (i.e. not subject to large changes in volume due to changes in moisture content). These soils are generally only present in the top 2 m on low gradient slopes, such as ridgelines and flats, and in the top 1 m on steep slopes.

Groundwater is usually deeper than 5 m due to the relatively high fracture permeability of the rockmass, the steepness and relatively high relief of the slopes.

Slopes that are underlain by Waipapa Group materials are generally characterised by moderate to steep sided slopes (15° to >30°) with minor shallow seated slippage and gully erosion within the soil mantle generally only within the steepest slopes (i.e. >30°). The slopes can generally stand at moderately steep gradients due to the relatively high strength of the rockmass and overlying soil mass.

2.2.2.2 Northland Allochthon

Northland Allochthon rocks underlie a significant proportion of the study areas, particularly Onerahi and Otaika. The “Northland Allochthon” is a collective name that refers to a wide variety of Late Cretaceous to Early Tertiary Age (110 to 23 million years old) predominantly marine sedimentary rocks that have been tectonically emplaced (regionally displaced) from the north over the Waipapa Group basement rocks. The lithologies within the Northland Allochthon have not been differentiated on the geological plan due to the internal complexity of the group of rocks. Northland Allochthon materials were previously widely referred to as the “Onerahi Formation”, “Onerahi Chaos”, and “Onerahi Chaos-breccia”. These names are still widely used by the geotechnical and civil engineering community.

The Northland Allochthon rocks range from non-calcareous (very weak to weak) mudstones and sandstones, through to highly calcareous and/or siliceous moderately strong (20 to 50 MPa) mudstones (marls) and limestones. The colouring of these rocks is also highly variable, ranging between greyish green, dark grey, reddish brown and purplish grey rocks through to light grey, and light greenish grey and greyish white. Swelling clays of the smectite group (e.g. montmorillonite) are present in differing quantities within almost all of the lithologies.

The Northland Allochthon lithologies are typically moderately to pervasively sheared and crushed, generally depending on lithology (rock type). Tectonic deformation, as a result of the regional displacement of the strata, appears to have mostly taken place in the softer lithologies, which are consequently highly to pervasively sheared and crushed. The harder lithologies have still undergone significant deformation, but to a lesser degree. The shear fabric within the rocks is variable, but is commonly at a low angle (generally between 0 and 30°), and the shear surfaces are typically highly polished and coated in clay. The rock mass strength therefore tends to have a relatively low horizontal shear strength. The shear strength of the Northland Allochthon mudstones is typically the lowest, due to the intense shearing, and also due to the high proportion of swelling clay minerals of the smectite group (e.g. montmorillonite) within the rocks. These materials usually have low residual friction angles between 8° and 16°. On the other hand, limestones and very calcareous and/or siliceous mudstones typically have the highest rockmass shear strength within the Northland Allochthon due to the strength of the intact rock.

The Northland Allochthon rocks tend to have a very shallow weathering profile, generally ranging from about 1.5 m to 3 m in thickness for the soft mudstone lithologies, progressively increasing in thickness through to about 5 m to 6 m thick for the harder calcareous and siliceous lithologies. Soils developed as a result of weathering are typically mottled light greyish white, light yellow, and light brown. The soils are also generally wet, highly plastic, and of low material shear strength (usually firm to stiff). The shear fabric within the parent materials is typically preserved, forming defects within the soil mass.

Groundwater is usually very close to the surface for the soft mudstone lithologies (<2 m) due to their very low permeability, increasing with depth in the more competent calcareous and siliceous rocks, which have higher rock mass permeabilities.

Slopes that are underlain by Northland Allochthon geology typically reflect the strength of the rockmass of the predominant lithology. Consequently, slopes underlain by these materials stand only at gentle to moderate gradients due to their general low to very low overall rockmass strength. For example, non-calcareous and non-siliceous mudstone lithologies (e.g. "Hukerenui Mudstone") tend to stand between 7° and 14°, calcareous and/ or siliceous mudstone lithologies (e.g. "Whangarei Formation") usually stand between 14° and 30°, whilst limestones and marls naturally stand at gradients greater than 30°.

The surface morphology of slopes underlain by Northland Allochthon lithologies is also typically (and distinctively) hummocked and undulating, mainly due to the susceptibility of the materials to slope instability. Localised "floaters" of harder Northland Allochthon lithologies incorporated within the sheared and crushed softer lithologies tend to stand proud, also providing a hummocked surface morphology.

The low rockmass strength and the generally high natural groundwater table within the highly sheared and crushed mudstones make this lithology the most unstable. It is also likely that most of the slopes underlain by these rocks are only just above equilibrium (with Factors of Safety less than 1.2), in addition to being generally the most sensitive to small changes in slope gradients.

Some mudstones and sandstones of the Northland Allochthon (called the "Whangai Formation" mudstone and "Omahutu sandstone") are particularly unstable, and may slip even on slopes of less than 10°. Steeper slopes underlain by Whangai Group, such as some in the Otaika area, tend to be made up of a series of complex, creeping landslides, probably about 5 m deep, but possibly up to 20 m deep in some places. Generally, areas underlain by these soft rocks of the Northland Allochthon are considered to have a high risk of failure where they have a gradient of 15° or more. This includes parts of Raumanga, Kioreroa, Morningside, Riverside, and much of the land south of the Otaika Fault.

There are many known examples of ancient and active landslides in the Whangarei area that are in Northland Allochthon lithologies. These include some very large slides such as the one at the Onerahi end of Riverside Drive, near Sherwood Rise, and another north of Otaika Creek. The former exhibits no signs of recent movement but the latter is probably currently creeping. There are also areas of known creeping in Morningside, Maunu, and Kamo. Much of this may be attributed to the effects of deforestation, although as slopes tend to settle to a semi-stable lower slope angle, and movement has generally been decreasing since the 1940's. Nonetheless, it is important that any modification of these slopes, or of drainage, accounts for the possibility of renewed instability.

2.2.2.3 Te Kuiti Group

Te Kuiti Group comprises three main units:

a Kamo Coal Measures

Kamo Coal Measures are present only in very small outcrops in the Kamo and Tikipunga areas, although mining and exploration drilling have shown them to be extensive at depth in these areas. They unconformably overlie the Waipapa Group greywacke and are conformably overlain by the Ruatangata sandstone or in tectonic contact with rocks of the Northland Allochthon. Kamo Coal Measures comprise basal sandstones overlain by one or two coal seams up to 8 m thick, separated by 20 m of carbonaceous mudstone, sandstone and fireclay. The top member of the formation is a conglomerate. The Coal Measures appear to have formed in a series of west-draining, WSW-ENE oriented half grabens and are therefore variable in thickness and pinch out completely in many areas.

At Kamo the Coal Measures are 1-49 m thick. The fine grained clastic facies predominate, and the two main coal seams are a total of 10 m thick. In the Kiripaka half-graben, the coal measures are at least 100 m thick. The lower coal measures consist of conglomerates derived from Waipapa Group argillites, sandstones, chert and vein quartz intercalated with upward-fining quartzose sandstones and capped by thin mudstones. Middle Coal Measures are predominantly mudstones and include a seam up to 9 m thick. The Upper Measures are several 2-10 m thick, unstratified/poorly stratified pebble-cobble conglomerates of Waipapa Group sandstone and argillite clasts intercalated with thin mudstone units.

