Land Use Capability Classification of the Gisborne – East Coast region

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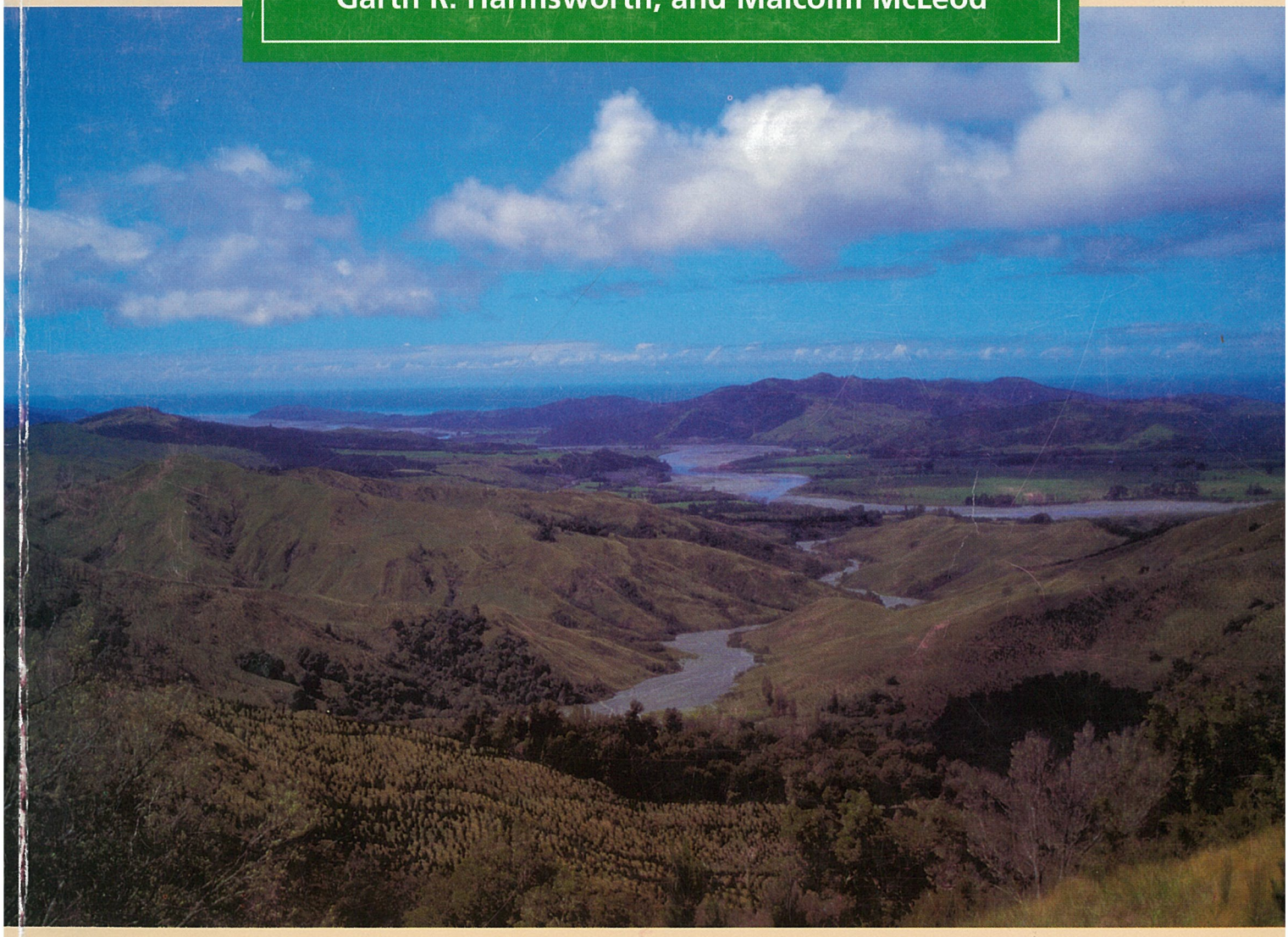

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Land use capability classification of the Gisborne – East Coast region:

A report to accompany the second-edition New Zealand Land Resource Inventory

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Cover:
Viewing east from grid ref. Z15/758615 down the gravel-infilled Totara Stream (LUC unit VIIIs2), flanked to the north and south in the middle ground by steep pasture-covered Miocene mudstone hills (LUC unit VIIe1), with the lower hills on mudstone north of Totara Stream representing LUC unit VIe2. Two-year-old pines cover seriously gully-prone argillite hills (LUC unit VIIe24) in the foreground, with patches of bush retained. Further east is the broad Waiapu River valley, dominated by the wide gravel-infilled Waiapu River (LUC unit VIIIs2), flowing to the sea in the distance. The river flats are in the Kakariki area, some 7 km north-east of Ruatoria township, comprising LUC units IIw1 (in sunshine), IIw2 (in shadow), and IIs1 on the slightly elevated terrace (also in shadow). Distant hills are a mixture of LUC units VIIe8 (steepest parts) and VIe22 (less steep parts) on argillite, here being more prone to soil slip rather than gully erosion, with typical patchwork covers of bush, pine plantations, and pasture.

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Summary

This report describes Land Use Capability (LUC) units established for the second-edition Gisborne – East Coast regional LUC classification. This classification, and associated map polygon delineations that contain inventory descriptions and LUC assessments, form part of the second-edition New Zealand Land Resource Inventory (NZLRI). The region covers 8852 km^2 in the east of the North Island of New Zealand.

Field work began in September 1995 and all field sheets (scale 1:50 000) were compiled and field-checked by October 1998. Data were converted into a digital spatial database by mid-February 1999. In total, 7790 map polygons were delineated, with an average size of 114 ha (median 59 ha). These were grouped into 104 LUC units on the basis of their similar physical characteristics, management requirements, and land-use potentials. These in turn were grouped into 11 LUC suites defined broadly on rock type or landform factors, creating a framework to help users understand the LUC classification and facilitate its use. The map polygon data, LUC assessments, and associated physical inventory information are managed in a Geographic Information System, accessible as primary or derivative (interpreted) plots and tabulations from Landcare Research or Gisborne District Council.

The report provides a description of each LUC unit outlining its physiography, rock types, soils, erosion status and potentials, vegetative covers, agricultural and forestry productivities, general management requirements for sustainable use, and present and potential land-use. Decision pathways provide keys to the recognition of LUC suites and units. Links between LUC units and the structure of the classification can be visualised in a set of relationship diagrams. A correlation of second-edition LUC units with the first-edition regional LUC classification of the Gisborne – East Coast, and relevant LUC units of the Northern Hawke's Bay and Eastern Bay of Plenty classifications is also given.

This second-edition classification and mapping replaces the now 25-year-old first-edition NZLRI of the region (Driver 1974), and its similar long-term and widespread use is expected.

Introduction

Purpose

This report is one of a series documenting the New Zealand Land Resource Inventory (NZLRI). It describes the Land Use Capability (LUC) classification for the second-edition NZLRI (1:50 000 scale) of the Gisborne – East Coast region. It includes descriptions and keys to the recognition of 104 LUC units.

The LUC classification described in this report and applied in associated NZLRI mapping, replaces the 25-year-old first-edition regional NZLRI (Driver 1974). It does not invalidate previous surveys based on the first-edition classification (such as farm plans or surveys for afforestation projects) or any document that uses or reports first-edition information.

New Zealand Land Resource Inventory (NZLRI)

The NZLRI is a national database of physical land-resource information. It comprises two sets of data:

1. An inventory of the five physical factors (rock type, soil, slope, present type and severity of erosion, and vegetation) basic to the assessment of land resources. A 'homogeneous unit area' approach is used to record physical factors (Eyles 1977), with the five factors being mapped simultaneously to an appropriate level of detail in relation to the presentation scale of 1:50 000.

2. An LUC rating of each map polygon based on an assessment of the ability of the inventory factors (above), together with climate, the effects of past land use, and the potential for erosion, to provide sustained agricultural production.

Detailed information about the NZLRI and LUC principles is given in the following chapter. Greater detail is available in Soil Conservation and Rivers Control Council (1971), and National Water and Soil Conservation Organisation (1979).

Data from the NZLRI are traditionally accessed from printed worksheets (maps), or as tabulations and plots. However, no worksheets will be printed for this coverage of the Gisborne – East Coast region. The policy is to rely on the computer database (managed in a Geographic Information System) for spatial output for specific applications. Access to the regional database is through Landcare Research. Gisborne District Council has a copy the database for its own use.

Gisborne – East Coast region

The second-edition NZLRI of the Gisborne – East Coast region follows the Gisborne District Council's administrative boundary, apart from small deviations in the north (Figure 1). The newly defined region includes the southern part of the Eastern Bay of Plenty NZLRI region and northern part of the Northern Hawke's Bay NZLRI region. The latter formerly extended to (and included) the Poverty Bay flats. Aligning the second-edition region with the Gisborne District Council area makes it possible to conduct district-wide interpretations without working across three regional boundaries and requiring familiarity with three LUC classifications.

The first-edition NZLRI region covers 5632 km^2, while the second-edition region covers 8852 km^2. The second-edition NZLRI region is slightly larger than the Gisborne District Council area (8339 km^2), due to the deviations in the north and map polygons that cross the district boundary. However, the district can be easily 'clipped-out' for district-wide applications.

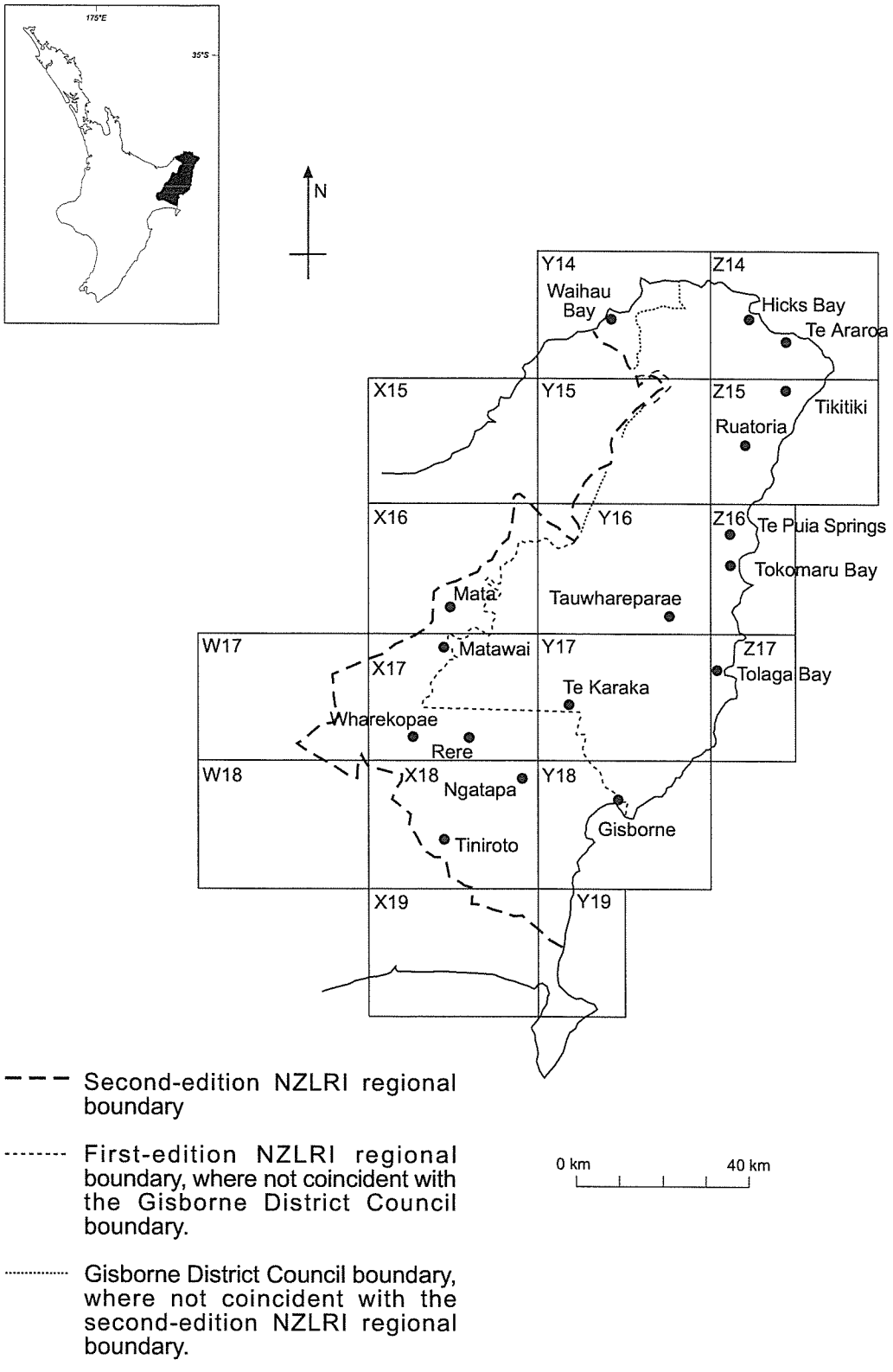


Figure 1. *Location of the Gisborne – East Coast region, North Isand, New Zealand, showing regional boundaries and the position of Infomap 260 sheets*

History of Land Use Capability (LUC) in the Gisborne – East Coast region

Earliest LUC surveys

The complex geology and relative abundance of erosion-prone lithologies in the Gisborne – East Coast region is reflected in a wide diversity of distinctive landscapes with different erosion susceptibilities, sustainable land-uses and land management options. Much of the region is degraded by erosion — some is natural (such as the erosion in forested mountain ranges), but much is accelerated erosion resulting from unwise land-use types and practices. Campbell's (1946) paper 'Down to the sea in slips' provided the first formal observations of land degradation in the region, and nature provided the most dramatic statements of the problem in the form of Cyclone Bola in March 1988 (described in Trotter 1988; Singleton *et al.* 1989). In the early 1960s, adoption (with modifications) of the 'land capability' approach to assessing and mapping land (Klingebiel and Montgomery 1961) appealed as way to begin formerly addressing the special problems of the region.

Land use capability was first introduced to the region as a soil conservation planning tool in 1964. It took the form of a region-wide LUC survey at a scale of one inch to two miles carried out between September 1963 and July 1964 (described by Harris *et al.*1964). That study mapped (Harris and McKee 1964) and defined to LUC class level all land (apart from class VII which was defined to LUC unit level), and formed the basis for the 'Wise Land Use and Community Development' report — also known as the 'Taylor Report' (National Water and Soil Conservation Organisation 1970). This four-year project provided an excellent analysis of East Coast problems and established a so-called 'blue line' separating 'critical headwaters' from the 'pastoral foreland'. The Soil Conservation and Rivers Control Council later supported a plan for greatest afforestation of the area defined as critical. The simple division by the blue line emphasised the problem initially, but as time passed the approach was widely considered too rigid (Poole 1983).

First-edition NZLRI

The first-edition NZLRI (using the LUC classification of Driver 1974) was a more rigorous LUC survey at the more detailed scale of 1:63 360 (one inch to one mile). It provided a major step forward allowing closer definition of areas that would benefit from erosion-control measures. The so called 'Red Report' (East Coast Project 1978 — 'Land use planning and development study for erosion-prone land of the East Cape region') soon followed this first-edition NZLRI when opportunities for improved region-wide planning of erosion control strategies were realised. The Red Report defined 'recommended land use' categories based on the LUC units of Driver (1974). These recommendations were implemented at the farm scale (by the Poverty Bay Catchment Board — later East Cape Catchment Board — now Gisborne District Council) using a 'farm planning' technique based on the detailed mapping of LUC and associated inventories. Now, after 25 years, some 70% of the pastoral land in the district has been mapped at farm-plan scales (many at 1:5 000) using the first-edition NZLRI (1:63 360) to provide classification and mapping standards.

Land use capability has consistently formed the basis for land-use planning at the district scale through District Schemes and now the proposed District Plan under the Resource Management Act (RMA 1991) where it is used to target rules (T. Freeman, Gisborne District Council, pers comm.). The various pastoral and forestry soil conservation incentive schemes from the 1970s to the East Coast Forestry project of today have all used LUC as a targeting mechanism.

Second-edition NZLRI

Over more than two decades of use, ever-increasing demands placed on the first-edition regional NZLRI revealed limitations. These included the less-detailed map polygon definition standards of the 1970s (that is, big polygons) — made worse by the use of base maps at a scale of 1:63 360 rather than 1:50 000, the use of a broad LUC classification (that is, not many LUC units representing a diverse terrain), and widespread changes to transient factors (such as erosion and vegetative cover). Users also recognised the availability of new information about

erosion, geology, soils, and vegetative cover. Fears were held that under the perceived increasing demands of the RMA for more detailed and defensible information, the first-edition database would not properly support policy aimed at improving land-use sustainability in the district. In such a sensitive district, any impediment to improved land-use planning is likely to slow much needed progress.

With the support of the Gisborne District Council (GDC) and funding from the Foundation for Research, Science and Technology, this second-edition NZLRI of the Gisborne – East Coast region was carried out. The survey began in September 1995, and ended with the publication of this report. The mapping was completed by October 1998.

Improvements to land resource information

Many advances made by the second-edition NZLRI of the Gisborne – East Coast region were facilitated by a close working relationship between the Landcare Research team and GDC soil conservation staff. Key improvements to the land resource information are:

- an alignment of the NZLRI regional boundary to the existing GDC administrative boundary, thereby avoiding the need to work across three NZLRI regional boundaries (and interpreting three LUC classifications) for district-wide investigations;

- a more detailed LUC classification (104 second-edition LUC units compared with 54 in the first-edition classification). Twenty second-edition LUC units were imported from adjacent classifications — mainly from Northern Hawkes Bay, 36 LUC units remain substantially unchanged from the first-edition classification, while the balance of LUC units reflect changed concepts but still with strong links to first-edition LUC units;

- more detailed mapping. This was provided for by a more detailed mapping scale of 1:50 000 (first-edition mapping was at 1:63 360) and the application of a more detailed mapping style (that is, delineating smaller map polygons). The average second-edition map polygon size is 114 ha (median 59 ha), whereas the average first-edition map polygon size is 373 ha (median 178 ha). The smallest reliably mapped polygon is 6.25 ha ($^1/_{16}$ th of a grid square on an Infomap — scale 1:50 000). Only 0.08% of the region has smaller map polygons (where prominent landforms such as tall escarpments, river valley flats, or elevated terrace tops are exceptional but small features in their landscape setting);

- a substantial upgrade of soil resource information in the hill country. There was no routine or widespread use of soil information in the hills because the soil units used (soil sets) were too generalised and poorly understood in the region. The second-edition NZLRI of the region maps soil subgroups. A user-friendly manual (Hewitt 1998) describes rules for allocating soil subgroups, and identifies a range of accessory properties associated with each classified soil — making the recorded soil many times more meaningful than soil sets;

- the incorporation of new geological information (supplied by the Institute of Geological & Nuclear Sciences), allowing much-improved depiction of standard NZLRI rock types;

- an updated regional assessment of present erosion type and severity (including improved assignment of erosion potentials in LUC unit descriptions); and

- a separate layer of vegetative cover information — independent of the multifactor polygon of previous NZLRI regional surveys — providing a very comprehensive vegetative cover dataset, and one that can be upgraded easily as changes occur.

The New Zealand Land Resource Inventory and principles of land use capability

This chapter summarises the New Zealand Land Resource Inventory (NZLRI), its Land Use Capability (LUC) system of land classification, and physical inventory components.

The NZLRI

The NZLRI is a national spatial database of physical land-resource information. It comprises two sets of information: an inventory of classified data describing five physical factors, and an interpreted LUC assessment. In practice, this core data set is supplemented on a Geographic Information System (GIS) with the addition of derived fields of productivity assessments and correlations or generalisations for particular applications.

The NZLRI is one of a collection of databases (managed in the Land Resource Information Systems programme — Landcare Research), that have been awarded 'national significance' status by the Foundation for Research, Science and Technology. Landcare Research is the custodian of the NZLRI; and the Public Good Science Fund provides funding for this purpose. While originally published as printed maps (worksheets) and still available from Landcare Research in that form, NZLRI data are now primarily managed as a computerised GIS database. The second-edition NZLRI of the Gisborne – East Coast is only available in the form of GIS products (plots and tables).

The NZLRI covers the country in 12 regions, each with a separate LUC classification. The first-edition NZLRI provides national coverage and was mapped between 1973 and 1979 at a scale of 1:63 360, and is supported by 'extended legends' of LUC units for all regions. Four regions are supported by regional reports (Blaschke 1985b; Noble 1985; Fletcher 1987; Page 1988). Second-edition NZLRI regional upgrades at a scale of 1:50 000, all with regional reports, have been completed for Northland (Harmsworth 1996), Wellington (Page 1995), part of Marlborough (Lynn 1996), and now the Gisborne – East Coast region.

Detailed information on aspects and interpretation of the NZLRI is available in the 'land use capability survey handbook' (Soil Conservation and Rivers Control Council 1971) and 'Our land resources' (National Water and Soil Conservation Organisation 1979) and has been summarised in, for example, Howard and Eyles (1979), Fletcher (1988), Eyles (1992), and Stephens and Jessen (1997).

Physical factors

The NZLRI presents mapped areas (polygons). The polygons are delineated using a 'homogeneous unit area' method (Eyles 1977), in which four physical factors of rock, soil, slope, and erosion are mapped simultaneously within the limitations of scale. Vegetative cover has been mapped with these four factors in the past, but was mapped separately for the first time in the second-edition NZLRI of the Gisborne – East Coast (GEC) region to provide better spatial definition of land cover.

The inventory of physical factors is obtained by reference to pre-existing information, field verification, and stereoscopic interpretation of vertical aerial photographs.

Rock type: a rock type classification has been developed to suit the requirements of the NZLRI (Lynn and Crippen 1991). This classification groups rocks with similar erosion susceptibilities and characteristics, and concentrates on those rocks that directly influence surface morphology and land use (Eyles 1992).

Soil: soil information is normally obtained from existing soil surveys, and field checks are used to validate the information. Where soil data are not available at an appropriate scale, physiographic analysis is used to re-interpret small-scale information to fit the 1:50 000 scale. For the GEC region, soils were interpreted into each map polygon with knowledge gained from the development of soil-landscape models (McLeod *et al.* 1995) and field work. New Zealand Soil Classification soil subgroups (Hewitt 1998) were recorded. These modifications to earlier NZLRI approaches for recording soils has led to greatly improved soils information for the region.

Slope: slope is classified into eight groups: A (0–3°), B (4–7°), C (8–15°), D (16–20°), E (21–25°), F (26–35°), G (36–42°), and H (>42°). These are based on broad land management criteria, such as the use of wheeled vehicles is appropriate up to and including slope C, tracked vehicles are appropriate up to and including D, and cultivation for cropping by vehicles is not possible in slope E and steeper. Slope H is new to the NZLRI, being used in the GEC region where slopes are bluffy and usually near to vertical.

Erosion: fifteen erosion types are recorded in the NZLRI (Eyles 1985). Up to four types are recorded in each map polygon and a severity ranking is applied to each type. The area of the map polygon affected by erosion is the main consideration when assessing erosion severity for most types.

Vegetation: for NZLRI vegetative-cover mapping, emphasis was placed on identifying important species and associations rather than on providing a botanical classification (Hunter and Blaschke 1986). Classes are recorded in five broad vegetation cover groups: grass, crops, scrub, forest, and herbaceous. Vegetation forms part of the multifactor inventory in previous regional NZLRI coverages, but for the second-edition NZLRI of the GEC region, vegetation was mapped separately to provide more spatial detail.

Climate: unlike other factors, climate is not mapped. However, broad climatic factors are recognised in many LUC units, especially the arable ones. In the second-edition GEC classification, for instance, a division between upland and lowland units at 550 m a.s.l. recognises that land-use versatility decreases at higher elevations where cooler growing conditions prevail, rainfall generally exceeds 1800 mm/yr, soils become more strongly leached and important nutrients are less freely available. Natural plant and animal communities are expected to be different, and so too are exotic forest tree-type selections and exotic forest productivity.

LUC assessment

A LUC assessment is made for every map polygon in the NZLRI. These assessments are based on the ability of the land to sustain agricultural production. The following mapped physical factors are considered when making LUC assessments: rock type, soil, slope, and the present type and severity of erosion. Climate and the potential for erosion are equally important. The effects of past land use may also influence LUC assessments. LUC assessments are made in a three-part hierarchy (Figure 2): LUC class, LUC subclass, and LUC unit. The LUC system used in the NZLRI was adapted from Klingebiel and Montgomery (1961). The LUC method of land classification is routinely used in over 50 countries in various adapted formats:

- the LUC class is the first and broadest category of the LUC classification system. It expresses the total degree of limitation to sustained use. There are eight LUC classes used in New Zealand, from class I (negligible limitation) to VIII (extreme limitation). Classes are usually denoted by Roman numerals, although Arabic numerals may be used (such as in Lynn 1996);

- the LUC subclass is the second category and expresses the major kind of limitation. The NZLRI uses four LUC subclass limitations: erosion (e), wetness (w), soil (s), and climate (c). The LUC subclass comprises the LUC class and subclass limitation, for example, VIe. There are only 30 LUC subclasses in New Zealand. Consequently, users need to be aware that land management strategies derived from LUC subclass alone are based on general information; and

- the LUC unit is the third and most detailed category. Each LUC unit is defined by its unique assemblage of physical factors. A LUC unit groups uniform land types together. Specifically, a LUC unit will group map polygons which 'respond similarly to the same management; are adapted to the same kinds of crops, pasture or forest species; have about the same potential yield, and require the same kind and intensity of soil conservation and other land management measures'. There are over 700 different LUC units in the NZLRI. They are therefore

much more useful for detailed planning than the LUC class or subclass. A LUC unit is indicated by an Arabic number placed after the subclass limitation symbol (for example, VIe1).

Each of the 12 NZLRI regions has a unique set of LUC units. For example, VIe1 in the Waikato region is specific to that region, and different from VIe1 in the Wellington region. Page (1985) correlated LUC units from the first-edition regional classifications of the North Island, by grouping together LUC units that are essentially the same, but in different regions, to help users who are working across NZLRI regional boundaries.

- In a classification of LUC units, the numerical ranking of units based on decreasing versatility and capability gives no direct indication of relationships between LUC units in their landscape setting. To enable these relationships to be better understood and help interpret LUC maps, related LUC units are arranged into groups, called LUC suites. A LUC suite is 'a group of LUC units which, although differing in capability, share a definitive physical characteristic which unites them in the landscape'. These characteristics may vary from suite to suite.

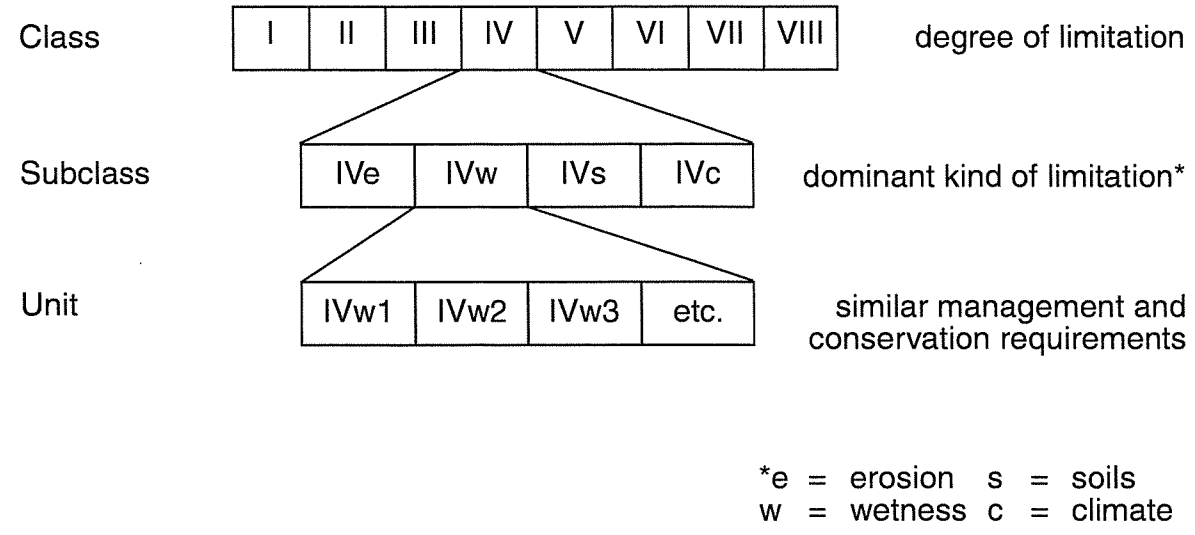


Figure 2. *Components of LUC classification*

Interpreting the NZLRI

Appropriate and inappropriate uses of the NZLRI

The NZLRI database can be used in two ways:

- for primary interpretations, depicting (or analysing) land attributes in a form little different from the database's stored state; and
- for understanding secondary interpretations of data to produce depictions (or analyses) of effectively new information.

Primary interpretations are those that seek information on one, or a combination of, previously recorded factor(s). No added information is required for primary enquiries. Commonly, primary uses of the NZLRI database are associated with regional and district-wide planning documents that link land use or management requirements to land classifications. For example, LUC class, subclass, or unit may be required to support a regional policy; or information on one of the inventory factors such as slope may be required to put a regional rule into effect. Users making primary interpretations should understand the principles of the LUC classification system (for LUC-based enquiries), the limitations of scale, and the significance of the time of data collection to changeable factors such as vegetative cover and erosion. Where these are not recognised by users (Jessen and Harmsworth 1997; Stephens and Jessen 1997), the use of the NZLRI database may been seen as inappropriate.

Secondary interpretations are those where the NZLRI intersects with other databases, or where new knowledge from other sources is added, to establish what is essentially a new interpretation. There are numerous examples of these kinds of uses:

- identification of 'high class soils' (Webb *et al.* 1995, 1997). Ten soil attributes from the National Soils Database and other unpublished soils datasets (two climatic factors and a slope factor) were linked to LUC data from the NZLRI;
- determination of rabbit-proneness ratings for New Zealand (Kerr and Ross 1990);
- corridor analysis (TransPower NZ Ltd 1988) for electricity transmission route feasibility;
- definition of land types for monitoring programmes (Eyles *et al.* 1993), and as frameworks for developing environmental performance indicators (Harmsworth 1988; Hall *et al.* 1988; Stephens *et al.* 1999);
- the quality of land involved in land-use change from pastoral agriculture to plantation forestry (Krausse *et al.* in press);
- soil carbon studies where the amount of carbon stored in New Zealand soils was assessed and a soil carbon map produced (Tate *et al.* 1993). A soil map of New Zealand has been produced using IPCC (International Panel on Climate Change) categories (Daly and Wilde 1997); and
- compilation of soil maps. The 'New Zealand soil classification' (Hewitt 1998) was linked to the NZLRI to produce a New Zealand map of soils (Rijkse and Hewitt 1995).

The key to the effectiveness of the NZLRI is that it is a spatial database covering the whole of New Zealand.

While the primary use of the NZLRI database is limited by the recorded factors, the secondary uses appear boundless. Nevertheless, limitations of the NZLRI database (such as those of scale, reliability of the data and interpretations, and the use of polygons with consequent information loss within polygon areas) need to be recognised to eliminate inappropriate uses.

Presentation scale

While the inventory classifications and the LUC system of land classification are independent of scale, inventory factors and LUC assessments are mapped in the NZLRI at a scale of 1:63 360 (first-edition) and 1:50 000 (second-edition). Second-

edition inventory map polygons have a minimum size that represents 6.25 ha on the ground ($^1/_{16}$th of a grid square on an Infomap — scale 1:50 000). It is implicit in mapping that the information recorded will not adequately describe some parts of the map polygon. A rule-of-thumb assumption for users of the information is that up to 20% of any map polygon might be poorly described. Therefore, it is important to avoid using NZLRI data at scales larger than the original mapping scale because the inherent non-representative parts of a map will be enhanced. When information is sought for areas that are best represented by larger mapping scales, or for site interpretations, data are best gathered separately from the NZLRI maps (still using the NZLRI maps as a guide), such as done for farm planning.

The need for second-edition NZLRI information

The NZLRI programme for the first-edition mapping in New Zealand was completed between 1973 and 1979. Second-edition mapping has been undertaken episodically in different regions from 1979 to the present.

Assessments of LUC (at class and subclass levels) for each map polygon are made by interpreting the physical factors of rock, soil, slope, type and severity of present erosion, potential erosion and climate, and the effects of past land use. Because these factors (except for present erosion severity) are relatively constant over time, the LUC assessment component of the NZLRI can remain valid for long periods (say many decades), except in rare instances where major drainage, flood-protection or irrigation schemes have been implemented. However, present erosion severity (and to a lesser degree erosion type) and vegetative cover can change and rapidly become dated components of the NZLRI.

While LUC assessments do not easily or rapidly become out-of-date theoretically (above), there have been considerable improvements to classification and mapping standards since 1979. Improved detail (more LUC units and smaller map polygons) and documentation standards (better explanations) will enable increased demands for land resource information to be met. Certainly, there are demands from territorial and regional authorities for higher quality (more defensible) information, more detail, and better explanations, as prompted by legislation (RMA 1991). There is also a growing need for improved land resource information from major land managers (for example, forestry companies), community groups with a wide range of interests, individual land managers, educators, government agencies, and scientists.

Physical attributes of the Gisborne – East coast region

Assessment of LUC is based on recognising the impact of climate, different rock types and soils, slopes, erosion characteristics, and the effects of past land use as reflected mainly by erosion and vegetative cover. This chapter describes the climate, and the mapped inventory factors of rock type, soils, slope, erosion, and vegetation in the Gisborne – East Coast region.

Climate

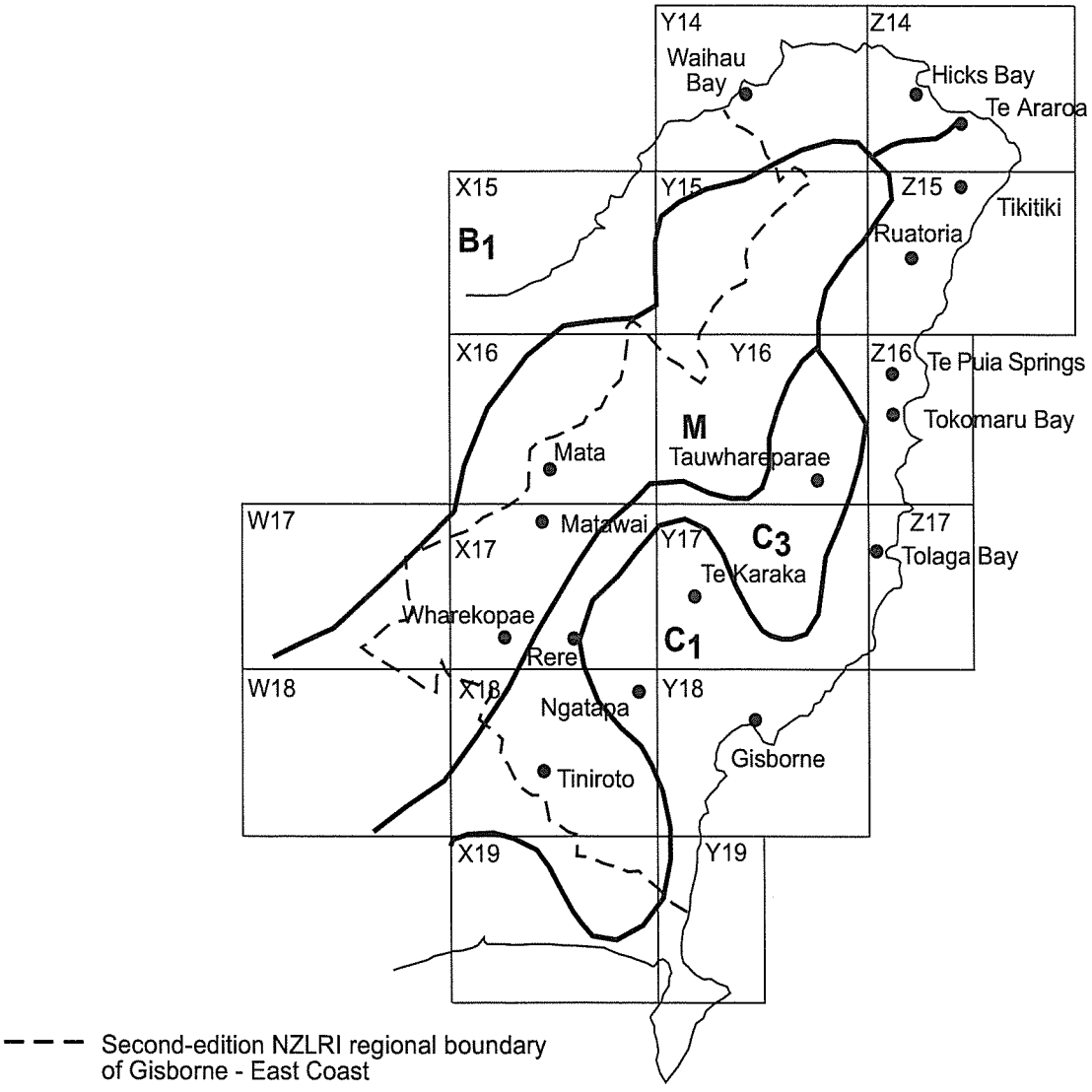
Climate zones

Figure 3 is simplified from part of the New Zealand Meteorological Service (1983) 1:2 000 000 climatic regions map. The climate zones identified on the map provide a concise summary of climates experienced in the region.

Rainfall, storms, and droughts

Rainfall increases on a steep gradient inland from the coast (Figure 4), such that mean rainfall ranges from less than 1000 mm/yr on the Poverty Bay flats to rise sharply to about 4000 mm/yr in the Raukumara Range (as seen in Figure 8 of Hessell 1980 that extracts the 1:500 000 isohyetal map from New Zealand Meteorological Service 1978). Tomlinson and Sanson (1994) update the rainfall data used for the map from active stations in the region, but the overall pattern remains the same. Wind-flows from the north and north-east tend to produce higher rainfall in the northern and western parts of the region but little rainfall at the coast, while those from the south-west and south produce rainfall at the coast but little inland (Hessell 1980). Winds from the south-east produces rainfall over most of the region since the main divide and coastline lie across these flows.

For any single month the rainfall is highly variable from year to year compared with most parts of New Zealand (National Water and Soil Conservation Organisation 1970), and this is most pronounced between December and April. The variability of rainfall is reflected by very frequent 'partial droughts' (period of more than 14 days during which no day receives more than 0.1 mm rainfall) and 'dry spells' (period of more than 14 days during which no day receives more than 1.0 mm rainfall), mostly during the months of October to February, and the effect of these is worsened by drying northerly and regionally predominant northwesterly winds. On the other hand, extreme rainfalls occur from, for example, extra-tropical cyclones from the north during March through May such as Cyclone Bola (Singleton *et al.* 1989) or winter storms of low intensity and long duration from the easterly quarter. Both types of storm cause erosion (mainly soil slip and gully), flooding, and sediment deposition, as have more localised, brief, high-intensity convective storms in spring and summer. Examination of Meteorological Service archives reveal 36 major events (with either local or region-wide impacts) from 1900 to 1988 (Appendix 1), which represents a frequency of one damaging storm somewhere in the region every 2.5 years. Storms and droughts, together with undesirable economic, social, and environmental consequences, provide a major challenge to the agricultural sector in particular and have acted as a catalysts for major land-use change in recent times (such as pasture converted to spaced tree plantings or plantation forestry).



Key for Climate Zones

B_1 Sunny rather sheltered areas, which receive rains of very high intensity at times from the north-east and north. Very warm summers and mild winter. Annual rainfall 1000 – 2000 mm with a winter maximum.

C_1 Very warm summers, day temperatures occasionally rise above 30° C with dry foehn northwesterlies. Annual rainfall 1000 – 1500 mm; marked decrease in amount and reliability of rain in spring and summer. Moderate winter temperatures with maximum rainfall in this season.

C_3 Cooler and wetter than C1. Very heavy rain at times from south and south-east. Annual rainfall mainly 1500 – 2500 mm.

M High-rainfall mountain climates. Conditions vary greatly with altitude and exposure.

Figure 3. *Climate zones of the Gisborne — East Coast region (after NZ Met. Service 1983)*

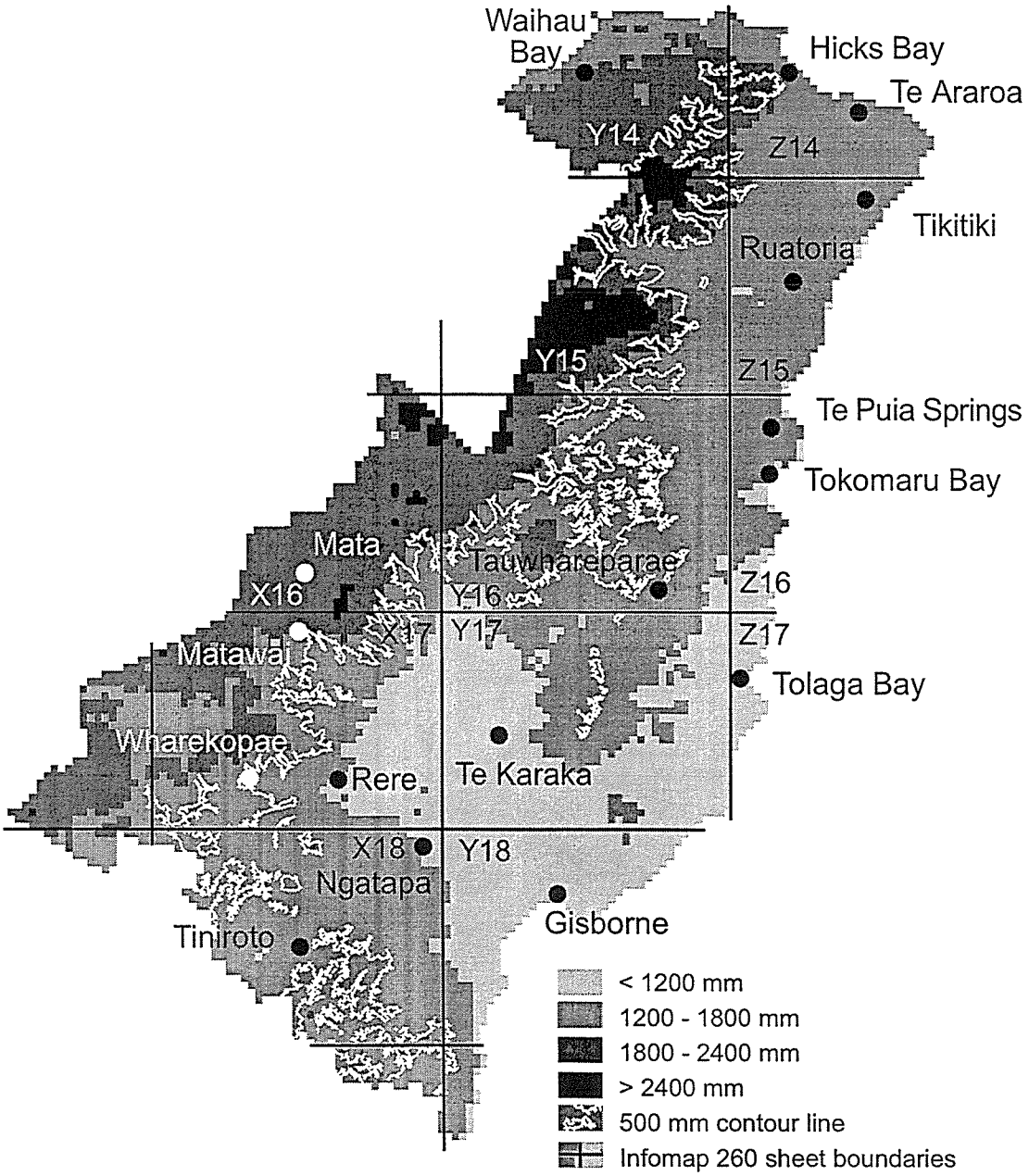


Figure 4. *Rainfall zones and 500 m a.s.l. contour in the Gisborne — East Coast region (rainfall zones after Giltrap 1993)*

Rock type

Recording rock type in the inventory, and information sources

Rock type was mapped using a combination of field work, interpretation of stereo-pairs of vertical aerial photographs (Appendix 2), and reference to existing geological information. This included the unpublished recent lithostratigraphic geological map (at 1:250 000 scale) and report (Moore *et.al.* 1989), and the associated maps at 1:50 000 scale (draft field sheets[1]) supplied by the Institute of Geological & Nuclear Sciences; and the published 'Sheet Y16 Tauwhareparae' of Mazengarb *et al.* (1991). Geological information on selected areas, such as that for Mangatu (Gage and Black 1979) were used where available. Additionally, rock types in O'Byrne (1967) were referred to, as these (along with data from the earlier 1:250 000 scale time stratigraphic maps, e.g., Kingma 1964) were used in the first edition Gisborne – East Coast LUC classification (Driver 1974). Information on tephra cover deposits was derived initially from tephra isopach maps of Pullar (1972, 1973) and inferred from published soil maps, then verified by field observation of tephra types, thicknesses, and distribution. Sources for rock-stratigraphic and other geological names commonly referred to in this report are listed in Appendix 3.

The rock type inventory factor was recorded in symbol form (Appendix 4) using the NZLRI rock type classification (Lynn and Crippen 1991). This classification, with minor changes, groups rocks with similar physical characteristics and erosion susceptibilities, concentrating on those rocks that directly influence surface morphology and land use (Eyles 1992). For each map polygon up to four rock type symbols were recorded. These were augmented by prefixes and other symbols indicating relationships between the recorded rock types.

Geology overview

The geology is extremely complex but understanding can be assisted by relating geology to easily observed landforms (Moore and Mazengarb 1992). Moore and Mazengarb recognize three main structural features: the Motu Block, East Coast Allochthon, and Neogene 'cover', and each gives rise to characteristic associations of landforms. Two more landform/geological features can also be considered: the Plains, terraces, and river flats, and the Tephra cover. This five-part subdivision provides a basis for the LUC classification (next chapter). Figure 5 shows the distribution of four of the structural features (with only the Plains part of the Plains, terraces and river flats shown due to the small scale of the map). The fifth feature (Tephra cover) is widespread over stable easier-sloping terrain but not on flood plain surfaces.

The *Motu Block* forms the western part of the region (and extends to the Bay of Plenty coast). Geologically speaking these rocks are considered autochthonous[2]. The dominant landform is the rugged mostly forested ranges (Raukumara Range), with some less steep hill country, bounded by the Raukokore River in the north, Mounts Hikurangi and Arowhana in the east, extending south-west through Matawai township to the Huiarau Range in the south. The ranges are formed of highly deformed but generally strong greywacke[3] (here of Cretaceous age) — indurated sandstones and mudstones, usually alternating, that form most of the North Island axial ranges and most of the Southern Alps. The associated hill country is formed of slightly younger (upper Cretaceous), less indurated, and less deformed sandstones and mudstones that usually, but not always, have a greywacke-like appearance and landform. Also, there is some easier terrain of younger argillites that approach the appearance of landforms found in the East Coast Allochthon.

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[1]unpublished maps covering Infomap 260 sheets X16–18, Y14–15, 17–18, Z14–17

[2]autochthonous: referring to bodies of rock that are essentially in place (*cf.* allochthonous). (noun: autochthon)

[3]greywacke is used here to encompass both indurated sandstones and mudstones. However, rock type usage for the LUC classification uses a three-way split: Gw Greywacke association of rocks — indurated, alternating and/or bedded dominantly sandstone; Ar Argillite — indurated, alternating and/or bedded dominantly mudstone; and Si — where the lithology is indurated, massive or very thick beds of sandstone.

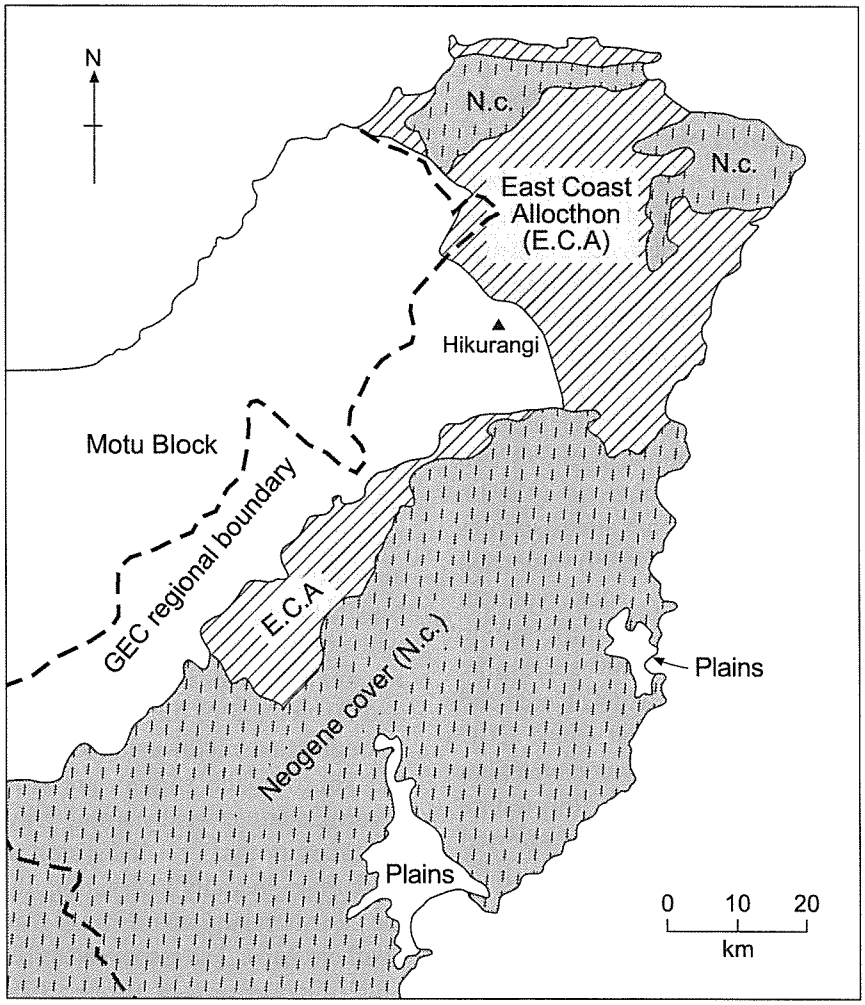


Figure 5. *Four geological structural features of the Gisborne – East Coast region (adapted from Moore and Mazengarb 1992)*

The *East Coast Allochthon*[4] is adjacent to the SE–NE edge of the Motu Block: a wide zone in the Maungahaumi–Mangatu area, a thinner zone in the Waitahia–Mata area; connecting with an extensive area to the north-east of the Motu Block (north of a line from Waipiro Bay to Raukokore, but excluding the separate hill country behind Whangaparaoa and Te Araroa). Active tectonism has created structurally very complex rocks that have been moved from their original position. The most widespread effect of this has been intense crushing and shearing creating very weak and unstable rocks that are prone to severe earthflow and gully erosion — Ac (crushed argillite) and cGw (crushed greywacke), Mx (sheared mixed lithologies, named 'melange'[5] in the region's geological literature), and Me (bentonite). The very unstable melange and bentonite are usually found along the boundary between, but sometimes within, the East Coast Allochthon and the Neogene 'cover'. All of these erosion-prone rocks are found extending from the

[4]The name allochthon refers to bodies of rock that have been moved (often considerable distances) from their original site. (adjective: allochthonous).

[5]Melange: 'a mappable body or rock characterised by the inclusion of fragments and blocks of different rock types, of all sizes, in a fragmented and generally sheared matrix' (Lynn and Crippen 1991). The melange in the region consists mainly of Cretaceous and Paleogene rock fragments in a mainly bentonitic matrix. It appears to be associated with the emplacement of the East Coast Allochthon (Mazengarb *et al.*1991).

Mangatu and Waipaoa headwaters, to the Tapuaeroa Valley and further north. However, resistant slivers of hard rocks occur in some areas — such as sandstones (Sm, Sb), limestones (Li) — repeated as a series of parallel ridges as seen in the Dome–Maungahaumi area. East Coast Allochthon landforms are frequently the subject of startling images in publications that highlight erosion and soil conservation issues (Allsop 1973; Cumberland 1981).

The northernmost bodies of the Allochthon comprise the steep resistant ancient Matakaoa Volcanics (In), forming the Pukeamaru and Matakaoa ranges. These are gigantic allochthonous blocks of intact rock, where slope instability is related more to slope steepness than rock-mass strength — contrasting with other allochthous rock terrains where very weak rock masses comprise blocks of argillite a few centimetres or less in diameter in a crushed and sheared clayey matrix.

The *Neogene*[6] *'cover'* forms the extensive area east and south of the East Coast Allochthon and Motu Block, mostly made up of rocks of Neogene or Quaternary age. This is the rolling to very steep hill country and associated upland plateaux extending from Waipiro Bay, south to Tiniroto and the Wharerata hills then west through Wharekopae to the Urewera Range at Maungapohatu[7]. It also forms the usually very steep non-volcanic hill country in the Whangaparaoa–Hicks Bay and Te Araroa areas. The rocks that make up these Neogene 'cover' landforms are the widespread non-indurated mudstones and sandstones, sometimes bedded, with minor limestones.

The *Plains, terraces and river flats* comprise the extensive Poverty Bay flats and the smaller Tolaga Bay flats, together with the Waiapu River flats and terraces, the coastal plains at Te Araroa and the coastal and valley terraces and flats in the Waihau, Whangaparaoa and Hicks Bay areas. There are extensive areas of Quaternary deposits: usually unconsolidated gravels, sands, and muds. Additionally, throughout the landforms of the three main structural features, narrow river flats and terraces occur.

The *Tephra cover* (volcanic ash) modifies landforms in the three main structural features by 'smoothing' hillslopes. Older more elevated terraces of the Plains, terraces and river flats are also often covered by tephra. The tephric material is sourced from either the Okataina (Rotorua) or Taupo Volcanic Centres. Tephra is thicker and individual tephra layers more distinct towards the west of the region. Tephra is mixed, thinner, and the individual layers are difficult to distinguish towards the east. However, much of the steep and erosion-prone hill country and areas underlain by unstable rock types have lost most of their tephra cover. Tephra presence or absence within their distribution range can therefore be used as a guide to hillslope stability.

Two NZLRI rock types (1 and 2 below) are used to identify tephra. They are broad groupings only, as ages of the tephra showers and individual tephra layers are not specifically identified. The following review gives ages and names taken from Froggart and Lowe (1990). Tephra distributions of the region can be seen on two tephra isopach maps of Pullar (1972, 1973).

