OVERSEER® Technical Manual

Technical Manual for the description of the OVERSEER® Nutrient Budgets engine

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Characteristics of soils

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Preface

OVERSEER® Nutrient Budgets

OVERSEER® Nutrient Budgets (OVERSEER) is a strategic management tool that supports optimal nutrient use on farm for increased profitability and managing within environmental limits.

OVERSEER provides users with information to examine the impact of nutrient use and flows within a farm and off-farm losses of nutrients and greenhouse gases. An OVERSEER nutrient budget takes into account inputs and outputs and the key internal recycling of nutrients around the farm.

See the OVERSEER website for more detailed information: http://www.overseer.org.nz

This technical manual

OVERSEER is made up of a user interface and an engine. These two components work together to enable users to generate nutrient budget reports. The Technical Manual provides details of the calculation methods used in the OVERSEER engine.

The OVERSEER engine is based on extensive published scientific research. Technical information about the model's development and use can be found in a growing number of conference proceedings and peer-reviewed papers. Given the ongoing upgrades many of the earlier papers no longer reflect the current version.

The Technical Manual chapters provide detailed descriptions of the methods used in the OVERSEER engine's main sub-models. The Technical Manual sets out the underlying principles and sources of data used to build the model engine. It is a description of the model as implemented, and hence references may not now be the most appropriate or cover the range of data of information currently available, or may not necessarily be the most up to date. If the source of some information and/or assumptions is not known or could not be found, this is acknowledged.

The chapters will continually be updated to reflect the current version.

If readers have feedback or further technical information that they consider could contribute to the future development of the model, please provide feedback via the website http://www.overseer.org.nz.

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1. Introduction

This chapter describes the soil properties used in the model. The soil properties are used throughout the model for the following purposes (with relevant Technical Manual chapter names in parentheses):

- Calculation of drainage and runoff (Hydrology chapter). Drainage is then used in the estimation of other processes such as leaching.
- Calculation of other nutrient transformations such as pasture nutrient contents.
- Calculation of nutrient transfers such as leaching losses and weathering.

Many of the soil properties described here are not presented to, or selected by, the user via the software interface. Many soil properties used in the model are defaults, including several that are used internally and therefore not seen or manipulated directly by the user. This data is listed in tables or a reference is given.

1.1. Chapter conventions

Each equation has a caption so that it can be referenced. Equations with multiple '=' options are cascading alternatives in the order they are considered. The condition is shown on the right hand side. The variable and parameter names are generally shortened names of the property. Under each equation there is a list of terms used in the equation that contains a definition, the units and a cross-reference as required. Within these lists, units are shown using ( ) and cross-references to other chapters of the Technical Manual or sections within this document are shown using [ ].

1.2. Workings of the technical manual

The aim of the technical manual is to provide a level of detail so that users of OVERSEER can clearly see the underlying principles and sources of data used to build the components of the model. This technical chapter is part of a series of technical manuals currently under development to explain the inner working of the OVERSEER engine.

In the equations in this manual, units are shown using ( ) and cross-references other equations and sections within this manual or to other chapters of the technical manual are shown using [ ]. Equations with multiple '=' options are cascading alternatives in the order they are considered. The condition is shown on the right hand side. The variable and parameter names used are generally shortened names of the property, and this naming convention is similar to the convention used in the OVERSEER engine model.

1.3. Abbreviations, chemical symbols, and subscripts

<u>Abbreviations:</u>

FC field capacity (section 3.2.4).

WP wilting point (section 3.2.4).

Sat saturation (section 3.2.4).

QT MAF Quick Test soil test values (section 2.4.1).

Kc nitric acid extractable K (cmol(+)/100 g soil).

PESo phosphate-extractable organic S test (mg/g soil) (section 2.4.1).

ASC Anion storage capacity (section 2.4.2).

Chemical symbols:

N, P, K, S, Ca, Mg, and Na refer to the nutrients nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and sodium respectively.