A late Eocene age is generally quoted for the Kamo Coal Measures, although different authors quote a slightly different age range. Isaac et al. (1995) say that the pollen included in the coal measures indicates an age in the order of 42.5-39 million years whilst White et al (2003) have them in the range of 38 to 36 million years.

In the Tikipunga area, the sediments are mostly coarse sandstones derived from greywacke, quartz and chert with conglomerate, rarer mudstone and coal seams up to 1 m thick. The coal is of sub-bituminous A to high-volatile bituminous C ASTM rank. They were deposited in a mostly non-marine coastal plain environment, with swampy ground and an accumulation of fluviatile sand, gravel and mud.

The Kamo Coal Measures are moderately strong and apparently stable. Weathering products can be very clay rich and impermeable.

There are some areas underlain by old mine workings that are subject to subsidence due to collapse of the drive roof or punching of pillars into underlying fireclay. This is worst where the coal seam was within 50 m of the surface, or where more than one coal seam was worked. Where subsidence propagates upwards to the surface it creates crater-like depressions in the order of 1 m deep and 3-4 m across, also causing cracking of concrete and brick structures.

b Ruatangata Sandstone

Ruatangata Sandstone is present in small outcrops in Kamo, Onerahi, Maunu and Otaika. It conformably overlies, or intercalates with, Kamo Coal Measures, or unconformably overlies Waipapa Group greywacke. Its upper contact with the Whangarei Limestone may be gradational over several metres. It is hard, massive or incipiently bedded, blue to greenish grey, with some purplish or brownish-grey units in the lower beds, calcite cemented, glauconitic, fine to medium grained muddy sandstone. Beds may be several decimetres thick, fine upwards and may exhibit hummocky cross stratification. It is fossiliferous, with abundant foraminifera and scattered shell fragments. These indicate formation in inner to outer shelf paleo environments and an early Oligocene age (in the order of 36.5-34 million years). The sandstone is typically in the range of 45-65 m thick, although it can reach thicknesses of 204 m, as at Whareora. The formation thins north of Kamo and at Hikurangi is less than 7 m thick. In some areas there is an associated basal conglomerate of 1-3 m (e.g. at Otaika Quarry).

The Ruatangata sandstone is very variable, but usually moderately weak where it is slightly weathered to very weak where it is highly weathered. It is normally stable, and may stand in tall bluffs but the weaker units can be unstable and minor landslides are reported.

The porosity and permeability of the Ruatangata sandstone are high enough to make it a fair to good aquifer. Calcareous members may contain solution cavities.

c Whangarei Limestone.

Whangarei Limestone is a glauconitic sandy limestone of Oligocene age (approximately 36 to 24 million years old), and is found in relatively small outcrops in the Kamo, Onerahi, Maunu and Otaika areas. In its unweathered form, the rock is a greyish white and strong, with thin millimetre-thick extremely closely bedded lenses of calcareous glauconitic sandstone. Where exposed to the elements, the sandy lenses weather out, giving the limestone its characteristic sharp layered pancake appearance.

The rockmass of the Whangarei Limestone typically comprises widely to very widely spaced (0.5 m and >2 m) subvertical joints. In general, these joints are open to cavernous (0.5 m to >1 m) due to the downwards percolation of acid rich groundwater through the joints resulting in the dissolution of the calcite rich rock forming the joint walls. The larger joint openings commonly appear to be infilled with clay and silt soils deposited as a result of the downwards transport of sediment from overlying formations into the more cavernous apertures. As a result of the weathering of the limestone, the upper surface of the strata is typically very pinnacled and uneven.

Groundwater lies at a relatively low level within the limestone due to the high rock mass fracture permeability provided by the open to cavernous joints within the strata. The Whangarei Limestone tends to act as a natural underdrainage layer, and therefore locally has a strong controlling influence on the groundwater regime in areas where it is present.

Due to the high intact and rockmass strength of the limestone, the Whangarei Limestone can stand vertically, as evidenced by coastal cliffs in other areas standing vertically for heights of up to 15 m or more. The ground is stable, except where underlain by soft rocks. Most of the waterfront of the Onerahi peninsula has Whangarei Limestone underlain by soft Ruatangata sandstone, and there are at least two recently active landslides. Similar landslides have also been reported on the edge of the Tikipunga Plateau and in parts of Maunu. West of the Whangarei hospital large blocks of Whangarei Limestone are being rafted downhill to the north by creep in underlying soft Ruatangata sandstone.

2.2.2.4 Coromandel Group Volcanics

The rhyolite of the Parahaki dome NNW of Onerahi is the only representative of the Coromandel Group in the study area. Parahaki rhyolite is medium grained and porphyritic, with 73% silica. The groundmass comprises quartz, plagioclase, orthoclase, biotite and magnetite, with accessory apatite and zircon, whilst phenocysts are plagioclase, quartz and biotite. The rhyolite is frequently altered and/or completely weathered to low-temperature clays and silica minerals. Over large areas the rhyolite is only represented by white clay-rich soils with scattered quartz crystals. Exposures that are close to sea level tend to be moderately weathered, weak to moderately strong and have joint spacing of 1-2 m. The rhyolite is of Early Miocene age (around 20 million years).

Minor regolith failures may be associated with the Parahaki rhyolite, especially in zones where they are deeply weathered or hydrothermally altered, but these are usually no more than 2 m deep. Such landslides tend to incorporate topsoil and colluvium sliding on the clayey contact with underlying weathered bedrock. Gulley erosion can be a problem, and there are some large ancient rock slides on the northwest slopes of Parahaki, and small rock falls.

2.2.2.5 Kerikeri Volcanics

The Kerikeri Volcanics are at ground surface over a significant proportion of the northern Kamo and Tikipunga areas. They are predominantly basaltic but some are dacitic. The lavas erupted sub-aerially and are inferred to be intra-plate. They consist of tuffs, scoria cones and ridge-top remnants and flows, constrained by modern topography. They are up to 80 m thick and tend to be very well drained. Scoria cones are usually made up of tightly packed, moderately weak to moderately strong clasts of diameter 50 mm to 1 m, with a firm to stiff groundmass. Basaltic lavas tend to be unweathered to slightly weathered, strong to very strong, columnar jointed and capped by up to 4 m of soil, ash and blocks of lava. Kerikeri basalts overlie blue clays, sands and greywacke gravels. They are of Plio-Pleistocene age (around 2-4 million years).

Land underlain by scoria cones of the Kerikeri Volcanics can be steep but tends to be stable. Where there are basalt lava flows, the land also tends to be stable unless underlain by soft rocks. In this case the soft rocks are subject to oversteepening of natural slopes and saturation by groundwater, which leads to a high degree of instability. The harder basaltic rocks may then be rafted down the slope by creep in the underlying lithologies. In the northern part of Tikipunga there are three ancient landslides that are still active with large-scale deep-seated creep. Failure on the edge of a large basalt flow has occurred as a result of failure of the underlying weak rocks. One of these slides, in the Mangakino Stream, contains large, semi-intact basalt blocks.

2.2.2.6 Holocene Sediments

Holocene age estuarine and fluvial sediments are present close to sea level underlying much of the low-lying areas within the study area. Locally peat is present.

Along the Whangarei Harbour coastline, the Holocene Sediments predominantly comprise deltas that have formed at the mouths of streams running into the sea. These deltaic deposits are likely to comprise loose sands and gravels with some silty zones. Softer estuarine muds are also expected.

There are small areas of man made fill on the reclaimed land around the edge of the harbour in the Onerahi and Otaika areas.