The two broad tephra groupings in the rock type classification are:
1. Kt — Taupo/Waimihia tephra. This includes Taupo Tephra (1850±10 yr B.P.) which mantles the entire region, but is thicker west and south-west of the Poverty Bay flats. It also includes Waimihia Lapilli (3280±20 yr B.P.) which is thicker more to the south-west of the region (Waimihia material can be soil-forming where Taupo Tephra has been removed or is thin). These tephra formations usually occur together in the region. Both Taupo and Waimihia tephra can give rise to Pumice Soils (Hewitt 1998) when >25 cm thick

[6]Neogene age rocks: Miocene to Pliocene age. With the term Paleogene (Paleocene to Oligocene) a convenient subdivision of the Tertiary-age rocks for New Zealand geology.

[7]Some of the hills and ranges in the Wharekopae to Maungapohatu area are made up of not Neogene but Paleogene rocks so could be considered part of the Motu Block, but in terms of LUC suites they are included here.

and materials are 'vitric'. Taupo Tephra and associated Waimihia Lapilli deposits are referred to locally as 'Taupo Pumice' or simply 'Pumice'. As a rule, Kt should be >25 cm thick before recording as a rock type.

2. Mo — Weathered, mainly rhyolitic tephra. In the region, these comprise:

•Rotoma Tephra (8530±10 yr B.P.) — present to the north-west and south-west but is thin

•Waiohau Tephra (11 850±60 yr B.P.) — present to the north-west and south-west and often soil-forming where Taupo/Waimihia tephra have been removed. An important tephra in the region, yielding much of the allophanic soil material required to designate soils in the Allophanic order

•Okareka Tephra (*c.*18 000 yr B.P.) — restricted mainly to the north-west

•Kawakawa Tephra (Oruanui Ash) (22 590±230 yr B.P.) — restricted to the south

•Mangaone Tephra (27 730±350 yr B.P.) — a prominent coarse ash and lapilli sometimes seen, e.g., at 2–3 m depth in profiles of cut banks in the middle and south, and west

•Rotoehu Tephra (52 000±7000 yr B.P.) — over the whole region but rarely exposed.

The above 'Mo' tephra are often not individually recognisable, but Waiohau and Mangaone materials in particular can be distinct in parts of the region. As a rule, Mo materials should collectively exceed 35 cm thickness before recording as a rock type.

Soils

Recording soils in the inventory, and information sources

Soil information was obtained from existing soil surveys (Appendix 5) where possible, but these only cover a small part of the Gisborne – East Coast area in the detail required for NZLRI mapping at a scale of 1:50 000. Most of the more detailed soil surveys were of the Poverty Bay flats, Tolaga Bay flats, and Waiapu River valley flats, leaving the hill country and mountain land with scant soils information — available only from the '4-mile' North Island survey (New Zealand Soil Bureau 1954). One significant output from the second-edition GEC regional NZLRI is the improved soils information for hilly and steep areas, and this will encourage greater use of the soil factor in farm, forestry, and soil conservation planning. However, the published soil maps of the fertile plains should be used in preference to NZLRI soil data for detailed horticultural planning because of their larger scales and more detailed soil-mapping units.

Soil information was obtained in three phases :

1. A general reconnaissance of soils on the major rock types defined by O'Byrne (1967) to identify the different non-tephric parent materials.

2. This allowed the selection of areas where soils were studied in detail using a soil–landscape modelling approach (for example, McLeod *et al.* 1995). The purpose of these models was to allow rapid recognition and mapping of soil patterns.

3. Using map polygons established by the NZLRI mapping team on compilation sheets (1:50 000 scale), soils of each polygon were determined to soil subgroup level according to the 'New Zealand Soil Classification' (Hewitt 1998). This used information acquired in 1 and 2 above, knowledge acquired from a second field reconnaissance, and interpreting map polygon inventory data and provisional LUC assessments.

A list of subgroups of soils for each of the 104 LUC units are listed in Appendix 6. Soil subgroups are represented in map polygons by three-part symbols that represent Soil Order, Soil Group, and Soil Subgroup (Hewitt 1998). For example; the code LOT refers to the soil subgroup 'Typic Orthic Allophanic Soils' where the soil order is 'Allophanic', the soil group is 'Orthic Allophanic', and the soil subgroup is 'Typic Orthic Allophanic'.

Correlation with the 'New Zealand Genetic Soil Classification' (Taylor and Pohlen 1968) soil types, series and sets is not reliably implied, although relationships may be seen in general terms.

Most map polygons contain more than one soil subgroup. That is, they contain a dominant and subdominant soil. For example, on steep slopes ROW+BOT (dominant Weathered Orthic Recent soils plus sub-dominant Typic Orthic Brown soils) may occur, the latter on stable ridges and spurs. A third sub-dominant soil is used in some map polygons.

Soils in the LUC unit descriptions (later chapter) are listed under two major headings: *'N.Z. Soil Classification soil groups'* (Hewitt 1998) and *'N.Z.Genetic Soil Classification'* (Taylor and Pohlen 1968).

1. Soils under *'N.Z. Soil Classification soil groups'* in the LUC unit descriptions are typical, listed in assessed order of prevalence. They are listed under one or more of four broad slope groupings, namely, F: flat to undulating slopes (NZLRI slope classes A and B); R: rolling slopes (class C); H: strongly rolling to moderately steep slopes (classes D and E) as surrogate for hilly land; and S: steep to precipitous slopes (classes F, G and H) as surrogate for steep land. The character of each of the soil orders and groups recorded in the region are summarised in Appendix 7, along with a note on the occurrence of soil orders in the region. Regular reference to this is highly recommended for users to get maximum value from the soils information. Regular reference to Hewitt (1993, 1998) is also recommended to obtain better understanding of the soils mapped, in particular, to obtain a review of accessory properties associated with soil orders and groups. The ability to associate these properties with mapped soils represents a major improvement over previous regional NZLRI soil inventories.

2. Soils under *'N.Z. Genetic Soil Classification'* (Taylor and Pohlen 1968) are soil types, series, or sets by geographic name and symbol. They are from existing soil surveys (Appendix 5). Many soil names associated with published soil maps of the fertile plains are widely known by land users.

Summary of the distribution of soils

The gross soil pattern is related to combinations of rock type (O'Byrne 1967), tephra cover, and rainfall (McLeod *et al.* in press).

Pallic Soils occur in low rainfall areas near the coast where phosphate retention is less than 30%, and soils have strongly developed structure and pale subsoil colours. They grade into Brown Soils at annual rainfall above 1600 mm, with phosphate retention over 30%, browner colours in the subsoil and less well-developed soil structure. Brown Soils are the most commonly recorded soil order in the region. Rare Podzols occur as annual rainfall increases further (>2600 mm/yr) in elevated inland areas.

Pumice Soils occur on stable easier hill country, rolling land, and terraces towards the south and west, where Taupo/Waimihia tephra deposits are more than 25 cm thick, phosphate retention is less than 85% and rainfall is below 1600 mm/yr. These grade into Allophanic Soils as rainfall and P-retention increases towards the west, and finally into Podzols, where annual rainfall exceeds 1800–2000 mm (commonly >550 m a.s.l.). The detailed soil pattern in Pumice Soil country, as revealed in soil surveys of farm blocks (Shepherd *et al.* 1991, 1995, 1998), can yield surprising results such as finding poorly drained Perch-gley Pumice Soils on steep hill slopes.

Recent Soils occur on steep hill slopes where soil profiles are rejuvenated by down-slope movement of soil materials. These soils and associated Raw Soils are widely distributed in the steep and/or erosion-prone land.

Soils associated with wetness occur in small areas on valley floors, on foot slopes, and on the alluvial plains throughout the region. These are Gley Soils where they are saturated for the greater part of the year, or a mottled subgroup of Pallic or Brown Soils, where they are saturated for only part of the year. The alluvial plains contain Recent Soils and Gley Soils whose profile development varies with the

frequency of flooding, soil drainage, and parent material. The areas of loamy alluvial soils of the Poverty Bay flats and Tolaga Bay flats are derived mainly from weakly consolidated sedimentary rocks (Pullar 1962; Rijkse and Pullar 1978), while alluvium near Ruatoria has been mapped as having more strongly consolidated greywacke parent material (Rijkse 1980). Limited areas of coastal sands have been mapped by Gibbs (1954), Pullar (1962), Rijkse (1980), and Rijkse and Pullar (1978) near Tolaga Bay.

Slope

Slope angle was recorded using the seven standard NZLRI slope groups (Soil Conservation and Rivers Control Council 1971), plus an additional slope group — 'H', precipitous. This was added to the NZLRI slope classification to better distinguish cliffs, bluffs, escarpments or other precipitous slopes commonly found in mountain land. The slope classification is given in Appendix 8.

Slopes are measured in degrees and the most commonly occurring (modal) slopes are recorded in map polygons. A combination of slope groups is often recorded, reflecting a complex slope pattern in the hill country. Slopes are initially estimated using stereo-pairs of vertical aerial photographs (Appendix 2) during map compilation, then routinely checked in the field using a hand-held inclinometer. Representative landscapes in the Waipaoa catchment were further checked for slope using a 20-m Digital Terrain Model.

The hilly nature of the region is revealed simply by examining the database for dominant slope groups: while flat to undulating land accounts for 10% of the region, and rolling to strongly rolling slopes 18%; moderately steep or steep slopes cover 60% of the region, and very steep or precipitous slopes account for 12%.

Erosion

The method used for recording erosion types and present erosion severity broadly follows the standard NZLRI scheme in Eyles (1985) by using a six-part erosion severity ranking system, relying on observational evidence, and recognising the erosion types described by Eyles. Appendix 9 explains in detail the assessment guidelines used in the second-edition NZLRI of the region and the types of erosion recognised.

Present erosion assessments are made by interpreting stereo-pairs of vertical aerial photographs (Appendix 2), and observing erosion in the field. Reference is also made to existing spatial erosion information. Sources include the erosion inventories in Gisborne District Council farm plans, first-edition NZLRI worksheets (National Water and Soil Conservation Organisation 1975–1979), and the 'erosion associations' mapped at 1:250 000 scale in the 'Erosion map of New Zealand', Sheet 9, Gisborne (Page 1976). Improved understanding of erosion processes gained from ongoing erosion research in the region (Trustrum *et al.* in press) helped mappers make erosion assessments, and provided some supporting quantitative information. Selected assessment guidelines from Fletcher *et al.* (1994) were also adapted for use. They suggested giving more importance to the 'area affected by erosion' criterion for assessing mass-movement and fluvial types of erosion. Tables 2 to 5 in Appendix 9 provide separate 'area affected' guidelines used for the most important erosion types in the region: soil slip, riparian slip, gully, and earthflow. These were used to derive preliminary present-erosion severities, then finalised after considering other assessment criteria (such as those listed below each of Tables 2 to 5) — adjusting the assessments up or down as necessary, or confirming them. Tables 2 to 5 adapt similar tables in Fletcher *et al.* (1994) — by adding a very severe class (conforming to NZLRI standards of Eyles 1985) and changing percentage area guidelines to follow GEC field experience more closely.

Present erosion is different from potential erosion. The latter is assessed separately for each LUC unit (given in the LUC unit descriptions) and in many cases potential erosion helps to decide land-use capability. All of the assessment criteria for present erosion (listed in Appendix 9) are used to assess erosion potential, but additionally, consideration is given to predominant land uses and vegetation

covers, and the frequency of erosion-causing events — these additional factors are not considered when assessing present erosion. The effects of vegetation covers on erosion potential are marked (Hicks 1989a, 1989b, 1991), and there is need to assess potentials under different covers (as done in the later chapter describing LUC units). The presence of soil conservation trees in pasturelands, such as willows in gullies and space-planted poplars on hillsides, were a sure indication of gully and earthflow erosion potential (also a guide for assessing present severity). The 'storm proofing' capability of *Pinus radiata* was demonstrated in a study that measured the impact of Cyclone Bola (March 1988) under different-aged forests (Phillips *et al.* 1990), where land under mature forests was found to have $^1/_{10}$ th of the erosion sustained by land under pasture. Nevertheless, 'windows of vulnerability' occur from years 2 to 8 in replanted forests (Marden and Rowan 1993; Marden *et al.* 1995). Most protection is found under indigenous forest and exotic pine plantations >8 years old. In young plantations the canopy cover is negligible and the root development is insufficient to resist forces that contribute to soil slip, therefore giving little extra protection against slip-producing storms (Phillips *et al.* 1990; Watson *et al.* 1995).

Vegetation

Recording vegetation in the inventory, and information sources

In a significant departure from previous NZLRI practice, vegetation is recorded separately from other inventory factors, resulting in a stand-alone vegetation-cover map of the region and providing a marked increase in spatial detail.

Vegetative cover was mapped using a national classification adapted from that used in first-edition NZLRI mapping (Hunter and Blaschke 1986). This revised classification has been used in previous second-edition NZLRI mapping (in Northland, Wellington, and Marlborough regions), and contains 53 vegetation classes (Appendix 10), most of which are recorded in the GEC region. These classes are arranged into five major vegetation groups: grass, crops, scrub, forest, and herbaceous.

Vegetation is interpreted as either 'clumped' or 'scattered'. 'Clumped' refers to spatially continuous covers, and 'scattered' to discontinuous covers. Scattered vegetation is denoted by the use of an asterisk after the class symbol, e.g., gIsM*. A scattered vegetation class is taken to be scattered throughout the preceding non-scattered vegetation class. For example, gIsM* is improved pasture with scattered manuka or kanuka, and gIsM*sG* is improved pasture with scattered manuka or kanuka, and scattered gorse.

Where possible, a map polygon depicts a single vegetation class, at times representing areas as small as 6.25 ha ($^1/_{16}$ th of a grid square on an Infomap — scale 1:50 000). However, due to scale and the nature of vegetation distribution patterns, up to four vegetation classes are recorded in a map polygon. Where more than a single class is recorded, the area of the polygon occupied by each class is estimated to the nearest 10%. This approach enables actual areas of vegetation classes to be calculated (as done in Table 1). The area of scattered vegetation is included in the area of the vegetation through which it is scattered.

Information on vegetation cover was derived from field work, interpreting stereo-pairs of vertical aerial photographs (Appendix 2), and reference to published (and unpublished) maps and associated reports. Information on the indigenous forests of the northern Huiarau and Raukumara ranges was obtained from New Zealand Forest Service Mapping Series 6 at a scale of 1:250 000 (Sheets 6 and 7) (New Zealand Forest Service 1971, 1974), and in the Ruakituri, Hangaroa, and Waioeka river headwaters from Forest Service Mapping Series 5 at a scale of 1:63 360 (Sheets 87 and 96) (Nicholls 1966a, 1966b). Data on significant indigenous forest and scrub remnants beyond the main ranges were obtained from surveys of the Motu, Pukeamaru, Turanga, and Waiapu ecological districts for the Department of Conservation's Protected Natural Areas Programme (Clarkson *et al.* 1986; Regnier *et al.* 1988; Clarkson and Clarkson 1991; Leathwick *et al.* 1995). Areas of exotic forest up to and including the 1997/98 planting season were provided by GDC from unpublished Ministry of Forestry data.

Summary of the vegetation pattern

Table 1 summarises the extent of the major vegetation types in Gisborne District (8339 km^2) as mapped by October 1998.

Improved and semi-improved pasture are the most extensive covers. Together, they occupy 4089 km^2 (49% of the district), with improved pasture most common on the fertile alluvial flats, terraces, and easy hill country, and semi-improved pasture dominating the steeper and more erodible hill country. A number of weed and scrub species are commonly scattered through the semi-improved pasture. These include thistles, ragwort, rushes in poorly drained areas, tauhinu and other coastal scrub species, and fern species in upland areas. Gorse and blackberry are uncommon, although local infestations occur. However, the major invasive scrub species in pasture are kanuka and manuka, especially north of Te Puia Springs township. Mappable blocks of kanuka and manuka scrub account for 443 km^2 (5.3% of the district), with as much as one-third of it on productive class VI land, while a mixture of secondary indigenous scrub species cover 329 km^2 (3.9% of the district). Also mostly in northern areas, large blocks of kanuka have attained forest status (defined as having an average canopy height exceeding 6 m), covering 146 km^2 (1.8% of the district).

Primary indigenous forest (excluding kanuka forest) now only covers 1442 km^2, which is 17.3% of the district, and one-third of it is on land with no agricultural or production forestry potential (LUC class VIII land). Much of the balance occurs in hill country in fragmented remnants, often less than 25 ha in area. Exotic conifer forest, overwhelmingly *Pinus radiata*, now occupies 1366 km^2, or 16.4% of the district. While nearly 30% of the exotic conifer forest occurs on LUC class VI land, the balance is on class VII land, mostly with severe to very severe erosion potential. Soil conservation trees (poplars and willows) are very commonly scattered through pasture on VIIe land, or less commonly as small blocks (the latter covering just 33 km^2, or 0.4% of the district).

A wide range of crops are grown on the Poverty Bay flats, and to a lesser extent on the Uawa flats at Tolaga Bay, and the Waiapu flats near Ruatoria, covering 138 km^2 (1.6% of the district). They include maize, grapes, vegetables, tomatoes, squash, citrus, pip and stone fruit, kiwifruit, and berry fruit. Maize and root and green fodder crops are sometimes grown on alluvial flats in narrow valleys.

Table 1: Coverage of key vegetation types in the Gisborne District – as at October 1998 (when field mapping was completed)

Vegetation	Area (km^2)	Percent of Gisborne District[1]
Improved & semi-improved pasture, with, or without scattered other vegetation (codes selected: gI, gS, gISm*, etc.). Indicates the area of pastoral farming land	4089	49.0 40.7% on LUC class VI land, 42.1% on class VII land, and 17.2% on other classes of land
Crops (codes selected: cM, cP, cG, cK, cS, cR, cV)	138	1.6
Mixed indigenous scrub (codes selected: sX, sT). Indicates the area of secondary scrub, excluding manuka or kanuka scrub	329	3.9 21.3% on LUC class VI land, 58.9% on class VII land, and 19.8% on other classes of land
Kanuka and manuka scrub (code selected: sM)	443	5.3 32.8% on LUC class VI land, 58.0% on class VII land, 9.2% on other classes of land
Kanuka forest (code selected: fN). Canopy height exceeds 6 m	146	1.8 30.0% on LUC class VI land, 60.9% on class VII land, 9.1% on other classes of land
Primary indigenous forest (codes selected: fC, fP, fO, fI, fD, fW, fG). Excludes kanuka forest	1442	17.3 22.4% on LUC class VI land, 40.5% on class VII land, 32.7% on class VIII land, 4.4% on other classes of land
Exotic conifer forest (codes selected: fF, efF)	1366	16.4 29.7% on LUC class VI land, 70.3% on class VII land

[1] Listed classes account for 91.4% of the district. The balance (8.6%) represents the area of bare ground, such as gravelly river beds, very severely eroded areas, bare mountain slopes, and unmapped areas such as townships, quarries, lakes and rivers.

Recognising LUC units

Physical factors influencing the structure of the LUC classification

Rock type, erosion, and LUC

The geology of the Gisborne – East Coast region is the starting point for recognising LUC suites, and thereby controls the structure of the classification. A strong relationship between rock type, erosion, and LUC has long been recognised in the region: intially during the first regional LUC survey (Harris *et al.* 1964, Harris and McKee 1964), with rock type-erosion relationships further documented in O'Byrne (1967), and then consolidated in the first-edition NZLRI of the region (Driver 1974), where hill country LUC units were mostly defined by rock type and erosion. The second-edition regional LUC classification follows the previous classifications by being structured on different broad rock type groups that have similar associations of erosion types. These relationships are summarised in Table 2.

Table 2: *Relationships between erosion, rock type, and LUC*

Geology[2] and rock type		**Association of erosion types**	**LUC suite and subsuite (ID number and name)[1]**
Motu Block	Greywacke, argillite, indurated sandstone	*Debris avalanche*[3], riparian slip, and minor other associated types (e.g., slumps) of steep hill country and mountain land (forested). *Soil slip* (pasture). Some severely eroded land (with elements of gully, sheet, soil slip, slump, etc.) in the Raukumara foothills on so called 'erodible greywacke' (O'Byrne 1967)	10 (Greywacke and argillite)
East Coast Allochthon	Crushed argillite, crushed greywacke, and sheared mixed lithologies, bentonite	*Gully and earthflow*, riparian slip, slump, soil slip (forested or pasture). The severe erosion that the pioneering soil conservationist D.A. Campbell used in his 1946 paper 'Down to the sea in slips' to highlight East Coast erosion problems were from these rock materials	11 (Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite)
	Ancient volcanics (Matakaoa)	*Debris avalanche*, riparian slip, slump, (forested), *soil slip*, riparian slip, slump, sheet (pasture)	9 (Basalt)
Neogene cover	Sandstones (massive, bedded)	*Soil slip*, sheet (pasture)	7 (Neogene sandstone)
	Mudstones (massive, bedded)	*Debris avalanche*, riparian slip, minor slump and gully (forested), *soil slip*, gully, riparian slip, slump, sheet (pasture)	6 (Neogene mudstone) — 6b (Massive mudstone), 6c (Bedded mudstone)
	Frittered mudstone, unconsolidated clays and silts	*Soil slip, earthflow, gully* (pasture)	6 (Neogene mudstone) — 6a (Frittered mudstone), 6d (Weber marl), 6e (Lacustrine muds)

Table 2 (cont'd)

Geology[2] and rock type		Association of erosion types	LUC suite and subsuite (ID number and name)[1]
Holocene and early Pleistocene tephra cover	Taupo/ Waimahia tephra	*Soil slip, sheet*, tunnel gully, gully, pasture. Usually geologically stable, with erosion concentrated in tephra covers	3 (Taupo/Waimihia tephra)
	Weathered tephra	*Soil slip*, slump, pasture. Geologically stable, with erosion concentrated in tephra covers	4 (Weathered tephra)
Alluvium on plains, terraces, and river flats	Fine alluvium, alluvial gravels	*Streambank, deposition*. Wind erosion when cultivated	1 (Broad flood plain), 2 (River valley)
Holocene coastal sands	Wind-blown sand	*Wind*	5 (Coastal sand and coastal cliffs)

[1] Refer to the decision pathways for detail about LUC suites and subsuites, and to the relationship diagrams for component LUC units and the entire structure of the classification

[2] Geology is reviewed in 'physical factors...rock type'

[3] Italicised erosion types are the principal types as related to land cover. Those not italicised are the main associated erosion types.

Recognising upland and lowland areas as surrogates for climatic differences

Appreciating that annual rainfall is mainly orographically controlled (Hessell 1980), and other climate factors such as growing degree days, mean annual temperature, frost days, etc., respond to differences in elevation, the LUC classification recognises 'upland' and 'lowland' areas. Somewhat pragmatically, 'upland' is defined as land above 550 m a.s.l. and 'lowland' is below this altitude. Above 550 m a.s.l. annual rainfall is greater than 1500 mm (mostly greater than 1800 mm). When annual rainfall is greater than about 1800 mm, soils in the region reveal the onset of strong leaching and Podzols or Podzolic soil subgroups are expected for upland units. Figure 4 (in the previous chapter) reproduces the 500 m a.s.l. contour as an approximate guide to the position of upland and lowland areas, and annual rainfall zones are shown as calculated by the topoclimatic model of Giltrap (1993).

The upland/lowland division is explicit for the tephra LUC suites 3 and 4, where the units are organised into upland and lowland LUC subsuites. While other LUC units may not occur entirely in either the upland or lowland, they occur naturally in one of these zones:

- LUC units of suite 1 (Broad flood plain) — entirely in the lowland
- LUC units of suite 2 (River valley) — mostly in the lowland
- LUC units of suite 5 (Coastal sand and coastal cliffs) — entirely in the lowland
- LUC units of suite 6 (Neogene and Quaternary mudstone) — mostly in the lowland
- LUC units of suite 7 (Neogene sandstone) — mostly in the lowland except for LUC units of subsuite 7b (mapped in the upland Wharerata hills)

- LUC units of suite 8 (Limestone) — mostly in the upland
- LUC units of suite 9 (Basalt) — entirely in the lowland
- LUC units of suite 10 (Greywacke and argillite) — mostly in the upland
- LUC units of suite 11 (Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite) — mostly in the upland, although lowland representatives are mapped. Recognition of intrinsically unstable rock types here outweighs general climatic considerations.

LUC unit recognition options

Four options for recognising LUC units are given:

1. Decision pathways. These guide users step-by-step through questions and answers until the correct LUC unit is derived.
2. Relationship diagrams. These enable users to rapidly visualise links between LUC units, and see the entire structure of the classification.
3. Correlation of second-edition LUC units with first-edition LUC units. This will help users to make the transition from the first-edition LUC classification to the second-edition classification.
4. Direct use of the LUC unit descriptions (next chapter).

LUC suites

Traditional numerical ranking of LUC units based on decreasing versatility and capability gives no direct indication of relationships between the units in their landscape setting. To enable these relationships to be better understood and to help interpret LUC maps, related LUC units are arranged into groups, called LUC suites. A LUC suite is defined as, 'LUC units which, although differing in capability, share a definitive physical characteristic which unites them in the landscape'. These characteristics may vary from suite to suite.

The use of suites as a tool in landscape interpretation is discussed in Blaschke (1985a).

One hundred and four LUC units have been arranged into 11 LUC suites based on rock type and landform. Five of the suites have been further divided into LUC subsuites on the basis of other factors such as climate, landform, or rock-type refinements. Some units occur in more than one suite, mostly due to the influence of the base rock being modified by significant tephra cover. For example, VIe20 is always part of both LUC suite 3 (Taupo/Waimihia tephra) and LUC suite 11 (crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite). While other LUC units are always part of a particular suite, they can also occur in another suite if certain conditions are met. For example, VIe2 is always part of LUC suite 6 (Neogene and Quaternary mudstone), and is sometimes part of LUC suites 3 or 4 (depending on the type of tephra) if tephra coverage exceeds 40% of the area. This is why some LUC units appear more than once in the decision pathways and relationship diagrams.

Decision pathway to recognise LUC suites and subsuites

When using the decision pathways to identify the LUC unit (next section), first choose the LUC suite by following the set of questions below. Read the questions until a 'yes' (Y) is obtained. Respond to a 'no' answer by moving to the next question.

1. Is the land on the Poverty Bay flats and associated major wide valleys leading toward the flats, Tolaga Bay flats, or Waiapu River valley flats (on the latter only with Puhunga silt loam, Mangoreia silt loam, or Waiohata silt loam soils), are all soils developed from alluvium, and is the land (as a general observation rather than a rule) limited more by soil drainage than by frequent flooding and sediment deposition? Y ⇨ **LUC suite 1 (broad flood plain)**

2. Is the land in a river valley cut through hill country anywhere in the region, including most of the Waiapu River valley flats or other eastern valley/plains systems, but not on the Tolaga Bay flats or Poverty Bay flats, and is the land on a lower or intermediate terrace or fan, in a river channel or swamp, and is it (as a general observation rather than a rule) limited more by frequent flooding and sediment deposition than by poor soil drainage?
   Y ⇨ **LUC suite 2 (river valley)**

   a) Is the land on an intermediate or high terrace and not significantly gravelly in A and B horizons of soils? Y ⇨ **LUC subsuite 2a (intermediate and high terraces)**

   b) Is the land in a swamp, on a fan or lower terrace, and not significantly gravelly in A and B horizons of soils, and are soils derived mainly from fine-grained alluvium?
   Y ⇨ **LUC subsuite 2b (river flats, swamps, fans, and lower terraces)**

   c) Is the land anywhere in a river valley with gravelly A and B horizons of soils?
   Y ⇨ **LUC subsuite 2c (river flats, terraces, and fans)**

3. Is the land, whatever the underlying rock type, covered by sandy pumiceous soil material derived from either, or usually both, Taupo Tephra or Waimihia Lapilli, and is the thickness of this material > 25 cm, and does tephra cover at least 40% of the area?
   Y ⇨ **LUC suite 3 (Taupo/Waimihia tephra)**

   a) Is the land below 550 m a.s.l.? Y ⇨ **LUC subsuite 3a (lowland Taupo/Waimihia tephra)**

   b) Is the land above 550 m a.s.l.? Y ⇨ **LUC subsuite 3b (upland Taupo/Waimihia tephra)**

4. Is the land, whatever the underlying rock type, covered by silty/clayey weathered tephra (older than Taupo Tephra or Waimihia Lapilli), and is the thickness of this material >35 cm, and does the tephra cover at least 40% of the area? Y ⇨ **LUC suite 4 (weathered tephra)**

   a) Is the land on a marine bench adjacent to the coast?
   Y ⇨ **LUC subsuite 4a (coastal weathered tephra)**

   b) Is the land below 550 m a.s.l.? Y ⇨ **LUC subsuite 4b (lowland weathered tephra)**

   c) Is the land above 550 m a.s.l.? Y ⇨ **LUC subsuite 4c (upland weathered tephra)**

5. Is the land adjacent to the coast on sand dunes and sand plains, or is it a coastal cliff?
Y ⇨ **LUC suite 5 (coastal sand and coastal cliffs)**

6. Is the rock type mainly mudstone? Mainly Neogene (Pliocene–Miocene) or Quaternary fine-grained rocks (that may be locally described as 'papa') and are rock-mass strengths usually 'weak to extremely weak'? Y ⇨ **LUC suite 6 (Neogene and Quaternary mudstone)**

   a) Is the mudstone frittered (closely or loosely jointed) and are slopes prone to associations of soil slip, earthflow, and gully erosion? Y ⇨ **LUC subsuite 6a (frittered mudstone)**

   b) Is the mudstone massive (massive to only weakly bedded)?
   Y ⇨ **LUC subsuite 6b (massive mudstone)**

   c) Is the mudstone bedded (from strongly bedded to conspicuously alternating)?
   Y ⇨ **LUC subsuite 6c (bedded mudstone)**

   d) Is the mudstone Weber marl (Weber Formation — calcareous mudstone and muddy limestone, sometimes sheared and bentonitic, within the Mangatu Group), and are slopes prone to earthflow erosion? Y ⇨ **LUC subsuite 6d (Weber marl)**. Note: rocks are older than Neogene (being Paleocene in age), making this subsuite an exception to the Neogene rule

   e) Are lacustrine muds and minor fluviatile gravels present (in low hills around the Poverty Bay flats)? Y ⇨ **LUC subsuite 6e (lacustrine muds)**

7. Is the rock type mainly sandstone? Neogene (Pliocene–Miocene) weak to very strong coarse-grained rock material. Y ⇨ **LUC suite 7 (Neogene sandstone)**

   a) Is the rock type either massive or bedded sandstone in the Ngatapa–Rere lower rainfall area, in hill country just west of the Poverty Bay flats? Y ⇨ **LUC subsuite 7a (massive to bedded sandstone in the Ngatapa–Rere lower rainfall area)**

   b) Is the rock type bedded sandstone (from strongly bedded to conspicuously alternating) and in the Wharerata hills? Y ⇨ **LUC subsuite 7b (bedded sandstone of the Wharerata hills)**

   c) Is the land in the Whangaparaoa area and are rock types from the Te Kahika Formation?
   Y ⇨ **LUC subsuite 7c (Te Kahika Formation of the Whangaparaoa area)**

   d) Is the rock type muddy sandstone in the East Cape area, north of the Waiapu River valley?
   Y ⇨ **LUC subsuite 7d (muddy sandstone of East Cape)**

   e) Is the rock type massive sandstone (massive to weakly bedded, and sometimes extremely thickly bedded with beds more than several metres thick) or bedded sandstone (from strongly bedded to conspicuously alternating)?
   Y ⇨ **LUC subsuite 7e (massive and bedded sandstone)**

8. Is the rock type limestone and are slopes steep to precipitous? Y ⇨ **LUC suite 8 (limestone)**

9. Are rock types 'ancient volcanics' — Matakaoa Volcanics (basaltic lavas, etc.) between Cape Runaway and Hicks Bay? Y ⇨ **LUC suite 9 (basalt)**

10. Is the rock type greywacke or argillite (from the Cretaceous and Paleogene Periods)? These are indurated and generally strong rock masses, mainly in the Raukumara Range and northern Huiarau Range, giving rise to steep hill country and mountain land.
Y ⇨ **LUC suite 10 (greywacke and argillite)**

11. Are the rock types crushed argillite, crushed greywacke, sheared mixed lithologies, or bentonite (from the Paleogene and Cretaceous Periods)? These are mainly indurated rocks, but now substantially weakened by crushing and shearing, giving rise to hill country with gully and earthflow as dominant erosion types. Y ⇨ **LUC suite 11 (crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite)**

Decision pathways to recognise LUC units

To help recognise LUC units, key LUC unit attributes are isolated in decision pathways. Use of the pathways is made easier because of the LUC suite framework.

Decision pathways will be most useful when new and more detailed special-purpose land resource surveys are carried out in the region. Mappers can use the logical sequence of questions as a prompt for the important questions for which they need answers to arrive at the correct LUC assessment. The decision pathways also provide a starting point for those unfamiliar with the land resources of the Gisborne – East Coast region, unfamiliar with the region's LUC classification, or with LUC principles.

Step 1:Identify the LUC suite using the previous decision pathway (used to identify LUC suites and subsuites), then go to the pathway that represents LUC units of the chosen suite.

Step 2:Use the pathways to identify LUC units. Answer 'yes' (Y) or 'no' (N) to the questions. A 'Y' may either lead to the correct LUC unit, or give an instruction to go to another numbered question. A 'N' is usually followed by an instruction to go to another question. If the chosen pathway does not lead to a satisfactory solution, it could mean that the land is not catered for, or that the wrong suite of LUC units has been entered (these two possibilities are indicated where appropriate). Where a 'N' answer is not possible (indicated by a blank in the space normally used for 'N' answers), the series of questions has reached a logical conclusion. If in doubt, refer to the detailed LUC unit descriptions (next chapter) to discover if the provisionally selected LUC unit really does cater for the known attributes of the land.

When conducting LUC surveys, the use of published soil maps (Appendix 5) and geological information (Appendix 3) is taken as standard practice. Consequently, some questions in the pathways refer to named soils or rock formations.

LUC units of suite 1 (broad flood plain)

1. Is the land on flat to gently undulating (0–3°) surfaces on higher parts of the Poverty Bay flats, near the margins of present flooding extents, and are soils moderately well drained or imperfectly drained and named either Matawhero or Waihirere in Pullar (1962)?
Y **LUC unit Iw1** N ⇨ 2

2. Is the land on flat to gently undulating (0–3°) terraces on higher parts of the Poverty Bay flats, away from the margins of present flooding extents, and are soils well drained and named either Matawhero or Waihirere in Pullar (1962)?
Y **LUC unit Ic1** N ⇨ 3

3. Is the land on either flat to gently undulating (0–3°) terraces or on low-angle fans on the Poverty Bay or Tolaga Bay flats, or in the Waiapu River valley, within the margins of present flooding extents, and are soils imperfectly to poorly drained and named either Matawhero or Waihirere in Pullar (1962), Puhunga or Mangoreia in Rijkse (1980), or Matawhero or Makauri in Rijkse and Pullar (1978)?
   Y **LUC unit IIw2** N ⇨ 4

4. Is the land adjacent to the lowest terrace associated with the Waipaoa River course, and are soils named Waipaoa in Pullar (1962)?
   Y ⇨ 5 N ⇨ 7

5. Is the land between modern stopbanks (unprotected) of the Waipaoa River Control Scheme?
   Y **LUC unit IIIw5** N ⇨ 6

6. Is the land protected by modern stopbanks of the Waipaoa River Control Scheme?
   Y **LUC unit IIIw4** N ⇨ 7

7. Is the land on flat to gently undulating (0–3°) terraces or low-angle fans on the Poverty Bay or Tolaga Bay flats, or in the Waiapu River valley, within the margins of present flooding extents, and are soils poorly or very poorly drained and named Makaraka, Makauri, or Kaiti in Pullar (1962), Makauri or Kaiti in Rijkse and Pullar (1978), or Waihoata in Rijkse (1980)?
   Y **LUC unit IIIw1** N ⇨ 8

8. Is the land saline and on very poorly drained tidal flats?
   Y **LUC unit VIs1** N ⇨ 9

9. Does the land occupy localised very poorly drained depressions with limited drainage outfall?
   Y **LUC unit IVw2** N ⇨ try LUC suite 2, or the land may not be catered for

LUC units of suite 2 (river valley)

1. Is the land on either lower or intermediate terraces, with well drained soils having gravelly A, or A and B horizons over gravels?
   Y ⇨2 N ⇨ 8

2. Do soils contain no more than 5–15% gravels to a depth of 45 cm from the soil surface?
   Y **LUC unit IIs2** N ⇨ 3

3. Do soils contain no more than 5–15% gravels to a depth of 30–45 cm from the soil surface?
   Y **LUC unit IIIs1** N ⇨ 4

4. Do soils contain no more than 5–15% gravels to a depth of 15–30 cm from the soil surface?
   Y **LUC unit IVs1** N ⇨ 5

5. Do soils contain no more than 5–15% gravels to a depth of <15 cm from the soil surface?
   Y **LUC unit VIs2** N ⇨ 6

6. Is gravel at the surface, are boulders embedded into/or strewn across the soil surface, and is the land on low river terraces or fans that are subject to very severe streambank erosion or flood-deposition?
Y **LUC unit VIIe26** N ⇨ 7

7. Is the land in an active river bed?
Y **LUC unit VIIIs2** N ⇨ the land may not be catered for

8. Is the land on lower terraces, with a predominance of soils from fine-grained alluvium (particles 2 mm diameter), and subject to various degrees of wetness and/or flooding?
Y ⇨ 9 N ⇨ 16

9. Is the land >550 m a.s.l. in river valleys in the Matawai–Motu area, are soil parent materials mostly tephric alluvium, being mainly well–to moderately well-drained, with minor poorly drained infilled channels?
Y **LUC unit IIIc2** N ⇨ 10

10. Are soils moderately well- or better drained, and is inundation by flood water expected to last 0.5–1.0 day and occur no more than once in 2 years, or last lesser durations no more than once in 1 year?
Y **LUC unit IIw1** N ⇨ 11

11. Is inundation by flood water expected to last 1–2 days and occur no more than once in 1 year, or last 2–3 days and occur no more than once in 2 years, killing flood-sensitive field crops, reducing yields of other field crops, reducing yields of common improved pasture grasses and annual legumes, but have little lasting effect on permanent horticultural crops?
Y **LUC unit IIIw3** N ⇨ 12

12. Is the land on a swamp margin with poorly drained, often peaty soils, and is the land considered only marginally arable due to drainage conditions?
Y **LUC unit IVw2** N ⇨ 13

13. Is inundation by flood water expected to last 2–3 days and occur no more than twice in 1 year, or last 3–5 days and occur no more than once in 1 year, rendering all field cropping marginal due to the onset of mortality in most crops, causing significant productivity losses in common improved pasture grass and annual legume pastures, and reducing yields of permanent horticultural crops?
Y **LUC unit IVw1** N ⇨ 14

14. Is inundation by flood or ponded water expected to last 5–15 days and occur no more than once in 1 year, or last 2–5 days no more than twice in 1 year, and /or is the watertable <45 cm from the soil surface for the greater part of a year, so that flooding and/or very poor drainage precludes arable use, but retains at least moderate livestock grazing potential?
Y **LUC unit VIw1** N ⇨ 15

15. Is the land in a swamp with 50% of its area covered by free-standing water for the greater part of a year?
Y **LUC unit VIIw1** N ⇨ 16

16. Is the land >550 m a.s.l. on elevated river valley terraces and covered by Taupo/Waimihia tephra on weathered tephra over gravels?
Y **LUC unit IIIc1** N ⇨ 17

17. Is land on an intermediate terrace in the Waiapu River valley?
Y ⇨18 N ⇨ 20

18. Have soils been given the name Hikuwai or Hoata in Rijkse (1980)?
Y **LUC unit IIs1** N ⇨19

19. Have soils been given the name Papawera in Rijkse (1980)?
Y **LUC unit IIIw2**

20. Is the land on an intermediate terrace or associated fan, in river valleys east of the Poverty Bay flats, and are soils mainly moderately well drained or better, and are soil parent materials various mixtures of sediments from surrounding hill country, loess, or reworked tephra?
Y **LUC unit IIs1** N ⇨ 21

21. Is the land on an intermediate terrace or associated fan, in river valleys east of the Poverty Bay flats, and are soils mainly poorly drained, and are soil parent materials various mixtures of sediments from surrounding hill country, loess, or reworked tephra?
Y **LUC unit IIIw2** N ⇨ 22

22. Are slopes very steep to precipitous (>36°) with potential for very severe erosion, and occur on riverside cliffs in terrace land, where stability is compromised by river undercutting?
Y **LUC unit VIIIe3** N ⇨ 23

23. Is the landform a terrace riser of an intermediate or higher terrace?
Y **LUC suite 7**, step 19 N ⇨the land may not be catered for

LUC units of suite 3 (Taupo/Waimihia tephra)

1. Does the land occupy an old slump that is presently inactive, but with potential for re-activation following a major triggering event, and are slopes mainly strongly rolling to moderately steep (16–25°)?
Y ⇨ **LUC unit VIe6** N ⇨ 2

2. Is the land on Weber marl, are slopes rolling to undulating (4–15°), and is present earthflow erosion under pasture negligible or slight, with limited potential for more serious earthflow?
Y **LUC unit IVe2** N ⇨ 3

3. Is the tephra on bedded mudstone?
Y ⇨ 4 N ⇨ 6

4. Are slopes mainly strongly rolling to moderately steep (16–25°), with occasional rolling (8–15°) or steep (25–35°) slopes, and inclined in the direction of the dip of bedded mudstone, shallowly dissected by gullies, with potential for severe earthflow, moderate riparian slip, and shallow gully?
Y **LUC unit VIIe7** N ⇨ 5

5. Are slopes mainly moderately steep to steep (21–35°), with occasional strongly rolling (16–20°) slopes, and is there potential for moderate soil slip?
Y **LUC unit VIe12**

6. Is the rock type frittered or massive mudstone, are slopes mainly strongly rolling to moderately steep (16–25°), with most slopes strongly rolling (16–20°), and is there potential for moderate earthflow?
   Y **LUC unit VIe2** N ⇨ 7

7. Is the land in the Ngatapa–Rere lower rainfall area (hill country just west of the Poverty Bay flats)?
   Y ⇨ 11 N ⇨ 8

8. Is the rock type massive or bedded sandstone, are slopes moderately steep to steep (21–35°), with steep slopes (26–35°) short?
   Y **LUC unit VIe11** N ⇨ 9

9. Is the land <550 m a.s.l?
   Y ⇨ 11 N ⇨ 10

10. Is the land >550 m a.s.l.?
    Y ⇨ 17

11. Are slopes mainly flat to gently undulating (0–3°) on coastal beach ridges and sand plains?
    Y **LUC unit IIIs3** N ⇨ 12

12. Are slopes mainly undulating to flat (0–7°), with undulating slopes (4–7°) short?
    Y **LUC unit IIIs2** N ⇨ 13

13. Are slopes mainly rolling to undulating (4–15°), with undulating slopes (4–7°) long, and most rolling slopes in the easier part of this slope class (<12°)?
    Y **LUC unit IIIe4** N ⇨ 14

14. Are slopes rolling to strongly rolling (8–20°), with most slopes rolling (8–15°) in the steeper part of this slope class (>12°), and with strongly rolling (16–20°) slopes short?
    Y **LUC unit IVe4** N ⇨ 15

15. Are slopes strongly rolling to moderately steep (16–25°), with most slopes strongly rolling (16–20°)?
    Y **LUC unit VIe7** N ⇨ 16

16. Are slopes mainly moderately steep to steep (21–35°), with most slopes moderately steep (21–25°)?
    Y **LUC unit VIe14** N ⇨ the land may not be catered for. Try a LUC suite defined by the underlying rock

17. Are slopes strongly rolling to moderately steep (16–25°) and does the tephra cover Neogene sandstones or mudstones?
    Y **LUC unit VIe19** N ⇨ 18

18. Are slopes mainly steep to moderately steep (21–35°), with most slopes steep (26–35°), is the land in the western part of the region in an elevation range of 550–1200 m a.s.l., and does tephra cover Neogene sandstones or mudstones?
    Y **LUC unit VIIe20** N ⇨ 19

19. Is the land in the elevation range 550–750 m a.s.l.?
Y ⇨ 20 N ⇨ 22

20. Are slopes mainly flat to undulating (0–7°), with undulating slopes (4–7°) short?
Y **LUC unit IIIc1** N ⇨ 21

21. Are slopes mainly undulating to rolling (4–15°),with undulating slopes (4–7°) long, and rolling slopes mostly in the easier part of this slope class (<12°)?
Y **LUC unit IIIe5**

22. Is the land in the elevation range 550–1100 m a.s.l., with most slopes rolling to strongly rolling (8–20°), and including long undulating slopes (4–7°) above 750 m a.s.l.?
Y **LUC unit IVe5** N ⇨ 23

23. Is the land in the elevation range 750–1100 m a.s.l. in the northern Huiarau Range area, and are slopes flat (0–3°), flat to undulating (0–7°), or rolling (8–15°), with most rolling slopes <12°?
Y **LUC unit IVc1** N ⇨ 24

24. Is the land in the Wharekopae area, on argillite and crushed argillite, with long, sloping, broad interfluves that are shallowly dissected by gullies, with potential for moderate riparian slip but with a lower potential for gully and earthflow, and are slopes mainly strongly rolling to moderately steep (16–25°)?
Y **LUC unit VIe20** N ⇨ 25

25. Is the land on greywacke or argillite, are slopes mainly moderately steep to steep (21–35°), with most slopes moderately steep (21–25°), with occasional strongly rolling slopes (16–20°)?
Y **LUC unit VIe23** N ⇨ 26

26. Is the land mainly on crushed argillite with potential for moderate gully, earthflow, soil slip, and riparian slip, and are slopes mainly strongly rolling to moderately steep (16–25°)?
Y **LUC unit VIe21** N ⇨ the land may not be catered for, or*

*(Recheck the validity of your original decision that Taupo/Waimihia tephra is sufficiently thick (>25 cm) or well-represented for the land to be considered part of this suite. If, on reconsideration, there is not enough Taupo/Waimihia tephra, the land should be classified in LUC suite 4 if weathered tephra dominates, or another suite as defined by rock type if weathered tephra is not sufficiently represented)

LUC units of suite 4 (weathered tephra)

1. Is the land <550 m a.s.l.?
Y ⇨ 3 N ⇨ 2

2. Is the land >550 m a.s.l.?
Y ⇨ 16

3. Is the land adjacent to the coast and on flat to rolling marine benches?
Y ⇨ 4 N ⇨ 7

4. Is the land on undulating to strongly rolling (4–20°) marine benches and terraces with abundant coarse gravelly and bouldery deposits incorporated into the soils?
   Y **LUC unit IVs3** N ⇨ 5

5. Are slopes flat to undulating (0–7°), with most slopes flat to gently undulating (0–3°)?
   Y **LUC unit IIe1** N ⇨ 6

6. Are slopes rolling to undulating (4–15°), with most slopes rolling (8–15°)?
   Y **LUC unit IIIe2**

7. Does the land occupy an old slump that is presently inactive, but with potential for re-activation following a major triggering event, and are slopes mainly strongly rolling to moderately steep (16–25°)?
   Y **LUC unit VIe6** N ⇨ 8

8. Is the rock type frittered or massive mudstone, are slopes mainly strongly rolling to moderately steep (16–25°), with most slopes strongly rolling (16–20°), and is there potential for moderate earthflow under pasture?
   Y **LUC unit VIe2** N ⇨ 9

9. Are rock types mainly crushed argillite or sheared mixed lithologies, are slopes strongly rolling to rolling (8–20°), with most slopes strongly rolling (16–20°), and is there potential for moderate earthflow and slight gully under pasture?
   Y **LUC unit VIe4** N ⇨ 10

10. Are slopes flat to undulating (0–7°), with undulating slopes (4–7°) short?
    Y **LUC unit IIs3** N ⇨ 11

11. Are slopes rolling to undulating (4–15°), with most slopes rolling (8–15°)?
    Y **LUC unit IIIe1** N ⇨ 12

12. Are slopes rolling to strongly rolling (8–20°), with strongly rolling slopes (16–20°) short?
    Y **LUC unit IVe1** N ⇨ 13

13. Are slopes strongly rolling to moderately steep (16–25°), with moderately steep slopes (21–25°) short, are rock types Neogene sandstones or mudstones, or Quaternary deposits, and is there potential for moderate soil slip?
    Y **LUC unit VIe1** N ⇨ 14

14. Are slopes moderately steep to steep (21–35°), are rock types Neogene sandstones or mudstones, or Quaternary deposits, and is there potential for moderate soil slip?
    Y **LUC unit VIe3** N ⇨ 15

15. Is the land in ancient basaltic hill country between Cape Runaway and Hicks Bay, and are slopes mainly moderately steep to steep (21–35°), with steep slopes (26–35°) short?
    Y **LUC unit VIe15**

16. Are slopes flat to rolling (0–15°), with most slopes undulating to rolling (4–15°)?
    Y **LUC unit IIIe3** N ⇨ 17

17. Are slopes rolling to strongly rolling (8–20°) at elevations between 550 and 1100 m a.s.l., and rolling to undulating (4–15°) at elevations between 750 and 1100 m a.s.l. (i.e., undulating slopes above 750 m a.s.l. are included)?

Y **LUC unit IVe3** N ⇨ 18

18. Are slopes mainly moderately steep to steep (21–35°), are rock types Neogene sandstones or mudstones, and with potential for moderate soil slip and riparian slip?

Y **LUC unit VIe8** N ⇨ 19

19. Is the land on greywacke or argillite with potential for moderate gully, riparian slip, and soil slip, and are slopes mainly moderately steep to steep (21–35°), with most slopes moderately steep (21–25°), sometimes with minor strongly rolling (16–20°) slopes?

Y **LUC unit VIe23** N ⇨ 20

20. Is the land mainly on crushed argillite with potential for moderate gully, earthflow, riparian slip and soil slip, and are slopes mainly strongly rolling to moderately steep (16–25°)?

Y **LUC unit VIe21** N ⇨ the land may not be catered for, or*

*(Recheck the validity of your original decision that Taupo/Waimihia tephra is absent, too thin (<25 cm) or poorly represented for the land to be considered part of LUC suite 3. If, on reconsideration, there is enough Taupo/Waimihia tephra, the land should be in LUC suite 3. Alternatively, try another LUC suite defined by the underlying rock type if tephra are not sufficiently represented).

LUC units of suite 5 (coastal sand and coastal cliffs)

1. Are slopes flat to gently undulating (0–3°) on coastal beach ridges and sand plains with a cover of Taupo/Waimihia tephra up to 30 cm thick?

Y **LUC unit IIIs3** N ⇨ 2

2. Are slopes mainly flat to undulating (0–7°) on stable older sand dunes and plains inland from the coastline?

Y **LUC unit IVs2** N ⇨ 3

3. Are slopes mainly undulating (4–7°) on stable sand flats and dunes inland from foredunes, with very weakly developed sandy soils and potential for slight wind erosion?

Y **LUC unit VIs3** N ⇨ 4

4. Is the land on undulating to rolling (4–15°) consolidated (older) sand dunes with potential for moderate wind erosion?