Subscripts:

nut the nutrients N, P, K, S, Ca, Mg, Na. Chloride (Cl) or acidity is also included but is not referred to in this chapter.

2. Soil data inputs

Soil inputs are broadly categorised into six groupings, namely:

- Soil classification which is used to define default values for a range of soil properties (section 3).
- Soil profile descriptors. These are used to define soil water properties (section 5) and to define default values for a limited range of soil properties (section 3).
- Site-specific properties: these are soil properties that may be measured for a given site, but typically, the default values would be used. For example, the bulk density and clay content for topsoil are usually default values based on the soil description selected, but they may be overridden by the user.
- Soil drainage characteristics that define the drainage status of the soil within defined blocks and artificial drainage systems.
- Soil tests provide soil input data that is readily obtained from a soil testing service. Typically, this testing is undertaken as part of fertiliser recommendation program.
- Soil potential settings. These are typically qualitative assessments of soil status. Changing these values from defaults should be undertaken with care. Inputs to determine change in soil carbon are included.
- Soil water focused inputs. An alternative method to using soil classification and soil descriptors for describing soil water contents is available using the soil-water focused inputs. This method uses elements from the other categories.

2.1. Soil classification

Soil classification can be entered in four ways, namely as a soil series, soil order or soil group, or as soil family or sibling.

2.1.1. Soil siblings

Soil order is the top level of the New Zealand soils classification whereas soil families and siblings are the fourth and fifth categories for soil classification (Webb and Lilburne, 2011). Webb and Lilburne (2011) noted that:

> *"The family is designed to identity the dominant lithological composition of soil profiles. ... Families are identified by sets of criteria describing soil materials occurring within 100 cm of the soil surface."*
>
> *"Each soils family is divided into siblings on the basis of soil depth, top soil stoniness, soil-texture profile, natural soil drainage and a unique sequence of up to six functional horizons."*

The soil sibling is the unique component of the S-map mapping unit (Lilburne *et al*., 2012), with each sibling having a fact sheet. Data for soil siblings can be obtained using an API link to S-map using the S-map name/ref. This link returns either soil order and soil profile descriptors (section 2.2.2), or soil order and soil water contents (section 2.3.2). In addition, the values for site-specific properties, except saturated conductivity, are also returned.

2.1.2. Soil series

In excess of 800 soil series names can be selected (appendix 1). The names of soil series that had a soil order were extracted from the National Soils Database (Wilde and Ross, 1996), and a limited selection of data for each type was extracted (soil order, anion storage capacity (ASC), nitric acid extractable K (Metson 1980) (Kc), bulk density, %carbon, %clay), calculated (structural integrity, section 4.4) or estimated (soil group, hydrologic index from soil texture, P model chapter). When data was missing, default data were estimated using the methods described in section 3.

2.1.3. Soil order

There are 13 soil orders that a user can select in OVERSER based on the 15 orders in the National Soils Database (Wilde and Ross, 1996). The 13 soil orders used are: Allophanic Soils, Brown Soils, Gley Soils, Granular Soils, Melanic Soils, Organic Soils, Oxidic Soils, Pallic Soils, Podzols Soils, Pumice Soils, Recent Soils, Semiarid Soils, and Ultic Soils. Anthropic Soils and Raw Soils soil orders are not represented. In most cases, when referring to soil orders, 'Soils' is omitted from the name.

Soils formed from sand, irrespective of the soil order, are covered under soil groups (section 2.1.4).

A default soil group (section 2.1.4) is also identified for each soil order.

2.1.4. Soil group

There are seven soil groups that a user can select, namely: Sedimentary, Volcanic, Pumice, Podzol, Sand (High P loss), Peat, and Recent/YGE/BGE.