3 Instability Hazard: Geotechnical Assessment recommendations

3.1 Summary

Table 1 below presents a summary description of each zone and the level of geotechnical assessment that is recommended for applications for Building Consent. Details of the geotechnical assessments are given in the following section.

Table 1: Zone description and geotechnical assessment recommendations

Zone	Colour	Hazard	Geotechnical Assessment
Low	Yellow	Erosion or landslide morphology is not apparent. Not considered to be at risk of instability. May, however, be at risk as a result of natural events, or development. Steeper slopes may be subject to soil creep.	Low level investigation
Medium	Orange	Land exhibits evidence of past slippage or erosion, and could be subject to inundation from landslide debris and slope deformation. Geology, slope and/or geomorphic evidence of past or ancient landslippage suggest the land should be developed carefully.	Moderate level investigation
High	Red	This land appears to be either subject to erosion or slippage, or is likely to be subject to erosion or slippage within the next 100 years based on geomorphic evidence. This land is generally considered to be geotechnically unsuitable for development, unless works can be undertaken to avoid, remedy or mitigate the hazard.	High level investigation

3.2 Geotechnical assessment details

The following recommended geotechnical assessment and land development criteria apply to the three land classes defined in Section 3.1. It is important to note that these criteria apply only to erosion or landslippage. Even where these matters have been addressed to the satisfaction of Council, site-specific geotechnical investigations may still be required to satisfy Council as to the adequacy of foundation conditions with respect to bearing capacity and settlement (under both static or seismic loads). Flood risk may also need to be determined, which would include the main floodways and secondary, or overland, flow paths.

In addition to erosion and landslippage of natural ground triggered by rainfall and/or seismic events, development works can accelerate, worsen or result in erosion and/or landslippage. These works include over-steepening of the land by cutting, surcharging the land by filling, increasing groundwater levels and/or piezometric pressures by putting stormwater and/or effluent waste water onto or into the land, and removal of vegetation (principally removing the effective cohesion provided by the roots).

3.2.1 Low stability hazard/ geotechnical assessment level

On this land erosion or landslippage is not apparent. However, sloping areas may be sufficiently sensitive to erosion or slippage that could occur due to inappropriate cutting, filling, and/or site disposal of stormwater and/or effluent waste water, and natural events (e.g. cyclonic short term high intensity rainfall events). These slopes could also be subject to soil creep.

Accordingly, applications for development of this land should be accompanied by a brief geotechnical report which summarises the results of a walk-over survey and a geological/geomorphological assessment (which describes how the particular landform has been formed, what it is made up of and what slope processes are, or are likely to be occurring) and provides an informed opinion on the suitability of the land for the intended purpose.

The geological/geomorphological assessment should entail most or all of the following steps, and the brief report should specifically address the expected effects of the subdivisional and/or building development on the land.

The geotechnical assessment of low risk land would be expected to include most or all of the following steps:

a) Walk-over inspection of the site and the surrounding land

b) Inspection of aerial photographs taken at various times to provide insight into the local geomorphology and evidence of any previous instability

c) Review of geological data (maps, bulletins)

d) Enquiry after local information about stability/instability of the ground

e) Seek existing data about the soil and rock profile (look for nearby exposures) or perform some simple subsurface investigation

f) Examination of the soil profile to confirm that if the soil is in-situ and not colluvium (slide debris)

g) Examination of the existing survey records for evidence of movement (slippage or erosion)

h) An opinion stated by a geotechnical specialist as to the stability of the land for development (including an assessment of the effects of development such as excavation, filling, removal of vegetation, disposal of stormwater or effluent wastewater into or over the area).

3.2.2 Moderate stability hazard/ geotechnical assessment level

This land does not exhibit any evidence of any recent instability but does display "relic" landslide geomorphology, or is sufficiently sloping to be potentially subject to instability due to either natural events (e.g. high intensity rainfall events or earthquake), or as a result of inappropriate cutting, filling, and/or site disposal of stormwater and/or effluent waste water.

Accordingly, applications for subdivision, building or other development (such as excavation, filling, removal of vegetation, disposal of stormwater or domestic wastewater into or over the area) may be allowed to proceed subject to consent conditions. These would include a requirement for a supporting geotechnical report which includes a stability assessment demonstrating that the proposed development will not accelerate, worsen or result in the land being subject to, or likely to be subject to, erosion or slippage, to the satisfaction of Council.

A geotechnical assessment on moderate risk land would be expected to include:

a) Topographic survey (if not already available) or slope profiles.

b) A description of the geology and geomorphology of the area, including comment on the areas surrounding the development site.

c) Definition of the nature and continuity of the strata over the whole area of land which is proposed to be developed (buildings, access and services) and to a depth below which slipping is most unlikely, by means of test pit and/or drilling and/or augering (unless existing exposures are adequate).

d) Assessment of the relative strength and the sensitivity of the soil in each stratum in which, or interface on which, sliding is possible.

e) Assessment of likely groundwater levels and piezometric pressures in the strata during extreme infiltration conditions.

f) An opinion stated by a geotechnical specialist as to the stability and suitability of the land for development. The stability of the whole slope (upon which the site may only form a part of) and the effects of the development (such as excavation, filling, removal of vegetation, disposal of stormwater or effluent waste water into or over the area) on this should be given.

3.2.3 High stability hazard/ geotechnical assessment level

This land exhibits evidence of recent or present slippage or erosion and/or is subject to processes such that slippage or erosion is considered likely to occur within the next 100 years, especially where the slope is devegetated or oversteepened during development. Accordingly, development of this land presents an identifiable hazard to property and could also, in some circumstances, threaten life.

On, above and especially below this land, no subdivision, building or other development including excavation, filling, removal of vegetation, disposal of stormwater or domestic wastewater into or over the area should be permitted unless a geotechnical report including an appropriate and adequately detailed stability analysis is produced to the satisfaction of Council.

The geotechnical report must demonstrate that the proposed development area will not be subject to erosion, or slippage, or inundation by debris from upslope. It should also show the proposed development, through preventative works or other measures, will ensure that any structure will not become damaged by erosion or slippage arising on or off the site, and that development will not accelerate, or worsen, erosion or slippage.

A geotechnical report on high landslip hazard areas land would be expected to include:

a) Topographic Survey (if not already available)

b) A description of the geology and geomorphology of the area and immediate surrounding areas.

c) Definition of the nature and continuity of the strata over the whole area of land involved, and to a depth below which slipping is most likely, by means of test pits and/or continuous recovery core drilling (unless existing exposures are adequate).

d) Determination of the peak and residual shear strength parameters (either from laboratory tests or back analysis of relevant slope failures) and the sensitivity of the soil in each stratum in which, or interface on which, sliding is possible.

e) Assessment of groundwater levels and piezometric pressures in the strata during extreme infiltration conditions.

f) Analysis of possible failure mechanisms, relevant to the specific geology and geomorphology of the site using effective stresses.

g) An opinion stated by a geotechnical specialist as to the stability of the ground and the preventative (or remedial) measures to be incorporated in the development. The stability of the whole slope (upon which the development site may form only part of) and the effects of the development (such as excavation, filling, removal of vegetation, disposal of stormwater or effluent waste water into or over the area) on this should be given.

Even with a thorough geotechnical report, which includes a stability analysis, complete avoidance of all risk may not be possible and no guarantee of absolute safety should be expected. Site development works in particular need to be carefully planned to ensure development does not result in slippage or erosion.