Y **LUC unit VIe25** N ⇨ 5

5. Is the land on unstable sand dunes immediately inland from the foredune, with potential for very severe wind erosion?

Y **LUC unit VIIe27** N ⇨ 6

6. Is the land a foredune?

Y **LUC unit VIIIe1** N ⇨ 7

7. Is the land on precipitous or very steep (>36°) coastal cliffs influenced by coastal erosion processes, and exposing any rock type?
   Y **LUC unit VIIIe2** N ⇨ the land may not be catered for

LUC units of suite 6 (Neogene and Quaternary mudstone)

1. Does the land occupy an old slump that is presently inactive, but with potential for re-activation following a major triggering event, and are slopes mainly strongly rolling to moderately steep (16–25°)?
   Y **LUC unit VIe6** N ⇨ 2

2. Are the mudstones mainly massive or bedded, sometimes associated with frittered mudstone or limestone, are slopes very steep to precipitous (>36°) with potential for very severe erosion, and occur in gorges or riverside cliffs where stability of the latter is compromised by river undercutting, or on tall erosion-prone escarpments elsewhere?
   Y **LUC unit VIIIe3** N ⇨ 3

3. Are slopes steep to precipitous (>26°), with most slopes very steep (36–42°), incised into bedded, massive, or frittered mudstone, and with potential for very severe soil slip and severe riparian slip to expose much bare ground?
   Y **LUC unit VIIe23** N ⇨ 4

4. Is the land situated in a very severely eroding amphitheatre-like gully or a collection of such gullies that dominate the mapped area, exposing mainly frittered or bedded Neogene mudstone?
   Y **LUC unit VIIIe9** N ⇨ 5

5. Is the rock type frittered or massive mudstone, are slopes mainly strongly rolling to moderately steep (16–25°), with most slopes strongly rolling (16–20°), and is there potential for moderate earthflow under pasture?
   Y **LUC unit VIe2** N ⇨ 6

6. Is the rock type mainly massive mudstone?
   Y ⇨ 11 N ⇨ 7

7. Is the rock type mainly bedded mudstone?
   Y ⇨ 13 N ⇨ 8

8. Is the land on Weber marl?
   Y ⇨ 16 N ⇨ 9

9. Is the land on mainly Quaternary lacustrine mud?
   Y ⇨ 20 N ⇨ 10

10. Is the rock type mainly frittered mudstone?
    Y ⇨ 25

11. Are slopes mainly steep to very steep (26–42°) on Pliocene mudstone in the 'Waihora' or 'Waimata' synclines?
    Y **LUC unit VIIe4** N ⇨ 12

12. Are slopes mainly steep to very steep (26–42°) on Miocene mudstone elsewhere in the region?
Y **LUC unit VIIe2**

13. Are slopes mainly moderately steep to steep (21–35°), with occasional strongly rolling (16–20°) slopes, and is there potential for moderate soil slip?
Y **LUC unit VIe12** N ⇨ 14

14. Are slopes steep to very steep (26–42°), with most slopes steep (26–35°), with potential for severe soil slip?
Y **LUC unit VIIe3** N ⇨ 15

15. Are slopes mainly strongly rolling to moderately steep (16–25°), with occasional rolling (8–15°) or steep (26–35°) slopes, and inclined in the direction of the dip of bedded mudstone, shallowly dissected by gullies, with potential for severe earthflow, moderate riparian slip, and shallow gully?
Y **LUC unit VIIe7**

16. Are slopes rolling to undulating (4–15°), and is present earthflow erosion under pasture negligible or slight, with limited potential for more serious earthflow?
Y **LUC unit IVe2** N ⇨ 17

17. Are slopes rolling to strongly rolling (8–20°), with potential for moderate earthflow and gully?
Y **LUC unit VIe9** N ⇨ 18

18. Are slopes mostly strongly rolling to moderately steep (16–25°), with potential for severe earthflow?
Y **LUC unit VIIe9** N ⇨ 19

19. Are slopes strongly rolling to steep (16–35°), with potential for very severe gully and soil slip (earthflow is often present but is potentially subordinate to gully and soil slip)?
Y **LUC unit VIIe21** N ⇨ 20

20. Are slopes mainly strongly rolling to moderately steep (16–25°), with minor rolling (8–15°) slopes, with potential for moderate earthflow and moderate shallow gully?
Y **LUC unit VIe18** N ⇨ 21

21. Are slopes mainly strongly rolling to moderately steep (16–25°), with minor rolling (8–15°) slopes, with potential for severe earthflow and moderate shallow gully (often also indicated by block-planted exotic conservation trees)?
Y **LUC unit VIIe12** N ⇨ 22

22. Are slopes moderately steep to steep (21–35°), with most slopes steep (26–35°), sometimes with short very steep (36–42°) slopes, with frequent 5–10 m high bluffs of pale yellow to grey compact silts?
Y **LUC unit VIIe5** N ⇨ 23

23. Are slopes mainly rolling to undulating (4–15°), with undulating slopes (4–7°) long, and most rolling slopes in the easier part of this slope class (<12°)?
Y **LUC unit IIIe4** N ⇨ 24

24. Are slopes rolling to strongly rolling (8–20°), with most slopes rolling (8–15°) in the steeper part of this slope class (>12°), and with strongly rolling (16–20°) slopes short?
Y **LUC unit IVe4**

25. Are slopes moderately steep to strongly rolling (16–25°), with most slopes moderately steep (21–25°), and with occasional steep (26–35°) slopes, with potential for moderate soil slip?
Y **LUC unit VIe10** N ⇨ 26

26. Are slopes steep to moderately steep (21–36°), with most slopes steep (26–35°), and with occasional very steep (36–42°) slopes, with potential for very severe soil slip?
Y **LUC unit VIIe1** N ⇨ 27

27. Are mudstones best described as 'loose-jointed', and are slopes strongly rolling to steep (16–35°), with potential for very severe gully and soil slip (earthflow is present but is potentially subordinate to gully and soil slip)?
Y **LUC unit VIIe21** N ⇨ 28

28. Are mudstones best described as 'loose-jointed', and are slopes strongly rolling to moderately steep (16–25°), with some rolling (8–15°) or steep (26–35°) slopes, with potential for very severe earthflow erosion (gully and riparian slip is often present but are subordinate to earthflow)?
Y **LUC unit VIIe6** N ⇨ the land may not be catered for

LUC units of suite 7 (Neogene sandstone)

1. Are rocks mainly muddy sandstone and minor massive mudstone of the East Cape area?
Y ⇨ 2 N ⇨ 5

2. Are slopes mainly strongly rolling to moderately steep (16–25°)?
Y **LUC unit VIe13** N ⇨ 3

3. Are slopes mainly steep to very steep (26–42°), with most slopes steep (26–35°) and long?
Y **LUC unit VIIe17** N ⇨ 4

4. Are slopes very steep to precipitous (>36°), with most slopes very steep (36–42°)?
Y **LUC unit VIIIe6**

5. Is the land in the Whangaparaoa area?
Y ⇨ 6 N ⇨ 9

6. Are slopes moderately steep to steep (21–35°), with most slopes moderately steep (21–25°), with occasional strongly rolling (16–20°) slopes, and steep slopes (26–30°) short, with insufficient weathered tephra (<40% coverage) to qualify as part of LUC suite 4?
Y ⇨ 19 N ⇨ 7

7. Are slopes steep to very steep (26–42°), with most slopes steep (26–35°), on Te Kahika Formation massive sandstone and mudstone?
Y **LUC unit VIIe16** N ⇨ 8

8. Are slopes very steep to precipitous (>36°) with most slopes very steep (36–42°), on Te Kahika Formation massive sandstone and mudstone?
Y **LUC unit VIIIe6**

9. Are slopes mainly very steep to steep (26–42°) with prominent bluffs associated with rock-strewn midslopes and footslopes that can be grazed (bluffs are usually not very tall — about 10 m)?
   Y **LUC unit VIIs1** N ⇨ 10

10. Are slopes precipitous to very steep (>36°), in gorges or on tall bluffs, where profuse hard (strong) bare rock surfaces resist erosion?
   Y **LUC unit VIIIs1** N ⇨ 11

11. Are sandstones massive or bedded, are slopes very steep to precipitous (>35°), with most slopes very steep (36–42°), with potential for very severe erosion, and occur in gorges or on riverside cliffs where stability of the latter is compromised by river processes, or on tall erosion-prone escarpments elsewhere?
   Y **LUC unit VIIIe3** N ⇨ 12

12. Is the land in the Ngatapa–Rere lower rainfall area (hill country just west of the Poverty Bay flats)?
   Y ⇨ 13 N ⇨ 15

13. Are slopes moderately steep to steep (21–35°), with steep (26–35°) slopes short?
   Y **LUC unit VIe11** N ⇨ 14

14. Are slopes steep to very steep (26–42°), with most slopes steep (26–35°) and long, with potential for severe soil slip?
   Y **LUC unit VIIe10**

15. Is the rock type mainly bedded sandstone (conspicuously alternating with thinner beds of mudstone) in the high rainfall area of the Wharerata hills?
   Y ⇨ 16 N ⇨ 18

16. Are slopes steep to moderately steep (21–35°), with steep slopes (26–35°) short?
   Y **LUC unit VIe17** N ⇨ 17

17. Are slopes steep to very steep (26–42°), with most slopes steep (26–35°) and long, with potential for severe soil slip?
   Y **LUC unit VIIe14**

18. Are slopes mainly steep to moderately steep (21–35°), with most slopes steep (26–35°), is the land in the western part of the region in an elevation range of 550–1200 m a.s.l., are rock types bedded or massive sandstones and are these covered by tephra?
   Y **LUC unit VIIe20** N ⇨ 19

19. Are slopes moderately steep to steep (21–35°), with most slopes moderately steep (21–25°), with occassional strongly rolling (16–20°) slopes, and steep slopes (26–35°) short?
   Y **LUC unit VIe16** N ⇨ 21

20. Are slopes steep to very steep (26–42°), with steep slopes (26–35°) long, with potential for severe soil slip?
   Y **LUC unit VIIe15** N ⇨ the land may not be catered for

LUC units of suite 8 (limestone)

1. Is the limestone Paleogene muddy limestone from upper Mangatu Group strata, often in association with other rock types such as argillite or massive mudstone, occurring as entire hills or major very steep to precipitous (>36°) escarpments with steep (26–35°) bouldery colluvial footslopes?
   Y **LUC unit VIIs2** N ⇨ 2

2. Are slopes precipitous to very steep (>36°), and occur in gorges or on tall bluffs, where profuse hard (strong) bare rock surfaces resist erosion?
   Y **LUC unit VIIIs1** N ⇨ 3

3. Are slopes very steep (36–42°) limestone-dominated unstable escarpments in Te Kahika Formation rock terrain of the Whangaparaoa area?
   Y **LUC unit VIIIe6** N ⇨ the land may not be catered for

LUC units of suite 9 (basalt)

1. Are slopes mainly <20°?
   Y ⇨ suite 4 N ⇨ 2

2. Are slopes moderately steep to strongly rolling (16–25°), with most slopes moderately steep (21–25°), often with some short steep slopes (26–35°)?
   Y **LUC unit VIe15** N ⇨ 3

3. Are slopes mainly steep to very steep (26–42°), with most slopes steep (26–35°) and long, with potential for severe soil slip?
   Y **LUC unit VIIe13** N ⇨ 4

4. Are slopes mainly very steep to precipitous (>36°)?
   Y **LUC unit VIIIe5** N ⇨ the land may not be catered for

LUC units of suite 10 (greywacke and argillite)

1. Is the land arable (slopes are flat to strongly rolling, without more than a slight potential for erosion under permanent vegetative cover, the climate is suitable and soil profile drainage better than very poorly)?
   Y ⇨ 2 N ⇨ 4

2. Is the land substantially covered by Taupo/Waimihia tephra (i.e., coverage exceeds 40% of the area)?
   Y ⇨ LUC suite 3 N ⇨ 3

3. Is weathered tephra sufficiently thick (>35 cm) and well distributed (i.e., coverage exceeds 40% of the area) to be considered part of LUC suite 4?
   Y ⇨ LUC suite 4

4. Is the land above the treeline?
   Y **LUC unit VIIIe8** N ⇨ 5

5. Are slopes very steep to precipitous (>36°), and occur in gorges or on tall bluffs, where profuse hard (strong) bare rock surfaces resist erosion?
   Y **LUC unit VIIIs1** N ⇨ 6

6. Are slopes steep to precipitous (>26°) mountain slopes in the Raukumara Range and mostly severely to very severely eroded by large failures with elements of gully, sheet, scree, slump, etc.?
   Y **LUC unit VIIIe7** N ⇨ 7

7. Are slopes mainly very steep to precipitous (>36°) mountain slopes in the Raukumara Range, with most slopes very steep (36–42°)?
   Y **LUC unit VIIIe4** N ⇨ 8

8. Are slopes steep to very steep (26–42°), with most slopes steep (26–35°), sometimes with moderately steep slopes (21–25°), with potential for severe soil slip?
   Y **LUC unit VIIe11** N ⇨ 9

9. Is the land in the Wharekopae area, on argillite and crushed argillite, with a substantial cover of Taupo/Waimihia tephra on weathered tephra (>40% coverage), with long, sloping broad interfluves that are shallowly dissected by gullies, with potential for moderate riparian slip erosion but with lower potential for gully and earthflow, and are slopes strongly rolling to moderately steep (16–25°)?
   Y **LUC unit VIe20** N ⇨ 10

10. Is the land on greywacke or argillite, are slopes mainly moderately steep (21–25°), with occasional strongly rolling (16–20°) or steep (26–35°) slopes, with a substantial cover (>40% coverage) of any kind (Taupo or older) of tephra?
    Y **LUC unit VIe23** N ⇨ 11

11. Is the land on greywacke or argillite, without a significant tephra cover, are slopes moderately steep to steep (21–35°), with most slopes moderately steep (21–25°) and with steep slopes (26–35°)short?
    Y **LUC unit VIe24** N ⇨ the land may not be catered for

LUC units of suite 11 (crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite)

1. Is the land arable (slopes are flat to strongly rolling, without more than a slight potential for erosion under permanent vegetative cover, the climate is suitable and soil profile drainage better than very poorly)?
   Y ⇨ 2 N ⇨ 4

2. Is the land substantially covered by Taupo/Waimihia tephra (i.e., coverage exceeds 40% of the area)?
   Y ⇨ LUC suite 3 N ⇨ 3

3. Is weathered tephra sufficiently thick (>35 cm) and well distributed (i.e., coverage exceeds 40% of the area) to be considered part of LUC suite 4?
   Y ⇨ LUC suite 4

4. Is the rock type mainly crushed greywacke, are slopes moderately steep to very steep (21–42°), with potential for very severe gully and severe earthflow (the potential is often indicated by the presence of active gullies)?
   Y **LUC unit VIIe22** N ⇨ 5

5. Is the land in the Wharekopae area, on argillite and crushed argillite, with a substantial cover of Taupo/Waimihia tephra on weathered tephra, with long, sloping broad interfluves that are shallowly dissected by gullies, with potential for moderate riparian slip erosion but with lower potential for gully and earthflow, and are slopes strongly rolling to moderately steep (16–25°)?
   Y **LUC unit VIe20** N ⇨ 6

6. Is the land situated in a very severely to extremely severely eroding amphitheatre-like gully or a collection of such gullies that dominate the mapped area?
   Y **LUC unit VIIIe9** N ⇨ 7

7. Are slopes steep to moderately steep (21–35°), with most slopes steep (26–35°), locally occupying more elevated terrain where the degree of crushing may be less, or with significant uncrushed (and stronger) argillite or moderately indurated sandstone beds, with potential for severe soil slip and comparatively little earthflow?
   Y **LUC unit VIIe8** N ⇨ 8

8. Are slopes strongly rolling to moderately steep (16–25°), with the clay mineral assemblage of rocks overwhelmingly dominated by bentonite, with potential for very severe earthflow (usually indicated by severe to very severe present earthflow, in combination with gully)?
   Y **LUC unit VIIe25** N ⇨ 9

9. Are slopes rolling to strongly rolling (8–20°), with most slopes rolling (8–15°), is annual rainfall >2000 mm and the land very wet, with potential for very severe earthflow (mostly north-west of the Waiapu River valley)?
   Y **LUC unit VIIe18** N ⇨ 10

10. Are slopes mainly strongly rolling to moderately steep (16–25°), with most slopes strongly rolling (16–20°), with potential for very severe earthflow (gully erosion is present, but there is greater potential for earthflow)?
   Y **LUC unit VIIe19** N ⇨ 11

11. Are slopes steep to moderately steep (21–35°), with potential for very severe gully (earthflow is present, but there is greater potential for gully)?
   Y **LUC unit VIIe24** N ⇨ 12

12. Are tephra cover deposits present, of sufficient thickness (>25 cm for Taupo/Waimihia materials and >35 cm for weathered tephra) and covering at least 40% of the area?
   Y ⇨ 13 N ⇨ 14

13. Are slopes strongly rolling to moderately steep (16–25°), with potential for moderate gully, earthflow, riparian slip, and soil slip?
   Y **LUC unit VIe21**

14. Are slopes strongly rolling to moderately steep (16–25°), with potential for moderate gully, earthflow, riparian slip, and soil slip?
   Y **LUC unit VIe22** N ⇨ 15

15. Are slopes strongly rolling to rolling (8–20°), with potential for moderate earthflow?
   Y **LUC unit VIe4** N ⇨ the land may not be catered for

Relationship diagrams of LUC units

Land use capability units of the Gisborne – East Coast region are arranged into LUC suites and subsuites and 'wired' to enable relationships between LUC units to be seen. The diagrams also illustrate the entire structure of the classification.

Key for using the relationship diagrams:

Ic1 LUC units in bold type are full-time members of the suite or subsuite. This means that these units are always part of the suite.

IVw2 LUC units in ordinary type are part-time members of the suite or subsuite, being considered part of the suite or subsuite only when specified conditions are met. The inclusion of part-time members in the diagrams is a reminder that they can be included for some interpretations. Choosing the particular instances where part-time members can be included involves a special examination of the inventory factors mapped (usually rock type), and can also require special knowledge of the area.

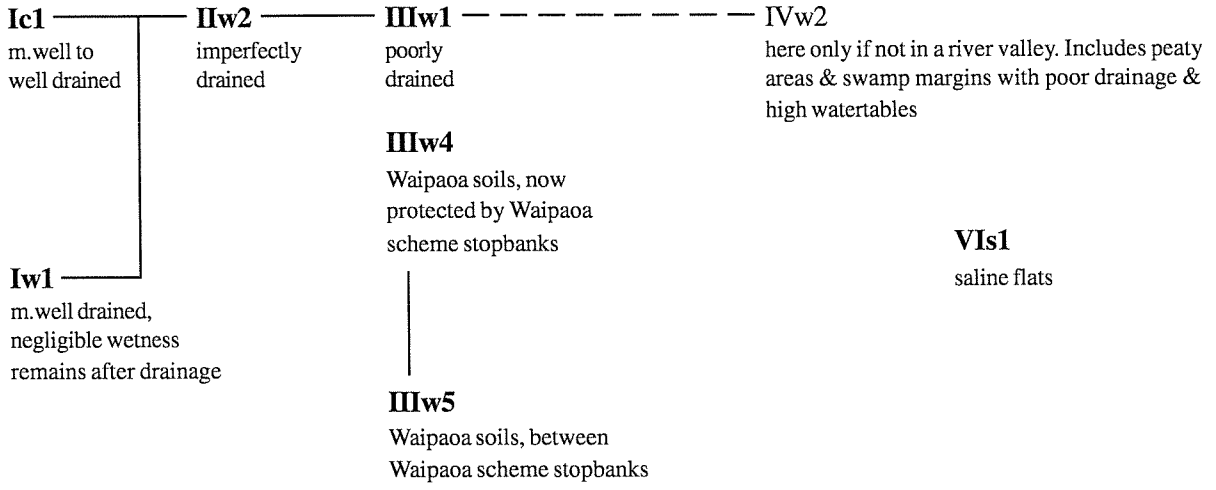
——— Solid lines show a clear and simple relationship between LUC units in a suite or subsuite. Usually, only a single mapped factor changes from one unit to the other, and often this is slope, for example, IVe4 (C, C', C+D, or D+C slopes) — VIe7 (D, or D+E slopes). The linking lines do not necessarily imply that one LUC unit changes to another in the process of landscape evolution, although this might be true in some pairs (for example, VIIIe4 could degrade to a VIIIe7 with the onset of extreme gully erosion following a major storm or tectonic disturbance).

— — Dotted lines suggest a more tenuous relationship, usually linking full-time members with part-time members.

Unlinked (stand-alone) LUC units (or, in some cases a group of linked LUC units standing alone from the main group) are part-time or full-time members of a suite or subsuite that are so distinctly different from other members that any linking line (solid or dotted) would imply a stronger than desirable relationship and be misleading. An example of an unlinked unit is VIs1 in Suite 1. While sharing the general 'plains' environment with the other LUC units of the suite (hence its placement in the suite), it's uniquely saline characteristics and terrain position separate it from the other LUC units of the suite (all on non-saline flood-plain alluvium).

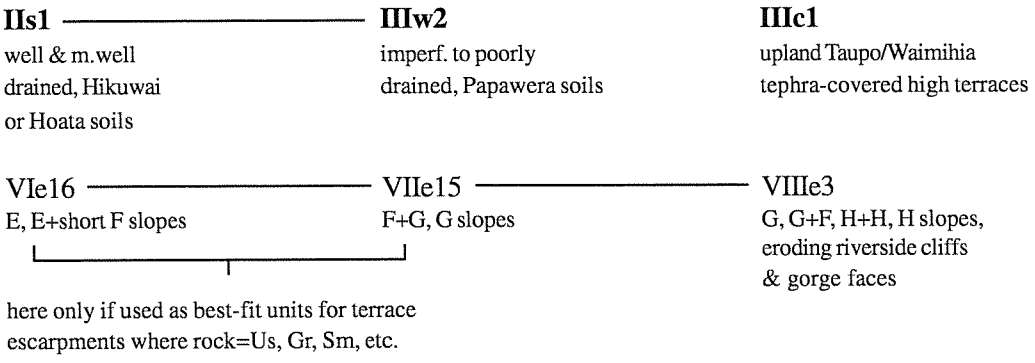
Notes: Factors identified to help recognise the LUC unit quickly, covering slopes, rock types, erosion potentials (as opposed to present erosion that can vary from polygon to polygon for a LUC unit), and other notes as necessary.

1 Broad flood plains LUC suite

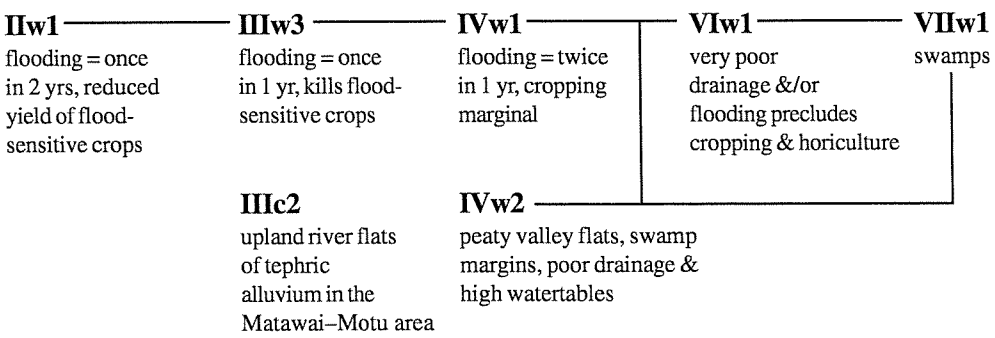


2 River valley LUC suite

2a Intermediate and high terraces (above modern flood plains, with loess and fine-grained alluvium, or Taupo/Waimihia tephra, usually gravelly at depth)



2b River flats, swamps, fans and lower terraces (fine-grained alluvium, wetness and/or inundation by flood water)



2c Gravels (river flats, terraces, and fans)

IIs2 — ≥45 cm depth from soil surface of no more than 5–15% gravels

IIIs1 — 30–45 cm depth from soil surface of no more than 5–15% gravels

IVs1 — 15–30 cm depth from soil surface of no more than 5–15% gravels, can have boulders on surface

VIs2 — <15 cm depth from soil surface of no more than 5–15% gravels, boulders on surface

VIIe26 — gravelly to extremely gravelly low river terraces & occasional fan, flooding, mod. to sev. streambank erosion & deposition

VIIIs2 — active river beds

3 Taupo/Waimihia tephra LUC suite

3a Lowland (<550 m a.s.l.)

IIIs2 — short B, B', A, A', A+B slopes

IIIe4 — B+C, C+B, B'+C, long B', B slopes

IVe4 — C, C', C+D, D+C slopes, sometimes D where short

VIe7 — D, D+E slopes mod. soil slip

VIe14 — E, E+F, E+D slopes, longer slopes, more active history of slipping than VIe7

significantly less tephra coverage than previous units in this subsuite

VIe11 — E, E+F, F+E slopes, here only if rock=pKt or pKt/pMo/Sb or on Sm, & tephra coverage > 40%, Ngatapa–Rere area

VIe12 — E, E+F, minor E+D slopes, here only if rock=pKt or pKt/pMo/Mb, & tephra coverage > 40%

IIIs3 — veneer of Kt, <30cm thick, on sand plains

IVe2 — B+C, C+B, C, long B slopes, Weber marl, here only if Kt coverage > 40%

VIe2 — D, D+E, E+D, D+C slopes, here only if rock=pKt or pKt/pMo//Mf, & tephra coverage > 40 %

VIe6 — D, D+E, D+C slopes, slumped, here only if rock=Kt or Kt/Mo/Mf, Mm, etc., & tephra coverage > 40%

3b Upland (>550 m a.s.l.)

IIIc1 — A, A+B slopes, high inland terraces, 550–750 m a.s.l.

IIIe5 — B+C, C+B, long B slopes, 550–750 m a.s.l.

IVe5 — C, C+D slopes 550–1100 m a.s.l., & C+B slopes, 750–110 m a.s.l.

IVc1 — A, A+B, B+C slopes 750-1100 m a.s.l., mainly in western parts

VIe19 — D, D+E, E+D, E slopes, > 550 m a.s.l., Neogene rocks, mod. soil slip

VIIe20 — F, F+E, minor F+G slopes, 550–1200 m a.s.l., Neogene rocks, in western parts

VIe20 — D, D+E slopes, rock=Kt/Mo/Ar* Ac, Kt/Mo/Ar, long stable even slopes, shallowly incised by gullies with riparian slips

VIe21 — D, D+E, E+D, E, minor C, C+D slopes, here only if Kt coverage > 40% on Ac rock

VIe23 — E, E+D, E+F, D+E, D slopes, here only if Kt coverage > 40% on Gw or Ar rock

VIIe7 — long dip slopes in bedded mudstone terrain, here only if Kt coverage > 40%

4 Weathered tephra LUC suite

4a Coastal

IIe1 — A, B+A, B+A, A+C slopes

IIIe2 — C+B, B+C, B slopes

IVs3 — C+B, B+C, D slopes, tephra, gravels or coarse slope deposits, highly variable characteristics

4b Lowland (<550 m a.s.l.)

IIs3 — A+B, A'+B, A, A', B, B' slopes

IIIe1 — C, B+C, C+B slopes

IVe1 — C+D, D+C, C', C, short D slopes, no potential for soil slip

VIe1 — D+E, E+D, D slopes, Neogene or younger rocks, mod. soil slip

VIe3 — E, E+F, some E+D slopes, longer slopes & more active history of slipping than VIe1, Neogene rocks, mod. soil slip

VIe2 — D, D+E, E+D, D+C slopes, here only if Mo coverage on Mf > 40%

VIe4 — D, C+D, D+C, C slopes, here only if Mo coverage on Ac > 40%

VIe6 — D, D+E, D+C slopes, slumped, here only if Mo coverage > 40%

VIe15 — E, E+D, D+E, E+F slopes, Matakaoa Volcanics, here only if Mo coverage on In or wIn > 40%

4c Upland (>550 m a.s.l.)

IIIe3 — B, B+C, C+B, C slopes, 550–750 m a.s.l.

IVe3 — C+D, D+C, C slopes, 550–1100 m a.s.l., & C, B+C slopes 750–1100 m a.s.l., no potential for soil slip

VIe5 — D+E, E+D, D slopes, 550–1100 m a.s.l., Neogene rocks, mod. soil slip

VIe8 — D, D+E, E+D slopes 550–1100 m a.s.l., Neogene rocks, longer slopes & more active history of slipping than VIe5

VIe21 — D, D+E, E+D, E, minor C, C+D slopes, here only if Mo coverage on Ac > 40%

VIe23 — E, E+D, E+F, D+E, D slopes, here only if Mo coverage on Gw or Ar > 40%

5 Coastal sand and coastal cliffs LUC suite

IIIs3 — veneer of Kt, < 30 cm thick, on sand plains

IVs2 — A, A+B slopes, stable sand dunes, inland from the coastline, loamy sand soils

VIs3 — B, A+B slopes, stable sand dunes & interdune flats, sand & minor loamy sand soils

VIe25 — B+C, B+C, A+B, C slopes, consolidated sand dunes, incl. interdune sand plains, mod. wind

VIIe27 — B+C, C+B, B, C, slopes, very unstable sand dunes, immediately inland from the foredune, v. sev. wind

VIIIe1 — foredunes

VIIIe2 — coastal cliffs

6 Neogene and Quaternary mudstone LUC suite

6a Frittered mudstone

VIe2 — D, D+E, E+D, D+C slopes, mod. earthflow, rock=Mf, pKt/Mf, pMo/Mf

VIe10 — E, E+D, E+F, minor D+E slopes, mod. soil slip

VIIe1 — F, F+E, minor F+G slopes, v. sev. soil slip

VIIe6 — D+E, E+D, E, D, C+D, some C, E+F slopes, v. sev. earthflow

VIIe21 — D+E, E+D, D, F, E+F, F+E, D+F slopes, v. sev. gully & soil slip

VIe6 — D, D+E, D+C slopes, slumped, usually associated with Mf, but can occur in other Neogene rock types

VIIe23 — F+G, G+F, F, G, F+H, G+H slopes, v. sev. soil slip, sev. riparian slip, here only if rock=Mf

VIIIe9 — G, G+H, F+E, E+F slopes, extreme gully in hill country. Map polygons comprise a single amphitheatre-style gully or many gullies coalesced. Here only if rock=Mf. Used normally with Ac, but occasionally used with other rock types

6b Massive mudstone

VIe2 — D, D+E, D+C slopes, mod. earthflow, rock=Mm, pKt/Mm, pMo/Mm

VIIe2 — F, F+G, F+E, minor G+F slopes, Miocene mudstone, sev. soil slip

VIIe4 — F, F+G, minor G+F slopes, Pliocene mudstone in the 'Waihora & Waimata' synclines, sev. soil slip

VIIe23 — F+G, G+F, F, G, F+H, G+H slopes, v. sev. soil slip, sev. riparian slip, here only if rock=Mm

VIIIe3 — G, G+F, G+H, H slopes, eroding riverside cliffs, gorge faces, or tall escarpments, here only if rock=Mm

6c Bedded mudstone

VIe12
E, E+F, minor E+D slopes, mod. soil slip

VIIe3
F, F+G, F+E, minor G+F slopes, sev. soil slip

VIIe7
D+C, C+D, D+E, E+D, E, E+D, E, D+F, long dip slopes sev. earthflow, shallow gully

VIIe23
F+G, G+F, F, G, F+H, G+H slopes, v. sev. soil slip, sev. riparian slip, here only if rock=Mb

VIIIe3
G, G+F, G+H, H slopes, eroding riverside cliffs, gorge faces and escarpments, here only if rock=Mb

6d Weber marl

IVe2
B+C, C+B, C, B slopes, slight earthflow, rock=Mf, pKt/Mf, etc.

VIe9
C, C+D, D+C, D slopes, mod. earthflow, rock=Mf, pKt/Mf, etc.

VIIe9
D, D+E, E+D, E, D+C slopes, sev. earthflow, rock=Mf

VIIe21
D+E, E+D, D, F, E+F, F+E slopes, very seriously eroded by gully & earthflow, here only if more severely eroded by gully rather than earthflow

6e Lacustrine muds

IIIe 4
B+C, C+B, B'+C, long B', B slopes, here only where tephra is on lacustrine muds (Uf)

IVe4
C, C', C+D, D+C slopes, sometimes D where short, here only where tephra is on lacustrine muds (Uf)

VIe18
D+E, E+D, E, D, C+D slopes, mod. earthflow rock=Uf, pKt/Uf, etc.

VIIe12
D, D+C, D+E, E slopes, sev. earthflow, block-planted with trees, rock=Uf

VIIe5
F, F+E, G+F, F+G slopes, compact lacustrine sediments exposed in small bluffs, sev. soil slip, rock=Mm, Mm + Sm, Mm + Uf, etc.

7 Neogene sandstone LUC suite

7a Massive to bedded sandstone in the Ngatapa–Rere lower rainfall area

VIe11
E, E+F, F+E slopes, mod. soil slip

VIIe10
F, F+G, G+F, F+ short H slopes, 'dry & hard' steep land, sev. soil slip

VIIs1
G, F+G, G+F, G+H, F slopes, incl. bluffs, rocky rather than erosion-prone, here only if in Ngatapa–Rere area

7b Bedded sandstone of the Wharerata hills

VIe17
F+E, E+F, short F, E slopes, Wharerata area, sandstone, conspicuously alternating with thinner beds of mudstone, mod. soil slip

VIIe14
F+G, F, G+F slopes Wharerata area, sandstone, conspicuously alternating with thinner beds of mudstone, sev. soil slip

7c Te Kahika Formation of the Whangaparaoa area

VIe16
E, E+D, E+F slopes, here used as a best-fit unit for easier hill country, Te Kahika & Waipaoa Fmn. rocks

VIIe16
F+G, F, minor F+E slopes, Te Kahika Fmn. sandstone or mudstone, & minor 'soft' sandstone of the Waipaoa Fmn., sev. soil slip

VIIIe6
G, G+H, H+G, G+F, minor H slopes, here only if rock Te Kahika Fmn. sandstone or mudstone, extreme soil slip

7d Muddy sandstone of East Cape

VIe13
D+E, E+D, E, D, minor E+F slopes, Mangaheia Gp. massive muddy sandstone & mudstone north of the Waiapu River valley in the East Cape area, mod. soil slip

VIIe17
F+G, G+F, F, F+E, short G slopes, Mangaheia Gp. massive muddy sandstone & mudstone north of the Waiapu River valley in the East Cape area, sev. soil slip

VIIIe6
G, G+H, H+G, G+F, minor H slopes, here only where rocks are Mangaheia Gp. massive muddy sandstone & mudstone north of the Waiapu River valley in the East Cape area, extreme soil slip

7e Massive and bedded sandstone

VIe16
E, E+D, E+F slopes, mod. soil slip

VIIe15
F+G, F, G+F, minor F+E, G slopes, sev. soil slip

VIIIe3
G, G+F, G+H, H slopes, eroding riverside cliffs, gorge faces, or tall escarpments, here only if rock=Sm or Sb

VIIs1
G, F+G, G+F, G+H, F slopes, incl. bluffs, rocky rather than erosion-prone, here only if rock=Sm or Sb

VIIIs1
H, G+H, H+G, G slopes, bluffs & gorges, large areas of resistant bare rock, here only if rock=Sm or Sb

VIIe20
F, F+E, minor F+G slopes, 550-1200 m a.s.l., western parts, Taupo & older tephra on massive or bedded sandstone

8 Limestone LUC suite (Paleogene and Neogene rocks)

VIIs2
G+H, F+H, F, G, minor E+F slopes, bluffs, escarpments, bouldery footslopes, usually Paleogene limestone

VIIIs1
H, G+H, H+G, G slopes, bluffs & gorges, large areas of resistant bare rock, here only if rock=Li

9 Basalt LUC suite (Ancient volcanics)

VIe15
E, E+D, D+E, E+F slopes, hill country between Cape Runaway and Hicks Bay, Matakaoa Volcanics, can have a patchy cover of weathered tephra, rock=In, wIn, pMo/In, etc., mod. soil slip & gully

VIIe13
F+G, F, F+E, minor G+F slopes, steep land between Cape Runaway & Hicks Bay, Matakaoa Volcanics, rock=In, v. sev. soil slip

VIIIe5
G+H, minor G, G+F, F+H slopes, steep land & mountains between Cape Runaway and Hicks Bay, Matakaoa Volcanics, rock=In

10 Greywacke and argillite LUC suite (Cretaceous and some Paleogene rock)

VIe24
E, E+F, F+E slopes, no significant tephra cover, rock=Gw or Ar, mod. gully & soil slip

VIIe11
F, F+G, F+E, E+F, minor short G slopes, foothills of, or in, the Raukumara and Huiarau ranges, rock=Gw, Ar, sev. soil slip, mod. soil slip on easier slopes

VIIIe4
G, G+H, G+F slopes, below the treeline in the Raukumara and Huiarua ranges, rock=Gw, Ar, v. sev. soil slip

VIIIe8
G+H, G+F, G slopes, & E+D, B+C, D, D+C slopes, on mountain tops, all areas above the treeline mainly in the Raukumara Range, rock=Gw, Ar

arable units from either suite 3-Taupo/Waimihia tephra, or suite 4-weathered tephra, that may be on Gw or Ar, but are best considered in the tephra suites for most interpretations

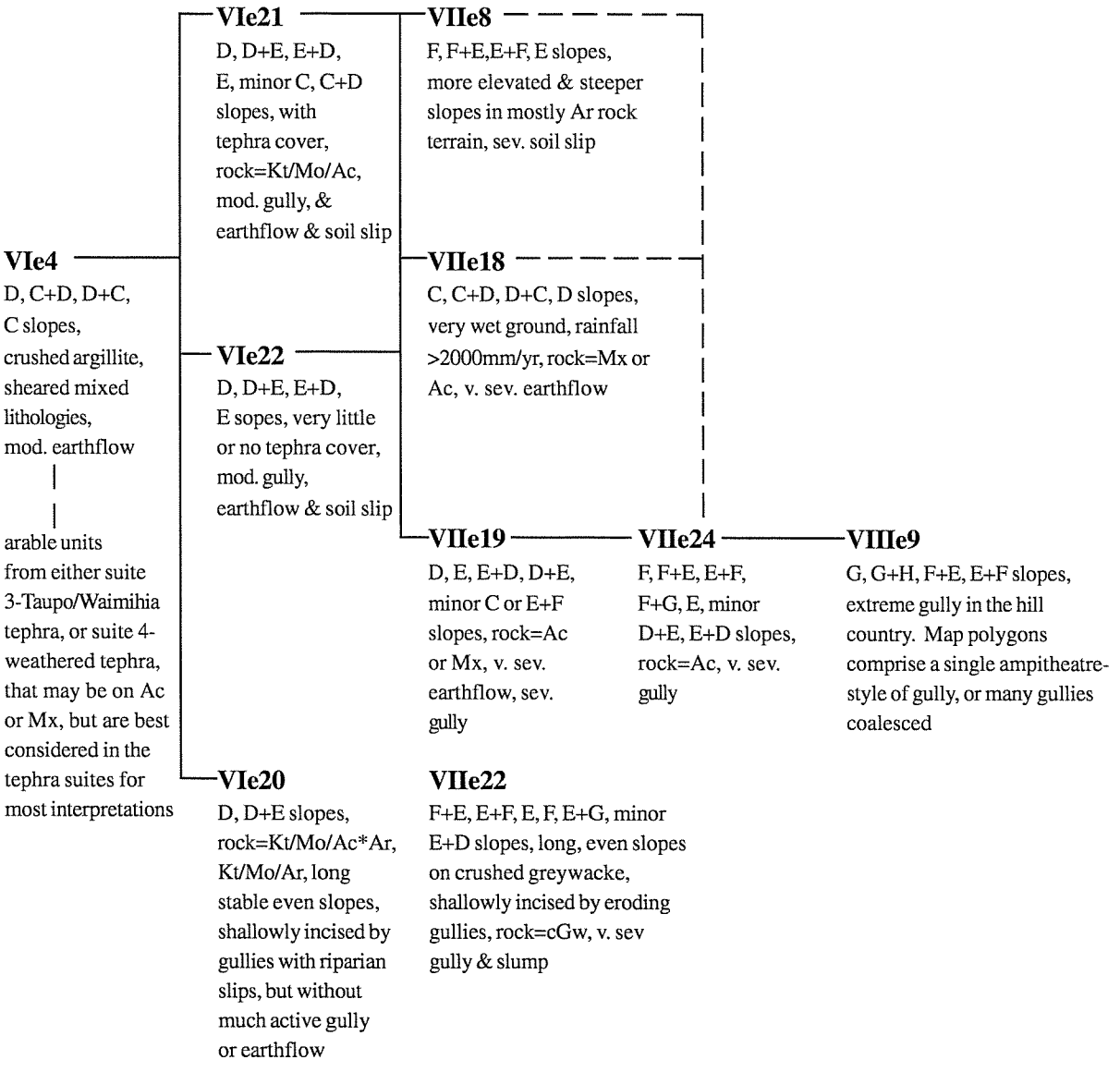
VIe23
E, E+D, E+F, D+E, D slopes, tephra cover, rock=Kt/Mo/Gw or Ar, or pKt/pMo/Gw or Ar, mod. gully & soil slip

VIIIs1
H, G+H, H+G, G slopes, bluffs & gorges, resistant bare rock, here only if rock=Gw or Si

VIe20
D, D+E slopes, here only if using the suite to isolate units on stable greywacke or argillite, rock=Kt/Mo/Ac+Ar, long even slopes, shallowly incised by gullies with riparian slips, but without much gully or earthflow erosion

VIIIe7
G, G+F, F+G, G+H slopes, sev. eroded by large failures with elements of gully, sheet, soil slip, slump, etc., below the treeline in the Raukumara Range, rock=Gw or cGw, extreme gully

11 Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite LUC suite (Paleogene and Cretaceous rocks)



Correlation of first- and second-edition LUC classifications

Table 3 correlates LUC units of the second-edition Gisborne – East Coast (GEC) classification with those of the first-edition GEC classification (Driver 1974), and relevant LUC units of the Northern Hawke's Bay (Page 1988), and Eastern Bay of Plenty (Page 1975) NZLRI regions. LUC units from these latter two regions occur in the correlation because the area of the second-edition GEC region covers parts of these NZLRI regions. The mapping carried out with the second-edition GEC classification in the areas of the latter two regions effectively replaces the first-edition coverage for those areas.

New LUC unit numbers are necessary because the second-edition classification recognises 104 LUC units and the first-edition GEC classification recognised just 54 units. Many of the new LUC units have simply been adopted from the two adjacent NZLRI regions (mostly from Northern Hawke's Bay). It is appreciated that because the first-edition GEC classification of some 25 years has been fully integrated into district planning documents, farm plans, forestry documents, and is widely used by forestry, farm, and district council professionals and land managers, there will be transition difficulties. Frequent use of this correlation table is an essential first step in overcoming these. In time, the new classification will become equally well used and known in the district.

A key point to bear in mind is that while the 'labels' have changed, the essential character of most of the land has not — for example, the LUC unit formerly known as VIIe18 (gullied crushed argillite) is still gullied crushed argillite, but is now labelled VIIe24. Other units have been split, hence some first-edition LUC units are listed more than once in Table 3. An example of this is the first-edition LUC unit VIe2, split in the second-edition classification to LUC units VIe1 (lowland) and VIe5 (upland). In a few instances, a first-edition class IV unit is correlated with a second-edition class III unit. This occurs because the first-edition LUC class IV unit (as applied in mapping) included LUC class III land due to the absence of a suitable class III unit or the effects of scale.

Users should refer frequently to the comments column in Table 3, as they help define the exactness of the correlation.

Table 3: *LUC units of the second-edition GEC classification correlated with first-edition units and those of Northern Hawke's Bay and Eastern Bay of Plenty NZLRI regions*

Second-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Northern Hawke's Bay	First-edition LUC unit, Eastern Bay of Plenty	Correlation comments (refer to notes before interpreting these comments) (=exact correlation) (-inexact correlation) (*unable to correlate)
Iw1		Iw1		=NHB
Ic1		Ic1		=NHB
IIe1	IIe1		IIe1	=GEC, =EBOP
IIw1	IIw1		IIw1	-GEC lower terraces, -EBOP lower terraces
IIw2		IIw1		=NHB

Second-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Northern Hawke's Bay	First-edition LUC unit, Eastern Bay of Plenty	Correlation comments (refer to notes before interpreting these comments) (=exact correlation) (-inexact correlation) (*unable to correlate)
IIs1	IIw1			-GEC intermediate terraces
IIs2	IIs1			=GEC
IIs3	IIIs2			-GEC weathered, mainly rhyolitic tephra
IIIe1	IVe2			-GEC undulating to rolling slopes, <550 m a.s.l.
IIIe2	IIIe1		IIIe1	=GEC, =EBOP
IIIe3	IVe2			-GEC undulating to rolling slopes, 550–750 m a.s.l.
IIIe4	IVe3	IIIe3		-GEC undulating to rolling slopes, <550 m a.s.l.; -NHB <550 m a.s.l.
IIIe5	IVe3	IIIe3		-GEC undulating to rolling slopes, 550–750 m a.s.l.,-NHB 550–750 m a.s.l.
IIIw1		IIIw1		=NHB
IIIw2	IIIw1			-GEC intermediate terraces with Papawera soils
IIIw3	IIIw1	IIIw1		=NHB, -GEC lower terraces
IIIw4		IIIw2		-NHB former floodway now protected by the Waipaoa scheme
IIIw5		IIIw2		=NHB
IIIs1	IIIs1			=GEC
IIIs2	IIIs2	IIIs3		=NHB, -GEC Taupo/Waimihia tephra, <550 m a.s.l.
IIIs3		IIIs5		=NHB
IIIc1	IIIc1		IIIc1	=GEC extra LUC unit, -EBOP upland high terraces
IIIc2			IIIc1	-EBOP lower terrace
IVe1	IVe2	IVe2	IVe1	-GEC, NHB <550 m a.s.l., =EBOP
IVe2	IVe1			=GEC

Table 3 (cont'd)

Second-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Northern Hawke's Bay	First-edition LUC unit, Eastern Bay of Plenty	Correlation comments (refer to notes before interpreting these comments) (=exact correlation) (-inexact correlation) (*unable to correlate)
IVe3	IVe2			-GEC 550–1100 m a.s.l.
IVe4	IVe3	IVe2		-GEC <550 m a.s.l., =NHB
IVe5	IVe3			-GEC 550–1100 m a.s.l.
IVw1	IVs2		IVw1	=GEC extra LUC unit, =EBOP
IVw2	IVw1	IVw1		=GEC, =NHB
IVs1	IVs1			=GEC
IVs2		IVs1	IVs1	=NHB, =EBOP
IVs3				*GEC (first-edition GEC IIIe1 formerly used)
IVc1		IVc1		=NHB
VIe1	VIe2		VIe1	-GEC <550 m a.s.l., =EBOP
VIe2	VIe1			-GEC Neogene mudstone
VIe3	VIe4		VIe2	-GEC <550 m a.s.l.,=EBOP
VIe4	VIe6b			=GEC extra LUC unit
VIe5	VIe2			-GEC >550 m a.s.l.
VIe6		VIe10		*GEC, -NHB Neogene rocks
VIe7	VIe3	VIe1	VIe3	-GEC <550 m a.s.l., =NHB, -EBOP Neogene rocks
VIe8	VIe4			-GEC >550 m a.s.l.
VIe9	VIe5			=GEC
VIe10	VIe6	VIe3		=GEC, =NHB
VIe11		VIe8		=NHB
VIe12	VIe7	VIe4		=GEC, =NHB
VIe13				*GEC (first-edition GEC VIe6 formerly used)

Table 3 (cont'd)

Second-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Northern Hawke's Bay	First-edition LUC unit, Eastern Bay of Plenty	Correlation comments (refer to notes before interpreting these comments) (=exact correlation) (-inexact correlation) (*unable to correlate)
VIe14	VIe8	VIe6		-GEC <550 m a.s.l., =NHB
VIe15	VIe9			=GEC
VIe16	VIe10			-GEC massive and bedded sandstone
VIe17		VIe14		=NHB
VIe18	VIe11			=GEC
VIe19		VIe11		=NHB
VIe20	VIe12			-GEC argillite with tephra, geologically stable
VIe21	VIe12			-GEC argillite with tephra
VIe22	VIe12			-GEC argillite without tephra
VIe23	VIe13		VIe5	=GEC, -EBOP >550 m.a.s.l
VIe24	VIe13			-GEC greywacke and argillite without tephra
VIe25		VIe13		=NHB
VIw1				*GEC (first-edition GEC IVw1 formerly used)
VIs1		VIs2		=NHB
VIs2		VIs3		=NHB
VIs3	VIs1			=GEC
VIIe1	VIIe1	VIIe1		=GEC, =NHB
VIIe2	VIIe1, VIIe2	VIIe1		-GEC, -NHB massive mudstone
VIIe3	VIIe2	VIIe2		=GEC, =NHB
VIIe4	VIIe1, VIIe2			-GEC massive mudstone in the Waihora or Waimata synclines
VIIe5	VIIe7			-GEC non-flowy land, steep, with compact lacustrine silts exposed in small bluffs
VIIe6	VIIe3	VIIe6		=GEC, =NHB

Table 3 (cont'd)

Second-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Northern Hawke's Bay	First-edition LUC unit, Eastern Bay of Plenty	Correlation comments (refer to notes before interpreting these comments) (=exact correlation) (-inexact correlation) (*unable to correlate)
VIIe7	VIIe2			-GEC dip slopes
VIIe8	VIIe4			=GEC
VIIe9	VIIe5			=GEC
VIIe10		VIIe5		=NHB
VIIe11	VIIe6		VIIe1	=EBOP
VIIe12	VIIe7			-GEC slopes up to E
VIIe13	VIIe8			=GEC
VIIe14		VIIe9		=NHB
VIIe15	VIIe9			-GEC massive and bedded sandstone
VIIe16	VIIe10			=GEC
VIIe17	VIIe11			-GEC flowy low-angle slopes
VIIe18	VIIe12			=GEC
VIIe19	VIIe13			=GEC
VIIe20		VIIe14		=NHB
VIIe21	VIIe14	VIIe10		=GEC, =NHB
VIIe22	VIIe15			-GEC strongly rolling slopes
VIIe23	VIIe16			=GEC
VIIe24	VIIe18			=GEC
VIIe25	VIIe20			=GEC
VIIe26	VIIe19			=GEC
VIIe27	VIIe21	VIIe13	VIIe3	=GEC, =NHB, =EBOP

Table 3 (cont'd)

Second-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Gisborne–East Coast	First-edition LUC unit, Northern Hawke's Bay	First-edition LUC unit, Eastern Bay of Plenty	Correlation comments (refer to notes before interpreting these comments) (=exact correlation) (-inexact correlation) (*unable to correlate)
VIIw1	VIIw1			=GEC
VIIs1	VIIe17			=GEC
VIIs2				*GEC (first-edition GEC VIIe6 formerly used)
VIIIe1	VIIIe1	VIIIe1		=GEC
VIIIe2	VIIIe2	VIIIe3		=GEC
VIIIe3				*GEC (was not recognised separately due to scale in the first-edition GEC)
VIIIe4	VIIIe3	VIIIe5	VIIIe1	-GEC greywacke and argillite, =NHB, =EBOP
VIIIe5	VIIIe3			-GEC ancient volcanics
VIIIe6	VIIIe3			-GEC Neogene sandstones
VIIIe7	VIIIe4	VIIIe6	VIIIe2	=GEC, -NHB greywacke and argillite
VIIIe8	VIIIe5	VIIIe9	VIIIe4	=GEC, =NHB, =EBOP
VIIIe9				*GEC (first-edition GEC VIIe18 formerly used)
VIIIs1	VIIIs1	VIIIs1		-GEC, -NHB a wider range of rock types
VIIIs2				*GEC (first-edition GEC VIIe19 formerly used, otherwise not mapped at all)

GDC = Gisborne District Council
GEC = Gisborne–East Coast
NHB = Northern Hawke's Bay
EBOP = Eastern Bay of Plenty

Note 1. 'GEC extra LUC unit' in the comments column refers to LUC units that Gisborne District Council set up after publication of the first-edition NZLRI. These additional LUC units were used for land that was not well classified by the first-edition NZLRI.

Note 2. All correlation comments are *inclusive*. For example, '-GEC undulating to rolling slopes, 550–750 m a.s.l.' means an inexact correlation exists between the second-edition LUC unit and the first-edition unit of the Gisborne–East Coast region and that the second-edition LUC unit can only be exactly correlated to the first-edition unit where undulating and rolling slopes occur and where these slopes are in the elevation range 550–750 m a.s.l.

Land Use Capability unit descriptions

This chapter provides descriptions of the 104 LUC units of the second-edition NZLRI classification of the Gisborne – East Coast region. Symbols in brackets (e.g., Gw, A+B, Ef) denote the NZLRI inventory factor classification symbols. Information about each LUC unit is arranged according to the following layout:

LUC unit: **for example: Iw1** — I = LUC class, Iw = LUC subclass, Iw1 = LUC unit. The mapped area of the LUC unit (in hectares) in the NZLRI region is given in brackets

LUC suite: The name and ID number of the principal LUC suite (s). A small number of LUC units are listed under two suites, but only when the units belong to both suites in all instances. Some other units belong to more than one suite, but not in all instances

LUC subsuite: The name and ID number of the LUC subsuite

Description: A brief description of the essential character of the LUC unit

Reference site: A six-figure grid reference and location, using Infomap 260 sheets, of land considered typical of the LUC unit and usually able to be seen from a road

Slope: Typical slopes expressed in a range of degrees that equate to standard NZLRI slope classes (Appendix 8), with the more common slopes first

Rock type: Common rock types according to the NZLRI rock type classification (Appendix 4), as well as relevant rock Formation names (Appendix 3), and other information

Soil: *N.Z. Soil Classification soil groups* – 'New Zealand Soil Classification' (Hewitt 1998) soil groups, listed in idealised descending order of regional coverage for the LUC unit. Given in slope classes of F: flat to undulating slopes (NZLRI slope classes A and B); R: rolling slopes (class C); H: strongly rolling to moderately steep slopes (classes D and E) as surrogate for hilly land; and S: steep to precipitous slopes (classes F, G and H) as surrogate for steep land. Soils were mapped to soil subgroup level and are summarised for each LUC unit in Appendix 6. The character of soil orders and groups in the region are summarised in Appendix 7.
N.Z. Genetic Soil Classification – refer to names and symbols of typical soils from previous soil surveys (Appendix 5), classified according to Taylor and Pohlen (1968). The soil survey is identified with a superscript number (for survey identification from the Appendix)

Erosion: *Present:* Typical types and degrees of erosion using the NZLRI erosion classification (Appendix 9)
Potential: Expected erosion severity potentials under different land uses or covers

Vegetation: Common vegetative covers mapped as NZLRI vegetation classes (Appendix 10)

Land use:

Present:	Common present land uses in general terms (with examples in brackets)
Agric. Potential:	Productivity potentials according to Appendix 9 terms for grazing, and in other general terms for horticulture and cropping. Assessed with appropriate land management measures in place
Forestry Potential:	Productivity potentials according to general terms in Appendix 9. Assessed with appropriate land management measures in place

Management: Measures to improve land-use sustainability and achieve land-use potentials. Measures for agriculture or horticulture follow the 'A' symbol, those for forestry follow 'F', and those for LUC class VIII land follow 'C'. The comment 'no special measures' does not (1) exclude standard measures for good environmental management, or (2) imply the absence of special local conditions that may require additional measures

Comments: General comments to improve understanding the LUC unit.

LUC unit: Iw1 (3204 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Flat to gently sloping surfaces on higher parts of the Poverty Bay flats, near the margins of present flooding extents. Soils are moderately well drained or imperfectly drained

Reference site: Y17/388801 between Ford and Bruce roads, 2 km south of Ormond

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Recent soils: Matawhero heavy silt loam (2b)[3]; Matawhero heavy silt loam, friable topsoil phase (2c)[3]; Waihirere silt loam, mottled subsoil phase (3b)[3];Waihirere heavy silt loam (3c)[3]; Waihirere heavy silt loam, gravelly topsoil phase (3d)[3]; Waihirere heavy silt loam, mottled subsoil phase (3e)[3]

Erosion: *Present:* Negligible to slight wind (0–1W)
Potential: Slight wind when cultivated. Slight streambank under any land use

Vegetation: Improved pasture (gI), grapes and berry fruit (cG), subtropical fruit (cS), vegetables, nurseries (cV), maize (cM), kiwifruit (cK), pip and stone fruit (cP)

Land use: *Present:* Intensive livestock farming, horticulture (citrus fruit, grapes and kiwifruit, apples, market vegetables), field cropping (maize, process vegetables)
Agric. Potential: Horticulture, field cropping, intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter, irrigation, streambank and flood protection. F: Streambank protection

Comments: This LUC unit represents, along with Ic1, the most versatile and highly productive land in the region.

LUC unit: Ic1 (2428 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Flat to very gently sloping surfaces on the Poverty Bay and Tolaga Bay flats, away from the margins of present flooding extents. Soils are well drained, highly versatile, and with negligible physical limitations

Reference site: Y18/405708 Matawhero

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Recent soils: Matawhero silt loam (2)[3]; Matawhero silt loam, friable topsoil phase (2a)[3]; Waihirere silt loam (3)[3]; Waihirere silt loam, gravelly topsoil phase (3a)[3]

Erosion: *Present:* Negligible (0)
Potential: Slight wind when cultivated. Negligible under pasture

Vegetation: Improved pasture (gI), grapes and berry fruit (cG), subtropical fruit (cS), vegetables, nurseries (cV), kiwifruit (cK), maize (cM), pip and stone fruit (cP)

Land use:
Present: Intensive livestock farming, horticulture (citrus fruit, grapes and kiwifruit, apples, market vegetables), field cropping (maize, process vegetables)
Agric. Potential: Horticulture, field cropping, intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter, irrigation. F: No special measures

Comments: This LUC unit represents, along with Iw1, the most versatile and highly productive land in the region.

LUC unit: IIe1 (1451 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4a. Coastal

Description: Flat to undulating high terraces and marine benches adjacent to the coast, mantled by at least 35 cm depth of weathered tephra

Reference site: Y14/493886 3 km south-west of Whangaparaoa

Slope: 0–3° (A, A'), 0–7° (B+A, A+B), 0–15° (A'+C)

Rock type: Weathered, mainly rhyolitic tephra (Mo)
Note: Tephra overlies undifferentiated intermediate and high terraces (Waipaoa Formation), or Quaternary beach deposits

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Brown Soils (BO)
R: Orthic Brown Soils (BO); Allophanic Brown Soils (BL)
N.Z. Genetic Soil Classification
Yellow-brown loams: Te Kaha sandy loam (52)[1]; Tikirau loam (11)[2]; Matakaoa sandy loam (56b)[1]

Erosion: *Present:* Negligible (0), negligible to slight gully (0–1G)
Potential: Slight wind, rill, sheet, and gully when cultivated. Slight gully under pasture

Vegetation: Improved pasture (gI), semi-improved pasture (gS), root and green fodder crops (cR)

Land use: *Present:* Intensive livestock farming, field cropping
Agric. Potential: Horticulture, field cropping, intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter. F: No special measures

Comments: Subject to salt-laden winds, particularly in the area from the Raukokore River mouth to Cape Runaway.