Works which can be undertaken to protect or restore the land include earthworks (to reduce slope angles or place buttress fills), drainage works (trench drains, buttress or counterfort drains aligned down the true slope angle are particularly effective), retaining structures, erosion protection structures, and planting.

4 Statutory responsibilities in relation to instability hazard

There are two primary pieces of legislation which define the responsibilities of WDC for the management of land hazards including instability (slippage). These are the Resource Management Act 1991 (RMAct) and the Building Act 2004 (BAct).

4.1 Resource Management Act 1991

The overall purpose of the RMAct is to promote the sustainable management of natural and physical resources. Under the Act WDC also has responsibilities for the avoidance and mitigation of natural hazards.

The specific functions of WDC are defined under Section 31 of the RMA, and include the avoidance and mitigation of natural hazards through the control of land use and subdivision.

Section 31(b) states that every District Council has, as a function:

> *The control of any actual or potential effects of the use, development, or protection of land, including for the purpose of the avoidance or mitigation of natural hazards.*

To carry out these functions, WDC must produce a District Plan, which describes how resource management issues will be managed to achieve the sustainable management of natural and physical resources. Section 74 of the Act requires that the District Plan be consistent with the relevant Regional Plan and Regional Policy Statement, thereby ensuring the integrated management of the natural and physical resources of the region and district.

With respect to the subdivision and use of land, WDC has requirements relevant to the avoidance or mitigation of natural hazards. Section 106 (l) specifies that a consent authority shall not grant subdivision consent for:

> *"(a) Any land … or any structure on that land (which) is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or*
>
> *(b) Any subsequent use that is likely to be made of the land (that) is likely to accelerate, worsen, or result in material damage to that land, other land, or structure, by erosion, falling debris, subsidence, slippage, or inundation from any source."*

unless the consent authority is satisfied the effects of the proposed subdivision will be avoided, remedied or mitigated.

With small-scale slippage, remedial or preventative works may be practicable. It may, however, be impractical to remedy or mitigate the hazard which large-scale slippage presents, and hence one approach to address the hazard is to avoid it by preventing development.

4.2 Building Act 2004

The purpose of the BAct is to provide the necessary controls over building works, use and safety. Under this Act the obligations for managing building works in relation to natural hazards are solely the responsibility of the District Council.

The BAct requires WDC to refuse the granting of a building consent for construction of a building, or major alterations to a building, if:

Section 71 *(1)* *the land on which the building work is to be carried out is subject or is likely to be subject to 1 or more natural hazards; or*

(a) *the building work is likely to accelerate, worsen, or result in a natural hazards on that land or any other property.*

Unless *(2)* *the building consent authority is satisfied that adequate provision has been or will be made to:*

(a) *protect the land, building work, or other property referred to in that subsection from the natural hazard or hazards; or*

(b) *restore any damage to that land or other property as a result of the building work.*

(3) *In this section and sections 72 to 74,* ***natural hazard*** *means any of the following:*

(a) *erosion (including coastal erosion, bank erosion, and sheet erosion)*

(b) *falling debris (including soil, rock, snow, and ice)*

(c) *subsidence*

(d) *inundation (including flooding, overland flow, storm surge, tidal effects, and ponding)*

(e) *slippage.*

72 ***Building consent for building on land subject to natural hazards must be granted in certain cases***

Despite section 71, a building consent authority must grant a building consent if the building consent authority considers that:

(a) *the building work to which an application for a building consent relates will not accelerate, worsen, or result in a natural hazard on the land on which the building work is to be carried out or any other property; and*

(b) *the land is subject or is likely to be subject to one or more natural hazards; and*

(c) *it is reasonable to grant a wavier or modification of the building code in respect of the natural hazard concerned.*

73 ***Conditions on building consents granted under section 72***

(1) *A building consent authority that grants a building consent under section 72 must include, as a condition of the consent, that the building consent authority will, on issuing the consent, notify the consent to:*

(a) in the case of an application made by, or on behalf of, the Crown, the appropriate Minister and the Surveyor-General; and

(b) in the case of an application made by, or on behalf of, the owners of Maori land, the Registrar of the Maori Land Court; and

(c) in any other case, the Registrar-General of Land.

(2) The notification under subsection (1)(a) or (b) must be accompanied by a copy of the project information memorandum that relates to the building consent in question.

(3) The notification under subsection (1)(c) must identify the natural hazard concerned.

4.3 Community expectations

No amount of controls on development can produce zero risk in the urban areas of Whangarei District, and we do not believe that the community expects that to be achieved.

What the community can rightly expect, however, is that the actual and potential hazards are properly identified, and that the potential consequences are clearly explained. This assessment is undertaken specifically to enable WDC to appropriately fulfil this expectation.

5 Effluent disposal potential zones

5.1 General

The disposal of effluent in New Zealand is controlled by the Australian and New Zealand Standard for on-site domestic-wastewater management (AS/NZS 1547:2000), the objective of which is "to provide the requirements for all primary and secondary treatment units for all persons and agencies involved with sustainable and effective on-site domestic wastewater management".

The standard describes different methods of managing wastewater, and the parameters which determine which types of on-site land-application system provides the best practical option for a particular site. Equally useful is the Auckland Regional Council Technical Publication No. 58, 'On-site Wastewater Systems: Design and Management Manual'. This technical paper provides more specific and conservative guidelines better suited to the northern New Zealand situation, where soils and climate differ markedly from those of Australia.

The significant factors in determining the suitability of a site for effluent disposal are the nature of the soil and thickness of the soil profile, surface water and groundwater levels and movements, vegetation cover, net lot area, site specific landforms and local climate.

Clearly, site specific considerations will ultimately be the determining factors on how wastewater is managed. Although soil type may be identified at the surface, variations with depth and the thickness of the soil profile may only be determined by subsurface investigations. The same is true of groundwater levels, including seasonal variations. The final land shape at an individual site scale is critical as it is directly or indirectly related to: mass soil movements (especially since ground that is currently stable could become unstable with the introduction of effluent), the need to protect erodible soils, local hydrology, and poorly drained land or land subjected to flood hazard. The shape of any slope will affect the infiltration or run-on and run-off of effluent applied to the surface.

At a regional scale, however, it is useful to know the surface soil type and underlying geology since this gives an indication of how suitable the soil is to effluent disposal and what population is likely to be sustainable in a given area. This approach is useful to WDC at a planning stage and may help determine the appropriate size of individual lots during subdivision, as well as targeting new areas for reticulation.

Although NZS 1547:2000 refers only to soil type, this study also takes into consideration the geology that underlies the soil. T&T's experience shows that certain lithologies (e.g. those associated with the Kamo Coal Measures or the Northland Allochthon) tend to produce relatively shallow soil profiles, especially on sloping ground. These same lithologies are generally of very low permeability and weather to soil types that are unfavourable to effluent disposal. Hence areas underlain by them are likely to be characterised by thin, unsuitable soils with low permeability rock close to the surface and will tend to have particularly unfavourable effluent disposal potential.

5.2 Sources of information

The main sources of information on requirements for effluent disposal used here are the AS/NZ standard 1547:2000, and the ARC TP58 mentioned above.

Information on the soil types represented in the area was mainly drawn from published soil maps. These included the 1 inch to 1 mile (1:63360) Whangarei County Soil Maps, sheets N16, N19, N20 and N24 and the New Zealand Soil Bureau 1:100000 series sheets for both Soil Types and Rock Types, Q06/07 (Rock Types, Markham, 1981: soil types, Sutherland et al., 1981a). Additional information was found in "Cretaceous and Cenozoic Sedimentary Basins of Northland, New Zealand", by Isaac et. al. (1994), "Geology of Northland", edited by Spörli and Kear (1989), and the NZ Geological Survey Map 1:250,000, Sheet 2A Whangarei by Thompson (1961). This information was verified and improved using:

- geological mapping carried out during the fieldwork for this study
- geological mapping carried out for other projects
- the T&T geological database
- published geological information
- aerial photograph analysis.

5.3 Regional soil characteristics

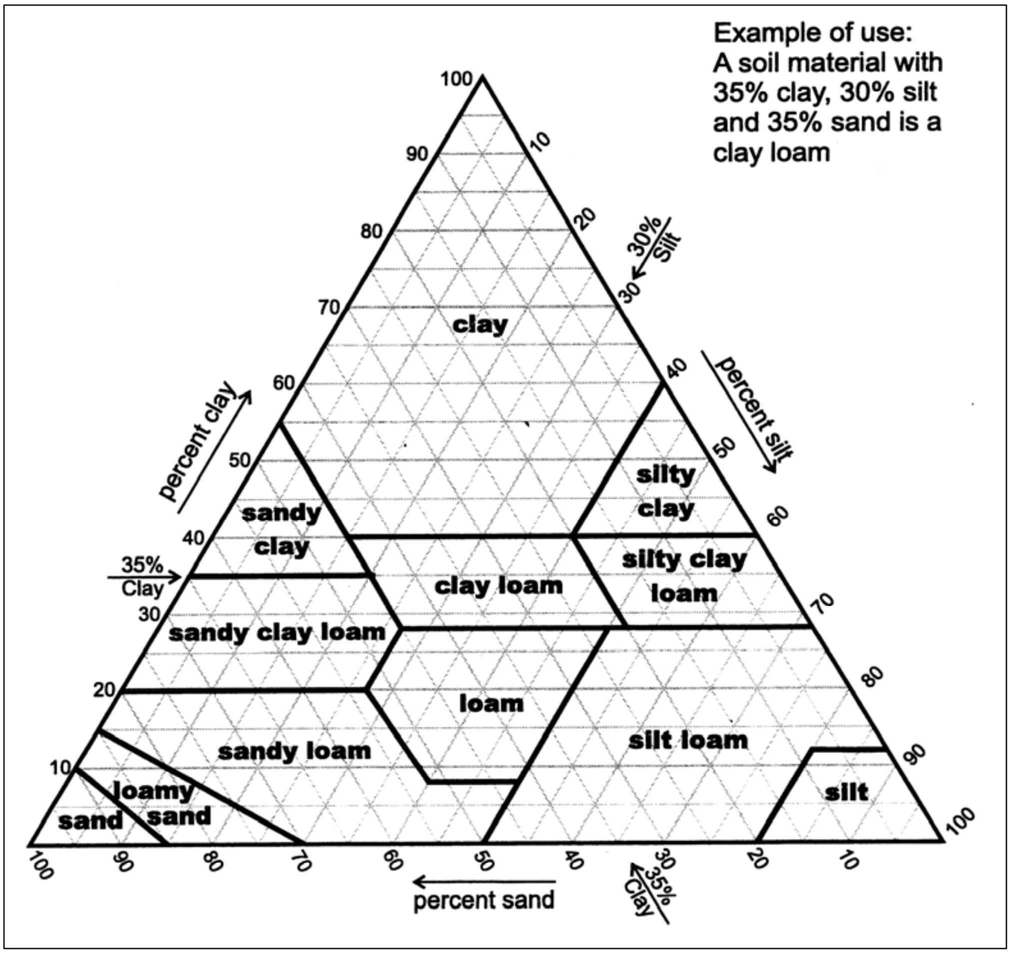

Figure 1. US Department of Agriculture textural classification of

Figure 1 is an example of how soil types may be classified. This diagram is sourced from the US Department of Agriculture.

5.3.1 Kamo

The soils in this area are dominated by silt loams and bouldery silt loams derived from *Kerikeri basaltic lavas*, and clays derived from *Kerikeri dacitic lavas*, *Northland Allochthon* lithologies and *Te Kuiti Group*. Smaller parts of the area have clay loams, primarily derived from greywacke of the *Waipapa Group*, but also some from *Kerikeri dacites*.

Where soils are the product of weathering of *Kerikeri volcanics*, there is quite a large variation in the potential to dispose of liquid effluent. Drainage tends to be very good in areas underlain by scoria, but not so good where there are significant ash layers. In general where the volcanic rocks have weathered to silt loams, the effluent disposal potential is moderate to good. The halloysitic clays derived from the dacite, on the other hand, provide very poor potential for disposal of liquid effluent.

The products of weathering of the *Kamo Coal Measures* are variable, and tend to be messy and dirty. In the Kamo area clays are the most common, whilst in Tikipunga they tend to weather to sandy loams. These soils have poor and good effluent disposal potential respectively. The fireclays that underlie the coal seams are a very significant unit in the coal measures. On the one hand they are of sufficient quality and quantity for industrial use- in the past having been used at the old Kamo brickworks. On the other hand, they are the cause of much of the mining subsidence in the area, where the pillars that were left in the mine to support the roof actually punch into the weaker underlying fireclay.

The soils associated with the *Ruatangata Sandstone* and the *Whangarei Limestone* are described below in the section on Maunu.

In this area the *Northland Allochthon* weathering products are mostly mapped as clays, clay loams and silt loams.

The remaining soils in the area are mostly *Holocene sediments*, either clays or clay loams, which are alluvial in origin (and tend to have poor effluent disposal potential).

5.3.2 Tikipunga

In the Tikipunga area the *Kerikeri volcanics* have mostly weathered to clays, although in the NE of the area, the products are mostly silt loams and bouldery silt loams. These have poor and moderate to good effluent disposal potential, respectively, as above. A significant proportion of the area is covered by clay loam of *Waipapa Group* origin.

The *Waipapa Group* weathers to form a soil mass (i.e. a regolith) of very stiff to hard light brown gravelly and clayey silts. The residual soil derived from these materials (typically very stiff silty clays and clayey silts) tend to contain predominantly non-swelling kaolinitic clays (i.e. not subject to large changes in volume due to changes in moisture content). These soils are generally only present in the top 2 m on low gradient slopes, such as ridgelines and flats, and in the top 1 m on steep slopes.

Groundwater is usually deeper than 5 m due to the relatively high fracture permeability of the rockmass, the steepness and relatively high relief of the slopes.

The relatively high strength of the rockmass and overlying soil mass means that introduction of effluent should induce less slope instability problems than other lithologies.

Other soils in the area include clays and clay/silt loams derived from *Northland Allochthon lithologies*, sandy loams, clay loams and clays with *Te Kuiti Group* parent rocks. These will be described in more detail in the following sections.

Once again the remaining soils are *Holocene* alluvial clays and clay loams of poor effluent disposal potential.

5.3.3 Onerahi

Much of Onerahi is underlain by *Northland Allochthon* . The mudstone parent rocks almost all contain swelling clays of the smectite group (e.g. montmorillonite). The allochthon lithologies in this area weather almost exclusively to clays, with properties similar to those of allochthon-derived soils in the Otaika area (see below).