LUC unit: IIw1 (4153 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. Flood plains, swamps, fans, and lower terraces

Description: Flat to gently undulating flood plains in narrow river valleys, subject to occasional flooding and deposition of fine sediment. Soils are generally well drained and highly productive

Reference site: Z15/785556 1 km north-east of Ruatoria on Mangakino – Waiomatatini Road

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF); Orthic Gley Soils (GO); Orthic Brown Soils (BO); Fluvial Raw Soils (WF)
N.Z. Genetic Soil Classification
Recent soils: Manawatu loam, silt loam, and sandy loam (1)[1]; Oweka fine sandy loam(Oaf)[5]; Oweka silt loam (Oa)[5]; Matahiia fine sandy loam (Mif)[5]; Matahiia sandy loam (Mi)[5]
Gleyed Recent soils: Makaraka silt loam (Mr)[4]; Makaraka silty clay loam (Mrc)[4]

Erosion: *Present:* Nil to moderate streambank (0–2Sb)
Potential: Slight wind under cultivation, moderate streambank under any land use

Vegetation: Improved pasture (gI), semi-improved pasture (gS), maize (cM), root and green fodder crops (cR), vegetables, nurseries (cV)

Land use: *Present:* Intensive livestock farming, field cropping
Agric. Potential: Field cropping, horticulture, intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Surface drainage, avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, exclude heavy machinery and cattle when soils are wet, use low-ground-pressure machinery, streambank protection, shelterbelts or artificial shelter. F: Surface drainage, streambank protection, use low-ground-pressure machinery

Comments: This unit is limited more by the risk of flooding and sediment deposition than by impeded drainage, although the latter can occur in places. Being in narrow river valleys, it can receive runoff water from nearby hill slopes, and surfaces can be discontinuous due to a meandering stream.

Inundation by flood water is expected to last 0.5–1.0 day and occur no more than once in 2 years, or last lesser durations no more than once in 1 year. Flood-sediment may be 1–2 cm thick. Sedimentation and/or flooding has little effect on plant survival but will reduce yields of flood-sensitive field crops and lower the productivity of common improved pasture grasses and annual legumes. Growth and survival of permanent horticultural crops will not be impaired.

LUC unit: IIw2 (4697 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Flat to gently undulating flood plains and low-angle fans within the margins of present flooding extents on the Poverty Bay flats, Tolaga Bay flats, and occasionally in the Waiapu River valley. Soils are imperfectly, and less commonly, poorly drained and remain slightly limited by soil wetness after drainage

Reference site: Y18/413734 Pilmers Road

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF); Orthic Gley Soils (GO)
N.Z. Genetic Soil Classification
Recent soils: Matawhero heavy silt loam (2d)[3]; Matawhero clay loam (2e)[3]; Matawhero silt loam (Ma)[4]; Waihirere clay loam (3f)[3]
Gleyed recent soils: Makaraka silt loam (5)[2]; Puhunga silt loam (Pn)[5]; Mangoreia silt loam (Man)[5]; Makauri silt loam (Mk)[4]; Makauri silty clay loam (Mkc)[4]

Erosion: *Present:* Nil to slight streambank (0–1Sb)
Potential: Slight streambank under any land use

Vegetation: Improved pasture (gI), maize (cM), subtropical fruit (cS), kiwifruit (cK), vegetables, nurseries (cV), grapes and berryfruit (cG), pip and stone fruit (cP), root and green fodder crops (cR)

Land use:

Present:	Intensive livestock farming, horticulture (citrus fruit, grapes and kiwifruit, apples, market vegetables), field cropping (maize, process vegetables)
Agric. Potential:	Intensive livestock farming, field cropping, horticulture
Forestry Potential:	Highly productive exotic plantation forestry

Management: A: Surface drainage, avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, exclude heavy machinery and cattle when soils are wet, use low-ground-pressure agricultural machinery, shelterbelts or artificial shelter, irrigation, streambank protection, flood protection.
F: Surface drainage, streambank protection, use low-ground-pressure machinery

Comments: This unit is limited more by imperfect and sometimes poor drainage than by the risk of flooding and accompanying sediment deposition, although flooding can occur during extreme events. Drainage conditions can impair the long-term performance of permanent horticultural crops.

If flooding occurs, inundation can be expected to last 0.5–1.0 day and occur no more than once in 2 years, or last lesser durations and occur no more than once in 1 year. Flood-sediment may be 1–2 cm thick. Sedimentation and/or flooding has little effect on plant survival but can reduce yields of flood-sensitive field crops and lower the productivity of common improved pasture grasses and annual legumes. Growth and survival of permanent horticultural crops will not be impaired by flooding.

This unit is a best-fit option on the Waiapu River valley flats only where Puhunga silt loams and Mangoreia silt loams occur.

LUC unit: IIs1 (4652 ha)

LUC suite: 2. River valley

LUC subsuite: 2a. Intermediate terraces

Description: Flat to undulating intermediate terraces and associated fans, in river valleys east of the Poverty Bay flats. Soils are well to moderately well drained and of moderately low nutrient status, and soil parent materials are various mixtures of sediments from surrounding hill country, loess, or reworked tephra

Reference site: Z15/756549 1 km north of the Waiapu River bridge, near the airstrip

Slope: 0–3° (A, A'), 0–7° (A+B, B+A), 4–7° (B)

Rock type: Loess and fine alluvium over alluvial gravels (terraces with Hikuwai soils — Lo*Af/Gr), fine alluvium or fine alluvium over alluvial gravels (fans with Hoata soils — Af, or Af/Gr), weathered, mainly rhyolitic tephra, admixed with fine alluvium over alluvial gravels (terraces with Pakira soils — Mo*Af/Gr), loess and fine alluvium (Lo+Af)
Note: Weathered tephric materials are reworked, being admixed with alluvium and loess

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Allophanic Soils (LO); Orthic Gley Soils (GO)
N.Z. Genetic Soil Classification
Yellow-brown earths: Hikuwai fine sandy loam (Hif)[5]; Hikuwai silt loam (4)[2]; Hikuwai mottled silt loam (Him)[5], (4A)[2]
Recent soils: Hoata silt loam (Hoa)[5]
Yellow-brown loams: Pakira sandy loam (8)[2]

Erosion: *Present:* Negligible to slight streambank (0–1Sb)
Potential: Slight deposition (on fans), slight streambank under any land use

Vegetation: Improved pasture (gI), semi-improved pasture (gS), maize (cM), root and green fodder crops (cR)

Land use:
Present: Intensive to semi-intensive livestock farming, field cropping (maize, root fodder crops), occasional horticulture (citrus fruit, grapes and kiwifruit, market vegetables)
Agric. Potential: Field cropping (root and green fodder, maize), horticulture (citrus, grapes), intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter, irrigation, surface drainage. F: No special measures

Comments: This LUC unit occurs mainly in the Waiapu River valley, and occasionally elsewhere in eastern river valleys. Terraces with significant reworked tephra (Pakira soils) are similar to LUC unit IIs3, but have been included with IIs1 to maintain consistency regarding representative landforms (i.e., intermediate terraces in river valleys). The main difference between the two units is that IIs1 comprises a mixture of reworked materials that give a wide range of soil properties, whereas IIs3 comprises mostly loess and air-fall tephra.

There is a slight risk of localised flooding and sandy/silty sedimentation on fans where Hoata soils are recorded.

LUC unit: IIs2 (532 ha)

LUC suite: 2. River valley

LUC subsuite: 2c. Gravels

Description: Flat to undulating well-drained low and intermediate river terraces, with gravelly subsoils. Soils contain no more than 5–15% gravels to >45 cm depth from the soil surface, and this slightly gravelly soil overlies gravels

Reference site: Z15/858623 Waiomatatini

Slope: 0–3° (A), 0–7° (A+B)

Rock type: Fine alluvium over alluvial gravels (Af/Gr), fine alluvium admixed with alluvial gravels over gravels (Af*Gr/Gr)

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Fluvial Recent Soils (RF); Orthic Gley Soils (GO); Fluvial Raw Soils (WF)
N.Z. Genetic Soil Classification
Yellow-brown loams and Recent soils: Kopua silt loam (78)[1]; Pakira sandy loam (8)[2]; Oweka shallow sandy loam (1A)[2]; Matahiia gravelly sandy loam (Mig)[5]; Takamore gravelly fine sandy loam (Tag)[5]

Erosion: *Present:* Nil to slight streambank (0–1Sb)
Potential: Negligible to slight wind, slight streambank when cultivated. Slight streambank under any land use

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM)

Land use: *Present:* Intensive and semi-intensive livestock farming
Agric. Potential: Intensive livestock farming, field cropping, horticulture
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts and artificial shelter, irrigation, streambank protection.
F: Streambank protection

Comments: Subject to summer droughts. Soils contain some tephric material. Old river beds over small parts of some map polygons may be too bouldery for feasible cropping. Lowest areas may experience occasional flooding and deposition of sandy/gravelly sediment.

LUC unit: IIs3 (1775 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4b. Lowland

Description: Flat to undulating high inland terraces below 550 m a.s.l., mantled by at least 35 cm depth of weathered tephra

Reference site: Z15/776564 4 km north of the Waiapu bridge

Slope: 0–7° (A+B, A'+B), 0–3° (A, A'), 4–7° (B', B)

Rock type: Weathered, mainly rhyolitic tephra (Mo), often over alluvial gravels (Mo/Gr), sometimes admixed with loess over alluvial gravels (Mo*Lo/Gr)

Soil:
N.Z. Soil Classification soil groups
F: Orthic Allophanic Soils (LO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL)
R: Orthic Allophanic Soils (LO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Matakaoa sandy loam (56b)[1], (9)[2], (Mak)[5]

Erosion:
Present: Negligible (0), negligible to slight streambank (0–1Sb), gully (0–1G)
Potential: Slight sheet, rill, wind, gully, and streambank when cultivated. Slight gully and streambank under pasture

Vegetation: Improved pasture (gI)

Land use:
Present: Semi-intensive livestock farming
Agric. Potential: Intensive livestock farming, field cropping (root and green fodder, maize), horticulture (citrus, grapes, and subtropical stone fruit)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter, irrigation, streambank protection. F: Streambank protection

Comments: The porous low-density soils have a low nutrient status due to leaching from high annual average rainfalls (>1600 mm, and further inland, as high as 2000 mm) and strong phosphorus fixation, but upper soil horizons have excellent physical properties due to the presence of allophane-enriched weathered tephric soil material. Loess materials increase progressively deeper in subsoils, to depths where gravelly terrace deposits are encountered. Undulating microtopography can impart a complex soil pattern, giving variable drainage and subsoil properties.

North of the Waiapu River valley this LUC unit is associated more with Brown Soils rather than Allophanic Soils. Here P-retention does not exceed 85%, and because of this, Allophanic Soils can not be classified. Nevertheless, soils retain the morphological character of Allophanic soils.

The high terraces are the isolated remnants of a once broad alluvial plain.

LUC unit: IIIe1 (784 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4b. Lowland

Description: Rolling to undulating slopes below 550 m a.s.l., on Neogene rocks mantled by at least 35 cm depth of weathered tephra

Reference site: Z16/748390 Te Puia golf course

Slope: 8–15° (C), 4–15° (B+C, C+B)

Rock type: Weathered, mainly rhyolitic tephra (Mo) over bedded mudstone (Mo/Mb), frittered mudstone (Mo/Mf), sheared mixed lithologies (Mo/Mx), unconsolidated sands and gravels (Mo/Us), etc.
Note: Provided that slopes are stable, and the depth and coverage of weathered tephra is sufficient, this unit may be recorded on any rock type. However, weaker rocks such as Mf often underlie the rolling land of this unit

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO)
R: Orthic Allophanic Soils (LO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL); Tephric Recent Soils (RT); Immature Pallic Soils (PI)
N.Z. Genetic Soil Classification
Yellow-brown loams: Patoka fine sandy loam (49)[1]; Tutira sandy loam (49a)[1]; Matakaoa sandyloam (56b)[1], (9)[2], (Mak)[5]

Erosion: *Present:* Negligible (0), negligible to slight riparian slip (0–1Rs)
Potential: Moderate sheet and rill, slight riparian slip when cultivated. Slight riparian slip under pasture

Vegetation: Improved pasture (gI), root and green fodder crops (cR)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder, maize)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter, contour cultivation. F: No special measures

Comments: While rolling land is typical, the unit can also include easier-sloping broad interfluves, dissected by shallow gullies (commonly in bedded mudstone country).

Rainfall increases from about 1200 mm/yr near the coast to about 1800 mm inland (sometimes 2000 mm inland). At higher annual rainfalls, reduced cropping versatility occurs and there is increased risk of sheet and rill erosion when cultivated. Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IIIe1) is interpreted if most land lies below the isohyet, and upland (IIIe3) if most land lies above.

North of the Waiapu River valley this LUC unit is associated more with Brown Soils rather than Allophanic Soils. Here, P-retention does not exceed 85%, and because of this, Allophanic Soils can not be classified. Nevertheless, soils retain the morphological character of Allophanic Soils.

LUC unit: IIIe2 (1519 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4a. Coastal

Description: Rolling to undulating marine benches and terraces adjacent to the coast, mantled by at least 35 cm depth of weathered tephra

Reference site: Z14/792907 Matakaoa Point Road

Slope: 4–15° (C+B, B+C), 8–15° (C), 4–7° (B)

Rock type: Weathered, mainly rhyolitic tephra (Mo), sometimes on massive sandstone (Mo/Sm), bedded sandstone (Mo/Sb), massive mudstone (Mo/Mm), bedded mudstone (Mo/Mb), unconsolidated sands and gravels (Mo/Us), ancient volcanics (Mo/In), or combinations of these (e.g., Mo/Sm+Us)
Notes: Us materials are either Quaternary beach deposits, undifferentiated intermediate and high terrace deposits, or Waipaoa Formation. Ancient volcanics are the basaltic Matakaoa Volcanics

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO)
R: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL)
N.Z. Genetic Soil Classification
Yellow-brown loams: Te Kaha sandy loam (52)[1]; Tikirau loam (11)[2]; Matakaoa sandy loam, rolling phase (9A)[2]

Erosion: *Present:* Negligible (0), negligible to slight sheet (0–1Sh), wind (0–1W), gully (0–1G)
Potential: Moderate sheet, rill, and wind, slight gully when cultivated. Slight sheet, wind, and gully under pasture

Vegetation: Improved pasture (gI), maize (cM), root and green fodder crops (cR)

Land use: *Present:* Semi-intensive livestock farming, field cropping
Agric. Potential: Semi-intensive livestock farming, field cropping
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation, shelterbelts or artificial shelter. F: No special measures

Comments: Subject to salt-laden winds.

Undulating microtopography imparts a complex soil pattern, giving variable drainage and subsoil properties. Soils are not considered highly fertile, but have good physical properties.

This LUC unit occurs mostly north of the Waiapu River valley and here, P-retention is commonly less than 85%, giving Brown rather than Allophanic Soils. Nevertheless, soils retain the morphological character of Allophanic Soils.

LUC unit: IIIe3 (1277 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4c. Upland

Description: Undulating to rolling slopes between 550 and 750 m a.s.l., mantled by at least 35 cm depth of weathered tephra

Reference site: Y16/533142 1.7 km along Tutamoe Road from the junction with Tauwhareparae Road

Slope: 4–7° (B), 4–15° (B+C, C+B), 8–15° (C) — atypical areas of 0–3° (A')

Rock type: Weathered, mainly rhyolitic tephra (Mo), also often recorded on frittered mudstone (Mo/Mf) or bedded mudstone (Mo/Mb).
Note: Provided that the slopes are stable, and that the depth and coverage of the weathered tephra is sufficient, this unit may be recorded on a wide range of rock types. However, mudstones underlie most of the unit

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Allophanic Soils (LO); Orthic Recent Soils (RO); Orthic Gley Soils (GO)
R: Orthic Allophanic Soils (LO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Patoka fine sandy loam (49)[1]; Tutira sandy loam (49a)[1]

Erosion: *Present:* Negligible (0)
Potential: Moderate sheet and rill, slight wind when cultivated. Negligible erosion under pasture

Vegetation: Improved pasture (gI), root and green fodder crops (cR), manuka, kanuka (sM)

Land use:
Present: Semi-intensive livestock farming, field cropping (fodder crops)
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation, surface drainage, shelterbelts or artificial shelter. F: No special measures

Comments: Significant parts of some map polygons have atypically flat to undulating slopes (these areas would be a IIIc if they could be delineated).

Rainfall generally exceeds 1800 mm/yr reducing cropping versatility and increasing the risk of erosion when cultivated. Soils are strongly leached, often with evidence of weak iron accumulation in subsoils. Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IIIe1) is interpreted if most land lies below the isohyet, and upland (IIIe3) if most land lies above.

LUC unit: IIIe4 (2915 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3a. Lowland

Description: Rolling to undulating slopes below 550 m a.s.l., mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra

Reference site: X18/187754 Airstrip at the junction of Pehiri Tahunga and Stafford roads

Slope: 4–15° (B+C, C+B, B'+C), 4–7° (B', B) — B slopes are long

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on massive sandstone (Kt/Mo/Sm), bedded sandstone (Kt/Mo/Sb), frittered mudstone (Kt/Mo/Mf), unconsolidated clays and silts (Kt/Mo/Uf), etc. Notes: (i) where mapped on Uf, the tephra overlies lacustrine muds around the margin of the Poverty Bay flats. (ii) Taupo/Waimihia tephra is recorded as lying directly over the local rock where weathered tephra is <35 cm thick (e.g., Kt/Uf). (iii) Taupo and Waimihia deposits usually occur together, but Waimihia Tephra thins considerably in the northern extent of this LUC unit's distribution

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Pumice Soils (MO); Orthic Allophanic Soils (LO); Orthic Brown Soils (BO); Orthic Gley Soils (GO); Tephric Recent Soils (RT)
R: Orthic Pumice Soils (MO); Orthic Allophanic Soils (LO); Orthic Brown Soils (BO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam (21)[1]

Erosion: *Present:* Negligible to slight tunnel gully (0–1T), gully (0–1G)
Potential: Moderate sheet, rill, and wind, slight tunnel gully when cultivated. Slight tunnel gully, gully and sheet under pasture

Vegetation: Improved pasture (gI), semi-improved pasture (gS), root and green fodder crops (cR), manuka, kanuka (sM)

Land use:

Present:	Semi-intensive and intensive livestock farming, field cropping (root and green fodder)
Agric. Potential:	Semi-intensive livestock farming, field cropping (maize, root and green fodder)
Forestry Potential:	Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation, shelterbelts or artificial shelter, surface drainage of poorly drained inclusions.
F: No special measures

Comments: Light-textured soils are prone to erosion when exposed by cultivation.

While most soils are developed from Taupo Tephra over Waimihia Tephra, some soils are from underlying weathered tephra, notably Waiohau Tephra, and these parts of the unit are similar to LUC unit IIIe1, and occur on strongly rolling slope segments where the Taupo and Waimihia deposits have been eroded.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IIIe4) is interpreted if most land lies below the isohyet, and upland (IIIe5) if most land lies above.

LUC unit: IIIe5 (2033 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Undulating to rolling slopes between 550 and 750 m a.s.l., mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra

Reference site: X17/002017 Homebrook on Te Wera Road

Slope: 4–15° (B+C, C+B), 4–7° (B)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra (Kt/Mo), on frittered or bedded mudstone (Kt/Mo/Mb, Kt/Mo/Mf), argillite (Kt/Mo/Ar), unconsolidated clays and silts (Kt/Mo/Uf), sands and gravels (Kt/Mo/Us), or Taupo/Waimihia tephra on massive sandstone (Kt/Sm), etc.
Notes: (i) Taupo/Waimihia tephra is recorded as lying directly over the local rock where weathered tephra is <35 cm thick (e.g., Kt/Sm). (ii) Taupo and Waimihia deposits usually occur together, but Waimihia Tephra thins considerably in the northern extent of this LUC unit's distribution

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Podzols (ZO); Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO)
R: Orthic Podzols (ZO); Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Patoka fine sandy loam (49)[1]; Matawai sandy loam (22)[1]

Erosion: *Present:* Negligible to slight tunnel gully (0–1T), sheet (0–1Sh)
Potential: Moderate sheet, rill, and wind, slight tunnel gully when cultivated. Slight tunnel gully and sheet under pasture

Vegetation: Improved pasture (gI), semi-improved pasture (gS), root and green fodder crops (cR)

Land use: *Present:* Intensive and semi-intensive livestock farming, field cropping (root and green fodder)
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation, shelterbelts or artificial shelter, surface drainage of poorly drained inclusions.
F: No special measures

Comments: Light-textured soils are prone to erosion when exposed by cultivation.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IIIe4) is interpreted if most land lies below the isohyet, and upland (IIIe5) if most land lies above.

LUC unit: IIIw1 (7374 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Flat to gently undulating wide flood plains and low-angle fans, mainly on the Poverty Bay and Tolaga Bay flats, and occasionally in the Waiapu River valley, with poorly drained soils, and within the limits of flooding for extreme events

Reference site: Y18/341728 Junction of Pipiwhakao Road and Highway 36

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Gley Soils (GO); Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Gleyed Recent soils: Makaraka heavy silt loam (4)[3]; Makaraka clay loam (4a)[3]; Makauri clay loam (5)[3]; Makauri clay loam, friable subsoil phase (5a)[3]; Makauri silty clay loam (Mkc)[4]; Kaiti silt loam (6)[3]; Kaiti heavy silt loam (6b)[3], Kaiti clay loam (6c)[3], Kaiti clay loam, shallow topsoil phase (6d)[3]; Waihoata silt loam (Wo)[5]
Gley soils: Kaiti silt loam (K)[4]; Kaiti silty clay (Kc)[4]

Erosion: *Present:* Nil (0)
Potential: Slight deposition from flood events under any land use

Vegetation: Improved pasture (gI), maize (cM), subtropical fruit (cS), root and green fodder crops (cR)

Land use:

Present:	Semi-intensive and intensive livestock farming, field cropping (fodder cropping, maize, process vegetables) and horticulture (market vegetables)
Agric. Potential:	Intensive livestock farming, field cropping (e.g., maize, process vegetables, root and green fodder cropping), horticulture (e.g., market vegetables)
Forestry Potential:	Poorly productive exotic plantation forestry

Management: A: Surface and subsurface drainage, incorporate green manure or crop residues into soils, exclude heavy machinery and cattle when soils are wet, use low-ground-pressure machinery, irrigation, streambank protection, flood protection. F: Exclude heavy machinery when soils are wet, streambank protection

Comments: While flooding is possible during extreme events, this unit is limited more by poor drainage. Drainage conditions can impair long-term performance, and, ultimately, survival of permanent horticultural crops sensitive to drainage conditions, e.g., kiwifruit. However, a wide variety of permanent horticultural and arable crops on much of this unit suggests that the land is used like a class II. Nevertheless, poor growing conditions imposed by wetter than normal winters on Gley Soils justifies class III assessments.

If flooding occurs, inundation by flood water is expected to last 1–2 days and occur no more than once in 1 year, or last 2–3 days and occur no more than once in 2 years. Sandy/silty/clayey flood-sediment may be 2–4 cm thick. Sedimentation and/or flooding will kill flood-sensitive field crops, reduce yields of other field crops and common improved pasture grasses and annual legumes, but have little effect on permanent horticultural crops provided the sediment around plants is removed.

This unit is a best-fit option on the Waiapu River valley flats only where Waihoata silt loams occur.

LUC unit: IIIw2 (406 ha)

LUC suite: 2. River valley

LUC subsuite: 2a. Intermediate terraces

Description: Flat to gently undulating intermediate terraces, mainly in eastern river valleys, with imperfectly to poorly drained soils of moderately low nutrient status and with clayey subsoils. Soil parent materials are various mixtures of sediments from surrounding hills, loess, or reworked tephra

Reference site: Z15/748528 3 km south-west of Ruatoria adjacent to Highway 35

Slope: 0–3° (A)

Rock type: Fine alluvium (Af), occasionally fine alluvium and peat over alluvial gravels (Af*Pt/Gr), weathered, mainly rhyolitic tephra, admixed with fine alluvium over alluvial gravels (Mo*Af/Gr), fine alluvium over alluvial gravels (Af/Gr), etc.
Note: Weathered tephric material is almost certainly reworked, being admixed with alluvium and loess

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Gley Soils (GO), Orthic Brown Soils (BO)
N.Z. Genetic Soil Classification
Gley soils: Papawera clay loam (Pwc)[5]
Note: includes Kakarangi peaty sandy loam (Kap)[5] on a best-fit basis (peaty materials are not typical of the unit)

Erosion: *Present:* Nil (0), negligible to slight gully (0–1G)
Potential: Nil to slight localised deposition from adjacent hillslopes and slight gully under any land use

Vegetation: Improved pasture (gI), maize (cM), root and green fodder cropping (cR)

Land use:

Present:	Semi-intensive livestock farming, field cropping (green fodder, maize)
Agric. Potential:	Semi-intensive livestock farming, field cropping (maize, green fodder)
Forestry Potential:	Poorly to moderately productive exotic plantation forestry

Management: A: Surface and subsurface drainage, incorporate green manure or crop residues into soils, exclude heavy machinery and cattle when soils are wet, use low-ground-pressure machinery, irrigation, streambank protection, flood protection. F: Exclude heavy machinery when soils are wet

Comments: This LUC unit is mainly in the Waipaoa River valley but it may be found in scattered localities elsewhere in eastern river valleys.

Effective drainage is difficult. Drainage conditions can impair the long-term performance, and ultimately, the survival of permanent horticultural crops sensitive to poor drainage. There is a slight risk of localised flooding and sandy/silty sedimentation on fans.

LUC unit: IIIw3 (18 362 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. Flood plains, swamps, fans, and lower terraces

Description: Flat to undulating narrow flood plains and low terraces in river valleys, subject to runoff from surrounding hills and flooding, usually accompanied by deposition of fine sediment

Reference site: Y17/641030 Takapau, junction of Arakihi and Tauwhareparae roads

Slope: 0–3° (A), 0–7° (A+B, B+A)

Rock type: Fine alluvium (Af), occasionally over Alluvial gravels (Af/Gr)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF); Orthic Gley Soils (GO); Fluvial Raw Soils (WF)
R: Immature Pallic Soils (PI); Orthic Brown Soils (BO); Orthic Gley Soils (GO); Fluvial Recent Soils (RF); Allophanic Brown Soils (BL)
N.Z. Genetic Soil Classification
Recent Soils: Manawatu loam, silt loam, and sandy loam (1)[1]; Oweka sandy loam (1)[2]; Oweka fine sandy loam (Oaf)[5]; Oweka silt loam (Oa)[5]; Tokata clay loam (3)[2]; Makaraka silt loam (Mr)[4]; Makaraka silt loam, sandy loam subsoil phase (Mrs)[4]; Makaraka silty clay loam (Mrc)[4]; Waipaoa clay loam (1b)[3]; Matawhero heavy silt loam (2b)[3]; Waihirere silt loam (3)[3]; Waihirere heavy silt loam (3c)[3]; Waihirere heavy silt loam, mottled subsoil phase (3e)[3]; Waihirere clay loam (3f)[3]
Gleyed Recent Soils: Makaraka clay loam (4a)[3]

Erosion: *Present:* Negligible to moderate streambank (0–2Sb), negligible to slight deposition (0–1D)
Potential: Moderate streambank and deposition, slight gully under any land use

Vegetation: Improved pasture (gI); rushes, sedges (hR); maize (cM), root and green fodder crops (cR)

Land use:

Present:	Semi-intensive livestock farming, field cropping (maize, root and green fodder)
Agric. Potential:	Intensive livestock farming, field cropping (maize, root and green fodder)
Forestry Potential:	Poorly to moderately productive exotic plantation forestry

Management: A: Surface and subsurface drainage, incorporate green manure or crop residues into soils, exclude heavy machinery and cattle when soils are wet, use low-ground-pressure machinery, streambank protection, flood protection. F: Exclude heavy machinery when soils are wet, streambank protection, surface drainage

Comments: This unit is limited more by the risk of flooding and sediment deposition than by impeded drainage, although the latter still occurs. Generally, the soils are moderately well drained but localised poor drainage is common. Being in narrow river valleys, this unit receives runoff water from nearby hill slopes, and surfaces are discontinuous due to meandering streams.

Inundation by flood water is expected to last 1–2 days and occur no more than once in 1 year, or last 2–3 days and occur no more than once in 2 years. Sandy/silty/clayey flood-sediment may be 2–4 cm thick. Sedimentation and/or flooding will kill flood-sensitive field crops, reduce yields of other field crops, common improved pasture grasses, and annual legumes, but have little effect on permanent horticultural crops provided the sediment around plants is removed.

LUC unit: IIIw4 (1035 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Flat to undulating low terraces with Waipaoa soils, now protected from flooding and sediment deposition by Waipaoa River Control Scheme flood-protection works

Reference site: Y18/379785 Between Ferry and Brown roads, Waerenga-a-hika

Slope: 0–3° (A), 0–7° (A+B)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Recent soils: Waipaoa heavy silt loam (1a)[3]; Waipaoa clay loam (1b)[3]; Waipaoa silt loam (1)[3]

Erosion: *Present:* Negligible (0)
Potential: Slight deposition under any land use

Vegetation: Improved pasture (gI), maize (cM), grapes and berryfruit (cG), root and green fodder crop (cR)

Land use:

Present:	Semi-intensive livestock farming, field cropping (maize, root and green fodder), horticulture (grapes)
Agric. Potential:	Semi-intensive livestock farming, horticulture (grapes, kiwifruit), field cropping (maize, root and green fodder)
Forestry Potential:	Moderately productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, surface drainage, exclude heavy machinery and cattle when soils are wet, incorporate green manure or crop residues into soils, shelterbelts or artificial shelter, irrigation, flood hazard preparedness for extreme events.
F: Exclude heavy machinery when soils are wet

Comments: The long-term risk of serious flooding and fine sediment deposition from large events is reduced by stopbanks of the Waipaoa River Control Scheme. However, the risk of associated ponding limits horticultural potential. Stopbank failure will result in serious flooding and sedimentation. Soils are generally well drained, although imperfectly to poorly drained soils exist. Soils have had insufficient time to develop good structure.

LUC unit: IIIw5 (1221 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Flat to undulating low terraces with Waipaoa soils, acting as a floodway between stopbanks of the Waipaoa River Control Scheme

Reference site: Y18/369794 Lavenham Road, Waituhi

Slope: 0–3° (A), 0–7° (A+B)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Recent soils: Waipaoa heavy silt loam (1a)[3]; Waipaoa clay loam (1b)[3]; Waipaoa silt loam (1)[3]

Erosion: *Present:* Slight to moderate streambank (1–2 Sb), negligible to slight deposition (0–1D)
Potential: Moderate streambank and deposition under any land use

Vegetation: Improved pasture (gI), maize (cM), root and green fodder crops (cR)

Land use: *Present:* Semi-intensive livestock farming, field cropping (maize, root and green fodder)
Agric. Potential: Semi-intensive livestock farming, field cropping (maize, root and green fodder)
Forestry Potential: Unsuitable

Management: A: avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, streambank protection, flood hazard preparedness. F: Not applicable

Comments: The risk of serious flooding and fine sediment deposition from large events limits horticultural potential to the extent that permanent horticultural crops should not be established. Soils are generally well drained, although imperfectly to poorly drained soils exist. Soils have had insufficient time to develop good structure. The physical continuity of the unit is impaired by meanders of the Waipaoa River.

In a normal year, inundation by flood water is expected to last 1–2 days and occur no more than once in 1 year, or last 2–3 days and occur no more than once in 2 years. Sandy/silty/clayey flood-sediment may be 2–4 cm thick (for extreme events, sediment depth will be greater). Sedimentation and/or flooding will kill flood-sensitive field crops, reduce yields of other field crops and lower the productivity of common improved pasture grasses and annual legumes, but have little effect on permanent horticultural crops provided the sediment around plants is removed. In longer return period extreme events, the above indications for this LUC unit are likely to be exceeded, in particular, flood-sediment depth will be much greater than 2–4 cm.

LUC unit: IIIs1 (946 ha)

LUC suite: 2. River valley

LUC subsuite: 2c. Gravels

Description: Flat to gently undulating, well-drained and low river terraces and intermediate terraces with gravelly drought-prone soils. Soils contain no more than 5–15% gravels to a depth of 30–45 cm from the soil surface, and this slightly gravelly soil overlies gravels

Reference site: Z15/786581 Adjacent to Highway 35 and Mangaoporo River

Slope: 0–3° (A)

Rock type: Fine alluvium over alluvial gravels (Af/Gr), alluvial gravels (Gr)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Raw Soils (WF); Orthic Brown Soils (BO); Fluvial Recent Soils (RF); Orthic Recent Soils (RO); Orthic Gley Soils (GO); Sandy Brown Soils (BS)
N.Z. Genetic Soil Classification
Recent soils: Tukituki sandy loam, stony gravel, etc. (1c)[1]; Waiapu stony sands (2)[2]; Waiapu stony sand (Wug)[5]; Oweka shallow sandy loam (Oag)[5]; Matahiia gravelly sandy loam (Mig)[5]

Erosion: *Present:* Nil to moderate streambank (0–2Sb), negligible to slight deposition (0–1D), gully (0–1G)
Potential: Moderate deposition and streambank, slight gully under any land use
Note: Occasionally, map polygons have severe present streambank erosion. This severity level is too high for a class III unit, but the land is included as a best-fit option.

Vegetation: Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM)

Land use:
Present: Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, field cropping (maize, green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, streambank protection, flood protection. F: Streambank protection

Comments: Soils are prone to drought conditions due to sandy textures and paucity of clay, although in some higher rainfall areas (with 1600–2000 mm/yr) the effects of drought may be lessened. Topsoils may contain reworked fine tephric material and this may assist moisture storage.

Map polygons may include more than one terrace level, and in parts may be too bouldery to cultivate. Lowest parts may experience occasional flooding and sedimentation of sands and gravels.

This unit can atypically occur on gravelly beach ridges.

LUC unit: IIIs2 (6177 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3a. Lowland

Description: Undulating to flat intermediate and higher terraces below 550 m a.s.l., mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra

Reference site: Y17/314940 Junction of Whatatutu and Kaitara roads

Slope: 4–7° (B, B'), 0–3° (A, A'), 0–7° (A+B) — B slopes are short

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra (Kt/Mo)
Notes: (i) Sometimes, when tephra deposits are less than 90 cm thick, underlying rock types (usually terrace deposits) are mapped (e.g., Kt/Mo/Us, Kt/Mo/Gr). (ii) Taupo/Waimihia tephra is recorded as lying directly over the local rock where weathered tephra is <35 cm thick (e.g., Kt/Sm). (iii) Taupo and Waimihia deposits usually occur together, but Waimihia Tephra thins considerably in the northern extent of this LUC unit's distribution

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Pumice Soils (MO); Allophanic Brown Soils (BL); Immature Pumice Soils (MI); Orthic Gley Soils (GO); Orthic Brown Soils (BO); Fluvial Recent Soils (RF); Perch-gley Pumice Soils (MP); Orthic Allophanic Soils (LO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam (21)[1]; Mohaka sandy loam (21a)[1]

Erosion: *Present:* Negligible (0)
Potential: Slight sheet, rill, and wind when cultivated. Negligible erosion under pasture

Vegetation: Improved pasture (gI), semi-improved pasture (gS), unimproved pasture (gU), root and green fodder crops (cR), manuka, kanuka (sM), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive livestock farming, field cropping (root and green fodder)
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, surface drainage of depressions. F: Surface drainage of depressions

Comments: Poorly drained shallow depressions on the terraces are common. Soils are light textured and prone to drought where not poorly drained.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IIIs2) is interpreted if most land lies below the isohyet, and upland (IIIc1) if most land lies above.

LUC unit: IIIs3 (836 ha)

LUC suite: 5. Coastal sand and coastal cliffs

LUC subsuite: -

Description: Flat to gently undulating stabilised beach ridges and sand plains with a mantle (up to 30 cm depth) of Taupo/Waimihia tephra

Reference site: Y18/435726 Junction of Cameron and Nelson roads

Slope: 0–3° (A)

Rock type: Taupo/Waimihia tephra over windblown sand (Kt/Wb), windblown sand (Wb)
Notes: (i) Up to 30 cm depth of Taupo/Waimihia tephra over fine beach and dune sand occur north of the Taruheru River (e.g., Kt/Wb). (ii) Waimihia Tephra is absent on these sands south of the Taruheru River. Taupo Tephra remains as a thin veneer and is not recorded in the rock type code (Wb)

Soil: *N.Z. Soil Classification soil groups*
F: Sandy Brown Soils (BS)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Te Hapara sandy loam (9)[3];Te Hapara mottled sandy loam (9a)[3]

Erosion: *Present:* Negligible to slight streambank (0–1Sb), wind (0–1W)
Potential: Slight wind when cultivated, negligible wind under pasture. Slight streambank under any use

Vegetation: Improved pasture (gI), kiwifruit (cK), subtropical fruit (cS), vegetables, nurseries (cV), exotic conifer forest (fF)

Land use:
Present: Semi-intensive livestock farming, field cropping (e.g., maize), horticulture (e.g., market vegetables, kiwifruit), small exotic conifer blocks
Agric. Potential: Semi-intensive livestock farming, field cropping, horticulture
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts or artificial shelter, irrigation, streambank protection. F: No special measures

Comments: This unit is on the fringe of Gisborne City.

Te Hapara mottled sandy loams in shallow depressions experience high watertables.

LUC unit: IIIc1 (3837 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Flat to undulating slopes on elevated inland river terraces between 550 and 750 m a.s.l., mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra on alluvial gravels or other local rock. Poorly drained very shallow depressions on the terraces are common

Reference site: X17/000010 Mahunga, Te Wera Road

Slope: 0–3° (A), 0–7° (A+B)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra (Kt/Mo)
Notes: (i) Taupo and Waimihia deposits usually occur together, but Waimihia Tephra thins considerably in the northern extent of this LUC unit's distribution. (ii) Sometimes, when tephra thickness is less than 90 cm, the underlying terrace deposits are mapped (e.g., Kt/Mo/Us or Kt/Mo/Gr). (iii) Waiohau Tephra is well represented in weathered tephra deposits

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Podzols (ZO); Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO); Orthic Gley Soils (GO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Matawai sandy loam (22)[1]; Gisborne sandy loam (21)[1]

Erosion: *Present:* Negligible to slight gully (0–1G), streambank (0–1Sb), riparian slip (0–1Rs)
Potential: Slight wind when cultivated. Slight gully, riparian slip, and streambank under any use

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming, undeveloped
Agric. Potential: Semi-intensive livestock farming, field cropping (e.g., root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, surface and subsurface drainage, terrace escarpment and drainage channel shrub or tree planting.
F: No special measures

Comments: Frosts, high annual rainfall, and areas of poor drainage impair cropping versatility.

Use of the 1800 mm/yr isohyet can help decide between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IIIs2) is interpreted if most land lies below the isohyet, and upland (IIIc1) if most land lies above.

LUC unit: IIIc2 (1256 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. Flood plains, swamps, fans, and lower terraces

Description: Flat to gently undulating flood plains and low river terraces above 500 m a.s.l., mainly in the upper Motu River valley, dominated by well- to moderately well-drained soils from tephric alluvium, with minor poorly drained infilled channels. Subject to frequent flooding in these channels, but not on the main surface of the flood plain except in extreme events

Reference site: X16/066144 Junction of Kowhai and Motu roads

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)
Note: The alluvium contains a significant amount of tephric material that has been eroded from hills

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF); OrthicBrown Soils (BO); Recent Gley Soils (GR); Orthic Podzols (ZO); Fluvial Raw Soils (WF)
N.Z. Genetic Soil Classification
Recent soils: Manawatu silt loam (1)[1]

Erosion: *Present:* Slight to moderate streambank (1–2Sb)
Potential: Moderate streambank under any use

Vegetation: Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR)

Land use:

Present:	Semi-intensive livestock farming
Agric. Potential:	Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential:	Highly productive exotic plantation forestry in the southern half of the unit's distribution, moderately to poorly productive exotic plantation forestry in northern parts

Management: A: Streambank protection, flood protection, surface drainage (northern parts). F: Streambank protection, flood protection

Comments: Similar (and geographically linked) to IIIc1, but occurs exclusively on lower flood-plain terraces and soils are developed from alluvium rather than air-fall tephra.

Frosts, high annual rainfall, areas of poor drainage, and flood risk in northern parts in particular, and unstable stream banks impair cropping opportunity. Flood risk is mostly localised in old channels. Brown Soils reflect lowest flood risk and older surfaces. In this LUC unit, Taupo Tephra material occurs as a discrete layer in soil profiles, the depth of which indicates the activity of flood deposition since AD 232, being at 150 cm at Kowhai Road to as shallow as 10 cm (in topsoils) closer to Matawai at X16/059077.

LUC unit: IVe1 (2618 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4b. Lowland

Description: Rolling to strongly rolling slopes below 550 m a.s.l., on mainly Neogene rocks, mantled by at least 35 cm depth of weathered tephra

Reference site: Y17/698923 Above Rototahi Station airstrip, 3.5 km north of Waihou Beach Road on Highway 35

Slope: 8–20° (C+D, D+C), 8–15° (C, C'), 16–20° (D) — D slopes are short
Note: C slopes are normal for the related IIIe1 unit, but where land has a potential for severe erosion under cropping on C slopes, IVe1 is used. Marginal thicknesses and coverages of tephra and easily eroded rock types commonly cause this

Rock type: Weathered, mainly rhyolitic tephra over frittered mudstone (Mo/Mf), bedded mudstone (Mo/Mb), or combinations of both (Mo/Mf*Mb), massive sandstone (Mo/Sm), ancient volcanics (Mo/In), argillite or crushed argillite association of rocks (Mo/Ar, Mo/Ac), sheared mixed lithologies (Mo/Mx), unconsolidated sands and gravels (Mo/Us), etc.
Notes: (i) Provided that slopes are stable, and the depth and coverage of weathered tephra sufficient, this unit may be recorded on any rock type. (ii) Occasionally, in eastern margins of tephra extents, patchy weathered tephra can occur (e.g., pMo/Sm), but coverage exceeds 40% of the map polygon. (iii) A veneer of Taupo/Waimihia tephra exists in parts, but is too thin (not >25 cm thick) or poorly distributed (not >20% of the area) to be recorded.

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL)
H: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL) Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown loams: Matakaoa sandy loam (56b)[1], (9)[2], (Mak)[5]; Matakaoa sandy loam, rolling phase (9A)[2]; Patoka fine sandy loam (49)[1]; Tutira sandy loam (49a)[1]; Rototahi sandy loam (50)[1]

Erosion: *Present:* Negligible (0), negligible to slight gully (0–1G), soil slip (0–1Ss), earthflow (0–1Ef)
Potential: Moderate sheet and rill, slight gully when cultivated. Negligible to slight gully, soil slip, or earthflow erosion under pasture

Vegetation: Improved pasture (gI), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, occasional field cropping (root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation, streambank protection. F: Streambank protection

Comments: Rainfall increases from about 1200 mm/yr near the coast to about 1800 mm/yr (sometimes 2000 mm/yr) inland. At higher annual rainfalls, reduced cropping versatility occurs and there is increased risk of sheet and rill erosion when cultivated. Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IVe1) is interpreted if most land lies below the isohyet, and upland (IVe3) if most land lies above.

The related non-arable LUC unit VIe1 is used where strongly rolling (D) slopes are recorded as a single slope class, but only if there is a potential for moderate soil slip erosion under pasture.

LUC unit: IVe2 (1049 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6d. Weber marl

Description: Rolling to undulating slopes in Weber marl with little potential for erosion under permanent vegetation. Often, but not always with a veneer of Taupo/Waimihia tephra

Reference site: Y18/613790 North side of the junction of Glenroy Road and Highway 35

Slope: 4–15° (B+C, C+B), 8–15° (C), 4–7° (B) — B slopes are long

Rock type: Frittered mudstone (Mf), occasionally with crushed argillite association of rocks (Mf+Ac), sometimes with a full or patchy cover of Taupo/Waimihia tephra (pKt/Mf, Kt/Mf), or weathered, mainly rhyolitic tephra (pMo/Mf, Mo/Mf).
Notes: (i) Weber marl (Weber Formation) is a calcareous mudstone or muddy limestone, sometimes sheared and bentonitic, within the Mangatu Group (Paleocene in age). (ii) Patchy and sometimes full covers of Taupo/Waimihia tephra (and occasionally weathered tephra) can occur on stable areas. Patchy tephra is recorded where tephra coverage exceeds 20% of the map polygon — where Taupo/Waimihia tephra exceeds 25 cm thickness, and/or weathered tephra exceeds 35 cm. Full tephra cover is recorded where coverage exceeds 75%.

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Brown Soils (BO); Perch-gley Pallic Soils (PP); Orthic Pumice Soils (MO)
R: Orthic Brown Soils (BO); Perch-gley Pallic Soils (PP); Orthic Gley Soils (GO); Immature Pallic Soils (PI); Allophanic Brown Soils (BL); Orthic Pumice Soils (MO)
N.Z. Genetic Soil Classification
Yellow-brown earths: Pakarae sandy loam (29c)[1]; Pouawa sandy loam (25hb)[1]; Wharekahika sandy loam (10)[2]

Erosion: *Present:* Negligible to slight earthflow (0–1Ef)
Potential: Moderate sheet and rill, slight earthflow and gully when cultivated. Slight earthflow under pasture

Vegetation: Improved pasture (gI), rushes, sedges (hR)

Land use:
Present: Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, occasional green fodder cropping
Forestry Potential: Moderately to poorly productive exotic plantation forestry

Management: Contour cultivation, subsurface drainage, surface drainage, exclude heavy machinery and cattle when soils are wet. F: No special measures

Comments: Weber marl LUC units contain rocks older than Neogene and in this respect are atypical of LUC suite 6. The units are placed in suite 6 because their lithology and behaviour is closer to frittered mudstone than crushed argillite of LUC suite 11.

Weber marl and products of its weathering impede water flow through soils, giving rise to poorly drained subsoils.

For some interpretations, this unit may be considered part of the tephra suites (3: Taupo/Waimihia, or 4: weathered tephra), but only where tephra covers >40% of the map polygon.

LUC unit: IVe3 (2017 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4c. Upland

Description: Rolling to strongly rolling slopes between 550 and 1100 m a.s.l., on mainly Neogene rocks, mantled by at least 35 cm depth of weathered tephra

Reference site: Y16/538197 Tauwhareparae Road, 6 km north of Tutamoe Road junction

Slope: 8–20° (C+D, D+C), 16–20° (D) at elevations between 550 and 1100 m a.s.l.; and 8–15° (C), 4–15° (B+C) at elevations between 750 and 1100 m a.s.l.

Rock type: Weathered, mainly rhyolitic tephra over frittered mudstone (Mo/Mf), bedded mudstone (Mo/Mb), massive sandstone (Mo/Sm), etc.
Notes: (i) Provided that the underlying rock and landform is stable and tephra depth sufficient, this unit may be recorded on other rock types. (ii) There may be a veneer of Taupo/Waimihia tephra, but deposits are usually <25 cm thick and are not recorded

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO); Orthic Podzols (ZO)
R: Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Orthic Brown Soils (BO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Patoka fine sandy loam (49)[1]; Tutira sandy loam (49a)[1]

Erosion: *Present:* Negligible to slight sheet (0–1Sh), rill (0–1R), gully (0–1G)
Potential: Severe sheet and rill, slight gully when cultivated. Slight gully under pasture

Vegetation: Improved pasture (gI), semi-improved pasture (gS), root and green fodder crops (cR), exotic conifer forest (fF), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming, exotic conifer plantation forestry
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Contour cultivation. F: No special measures

Comments: Rainfall is between 1600 and 2400 mm/yr, and most of the unit occurs where rainfall exceeds 1800 mm/yr. Most soils are strongly leached with evidence of weak iron accumulation in subsoils, although processes have not advanced enough for the widespread occurrence of Podzols. Iron accumulation in subsoils is stronger above 750 m a.s.l. Leaching induces lower levels of available soil nutrients.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IVe1) is interpreted if most land lies below the isohyet, and upland (IVe3) if most land lies above.

Areas of undulating to easy rolling land are included in this unit above 750 m a.s.l. as a best-fit option — these would normally be LUC subclass IVc but are too poorly represented in the region to warrant a separate unit.

LUC unit: IVe4 (5471 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3a. Lowland

Description: Rolling to strongly rolling slopes below 550 m a.s.l., on mainly Neogene rocks, mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra

Reference site: X17/300080 1 km south-west of a point 1.5 km along Mangatu Road from the junction with Wairere Road

Slope: 8–15° (C, C'), 8–20° (C+D, D+C), sometimes 16–20° (D) if short

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on frittered mudstone (Kt/Mo/Mf), bedded mudstone (Kt/Mo/Mb), massive sandstone (Kt/Mo/Sm), bedded sandstone (Kt/Mo/Sb), unconsolidated clays and silts (Kt/Mo/Uf), etc.
Notes: (i) Where mapped on Uf, the tephra overlies lacustrine muds around the margin of the Poverty Bay flats. (ii) Taupo/Waimahia tephra is recorded as lying directly on the underlying rock where weathered tephra is <35 cm thick (e.g., Kt/Mf). (iii) Taupo and Waimihia deposits usually occur together in the region, but Waimihia Tephra thins considerably toward the northern extent of this unit's distribution

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Pumice Soils (MO), Orthic Gley Soils (GO); Fluvial Recent Soils (RF)
R: Orthic Pumice Soils (MO); Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Orthic Gley Soils (GO)
H: Orthic Pumice Soils (GO); Orthic Brown Soils (BO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam (21)[1]; Matawai sandy loam (22)[1]

Erosion: *Present:* Negligible to slight sheet (0–1Sh), tunnel gully (0–1T), gully (0–1G)
Potential: Severe sheet and rill, moderate wind, slight tunnel gully and gully, and earthflow when cultivated. Slight sheet, tunnel gully, gully, and earthflow under pasture

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation, shelterbelts or artificial shelter, surface drainage of poorly drained inclusions. F: No special measures

Comments: While strongly rolling slopes (D) without rolling slope-inclusions indicates LUC unit VIe7, sometimes these slopes are mapped as IVe4 where tephra is particularly well represented and slopes are very stable.

On some parts, allophanic soil material is >35 cm thick and Allophanic Soils are recorded, while in other parts, Taupo/Waimihia tephra and the weathered tephra do not meet the criteria for Pumice Soils or Allophanic Soils. Soil variability is high. A predominance of light-textured Pumice Soils increases the erosion hazard (when exposed by cultivation) over similar land dominated by Allophanic Soils (such as LUC unit IVe1).

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IVe4) is interpreted if most land lies below the isohyet, and upland (IVe5) if most land lies above.

LUC unit: IVe5 (7953 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Rolling to strongly rolling, sometimes undulating slopes, between 550 and 1100 m a.s.l., mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra on any lithology

Reference site: Y16/408188 Tutamoe Plateau

Slope: 8–15° (C), 8–20° (C+D) at elevations between 550 and 1100 m a.s.l.; and 4–15° (C+B) at elevations between 750 and 1100 m a.s.l.

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra, on a variety of rock types such as massive sandstone (Kt/Mo/Sm), frittered mudstone (Kt/Mo/Mf), argillite (Kt/Mo/Ar), greywacke association of rocks (Kt/Mo/Gw), unconsolidated sands and gravels (Kt/Mo/Us), etc.
Note: Taupo and Waimihia deposits usually occur together in the region, but Waimihia Tephra thins considerably toward the northern extent of this unit's distribution

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Podzols (ZO)
R: Orthic Podzols (ZO); Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO)
H: Orthic Podzols (ZO); Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Matawai sandy loam (22)[1]; Gisborne sandy loam (21)[1]

Erosion: *Present:* Negligible to moderate soil slip (0–2Ss), negligible to slight sheet (0–1Sh), streambank (0–1Sb), gully (0–1G), tunnel gully (0–1T)
Potential: Severe sheet and rill, moderate wind, tunnel gully, soil slip, slight gully and streambank when cultivated. Moderate soil slip, slight sheet, gully, tunnel gully, and streambank under pasture

Vegetation: Podocarp-broadleaved-beech forest (fP), lowland beech forest (fW), semi-improved pasture (gS)

Land use: *Present:* Undeveloped, semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Moderately to poorly productive exotic plantation forestry

Management: A: Contour cultivation. F: No special measures

Comments: This unit is similar to IVc1, but steeper slopes impose a greater erosion hazard when the light-textured soils are exposed by cultivation. In addition to the erosion hazard, cool temperatures and short growing season, frosts, and high annual rainfalls (usually >2000 mm) seriously impair cropping versatility.

Areas of easy rolling to undulating land are included in this unit above 750 m a.s.l. as a best-fit option — these would normally be LUC subclass IVc but are too poorly represented in the region to warrant a separate unit.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (IVe4) is interpreted if most land lies below the isohyet, and upland (IVe5) if most land lies above.

LUC unit: IVw1 (4051 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. Flood plains, swamps, fans, and lower terraces

Description: Flat to undulating narrow flood plains and low terraces in river valleys. Subject to runoff from surrounding hills and frequent flooding, usually accompanied by the deposition of fine sediment

Reference site: Y16/699271 Bridge at Mangaiti, Mata Road

Slope: 0–3° (A, A'), 0–7° (A+B, A'+B), 4–7° (B, B')

Rock type: Fine alluvium (Af), fine alluvium and alluvial gravels (Af+Gr)
Note: Taupo/Waimihia tephra and/or weathered, mainly rhyolitic tephra, or loess/colluvium-covered and more elevated terrace remnants can occur in places (e.g., Af+Kt/Mo)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF); Fluvial Raw Soils (WF); Orthic Gley Soils (GO); Orthic Allophanic Soils (LO)
N.Z. Genetic Soil Classification
Recent soils: Manawatu loam, silt loam, and sandy loam (1)[1]; Waipaoa silt loam (Wp)[4]; Waipaoa sandy loam (Wps)[4]; Waiapu sandy loam (Wu)[5]

Erosion: *Present:* Slight to moderate streambank (1–2Sb), negligible to moderate deposition (0–2D)
Potential: Moderate streambank and deposition, slight gully under any land use

Vegetation: Semi-improved pasture (gS), improved pasture (gI), rushes, sedges (hR)

Land use:

Present:	Semi-intensive livestock farming, undeveloped
Agric. Potential:	Semi-intensive livestock farming, occasional field cropping (fodder)
Forestry Potential:	Unsuitable

Management: A: Surface drainage, streambank protection, flood protection. F: Not applicable

Comments: This unit is limited more by the risk of flooding and sediment deposition than by impeded drainage, although the latter still occurs. Generally, the soils are moderately well drained but poor drainage is common. Being in narrow river valleys, this unit receives runoff water from nearby hill slopes. Surfaces are discontinuous due to meandering streams. Different terrace levels result in different levels of flood risk when map polygons are examined in detail.