In about half of the area clay loam is present at the ground surface. The parent lithologies are *Whangarei Limestone, Ruatangata sandstones* (see below, as for Otaika area) and *Waipapa Group* greywacke (as in the Tikipunga area), with some *Holocene alluvium*.

Soils derived from the *Parahaki Volcanics* tend to be poorly drained clays-i.e. poor effluent disposal potential. The Parahaki volcanics have been extensively hydrothermally altered to halloysitic clays, which are potentially suitable for china clay and has been mined on the western side of Parahaki. These clays are not as unstable as the smectite clays derived from weathering of the Northland Allochthon, but nonetheless they are slightly susceptible to landsliding. However, the failures are usually limited to the uppermost 2 m of the regolith, incorporating topsoil and weathered colluvium sliding on the interface with underlying weathered bedrock.

Significant outcrops of *Kerikeri Volcanics* are mapped in the area. These appear to have weathered mostly to silt loams and friable clays, although sometimes sandy loams are also present. The western outcrops of Kerikeri basalt, in the vicinity of Memorial Drive and Mackey Road are roughly 50% silt loam and 50% clay. The outcrops near Awaroa River Road have apparently weathered to friable clay. In the northern part of the peninsula soil products of the Kerikeri basalt are mapped as having weathered to silty loams in an area approximately 1 km long and up to 0.5 km wide. This runs from Clotworthy Crescent in the North to the Junction of Onerahi and Old Onerahi Roads in the south, and from Robin Hood Place in the west to Onerahi Road in the east. Surrounding this area friable clays are apparently the major product of weathering the Kerikeri basalt. The central, narrow part of the peninsula is mapped as having Kerikeri basalt mainly weathering to friable clays, with a little sandy clay loam and sandy loam. The outcrop of Kerikeri basalt in the southern part of the peninsula again is mapped as having a 1x0.5 km area of silt loam surrounded by friable clay.

5.3.4 Maunu

Ruatangata Sandstone weathers variably to clays and clay loams (poor and moderate effluent disposal potential respectively). The parent rock itself is of sufficient porosity and permeability to be a fairly good aquifer. It is the least stable member of the Te Kuiti Group, although it is also very variable in strength- some minor landslides being present in the weaker weathered sandstones, whilst other units are strong enough to stand in steep bluffs.

Whangarei Limestone weathers to a heavy clay. Joints in the rock also tend to be infilled and coated with clay and silt soils, some of which are due to the downwards transport of sediment and the collapse of the overlying strata into the more cavernous fractures of the limestone.

In this area the *Northland Allochthon* weathering products are mapped as clays and sandy clays with some clay loams and silt loams.

Groundwater lies at a relatively low level within the limestone due to the high rock mass fracture permeability provided by the open to cavernous joints within the strata. The Whangarei Limestone tends to act as a natural underdrainage layer, and therefore may have a strong controlling influence on the groundwater regime.

Kerikeri Basalt in the Maunu area has mostly weathered to silt loam and bouldery silt loam. In the western part of the outcrop, however, the weathering products are mapped as clay loam and clay, whilst in the east, from Puriri Park Road to West End Avenue they are clays.

Many of the soils in this southern area are derived from *Waipapa Group greywacke*. They comprise clay loams, with stony clay loams, generally imperfectly drained but fairly stable and have moderate potential to accept effluent, as in the other study areas (see above).

The *Holocene alluvium* in this area, tends to be made up of silty clay loams and clay loams. Again these have fairly poor effluent disposal potential.

5.3.5 Otaika

Almost all the soils in the Otaika area are clays, most being the weathering products of *Northland Allochthon* rocks. These lithologies are very problematic in terms of slope stability.

The Northland Allochthon rocks typically have a very shallow weathering profile, usually 1.5 m to 3 m thick for the soft mudstone lithologies, progressively increasing in thickness through to about 5 m to 6 m thick for the harder calcareous and siliceous lithologies. Soils developed as a result of weathering are variable. Poorly and very poorly drained clays are the most common, with imperfectly to poorly drained clay loams and occasional silt loams comprising the remainder. These are typically mottled light greyish white, light yellow, and light brown. The soils are also generally wet, highly plastic, and of low material shear strength (usually firm to stiff). The shear fabric within the parent materials is typically preserved, forming defects within the soil mass. These soils have very poor effluent disposal potential- particularly the clays. Not only do they have very low DLR/LTAR (Design loading rate and long term acceptance rate- both measures of how well the soil takes up the liquid that is introduced), but they also tend to produce unstable ground that may be further destabilised by introduction of fluids.

Other clays are produced by the weathering of *Whangarei Limestone, Ruatangata Formation* and some of the *Waipapa Group* greywacke. The remainder of the soils are clay loams, mostly representing *Holocene* alluvium, but small areas are due to the weathering of *Waipapa Group.*

6 Effluent disposal potential: recommendations

The nature of the top few metres of the ground is one of the most influential factors taken into account when considering the disposal of effluent. The Australian and New Zealand Standard for On-site domestic waste water management defines six soil categories, listed below in Table 2. These are used as the basis for determining the most appropriate method of disposing of effluent, and also to give a general indication of the permeability, design loading rate (DLR) and long term acceptance rate (LTAR) of the soils, which are parameters used in the design calculations. These soil types are therefore the primary factor used here in assigning an effluent disposal potential zone. Where there is a mixture of soil types present the 'worst case scenario' is used to assign the zonation.

Table 2. Definition of effluent disposal potential zone from the AS/NZS 1547:2000 soil category.

Soil category	Structure	Indicative drainage class	Effluent disposal potential zone	Colour
1	Gravels and sands	Rapidly Drained	High	Green
2	Sandy Loams	Well Drained		
3	Loams (including silty loams, and gravely silt loams)	Moderately well drained	Moderate	Turquoise
4	Clay Loams (including silty and sandy clay loams)	Imperfectly Drained		
5	Light Clays (including sandy and silty clays)	Poorly Drained	Low	Blue
6	Heavy Clays	Very Poorly Drained		

These zones are gradational. In particular the moderate zone covers a fairly wide range of soil types/properties. This is significant, since most of the areas covered in this study have clay loams at the ground surface. The zones are therefore refined by considering the underlying geology. Certain lithologies have particularly low permeability, are unstable and tend to have relatively thin veneers of undesirable soils, resulting in the low permeability parent rock being within the crucial top few metres of the ground. Clays and clay loams that were produced by the weathering of Northland Allochthon lithologies formation will probably contain smectite-bearing clays, and will tend to be at the poorly drained end of the moderate scale. Kamo Coal Measures contain some mudstones and tend to be overlain by undesirable, soils. Consequently, areas that have clay loam at surface, underlain by allochthon or Kamo Coal Measures are zoned as having low effluent disposal potential. Silt loams underlain by allochthon or Kamo Coal Measures are considered to have a moderate effluent disposal potential, but should be considered moderate to poor rather than moderate to good. Clay loams produced by the weathering of andesites or greywacke, on the other hand, tend to contain non smectite-bearing clays, and tend to be less problematic and are therefore zoned as having moderate effluent disposal potential.

Where alluvium or peat is mapped at the ground surface, on the geological map, soils that would otherwise be zoned 'low' are assigned to a 'moderate' effluent disposal zone whilst those that would otherwise be zoned as 'moderate' are assigned as 'low'. This is not so much because alluvium and peat tend to have low permeability, but rather because they tend to form in low-lying areas where the ground is likely to be saturated and unable to accept any effluent.