Inundation by flood water may last 2–3 days and occur no more than twice in 1 year, or last 3–5 days and occur no more than once in 1 year. Sandy/silty/clayey flood-sediment may be 4–6 cm thick. Sedimentation and/or flooding will kill flood-sensitive field crops and reduce yields of other field crops, making all field cropping marginal; cause significant productivity losses in common improved pasture grasses and annual legume pastures; and reduce yields of permanent horticultural crops and seriously damage these crops unless the sediment from around plants is removed.

LUC unit: IVw2 (707 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. Flood plains, swamps, fans, and lower terraces

Description: Flat to gently undulating, low-lying and poorly drained frequently peaty areas, mainly on swamp margins

Reference site: Z15/818537 North side of Mahora Wairoa Road, 1 km from the Tuparoa Road junction

Slope: 0–3° (A)

Rock type: Fine alluvium and peat (Af+Pt), fine alluvium (Af)

Soil:
N.Z. Soil Classification soil groups
F: Orthic Gley Soils (GO); Humic Organic Soils (OH); Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Organic soils: Poukawa peaty loam (107a)[1]; Te Piki peaty loam (6)[2]; Kaiti silt loam, peaty variant (Kp)[4]

Erosion:
Present: Nil (0)
Potential: Slight streambank and deposition under any land use

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), rushes, sedges (hR), wetland vegetation (hW)

Land use:
Present: Semi-intensive livestock farming and undeveloped
Agric. Potential: Semi-intensive livestock farming, field cropping (green fodder)
Forestry Potential: Unsuitable

Management: A: Surface drainage. F: Not applicable

Comments: This unit is limited more by poor subsoil drainage, high watertables, and periods with standing water, than by the risk of flooding from streams and sedimentation. Effective drainage is difficult due to low topographic position and close association with swamps. If inundation by flood water and sedimentation occurs, the effects are similar to those of IVw1.

LUC unit: IVs1 (944 ha)

LUC suite: 2. River valley

LUC subsuite: 2c. Gravels

Description: Flat to undulating low river terraces, intermediate terraces, and occasionally coastal gravelly ridges, with gravelly, frequently bouldery, drought-prone soils. Soils contain no more than 5–15% gravels to a depth of 15–30 cm from the soil surface, and this slightly gravelly topsoil overlies alluvial gravels

Reference site: Y15/590590 Ohinepoutea, Tapuaeroa Valley Road

Slope: 0–3° (A, A'), 4–7° (B, B')

Rock type: Fine alluvium over alluvial gravels (Af/Gr), alluvial gravels (Gr)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Raw Soils (WF); Fluvial Recent Soils (RF); Orthic Recent Soils (RO); Sandy Brown Soils (BS)
N.Z. Genetic Soil Classification
Recent soils: Tukituki sandy loam, stony gravel, etc. (1c)[1]; Oweka shallow sandy loam (Oag)[5]

Erosion: *Present:* Nil to moderate streambank (0–2Sb), negligible to slight gully (0–1G), deposition (0–1D)
Potential: Moderate deposition, streambank and slight gully under any land use

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), rushes, sedges (hR), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming, field cropping (green fodder)
Agric. Potential: Semi-intensive livestock farming (best for winter grazing), field cropping (maize, green fodder)
Forestry Potential: Highly productive exotic plantation forestry
Note: Shallow soil depth limits forest establishment, and water deficiencies impede early growth rates

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, streambank protection, flood protection. F: Streambank protection

Comments: Soils are prone to drought conditions due to sandy textures and paucity of clay, although in some higher rainfall areas (with 1600–2000 mm/yr) the effects of drought may be lessened. Topsoils may contain reworked fine tephric material and this may assist moisture storage.

Small areas of river bars may be too bouldery for feasible field cropping. Some low areas may experience flooding and deposition of sands/gravels. Map polygons can include more than one terrace level, separated by low (1–2 m) terraces risers.

This unit can atypically occur on gravelly beach ridges.

LUC unit: IVs2 (440 ha)

LUC suite: 5. Coastal sand and coastal cliff

LUC subsuite: -

Description: Flat to gently undulating and undulating older stable sand plains and dunes inland from the coastline

Reference site: Y18/428696 Gisborne Airport grounds off Awapuni Road

Slope: 0–3° (A), 0–7° (A+B)

Rock type: Windblown sand (Wb), occasionally with gravels (Wb+Gr), fine alluvium (Wb+Af), or peat (Wb+Pt)

Soil: *N.Z. Soil Classification soil groups*
F: Sandy Brown Soils (BS); Orthic Gley Soils (GO); Recent Gley Soils (GR)
N.Z. Genetic Soil Classification
Yellow-brown sands: Opoutama loamy sand (8a)[3]

Erosion: *Present:* Negligible to slight wind (0–1W)
Potential: Slight wind under pasture, moderate wind and slight rill erosion when cultivated

Vegetation: Improved pasture (gI), semi-improved pasture (gS)

Land use:
Present: Urban-fringe pasture for hobby farming and other common peri-urban activities, semi-intensive livestock farming, active recreation (golf)
Agric. Potential: Semi-intensive livestock farming (winter grazing), occasional field cropping (root and green)
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, shelterbelts, irrigation. F: No special measures

Comments: This unit is mostly on the fringe of Gisborne City. It is also recorded in some eastern coastal embayments such as Hicks Bay, although the class IV assessment of this area is a best-fit option — the land being somewhat better than a class IV. The small total area of this unit does not justify establishing a related class III LUC unit.

LUC unit: IVs3 (311 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4a. Coastal

Description: Undulating to strongly rolling gravelly terraces and benches adjacent to, or near the coast, usually mantled by various combinations of weathered tephra, coarse slope deposits and/or alluvial gravels

Reference site: Y14/624930 Potikirua Road, 5 km west of Lottin Point

Slope: 4–15° (C+B, B+C), 16–20° (D)

Rock type: Gravels and coarse slope deposits (Gr+Cl), coarse slope deposits with alluvial gravels over ancient volcanics (Cl*Gr/In), fine alluvium (Af), weathered, mainly rhyolitic tephra over unconsolidated sands and gravels (Mo/Us), with coarse slope deposits over ancient volcanics (pMo*Cl/In)
Note: These terraces and benches are cut into basaltic Matakaoa Volcanics, and/or are made up of Waipaoa Formation sands and gravels or younger raised beach deposits. The tephra cover is variable in depth and extent

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO)
R: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Allophanic Soils (LO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Tikirau loam (11)[2]; Matakaoa sandy loam (9)[2]

Erosion: *Present:* Negligible to slight gully (0–1G), soil slip (0–1Ss), wind (0–1W)
Potential: Slight sheet, gully,and wind under pasture; moderate wind and rill, and slight gully when cultivated

Vegetation: Semi-improved pasture (gS), improved pasture (gI)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder), horticulture (sheltered parts give a favourable microclimate)
Forestry Potential: Moderately productive exotic plantation forestry
Note: tree growth may be limited by coastal exposure and suspected element toxicity — see comments

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, surface drainage that includes cut-off drains at the base of nearby hillslopes, contour cultivation, artificial shelter. F: No special measures

Comments: Physical characteristics are highly variable within and between individual map polygons — parts are bouldery, other areas have a significant depth of tephra, and small areas are poorly drained due to seepage from adjacent steep slopes. The unit is limited in area.

Copper-rich seepages from Matakaoa Volcanics are suspected to contribute to *Pinus radiata* mortality at the boundary between this unit and VIIe13.

LUC unit: IVc1 (931 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Flat to easy rolling, upland river terraces, basins, or high benches, mainly in the northern Huiarau Range area between 750 and 1100 m a.s.l., mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra on alluvial gravels or other lithologies

Reference site: W18/775770 Headwaters of the Ruakituri River, Urewera Ranges

Slope: 0–3° (A), 0–7° (A+B), 3–15° (B+C) — C slopes mostly <12°

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on alluvial gravels (Kt/Mo/Gr), massive sandstone (Kt/Mo/Sm), bedded mudstone (Kt/Mo/Mb), etc.

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Podzols (ZO)
R: Orthic Podzols (ZO), Orthic Pumice Soils (MO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Matawai sandy loam (22)[1]; Gisborne sandy loam (21)[1]

Erosion: *Present:* Negligible (0)
Potential: Moderate wind and sheet when cultivated. Negligible erosion under pasture

Vegetation: Podocarp-broadleaved-beech forest (fD), lowland beech forest (fW), upland beech forest (fG)

Land use: *Present:* Undeveloped
Agric. Potential: Semi-intensive livestock farming, field cropping (root and green fodder)
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Avoid cultivation when strong equinoctial winds prevail, roll cultivated soil and avoid excessively fine tilth, contour cultivation. F: No special measures

Comments: Similar to IVe5, but lacks the severe erosion hazard due to less steep slopes. Cool temperatures and short growing season, frosts, and high annual rainfall (usually >2000 mm) limits cropping. However, development seems unlikely due to its isolated positions in the forested ranges.

LUC unit: VIe1 (7966 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4b. Lowland

Description: Strongly rolling to moderately steep slopes in stable hill country below 550 m a.s.l., on Neogene or Quaternary rocks mantled by at least 35 cm depth of weathered tephra

Reference site: Y14/681880 Wharekahika Valley, 11 km west of Hicks Bay, Highway 35

Slope: 16–25° (D+E, E+D), 16–20° (D)

Rock type: Weathered, mainly rhyolitic tephra on massive sandstone (Mo/Sm), frittered mudstone (Mo/Mf), bedded mudstone (Mo/Mb), unconsolidated sands and gravels (Mo/Us), etc.
Note: A veneer of Taupo/Waimihia tephra exists in parts, but is usually too thin (i.e., <25 cm) or poorly distributed (<20% of the area) to be recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Orthic Brown Soils (BO); Tephric Recent Soils (RT)
H: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown loams: Matakaoa sandy loam (56b)[1], (9)[2], (Mak)[5]; Matakaoa hill soils (9H)[2]; Patoka fine sandy loam (49)[1]; Patoka fine sandy loam, hill soil (49H)[1]; Tutira sandy loam (49a)[1]; Tutira sandy loam, hill soil (49aH)[1]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), gully (0–1G)
Potential: Moderate soil slip and slight gully under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Open-plant trees, plant trees along banks of hillslope channels. F: No special measures

Comments: Along with VIe2, this unit represents the most versatile and productive hill country in the region.

Rainfall increases from about 1200 mm/yr near the coast to about 1800 mm/yr (sometimes 2000 mm/yr) inland. Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (VIe1) is interpreted if most land lies below the isohyet, and upland (VIe5) if most land lies above.

The related arable LUC unit IVe1 is used where strongly rolling (D) slopes are recorded as a single slope class, but only if there is no significant potential for soil slip erosion under permanent vegetation.

LUC unit: VIe2 (7827 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6a. Frittered mudstone
6b. Massive mudstone

Description: Strongly rolling to moderately steep and sometimes rolling slopes, in Neogene mudstone hill country, with or without a cover of Taupo/Waimahia tephra or weathered tephra

Reference site: Z17/726991 2 km south of Tolaga Bay, west of Highway 35

Slope: 16–20° (D), 16–25° (D+E, E+D), sometimes 8–20° (D+C)

Rock type: Frittered mudstone (Mf) and occasionally massive mudstone (Mm), frequently with patchy tephra, e.g., Taupo/Waimihia tephra (pKt/Mf), or weathered, mainly rhyolitic tephra (pMo/Mf).
Notes: (i) Frittered or massive Neogene mudstone sequences where bedding is either absent, faint or poorly developed, commonly in Tolaga Group rocks. (ii) Patchy Taupo/Waimihia tephra and/or weathered tephra occur on stable slope segments — especially west of the Poverty Bay flats. Patchy tephra is recorded where coverage >20% and <75% of the map polygon.

Soil: *N.Z. Soil Classification soil groups*
R: Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Orthic Recent Soils (RO)
H: Orthic Brown Soils (BO); Immature Pallic Soils (PI); Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown earths: Mangatea clay loam and silt loam, hill soil (25H)[1]; Kourarau silt loam, hill soil (25cH)[1]

Erosion: *Present:* Slight to moderate (mostly slight) earthflow (1–2Ef), negligible to slight soil slip (0–1Ss), gully (0–1G)
Potential: Moderate earthflow, slight soil slip, gully, and riparian slip under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Open-plant trees, plant trees along banks of hillslope channels. F: Exclude heavy machinery when soils are wet

Comments: Along with VIe1, this unit represents the most versatile and productive hill country in the region. Soils have a moderately high nutrient status due to a predominance of base-rich mudstone parent materials and long periods of slope stability. Most of VIe2 is in the lowland (<550 m a.s.l.) and benefits from better growing conditions than upland areas.

For interpretations requiring the recognition of tephra, consideration of this LUC unit as part of LUC suites 3 or 4 (according to the type of tephra) is justified when tephra coverage exceeds 40% of the map polygon.

LUC unit: VIe3 (8955 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4b. Lowland

Description: Moderately steep to steep and minor strongly rolling slopes in stable hill country below 550 m a.s.l., on Neogene or Quaternary rocks, mantled by weathered tephra of variable depth

Reference site: Y14/674885 Wharekahika Valley, just north of Highway 35, 12 km west of Hicks Bay

Slope: 21–25° (E), 21–35° (E+F), occasionally 16–25° (E+D)

Rock type: Weathered, mainly rhyolitic tephra over massive sandstone (Mo/Sm), frittered mudstone (Mo/Mf), bedded mudstone (Mo/Mb), bedded sandstone (Mo/Sb), etc. Tephra cover is frequently patchy (e.g., pMo/Mf). Notes: (i) Tephra overlies a variety of stable Neogene rocks from, e.g., Mangaheia Group, Tolaga Group and upper Mangatu Group. (ii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon, but in this LUC unit, coverage exceeds 40%. (iii) A veneer of Taupo/Waimihia tephra exists in parts, but deposits are usually too thin (i.e., <25 cm) to be recorded

Soil: *N.Z. Soil Classification soil groups*
R: Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Orthic Brown Soils (BO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Allophanic Brown Soils (BL); Tephric Recent Soils (RT); Orthic Allophanic Soils (LO); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown loams: Matakaoa hill soils (9H)[2]; Patoka fine sandy loam, hill soil (49H)[1]; Tutira sandy loam, hill soil (49aH)[1]

Erosion: *Present:* Negligible to moderate soil slip (1–2Ss), negligible to slight gully (0–1G), slight sheet (0–1Sh)
Potential: Moderate soil slip, slight gully, riparian slip, and sheet under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), fern (sF), mixed indigenous scrub (sX), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Open-plant trees, plant trees along banks of hillslope channels. F: No special measures

Comments: This unit contrasts with VIe1 by having steeper and/or longer slopes; shallower, often patchy tephra cover; and more frequent soil slip scars. However, as in VIe1, the essence of this LUC unit remains, which is a good cover of weathered tephra, and if patchy, tephra usually exceeds 40% coverage.

Rainfall increases from about 1200 mm/yr near the coast to about 1800 mm/yr (sometimes 2000 mm/yr) inland. Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (VIe3) is interpreted if most land lies below the 1800 mm isohyet, and upland (VIe8) if most land lies above.

LUC unit: VIe4 (2500 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Strongly rolling to rolling slopes in low hill country on crushed argillite, argillite, or sheared mixed lithologies (melange), with or without a cover of weathered tephra, with potential for moderate earthflow and slight gully

Reference site: Z15/700470 1 km south-west of the junction of Makarika Road and Highway 35

Slope: 16–20° (D), 8–20° (D+C, C+D), 8–15° (C)

Rock type: Crushed argillite association of rocks (Ac), argillite (Ar), sheared mixed lithologies (Mx), or combinations of these (e.g., Ar+Mx), sometimes with a patchy cover of weathered, mainly rhyolitic tephra (pMo/Ac, pMo/Mx, etc.)
Notes: (i) Recorded in allocthonous rock terrain. (ii) Includes Whangai Formation and other Paleogene and Cretaceous fine-grained indurated material. More stable parts of melange zones (usually Mx) are included. (iii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Gley Soils (GO); Immature Pallic Soils (PI)
R: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Immature Pallic Soils (PI); Orthic Gley Soils (GO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Immature Pallic Soils (PI); Allophanic Brown Soils (BL)
N.Z. Genetic Soil Classification
Yellow-brown earths: Tinui silt loam and Waikura sandy loam (28)[1]; Tinui silt loam and Waikura sandy loam, hill soil(28H)[1]
Yellow-brown loams: Matakaoa sandy loam (56)[1]; Matakaoa sandy loam, hill soil (56bH)[1]

Erosion: *Present:* Negligible to slight earthflow (0–1Ef), gully (0–1G), soil slip (0–1Ss)
Potential: Moderate earthflow, slight gully, soil slip, and streambank under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), rushes, sedges (hR)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Open-plant trees, plant trees along banks of hillslope channels, surface drainage. F: Exclude heavy machinery when soils are wet

Comments: This unit occurs mostly in the lowland (<550 m a.s.l.), and is considered the most productive parts of hill country farms in areas where this unit is recorded. The landscape is subdued. The potential for characteristic crushed argillite erosion forms is considerably lower than for other units in LUC suite 11, with gully erosion potential being slight and gullies shallow and easier to manage. Earthflows likewise are easier to manage than earthflows on related class VI and VII units in the suite.

For interpretations requiring recognition of weathered tephra, consideration of this LUC unit as part of LUC suite 4 is justified when tephra coverage exceeds 40% of the map polygon.

LUC unit: VIe5 (6816 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4c. Upland

Description: Strongly rolling to moderately steep slopes in stable hill country between 550 and 1100 m a.s.l., on Neogene rocks, mantled by at least 35 cm depth of weathered tephra

Reference site: Y16/554236 1 km north along Puketawa (Matanui Stn) Road from the junction with Fernside Road

Slope: 16–25° (D+E, E+D), 16–20° (D)

Rock type: Weathered, mainly rhyolitic tephra over frittered mudstone (Mo/Mf), bedded mudstone (Mo/Mb), sometimes limestone (Mo/Li), etc.
Notes: (i) Tephra covers a variety of stable Neogene rocks, mainly from Tolaga and Mangaheia Groups. (ii) A veneer of Taupo/Waimihia tephra occurs in places, but depsoits are usually too thin (i.e., <25 cm) or poorly distributed (<20% of the area) to be recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Orthic Podzols (ZO); Allophanic Brown Soils (BL)
H: Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Orthic Recent Soils (RO); Orthic Podzols (ZO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Patoka fine sandy loam (49)[1]; Patoka fine sandy loam, hill soil (49H)[1]; Tutira sandy loam (49a)[1]; Tutira sandy loam, hill soil (49aH)[1]; Matakaoa sandy loam (56b)[1], (9)[2], (Mak)[5]; Matakaoa hill soils (9H)[2]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss)
Potential: Moderate soil slip and slight gully under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), manuka, kanuka (sM)

Land use:

Present:	Semi-intensive livestock farming
Agric. Potential:	Semi-intensive livestock farming
Forestry Potential:	Moderately to highly productive exotic plantation forestry

Management: A: Open-plant trees, plant trees along banks of hillslope channels. F: No special measures

Comments: Rainfall is between 1600 and 2400 mm/yr, and most of the unit occurs where rainfall exceeds 1800 mm/yr. Most soils are strongly leached with evidence of weak iron accumulation in subsoils, being more strongly expressed above 750 m a.s.l. Leaching induces lower levels of available soil nutrients.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (VIe1) is interpreted if most land lies below the isohyet, and upland (VIe5) if most land lies above.

LUC unit: VIe6 (1701 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6a. Frittered mudstone

Description: Strongly rolling to moderately steep and sometimes rolling slopes on old slumped features in Neogene rock terrain, presently inactive, but with potential for re-activation following a major triggering event. They can be incised by shallow gullies and often have shallow earthflows on their surface. Slumps are usually mantled unevenly by various tephra

Reference site: Y17/604980 Rangikohua Road, near the junction with Kiore Road

Slope: 15–20° (D), 15–25° (D+E), 8–20° (D+C)

Rock type: A range of Neogene lithologies are mapped, most commonly frittered mudstone (Mf), sometimes with a full or patchy cover of Taupo/Waimihia tephra on weathered, mainly rhyolitic tephra (Kt/Mo/Mf), or weathered, mainly rhyolitic tephra (pMo/Mf). Mf is common, even in terrain dominated by other lithologies, because the process of slumping destroys rock-mass structures

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Podzols (ZO); Immature Pallic Soils (PI); Tephric Recent Soils (RT); Orthic Gley Soils (GO)
H: Immature Pallic Soils (PI), Tephric Recent Soils (RT); Orthic Recent Soils (RO); Orthic Brown Soils (BO); Orthic Podzols (ZO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Patoka fine sandy loam (49)[1]; Patoka fine sandy loam, hill soil (49H)[1]; Tutira sandy loam (49a)[1]; Tutira sandy loam, hill soil (49aH)[1]; Matakaoa sandy loam (56b)[1], (9)[2]; Matakaoa hill soils (9H)[2]

Erosion: *Present:* Negligible to moderate gully (0–2G), earthflow (0–2Ef), negligible to slight sheet (0–1Sh), streambank (0–1Sb)
Potential: Moderate gully and earthflow, slight slump, soil slip, and sheet under pasture. Moderate gully, slight slump and streambank under forest

Vegetation: Improved pasture (gI), manuka, kanuka (sM), mixed indigenous scrub (sX)

Land use: *Present:* Semi-intensive livestock farming, field cropping (root and green)
Agric. Potential: Semi-intensive livestock farming, occasional root and green fodder cropping and cultivationnfor pasture renewal
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, re-establish ground cover on eroded areas, open-plant trees, plant trees along banks of hillslope channels, avoid major earthworks in the toe of the old slump, main-channel stabilisation in the toe area. Major utilities should not be built if feasible alternatives exist. F: Main-channel stabilisation in the toe area

Comments: This unit has long-term potential for slump reactivation, but in most cases signs of recent activity (extension cracks, etc.) are rare to absent. Tephra presence indicates most slumps have been stable for thousands of years, but localised activity is common. Similar small slumped features are scattered throughout the region and, due to scale, are mostly incorporated into existing map polygons of other LUC units.

For interpretations requiring recognition of weathered tephra, consideration of this LUC unit as part of LUC suites 3 or 4 (according to the type of tephra) is justified when tephra coverage exceeds 40% of the map polygon.

LUC unit: VIe7 (25 447 ha)

LUC suite: 3. Taupo/Waimihia tephra
LUC subsuite: 3a. Lowland

Description: Strongly rolling to moderately steep slopes in stable hill country below 550 m a.s.l., on mainly Neogene rocks, mantled by at least 25 cm depth of Taupo/Waimihia tephra over a variable depth of weathered tephra

Reference site: X17/293087 Mangatu Road, 1.5 km north of Wairere Road junction

Slope: 16–20° (D), 16–25° (D+E)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on frittered mudstone (Kt/Mo/Mf), massive sandstone (Kt/Mo/Sm), bedded sandstone (Kt/Mo/Sb), massive mudstone (Kt/Mo/Mm), etc.
Notes: (i) Kt is recorded as lying directly over the local parent rock where weathered tephra is <35 cm thick (e.g., Kt/Sb). (ii) Taupo and Waimihia deposits usually occur together, but Waimihia Tephra thins considerably toward the northern extent of this unit's distribution

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO); Allophanic Brown Soils (BL); Orthic Brown Soils (BO); Tephric Recent Soils (RT); Orthic Recent Soils (RO); Perch-gley Pallic Soils (PP)
H: Orthic Pumice Soils (MO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Tephric Recent Soils (RT); Orthic Brown Soils (BO); Orthic Recent Soils (RO); Immature Pallic Soils (PI)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam (21)[1]; Gisborne sandy loam, hill soil (21H)[1]; Ngaroma sandy silt (19)[1]; Ngaroma sandy silt, hill soil (19H)[1]; Taupo shallow sandy silt (18a)[1]; Taupo shallow sandy silt, hill soil (18aH)[1]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), sheet (0–1Sh), tunnel gully (0–1T), gully (0–1G)
Potential: Moderate soil slip, slight sheet, tunnel gully, and gully under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM)

Land use:

Present:	Semi-intensive livestock farming
Agric. Potential:	Semi-intensive livestock farming
Forestry Potential:	Highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, re-establish ground cover on eroded areas, open-plant trees, plant trees along banks of hillslope channels, plant trees in tunnel gullies. F: No special measures

Comments: A large rainfall range of between 1200 and 1800 mm/yr provides differences in soil properties. At higher rainfalls (at altitudes close to 550 m a.s.l.), soils may be strongly leached and have evidence of iron accumulation in subsoils.

Allophanic Soils are very common in this unit despite the widespread and significant depth of Taupo/Waimihia tephra (that might be expected to give rise to Pumice Soils). This occurs because Allophanic Soils key-out before Pumice Soils (Hewitt 1998) where the thickness of Allophanic soil material is greater than 35 cm. Previously, under the N.Z. Genetic soil classification, many of these soils were described as composite yellow-brown pumice soils on yellow-brown loams.

LUC unit: VIe8 (3280 ha)

LUC suite: 4. Weathered tephra

LUC subsuite: 4c. Upland

Description: Moderately steep to steep and some strongly rolling slopes in stable hill country between 550 and 1100 m a.s.l., on mainly Neogene rocks, mantled by weathered tephra of variable depth

Reference site: Y16/440260 Wairangi Station, beyond the end of Tarndale Road

Slope: 21–25° (E), 21–35° (E+F), occasionally 16–25° (E+D)

Rock type: Weathered, mainly rhyolitic tephra on frittered mudstone (Mo/Mf), bedded mudstone (Mo/Mb), massive sandstone (Mo/Sm), etc. Tephra cover is frequently patchy (pMo/Mf, etc.).
Notes: (i) Tephra overlies a variety of stable Neogene rocks from, e.g., Mangaheia Group, Tolaga Group and upper Mangatu Group. (ii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon, but in this LUC unit, coverage exceeds 40%. (iii) A veneer of Taupo/Waimihia tephra occurs in parts, but depsoits are usually too thin (i.e., <25 cm) or poorly distributed (<20% of the area) to be recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Orthic Podzols (ZO)
H: Allophanic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Allophanic Soils (LO)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Patoka fine sandy loam, hill soil (49H)[1]; Tutira sandy loam, hill soil (49aH)[1]; Matawai sandy loam, hill soil (22H)[1]; Matakaoa hill soils (9H)[2]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), negligible to slight gully (0–1G), earthflow (0–1Ef)
Potential: Moderate soil slip and riparian slip, slight gully, earthflow, and sheet under pasture. Negligible erosion under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), fern (sF), mixed indigenous scrub (sX), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Open-plant trees, plant trees along banks of hillslope channels, pair-plant non-suckering/non-cracking willows in gullies, re-establish ground cover on eroded areas. F: No special measures

Comments: This unit contrasts with VIe5 by having steeper and/or longer slopes; shallower, often patchy tephra cover; and more frequent soil slip scars. However, as in VIe5, the essence of this LUC unit remains, which is a good cover of weathered tephra, and if patchy, tephra exceeds 40% coverage.

Annual rainfall is between 1600 and 2400 mm, and most of the unit occurs where rainfall exceeds 1800 mm/yr. Most soils are strongly leached with evidence of weak iron accumulation in subsoils, being more strongly expressed above 750 m a.s.l. Leaching induces lower levels of available soil nutrients.

Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (VIe3) is interpreted if most land lies below the isohyet, and upland (VIe8) if most land lies above.

LUC unit: VIe9 (2469 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6d. Weber marl

Description: Rolling to strongly rolling slopes in Weber marl hill country, with potential for moderate earthflow and gully

Reference site: Y18/615784 East side of the junction of Glenroy Road and Highway 35

Slope: 8–15° (C), 8–20° (C+D, D+C), 16–20° (D)

Rock type: Frittered mudstone (Mf), frittered mudstone with sheared mixed lithologies (Mf+Mx), occasionally with patchy Taupo/Waimihia tephra (pKt/Mf)
Notes: (i) Weber marl (Weber Formation) is a calcareous mudstone or muddy limestone, sometimes sheared and bentonitic, within the Mangatu Group (Paleocene in age).
(ii) Taupo/Waimihia tephra (and occasionally weathered tephra) occurs in parts, but deposits are usually too thin (<25 cm) or poorly distributed (<20% of the area) to be recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Perch-gley Pallic Soils (PP); Immature Pallic Soils (PI); Orthic Gley Soils (GO); Orthic Pumice Soils (MO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Immature Pallic Soils (PI); Perch-gley Pallic Soils (PP); Tephric Recent Soils (RT); Allophanic Brown Soils (BL)
N.Z. Genetic Soil Classification
Yellow-brown earths: Pouawa sandy loam (25b)[1]; Pakarae sandy loam (29c)[1]; Wanstead clay loam (25a)[1]; Pakarae sandy loam, hill soil (29cH)[1]

Erosion: *Present:* Slight to moderate earthflow (1–2Ef), negligible to slight gully (0–1G), tunnel gully (0–1T)
Potential: Moderate earthflow and gully, slight soil slip under pasture. Slight earthflow and gully under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, re-establish ground cover on eroded areas, open-plant trees, plant trees along banks of hillslope channels, drain springs on earthflows. F: Take care with earthworks and shrub/tree removal

Comments: Weber marl LUC units contain rocks older than Neogene and in this respect are atypical of LUC suite 6. Weber marl units are in suite 6 because their lithology and behaviour is closer to frittered mudstone than the crushed argillite of LUC suite 11 (and Weber marl is mapped as Mf).

Weber marl and products of its weathering impede water flow through soils, giving rise to poorly drained subsoils. As a result, while forestry on this unit may be moderately to highly productive in the longer term, there will be establishment and early growth difficulties.

LUC unit: VIe10 (45 919 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6a. Frittered mudstone

Description: Moderately steep to steep and sometimes strongly rolling slopes in Neogene frittered mudstone hill country, with potential for moderate soil slip and earthflow

Reference site: Z17/708966 Behind Whareopaia, 5.5 km south of Tolaga township on Highway 35

Slope: 20–25° (E), 16–25° (E+D), 20–35° (E+F), occasionally 16–25° (D+E)

Rock type: Frittered mudstone (Mf), sometimes combined with other rock types such as bedded mudstone (Mf+Mb). Occasionally, with patchy tephra covers, e.g., Taupo/Waimihia tephra (pKt/Mf), or weathered, mainly rhyolitic tephra (pMo/Mf).
Notes: (i) Tolaga Group rocks are strongly represented. (ii) Occasional patchy Taupo/Waimihia tephra (and sometimes weathered tephra) occurs on ridges — especially west of the Poverty Bay flats. Patchy tephra is recorded where coverage >20% and <75% of the map polygon.

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Recent Soils (RO); Orthic Pumice Soils (MO); Allophanic Brown Soils (BL)
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI); Tephric Recent Soils (RT); Allophanic Brown Soils (BL); Orthic Pumice Soils (MO)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Pakarae complex, hill soil (29dH)[1]; Mangatea clay loam and silt loam, hill soil (25H)[1]; Pakarae sandy loam, hill soil (29cH)[1]; Mangaomeko, hill soils (12H)[2]; Tikitiki steepland soils (19)[2]; Taihape silt loam (114a)[1]; Turakina silt loam (114b)[1]

Erosion: *Present:* Slight to moderate (mostly slight) soil slip (0–2Ss), negligible to moderate (mostly slight) earthflow (0–2Ef), negligible to slight gully (0–1G), riparian slip (0–1Rs), sheet (0–1Sh)
Potential: Moderate soil slip, earthflow, slight gully, riparian slip, and sheet under pasture. Slight riparian slip and earthflow under forest

Vegetation: Improved pasture (gI), rushes, sedges (hR), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, re-establish ground cover on eroded areas, open-plant trees, install gully-control structures, plant trees along banks of hillslope channels. F: No special measures

Comments: This unit is subject to considerable landslide damage during extreme events such as to Cyclone Bola of March 1988.

Tephra coverage, where present, does not exceed 40% of any map polygon and the unit should not be considered part of the tephra LUC suites (3 or 4) for any interpretation.

LUC unit: VIe11 (5454 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7a. Massive to bedded sandstone in Ngatapa–Rere lower rainfall area

Description: Moderately steep to steep slopes in Neogene massive or bedded sandstone hill country below 550 m a.s.l. in the Ngatapa–Rere area, just west of the Poverty Bay flats, with or without a patchy cover of Taupo/Waimihia tephra, and with potential for moderate soil slip and sheet

Reference site: X17/140850 Near the Tangihau and Wharekopae roads junction

Slope: 21–25° (E), 21–35° (E+F, F+E) – F slopes are short

Rock type: Massive or bedded sandstone (Sm, Sb), or combinations of both (e.g., Sb+Sm), sometimes with a patchy cover of Taupo/Waimihia tephra with, or without weathered, mainly rhyolitic tephra (pKt/pMo/Sb, pKt/Sm, etc.)
Note: Patchy tephra is recorded where coverage >20% and <75% of the map polygon

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO), Orthic Brown Soils (BO); Immature Pallic Soils (PI); Orthic Pumice Soils (MO); Tephric Recent Soils (RT)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-grey earth/Yellow-brown earth intergrades, and Yellow-brown earths and related steepland soils: Otamauri sandy loam (11aH)[1]; Waihua stony sandy loam and sandy silt (117d)[1]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), negligible to slight sheet (0–1Sh), tunnel gully (0–1T), gully (0–1G)
Potential: Moderate soil slip and sheet, slight riparian slip, gully, and tunnel gully under pasture. Negligible soil slip and riparian slip under forest

Vegetation: Improved pasture (gI), manuka, kanuka (sM), rushes, sedges (hR)

Land use: *Present:* Semi-intensive to extensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, plant trees along banks of hillslope channels.
F: No special measures

Comments: Annual rainfall of between 1000 and 1400 mm is relatively low for hill country in the region, and the area is often seriously affected by drought — made worse by widespread shallow soils on coarse-grained rock types.

For interpretations that require the recognition of tephra, this unit may be considered part of the Taupo/Waimihia tephra suite (LUC suite 3), but only where tephra coverage exceeds 40% of the map polygon. This prerequisite is not commonly met.

LUC unit: VIe12 (13 352 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6c. Bedded mudstone

Description: Moderately steep to steep and minor strongly rolling slopes in Neogene bedded mudstone hill country, with potential for moderate soil slip

Reference site: Z16/713218 Adjacent to Highway 35, 1.8 km south of Hikuwai (Parenga Road junction)

Slope: 20–25° (E), 20–35° (E+F), occasionally 16–25° (E+D)

Rock type: Bedded mudstone (Mb), occasionally with other rock types such as frittered mudstone (Mb+Mf), sometimes with a patchy cover of Taupo/Waimihia tephra or weathered, mainly rhyolitic tephra, or both (pKt/pMo/Mb, pKt/Mb, pMo/Mb).
Notes: (i) Neogene alternating mudstone and sandstone where mudstone dominates the sequence, or well-bedded mudstone. Seen commonly in Ramanui Formation and Tolaga Group rock terrain. (ii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Orthic Gley Soils (GO)
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI); Tephric Recent Soils (RT); Orthic Allophanic Soils (LO); Orthic Gley Soils (GO)
S:Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Pakarae complex, hill soils (29dH)[1]; Mahoenui silt loam (115)[1]; Pahiatua silt loam (115a)[1]; Whangaehu loam (114)[1]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), negligible to slight earthflow (0–1Ef), gully (0–1G)
Potential: Moderate soil slip, slight earthflow, riparian slip, gully, and sheet under pasture. Slight gully, riparian slip, and earthflow under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), mixed indigenous scrub (sX), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive to extensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, plant trees along banks of hillslope channels, recognise and provide for nearby receiving urban developments. F: Take care with earthworks and shrub/tree removal, recognise and provide for nearby receiving urban developments

Comments: Most of this unit occurs in the lowland (<550 m a.s.l.).

For interpretations that require recognition of tephra, this unit may be considered part of the tephra LUC suites (3 or 4), but only where tephra coverage exceeds 40% of the map polygon. This prerequisite is not commonly met.

LUC unit: VIe13 (1982 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7d. Muddy sandstone of East Cape

Description: Strongly rolling to moderately steep and sometimes steep slopes on Neogene massive muddy sandstone and mudstone in the East Cape area, with potential for moderate soil slip and sheet

Reference site: Z14/943727 Northeast of Rangitukia East Cape Road, 9 km from Rangitukia

Slope: 16–25° (D+E, E+D), 21–25° (E), 16–20° (D), sometimes 21–35° (E+F)

Rock type: Massive sandstone and massive mudstone (Sm+Mm), sometimes massive sandstone (Sm) or massive mudstone (Mm), occasionally with a patchy cover of weathered, mainly rhyolitic tephra (pMo/Sm*Mm)
Note: Two main rock units occur: 1. most extensive and uppermost in the sequence is late Miocene to Pliocene muddy sandstone (frequently bluff-forming in VIIe17 and VIIIe6), and 2. least extensive and lower in the sequence, early to mid-Miocene massive mudstone (similar to Neogene massive mudstone elsewhere in the region)

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Allophanic Brown Soils (BL)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Allophanic Brown Soils (BL)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Wharekahika hill complex (10H)[2]; Marangairoa steepland soils (20)[2]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss)
Potential: Moderate soil slip and sheet, slight riparian slip and gully under pasture. Slight soil slip under forest

Vegetation: Broadleaved forest (fB), exotic conifer forest (fF), manuka, kanuka (sM), semi-improved pasture (gS), mixed indigenous scrub (sX)

Land use: *Present:* Undeveloped, exotic plantation forestry, extensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, recognise and provide for the sensitive coastal receiving environment in coastward areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, recognise and provide for the sensitive coastal receiving environment in coastward areas

Comments: Pastures are difficult to manage — they are prone to rapid weed infestation when cleared of scrub, soils are shallow, natural fertility is low. Rainfall is between 1600 and 2400 mm/yr, with most of the unit between 1600 and 2000 mm/yr.

Few precedents exist for assessing erosion potential under pasture in this unit because most of it is under scrub or forest.

LUC unit: VIe14 (29 913 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3a. Lowland

Description: Moderately steep to steep and occasionally strongly rolling slopes in stable hill country below 550 m a.s.l., on a range of Neogene rocks, mantled by Taupo/Waimihia tephra over a variable depth of weathered tephra, with potential for moderate soil slip

Reference site: X17/288077 Junction of Mangatu and Wairere roads

Slope: 21–25° (E), 21–35° (E+F), sometimes 16–25° (E+D)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on various Neogene rocks, e.g., massive sandstone (Kt/Mo/Sm), bedded mudstone (Kt/Mo/Mb), or lying directly on Neogene rocks (Kt/Sm, etc.). Sometimes, one or both tephra are patchy (e.g., pKt/Mo/Sb, pKt/pMo/Mf)
Notes: (i) Patchy tephra is recorded where coverage >20% and <75% of the map polygon. (ii) Taupo and Waimihia deposits usually occur together, but Waimihia Tephra thins considerably toward the northern extent of this unit's distribution

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Pumice Soils (MO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Tephric Recent Soils (RT); Orthic Podzols (ZO)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam, hill soil (21H)[1]; Taupo shallow sandy silt, hill soil (18aH)[1]

Erosion: *Present:* Slight to moderate soil slip (0–2Ss), negligible to slight gully (0–1G), tunnel gully (0–1T), earthflow (0–1Ef), sheet (0–1Sh)
Potential: Moderate soil slip, slight gully, tunnel gully, riparian slip, earthflow, and sheet under pasture. Slight gully and riparian slip under forest

Vegetation: Semi-improved pasture (gS), exotic conifer forest (fF), mixed indigenous scrub (sX), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, install gully-control structures, re-establish ground cover on eroded areas, open-plant trees, plant trees along banks of hillslope channels, plant trees in tunnel gullies. F: Take care with earthworks and shrub/tree removal

Comments: This unit contrasts with VIe7 by having typically steeper and/or longer slopes; shallower, more patchy tephra cover, and more frequent soil slip scars. However, as in VIe7, the essence of this LUC unit remains, which is a good cover of Taupo/Waimihia tephra, over more than 40% of the map polygon.

A large rainfall range of 1200 to 1800 mm/yr provides differences in soil properties. At higher rainfalls (at altitudes close to 550 m a.s.l.), soils may be strongly leached and have evidence of iron accumulation in subsoils. Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (VIe14) is interpreted if most land lies below the isohyet, and upland (VIe19) if most land lies above.

LUC unit: VIe15 (2689 ha)

LUC suite: 9. Basalt

LUC subsuite: -

Description: Moderately steep, strongly rolling and occasionally short steep slopes in basaltic hill country between Cape Runaway and Hicks Bay, sometimes with a discontinuous cover of weathered tephra, with potential for moderate soil slip, gully, riparian slip, and sheet

Reference site: Z14/765906 Above the northern end of Hicks Bay

Slope: 21–25° (E), 16–35° (E+D, D+E), 21–35° (E+F) — F slopes are short

Rock type: Ancient volcanics (In), sometimes with coarse slope deposits (In+Cl), commonly with a patchy cover of weathered, mainly rhyolitic tephra (pMo/wIn*Cl, pMo/In, etc.), occasionally with a full cover of weathered tephra (Mo/wIn, etc.)
Notes: (i) Matakaoa Volcanics — basaltic lavas, breccia, and unconsolidated rocks of Cretaceous and Paleogene age. (ii) Strongly weathered to several metres depth in places. (iii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Allophanic Brown Soils (BL); Orthic Podzols (ZO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO)
S: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Orthic Raw Soils (WO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Complex of yellow-brown loams and red-brown loams: Wharekahika hill complex (10H)[2]; Potikirua steepland soils (22)[2]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), gully (0–1G), debris avalanche (0–1Da), sheet (0–1Sh)
Potential: Moderate soil slip, gully, riparian slip, and sheet under pasture. Slight debris avalanche under forest

Vegetation: Mixed indigenous scrub (sX), manuka, kanuka (sM), semi-improved pasture (gS)

Land use: *Present:* Undeveloped, semi-intensive livestock farming, some reversion to scrub
Agric. Potential: Extensive to semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Recognise and provide for the sensitive coastal receiving environment, re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas. F: Recognise and provide for the sensitive coastal receiving environment, re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas.

Comments: Moderately high to high annual average rainfalls (1600–2400 mm) are typical of the area, and this, through leaching, induces lower levels of available soil nutrients.

Few precedents exist for assessing erosion potential under pasture in this unit because most of it is under scrub, but grazed hill slopes on similar strongly weathered volcanics elsewhere in the North Island of New Zealand are prone to serious storm damage and deeper-seated landslides.

For interpretations that require the recognition of weathered tephra, this unit may be considered part of the weathered tephra suite (LUC suite 4), but only where tephra coverage exceeds 40% of the map polygon. This generally occurs where map polygons contain D slopes and pMo is recorded.

LUC unit: VIe16 (6906 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7e. Massive and bedded sandstone

Description: Moderately steep to steep and occasionally strongly rolling slopes in Neogene massive or bedded sandstone hill country, with potential for moderate soil slip and sheet

Reference site: Z17/716093 Mangatuna, south-east side of Kopuatarakihi Road and Highway 35 junction

Slope: 21–25° (E), 16–25° (E+D), 21–35° (E+F)

Rock type: Massive sandstone (Sm), bedded sandstone (Sb), sometimes combined (e.g., Sm+Sb), alluvial gravels and unconsolidated sands and gravels (Gr+Us+Sm, etc.) on intermediate terrace escarpments.
Notes: (i) Tokomaru Sandstone is well represented. (ii) There are occasional patchy covers of weathered, mainly rhyolitic tephra (e.g., pMo/Sb) on strongly rolling slopes, but do not exceed 40% of any map polygon

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL)
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Mangatea clay loam and silt loam, hill soil (25H)[1]; Marangairoa steepland soils (20)[2]; Whangamomona silt loam (116)[1]

Erosion: *Present:* Negligible to moderate (mostly slight) soil slip (0–2Ss), negligible to slight sheet (0–2Sh)
Potential: Moderate soil slip and sheet, slight riparian slip under pasture. Negligible erosion under forest

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), manuka, kanuka (sM), exotic conifer forest (fF), mixed indigenous scrub (sX)

Land use: *Present:* Extensive to semi-intensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential: Extensive to semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees on steepest areas, re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas.
F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal

Comments: Rapid reversion to scrub is a problem, mainly because soils are shallow with low natural nutrient status and very low soil moisture storage capability. Erosion scars are slow to heal.

This unit, and the related LUC unit VIIe15, are used as best-fit options for steep terrace escarpments and steeply dissected V-shaped incisions into intermediate terrace surfaces where a variety of lithologies are exposed. Lithologies include alluvial gravel and sand, mudstone, greywacke, etc., as well as sandstone.

It is also used as a best-fit option in LUC subsuite 7c in Te Kahika Formation rock terrain on the E+F sloping land on the margins of the steep land represented by LUC unit VIIe16. Here, there is greater representation of 'soft' sandstone of the Waipaoa Formation, and there may be residual weathered, mainly rhyolitic tephra in places.

LUC unit: VIe17 (7749 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7b. Bedded sandstone of the Wharerata hills

Description: Steep to moderately steep Neogene bedded sandstone hill country in the high-rainfall Wharerata hills, with potential for moderate soil slip

Reference site: Y19/331453 2 km along Paritu Road, south of the junction of Paritu Road with Highway 2

Slope: 21–35° (F+E, E+F), short 25–35° (F), 21–25° (E)

Rock type: Bedded sandstone (Sb), sometimes with a patchy cover of Taupo/Waimihia tephra (pMo/Sb), or Taupo/Waimihia tephra on weathered, mainly rhyolitic tephra (pKt/pMo/Sb)
Notes: (i) Strongly alternating Miocene sandstone and mudstone, where distinct sandstone beds dominate the sequence. (ii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Allophanic Brown Soils (BL); Orthic Podzols (ZO); Orthic Brown Soils (BO)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Mangatea clay loam and silt loam, hill soil (25H)[1]; Marangairoa steepland soils (20)[2]; Whangamomona silt loam (116)[1]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), sheet (0–1Sh)
Potential: Moderate soil slip, slight riparian slip, gully, and sheet under pasture. Slight soil slip and riparian slip under forest

Vegetation: Exotic conifer forest (fF), semi-improved pasture (gS), manuka, kanuka (sM), unimproved pasture (gU), mixed indigenous scrub (sX), tauhinu (sC), fern (sF)

Land use: *Present:* Exotic plantation forestry, extensive and semi-intensive livestock farming, reversion to scrub
Agric. Potential: Extensive to semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees on steeper areas, re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas.
F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal

Comments: Average rainfall ranges from 1400 mm/yr in lowest elevations to 2400 mm at highest elevations. Most of the unit occurs at high elevations (i.e., >550 m a.s.l.).

Soils have a lower nutrient status than those from the bedded sandstones of VIe11, and VIe16, probably reflecting the higher leaching regime of the Wharerata hills area.

The influence of Taupo/Waimihia tepha in topsoils is widespread in the area, but deposits are usually too thin (<25 cm) to record, and weathered tephra (where present) cover less than 40% of any map polygon. Consequently, this unit should not be considered part of tephra LUC suites (3 or 4) for interpretations that require tephra recognition.

LUC unit: VIe18 (5838 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6e. Lacustrine muds

Description: Strongly rolling to moderately steep, sometimes rolling earthflow-prone slopes, underlain by Quaternary mainly lacustrine clays, minor sands and gravels or weakly consolidated conglomerates, mostly forming low hills around the eastern and north-eastern margins of the Poverty Bay flats

Reference site: Y18/461754 Matokitoki Valley Road, 2 km north of Gisborne Hospital

Slope: 16–25° (D+E, E+D), 21–25° (E), 16–20° (D), 8–20° (C+D, D+C)

Rock type: Unconsolidated clays and silts (Uf), sometimes associated with unconsolidated sands and gravels (Uf+Us), alluvial gravels (Uf+Gr), occasional weakly consolidated conglomerate (Uf+Cw), and often with a patchy cover of Taupo/Waimihia tephra, with or without weathered, mainly rhyolitic tephra (e.g., pKt/Uf, pKt/pMo/Uf*Us). Occasional small bluffs of locally resistant lacustrine silts are recorded as massive siltstone (e.g., Uf+Mm)
Notes: (i) Quaternary lake beds of variable lithology (some estuarine muds may also be included in the sequence), and Pliocene claystone near Kaitaratahi. (ii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon, but does not exceed 40% coverage in this unit

Soil: *N.Z. Soil Classification soil groups*
R: Perch-gley Pallic Soils (PP); Immature Pallic Soils (PI); Orthic Pumice Soils (MO); Orthic Gley Soils (GO)
H: Orthic Brown Soils (BO); Perch-gley Pallic Soils (PP); Immature Pallic Soils (PI); Tephric Recent Soils (RT); Orthic Recent Soils (RO); Orthic Pumice Soils (MO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam (21)[1]; Gisborne sandy loam, hill soil (21H)[1].
Note: Yellow-brown pumice soils were recorded in previous surveys, but soils are closer to Yellow-grey earths–yellow-brown earth intergrades

Erosion: *Present:* Slight to moderate (mostly moderate) earthflow (1–2Ef), negligible to moderate slump (0–2Su), negligible to slight gully (0–1G), soil slip (0–1Ss), sheet (0–1Sh)
Potential: Moderate earthflow, gully, and soil slip, slight sheet and slump under pasture. Slight earthflow, gully, and slump under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM), lowland podocarp-broadleaved forest (fO), erosion-control exotic broadleaved forest (efF)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Open-plant trees, divert water from earthflow heads, avoid earthworks that add weight to earthflow surfaces or remove toe support, plant trees along banks of hillslope channels, take care in siting high value-capital structures, recognise and provide for nearby receiving urban developments. F: Avoid earthworks that add weight to earthflow surfaces or remove toe support, take care in siting high-value capital structures, take care with earthworks and shrub/tree removal, recognise and provide for nearby receiving urban developments

Comments: A broken hummocky surface locally impedes natural drainage and restricts opportunities for artificial drainage. Slowly permeable clays impede water flow through soils, giving rise to poorly drained subsoils.

Tephra are too poorly distributed for this unit to be considered part of the tephra LUC suites (3 or 4), for interpretations that require tephra recognition.

LUC unit: VIe19 (30 697 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Strongly rolling to moderately steep hill slopes in the western part of the region above 550 m a.s.l., on a variety of mainly Neogene rocks, mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra, with potential for moderate soil slip and gully

Reference site: X17/998843 3 km south-west of Wharekopae

Slope: 16–20° (D), 16–25° (D+E, E+D), 21–25° (E)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on bedded sandstone (Kt/Mo/Sb), massive sandstone (Kt/Mo/Sm), bedded mudstone (Kt/Mo/Mb), frittered mudstone (Kt/Mo/Mf), or combinations of these (e.g., Kt/Mo/Sm*Mb), occasionally with other lithologies such as limestone (Kt/Mo/Sb*Li), argillite (Kt/Mo/Sm*Ar), etc.
Note: Some areas of Cretaceous to Paleogene rocks such as in Karekare and Whangai formations are mapped as bedded sandstone (Sb) and bedded mudstone (Mb). These are included as best-fit options. Elsewhere, a perceived increase in rock-mass strength and resistence to weathering results in these rock formations being mapped as greywacke or argillite (Gw, Ar) and this land is classified as LUC unit VIe23, etc.

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Podzols (ZO); Orthic Allophanic Soils (LO)
H: Orthic Podzols (ZO); Orthic Allophanic Soils (LO); Orthic Pumice Soils (MO); Orthic Brown Soils (BO)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Podzolised yellow-brown pumice soils: Ngaroma sandy silt, hill soil (19H)[1]; Matawai sandy loam (22)[1]; Matawai sandy loam, hill soil (22H)[1]; Ruakituri sand (RU)[7]; Ruakituri hill soils (RUH)[7]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), slump (0–1Su), gully (0–1G), tunnel gully (0–1T) — all erosion mostly negligible
Potential: Moderate soil slip and gully, slight slump, riparian slip, tunnel gully, and sheet under pasture. Slight soil slip, riparian slip, and gully under forest

Vegetation: Podocarp-broadleaved-beech (fD), lowland beech forest (fW), lowland podocarp-broadleaved forest (fO), semi-improved pasture (gS), mixed indigenous scrub (sX), manuka, kanuka (sM)

Land use: *Present:* Undeveloped, extensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas

Comments: Use of the 1800 mm/yr isohyet can be helpful when deciding between upland (>550 m a.s.l.) and lowland (<550 a.s.l.) units when map polygons span the 550 m contour line: lowland (VIe14) is interpreted if most land lies below the isohyet, and upland (VIe19) if most land lies above. Most of this unit receives in excess of 2000 mm/yr rainfall. Soils are strongly leached with evidence of iron accumulation in subsoils to the extent that Podzols predominate.

Poorly productive exotic plantations are restricted to the more elevated land in the unit's disribution.

LUC unit: VIe20 (6053 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite
3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Strongly rolling to moderately steep, relatively stable, long hill slopes with wide interfluves on argillite and crushed argillite at altitudes over 550 m a.s.l., mostly in the Wharekopae area. Mantled by thick deposits of Taupo/Waimihia tephra on weathered tephra. Dissected by long and shallow gullies, with riparian slips, but with little active gully erosion and earthflow

Reference site: X17/948863 Tahora Settlement Road, 2 km from the junction with Te Wera Road

Slope: 16–20° (D),16–25° (D+E)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on a combination of argillite and crushed argillite (Kt/Mo/Ar*Ac), or occasionally on argillite (Kt/Mo/Ar)
Notes: (i) Mostly includes Whangai Formation rocks, here possibly autocthonous, but atypically crushed and sheared. (ii) Tephra deposits are commonly 100–130 cm thick

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Pumice Soils (MO); Orthic Podzols (ZO)
H: Orthic Pumice Soils (MO); Orthic Podzols (ZO); Orthic Brown Soils (BO)
N.Z. Genetic Soil Classification
Podzolised yellow-brown pumice soils: Ngaroma sandy silt, hill soil (19H)[1]
Yellow-brown pumice soils: Gisborne sandy loam, hill soil (21H)[1]

Erosion: *Present:* Negligible to slight riparian slip (0–1Rs), gully (0–1G), soil slip (0–1Ss), earthflow (0–1Ef)
Potential: Moderate riparian slip and earthflow, slight soil slip, gully, and tunnel gully under pasture. Slight riparian slip under forest

Vegetation: Improved pasture (gI), semi-improved pasture (gS)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, re-establish ground cover on eroded areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas

Comments: Landforms are locally subdued.

This LUC unit fits both LUC suite 11 (crushed argillite, etc.) and 3 (Taupo/Waimihia tephra). The deep tephra mantle suggests long periods of hillslope stability. Nevertheless, under grassland farming there is a need to care for the incised hillslope channels to avoid initiating both serious gully erosion, and associated earthflow in the crushed-rock parts of the unit.

LUC unit: VIe21 (9447 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Strongly rolling to moderately steep and sometimes rolling slopes on mainly crushed argillite hill country, with potential for moderate gully, earthflow, riparian slip, and soil slip, mantled by a variable depth of weathered tephra with, or without, a cover of Taupo/Waimihia tephra

Reference site: Y16/309133 Tarndale Road, 4.5 km past Armstrong Road junction

Slope: 16–20° (D), 16–25° (D+E, E+D), sometimes 8–20° (C, C+D)

Rock type: Crushed argillite association of rocks, less commonly argillite, sometimes combined, and sometimes with other lithologies such as mixed sheared lithologies, indurated sandstone, etc., with a cover of weathered, mainly rhyolitic tephra (Mo/Ac, Mo/Ar, Mo/Ac*Ar, Mo/Mx, Mo/Ac*Si, etc.), or with Taupo/Waimihia tephra on weathered tephra (Kt/Mo/Ac, etc.). The tephra cover is often patchy (pKt/pMo/Ac, pMo/Ac, etc.).
Notes: (i) Recorded in allocthonous rock terrain. (ii) Includes Whangai Formation and other Paleogene and Cretaceous fine-grained indurated materials. Melange zones may be included, but are uncommon (where Mx is recorded). (iii) Patchy tephra is recorded where coverage >20% and <75% of the map polygon, and coverage exceeds 40% in this unit

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Orthic Recent Soils (RO)
H: Orthic Brown Soils (BO); Orthic Allophanic soils (LO); Orthic Recent Soils (RO); Allophanic Brown Soils (BL); Orthic Podzols (ZO)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam, hill soil (21H)[1]
Yellow-brown loams: Patoka fine sandy loam (49)[1]; Patoka fine sandy loam, hill soil (49H)[1]
Yellow-brown earths: Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]

Erosion: *Present:* Slight to moderate gully (1–2G), earthflow (1–2Ef) (earthflow and gully mostly slight), slight soil slip (1Ss), negligible to slight slump (0–1Su), sheet (0–1Sh)
Potential: Moderate gully, earthflow, soil slip, and riparian slip, slight sheet and slump under pasture. Slight gully and slump under forest

Vegetation: Exotic conifer forest (fF), semi-improved pasture (gS), improved pasture (gI), rushes, sedges (hR), manuka, kanuka (sM)

Land use: *Present:* Exotic plantation forestry, semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, plant trees along banks of hillslope channels. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas

Comments: The long-term potential for the scale of gully erosion typified by Mangatu, Tarndale, and Barton's gullies should be recognised, even if the risk of this is presently slight.

For interpretations that require the recognition of tephra, this unit can be considered part of the tephra LUC suites (3: Taupo/Waimihia tephra, or 4: weathered tephra). This consideration requires that at least 40% of the map polygon is covered by tephra — a requirement mostly met.

LUC unit: VIe22 (11 379 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Strongly rolling to moderately steep slopes in crushed argillite and sometimes argillite hill country, without a significant cover of tephra, with potential for moderate gully, earthflow, riparian slip, and soil slip

Reference site: Z15/717468 Highway 35, 1 km south of Makarika Road junction

Slope: 16–20° (D), 16–25° (D+E, E+D), 21–25° (E)

Rock type: Crushed argillite association of rocks (Ac), some argillite (Ar), often combined (Ac+Ar), or combined with lithologies such as sheared mixed lithologies (Ac+Mx), coarse slope deposits(Ac+Cl), etc. Occasionally, with a patchy cover of weathered, mainly rhyolitic tephra, with or without, a cover of Taupo/Waimihia tephra (pMo/Ac*Ar, pKt/pMo/Ac, etc.)
Notes: (i) Recorded in allocthonous rock terrain. (ii) Includes Whangai Formation rocks and other Paleogene and Cretaceous fine grained indurated materials. Melange zones may be included, but are uncommon (where Mx is recorded). (iii) Patchy tephra does not exceed 40% of any map polygon in this unit

Soil: *N.Z. Soil Classification soil groups*
R: Allophanic Brown Soils (BL); Orthic Recent Soils (RO); Orthic Gley Soils (GO); Immature Pallic Soils (PI)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown earths: Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]; Wanstead clay loam, hill soils (25aH)[1]; Mangatu hill complex (13H)[1]

Erosion: *Present:* Slight to moderate gully (1–2G), earthflow (1–2Ef) (gully and earthflow mostly slight), slight soil slip (1Ss), negligible to slight slump (0–1Su), sheet (0–1Sh), riparian slip (0–1Rs)
Potential: Moderate gully, earthflow, riparian slip, and soil slip under pasture. Slight gully, riparian slip, and earthflow under forest

Vegetation: Semi-improved pasture (gS), improved pasture (gI), exotic conifer forest (fF), manuka, kanuka (sM), rushes, sedges (hR)

Land use: *Present:* Semi-intensive livestock farming, exotic plantation forestry, some undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, plant trees along banks of hillslope channels. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas

Comments: The long-term potential for the scale of gully erosion typified by Mangatu, Tarndale, and Barton's gullies should be recognised, even if the risk of this is presently slight.

LUC unit: VIe23 (35 892 ha)

LUC suite: 10. Greywacke and argillite

LUC subsuite: -

Description: Moderately steep, sometimes strongly rolling or steep slopes in greywacke or argillite foot hills of the Raukumara and northern Huiarau ranges and some areas within the ranges, mantled by a variable depth of weathered tephra with, or without a cover of Taupo/Waimihia tephra, with potential for moderate gully, riparian slip, and soil slip

Reference site: X17/006044 The junction of Te Wera Road and Highway 2

Slope: 21–25° (E), 16–25° (E+D), 21–35° (E+F), occasionally 16–25° (D+E), 16–20° (D)
Note: Very occasional rolling slopes on old slumps and upland basins

Rock type: Greywacke association of rocks, argillite, sometimes combined with indurated sandstone or coarse slope deposits, with a cover of Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra (Kt/Mo/Gw, Kt/Mo/Ar, Kt/Mo/Ar*Si, Kt/Mo/Gw*Cl, etc.); or weathered tephra (Mo/Gw, etc.). Tephra deposits are often patchy (e.g., pKt/pMo/Ar).
Notes: (i) Recorded in autocthonous rock terrain. (ii) Indurated sandstone and mudstone (greywacke and argillite) of Cretaceous and Paleogene age, e.g., in Urewera and Matawai groups, some Whangai (see also the note under rock type in LUC unit VIe19) and Tikihore formation rocks. (iii) Patchy tephra is recorded where coverage >20% and <75% of a map polygon, and coverage exceeds 40% in this unit

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Orthic Brown Soils (BO); Orthic Podzols (ZO)
H: Orthic Podzols (ZO); Orthic Recent Soils (RO); Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow-brown loams: Tutira sandy loam, hill soil (49aH)[1]; Matakaoa sandy loam, hill soil (56bH)[1]
Yellow-brown pumice soils: Gisborne sandy loam, hill soil (21H)[1]
Steepland soils: Raukumara steepland soils (124a)[1], (16)[2]

Erosion: *Present:* Negligible to moderate (mostly slight) soil slip (0–2Ss), negligible to slight gully (0–1G), debris avalanche (0–1G), scree (0–1Sc), riparian slip (0–1Rs), slump (0–1Su), earthflow (0–1Ef), sheet (0–1Sh)
Potential: Moderate gully, soil slip, and riparian slip, slight scree, slump, and earthflow under pasture. Slight debris soil slip, gully, earthflow, and slump under forest

Vegetation: Unimproved pasture (gU), semi-improved pasture (gS), fern (sF), lowland beech forest (fW), lowland podocarp-broadleaved forest (fO), exotic conifer forest (fF)

Land use:
Present: Semi-intensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, plant trees along banks of hillslope channels. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas

Comments: This unit lies mostly above 550 m a.s.l., occurring up to 1100 m a.s.l., and experiences high rainfall, usually in the range 3000–4000 mm/yr.

For interpretations that require the recognition of tephra, this unit can be considered part of tephra LUC suites 3: Taupo/Waimihia tephra, or 4: weathered tephra, according to the type of tephra. This consideration requires that at least 40% of the map polygon is covered by tephra if patchy covers are recorded — a requirement mostly met in this unit.

LUC unit: VIe24 (1568 ha)

LUC suite: 10. Greywacke and argillite

LUC subsuite: -

Description: Moderately steep to steep slopes in greywacke or argillite foothills of the Raukumara Range, without a significant cover of tephra, and with potential for moderate gully, soil slip, riparian slip, and sheet

Reference site: Y15/614494 Hikurangi Spur, Taoroa Station, 3 km south of Mount Hikurangi

Slope: 21–25° (E), 21–35° (E+F, F+E)

Rock type: Greywacke association of rocks (Gw), crushed greywacke (cGw), argillite (Ar), indurated sandstone (Si), sometimes combined (Gw+Ar, Si+Ar, etc.), or with other lithologies such as coarse slope deposits (e.g., Gw+Cl) or limestone (e.g., Ar+Li). Occasionally with a patchy cover of weathered, mainly rhyolitic tephra, with or without, a cover of Taupo/Waimihia tephra (pMo/Gw*Ar, pKt/pMo/Gw, etc.)
Notes: (i) Recorded in autocthonous rock terrain. (ii) Indurated sandstone and mudstone (greywacke and argillite) of Cretaceous and Paleogene age, e.g., in Urewera and Matawai groups, some Whangai and Kerekere (see also the note under rock type in LUC unit VIe19) and Tikihore formation rocks. (iii) Patchy tephra does not exceed 40% of the map polygon in this unit

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Allophanic Brown Soils (BL);Orthic Podzols (ZO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Podzols (ZO)
S: Orthic Recent Soils (RO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Ruatoria stony silt loam (121)[1]; Tuparoa silt loam (121a)[1]

Erosion: *Present:* Negligible to moderate soil slip (0–2Ss), gully (0–2G) (mostly slight forsoil slip and gully), sheet (0–2Sh) (mostly negligible for sheet), negligible to slight earthflow (0–1Ef)
Potential: Moderate gully, soil slip, riparian slip, and sheet, slight slump, and earthflow under pasture. Slight soil slip, riparian slip, earthflow and slump erosion under forest

Vegetation: Unimproved pasture (gU), semi-improved pasture (gS), fern (sF), rushes, sedges (hR), lowland beech forest (fW), lowland podocarp-broadleaved forest (fO), exotic conifer forest (fF)

Land use: *Present:* Extensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, plant trees along banks of hillslope channels, drain springs on earthflows. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas

Comments: This unit lies mostly above 550 m a.s.l. and can occur up to 1100 m a.s.l., experiencing high rainfall, usually in the range 3000–4000 mm/yr.

This unit lacks the substantial tephra cover of VIe23, with tephra being too poorly distributed (<40% of the map polygon), to be considered part of the tephra LUC suites (3 or 4), for interpretations that require tephra recognition.

LUC unit: VIe25 (271 ha)

LUC suite: 5. Coastal sand and coastal cliffs

LUC subsuite: -

Description: Undulating to rolling coastal sand dunes and flat to gently undulating plains inland from foredunes, subject to moderate wind erosion

Reference site: Y18/409671 Centennial Marine Drive, Gisborne

Slope: 4–15° (B+C), 0–7° (A+B, B+A), 8–15° (C)

Rock type: Windblown sand (Wb)

Soil: *N.Z. Soil Classification soil groups*
R: Sandy Brown Soils (BS); Sandy Raw Soils (WS); Sandy Recent Soils (RS)
N.Z. Genetic Soil Classification
Yellow-brown sands: Opoutama sand (8)[3]; Opoutama loamy sand (8a)[3]

Erosion: *Present:* Moderate wind (2W)
Potential: Moderate wind under pasture. Negligible erosion under forest

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), sand dune vegetation (gD)

Land use: *Present:* Undeveloped, semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming (winter grazing)
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, prevent vegetation trampling. F: Re-establish ground cover on eroded areas

Comments: Subsoils and most topsoils are poorly structured, without resilience to resist wind erosion when vegetation is removed. Soils are mostly well drained, although some sand-plain areas have high watertables that are difficult to lower.

LUC unit: VIw1 (325 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. Flood plains, swamps, fans, and lower terraces

Description: Flat to undulating, very poorly drained and often peaty low terraces, narrow flood plains and swamps in river valleys, where cropping is precluded by permanently high watertables and/or frequent or long-duration flooding/ponding. Flooding is usually accompanied by deposits of fine sediment

Reference site: Y17/304022 Adjacent to Mangatu and Mangamaia roads

Slope: 0–3° (A, A'), 0–7° (A+B, A'+B)

Rock type: Fine alluvium (Af), Peat (Pt), or both (Af+Pt)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Recent Soils (RF); Fluvial Raw Soils (WF); Orthic Gley Soils (GO); Recent Gley Soils (GR); Mesic Organic Soils (OM)
N.Z. Genetic Soil Classification
Recent and organic soils: Kakerangi peaty sandy loam (Kap)[5]; Waihoata silt loam (Wo)[5]; Puhunga silt loam (Pn)[5]

Erosion: *Present:* Negligible to severe deposition (0–3D), negligible to moderate streambank (0–2Sb)
Potential: Severe deposition and moderate streambank under any land use

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), rushes, sedges (hR), wetland vegetation (hW)

Land use: *Present:* Extensive livestock farming (summer grazing), undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Unsuitable

Management: A: Surface drainage, streambank protection, flood protection. F: Not applicable

Comments: Inundation by flood or ponded water may last 5–15 days and occur no more than once in 1 year, or last 2–5 days and occur no more than twice in 1 year. Sandy/silty/clayey flood-sediment may be 6–10 cm thick. Field cropping and horticulture is precluded by flooding (and sedimentation), ponding, or high watertables. The watertable is <45 cm from the soil surface for the greater part of the year. Sedimentation and/or flooding, ponded water and high watertables make it difficult to maintain improved pasture grass and annual legume pastures, and pasture composition is dominated by low-producing species. Flood events will kill common improved pasture grasses and annual legumes.

LUC unit: VIs1 (607 ha)

LUC suite: 1. Broad flood plain

LUC subsuite: -

Description: Strongly saline and poorly drained reclaimed tidal flats

Reference site: Y18/400669 Between Centennial Marine Drive and Willows Road, 2 km north of the Waipaoa River mouth

Slope: 0–3° (A)

Rock type: Fine alluvium (Af)

Soil: *N.Z. Soil Classification soil groups*
F: Recent Gley Soils (GR); Orthic Gley Soils (GO); Fluvial Recent Soils (RF); Sandy Brown Soils (BS)
N.Z. Genetic Soil Classification
Saline gley soils: Muriwai clay loam (7)[3]; Muriwai clay (7a)[3]; Makaraka clay loam, saline phase (4b)[3]

Erosion: *Present:* Negligible to slight deposition (0–1D)
Potential: Slight deposition under any land use

Vegetation: Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), saline vegetation (hS), root and green fodder crops (cR)

Land use: *Present:* Semi-intensive livestock farming, occasional field cropping
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Unsuitable

Management: A: Surface drainage, streambank protection, flood protection. F: Not applicable

Comments: Soil and drainage conditions are highly variable, and small areas may be cropped occasionally for fodder.

LUC unit: VIs2 (431 ha)

LUC suite: 2. River valley

LUC subsuite: 2c. Gravels

Description: Flat to gently undulating low river terraces with gravels at very shallow depth. There is less than 15 cm depth of no more gravelly than slightly gravelly (5–15% gravels) soil over alluvial gravels

Reference site: Z14/810833 Katakatuwhero River bridge, Highway 35, 3 km west of Te Aroroa

Slope: 0–3° (A, A')

Rock type: Alluvial gravels (Gr), alluvial gravels with fine alluvium on gravels (Gr+Af/Gr)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Raw Soils (WF); Sandy Raw Soils (WS); Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Podzols (ZO); Fluvial Recent Soils (RF)
N.Z. Genetic Soil Classification
Recent soils: Tukituki stony gravel (1c)[1]; Waiapu stony sand (Wug)[5]

Erosion: *Present:* Negligible to moderate streambank (0–2Sb), deposition (0–2D)
Potential: Moderate deposition and streambank under any land use

Vegetation: Unimproved pasture (gU), semi-improved pasture (gS), manuka, kanuka (sM)

Land use: *Present:* Extensive livestock farming, undeveloped
Agric. Potential: Semi-intensive livestock farming (best for winter grazing)
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Streambank protection. F: Streambank protection

Comments: This unit has sufficient soil to sustain at least semi-improved pastures, but is unable to be cultivated for cropping. Very shallow soil depth limits exotic forest establishment. Boulders can occur on the soil surface.

This unit also occurs in coastal areas on gravel beach ridges and/or near river mouths, e.g., Waihau Bay.

LUC unit: VIs3 (365 ha)

LUC suite: 5. Coastal sand and coastal cliffs

LUC subsuite: -

Description: Undulating stable sand flats and dunes inland from foredunes, with very weakly developed sandy soils

Reference site: Z14/776876 Hicks Bay

Slope: 4–7° (B), 0–7° (A+B)

Rock type: Windblown sand (Wb)

Soil: *N.Z. Soil Classification soil groups*
F: Sandy Raw Soils (WS); Fluvial Recent Soils (RF)
R: Sandy Brown Soils (BS); Sandy Recent Soils (RS); Sandy Raw Soils (WS)
N.Z. Genetic Soil Classification
Yellow-brown sands: Opoutama black sand (7)[2]; Opoutama sand (8)[3]; Opoutama loamy sand (8a)[3]; Patea sand (23)[1]

Erosion: *Present:* Negligible to slight wind (0–1W)
Potential: Slight wind under pasture or sand dune vegetation

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), sand dune vegetation (gD)

Land use: *Present:* Extensive livestock farming, undeveloped
Agric. Potential: Extensive livestock farming (best for winter grazing)
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, prevent vegetation trampling. F: Re-establish ground cover on eroded areas

Comments: Most topsoils and all subsoils are poorly structured, very sandy, and prone to drought.

Exposure will limit the production of coastward of trees.

LUC unit: VIIe1 (54 153 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6a. Frittered mudstone

Description: Steep to moderately steep slopes in Neogene frittered mudstone hill country, with potential for very severe soil slip, associated with a potential for moderate earthflow

Reference site: Y17/583833 Northern end of Glenroy Road

Slope: 26–35° (F), 21–35° (F+E), occasionally 26–42° (F+G)

Rock type: Frittered mudstone (Mf), occasionally with other lithologies such as bedded mudstone (Mf+Mb), massive sandstone (Mf+Sm), limestone (Mf+Li), etc.
Notes: (i) Tolaga Group rocks are strongly represented. (ii) Patches of Taupo/Waimihia tephra, or weathered, mainly rhyolitic tephra can occur on stable ridges and footslopes, but poor coverage (<20% of the area) usually prevents these deposits being recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI); Tephric Recent Soils (RT); Orthic Allophanic Soils (LO)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT); Orthic Raw Soils (WO); Orthic Brown Soils (BO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Taihape silt loam (114a)[1]; Tikitiki steepland soils (19)[2]
Yellow brown earths: Pakarae sandy loam, hill soil (29cH)[1]

Erosion:
Present: Slight to moderate soil slip (1–2Ss) — occasionally severe (3Ss), slight to moderate gully (1–2G) and earthflow (1–2Ef) (mostly slight gully and earthflow), negligible to slight riparian slip (0–1Rs), slump (0–1Su), sheet (0–1Sh)
Potential: Very severe soil slip, moderate earthflow, gully, riparian slip, and slight slump under pasture. Moderate gully, slight soil slip, earthflow, riparian slip, and slump under forest

Vegetation: Improved pasture (gI), manuka, kanuka (sM), exotic conifer forest (fF), erosion-control exotic conifer forest (efF)

Land use:
Present: Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, install gully-control structures, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal. F: Pair-plant non-suckering/non-cracking willows in gullies, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal

Comments: This unit is widespread in the Neogene-cover rock terrain.

LUC unit: VIIe2 (8144 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6b. Massive mudstone

Description: Steep to very steep, long even slopes in Miocene massive mudstone hill country, with potential for severe soil slip

Reference site: X18/122603 Ahirau No. 2 trig, 6 km along from the western end of Parikanapa Road

Slope: 26–35° (F), 26–42° (F+G), sometimes 21–35° (F+E), occasionally 26–42° (G+F)

Rock type: Massive mudstone (Mm), sometimes with bedded mudstone (Mm+Mb) or massive sandstone (Mm+Sm), etc.
Notes: (i) Tolaga Group rocks are strongly represented (i.e., Miocene, rather than Pliocene-aged rocks of VIIe4). (ii) Used where bedding is either absent, faint, or poorly developed in the main rock type

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Mahoenui steepland soils (115)[1], (MeS)[6]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss) — occasionally severe (3Ss), negligible to moderate sheet (0–2Sh), riparian slip (0–2Rs), negligible to slight gully (0–1G)
Potential: Severe soil slip, moderate sheet, riparian slip, and slight gully under pasture. Slight soil slip under forest

Vegetation: Semi-improved pasture (gS), manuka, kanuka (sM), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal

Comments: Compared with VIIe1, this unit has longer, uniformly steeper, and more planar slopes. It has a relative scarcity of earthflow and gully erosion, and lower apparent susceptibility to storm damage (evidenced by fewer old slip scars). Soils are shallower and more droughty

The unit is most like VIIe4 and VIIe3 in appearance, but i) it generally lacks the ubiquitous old soil slip scars of VIIe4, soils are shallower and more prone to drought, and ii) the hillslope pattern is more symmetrical than in VIIe3 bedded-rock terrain; it lacks the occasional outcropping rock and the infrequent slumps of VIIe3.

LUC unit: VIIe3 (34 306 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6c. Bedded mudstone

Description: Steep to very steep, long slopes and occasionally moderately steep slopes, in Neogene bedded mudstone hill country, with potential for severe soil slip

Reference site: Y16/568103 East side of Tauwhareparae Road, 0.75 km south of the junction with Hokoroa Road

Slope: 26–35° (F), 26–42° (F+G), some 21–35° (F+E), occasionally 26–42° (G+F)

Rock type: Bedded mudstone (Mb), sometimes with other lithologies such as frittered mudstone (Mb+Mf), massive mudstone (Mb+Sm), bedded sandstone (Mb+Sb), etc.
Note: Neogene alternating mudstone and sandstone where mudstone dominates the sequence, or well-bedded mudstone. Seen commonly in Ramanui Formation and in the Tolaga Group

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Tephric Recent Soils (RT); Orthic Brown Soils (BO); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Mahoenui silt loam (115)[1]; Pahiatua silt loam (115a)[1]; Whangaehu loam (114)[1]; Taihape silt loam (114a)[1]; Whangamomona silt loam (116)[1]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss) — occasionally severe (3Ss), negligible to moderate sheet (0–2Sh), gully (0–2G), slump (0–2Su), negligible to slight riparian slip (0–1Rs), rock fall (0–1Rf)
Potential: Severe soil slip, moderate sheet, gully, riparian slip, and slump, slight rock fall under pasture. Slight gully, slump, riparian slip, and rock fall under forest

Vegetation: Semi-improved pasture (gS), manuka, kanuka (gM), exotic conifer forest (fF), mixed indigenous scrub (sX), mixed indigenous scrub with tree fern (sT), lowland podocarp-broadleaved forest (fO)

Land use: *Present:* Semi-intensive to extensive livestock farming, exotic plantation forestry, and farm woodlot forestry, undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal

Comments: Asymmetric hillslope patterns help identify this unit where rock exposures are difficult to find.

The LUC unit VIIe7 is used for long dip-slopes associated with bedded mudstone terrain, that have a potential for severe earthflow.

LUC unit: VIIe4 (11 729 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6b. Massive mudstone

Description: Steep to very steep, long slopes in Pliocene 'Waihora siltstone' hill country, with potential for severe soil slip

Reference site: Y17/401955 Southeast of Kanakanaia Road, 8 km along from Te Karaka

Slope: 26–35° (F), 26–42° (F+G), occasionally 26–42° (G+F)

Rock type: Massive mudstone (Mm), occasionally combined with bedded mudstone (Mm+Mb)
Note: Massive siltstone locally named 'Waihora siltstone' (GDC pers. comm.). Restricted to Pliocene rocks in the Waihora and Waimata synclines, forming part of the Mangaheia Group of rocks

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Tephric Recent Soils (RT); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Pahiatua silt loam (115a)[1]; Mahoenui silt loam (115)[1]; Whangaehu loam (114)[1]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), negligible to moderate sheet (0–2Sh), negligible to slight gully (0–1G)
Potential: Severe soil slip, moderate sheet and riparian slip, and slight gully under pasture. Slight soil slip and gully under forest

Vegetation: Semi-improved pasture (gS), exotic plantation forest (fF), mixed indigenous scrub (sX), lowland podocarp-broadleaved forest (fO)

Land use: *Present:* Semi-intensive livestock farming, exotic plantation forestry, small areas undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal

Comments: This unit is most like VIIe2 and VIIe3 in appearance, but i) slopes are more strongly affected by old and recent soil slip scars than VIIe2, and soils are generally better developed (on hilly slope segments), and ii) the hillslope pattern is more symmetrical than in VIIe3 bedded-rock terrain; it lacks the occassional outcropping rock and the infrequent slumps of VIIe3.

LUC unit: VIIe5 (742 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6e. Lacustrine muds

Description: Steep, some moderately steep, and occasional very steep slopes on Quaternary lacustrine deposits of variable lithology, with frequent 5–20 m bluffs of compact pale yellow to grey silts, often associated with Neogene massive or frittered mudstone, with potential for severe soil slip

Reference site: Y18/475754 End of Matokitoki Valley Road, near Gisborne City

Slope: 26–35° (F), 21–35° (F+E), occasional short 26–42° (G+F, F+G)

Rock type: Massive mudstone (Mm), sometimes combined with other lithologies such as massive sandstone (Mm+Sm), frittered mudstone (Mm+Mf), unconsolidated clays and silts (Mm+Uf), unconsolidated sands and gravels (Mm+Us), etc.
Notes: (i) Quaternary lake beds of variable lithology (some estuarine muds and associated deposits may also be included in the sequence). (ii) Quaternary pale-coloured silts exposed in bluffs are recorded as Mm due to their compact to very compact nature. (iii) Pliocene massive mudstone (also Mm) are sometimes included, as well as Miocene frittered mudstone (Mf) in lowest slope segments

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Immature Pallic Soils (PI); Perch-gley Pallic Soils (PP)
S: Orthic Recent Soils (RO); Orthic Raw soils (WO); Rocky Recent Soils (RX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Whangaehu loam (114)[1]

Erosion: *Present:* Slight to moderate soil slip (0–2Ss), sheet (0–2Sh), negligible to slight earthflow (0–1Ef)
Potential: Severe soil slip, moderate earthflow, sheet, slight slump and gully under pasture. Slight soil slip under forest

Vegetation: Semi-improved pasture (gS), manuka, kanuka (sM), mixed indigenous scrub (sX), exotic conifer forest (fF)

Land use: *Present:* Extensive livestock farming, undeveloped, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal, recognise and provide for nearby receiving urban developments. F: Open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, recognise and provide for nearby receiving urban developments

Comments: While this unit is related to VIe18 and VIIe12 (also on mainly lacustrine deposits), its steeper slopes, frequent bluffs of compact silts, and less influence of unconsolidated silts and clays, make it more droughty and relatively infertile.

LUC unit: VIIe6 (17 870 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6a. Frittered mudstone

Description: Strongly rolling to moderately steep and some rolling slopes in unstable loose-jointed Neogene frittered mudstone hill country, with potential for very severe earthflow erosion

Reference site: Z16/720275 2.5 km north-west of the junction of Mata Road and Highway 35

Slope: 16–25° (D+E, E+D), 21–25° (E), 16–20° (D), sometimes 8–20° (C+D, C), occasional 21–35° (E+F)

Rock type: Frittered mudstone (Mf), sometimes combined with other rock types such as bedded mudstone (Mf+Mb), sheared mixed lithologies (Mf+Mx), etc., sometimes with a patchy cover of Taupo/Waimihia tephra, with or without weathered, mainly rhyolitic tephra (e.g., pKt/pMo/Mf, pMo/Mf, etc.)
Notes: (i) Highly fractured 'loose-jointed mudstone' with extremely weak rock-mass strength, seen commonly in Tolaga Group rocks. (ii) Tephra can persist on undisturbed ridges, or on 'floating islands' of intact soil on creeping earthflows. Coverage generally does not exceed 40% of the map polygon where recorded, except where Orthic Allophanic Soils and Orthic Pumice Soils are the principal soils

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Allophanic Soils (LO); Orthic Brown Soils (BO); Orthic Gley Soils (GO); Orthic Pumice Soils (MO)
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Immature Pallic Soils (PI); Orthic Pumice Soils (MO); Tephric Recent Soils (RT)
S: Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Yellow brown earths: Wanstead clay loam, hill soil (25aH)[1]; Kourarau silt loam, hill soil (25cH)[1]; Pakarae sandy loam, hill soil (29cH)[1]

Erosion: *Present:* Slight to severe (mostly moderate) earthflow (1–3Ef), slight to moderate (mostly slight) gully (1–2G), negligible to moderate riparian slip (0–2Rs), slump (0–2Su)
Potential: Very severe earthflow, severe gully, moderate riparian slip, and slight sheet under pasture. Moderate earthflow, slight riparian slip, and slight gully under forest

Vegetation: Semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM), erosion-control exotic broadleaved forest (efR), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, open-plant trees, divert water from earthflow heads, avoid earthworks that add weight to earthflow surfaces or remove toe support, install gully-control structures, plant trees along banks of hillslope channels, drain springs on earthflows, take care with earthworks and shrub/tree removal. F: Open-plant trees, pair-plant non-suckering/non-cracking willows in gullies, divert water from earthflow heads, avoid earthworks that add weight to earthflow surfaces or remove toe support, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal

Comments: This unit has poor surface and sub-surface conditions over most of its area. It differs from the related LUC unit VIIe21 mainly in that actual and potential gully erosion is less severe. The unit is sometimes mapped on coastal hillslopes, where wave action worsens the erosion and makes control more difficult.

For interpretations that require the recognition of tephra, this unit can very occasionally be considered part of the tephra LUC suites if tephra covers more than 40% of map polygon.

LUC unit: VIIe7 (3567 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6c. Bedded mudstone

Description: Long dip slopes of bedded Neogene mudstone, and less commonly, bedded sandstone, sometimes with patchy and variable depth of tephra, with potential for severe earthflow, moderate riparian slip, and shallow gully erosion, mostly south-west of the Poverty Bay flats

Reference site: X18/124535 Mangarangiora Valley, 3 km east of Whakapunake

Slope: 8–20° (D+C, C+D), 15–25° (D+E, E+D), 21–25° (E), 16–20° and 26–35° (D+F)

Rock type: Frittered mudstone (Mf) surface lithology in bedded mudstone sequences (Mb), sometimes combined (Mb+Mf), or with other lithologies such as bedded sandstone (Mf+Sb), and often with a patchy cover of Taupo/Waimihia tephra, with or without, weathered, mainly rhyolitic tephra (pKt/pMo/Mb, pKt/Mb*Mf, etc.)
Notes: (i) Neogene alternating mudstone and sandstone where frittered mudstone beds dominate the sequence, or well bedded mudstone. (ii) Tephra can persist on ridges or coherent blocks of rafted debris on creeping earthflows. These deposits generally cover less than 40% of the map polygon where recorded

Soil: *N.Z. Soil Classification soil groups*
R: Allophanic Brown Soils (BL); Orthic Allophanic Soils LO); Orthic Podzols (ZO)
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI); Orthic Podzols (ZO); Allophanic Brown Soils (BL); Tephric Recent Soils (RT)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne series (GiH)[6] Steepland soils related to yellow-brown pumice soils: Hangaroa series (115b)[1], (Has)[6]; Waihua series (117d)[1], (Wis)[6]

Erosion: *Present:* Slight to moderate earthflow (1–2Ef), gully (1–2G), negligible to moderate soil slip (0–2Ss), negligible to slight slump (0–1Su), sheet (0–1Sh)
Potential: Severe earthflow, moderate gully, riparian slip, slight slump, soil slip, and sheet under pasture. Slight earthflow, gully, and riparian slip under forest

Vegetation: Semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive livestock farming and farm woodlot forestry
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately to highly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, open-plant trees, divert water from earthflow heads, avoid earthworks that add weight to earthflow surfaces or remove toe support, install gully-control structures, plant trees along banks of hillslope channels, drain springs on earthflows, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas.
F: Open-plant trees, pair-plant non-suckering/non-cracking willows in gullies, divert water from earthflow heads, avoid earthworks that add weight to earthflow surfaces or remove toe support, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas

Comments: This unit is recorded only where extensive (mappable) areas of dip-slope terrain occurs and where there is potential for severe erosion. Most earthflow and gully erosion is shallow and occurs in the fritted mudstone bed on dip slopes. Erosion depth is limited by the next resistant rock layer (usually sandstone in the bedded sequence). For interpretations that require the recognition of tephra, this unit can occasionally be considered part of LUC suite 3 if Taupo/Waimihia tephra covers more than 40% of the map polygon.

LUC unit: VIIe8 (20 765 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Steep to moderately steep slopes on argillite or crushed argillite, with potential for severe soil slip

Reference site: Z15/845611 Junction of the Wairoa and Waiapu rivers, 10 km along Mangakino–Waiomatatini Road from Ruatoria

Slope: 26–35° (F), 21–35° (F+E, E+F), 21–25° (E)

Rock type: Argillite (Ar), crushed argillite association of rocks (Ac), combinations of both (Ar+Ac, Ac+Ar), sometimes either Ar or Ac with other lithologies such as greywacke association of rocks (Ac+Gw), indurated sandstone (Ac+Si), coarse slope deposits (Ac+Cl), etc. Very occasionally with a patchy cover of weathered, mainly rhyolitic tephra, with or without, a cover of Taupo/Waimahia tephra (pKt/pMo/Ar, pMo/Ar, etc.)
Notes: (i) Includes Whangai Formation rocks and other Paleogene and Cretaceous fine-grained indurated materials. (ii) Local stability and steep slopes may occur due to substantial moderately indurated sandstone beds, where recorded in Tapuwaeroa Formation terrain in particular. (iii) Patchy tephra covers less than 40% of the map polygon where recorded

Soil: *NZ Soil Classification*
R: Orthic Brown Soils (BO); Orthic Allophanic Soils (LO)
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL)
S: Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Brown Soils (BO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Ruatoria stony silt loam (121)[1];Tuparoa silt loam (121a)[1]; Arowhana sandy loam (121b)[1]
Yellow-brown earths: Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), gully (1–2G) (mostly slight soil slip and gully), negligible to moderate (mostly negligible) earthflow (0–2Ef), negligible to slight sheet (0–1Sh), riparian slip (0–1Rs), scree (0–1Sc)
Potential: Severe soil slip, moderate gully, sheet, earthflow, and riparian slip, slight scree under pasture. Slight soil slip, riparian slip, and gully under forest

Vegetation: Semi-improved pasture (gS), exotic conifer forest (fF), manuka, kanuka (sM), mixed indigenous scrub (sX), podocarp-broadleaved forest (fO)

Land use: *Present:* Semi-intensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, open-plant trees, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, install gully-control structures, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Open-plant trees, pair-plant non-suckering/non-cracking willows in gullies, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal, encourage regeneration and maintain indigenous shrubs and trees on steeper areas.

Comments: This unit is steeper than other LUC units on argillite and crushed argillite, occupying locally the more elevated hillslopes. It is dominated by soil slip rather than earthflow and/or gully erosion (although the latter erosion types still occur). Particularly steep and stable areas of this unit are closest to VIIe11 in appearance (although the latter is recorded in autocthonous terrain and is slightly more stable).

LUC unit: VIIe9 (2866 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6d. Weber marl

Description: Strongly rolling to moderately steep and occasionally rolling slopes in Weber marl hill country, with potential for severe earthflow erosion

Reference site: Y17/649833 0.5 km south of the Highway 35 and Panikau Road junction

Slope: 16–20° (D), 16–25° (D+E, E+D), 21–25° (E), occasionally 8–20° (D+C)

Rock type: Frittered mudstone (Mf), sometimes with crushed argillite association of rocks (Mf+Ac)
Notes: (i) Weber marl (Weber Formation) is a calcareous mudstone or muddy limestone, sometimes sheared and bentonitic. (ii) Weathered, mainly rhyolitic tephra, often with a veneer of Taupo/Waimihia tephra, can persist on ridges, but poor coverage (<20% of the area) prevents these deposits being recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Orthic Gley Soils (GO); Immature Pallic Soils (PI); Perch-gley Pallic Soils (PP)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Immature Pallic Soils (PI); Tephric Recent Soils (RT); Orthic Gley Soils (GO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Yellow-brown earths: Pakarae complex, hill soil (29dH)[1]; Wanstead clay loam, hill soil (25aH)[1]; Pouawa sandy loam, hill soil (25bH)[1]

Erosion: *Present:* Slight to severe (mostly moderate) earthflow (1–3Ef), negligible to moderate (mostly slight) gully (0–2G), negligible to slight soil slip (0–1Ss), riparian slip (0–1Rs)
Potential: Severe earthflow, moderate gully, slight soil slip, and riparian slip under pasture. Moderate earthflow and slight gully under forest

Vegetation: Semi-improved pasture (gS), rushes, sedges (hR), erosion control exotic conifer forest (efF)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, open-plant trees, avoid earthworks that add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, install gully-control structures, drain springs on earthflows, take care with earthworks and shrub/tree removal. F: Open-plant trees, pair-plant non-suckering/non-cracking willows in gullies, avoid earthworks that add weight to earthflow surfaces or remove toe support, plant trees along banks of hillslope channels, take care with earthworks and shrub/tree removal

Comments: Weber marl LUC units contain rocks older than Neogene and in this respect are atypical of LUC suite 6. Weber marl units are in suite 6 because their lithology and behaviour is closer to frittered mudstone than the crushed argillite of LUC suite 11.

Where gully erosion is severe and presents a greater management problem than earthflow, the LUC unit VIIe21 should be used.

While moderately productive for forestry in the longer term, there will be establishment and early growth difficulties due to poor drainage, and losses due to active earthflow.

LUC unit: VIIe10 (9291 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7a. Massive to bedded sandstone in Ngatapa–Rere lower rainfall area

Description: Steep to very steep, long slopes in Neogene massive or bedded sandstone hill country below 550 m a.s.l., in the low-rainfall Ngatapa–Rere area just west of the Poverty Bay flats, with potential for severe soil slip

Reference site: X18/284775 3 km south of Ngatapa on Wharekopae Road

Slope: 26–35° (F), 26–42° (F+G, G+F), occasionally 26–35° and short >42° (F+H)

Rock type: Bedded or massive sandstone (Sb, Sm), sometimes combined (Sm+Sb),occasionally with other lithologies such as limestone (Sm+Li)
Note: A veneer of Taupo/Waimahia tephra, sometimes on weathered, mainly rhyolitic tephra, persists on some ridges, but poor coverage (<20% of the area) prevents these deposits being recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown pumice soils and yellow-brown earths: Waihua stony sandy loam and sandy silt (117d)[1]; Waihua series (WiS)[1]

Erosion: *Present:* Sight to moderate soil slip (1–2Ss), sheet (1–2Sh), negligible to slight gully (0–1G)
Potential: Severe soil slip, moderate sheet, slight riparian slip under pasture. Slight soil slip and riparian slip under forest

Vegetation: Semi-improved pasture (gS), manuka, kanuka (sM), exotic conifer forest (fF)

Land use: *Present:* Semi-intensive to extensive livestock farming
Agric. Potential: Semi-intensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, maintain existing indigenous cover, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, maintain existing indigenous cover, encourage regeneration and maintain indigenous shrubs and trees on steeper areas

Comments: Annual average rainfalls of between 1000 and 1400 mm/yr is relatively low for hill country in the region. This unit is seriously affected by drought, being in an area of lower rainfall combined with coarsely textured shallow soils and coarse-grained rock types.

LUC unit: VIIe11 (60 845 ha)

LUC suite: 10. Greywacke and argillite

LUC subsuite: -

Description: Steep to very steep and some long moderately steep slopes below the treeline in greywacke or argillite hill country and mountain land in the Raukumara and northern Huiarau ranges and foothills, with potential for severe soil slip

Reference site: X17/015051 Opposite Highway 2, 5 km west from Matawai

Slope: 26–35° (F), 26–42° (F+G), 21–35° (F+E, E+F), occasional short 36–42° (G)

Rock type: Greywacke association of rocks (Gw), argillite (Ar), occasionally indurated sandstone (Si), sometimes combined (Gw+Ar), also with other lithologies such as crushed greywacke (Ar+cGw), coarse slope deposits (Gw+Cl), etc. Can have patchy weathered, mainly rhyolitic tephra, with or without, a cover of Taupo/Waimihia tephra (pKt/pMo/Gw, pMo/Ar, etc.).
Notes: (i) Recorded in autocthonous rock terrain. (ii) Indurated sandstone and mudstone (greywacke and argillite) of Cretaceous and Paleogene age, e.g., in Urewera and Matawai groups, some Whangai (see also the note under rock type in LUC unit VIe19) and Tikihore formation rocks. (iii) Patchy tephra generally covers less than 40% of the map polygon where recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Podzols (ZO); Orthic Brown Soils (BO); Orthic Allophanic Soils (LO); Rocky Raw Soils (WX); Allophanic Brown Soils (BL); Tephric Recent Soils (RT)
S: Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Raw Soils (WO); Orthic Brown Soils (BO); Orthic Podzols (ZO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown pumice soils: Raukumara sandy loam (124a)[1]; Raukumara steepland soils (16)[2]; Urewera sandy silt and sand (125a)[1]

Erosion: *Present:* Slight to severe (mostly slight) soil slip (1–3Ss), negligible to moderate (mostly slight) debris avalanche (0–2Da), gully (0–2G), negligible to slight scree (0–1Sc), riparian slip (0–1Rs), rock fall (0–1Rf), wind (0–1W) — wind on exposed hill tops
Potential: Severe soil slip (moderate soil slip in areas with F+E, E+F slopes), moderate gully, slight riparian slip, rockfall, and scree under pasture. Moderate sheet and wind on exposed hill tops. Slight soil slip and gully under forest

Vegetation: Lowland beech forest (fW), lowland podocarp-broadleaved forest (fO), podocarp-broadleaved-beech forest (fD), semi-improved pasture (gS), unimproved pasture (gU), fern (sF), mixed indigenous scrub (sX), exotic conifer forest (fF)

Land use: *Present:* Undeveloped, extensive livestock farming, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover

Comments: Rainfall is high, being greater than 2000 mm/yr, and frequently at 3000–4000 mm/yr. Pastures readily revert to scrub, fern, and weeds.

Atypical hill or mountain tops such as on Aorangi, are included where below the treeline.

While VIIe11 has potential for severe soil slip, this is realised only occasionally where local crushing has weakened the greywacke, and on steepest slopes. Generally, greywacke areas do not experience soil slip to the same high degree as that found in most Neogene rock terrains.

LUC unit: VIIe12 (397 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6e. Lacustrine muds

Description: Strongly rolling to moderately steep and occasionally rolling slopes on Quaternary lacustrine clays, with potential for severe earthflow

Reference site: Y17/336962 1.5 km north-east of the end of Rangatira Road

Slope: 16–20° (D), 16–25° (D+E, E+D), 8–20° (D+C)

Rock type: Unconsolidated clays and silts (Uf)
Note: Quaternary lake beds of variable lithology (some estuarine muds may also be included)

Soil: *N.Z. Soil Classification soil groups*
R: Perch-gley Pallic Soils (PP); Immature Pallic soils (PI)
H: Immature Pallic soils (PI); Perch-gley Pallic Soils (PP)
N.Z. Genetic Soil Classification
Yellow-brown pumice soils: Gisborne sandy loam (21)[1]; Gisborne sandy loam, hill soil (21H)[1].
Note: Yellow-brown pumice soils were recorded in previous surveys, but soils are closer to Yellow-grey earth – yellow-brown earth intergrades

Erosion: *Present:* Moderate earthflow (2Ef)
Potential: Severe earthflow, moderate gully, slight soil slip, and sheet under pasture. Moderate earthflow and slight gully under forest or block-planted soil conservation trees

Vegetation: Erosion control exotic broadleaved forest (efR), semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM)

Land use: *Present:* Extensive livestock farming, planted in blocks of erosion-control trees
Agric. Potential: Extensive livestock farming (summer grazing)
Forestry Potential: Poorly productive exotic plantation forestry

Management: A: Surface drainage, open-plant trees, divert water from earthflow heads, avoid earthworks that add weight to earthflow surfaces or remove toe support, take care in siting high value capital structures, drain springs on earthflows, take care with earthworks and shrub/tree removal, closely plant trees in worst areas. F: Open-plant trees, avoid earthworks that add weight to earthflow surfaces or remove toe support, drain springs on earthflows, take care with earthworks and shrub/tree removal

Comments: A broken hummocky surface locally impedes natural drainage and restricts opportunities for artificial drainage. Slowly permeable clays and products of its weathering impede water flow through soils, giving rise to poorly drained subsoils.

Present earthflow erosion is not as severe as might be expected because most of the area is block-planted with erosion-control trees.

LUC unit: VIIe13 (5906 ha)

LUC suite: 9. Basalt

LUC subsuite: -

Description: Steep to very steep slopes in basaltic hill country between Cape Runaway and Hicks Bay, with potential for severe soil slip

Reference site: Z14/777905 Patangata trig, north side of Hicks Bay

Slope: 26–42° (F+G), 26–35° (F), 21–35° (F+E), occasional 26–42° (G+F)

Rock type: Ancient volcanics (In)
Note: Matakaoa Volcanics — basaltic lavas, breccia, and unconsolidated rocks of Cretaceous and Paleogene age

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO)
S: Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Red-brown loam steepland soils: Potikirua steepland soils (22)[2]

Erosion: *Present:* Negligible to moderate (mostly slight) soil slip (0–2Ss), negligible to moderate debris avalanche (0–2Da), negligible to slight sheet (0–1Sh)
Potential: Severe soil slip, moderate earthslip, riparian slip and sheet under pasture. Slight soil slip, earth slip, riparian slip, and debris avalanche under forest

Vegetation: Broadleaved forest (fB), mixed indigenous scrub with tree fern (sT), exotic conifer forest (fF), semi-improved pasture (gS), mixed indigenous scrub (sX), manuka, kanuka (sM), *Cassinia* (sC)

Land use: *Present:* Undeveloped, semi-intensive livestock farming, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover

Comments: This unit receives moderately high to high rainfalls of 1600–2400 mm/yr, and this, through leaching, induces lower levels of available soil nutrients.

LUC unit: VIIe14 (6098 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7b. Bedded sandstone of the Wharerata hills

Description: Steep to very steep Neogene bedded sandstone hill country in the high rainfall area of Wharerata hills, with potential for severe soil slip

Reference site: Y19/319479 North side of Wharerata lookout, Highway 2

Slope: 26–42° (F+G), 26–35° (F), 26–42° (G+F)

Rock type: Bedded sandstone (Sb)
Notes: (i) Strongly alternating Miocene sandstone and mudstone, where distinct sandstone beds dominate the sequence. (ii) Can have a patchy cover of weathered, mainly rhyolitic tephra, usually with a veneer of Taupo/Waimihia tephra, but poor coverage (<20% of the area) prevents these deposits being recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL); Orthic Podzols (ZO)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Wharerata sandy loam (117h)[1]; Wharerata series (Was)[6]

Erosion: *Present:* Negligible to moderate (mostly negligible) soil slip (0–2Ss), negligible to slight sheet (0–1Sh)
Potential: Severe soil slip, moderate sheet and riparian slip under pasture. Moderate soil slip and riparian slip under forest

Vegetation: Mixed indigenous scrub (sX), exotic conifer forest (fF), manuka, kanuka (sM), tauhinu (sC), fern (sF), unimproved pasture (gU)

Land use: *Present:* Exotic plantation forestry, extensive and semi-intensive livestock farming, reversion to scrub
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover

Comments: Rainfall ranges from 1400 mm/yr at lowest elevations to 2400 mm at highest elevations. Most of the unit occurs in areas receiving more than 2000 mm/yr rainfall.

LUC unit: VIIe15 (31 640 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7e. Massive and bedded sandstone

Description: Steep to very steep slopes in Neogene massive or bedded sandstone hill country, with potential for severe soil slip

Reference site: Z17/750980 1 km south-east of the intersection of Wharf and Shelton roads

Slope: 26–42° (F+G), 26–35° (F), 26–42° (G+F), occasional 21–35° (F+E), 36–42° (G)

Rock type: Massive sandstone (Sm), bedded sandstone (Sb), sometimes combined (Sm+Sb) or with other lithologies such as bedded mudstone (Sm+Mb), massive mudstone (Sb+Mm), frittered mudstone (Sb+Mf), etc. A variety of rock types are recorded on terraces escarpments (see comments) such as alluvial gravels and massive sandstone (Gr+Sm), alluvial gravels, and unconsolidated sands and gravels (Gr+US), etc.
Note: Tokomaru Sandstone (usually Sm) is well represented

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI); Tephric Recent Soils (RT)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Orthic Brown Soils (BO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Whangamomona silt loam (116)[1]; Mokau sandy loam (117c)[1]; Waihua stony sandy loam and sandy silt (117d)[1]; Wharerata sandy loam (117h)[1]

Erosion:
Present: Slight to moderate (mostly slight) soil slip (1–2Ss), negligible to moderate sheet (0–2Sh), riparian slip (0–2Rs)
Potential: Severe soil slip, moderate sheet and riparian slip under pasture. Slight soil slip and riparian slip under forest

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), mixed indigenous scrub (sX), manuka, kanuka (sM), exotic conifer forest (fF)

Land use:
Present: Extensive livestock farming, undeveloped, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and on steepest slopes, take care with earthworks and shrub/tree removal, maintain existing indigenous cover. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover

Comments: Minor bluffs are included in this unit. Pasture maintenance and reversion to manuka is a problem, mainly because soils are shallow with low natural nutrient status and very low soil moisture storage capability. Erosion scars are slow to heal.

LUC unit VIIe15, and the related unit VIe16, are used as best-fit options for terrace escarpments and dissected V-shaped incisions into intermediate terrace surfaces (LUC subsuite 2a) where a variety of lithologies are exposed. Lithologies include alluvial gravel and sand, mudstone, greywacke, etc., as well as sandstone.

LUC unit: VIIe16 (8458 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7c. Te Kahika Formation of Whangaparaoa

Description: Steep to very steep slopes in strongly dissected hill country south-east of Whangaparaoa in Neogene Te Kahika Formation massive sandstone and mudstone, with potential for severe soil slip

Reference site: Y14/622880 3 km south-west of Potaka (accessible from the forestry road at Mangaparua, west of Potaka)

Slope: 26–42° (F+G), 26–35° (F), occasional 21–35° (F+E)

Rock type: Massive sandstone (Sm), sometimes with massive mudstone (Sm+Mm), occasionally with unconsolidated sands and gravels (Sm+Us, Us+Sm).
Note: Te Kahika Formation rocks comprising massive sandstone and massive mudstone

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Allophanic Brown Soils (BL)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Whangaparaoa steepland soils (21)[2]; Mokau sandy loam (117c)[1]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), negligible to moderate debris avalanche (0–2Da), negligible to slight slump (0–1Su), gully (0–1G)
Potential: Severe soil slip, moderate riparian slip, gully, and sheet, and slight slump under pasture. Moderate soil slip and debris avalanche, slight gully, riparian slip, and slump under forest

Vegetation: Podocarp-broadleaved-beech forest (fD), broadleaved forest (fB), mixed indigenous scrub with tree fern (sT)

Land use: *Present:* Undeveloped
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and on steepest slopes, take care with earthworks and shrub/tree removal, maintain existing indigenous cover. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover

Comments: Rainfall is 2000–3000 mm/yr and the area is exposed to mostly cyclonic storms arriving from the north. Once cleared of forest, soil slip erosion can be very severe. Erosion scars are slow to heal as soils have low nutrient status, largely due to the very strong leaching regime and sandy parent materials.

LUC unit: VIIe17 (9493 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7d. Muddy sandstone of East Cape

Description: Steep to very steep and some moderately steep slopes in Neogene massive muddy sandstone and mudstone in the East Cape area, with potential for severe soil slip

Reference site: Z14/938717 West side of Rangitukia East Cape Road, 8 km from Rangitukia

Slope: 26–42° (F+G, G+F), 26–35° (F), 21–35° (F+E), short 36–42° (G)

Rock type: Massive sandstone and massive mudstone (Sm+Mm), occasionally massive sandstone (Sm).
Note: Two main rock units occur: 1. most extensive and uppermost in the sequence late Miocene to Pliocene muddy sandstone (frequently bluff-forming), and 2. least extensive and lower in the sequence, early to mid-Miocene massive mudstone (similar to Neogene massive mudstone elsewhere in the region)

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Marangairoa steepland soils (20)[2]

Erosion: *Present:* Slight to moderate soil slip (1–2Ss), negligible to slight sheet (0–1Sh), gully (0–1G), debris avalanche (0–1Da)
Potential: Severe soil slip, moderate riparian slip, sheet, and gully under pasture. Moderate soil slip, riparian slip, and slight gully under forest

Vegetation: Broadleaved forest (fB), exotic conifer forest (fF), manuka, kanuka (sM), mixed indigenous scrub (sX), semi-improved pasture (gS)

Land use: *Present:* Undeveloped, extensive livestock farming, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and on steepest slopes, take care with earthworks and shrub/tree removal, maintain existing indigenous cover, recognise and provide for the sensitive coastal receiving environment. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, take care with earthworks and shrub/tree removal, maintain existing indigenous cover, recognise and provide for the sensitive coastal receiving environment

Comments: Pastures are difficult to manage. They are prone to rapid weed infestation when cleared of forest and indigenous shrubby plants. Soils are shallow and natural fertility is low.