It should be noted that in considering the underlying geology, a certain area may be 'demoted' to a less favourable effluent disposal potential zone, but never 'promoted' to a more favourable one.

Whilst most of the coastal region in this study is assigned a 'moderate' effluent potential zone, it is worth highlighting the fact that almost all of this area has clay loam at surface, which tends to put it at the lower end of the moderate range. In using this information it is therefore wise to err on the conservative side.

These Effluent Potential Zones are designed to help Council with planning, in terms of targeting areas for reticulation and assigning appropriate subdivision size and predict populations in areas that will not have sewage systems installed. They are not in any way to replace site specific investigations.

7 Statutory responsibilities in relation to effluent disposal

7.1 Resource Management Act 1991

7.1.1 Sustainable management

Although the Resource Management Act (RMA) does not deal directly with issues of effluent disposal, its overall purpose is to promote the sustainable management of natural and physical resources (section 5(1)). The Act defines "sustainable management' as:

> *"..managing the use , development and protection of natural ad physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety while-*
>
> *a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations: and*
>
> *b) Safeguarding the life-supporting capacity of air, water soil and ecosystems; and*
>
> *c) Avoiding, remedying or mitigating any adverse effects of activities on the environment."*

Section 15 of the RMA relates directly to the discharge of contaminants such as on-site wastewater disposal. It states that

"(1) No person may discharge any –

> *a) Contaminant or water into water; or*
>
> *b) Contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water; or*
>
> *c) Contaminant from any industrial or trade premises into air; or*
>
> *d) Contaminant from any industrial or trade premises onto or into land –*
>
> *unless the discharge is expressly allowed by a rule [in a regional plan and in any relevant proposed regional plan], a resource consent, or regulations."*

The specific functions of WDC, as defined under Section 31 of the RMA, that relate to effluent disposal include

> *"a) The establishment, implementation, and review of objectives, policies, and methods to achieve integrated management of the effects of the use, development, or protection of land and associated natural and physical resources of the district:*
>
> *b) the control of any actual or potential effects of the use, development, or protection of land, including for the purpose of –*
>
> > *(i) The avoidance or mitigation of natural hazards; and*

(ii) The prevention or mitigation of any adverse effects of the storage, use, disposal, or transportation of hazardous substances"

To carry out these functions, WDC must produce a District Plan, which describes how resource management issues will be managed to achieve the sustainable management of natural and physical resources. Section 74 of the Act requires that the District Plan be consistent with the relevant Regional Plan and Regional Policy Statement, thereby ensuring the integrated management of the natural and physical resources of the region and district.

The WDC will therefore also be required to conform to the regulations that apply to regional councils. These are set out in section (30) of the act

"(c) The control of the use of land for the purpose of—

(i) Soil conservation:

(ii) The maintenance and enhancement of the quality of water in water bodies and coastal water:

(iii) The maintenance of the quantity of water in water bodies and coastal water:

[(iiia)the maintenance and enhancement of ecosystems in water bodies and coastal water:]

(iv) The avoidance or mitigation of natural hazards:

(v) The prevention or mitigation of any adverse effects of the storage, use, disposal, or transportation of hazardous substances:

(d) In respect of any coastal marine area in the region, the control (in conjunction with the Minister of Conservation) of—

(i) Land and associated natural and physical resources:

[(ii) The occupation of space on land of the Crown or land vested in the regional council, that is foreshore or seabed, and the extraction of sand, shingle, shell, or other natural material from that land:]

(iii) The taking, use, damming, and diversion of water:

(iv) Discharges of contaminants into or onto land, air, or water and discharges of water into water:

[(iva)The dumping and incineration of waste or other matter and the dumping of ships, aircraft, and offshore installations:]

(v) Any actual or potential effects of the use, development, or protection of land, including the avoidance or mitigation of natural hazards and the prevention or mitigation of any adverse effects of the storage, use, disposal, or transportation of hazardous substances:

(vii) Activities in relation to the surface of water:

(e) The control of the taking, use, damming, and diversion of water, and the control of the quantity, level, and flow of water in any water body, including—

(i) The setting of any maximum or minimum levels or flows of water:

(ii) The control of the range, or rate of change, of levels or flows of water:

(f) *The control of discharges of contaminants into or onto land, air, or water and discharges of water into water:*

Section 104(1) states that :

"When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to–

(a) *any actual and potential effects on the environment of allowing the activity"*

Section 104 deals with matters that would otherwise contravene section 15:

"(1) If an application is for a discharge permit or coastal permit to do something that would contravene section 15, the consent authority must, in addition to the matters in section 104(1), have regard to –

a) *the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and*

b) *the applicant's reasons for the proposed choice; and*

c) *any possible alternative methods of discharge, including discharge into any other receiving environment.*

and section 107 specifies minimum restrictions on granting a permit to do something that would otherwise contravene Section 15, including that a discharge of contaminant may not directly or indirectly enter water:

"if, after reasonable mixing, the contaminant or water discharged (either by itself or in combination with the same, similar, or other contaminants or water), is likely to give rise to all or any of the following effects in the receiving waters:

(c) *The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:*

(d) *Any conspicuous change in the colour or visual clarity:*

(e) *Any emission of objectionable odour:*

(f) *The rendering of fresh water unsuitable for consumption by farm animals:*

(g) *Any significant adverse effects on aquatic life."*

Section 105 defines conditions that can be set when granting resource consents:

"[(2)A resource consent may include any one or more of the following conditions:

(e) *Subject to subsection (8), in respect of a discharge permit or a coastal permit to do something that would otherwise contravene section 15 (relating to the discharge of contaminants) or section 15B, a condition requiring the holder to adopt the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of the discharge and other discharges (if any) made by the person from the same site or source:*

[(4)Without limiting subsection (3), a condition made under that subsection may require the holder of the resource consent to do one or more of the following:

(a) *To make and record measurements:*

(b) *To take and supply samples:*

(c) *To carry out analyses, surveys, investigations, inspections, or other specified tests:*

(d *To carry out measurements, samples, analyses, surveys, investigations, inspections, or other specified tests in a specified manner:*

(e) *To provide information to the consent authority at a specified time or times:*

(f) *To provide information to the consent authority in a specified manner:*

(g) *To comply with the condition at the holder of the resource consent's expense.]*

(8) *Before deciding to grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15 (relating to the discharge of contaminants) [or 15B] subject to a condition described in subsection [(2)(e)], the consent authority shall be satisfied that, in the particular circumstances and having regard to –*

a) *The nature of the discharge and the receiving environment; and*

b) *Other alternatives, including any condition requiring the observance of minimum standards of quality of the receiving environment –*

the inclusion of that condition is the most efficient and effective means of preventing or minimising any actual or likely adverse effect on the environment."

With respect to the subdivision and use of land, WDC has requirements relevant to the avoidance or mitigation of natural hazards. Section 106 (l) specifies that a consent authority shall not grant subdivision consent for:

"(a) *Any land … or any structure on that land (which) is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or*

(b) *Any subsequent use that is likely to be made of the land (that) is likely to accelerate, worsen, or result in material damage to that land, other land, or structure, by erosion, falling debris, subsidence, slippage, or inundation from any source."*

unless the consent authority is satisfied the effects of the proposed subdivision will be avoided, remedied or mitigated. This includes situations where introduction of effluent into the ground induces instability into otherwise unstable ground.

7.1.2 Sections relating to iwi values

Section 6 of the RMAct sets out "Matters of national importance". It states

"In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall recognise and provide for the following matters of national importance:

(a) *The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:*

(e) The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga."

The term "water" in subsection (e) is further defined:

"(a) Means water in all its physical forms whether flowing or not and whether over or under the ground:

(b) Includes fresh water, coastal water, and geothermal water:

(c) Does not include water in any form while in any pipe, tank, or cistern:"

Section 7 of the RMAct also refers to Maori issues:

"In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to –

(a) Kaitiakitanga:

[(aa) The ethic of stewardship:]

[``Kaitiakitanga'' means the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Maori in relation to natural and physical resources; and includes the ethic of stewardship:] "

Section 8 refers directly to the Treaty of Waitangi:

" In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi)."

It is important to understand the disposal of effluent can be a sensitive issue to the tangata whenua, who connect the passing of water through or over the land with a restoration of its mauri (life force). Hence, the disposal of wastewater must be handled carefully so as to protect the relationship of tangata whenua, their culture and traditions with their ancestral lands, water, sites, waahi tapu and other taonga. Specific concerns include mixing of different types of water, such as effluent and storm water, and the direct discharge of any liquid waste into a water body.

It is therefore recommended that councils consult with local iwi representatives as part of their planning process.

7.2 Building Act 2004

Through building consents WDC can ensure that appropriate on-site wastewater systems are installed and that they can operate without posing a threat to public health. The requirements applied to systems that store or treat wastewater are given in the New Zealand Building Code 1992.

Section 8 of the BAct classifies wastewater treatment plants as buildings. The relevant parts are quoted below.

"Building: what it means and includes –

(1) In this Act, unless the context otherwise requires, building –

(b) includes – (i)a mechanical, electrical, or other system;

(2) Subsection (1)(b)(i) only applies if—

(a) the mechanical, electrical, or other system is attached to the structure referred to in subsection (1)(a); and

(b) the system (i) is required by the building code; or

(ii) if installed, is required to comply with the building code."

Treatments systems must therefore comply with clause B1 (Structure) and Clause B2 (Durability) of the Building Code 1992 as well as the clauses that relate more directly to wastewater:

- Clause G1 , Personal hygiene
- Clause G13, Foul Water (sanitary drainage, sanitary plumbing)
- Clause G14, Industrial Liquid Waste (includes on-site foul water).

The objective of Clause G1 is to:

"a) Safeguard people from illness caused by infection or contamination,

b) Safeguard people from loss of amenity arising from the absence of appropriate personal hygiene facilities"

The objective of Clause G13.1 is similar. It is to:

"a Safeguard people from illness caused by infection or contamination resulting from personal hygiene activities

b) Safeguard people from loss of amenity due to the presence of unpleasant odours or the accumulation of offensive matter resulting from foul water disposal"

Clause G13.3.4 requires that:

"Where no sewer is available, an adequate on-site disposal system shall be provided for foul water in the same manner as is detailed in clause G14 "Industrial Liquid waste"

Clause G14.3.2 Requires that:

"Facilities for the storage, treatment and disposal of industrial waste shall be constructed:

a) With adequate capacity for the volume of waste and the frequency of disposal

d) To avoid the likelihood of contamination of soils, ground water and waterways except as permitted under the Resource Management Act 1991."

Once again section 71 of the Building Act applies, if the building of an effluent disposal system that is likely to induce land instability, and WDC must refuse the granting of a consent to undertake building works where:

"(b) the building work is likely to accelerate, worsen, or result in a natural hazard on that land or any other property."

One of the natural hazards specifically mentioned is slippage.

7.3 The Local Government Act 2002

Sections 127 and 128 refer to the responsibility of local authorities in assessing all wastewater sanitary services, including on-site waste water systems in their district.

"127.Information required in assessment of sanitary services –

An assessment of sanitary services must contain the following information:

(a) a description of the sanitary services provided within the district for each community in it; and

(b) a forecast of future demands for sanitary services within the district and each community in it; and

(c) a statement of the options available to meet the forecast demands and an assessment of the suitability of each option for the district and each community in it; and

(d) a statement of the territorial authority's intended role in meeting the forecast demands; and

(e) a statement of the territorial authority's proposals for meeting the forecast demands, including proposals for any new or replacement infrastructure; and

(f) a statement about the extent to which the proposals will ensure that public health is adequately protected."

"128.Process for making assessments –

(1) In making an assessment under section 125, the territorial authority must –

(a) consult the appropriate Medical Officer of Health; and

(b) take into account the duties of the territorial authority under section 23 of the Health

(2) In making an assessment of current and future demands for water services and options to meet those demands, a territorial authority must consider –

(a) the full range of options and their environmental and public health impacts, including (but not limited to) –

(i) on-site collection and disposal; and

(ii) grey water and stormwater reuse or recycling; and

(iii) demand-reduction strategies, including public education, information, promotion of appropriate technologies, pricing, and regulation; and

(iv) the full range of technologies available; and

(b) any comments by the Medical Officer of Health.

(3) An assessment of sanitary services is not required to address matters that a territorial authority considers have been adequately addressed in –

(a) an assessment made under section 125; or

(b) a waste management plan made under Part 31 of the Local Government Act 1974.

(4) *In this subpart, ``Medical Officer of Health'' has the meaning given to it in section 2(1) of the Health Act 1956."*

7.4 The Health Act 1956

Section 23 of this act states that:

"Subject to the provisions of this Act, it shall be the duty of every local authority to [improve, promote, and protect] public health within its district, and for that purpose every local authority is hereby empowered and directed—

(b) *To cause inspection of its district to be regularly made for the purpose of ascertaining if any nuisances, or any conditions likely to be injurious to health or offensive, exist in the district:*

(c) *If satisfied that any nuisance, or any condition likely to be injurious to health or offensive, exists in the district, to cause all proper steps to be taken to secure the abatement of the nuisance or the removal of the condition"*

Section 29:

"Nuisances defined for purposes of this Act—

Without limiting the meaning of the term ``nuisance'', a nuisance shall be deemed to be created in any of the following cases, that is to say:

(a) *Where any pool, ditch, gutter, watercourse, sanitary convenience, cesspool, drain, or vent pipe is in such a state or is so situated as to be offensive or likely to be injurious to health:*

(b) *Where any accumulation or deposit is in such a state or is so situated as to be offensive or likely to be injurious to health:*

(c) *Where any premises, including any accumulation or deposit thereon, are in such a state as to harbour or to be likely to harbour rats or other vermin:*

(d) *Where any premises are so situated, or . . . are in such a state, as to be offensive or likely to be injurious to health":*

Other issues covered by this act include the application by councils for abatement orders (sections 33 and 34); prohibition of the sale, letting or occupation of any part of a building used for a dwelling unless its waste water systems is deemed adequate according to the Building Act (section 39); cleansing orders, closure orders and requirements by council of repairs if residential facilities are unsanitary -including wastewater treatment systems (Sections 41 and 42) (section 44 allows Medical Officers of Health to issue similar orders); the requirement of authorisation by council to desludge septic tanks and dispose of the sludge (because this is an 'offensive trade')(section 54) and the polluting of watercourses, including those for municipal supply (section 60).

8 Applicability

This report has been prepared for the benefit of Whangarei District Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

TONKIN & TAYLOR LTD

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