LUC unit: VIIe18 (3954 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Rolling to strongly rolling slopes in low hill country on crushed argillite and sheared mixed lithologies (melange) with potential for very severe earthflow, mainly north-west of the Waiapu River valley and where annual rainfall exceeds 2000 mm/yr

Reference site: Y14/610820 Opposite Waitangihia Station, 12.5 km along Waikura (valley) Road

Slope: 8–15° (C), 8–20° (C+D, D+C), 16–20° (D)

Rock type: Sheared mixed lithologies (Mx), crushed argillite association of rocks (Ac), sometimes combined (e.g., Mx+Ac), occasionally with a patchy cover of weathered, mainly rhyolitic tephra (e.g., pMo/Mx)
Notes: (i) Recorded in allocthonous rock terrain. (ii) Includes Whangai Formation and other Paleogene and Cretaceous fine-grained indurated material and melange. (iii) Patchy weathered tephra occurs on stable ridges or on small coherent blocks of rafted debris. These deposits generally cover less than 40% of the map polygon where recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Orthic Gley Soils (GO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Allophanic Soils (LO); Allophanic Brown Soils (BL); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Yellow-brown earths: Waikura hill soils (14H)[2]; Mangatu hill complex (13H)[2];Tinui silt loam and Waikura sandy loam (28)[1]; Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]; Wanstead clay loam, hill soil (25aH)[1]

Erosion: *Present:* Moderate to very severe (mostly severe) earthflow (2–4Ef), slight to severe (mostly slight to moderate) gully (1–3Ef), negligible to slight slump (0–1Su), streambank (0–1Sb), soil slip (0–1Ss)
Potential: Very severe earthflow, severe gully, slight slump and streambank under pasture. Severe earthflow, slight gully, slump, and streambank under forest

Vegetation: Semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM)

Land use: *Present:* Semi-intensive livestock farming
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Open-plant trees, surface drainage, avoid earthworks that add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, install gully-control structures, plant trees along banks of hillslope channels, drain springs on earthflows, take care with earthworks and shrub/tree removal. F: Avoid earthworks that add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas, install gully-control structures associated with willows, take care with earthworks and shrub/tree removal

Comments: The landscape is subdued, with many rushes in pastures. Relatively high rainfall (>2000 mm/yr) and lack of drying conditions for significant periods in a normal year, and very slowly permeable rock material ensures that this unit remains very wet. Drainage is difficult.

This unit is most like VIIe19 but has easier slopes and gullies are not as deeply incised. In a few areas, where land better fits the physical description of VIIe18, the unit VIIe19 is recorded because rainfall is less than 2000 mm/yr.

LUC unit: VIIe19 (27 437 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Strongly rolling to moderately steep and occasionally rolling or steep slopes in hill country of crushed argillite and sheared mixed lithologies (melange), with potential for very severe earthflow and severe gully

Reference site: Y16/525364 Mata Link Road, 1 km from the junction with Ihungia Road

Slope: 16–20° (D), 21–25° (E), 16–25° (E+D, D+E), occasional 8–20° (C+D, D+C) and 21–35° (E+F)

Rock type: Crushed argillite association of rocks (Ac), sheared mixed lithologies (Mx), sometimes combined (e.g., Ac+Mx), often with other lithologies such as argillite (Ac+Ar), crushed greywacke (Ac+cGw), etc. Sometimes with patchy weathered, mainly rhyolitic tephra, with or without, a cover of Taupo/Waimahia tephra (e.g., pMo/Ac, pKt/pMo/Ac*Mx)
Notes: (i) Recorded in allocthonous rock terrain. (ii) Includes Whangai Formation and other Paleogene and Cretaceous fine-grained indurated material, and melange. (iii) Tephra can occur on stable ridges, or on coherent blocks of rafted debris. These deposits generally cover less than 40% of the map polygon where recorded

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Allophanic Brown Soils (BL); Orthic Gley Soils (GO); Orthic Allophanic Soils (LO); Orthic Podzols (ZO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Orthic Podzols (ZO); Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Orthic Gley Soils (GO); Orthic Pumice Soils (MO); Immature Pallic Soils (PI)
S: Orthic Recent Soils (RO); Tephric Recent Soils (RT); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]; Waikura hill soils (14H)[2]; Tuparoa silt loam (121a)[1]; Ruatoria stony silt loam (121)[1]; Arowhana sandy loam (121b)[1]; Mangahaumia sandy loam (121c)[1]

Erosion: *Present:* Slight to very severe (mostly moderate to severe) earthflow (2–4Ef), slight to severe gully (1–2Ef), negligible to moderate riparian slip (0–2Rs), slump (0–2Su), negligible to slight soil slip (0–1Ss)
Potential: Very severe earthflow, severe gully, moderate slump and riparian slip, and slight soil slip under pasture. Severe earthflow, moderate gully, slight riparian slip and slump under forest

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), exotic conifer forest (fF), manuka, kanuka (sM), mixed indigenous scrub (sX)

Land use:

Present:	Semi-intensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential:	Extensive livestock farming
Forestry Potential:	Moderately productive exotic plantation forestry

Management: A: Closely plant trees, pair-plant non-suckering/non-cracking willows in gullies, avoid earthworks that add weight to earthflow surfaces or remove toe support, install gully-control structures, plant trees along banks of hillslope channels, drain springs on earthflows, specialised site-specific measures needed for earthworks and tree/shrub removal. F: Closely plant trees, pair-plant non-suckering/non-cracking willows in gullies, avoid earthworks that add weight to earthflow surfaces or remove toe support, install gully-control structures, plant trees along banks of hillslope channels, specialised site-specific measures needed for earthworks and tree/shrub removal

Comments: Erosion debris has serious offsite effects such as increasing the flood risk in river valleys and on flood plains. Very poor surface and internal drainage. Ample rainfall and moderately fertile soils encourage rapid herbaceous covers after logging.

This unit is similar to VIIe18 but is not restricted to areas >2000 mm/yr rainfall, has steeper slopes, and gullies are more deeply incised. VIIe24 is used where gullies become very serious.

LUC unit: VIIe20 (13 769 ha)

LUC suite: 3. Taupo/Waimihia tephra

LUC subsuite: 3b. Upland

Description: Steep to moderately steep and sometimes very steep slopes in mountain land and hill country in the western part of the region at 550–1200 m a.s.l., on Neogene bedded or massive sandstone, mantled by at least 25 cm depth of Taupo/Waimihia tephra over weathered tephra, with potential for severe soil slip and sheet

Reference site: X18/901793 5 km past Hangaroa River bridge, Waimaha-Rua's Track Road

Slope: 26–35° (F), 21–35° (F+E), occasionally 26–42° (F+G)

Rock type: Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra on bedded sandstone (Kt/Mo/Sb), massive sandstone (Kt/Mo/Sm), occasionally with other rock types such as limestone (Kt/Mo/Sb*Li). Frequently with patchy Taupo/Waimihia tephra (e.g., pKt/Mo/Sb), and occasionally without Taupo/Waimahia tephra (e.g., Mo/Sb).
Notes: (i) Some areas of Cretaceous to Paleogene rocks such as in Karekare and Whangai formations are mapped as bedded sandstone (Sb) and bedded mudstone (Mb) and included as a best-fit option in this LUC unit. Elsewhere, a perceived increase in rock-mass strength and resistence to weathering results in these rock formations being mapped as greywacke or argillite (Gw, Ar) and this land is classified as VIIe11. (ii) Patchy tephra generally covers more than 40% of the map polygon where recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Podzols (ZO); Orthic Recent Soils (RO); Orthic Brown Soils (BO); Orthic Allophanic Soils (LO)
S: Orthic Podzols (ZO); Orthic Recent Soils (RO); Orthic Raw Soils (WO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Steepland soils related to podzolised yellow-brown pumice soils: Waikaremoana steepland soils (YkS)[7]
Podzolised yellow-brown pumice soils: Ruakituri hill soils (RUH)[7]; Matawai hill soils (MaWH)[7]; Matawai sandy loam, hill soil (22H)[1]; Ngaroma sandy silt, hill soil (19H)[1]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), debris avalanche (0–1Da)
Potential: Severe soil slip and sheet, moderate riparian slip, slight gully under pasture. Moderate debris avalanche, slight gully and riparian slip under forest

Vegetation: Podocarp-broadleaved-beech (fD), lowland beech forest (fW), lowland podocarp-broadleaved forest (fO), semi-improved pasture (gS)

Land use: *Present:* Undeveloped, extensive livestock farming
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, maintain existing indigenous cover, control shrub and tree pests, specialised site-specific measures needed for earthworks and tree/shrub removal. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian areas, maintain existing indigenous cover, specialised site-specific measures needed for earthworks and tree/shrub removal

Comments: Most of this unit receives in excess of 2000 mm/yr rainfall. Soils have low nutrient status being very strongly leached.

Few precedents exist for assessing erosion potential under pasture, but similar deforested steep slopes elsewhere in high rainfall montane environments results in serious erosion.

LUC unit: VIIe21 (24 705 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6a. Frittered mudstone

Description: Strongly rolling to moderately steep to steep slopes in unstable loose-jointed Neogene frittered mudstone hill country, with potential for very severe gully and soil slip

Reference site: Y16/543182 East side of Tauwhareparae Road, 4 km north from the junction with Tutamoe Road

Slope: 16–25° (D+E, E+D), 16–20° (D), 26–35° (F), 21–35° (E+F, F+E), 16–20° and 26–35° (D+F)

Rock type: Frittered mudstone (Mf), sometimes combined with other rock types such as bedded mudstone (Mb), sheared mixed lithologies (Mf+Mx), etc., and very occasionally with patchy weathered rhyolitic tephra, with or without a cover of Taupo/Waimihia tephra (e.g., pKt/pMo/Mf)
Notes: (i) Highly fractured loose-jointed mudstone with extremely weak rock-mass strength, seen commonly in Tolaga Group terrain. (ii) Patchy tephra covers less than 40% of the map polygon where recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI); Orthic Pumice Soils (MO); Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO)
S: Orthic Recent Soils (RO), Orthic Brown Soils (BO); Orthic Raw Soils (WO); Tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Yellow brown earths: Wanstead clay loam, hill soil (25aH)[1]; Kourarau silt loam, hill soil (25cH)[1]; Pakarae sandy loam, hill soil (29cH)[1]
Yellow-brown earths and related steepland soils: Mahoenui silt loam (115)[1]; Pahiatua silt loam (115a)[1]; Pakarae sandy loam, hill soils (29cH)[1]

Erosion:
Present: Slight to very severe (mostly moderate to severe) gully (1–4G), soil slip (1–4Ss), slight to severe earthflow (1–3Ef), negligible to severe slump (0–3Su), negligible to moderate riparian slip (0–2Rs), negligible to slight sheet (0–1Sh)
Potential: Very severe gully and soil slip, severe earthflow, slump, and riparian slip, moderate sheet under pasture. Severe gully, moderate soil slip, earthflow, slump, and riparian slip under forest

Vegetation: Semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM), erosion-control exotic broadleaved forest (efR), erosion-control exotic conifer forest (efF)

Land use:
Present: Semi-intensive livestock farming, erosion control forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Moderately productive exotic plantation forestry

Management: A: Closely plant trees, control erosion in more elevated parts of catchments, pair-plant non-suckering/non-cracking willows in gullies, avoid earthworks that add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and steepest slopes, drain springs on earthflows, specialised site-specific measures needed for earthworks and tree/shrub removal. F: Measures are the same as for A: above

Comments: This unit differs from the related LUC unit VIIe6 mainly by having more severe actual and potential gully and soil slip erosion. Gully erosion can have serious offsite effects such as increasing flood risk lower in the catchment. Large gullies are extremely difficult to stabilise. Management is best directed at stopping new gullies forming.

If gullies in this unit coalesce and become mappable as single large gully structures, the unit VIIIe9 is used.

LUC unit: VIIe22 (10 784 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Moderately steep, steep to very steep and some strongly rolling slopes on crushed greywacke in the Raukumara Range and foothills, where slopes are long and closely dissected by gullies, with potential for very severe gully and slump, and severe earthflow

Reference site: Y16/323230 Tarndale Road, 1 km past the junction with a forestry road

Slope: 21–35° (F+E, E+F), 21–25° (E), 26–35° (F), 26–42° (F+G), occasional 16–26° (E+D)

Rock type: Crushed greywacke association of rocks (cGw), sometimes with other rock types such as coarse slope deposits (cGw+Cl), crushed argillite association of rocks (cGw+Ac), etc.. Very occasionally with a patchy cover of Taupo/Waimihia tephra over weathered, mainly rhyolitic tephra (e.g., pKt/pMo/cGw) or weathered tephra (e.g., pMo/cGw).
Notes: (i) Recorded in allochthonous rock terrain. (ii) Crushed indurated sandstone and mudstone of typically Cretaceous age, e.g., Tikihore Formation rocks. (iii) Patchy tephra covers less than 40% of the area where recorded

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Podzols (ZO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL); Orthic Allophanic Soils (LO); Rocky Raw Soils (WX)
S: Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Yellow-brown earths and related steepland soils: Raukumara sandy loam (124a)[1]; Raukumara steepland soils (16)[2]; Urewera sandy silt and sand (125a)[1]; Ruatoria steepland soils (16)[2]; Waikura hill soils (14)[2]

Erosion: *Present:* Slight to very severe (mostly moderate) gully (1–4G), slump (1–4Su), slight to severe soil slip (1–3Ss), earthflow (1–3Ef), scree (1–3Sc), negligible to moderate riparian slip (0–2Rs), streambank (0–2Sb)
Potential: Very severe gully and slump, severe earthflow and soil slip, moderate riparian slip, scree, and streambank under pasture. Moderate gully, slump, and riparian slip, slight scree and debris avalanche under forest

Vegetation: Lowland podocarp-broadleaved forest (fO), podocarp-broadleaved-beech forest (fD), semi-improved pasture (gS), unimproved pasture (gU), exotic conifer forest (fF), manuka, kanuka (sM), mixed indigenous scrub (sX), fern (sF)

Land use: *Present:* Undeveloped, extensive livestock farming, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Closely plant trees, control erosion in more elevated parts of catchments, pair-plant non-suckering/non-cracking willows in gullies, avoid earthworks which add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and steepest slopes, maintain existing indigenous cover, control shrub and tree pests, drain springs on earthflows, specialised site-specific measures needed for earthworks and tree/shrub removal. F: Measures are the same as for A above

Comments: Rainfall is high, generally greater than 2000 mm/yr. The strong leaching environment contributes to low natural nutrient contents of soils, vigorous scrub reversion, and weed infestation in pastures.

Gully erosion has serious offsite effects such as increasing flood risk lower in the catchment. Gullies are numerous but individual gullies are not particularly deep. Very large greywacke boulders occur throughout this unit, imparting a degree of local stability and resistence to deep gully formation of the kind seen in crushed argillite hill country.

LUC unit: VIIe23 (11 193 ha)

LUC suite: 6. Neogene and Quaternary mudstone

LUC subsuite: 6c. Bedded mudstone
6a. Frittered mudstone
6b. Massive mudstone

Description: Steep, very steep to precipitous slopes, mostly severely eroded by combinations of soil slip, riparian slip, gully, and sheet, exposing much bare ground in Neogene bedded, frittered, or massive mudstone hill country

Reference site: Y16/640270 Makomako catchment, 1 km west of Makomako Station Road turn-off on Mata Road

Slope: 26–42° (F+G, G+F), 26–35° (F), 36–42° (G), >26° (F+H), >36° (G+H)

Rock type: Bedded mudstone (Mb), frittered mudstone (Mf), massive mudstone (Mm), sometimes combined (e.g., Mb+Mf)
Note: Tolaga Group rocks are strongly represented

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Mahoenui silt loam (115)[1], (MeS)[6]; Pahiatua silt loam (115a)[1]; Taihape silt loam (114a)[1]

Erosion: *Present:* Moderate to very severe (mostly moderate to severe) soil slip (2–4Ss), slight to severe riparian slip (1–3Rs), gully (1–3G), sheet (1–3Sh), negligible to moderate slump (0–2Su), negligible to slight scree (0–1Sc), earthflow (0–1Ef)
Potential: Very severe soil slip, severe riparian slip, gully, sheet, moderate earthflow and slump under pasture. Severe soil slip and riparian slip, moderate gully under forest
Note: erosion remains severe under forest as eroding faces will not support trees

Vegetation: Semi-improved pasture (gS), manuka, kanuka (sM), exotic conifer forest (fF), unvegetated (uV)

Land use: *Present:* Semi-intensive livestock farming, exotic plantation forestry
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees in riparian and steepest areas, maintain existing indigenous cover, control shrub and tree pests, closely plant trees, specialised site-specific measures needed for earthworks and tree/shrub removal, retire from grazing. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian and steepest areas, maintain existing indigenous cover, control shrub and tree pests, closely plant trees, specialised site-specific measures needed for earthworks and tree/shrub removal, control erosion in more elevated parts of the subcatchment

Comments: Numerous soil slips have coalesced to form many large bare-rock faces. Plant establishment here is extremely difficult due to slope steepness, lack of soil, and unstable frittering (slaking) mudstone surfaces (where frittered mudstone is recorded). The variation in exotic forest productivity is related to the frequency and extent of bare-rock areas in map polygons.

LUC unit: VIIe24 (17 963 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Steep to moderately steep and sometimes very steep slopes in hill country of mainly crushed argillite and associated lithologies, with potential for very severe gully erosion — usually indicated by the presence of severe to very severely eroding gullies

Reference site: X16/285173 West side of Tarndale Road, 0.5 km before the Tarndale slip/Mangatu gully

Slope: 26–35° (F), 21–35° (F+E, E+F), 26–42° (F+G), 21–25° (E), occasional 16–25° (D+E, E+D)

Rock type: Crushed argillite association of rocks (Ac), occasionally sheared mixed lithologies (Mx), sometimes combined (e.g., Ac+Mx), sometimes with other rock types such as argillite (Ac+Ar), crushed greywacke (Ac+cGw), ancient volcanics (Ac+In), etc..
Notes: (i) Recorded in allocthonous rock terrain. (ii) Includes Whangai Formation rocks and other Paleogene and Cretaceous fine-grained indurated material, and melange.

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Orthic Brown Soils (BO); Allophanic Brown Soils (BL); Orthic Podzols (ZO); Rocky Raw Soils (WX)
S: Orthic Recent Soils (RO); Orthic Raw Soils (RO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Ruatoria stony silt loam (121)[1]; Ruatoria steepland soils (17)[2]; Tuparoa silt loam (121a)[1]; Arowhana sandy loam (121b)[1]; Mangahaumia sandy loam (121c)[1]
Yellow-brown earths: Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]; Waikura hill soils (14H)[2]

Erosion: *Present:* Moderate to very severe (mostly severe) gully (2–4G), slight to severe earthflow (1–3Ef), negligible to severe riparian slip (0–3Rs), slump (0–3Su), soil slip (0–3Ss), streambank (0–3Sb), negligible to moderate sheet (0–2Sh)
Potential: Very severe gully, severe earthflow, slump and riparian slip, moderate soil slip, streambank, and sheet under pasture. Severe gully, riparian slip, and slump, moderate earthflow, streambank, and slight debris avalanche under forest

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), exotic conifer forest (fF), manuka, kanuka (sM), mixed indigenous scrub (sX), podocarp-broadleaved-beech forest (fD), broadleaved forest (fB)

Land use: *Present:* Extensive and semi-intensive livestock farming, exotic plantation forestry, undeveloped
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly to moderately productive exotic plantation forestry

Management: A: Encourage regeneration and maintain indigenous shrubs and trees in riparian and steepest areas, maintain existing indigenous cover, control shrub and tree pests, closely plant trees, specialised site-specific measures needed for earthworks and tree/shrub removal, retire from grazing. F: Encourage regeneration and maintain indigenous shrubs and trees in riparian and steepest areas, maintain existing indigenous cover, control shrub and tree pests, closely plant trees, specialised site-specific measures needed for earthworks and tree/shrub removal, control erosion in more elevated parts of the catchment

Comments: The gullied area does not exceed half of the map polygon, usually 10–25%. LUC unit VIIIe9 is used where individual gullies are large enough to map separately. Erosion debris has serious offsite effects such as increasing the flood risk in river valleys and on flood plains.

The variation in exotic forest productivity is related to the proportion of gullies in map polygons. Ample rainfall and moderately fertile soils encourage rapid herbaceous revegetation after logging.

LUC unit: VIIe25 (3943 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Strongly rolling to moderately steep and occasionally undulating to rolling slopes in bentonite hill country, with potential for very severe earthflow

Reference site: Z15/855573 North of Mahora – Wairoa Road, 2 km north of Reporua

Slope: 16–20° (D), 21–25° (E), 16–25° (D+E, E+D), 8–20° (C+D, D+C), 4–7° and 16–20° (B+D)

Rock type: Bentonitic mudstone (Me), often with sheared mixed lithologies (Me+Mx).
Notes: (i) Recorded in allocthonous rock terrain along narrow shear/crush zones. (ii) The clay mineral assemblage of rocks is overwhelmingly dominated by bentonite. (iii) Associated with melange derived from a mixture of mostly Cretaceous and Paleogene rocks, and smectitic mudstone of the Mangatu Group

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Gley Soils (GO)
R: Orthic Gley Soils (GO); Perch-gley Pallic Soils (PP); Immature Pallic Soils (PI)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Immature Pallic Soils (PI)
N.Z. Genetic Soil Classification
Yellow-brown earths: Wanstead clay loam, hill soil (25aH)[1]

Erosion: *Present:* Moderate to very severe (mostly very severe) earthflow (2–4Ef), slight to severe (mostly moderate) gully (1–G), negligible to moderate slump (0–2Su), streambank (0–2Sb), negligible to slight sheet (0–1Sh)
Potential: Very severe earthflow, severe gully and slump under pasture. Severe earthflow, moderate gully and slump under forest

Vegetation: Semi-improved pasture (gS), unimproved pasture (gU), rushes, sedges (hR), manuka, kanuka (sM)

Land use: *Present:* Extensive livestock farming
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly productive exotic plantation forestry

Management: A: Pair-plant non-suckering/non-cracking willows in gullies, divert water from earthflow heads, avoid earthworks which add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and steepest parts (usually head scarps of slumps), drain springs on earthflows, closely plant trees, specialised, site specific measures needed for earthworks and tree/shrub removal, control erosion in more elevated parts of the subcatchments. F: Pair-plant non-suckering/non-cracking willows in gullies, divert water from earthflow heads, avoid earthworks which add weight to earthflow surfaces or remove toe support, encourage regeneration and maintain indigenous shrubs and trees in riparian areas and steepest parts (usually head scarps of slumps), closely plant trees, specialised, site-specific measures needed for earthworks and tree/shrub removal, control erosion in more elevated parts of the catchment

Comments: This unit occurs in melange with large mappable areas of bentonite.

Very poor internal and surface drainage and creeping earthflows and slumps will impair the establishment of exotic forest plantations and impair early growth. As blocks mature, forest growth may benefit from the dewatering effect of trees.

LUC unit: VIIe26 (1054 ha)

LUC suite: 2. River valley

LUC subsuite: 2c. Gravels

Description: Flat to undulating usually extremely gravelly, often bouldery, low river terraces subject to frequent flooding, gravel deposition, and persistent severe streambank erosion; and some extremely gravelly alluvial fans that frequently receive erosion debris from active gullies

Reference site: Y16/350180 Waipaoa River flats, 5 km up valley from Mangatu Forest Headquarters
Note: the long-term survival of any reference site is threatened due to river channel migration

Slope: 0–3° (A, A'), 4–7° (B)

Rock type: Alluvial gravels (Gr), fine alluvium over alluvial gravels (Af/Gr), fine alluvium and gravels (Gr+Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Raw Soils (WF); Fluvial Recent Soils (RF); Orthic Recent Soils (RO); Orthic Brown Soils (BO); Sandy Raw Soils (WS)
N.Z. Genetic Soil Classification
Recent soils: Waiapu stony sands (2)[2]; Waiapu stony sand (Wug)[5] ;Tukituki stony gravel (1c)[1]

Erosion: *Present:* Slight to very severe (mostly severe) deposition (1–4D), slight to very severe (mostly moderate to severe) streambank (1–4Sb), negligible to slight gully (0–1G)
Potential: Very severe deposition and streambank, slight gully under any land use

Vegetation: Unimproved pasture (gU), manuka, kanuka (sM), unvegetated (uV)

Land use: *Present:* Extensive livestock farming, undeveloped
Agric. Potential: Extensive livestock farming
Forestry Potential: Unsuitable

Management: A: Streambank protection, take care in siting high-value capital structures, control erosion in more elevated parts of the catchment. F: Not applicable

Comments: This unit is sometimes recorded in combination with other LUC units, most commonly VIIIs2 (when areas contain significant river beds).

Temporary, rather than permanent extensive grazing is possible. The fan component is generally less prone to streambank erosion.

LUC unit: VIIe27 (571 ha)

LUC suite: 5. Coastal sand and coastal cliffs

LUC subsuite: -

Description: Undulating to rolling unstable coastal sand dunes, immediately inland from the foredune complex, with very severe wind erosion unless carefully managed

Reference site: Z14/944795 Hautai Beach, Te Araroa East Cape Road, 13 km from Te Araroa

Slope: 4–15° (B+C, C+B), 4–7° (B), 8–15° (C)

Rock type: Windblown sand (Wb)

Soil: *N.Z. Soil Classification soil groups*
F: Sandy Raw Soils (WS); Humic Organic Soils (OH)
R: Sandy Raw Soils (WS); Sandy Brown Soils (BS); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Yellow-brown sands: Patea sand (23)[1]; Opoutama black sand (7)[3]; Opoutama grey sand (7A)[3]

Erosion: *Present:* Slight to severe (mostly severe) wind (1–3W)
Potential: Very severe wind under any use

Vegetation: Sand dune vegetation (gD), unimproved pasture (gU), rushes, sedges (hR)

Land use: *Present:* Undeveloped, extensive livestock farming
Agric. Potential: Extensive livestock farming (winter grazing)
Forestry Potential: Unsuitable

Management: A: Re-establish ground cover on eroded areas, prevent vegetation trampling, retire from grazing, recognise and provide for the sensitive coastal receiving environment. F: Not applicable

Comments: Soils have little resistence to wind erosion when vegetation is damaged or removed.

LUC unit: VIIw1 (303 ha)

LUC suite: 2. River valley

LUC subsuite: 2b. River flats, swamps, fans, and lower terraces

Description: Swamps in river valleys where drainage is not feasible

Reference site: Z15/813533 Mahora, Tuparoa Road

Slope: 0–3° (A)

Rock type: Peat and fine alluvium (Pt+Af, Af+Pt)

Soil: *N.Z. Soil Classification soil groups*
F: Orthic Gley Soils (GO); Mesic Organic Soils (OM); Recent Gley Soils (GR); Fluvial Recent Soils (RF); Orthic Brown Soils (BO)
N.Z. Genetic Soil Classification
Organic soils: Pongakawa peaty loam (107f)[1]

Erosion: *Present:* Negligible to slight (mostly negligible) deposition (0–1D)
Potential: Slight deposition under any land use

Vegetation: Wetland vegetation (hW)

Land use: *Present:* Undeveloped
Agric. Potential: Extensive livestock grazing (summer)
Forestry Potential: Unsuitable

Management: A: Retain as wetland, retire from grazing

Comments: Permanently high watertables and extensive areas (at least 50% of map polygons) of free-standing water for most of the year precludes productive use. Drainage is very difficult.

LUC unit: VIIs1 (4129 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7e. Massive and bedded sandstone

Description: Very steep to steep, sometimes precipitous slopes with bluffs and associated rock-strewn midslopes that can be grazed, in mainly Neogene massive or bedded sandstone hill country. Soils are very shallow and the potential for erosion is limited

Reference site: Y16/403178 1.5 km north of Areoma (8913) Trig, Tutamoe Plateau; off Birch Road, Mangatu Forest

Slope: 36–42° (G), 26–42° (F+G, G+F), >36° (G+H), 26–35° (F)

Rock type: Massive sandstone (Sm), bedded sandstone (Sb), sometimes sandstones are with other lithologies such as limestone (Sm+Li), bedded mudstone (Sb+Mb), etc.
Note: Very hard (very strong) often bluff-forming Tokomaru sandstone is well represented

Soil: *N.Z. Soil Classification soil groups*
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Whangamomona silt loam (116)[1]; Mokau sandy loam (117c)[1]; Wharerata sandy loam (117h)[1]

Erosion: *Present:* Negligible to slight soil slip (0–1Ss), sheet (0–1Sh), rock fall (0–1Rf)
Potential: Moderate soil slip, sheet, and rock fall under pasture. Slight rock fall under forest or scrub

Vegetation: Mixed indigenous scrub associations (sX), manuka, kanuka (sM), exotic conifer forest (fF), unimproved pasture (gU)

Land use: *Present:* Undeveloped, exotic plantation forestry, extensive livestock farming
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly productive exotic plantation forestry

Management: A: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees around bluffs and steepest slopes, and retire from grazing. F: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees around bluffs and steepest slopes, and specialised site-specific measures needed for earthworks and tree/shrub removal

Comments: Bluffs are not very tall — about 10 m.

Erosion is limited by the lack of soil material available to erode. Slips usually expose very hard (and very strong) bedrock and will not heal. Pasture maintenance is a problem, mainly because soils are shallow with low nutrient status and very low soil moisture storage capacity. Full use of the available land is not possible in plantation forests.

LUC unit: VIIs2 (2766 ha)

LUC suite: 8. Limestone

LUC subsuite: -

Description: Steep, very steep, and precipitous stable hills or major escarpments, with bouldery colluvial footslopes, in Paleogene, mainly muddy limestone hill country. Soils are very shallow and potential for erosion is limited

Reference site: X16/274108 Above Wairere Mangatahu Road, 1.5 km past the Mangatu River bridge

Slope: >36° (G+H), >26° (F+H), 26–36° (F), 36–42° (G), occasionally 21–36° (F+E)

Rock type: Limestone (Li), often combined with other rock types such as argillite (Li+Ar), coarse slope deposits (Li+Cl), massive siltstone (Li+Mm), etc.
Notes: (i) In upper Mangatu Group materials. (ii) The lithology is frequently a hard to very hard (and very strong) fine-grained rock, but is not always highly calcareous. Hence, it is often mapped in association with other lithologies

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Brown Soils (BO)
S: Orthic Raw Soils (WO); Orthic Recent Soils (RO); Rocky Raw Soils(WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Te Mata sandy loam (113a)[1]

Erosion: *Present:* Negligible to moderate (mostly slight) soil slip (0–2Ss), negligible to moderate (mostly negligible) sheet (0–1Sh), negligible to slight rock fall (0–1Rf)
Potential: Moderate soil slip and sheet, slight rock fall under pasture. Slight rock fall under forest or scrub

Vegetation: Unimproved pasture (gU), semi-improved pasture (gS), fern (sF), manuka, kanuka (sM), mixed indigenous scrub (sX), unvegetated (uV)

Land use: *Present:* Extensive livestock farming, undeveloped
Agric. Potential: Extensive livestock farming
Forestry Potential: Poorly productive exotic plantation forestry

Management: A: Re-establish ground cover on eroded areas, maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas, specialised site-specific measures needed for earthworks and tree/shrub removal. F: Maintain existing indigenous tree cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas, and specialised site- specific measures required for earthworks and shrub/tree removal

Comments: Erosion is limited by the lack of soil material available to erode. Slips usually expose bedrock and will not heal.

LUC unit: VIIIe1 (598 ha)

LUC suite: 5. Coastal sand and coastal cliffs

LUC subsuite: -

Description: Undulating and rolling foredunes subject to extreme wind erosion and erosion by wave action

Reference site: Z14/962777 Hautai Beach, Te Araroa East Cape Road, 15.5 km from Te Araroa

Slope: 4–7° (B), 8–15° (C)

Rock type: Windblown sand (Wb), occasionally combined with alluvial gravels (Wb+Gr)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Raw Soils (WF); Sandy Raw Soils (WS)
R: Sandy Raw Soils (WS); Sandy Brown Soils (BS); Sandy Recent Soils (RS); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Yellow-brown sands: Opoutama grey sand (7A)[3]; Patea sand (23)[1]

Erosion: *Present:* Moderate to extreme wind (2–5W), negligible to moderate deposition (0–2D)
Potential: Extreme wind under any land use

Vegetation: Sand dune vegetation (gD), unvegetated (uV)

Land use: *Present:* Undeveloped and extensive grazing
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Re-establish ground cover on eroded areas, prevent vegetation trampling, retire from grazing.
F: Not applicable

Comments: This unit is mapped immediately inland from the mean high-spring tide level.

LUC unit: VIIIe2 (1498 ha)

LUC suite: 5. Coastal sand and coastal cliffs

LUC subsuite: -

Description: Precipitous and very steep coastal cliffs influenced by coastal erosion processes, on a wide range of rock types

Reference site: Y18/420599 Young Nick's Head

Slope: >42° (H), 36–>42° (H+G, G+H), 36–42° (G), 26–35° and >42° (F+H)

Rock type: Bedded mudstone (Mb), massive sandstone (Sm), massive mudstone (Mm), frittered mudstone (Mf), ancient volcanics (In), etc.
Note: This unit is recorded on any rock type

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Raw Soils (RO); Orthic Brown Soils (BO); Immature Pallic Soils (PI)
S: Orthic Raw Soils (WO); Orthic Recent Soils (RO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Taihape silt loam (114a)[1]; Mahoenui silt loam (115)[1]; Whangamomona silt loam (116a)[1]
Note: There is much bare rock with no soil development

Erosion: *Present:* Moderate to extreme sheet (2–5Sh), slight to extreme soil slip (1–5Ss), negligible to very severe gully (0–4G) and slump (0–4Su), negligible to severe scree (0–3Sc), negligible to moderate rock fall (0–2Rf) and earthflow (0–2Ef)
Potential: Extreme erosion under any land use, with erosion types largely determined by the lithology, e.g., with strong rocks soil slip and sheet will occur, with weaker rocks slumps will occur along with other forms of erosion

Vegetation: Unvegetated (uV), unimproved pasture (gU), manuka, kanuka (sM), coastal forest (fC)

Land use: *Present:* Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Control shrub and tree pests, retire from grazing, recognise and provide for the sensitive coastal receiving environment. F: Not applicable

Comments: Less steeply sloping coastward slopes are often recorded in LUC suites and subsuites according to rock type and choice of LUC units is made according to slope and erosion — i.e., not all coast-facing slopes are recorded as VIIIe2.

LUC unit: VIIIe3 (4226 ha)

LUC suite:
6. Neogene and Quaternary mudstone
7. Neogene sandstone

LUC subsuite:
6c Bedded mudstone
7e. Massive and bedded sandstone
6b. Massive mudstone

Description: Very steep to precipitous slopes on Neogene mudstone or sandstone, in gorges or on riverside cliffs where stability of the latter is compromised by river processes, or on tall erosion-prone escarpments and ridges elsewhere

Reference site: Y16/338124 Waipaoa River, downstream of Armstrong River bridge

Slope: 36–42° (G), 26–42° (G+F), >36° (G+H), >42° (H)

Rock type: Bedded mudstone (Mb), bedded sandstone (Sb), massive mudstone (Mm), sometimes combined (e.g., Mb+Sb), and sometimes combined with other rock types such as limestone (e.g., Mb+Li), frittered mudstone (e.g., Mb+Sb+Mf).
Note: This LUC unit is recorded on any Neogene rock type

Soil: *N.Z. Soil Classification soil groups*
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Rocky Raw Soils (WX); tephric Recent Soils (RT)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Taihape silt loam (114a)[1]; Mahoenui silt loam (115)[1]; Whangamomona silt loam (116a)[1]

Erosion:
Present: Negligible to severe (mostly severe) riparian slip (0–3Rs), slight to severe (mostly moderate) soil slip (1–3Ss), slight to severe (mostly moderate) sheet (1–3Sh), negligible to severe (mostly slight) debris avalanche (0–3Da), slump (0–3Su), negligible to slight gully (0–1G), rock fall (0–1Rf)
Potential: Very severe riparian slip, severe soil slip, slump, scree, and rock fall, moderate gully under any land use

Vegetation: Unvegetated (uV), manuka, kanuka (sM), mixed indigenous scrub (sX)

Land use:
Present: Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Control shrub and tree pests, exclude livestock. F: Not applicable

Comments: This LUC unit is recorded in the same terrain as VIIIs1, but unlike VIIIs1, VIIIe3 has a potential for very severe erosion.

LUC unit: VIIIe4 (55 883 ha)

LUC suite: 10. Greywacke and argillite

LUC subsuite: -

Description: Very steep to precipitous greywacke slopes below the treeline in the Raukumara and northern Huiarau ranges, with potential for very severe soil slip

Reference site: Y15/580660 Western side of the middle reach of Raparapaririki Stream (the 'Rip')

Slope: 36–42° (G), 36–>42° (G+H), 26–42° (G+F)

Rock type: Greywacke association of rocks (Gw), occasionally argillite (Ar)
Notes: (i) Recorded in autocthonous rock terrain. (ii) Greywacke represents an association of strong, interbedded, indurated sandstone (greywacke) and mudstone (argillite), and other associated lithologies, of Cretaceous and Paleogene age, e.g., Urewera and Matawai groups

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Podzols (ZO)
S: Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Raw Soils (WO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown pumice soils and yellow-brown earths: Raukumara sandy loam (124a)[1]; Raukumara steepland soils (16)[2]; Urewera sandy silt and sand (125a)[1]

Erosion: *Present:* Slight to severe (mostly moderate) debris avalanche (1–3Da), negligible to severe (mostly negligible) scree (0–3Sc), negligible to moderate gully (0–2G), riparian slip (0–2Rs), negligible to slight slump (0–1Su), soil slip (0–1Ss)
Potential: Very severe soil slip, severe riparian slip, scree, and gully under pasture. Severe debris avalanche, scree, moderate gully, riparian slip, and slump under forest

Vegetation: Lowland podocarp-broadleaved forest (fO), lowland beech forest (fW), podocarp-broadleaved-beech forest (fD)

Land use: *Present:* Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas. F: Not applicable

Comments: Rainfall is very high, being between 3000 and 4000 mm/yr.

LUC unit VIIIe5 (5288 ha)

LUC suite: 9. Basalt

LUC subsuite: -

Description: Very steep to precipitous slopes, in basaltic mountain land between Cape Runaway and Hicks Bay

Reference site: Z14/745853 Above Waimate Falls, viewed from Highway 35, 3 km from Hicks Bay

Slope: >36° (G+H), occasionally 36–42° (G), 26–42° (G+F), and >26° (H+F, F+H)

Rock type: Ancient volcanics (In)
Note: Matakaoa Volcanics — basaltic lavas, breccia, and unconsolidated rocks of Cretaceous and Paleogene age

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO); Orthic Brown Soils (BO)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to red-brown loams: Potikirua steepland soils, very steep phase (20A)[2]

Erosion: *Present:* Negligible to very severe (mostly negligible) debris avalanche (0–4Da), negligible to severe (mostly negligible) soil slip (0–3Ss), negligible to slight scree (0–1Sc), gully (0–1G)
Potential: Extreme soil slip, very severe riparian slip, severe sheet and gully, and moderate scree under pasture. Severe debris avalanche, moderate scree, gully, and riparian slip under forest

Vegetation: Broadleaved forest (fB), mixed indigenous scrub with tree fern (sT), semi-improved pasture (gS), coastal forest (fC), beech forest (fW)

Land use: *Present:* Undeveloped, extensive livestock farming
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas, exclude livestock. F: Not applicable

Comments: Rainfall is moderately high, being between 1600 and 2400 mm/yr, and the area is particularly prone to storms from the north and north-east.

LUC unit: VIIIe6 (3777 ha)

LUC suite: 7. Neogene sandstone

LUC subsuite: 7c. Te Kahika Formation of Whangaparaoa
7d. Muddy sandstone of East Cape

Description: Very steep to precipitous hill country slopes forming valleys in Neogene Te Kahika Formation sandstone and mudstone south-east of Whangaparaoa, and a few instances of very steep to precipitous hill slopes in Neogene muddy sandstone and mudstone in the East Cape area

Reference site: Z14/853814 Otawhau catchment, across the Awatere River from Te Araroa

Slope: 36–42° (G), >36° (G+H, H+G), 26–42° (G+F), occasionally >42° (H)

Rock type: Massive sandstone (Sm), sometimes with massive mudstone (e.g., Sm+Mm) — used in Te Kahika Formation, and massive sandstone combined with massive mudstone (Sm+Mm) — used for muddy sandstone and mudstone of the East Cape area.
Notes: (i) Two main rock units occur in the East Cape area: 1. most extensive and uppermost in the sequence late Miocene to Pliocene muddy sandstone (frequently bluff-forming), and 2. least extensive and lower in the sequence, early to mid-Miocene massive mudstone (similar to Neogene massive mudstone elsewhere in the region). (ii) Can include limestone-dominated unstable escarpments in Te Kahika Formation of the Whangaparaoa area

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO)
S: Orthic Recent Soils (RO); Orthic Raw Soils (WO); Rocky Raw Soils (WX)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Marangairoa steepland soils, very steep phase (20A)[2]; Whangaparaoa steepland soils (21)[2]

Erosion: *Present:* Negligible to moderate (mostly slight and moderate) soil slip (0–2Ss), debris avalanche (0–2Da)
Potential: Extreme soil slip, severe riparian slip and sheet, moderate gully under pasture. Very severe debris avalanche, moderate soil slip and slight gully under forest

Vegetation: Broadleaved forest (fB), podocarp-broadleaved-beech forest (fD), mixed indigenous scrub with tree fern (sT), semi-improved pasture (gS)

Land use: *Present:* Undeveloped, semi-intensive pastoral farming, reversion to scrub
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas, exclude livestock. F: Not applicable

Comments: This unit is recorded in LUC subsuites 7d and 7c of the sandstone suite, and so the terrain differs somewhat (7d: very steep hills, and 7c: very steep, large-scale V-shaped valleys incised into hill country).

LUC unit: VIIIe7 (4218 ha)

LUC suite: 10. Greywacke and argillite

LUC subsuite: -

Description: Very steep, steep, sometimes precipitous, severely eroding greywacke and crushed greywacke hill or mountain slopes in the Raukumara Range below the treeline. Slope failures are very large, exposing much bare rock

Reference site: Y15/595665 Side valley on the east of the middle reach of Raparapaririki Stream (the 'Rip')

Slope: 36–42° (G), 26–42° (G+F, F+G), 36–>42° (G+H)

Rock type: Greywacke association of rocks (Gw), occasionally crushed greywacke (cGw)
Notes: (i) Recorded in autocthonous rock terrain. (ii) Gw represents an association of strong, interbedded, indurated sandstone (greywacke) and mudstone (argillite) and other associated lithologies, of Cretaceous and Paleogene age, e.g., in Urewera and Matawai groups. However, localised crushing has weakened this greywacke terrain and serious erosion occurs

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO)
S: Rocky Raw Soils (WX); Orthic Raw Soils (WO); Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown pumice soils and yellow-brown earths: Raukumara sandy loam (124a)[1]; Urewera sandy silt and sand (125a)[1]

Erosion: *Present:* Moderate to very severe (mostly severe to very severe) gully (0–4G), debris avalanche (2–4Da), negligible to severe slump (0–3Su), scree (0–3Sc), negligible to moderate streambank (0–2Sb)
Potential: Extreme gully, soil slip, scree, and very severe slump, streambank, and riparian slip under pasture. Very severe gully, slump, debris avalanche, and severe scree under forest
Note: erosion occurs in (and forms) large single or coalesced gully structures with elements of scree, gully, and slump

Vegetation: Lowland podocarp-broadleaved forest (fO), mixed indigenous scrub (sX), unvegetated (uV), lowland beech forest (fW)

Land use: *Present:* Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas, exclude livestock. F: Not applicable

Comments: Rainfall is very high, being between 3000 and 4000 mm/yr.

LUC unit: VIIIe8 (2245 ha)

LUC suite: 10. Greywacke and argillite

LUC subsuite: -

Description: Very steep to precipitous and sometimes rolling greywacke slopes above the treeline in Raukumara Range mountain land and on isolated mountain tops

Reference site: Y15/549524 Mount Hikurangi

Slope: >36° (G+H), 26–42° (G+F), 36–42° (G) — mountain side slopes
16–25° (E+D), 4–15° (B+C), 16–20° (D), 8–20° (D+C) — mountain tops

Rock type: Greywacke association of rocks (Gw), sometimes indurated sandstone (Si). Mountain tops have a cover of Taupo/Waimihia tephra on weathered, mainly rhyolitic tephra (e.g., Kt/Mo/Gw). Some slopes have a patchy cover of weathered, mainly rhyolitic tephra on coarse colluvium (e.g., pMo/Cl*Gw).
Notes: (i) Recorded in autocthonous rock terrain. (ii) Gw represents an association of strong, interbedded, indurated sandstone (greywacke) and mudstone (argillite) and other associated lithologies, of Cretaceous and Paleogene age, e.g., in Urewera and Matawai groups

Soil: *N.Z. Soil Classification soil groups*
R: Orthic Podzols (ZO)
H: Orthic Brown Soils (BO); Orthic Recent Soils (RO); Rocky Raw Soils (WX); Orthic Podzols (ZO)
S: Rocky Raw Soils (WX); Orthic Recent Soils (RO)
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown pumice soils and yellow-brown earths: Raukumara sandy loam (124a)[1]; Urewera sandy silt and sand (125a)[1]

Erosion: *Present:* Slight to moderate debris avalanche (0–1Da), negligible to moderate sheet (0–2Sh), scree (0–2Sc)
Potential: Very severe scree, severe debris avalanche, soil slip, sheet and moderate gully under subalpine covers

Vegetation: Short tussock (gT), subalpine scrub (sS), unvegetated (uV)

Land use: *Present:* Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Maintain existing indigenous cover, control shrub and tree pests, encourage regeneration and maintain indigenous shrubs and trees on steeper areas, exclude livestock. F: Not applicable

Comments: Rainfall is very high, being between 3000 and 4000 mm/yr.

This unit is used, in a single instance, as a best-fit option on Neogene bedded sandstone on Maungapohatu in the northern Huiarau Range

LUC unit: VIIIe9 (865 ha)

LUC suite: 11. Crushed argillite, crushed greywacke, sheared mixed lithologies, and bentonite

LUC subsuite: -

Description: Very steep to precipitous and occasionally moderately steep slopes, substantially enclosed within active large gullies in hill country of crushed argillite and associated lithologies, and sometimes in Neogene mudstone terrain

Reference site: X16/295180 Tarndale slip

Slope: 36–42° (G), >36° (G+H), 21–35° (F+E, E+F) — E slope components are more common in very severely gullied Neogene mudstone terrain

Rock type: Crushed argillite association of rocks (Ac), occasionally sheared mixed lithologies (Mx), or Neogene rock types such as frittered mudstone (Mf), bedded mudstone (Mb), sometimes combined (Mf+Mb)
Notes: (i) Recorded mainly in allocthonous rock terrain where Ac and Mx is recorded. (ii) Includes Whangai Formation and other Paleogene and Cretaceous fine-grained indurated material, and melange. (iii) Includes very severely gullied, mainly Tolaga Group mudstone

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Raw Soils (WO); Orthic Recent Soils (RO)
S: Orthic Raw Soils (WO); Rocky Raw Soils (WX)
Note: Most of the area has no soil development
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Ruatoria stony silt loam (121)[1]; Ruatoria steepland soils (17)[2]; Tuparoa silt loam (121a)[1]; Arowhana sandy loam (121b)[1]; Mangahaumia sandy loam (121c)[1]
Yellow-brown earths: Tinui silt loam and Waikura sandy loam, hill soil (28H)[1]; Waikura hill soils (14H)[2]

Erosion: *Present:* Very severe to extreme gully (4–5G), negligible to very severe (mostly negligible) earthflow (0–4Ef), negligible to moderate soil slip (0–2Ss), riparian slip (0–2Rs)
Potential: Extreme gully erosion and riparian slip, earthflow, etc. under any land use

Vegetation: Unvegetated (uV), exotic conifer forest (fF), semi-improved pasture (gS), improved pasture (gI)

Land use: *Present:* Exotic plantation forestry (erosion control), semi-intensive pastoral farming
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: There are no feasible methods of erosion control within gullies — management strategies are best aimed at preventing new gullies and restricting the growth of existing gullies. Plant and maintain an edge-buffer of trees and close-plant trees where practical. F: Not applicable

Comments: The gullied area exceeds half of the map polygon, usually >75%. Mostly, this unit is recorded where gullies are large enough to map separately. Commonly, the gullies are single large amphitheatre-like structures.

Erosion debris has serious off-site effects such as increasing the flood risk in river valleys and on flood plains.

LUC unit: VIIIs1 (4444 ha)

LUC suite: 7. Neogene sandstone
10. Greywacke and argillite
8. Limestone

LUC subsuite: 7e. Massive and bedded sandstone

Description: Precipitous to very steep bluffs, tall escarpments, and gorge faces in hill country or mountain land below the treeline, on a variety of hard (strong) lithologies providing much erosion-resistant bare rock

Reference site: Y16/673109 Bluffs above Mangatokerau Road, 3 km from the start of the road

Slope: >42° (H), >36° (G+H, H+G), 36–42° (G)

Rock type: Massive sandstone (Sm), bedded sandstone (Sb), indurated sandstone (Si), occasionally Limestone (Li), or combinations of these lithologies (e.g., Sb+Li)
Note: Very hard (very strong) often bluff-forming Tokomaru sandstone is well represented, along with early Cretaceous indurated sandstone forming major peaks such as Hikurangi

Soil: *N.Z. Soil Classification soil groups*
H: Orthic Recent Soils (RO)
S: Orthic Raw Soils (WO); Orthic Recent Soils (RO); Rocky Raw Soils (WX)
Note: Most of the area has no soil development
N.Z. Genetic Soil Classification
Steepland soils related to yellow-brown earths: Whangamomona silt loam (116)[1]; Mokau sandy loam (117c)[1]; Raukumara sandy loam (124a)[1]

Erosion: *Present:* Negligible to moderate (mostly slight) soil slip (0–2Ss), sheet (0–2Sh), scree (0–2Sc), negligible to slight debris avalanche (0–1Da), rock fall (0–1Rf)
Potential: Moderate soil slip, sheet, scree, debris avalanche, and slight rock fall under any land use

Vegetation: Unvegetated (uV), manuka, kanuka (sM)

Land use: *Present:* Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Few measures are feasible or required. F: Not applicable

Comments: This LUC unit is recorded in the same terrain as VIIIe3, but unlike VIIIe3 it has a low erosion potential, largely because there is very little soil to erode.

LUC unit: VIIIs2 (7923 ha)

LUC suite: 2. River valley

LUC subsuite: 2c. Gravels

Description: River beds that are presently active

Reference site: Y15/677572 Confluence of the Tapuaeroa and Waiorongamai rivers

Slope: 0–3° (A, A'), occasionally 4–7° (B, B')

Rock type: Alluvial gravels (Gr), very occasionally with fine alluvium (Gr+Af)

Soil: *N.Z. Soil Classification soil groups*
F: Fluvial Raw Soils (WF); Rocky Raw Soils (RX); Fluvial Recent Soils (RF); Orthic Recent Soils (RO)
Note: Most of the area has no soil development
N.Z. Genetic Soil Classification
Recent soils: Not mapped in past soil surveys

Erosion: *Present:* Very severe to extreme deposition (4–5D), negligible to severe streambank (0–3Sb)
Potential: Extreme deposition and severe streambank under any land use
Note: streambank erosion is usually accounted for in the adjoining map polygons and not the river bed itself. If it is recorded, it refers to bank erosion of mid-stream vegetated bars, etc.

Vegetation: Unvegetated (uV), manuka, kanuka (sM)

Land use: *Present:* Undeveloped
Agric. Potential: Unsuitable
Forestry Potential: Unsuitable

Management: C: Control erosion in more elevated parts of the catchment. F: Not applicable

Comments: This unit is closely associated with VIIe26, and is often mapped with it as a complex.

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Appendices

Appendix 1. Major storm rainfall events that caused significant floods and erosion in the GEC region

This sequence of storms was extracted from Meteorological Service archives

Year	Intensity	Coverage
1988	300–900 mm (72hrs)	Entire GEC region (Cyclone Bola)
1985	225–300 mm (36 hrs)	Ngatapa–Gisborne
1982		Waipaoa catchment
1977	100–450 mm (24 hrs)	Waimata–Gisborne
1967	190 mm (24 hrs)	Waipaoa headwaters
1965	150–300 mm (48 hrs)	East Coast
1964		Waipaoa district
1960		Waipaoa catchment
1958		Waipaoa district
1952		Waipaoa district
1951	170 mm (48 hrs)	Waipaoa district (series of smaller events in rapid succession)
1950	160 mm (72 hrs)	Waipaoa catchment (series of smaller events in rapid succession)
1948	315 mm (72 hrs)	East Coast
1947	100 mm (24 hrs)	
1946	65 mm (24 hrs)	Waipaoa catchment
1944	190 mm (24 hrs)	East Coast (and other isolated events)
1942	85 mm (24 hrs)	upper Waipaoa catchment
1938	275 mm (96 hrs) 90 mm (24 hrs)	3 storms (East Coast, Waipaoa, Te Arai)
1937	60 mm (24 hrs)	Waipaoa district
1936	65 mm (18 hrs)	East Coast
1935	100 mm (48 hrs)	Gisborne–Waimata–Ngatapa–Te Arai

Year	Intensity	Coverage
1933	225 mm (48 hrs)	
1932	350 mm (168 hrs)	2 storms (East Coast, Waipaoa catchment)
1930		Waipaoa district
1929	80 mm (24 hrs) 170 mm (48 hrs)	Gisborne–Waimata–Ngatapa–Te Arai
1927	72 mm (24 hrs)	Waimata
1925		Waipaoa district
1921	60 mm (24 hrs)	
1920	560 mm (24 hrs)	
1918		
1916	210 mm (48 hrs)	
1914	244 mm (48 hrs)	
1910	365–585 mm (72 hrs)	
1906	230 mm (72 hrs)	
1884	400 mm (72 hrs)	
1879		
1876	210 mm (48 hrs)	
1853		

Appendix 2. Aerial photographs used

Sheet no.[1]	Sheet name	Survey number	Photo runs	Flown by[2]	Date of photography	Approximate scale of photograph
pt W17	Urewera	542	1638–1640	1	1958	1:19 000
pt W18	Waikaremoana	542	1641–1648	1	1958	1:19 000
pt X15	Omaio		165279, 177065–067	2	1992–5	1:25 000
pt X16	Motu	11485.F	A–D	3 SE area	1988	1:25 000
			165450–455 165508–515 165662–668 177020–022 177035–039	2 NE & SW areas	1992–5	1:25 000
pt X17	Matawai	11485.E	A–J	3	1988	1:25 000
		11485.F	A–D	3	1988	1:25 000
		11485.I	A–J	3	1988	1:25 000
			165528–533 165585–590 165599–605 165624–631	2 NW area	1992	1:25 000
pt X18	Tiniroto	11485.E	A–K	3	1988	1:23 500
pt X19	Wairoa	11485.E	C–K	3	1988	1:25 000
		8260	E–F	3	1983	1:50 000
pt Y14	Cape Runaway		165018–020 165029–032 165048–051 165068–071	2 Western area	1991	1:25 000
		11485.J	AA, A–E	3	1988	1:25 000
pt Y15	Hikurangi		165171–172 165208–210 165219–224 181360–364	2 Western area	1992, 1995	
		11485.J	AA, A–E	3 Eastern area	1988	1:25 000

Sheet no.[1]	Sheet name	Survey number	Photo runs	Flown by[2]	Date of photography	Approximate scale of photograph
pt Y16	Tauwhareparae	11485.F	E–O	3	1988	1:25 000
		8132	A–D	1 Northern & NE areas	1982	1:25 000
Y17	Te Karaka	8132	H–N	1	1982	1:25 000
Y18	Gisborne	11485.E	K	3	1988	1:23 500
		11485.F	F–I	3	1988	1:23 500
		11485.H	P, G, R, S	3	1988	1:23 500
pt Y19	Wharerata	11485.F		3	1988	1:23 500
		8260	E, F	1	1983	1:50 000
Z14	East Cape	11485.J	F–N	3	1988	1:25 000
Z15	Ruatoria	11485.J	F–H, J–N	3	1988	1:25 000
Z16	Tokomaru Bay	11485.F	O, Q, R	3	1988	1:23 500
		11485.J	F, G, I, II	3	1988	1:25 000
		8132	A–D	1 Northern area	1982	1:25 000
Z17	Tolaga Bay					

[1] 1:50 000 scale Infomaps. pt refers to part of the listed Infomap

[2] 1–NZ Aerial Mapping Ltd, Hastings (black and white)
2–Air Maps NZ 1988 Ltd, Tauranga (colour. Negative numbers are given in the photo run column - there are no survey or run numbers for this survey)
3–Aerial Surveys Ltd, Nelson (black and white)

Appendix 3. References for stratigraphic and other geological names

Rock-stratigraphic and other geological names are used to help define LUC units. Many of these names are well known in the district, and are derived from geological work carried out mainly by DSIR Geological Survey (now Institute of Geology & Nuclear Sciences). The present report just precedes a new geological map from IGNS for the district — 'Q-Map Raukumara' at a scale of 1:100 000. This map will form an important additional fundamental information source for interpretations of land resources, and further help users place LUC units into geological context.

Geological Unit	Reference(s)
Areoma Sandstone	Mazengarb *et al.* 1991
Karakere Formation	Mazengarb *et al.* 1991, Moore *et al.* 1989
Mangaheia Group	Mazengarb *et al.* 1991, Moore *et al.* 1989
Mangatu Group	Mazengarb *et al.* 1991, Moore *et al.* 1989
Matakaoa Volcanics	Moore *et al.* 1989
Matawai Group	Mazengarb *et al.* 1991, Moore *et al.* 1989
Ramanui Formation	Mazengarb *et al.* 1991, Moore *et al.* 1989
Taupo Tephra	Froggart and Lowe 1990
Te Kahika Formation	Moore *et al.* 1989
Tikihore Formation	Mazengarb *et al.* 1991, Moore *et al.* 1989
Tokomaru Sandstone	Mazengarb *et al.* 1991, Moore *et al.* 1989
Tolaga Group	Mazengarb *et al.* 1991, Moore *et al.* 1989
Urewera Group	Moore *et al.* 1989
Waihora Syncline	Moore *et al.* 1989
Waimihia Tephra	Froggart and Lowe 1990
Waimata Syncline	Moore *et al.* 1989
Waipaoa Formation	Moore *et al.* 1989
Weber Formation	Moore *et al.* 1989
Weber marl	O'Byrne 1967
Whangai Formation	Mazengarb *et al.* 1991, Moore *et al.* 1989

Appendix 4. NZLRI rock type classification

This classification is from Lynn and Crippen (1991) and was developed for all of New Zealand. Rock types marked with an * symbol were mapped in the Gisborne – East Coast NZLRI region. Some are named differently in this NZLRI project to make the rock-type name more specific to the GEC region. In these cases the GEC name is given first (with the Lynn and Crippen name second, in brackets).

A. Igneous rocks

(i) **extremely weak to very weak igneous rocks**

Ng		Ngauruhoe tephra
Rm		Rotomahana mud
Ta		Tarawera tephra
Sc		Scoria
Lp		Pumiceous lapilli
Kt	*	Taupo/Waimihia tephra (Kaharoa and Taupo ashes) — should exceed 25 cm thickness before recording
Tp		Taupo and Kaharoa breccia and pumiceous alluvium
Mo	*	Weathered, mainly rhyolitic tephra (Ashes older than Taupo ash) — should exceed 35 cm thickness before recording
Ft		Quaternary breccias older than Taupo breccia
La		Lahar deposits
Vu		Extremely weak altered volcanics

(ii) **weak to extremely strong igneous rocks**

Vo		Lavas and welded ignimbrites
Tb		Indurated fine-grained pyroclastics
Vb		Indurated volcanic breccias
In	*	Ancient volcanics
Gn		Plutonics
Um		Ultramafics

B. Sedimentary rocks

(i) **very loose to compact (very soft to stiff) sedimentary rocks**

Pt	*	Peat
Lo	*	Loess
Wb	*	Windblown sand
Af	*	Fine alluvium
Gr	*	Alluvial gravels
Cl	*	coarse slope deposits
Gl		Glacial till
Uf	*	Unconsolidated clays and silts
Us	*	Unconsolidated sands and gravels

(ii) **very compact (very stiff) to weak sedimentary rocks**

Mm	*	Massive mudstone
Mb	*	Bedded mudstone
Mf	*	Frittered mudstone
Me	*	Bentonitic mudstone
Sm	*	Massive sandstone
Sb	*	Bedded sandstone
Cw	*	Weakly consolidated conglomerate
Mx	*	Sheared mixed lithologies
Ac	*	Crushed argillite association of rocks

(iii) **moderately strong to extremely strong sedimentary rocks**

Ar	*	Argillite
Si	*	Indurated sandstone
Cg	*	Conglomerate and breccia
Gw	*	Greywacke association of rocks
Li	*	Limestone

C. Metamorphic rocks

Sx	Semi-schist
Sy	Schist
Gs	Gneiss
Ma	Marble

D. Perennial ice and snow

I	Perennial ice and snow

Prefixes

p denotes that the rock type is present only in patches, or of localised significance, e.g., pAf/Mx, means patchy fine alluvium overlying sheared mixed lithologies. This prefix usually relates to cover deposits such as tephra or loess. Coverages of a rock type between 20% and 75% of the map polygon should be recorded as patchy; coverages less than 20% are not recorded; and coverages greater than 75% are considered full coverage and the patchy symbol is omitted. Coverage is subjectively assessed in the NZLRI.

w denotes a significant degree and depth of weathering such that the rock's physical characteristics are significantly different from its unweathered characteristics, e.g., wGw, weathered greywacke.

c denotes that the rock type is crushed and sheared, e.g., cGw[1].

Combining symbols

/ denotes stratigraphic sequence with the surface rock type first, e.g., Kt/Mo, Taupo/Waimihia tephra cover over weathered, mainly rhyolitic tephra. A maximum of two '/'s may be used in any one code.

\+ denotes that there are two or more rock types present and the first one is dominant, e.g., Af+Pt, fine alluvium and peat. A maximum of two '+'s may be used in any one code.

* used in conjunction with the symbol '/', indicates that the rock type preceding the backward slash overlies both rock types after the backward slash, e.g., Uf/Mb * Sb, unconsolidated clays and silts overlies both bedded mudstone and bedded sandstone. (This contrasts with Uf/Mb + Sb, where the unconsolidated clays and silts overlie Mb only.) It can also indicate that two rock types overlie the rock type after the backward slash, e.g., Mo*Lo/Gr, weathered, mainly rhyolitic tephra and loess overlie alluvial gravels.

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[1] The prefix 'c' was not used in the original NZLRI rock type classification. However, for the GEC project it was decided to use it in conjunction with Gw — greywacke association of rocks — to indicate areas of greywacke where rock masses are significantly weaker due to crushing and shearing. Found, for example, in areas of Tikihore Formation (Moore *et al* 1989) in the Waipaoa and Mangatu headwaters. Crushed greywacke is similar to crushed argillite association of rocks in the degree of crushing and shearing but was given a separate symbol due to its coarser nature of intact fragments and having generally only gully erosion associated with it (rather than earthflow and gully normally associated with crushed argillite).

Appendix 5. Soil surveys used

Soil surveys used in the second-edition NZLRI for the GEC region are listed.

Symbol[1]	Soil survey	Reference
1	General survey of the soils of North Island, New Zealand. *Soil Bureau Bulletin 5*, 1954. Sheets 4, 5, and 7	New Zealand Soil Bureau (1954)
2	Soils and agriculture of Matakaoa County, New Zealand. *Soil Bureau Bulletin 11*, 1954	Gibbs (1954)
3	Soils and Agriculture of Gisborne Plains. *Soil Bureau Bulletin 20*, 1962	Pullar (1962)
4	Soils of Tolaga Bay flats, East Coast, North Island, New Zealand. *N.Z. Soil Survey Report 40*, 1978	Rijkse and Pullar (1978)
5	Soils and agriculture of Waiapu Valley, East Coast, North Island, New Zealand. *N.Z. Soil Survey Report 60*, 1980	Rijkse (1980)
6	Soils of part Tiniroto-Wairoa area, North Island, New Zealand. *N.Z. Soil Survey Report 48*, 1979	Rijkse (1979b)
7	Soils of part Urewera–Waikaremoana[2], North Island, New Zealand. *N.Z. Soil Survey Report 45*, 1979	Rijkse (1979a)

[1] These numbers appear as superscripts beside soils in the LUC unit descriptions to identify the origin of the soil name and symbol

[2] This survey abuts the GEC region. Soil taxonomic and mapping units from this survey were used as a guide for mapping along the south-western border of the GEC region.

Appendix 6. New Zealand Soil Classification subgroups listed for LUC units according to slope and anticipated order of prevalence

The following table lists soil subgroups, classified asccording to the 'New Zealand Soil Classification' (Hewitt 1998), in descending order of importance under four broad slope categories: flat to undulating, rolling, strongly rolling to moderately steep, steep–very steep–precipitous.

Hewitt (1998) provides an explanation of the 'New Zealand Soil Classification' with full descriptions of characterising attributes for all soils. Frequent reference to Hewitt (1998), in addition to his 'methods and rationale' publication (Hewitt 1993), is highly recommended to users when interpreting soils in LUC units or individual map polygons.

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
Iw1	RFW, RFM, RFT			
Ic1	RFW, RFM, RFT			
IIe1	BOT	BOT, BLT		
IIw1	RFW, RFT, RFM, GOT, BOT, WF			
IIw2	RFM, RFW, GOT, RFT, RFMA			
IIs1	BOT, ROT, LOT, BOP, GOT			
IIs2	ROT, BOT, RFT, GOT, WF			
IIs3	LOT, BOT, BLT	LOT		
IIIe1	BOP, LOT	LOT, BOP, BLT, RTM, BOT, PID		
IIIe2	BOT, LOT, BOP	BOT, LOT, BOP, BLT		
IIIe3	LOT, ROW, GOT	LOT		
IIIe4	MOT, LOT, BOP, GOT, RTM	MOT, LOT, BOP, RTM		
IIIe5	ZOH, LOT, MOT, MOL	ZOH, LOT, MOT		

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
IIIw1	GOT, RFM, RFW			
IIIw2	GOT, BOT, GOO			
IIIw3	RFM, RFW, RFT, GOT, WF	PID, BOT, GOT, RFM, BLT		
IIIw4	RFT			
IIIw5	RFT, RFW			
IIIs1	WF, BOT, RFT, ROT, GOT, RFW, ROW, RFMA, BST			
IIIs2	MOT, BLT, MIT, GOT, MOI, BOT, RFM, BOP, MOM, MPT, LOT			
IIIs3	BST, BSM			
IIIc1	ZOH, LOT, MOT, GOT			
IIIc2	RFT, BOT, GRT, RFM, ZOH, WF			
IVe1		LOT, BOT, BLT, BOP	BOT, LOT, BLT, BOP, RTM	
IVe2	BOP, PPT, MOT	BOP, PPT, GOT, PIT, BLT, MOT		
IVe3	LOT, MOZ, ZOH	LOT, BLT, BOT		
IVe4	MOM, MOT, GOT, RFT	MOT, BOP, LOT, MOM, MOZ, MOL, BLT, GOT	MOT, BOP, RTT, RTM	
IVe5	ZOH	ZOH, LOT, MOT, ZOT	ZOH, LOT, MOZ	
IVw1	RFT, RFM, WF, RFW, GOT, LOT			
IVw2	GOT, OHM, RFM			

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
IVs1	WF, RFT, ROT, BST			
IVs2	BST, GOT, GRQ			
IVs3	BOT, BOP, LOT	BOT, BOP, ROW, LOT		
IVc1	ZOH	ZOH, MOT		
VIe1		LOT, BLT, BOP, BOT, RTT	BOT, BOP, LOT, BLT, ROW, RTT, RTM	
VIe2		BLT, LOT, ROM	BOT, BOP, PID, ROW, PIT, RTM	
VIe3		BLT, LOT, BOP, BOT	BOT, ROW, BLT, BOP, RTT, LOT, PID	ROW, RTT
VIe4	GOT, PIM	BOP, BOT, LOT, BLT, PIM, GOT	BOT, ROT, BOP, PIT, PIM, BLT	
VIe5		LOT, ZOH, BLT	BLT, LOT, ROW, ZOH	
VIe6		ZOH, PIT, RTM, GOT	PIT, RTT, BOP, ROW, ZOT	
VIe7		LOT, MOT, BLT, LOT, BOP, RTM, ROM, PPT	MOT, LOT, BLT, RTT, RTM, BOT, ROW, ROM, PID	
VIe8		LOT, ZOH	BLT, ROW, PID, PPT, PIT, RTM, BOT, LOT	ROW
VIe9		BOP, PPT, PID, GOT, MOT	BOP, ROW, PID, PIT, PPT, PIM, RTM, BLT	
VIe10		ROM, MOT, BLT	ROW, BOP, PID, BOT, RTM, ROT, BLT, MOT, RTT, BOP	ROW, RTT, ROT

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
VIe11			ROW, BOP, BOT, ROT, PID, MOT, RTT	ROT, ROW, RTT
VIe12		BOP, GOT	ROW, BOP, PIT, BOT, PID, RTT, LOT, PIM, GOT	ROW, ROT
VIe13		BOP, BOM, BLT, LOT	BOT, BOP, ROW	ROW
VIe14		LOT, MOT	BOT, ROW, MOT, LOT, BOP, BLT, RTM, ROT, MOZ, ZOH	ROW, ROT
VIe15		BOP, BOT, BOM, BLT, ZOH	BOT, ROW, BOP	ROW, BOT, ROT, WX
VIe16		BOM, LOT, BLT	ROW, BOT, BOP, PIT, ROT, PID	ROT, ROW
VIe17			ROW, BLT, ROT, ZOH, BOT, BOP, BLD	ROT, ROW, RTT
VIe18		PPT, PID, MOT, GOT	BOP, PPT, PID, RTM, ROM, ROW, MOT, BOM	
VIe19		ZOH, LOT	ZOH, LOT, MOT, BOT, MOZ	ROW
VIe20		MOT, ZOT	MOT, ZOT, BOT	
VIe21		LOT, BLT, ROW	BOT, LOT, ROW, ROT, BLT, ZOH, BOP	ROW, RTT
VIe22		BLT, ROW, GOT, PIM	BOT, ROW, BOP, ROT, PIT	ROT, ROW
VIe23		LOT, BLT, BOT, ZOH	ZOH, ROW, BOT, LOT, ROT, ZOT, BLT	ROT, ROW

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
VIe24		BOT, BLT, ZOH	BOT, ROW, ROT, ZOH	ROT, ROW, WX
VIe25		BST, WS, RST		
VIw1	RFW, WF, GOT, GRT, OMA			
VIs1	GRQ, GOT, RFMQ, BST			
VIs2	WF, WS, ROT, WX, ZOH, RFT			
VIs3	WS, RFT	BST, BSM, WS		
VIIe1			ROW, ROT, BOP, PID, RTM, BOT, ROT, LOT	ROW, ROT, RTM, WO, BOT, BOP, RTT
VIIe2			ROW, ROT, BOT, BOP, PIT	ROT, ROW, WO
VIIe3			ROW, ROT, RTM, BOP, BOT, PID	ROT, ROW, WO
VIIe4			BOP, ROT, RTM, PID	ROW, ROT, WO
VIIe5			ROW, ROM, PID, PIM, ROT, PPT	ROT, ROW, WO, RXT
VIIe6		LOT, BOP, GOT, MOT	ROW, BOP, BLT, LOT, PID, BOT, BOM, MOT, RTT, PIT, PIM, RTM	ROW, ROT
VIIe7		BLT, LOT, ZOH	ROW, BOP, PID, ZOH, BLT, RTM	ROW, RTT, WO
VIIe8		BOT, LOT	ROW, ROT, BOT, BOP, BLT	ROT, ROW, WX, BOT, WO
VIIe9		BOP, GOT, PIM, PPT	BOP, ROW, PIM, RTM, RTT, GOT, WO	
VIIe10			ROW, BOT, ROT, BOP, BLT, BLD	ROT, ROW, WO, RTT

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
VIIe11			ROT, ROW, ZOH, BOT, LOT, WX, BLT, RTT	ROT, WX, ROW, WO, BOT, ZOT
VIIe12		PPT, PID	PID, PPT	
VIIe13			ROW, BOT, ROT	ROT, ROW, WX, WO
VIIe14			ROW, BOT, BLT, ZOH	ROT, ROW, WO, RTT
VIIe15			ROW, BOP, ROT, BOT, PID, RTT, RTM	ROT, ROW, WO, BOP, WX
VIIe16			BOT, ROW, ROT, BLT	ROT, ROW, WO
VIIe17			ROW, BOT, ROT	ROT, ROW, WO, WX
VIIe18		BOT, ROW, BOP, LOT, BOM, BLT, GOT	BOT, ROW, BOP, ROT, LOT, BLT, WX	
VIIe19		BOT, ROW, BLT, ROT, GOT, LOT, ZOH	BOT, ROT, ROW, BOP, ZOH, BLT, LOT, BOM, GOT, MOT, PIT	ROT, ROW, RTM, WX
VIIe20			ZOH, ROW, BOT, LOV, ROT	ZOH, ROW, ROT, WO, ZOT, RTT
VIIe21			ROW, BOP, BOT, PID, MOT, BLT, LOT	ROW, ROT, BOT, WO, RTT
VIIe22			ROW, ROT, ZOH, ZOT, BOT, BLT, LOT, WX	ROT, WX, ROW, WO
VIIe23			ROW	ROT, WO, ROW
VIIe24			ROW, ROT, WO, BOT, BOP, BLT, ZOT, ZOH, WX	ROT, ROW, WO, WX

LUC unit	Flat to undulating slopes (0–7°)	Rolling slopes (8–15°)	Strongly rolling to mod. steep slopes (16–25°)	Steep, v. steep & precipitous slopes (>25°)
VIIe25	GOT	GOT, PPT, PIM, PIT	BOP, BOT, BOM, ROM, PIT, PIM	
VIIe26	WF, RFT, RFW, RFM, ROT, ROW, BOM, WS			
VIIe27	WS, OHM	WS, BST, WX		
VIIw1	GOT, OMA, ROW, GRQ, OMH, RFT, BOT, BOP			
VIIs1				ROT, WO, ROW, WX
VIIs2			BOT, BOP	WO, ROT, WX, ROW
VIIIe1	WF, WS	WS, BST, RST, WO		
VIIIe2			ROW, ROT, BOP, PIT	WO, ROT, WX, ROW
VIIIe3				ROT, WO, WX, ROW, RTT
VIIIe4			ROT, WX, ROW, ZOT, ZOH	ROT, WX, WO, ROW
VIIIe5			ROW, ROT, BOT	ROT, WO, WX, ROW
VIIIe6			ROW, ROT	ROT, WO, ROW, WX
VIIIe7			ROT, ROW	WX, WO, ROT
VIIIe8		ZOH	BOT, ROW, WX, ZOT	WX, ROT, ROW
VIIIe9			WO, ROT, ROW	WO, WX
VIIIs1			ROT, ROW	WO, ROT, WX
VIIIs2	WF, WX, RFM, RFT, ROT			

Appendix 7. Summary descriptions of soil orders and soil groups recorded in the GEC region

A summary of the main attributes of soil orders and groups of the 'New Zealand Soil Classification' (Hewitt 1998) recorded in the GEC region is provided, as adapted from a synopsis given in (Molloy 1998). Nearest equivalent 'New Zealand Genetic Soil Classification' (Taylor and Pohlen 1968) classes are listed for soil groups.

Allophanic Soils - L

Allophanic Soils are dominated by allophane (and also imogolite or ferrihydrite) minerals. These stiff-jelly-like minerals coat the sand and silt grains and maintain a very porous, low-density structure with weak strength. The soils are identified by a distinctly greasy feel when moistened and rubbed firmly between the fingers. They are easy to dig and samples crumble very easily when crushed in the hand.

Occurrence – Predominantly in North Island air-fall tephra, and in the weathering products of other volcanic rocks. They also occur in the weathering products of greywacke and schist in the South Island high country. These are common soils in the stable easier hill country, rolling land, and on terraces in the eastern and northern parts of the GEC region, where the influence of Taupo Pumice is not great. They cover 5% of New Zealand.

Physical properties – Because the bulk density is very low and there is little resistance to root growth, topsoil and subsoil horizons are very friable. Topsoils are stable and resist the impact of machinery or grazing animals in wet weather. Erosion rates are generally low except on steep slopes or exposed sites.

Chemical properties – The ability to retain phosphorus is very high. Natural fertility is low.

Biological properties – Soils contain large populations of soil organisms, particularly in A horizons

Climate – Soils are usually moist with more than 1000 mm/year rainfall.

Soil groups of the Allophanic Soils order
Perch-gley Allophanic Soils (LP) – periodic wetness caused by a perched watertable
Gley Allophanic Soils (LG) – periodic wetness caused by a groundwater-table
Impeded Allophanic Soils (LI) – have a hard layer that impedes roots and water
Orthic Allophanic Soils (LO) – other Allophanic Soils

Nearest equivalent New Zealand Genetic Soil Classification classes
Perch-gley Allophanic Soils (LP) – gley soils
Gley Allophanic Soils (LG) – gley soils
Impeded Allophanic Soils (LI) – yellow-brown loams
Orthic Allophanic Soils (LO) – yellow-brown loams

Brown Soils - B

Brown Soils have a brown or yellow-brown subsoil below a dark grey-brown topsoil. The brown colour is due to thin coatings of iron oxides that have weathered from the parent material.

Occurrence – Brown Soils occur in places where summer drought is uncommon (except in some stony and sandy sites) and which are not waterlogged in winter. They are the most extensive New Zealand soils covering 43% of the country. Brown Soils are common in the hill country of the GEC region: in particular, where erosion is not severe and where older weathered tephric soil material (if present) is not thick enough; or if thick enough, the P-retention values are too low to qualify soils as Allophanic.

Physical properties – They have relatively stable topsoils with well-developed polyhedral or spheroidal topsoil structure.

Chemical properties – Soils have low to moderate base saturation. Clay minerals are dominantly mica/illite and vermiculite, with allophane in Allophanic Brown Soils.

Biological properties – Soils contain large, active populations of soil organisms, particularly earthworms.

Climate – Rainfall is more than 1000 mm/yr. Soils are rarely dry except for some stony and sandy soils.

Soil groups of the Brown Soils order
Allophanic Brown Soils (BL) – have an horizon with soil properties dominated by allophanic material
Sandy Brown Soils (BS) – dominated by sand or loamy sand to depth
Oxidic Brown Soils (BX) – similar to Oxidic Soils but with significant weatherable minerals
Mafic Brown Soils (BM) – in materials from dark igneous rocks or sediments
Acid Brown Soils (BA) – strongly or extremely acid
Firm Brown Soils (BF) – strong, apedal subsurface horizon
Orthic Brown Soils (BO) – other Brown Soils

Nearest equivalent New Zealand Genetic Soil Classification classes
Allophanic Brown Soils (BL) – yellow-brown earths (upland and high country)
Sandy Brown Soils (BS) – yellow-brown sands
Oxidic Brown Soils (BX) – yellow-brown earths (northern)
Mafic Brown Soils (BM) – brown granular loams and clays
Acid Brown Soils (BA) – podzolised yellow-brown earths or yellow-brown earths
Firm Brown Soils (BF) – yellow-brown earths, yellow-brown shallow and stony soils
Orthic Brown Soils (BO) – yellow-brown earths, yellow-brown shallow and stony soils

Gley Soils - G

Gley Soils are strongly affected by waterlogging and have been chemically reduced. They have light grey subsoils, usually with reddish brown or brown mottles. The grey colours usually extend to more than 90 cm depth. Waterlogging occurs in winter and spring, and some soils remain wet all year.

Occurrence – Gley Soils occur throughout New Zealand, usually in low parts of the landscape where there are high groundwater-tables, and in places where there are seepages. Large areas of Gley Soils have been artificially drained to form productive agricultural land, on flood plains, such as on the Poverty Bay and Tolaga Bay flats. They cover 3% of New Zealand.

Physical properties – These soils have high groundwater-tables, shallow potential rooting depth, and relatively high bulk density. Trafficability is limited when soils are wet. Drainage is necessary for most agricultural development.

Chemical properties – Soils have common segregated iron and manganese oxide mottles, concretions, or nodules. Organic matter content is usually high.

Biological properties – Many soil organisms are restricted because of anaerobic conditions.

Soil groups of the Gley Soils order
Sulphuric Gley Soils (GU) – sulphuric acid or the mineral jarosite in marine estuarine soils
Sandy Gley Soils (GS) – dominated by sand or loamy sand to depth
Acid Gley Soils (GA) – strongly or extremely acid
Oxidic Gley Soils (GX) – similar to Oxidic Soils but with less iron oxide
Recent Gley Soils (GR) – on young land surfaces, mainly alluvial or estuarine
Orthic Gley Soils (GO) – other Gley Soils

Nearest equivalent New Zealand Genetic Soil Classification classes
Sulphuric Gley Soils (GU) – gley soils
Sandy Gley Soils (GS) – gley soils
Acid Gley Soils (GA) – gley soils
Oxidic Gley Soils (GX) – gley soils
Recent Gley Soils (GR) – gleyed recent soils
Orthic Gley Soils (GO) – gleyed recent soils

Organic Soils – O

Organic Soils are formed in the partly decomposed remains of wetland plants (peat) or forest litter. Some mineral material may be present but the soil is dominated by organic matter.

Occurrence – Organic Soils occur in wetlands in most parts of New Zealand or under forest that produces acid litter in areas with high precipitation. They cover 1% of New Zealand.

Physical properties – Organic Soils have very low bulk densities, low bearing strength, high shrinkage potential when dried, very low thermal conductivity, and high total available-water capacity.

Chemical properties – Soils have high cation exchange capacities, but are usually strongly or extremely acid, and nutrient deficiencies are common.

Biological properties – High carbon/nitrogen ratios indicate slow decomposition rates. Many soil organisms are restricted because of anaerobic conditions.

Soil groups of the Organic Soils order
Litter Organic Soils (OL) – thick litter that has accumulated under forest
Fibric Organic Soils (OF) – in peat with plant fibres that are only weakly decomposed
Mesic Organic Soils (OM) – in peat that is moderately decomposed
Humic Organic Soils (OH) – in peat that is strongly decomposed.

Nearest equivalent New Zealand Genetic Soil Classification classes
Litter Organic Soils (OL) – unclassified
Fibric Organic Soils (OF) – organic soils
Mesic Organic Soils (OM) – organic soils
Humic Organic Soils (OH) – organic soils

Pallic Soils - P

Pallic Soils have pale coloured subsoils due to low contents of iron oxides. The soils have weak structure and high density in subsurface horizons. Pallic Soils become dry in summer and wet in winter.

Occurrence – Pallic Soils occur predominantly in the seasonally dry eastern parts of the North and South islands, and in the Manawatu region. They cover 12% of New Zealand, but are relatively poorly represented in the GEC region, being confined to lower rainfall areas such as the eastern coastal areas and around the margins of the Poverty Bay flats. Parent materials are commonly loess derived from schist or greywacke.

Physical properties – Soils have slow permeability with limited rooting depth, and medium to high bulk density. They are susceptible to erosion because of their high potential for slaking and dispersion. Pallic Soils of the GEC region developed on mudstones have perched watertables.

Chemical properties – Soils have medium to high natural nutrient content (except for sulphur), high base saturation, low concentrations of secondary oxides, and low organic matter contents. Phosphorus-retention values are less than 30%.

Biological properties – Soils are strongly worm-mixed at the boundary between the A and B horizons.

Climate – Annual rainfall is usually between 500 and 1000 mm and the climate is typically droughty in summer, and moist and wet in winter.

Soil groups of the Pallic Soils order
Perch-gley Pallic Soils (PP) – periodic wetness caused by a perched watertable
Duric Pallic Soils (PU) – silica-cemented pan in the subsoil
Fragic Pallic Soils (PX) – a compact pan in the subsoil
Laminar Pallic Soils (PL) – clay accumulation as thin bands in the subsoil
Argillic Pallic Soils (PJ) – clay accumulation as thin coatings on peds or in pores
Immature Pallic Soils (PI) – weakly expressed pallic soil features

Podzols - Z

Podzols are strongly acid soils that usually have a bleached horizon immediately beneath the topsoil. This horizon is the source of aluminium and iron oxides, which have accumulated, in association with organic matter, in an underlying dark or reddish-coloured horizon.

Occurrence – Podzol Soils occur in areas of high rainfall and are usually associated with forest trees that produce an acid litter. They are most common in Northland, the North Island high country, and the West Coast and high country of the South Island. The soils occur mainly in materials from silica-rich rocks such as granite, greywacke, schist, rhyolite, or rhyolitic ash. They cover 13% of New Zealand, and are found in upland areas (>550 m a.sl.) of the GEC region. Sandy Taupo and Waimihia tephric soil materials are prone to processes that result in the formation of Podzols.

Physical properties – Cemented or compacted B horizons are common, with associated slow permeability and limited root depth. E and B horizons are weakly pedal or lack pedality.

Chemical properties – Podzols have low natural fertility, low base saturation, and are strongly acid. Secondary oxides and other clay minerals are strongly differentiated with depth.

Biological properties – Podzols have low biological activity. The vegetation comprises plants that deposit a mor-forming acid litter.

Climate – The soils are moist throughout the year with annual rainfall more than about 1500 mm (and in the GEC region, more than about 1800 mm/yr).

Soil groups of the Podzol Soils order
Densipan Podzol Soils (ZD) – high density, pale coloured, pan just beneath the topsoil
Perch-gley Podzol Soils (ZP) – periodic wetness caused by a perched watertable
Groundwater-gley Podzol Soils (ZG) – periodic wetness caused by a groundwater-table
Pan Podzol Soils (ZX) – with a subsoil cemented pan
Orthic Podzol Soils (ZO) – other Podzols

Nearest equivalent New Zealand Genetic Soil Classification classes
Densipan Podzol Soils (ZD) – podzols
Perch-gley Podzol Soils (ZP) – gley-podzols
Groundwater-gley Podzol Soils (ZG) – gley-podzols
Pan Podzol Soils (ZX) – podzols
Orthic Podzol Soils (ZO) – podzols

Pumice Soils - M

Pumice Soils are sandy or gravelly soils that are dominated by pumice, or pumice sand with a high content of natural glass. Drainage of excess water is rapid but the soils are capable of storing large amounts of water for plants. They occur in tephra ranging from 700 to 3500 years old. Pumice Soils are formed in both Taupo Pumice (1850±10 yr B.P.) and Waimihia Lapilli (3280±20 yr B.P.) in the GEC region.

Occurrence – Pumice Soils occur mainly in the central North Island, particularly in the Volcanic Plateau. They cover 7% of New Zealand. The GEC region lies at the eastern margin for Pumice Soils. While Taupo and Waimihia materials are frequently present in topsoils further to the east and north of the region, they are less than 25 cm thick and not sandy enough for Pumice Soils.

Physical properties – Clay contents are low, generally less than 10%. They have low soil strengths, high macroporosity, and deep rooting depth. Soils have low strength when disturbed, but are generally resistant to livestock treading damage.

Chemical properties – The pumice is fresh or only moderately weathered with low reserves of major nutrient elements. Trace elements are likely to be deficient. Clay minerals are dominated by allophane.

Biological properties – Soil animal populations are low with most species concentrated in the topsoil. Earthworm populations are limited by droughtiness and coarse texture.

Soil groups
Perch-gley Pumice Soils (MP) – periodic wetness caused by a perched watertable
Impeded Pumice Soils (MI) – with a subsoil layer that restricts water movement and roots
Orthic Pumice Soil (MO) – other Pumice Soils

Nearest equivalent NZ Genetic Soil Classification classes
Perch-gley Pumice Soils (MP) – gley soils
Impeded Pumice Soils (MI) – yellow-brown pumice soils
Orthic Pumice Soil (MO) – yellow-brown pumice soils

Raw Soils - W

Raw Soils are very young soils. They lack distinct topsoil development or are fluid at a shallow depth. They occur in environments where the development of topsoils is prevented by rockiness, by active erosion, or deposition.

Occurrence – Raw Soils are scattered throughout New Zealand, particularly in association with high mountains (alpine rock areas and active screes), braided rivers, beaches, and tidal estuaries. They cover 3% of New Zealand. In the GEC region, they are most common in the Raukumara Range mountain land and steep foothills, and on eroded areas elsewhere such as in gullies, on active earthflows or on sites affected by slip erosion, and in valleys where there is frequent sediment deposition.

Physical properties – Raw Soils have no B horizon, and the topsoil is either absent or less than 5 cm thick.

Chemical properties – Fertility is limited by lack of organic matter and nitrogen deficiency.

Biological properties – Vegetation cover is sparse and often consists of ephemeral herbaceous plants, mosses, or lichens.

Soil groups of the Raw Soils order
Gley Raw Soils (WG) – periodically wet
Hydrothermal Raw Soils (WH) – soils naturally warmed by geothermal activity
Rocky Raw Soils (WX) – rock at shallow depths
Sandy Raw Soils (WS) – dominated by sand or loamy sand to depth
Fluvial Raw Soils (WF) – in sediments deposited by flowing water
Tephric Raw Soils (WT) – in sediments originating as volcanic ejecta
Orthic Raw Soils (WO) – other Raw Soils

Nearest equivalent New Zealand Genetic Soil Classification classes
Gley Raw Soils (WG) – unclassified
Hydrothermal Raw Soils (WH) – hydrothermal soils
Rocky Raw Soils (WX) – unclassified
Sandy Raw Soils (WS) – unclassified
Fluvial Raw Soils (WF) – unclassified
Tephric Raw Soils (WT) – unclassified
Orthic Raw Soils (WO) – unclassified

Recent Soils - R

Recent Soils are weakly developed and show limited signs of soil-forming processes. A distinct topsoil is present but a B horizon is either absent or only weakly expressed, as they lack pedality or are only weakly pedal.

Occurrence – Recent soils occur throughout New Zealand on young land surfaces, including alluvial flood plains, unstable steep slopes, and slopes mantled by very young tephra. Their age varies depending upon the environment and soil materials but most are less than 1000 to 2000 years old. They cover 6% of New Zealand. These soils are very common in much of the eroding and steep hill country and river valleys of the GEC region.

Physical properties – The soils have variable soil texture, with common stratification of contrasting materials, spatial variability is high. They are generally deep rooting and have high plant-available water capacity.

Chemical properties – Natural fertility is usually high with high base saturation. The clay mineralogy is usually dominated by illite.

Biological properties – A continuous cover of vascular plants is normally well established.

Soil groups of the Recent Soils order
Hydrothermal Recent Soils (RH) – soils naturally warmed by geothermal activity
Rocky Recent Soils (RX) – rock at shallow depths
Sandy Recent Soils (RS) – dominated by sand or loamy sand to depth
Fluvial Recent Soils (RF) – in sediments deposited by flowing water
Tephric Recent Soils (RT) – in sediments originating as volcanic ejecta
Orthic Recent Soils (RO) – other Recent Soils, most commonly on slopes

Nearest equivalent New Zealand Genetic Soil Classification classes
Hydrothermal Recent Soils (RH) – recent soils
Rocky Recent Soils (RX) – lithosols
Sandy Recent Soils (RS) – recent soils
Fluvial Recent Soils (RF) – recent soils
Tephric Recent Soils (RT) – recent soils
Orthic Recent Soils (RO) – recent soils

Appendix 8. NZLRI slope classification

Slopes used for the second-edition NZLRI of the Gisborne – East Coast region are arranged into the seven slope groups of Soil Conservation and Rivers Control Council (1971) plus an extra group (H) to recognise precipitous slopes.

Slope groups	Slope angle (degrees)	Slope description
A	0–3	Flat to gently undulating
B	4–7	Undulating
C	8–15	Rolling
D	16–20	Strongly rolling
E	21–25	Moderately steep
F	26–35	Steep
G	36–42	Very steep
H	>42	Precipitous

Additional symbols:

D/E A slope between two slope groups — here showing most slopes are 20 to 21 degrees
D+E Complex slopes, first slope group is dominant
A' Dissected slopes

Appendix 9. NZLRI erosion type and severity

The method used for recording erosion types and present erosion severity broadly follows the standard NZLRI scheme in Eyles (1985) by using a six-part erosion severity ranking system, relying on observational evidence, and recognising the erosion types described by Eyles.

Selected assessment guidelines from Fletcher *et al.* (1994) were also used, as adapted by adding a 'very severe' class (to conform to NZLRI standards of Eyles 1985) and changing percentage area guidelines to follow GEC field experience more closely. These guidelines give more importance to the percentage area of the map polygon affected by erosion for assessing mass-movement and fluvial erosion types. Tables 2 to 5 (this appendix) provide the guidelines used by the second-edition NZLRI of the GEC region for the most important erosion types in the region: soil slip, riparian slip, gully, and earthflow. The 'percentage area affected' guidelines were used to derive preliminary present erosion severities, which were then finalised after considering other criteria (such as those listed under each of Tables 2 to 5) — adjusting the preliminary assessments up or down as necessary, or confirming them.

When interpreting erosion information, it should be recognised that while the percentage area of the map polygon affected is important for all types, the actual area affected by erosion can not be calculated from the erosion inventory code (except for surface erosion types). The usual data appraisal method involves deriving the total area of map polygons affected by an erosion type of defined severity (Eyles 1983). It is also important to recognise that no quantitative erosion information is presented in terms of mass yields of sediment, degradation rates, etc. The collection of these data requires direct measurement from usually long-term monitoring programmes or the construction of catchment sediment budgets (Page *et al.* 1994) to produce information on, for example, storm soil slip volumes (Reid and Page in press), to model sediment generation and sediment delivery to streams, or model gully contributions of sediment (De Rose *et al.* 1998), etc.

The second-edition NZLRI of the GEC region introduced for the first time the erosion types of riparian slip and rock fall: the former are soil slips restricted to riparian areas that have occurred as a consequence of stream channel and hillslope interactions; the latter records very steep or precipitous landforms such as bluffs and escarpments from which rocks fall.

The erosion classification is given below:

Surface erosion (recorded on an areal basis alone, see Table 1 below).

Sh	-	sheet
W	-	wind
Sc	-	scree

Mass-movement erosion (main assessment criteria: a combination of aerial extent using the area of unvegetated erosion scars for slips, rate and depth of movement, technical feasibility and cost of control using knowledge of physical and chemical properties of rocks and soils, slope, climate, etc., and considering the impact of the erosion on productivity and expected economic/environmental benefits having carried out soil conservation measures).

Ss	-	soil slip
Rs	-	riparian slip
Es	-	earth slip
Su	-	slump
Da	-	debris avalanche
Rf	-	rock fall
Ef	-	earthflow

Fluvial erosion (main assessment criteria: a combination of aerial extent as determined by the area of unvegetated ground for rill, gully, and deposition; rate and depth of movement (or thickness of deposits), technical feasibility and cost of control using knowledge of physical and chemical properties of rocks and soils, slope, climate, etc., and considering the impact of the erosion on productivity and expected economic/environmental benefits having carried out soil conservation measures).

R - rill
G - gully
T - tunnel gully
Sb - streambank
D - deposition

Table 1: *Surface erosion guidelines*

Symbol	Severity name	Percentage bare ground
0	negligible	<1
1	slight	1–10
2	moderate	11–20
3	severe	21–40
4	very severe	41–60
5	extreme	>60

Table 2: *Guidelines[1] for relating the area affected by soil slip[2] to erosion severity*

Symbol	Severity name	Percentage area affected
0	negligible	<0.5
1	slight	0.5–2
2	moderate	3–5
3	severe	6–10
4	very severe	11–20
5	extreme	>20

[1] Used in conjunction with assessment criteria below
[2] Considering scar area only — not scar and debris tails

Main additional considerations for soil slip:

- physical and chemical properties of the rock, regolith, and soil
- slope angle and lenght
- average depth and area of individual scars
- the relationship of debris with hillslope channels (direct, indirect, or not associated) — the affected hillslope position
- impending or active processes likely to re-activate failures or cause erosion of slip scars and debris tails
- the effectiveness of soil conservation measures in other similar situations

Table 3: *Guidelines[1] for relating the area affected by riparian slip[2] to erosion severity*

Symbol	Severity name	Percentage area affected
0	negligible	<0.1
1	slight	0.1–0.5
2	moderate	0.6–1
3	severe	2–5
4	very severe	6–10
5	extreme	>10

[1] Used in conjunction with assessment criteria below
[2] Considering scar area — not scar and debris tails

Main additional considerations for riparian slip:

- length of hillslope channel affected by slips
- density of affected hillslope channels
- fluvial characteristics of affected hillslope channels
- average depth and area of individual scars
- physical and chemical properties of the rock, regolith, and soil
- slope angle of riparian slopes
- the effectiveness of soil conservation measures in other similar situations

Table 4: *Guidelines[1] for relating the area affected by gully to gully severity*

Symbol	Severity name	Percentage area affected
0	negligible	<0.1
1	slight	0.1–1
2	moderate	2–5
3	severe	6–10
4	very severe	11–20
5	extreme	>20

[1] Used in conjunction with assessment criteria below

Main additional considerations for gully:

- physical and chemical properties of the rock
- length, width, and depth of gullies
- number of gullies in map polygon
- size of runoff-contributing area above the gully headwalls
- fluvial characteristics of gully channels
- slope of gully walls
- the effectiveness of soil conservation measures in other similar situations

Table 5: *Guidelines[1] for relating the area affected by earthflow to earthflow severity*

Symbol	Severity name	Percentage area affected
0	negligible	<1
1	slight	1–5
2	moderate	6–10
3	severe	11–25
4	very severe	26–40
5	extreme	>40

[1] Used in conjunction with other assessment criteria below

Main additional considerations for earthflow:

- evidence of ground disruption as indicator of earthflow activity (rate of movement)
- depth to stable bedrock
- physical and chemical properties of the rock, regolith (the flow debris), and soil
- slope angle, length, and hillslope position of flows
- average annual rainfall (consider high if above 2000 mm/yr)
- impending or active processes likely to lower or raise the rate of movement, or change the scale of movement (such as a stream destabilising the toe and removing material, presence of springs and source areas for water)
- the effectiveness of soil conservation measures in other similar situations

Appendix 10. NZLRI vegetation classification classes

The classification was adapted from an earlier version (Hunter and Blaschke 1986), and is the same as used in other second-edition NZLRI regions (such as Wellington — Page 1995), except for the addition of 'fN' for kanuka forest.

Grass

gI	Improved pasture
gS	Semi-improved pasture
gU	Unimproved pasture
gT	Short tussock grassland
gW	Snow tussock grassland
gR	Red tussock grassland
gD	Sand dune vegetation

Crops

cC	Wheat, oats, barley, etc.
cM	Maize
cP	Pip and stone fruit
cG	Grapes and berry fruit
cK	Kiwifruit
cS	Subtropical fruit
cR	Root and green fodder crops
cV	Vegetables, nurseries

Scrub

sM	Manuka, kanuka
sC	*Cassinia*
sD	*Dracophyllum*
sF	Fern
sS	Subalpine scrub
sX	Mixed indigenous scrub
sT	Mixed indigenous scrub with tree fern
sB	Broom
sG	Gorse
sK	Blackberry
sW	Sweet brier
sA	Matagouri
sV	Mangrove
sL	Lupin
sH	Heath
sO	Coastal scrub
sE	Exotic scrub

Forest

fC	Coastal forest
fK	Kauri forest
fP	Podocarp forest
fB	Broadleaved forest
fO	Lowland podocarp-broadleaved forest
fI	Highland podocarp-broadleaved forest
fD	Podocarp-broadleaved-beech forest
fW	Lowland beech forest
fG	Highland beech forest
fU	Beech forest, undifferentiated
fN	Kanuka forest (trees >6 m tall)
fF	Exotic conifer forest
fR	Exotic broadleaved forest

Herbaceous

hW	Wetland vegetation
hR	Rushes, sedges
hA	Alpine and subalpine herbfield/fellfield vegetation
hS	Saline vegetation
hP	Pakihi vegetation
hM	Semi-arid herbaceous vegetation
hH	Hieracium

Unvegetated

uV	Unvegetated land

Other Symbols

Placed before class:

c	cutover
s	stunted
e	erosion-control trees
n	naturalised exotic trees

Placed after class:

*	scattered (suffix)

Notes

Vegetation is recorded to the nearest 10% abundance for each vegetation class, and the distribution of vegetation in the map polygons is recorded as either 'clumped' or 'scattered'. Scattered vegetation is denoted by the use of an asterisk after the class symbol, e.g., gIsM*, and clumped vegetation has no additional symbol, e.g., gIsM.

In denoting the nearest 10% covers, codes contain a subscript number for each class, e.g., gI_7sM_3 records a 70% cover of improved pasture and a 30% cover of manuka or kanuka scrub. There is no percentage cover given for scattered vegetation.

A vegetation class is scattered throughout the clumped vegetation class immediately preceding it in the vegetation code. For example, gIsM* is improved pasture with scattered manuka or kanuka scrub, and gIsM* would be recorded as 100%; or gIsM*sG* is improved pasture with scattered manuka or kanuka scrub, and scattered gorse.

Stunted vegetation is represented by the symbol 's' before the class symbol, e.g., sfE is stunted exotic conifer forest, usually recorded in coastal buffer zones. Erosion control trees are represented by the symbol 'e' before the class symbol, e.g., efR is exotic broadleaved trees planted for erosion control. Naturalised exotic conifer trees are represented by the symbol 'n' before the class symbol, e.g., nfF is exotic conifers, usually self-seeded and growing wild, usually without any form of silvicultural management, and where trees represent a range of ages.

Appendix 11. Potential productivity indications for LUC units

Attainable physical productivity classes are given in Table 3 (below) for LUC units in the Gisborne – East Coast region. In previous NZLRI regional reports, numerical data are presented on present average, top farmer, and attainable physical potentials, together with exotic forest growth potentials, and were collected in conjunction with Ministry of Agriculture and Fisheries and Ministry of Forestry advisors. These data were not collected for this second-edition GEC classification, but because data were collected both for the first-edition GEC classification (unpublished data, but part of the NZLRI database) and Northern Hawke's Bay classification (Page 1988), enough productivity knowledge could be carried through to allow reliable broad indications within the rankings given in Tables 1 and 2 (below). Productivity statements in soil survey reports were also helpful, as was knowledge obtained from discussions with many land users during the fieldwork phase of the project.

Table 1: *Potential stock-carrying capacity rankings and livestock farming intensities*

Stock-carrying capacity ranking	Potential stock units per ha[1]	Livestock farming intensity (implied productivity)[2]
very high	>25	intensive
high	21–25	
moderately high	16–20	semi-intensive
moderate	11–15	
low	6–10	extensive
very low	1–5	
sparse	<1	

[1] One stock unit is equivalent to a breeding ewe (55 kg at mating) weaning one lamb
[2] These terms are used in the LUC unit descriptions to broadly define potential grazing productivity

Table 2: *Site index rankings for Pinus radiata*

Site index in metres[2]	Site index ranking	Forest productivity[1]
>35	very high	highly productive
30–35	high	
25–29	moderate	moderately productive
20–24	low	poorly productive
<20	very low	

[1] These terms are used in the LUC unit descriptions to broadly define potential forest productivity
[2] The mean top height in metres of *P. radiata* at age 20 years

Table 3: *Potential productivity indications*

LUC unit	Attainable physical potential interms of stock-carrying capacity rankings	Attainable physical potential for exotic forestry in terms of site index for *P. radiata* rankings
Iw1	very high	very high
Ic1	very high	very high
IIe1	very high	very high
IIw1	very high	high
IIw2	very high	high
IIs1	very high	very high
IIs2	very high	very high
IIs3	high	high to very high
IIIe1	moderately high	high
IIIe2	moderately high	high
IIIe3	moderately high	high
IIIe4	moderately high	high
IIIe5	moderately high	high
IIIw1	very high	low
IIIw2	moderately high	low to moderate
IIIw3	very high	low to moderate
IIIw4	moderately high	moderate
IIIw5	moderately high	unsuitable
IIIs1	moderately high	high
IIIs2	moderate	high
IIIs3	moderate	high
IIIc1	moderate	moderate to high
IIIc2	moderately high	high (in southerly parts) moderate to low (in northerly parts)

LUC unit	Attainable physical potential interms of stock-carrying capacity rankings	Attainable physical potential for exotic forestry in terms of site index for *P. radiata* rankings
IVe1	moderately high	high
IVe2	moderately high	moderate to low
IVe3	moderate to moderately high	high
IVe4	moderately high	high
IVe5	moderate to low	moderate to low
IVw1	moderately high	unsuitable
IVw2	moderate	unsuitable
IVs1	moderate	high
IVs2	moderate	high
IVs3	moderately high	moderate
IVc1	low to moderate	low to moderate
VIe1	moderately high	high
VIe2	moderately high	high
VIe3	moderately high	high
VIe4	moderately high	high
VIe5	moderate to moderately high	moderate to high
VIe6	moderately high	high
VIe7	moderately high	high
VIe8	moderate	moderate to high
VIe9	moderate	moderate to high
VIe10	moderately high	high
VIe11	moderate	high
VIe12	moderate	high
VIe13	moderate	high

LUC unit	Attainable physical potential interms of stock-carrying capacity rankings	Attainable physical potential for exotic forestry in terms of site index for *P. radiata* rankings
VIe14	moderate	high
VIe15	low to moderate	high
VIe16	low to moderate	high
VIe17	low to moderate	moderate
VIe18	moderate	moderate to high
VIe19	low to moderate	low to moderate
VIe20	moderate	low to moderate
VIe21	moderate	high
VIe22	moderate	moderate
VIe23	moderate	moderate
VIe24	low	low to moderate
VIe25	moderate	low to moderate
VIw1	moderate	unsuitable
VIs1	moderate	unsuitable
VIs2	low	low to moderate
VIs3	low	moderate
VIIe1	moderate	moderate to high
VIIe2	moderate	moderate to high
VIIe3	moderate	moderate to high
VIIe4	moderate	moderate to high
VIIe5	low	moderate
VIIe6	moderate	moderate
VIIe7	moderate	moderate to high
VIIe8	moderate	moderate

LUC unit	Attainable physical potential interms of stock-carrying capacity rankings	Attainable physical potential for exotic forestry in terms of site index for *P. radiata* rankings
VIIe9	moderate	moderate
VIIe10	moderate	moderate
VIIe11	low	moderate
VIIe12	low	low
VIIe13	low	moderate
VIIe14	low	moderate
VIIe15	low	moderate
VIIe16	very low	moderate
VIIe17	low	low to moderate
VIIe18	very low	moderate
VIIe19	very low	moderate
VIIe20	very low	moderate
VIIe21	low	moderate
VIIe22	very low	low to moderate
VIIe23	very low	low to moderate
VIIe24	very low	low to moderate
VIIe25	low	low
VIIe26	sparse	unsuitable
VIIe27	very low	moderate
VIIw1	very low to low	unsuitable
VIIs1	very low	very low
VIIs2	very low	very low
VIII	all class VIII units are unsuitable for primary production	

Appendix 12. Authors and dates of compilation for NZLRI data[1]

Sheet no.[2]	Sheet name	Authors	Compilation dates
pt W17	Urewera	T.F. Crippen, M.J. Page	June – August '98
pt W18	Waikaremoana	M.J. Page	June '98
pt X15	Omaio	T.F. Crippen	September '97
pt X16	Motu	T.F. Crippen	September '97 – August '98
pt X17	Matawai	T.F. Crippen, M.J. Page	March – August '98
pt X18	Tiniroto	T.F. Crippen	August '95 – February '96
pt X19	Wairoa	T.F. Crippen	October '95 – February '96
pt Y14	Cape Runaway	T.F. Crippen	January – August '97
pt Y15	Hikurangi	T.F. Crippen	August '96 – August '97
pt Y16	Tauwhareparae	T.F. Crippen	January – October '96
Y17	Te Karaka	M.J. Page, G.R. Harmsworth, T.F. Crippen	December – May '96
Y18	Gisborne	M.R. Jessen	May – September '98
pt Y19	Wharerata	T.F. Crippen	October '95 – February '96
Z14	East Cape	G.R. Harmsworth	April – November '97
Z15	Ruatoria	M.R. Jessen	May – November '97
Z16	Tokomaru Bay	T.F. Crippen	August '96 – June '97
Z17	Tolaga Bay	M.J. Page	May '97

1 data refers to map unit boundary, land use capability, and all inventory information except for vegetation cover
2 1:50 000 scale Infomaps. pt refers to part of the listed Infomaps

Appendix 13. Authors and dates of compilation for NZLRI vegetative cover data[1]

Sheet no.[2]	Sheet name	Authors	Compilation dates
pt W17	Urewera	T.F. Crippen, M.J. Page	July '98
pt W18	Waikaremoana	M.J. Page	June '98
pt X15	Omaio	T.F. Crippen	September '97
pt X16	Motu	T.F. Crippen	September '97 – April '98
pt X17	Matawai	T.F. Crippen, M.J. Page	March – June '98
pt X18	Tiniroto	G.R. Harmsworth	April – June '98
pt X19	Wairoa	G.R. Harmsworth	April – June '98
pt Y14	Cape Runaway	T.F. Crippen	January – June '97
pt Y15	Hikurangi	T.F. Crippen	August '96 – June '97
pt Y16	Tauwhareparae	M.J. Page	December '97 – January '98
Y17	Te Karaka	M.J. Page	March – June '97
Y18	Gisborne	G.R. Harmsworth	April – June '98
pt Y19	Wharerata	G.R. Harmsworth	April – June '98
Z14	East Cape	G.R. Harmsworth	April – November '97
Z15	Ruatoria	M.J. Page	March '98
Z16	Tokomaru Bay	M.J. Page	March '98
Z17	Tolaga Bay	M.J. Page	May '98

[1] Prepared separately from (and is independent of) map polygons prepared in Appendix 12
[2] 1:50 000 scale Infomaps. pt refers to part of the listed Infomaps