The groups were classified based initially on the analysis of a P database of fertiliser trials conducted in New Zealand (Metherell *et al.*, 1995), where there was only sufficient data to identify four broad soil groups (Sedimentary, Volcanic, Pumice and High P loss soils). Peats were added later (O'Connor *et al.*, 2001). The Sedimentary, Volcanic, Pumice and Peat groups are defined in Morton and Roberts (1993), Roberts and Edmeades (1993), and Roberts *et al*. (1994), and are summarised here as:

- Volcanic or Ash — yellow brown loams, brown granular clays and loams, and the poorly-drained (gley) soils formed from volcanic ash.
- Pumice — yellow brown pumice soils and gley soils formed from pumice.
- Peat — soils with little or no mineral matter, made up of plant residues.
- Sedimentary — any other soil.

For P, information related to High P loss soil group was included as reported by Metherell *et al*. (1995). These are predominately the sands. Soils formed from sand can occur in Recent, Pallic, Brown, Podzol (and Raw) soil orders. These were separated because, for soil water contents, they are different from other soils in the order, but are similar to each other (T. Webb, Landcare Research, pers. comm.). Thus, sands were identified as a separate group. This implies that these soils should be identified by selecting a 'Sand' soil group rather than the soil order. The exception is sandy pumice soils (see section 3.2.4).

Podzols and Recent/YGE/BGE were added due to differences in default reserve K status from sedimentary soils (section 2.4.3).

2.2. Soil profile

2.2.1. Profile drainage class

Profile drainage class defines how well the soil is drained in its natural state i.e. without artificial drainage. It is not a measure of the rate of drainage or permeability of the soil. The actual characteristics associated with different drainage class are described below in Table 1. A value can be selected if known; otherwise, the default value based on soil classification is used. Profile drainage class is used in the estimation of current drainage status (section 4.7).

To assess the profile drainage class, observations of the depth to water table, propensity of soil to be damaged under grazing in its natural (un-drained) state and soil colour down to one metre can assist. A description of characteristics associated with each drainage class (A. Hewitt, pers. comm.) and a technical description based on Milne *et al*. (1995 pp148-149) is shown in Table 1.

Table 1. Description of profile drainage classes (Adapted from Milne *et al*. 1995 and A. Hewitt, pers. comm.)

Profile drainage class	Description
Good	Well drained. Water table never within 1 m of the soil surface. Can be grazed with minimal pugging damage most of the year. No evidence of grey colours or rust mottling within the soil. <u>Technical</u>: Mottles are absent or rare. There is either no soil mottling in the top 90 cm, or less than 2% reddish mottles.
Moderate	Generally well drained. Water table may be above 1 m below the soil surface for short periods following prolonged periods of medium to heavy rain events, or during winter. Must be grazed with caution during these periods to avoid pugging damage. Soil is grey in colour or rust mottled at depth (below 60 cm). <u>Technical</u>: Common deep mottling. At 30-60 cm depth, there is at least 2% reddish mottles, and at 60-90 cm depth, at least 50% is grey mottles.
Imperfect	Water table within 1 m of surface or a perched water table occurs due to an impediment to drainage over most of winter. Drainage required if stock are to graze over winter otherwise heavy pugging damage occurs. Pale (Grey) colours in soil between 30 and 60 cm. <u>Technical</u>: Common shallow mottles. At depths less than 30 cm, less than 50% of the soil is grey mottles, or, soil at 30-60 cm contains at least 50% grey mottles.
Poor	Water table within 1 m of surface or perched water table occurs due to an impediment to drainage outside of winter period. Drainage required if stock are to graze during rain events otherwise heavy pugging damage occurs. Soil has grey colours between 10 and 30 cm. <u>Technical</u>: Abundant shallow mottles. Soil between 10-30 cm is at least 50% grey mottles.
Very Poor	There is an organic horizon with dominant grey immediately beneath – i.e. a peaty topsoil or is an Organic Soil

2.2.2. Soil profile descriptors

In addition to the soil classification information there are soil profile descriptors for top soil (0-10 cm) and lower profile/subsoil (>10 cm). These inputs are only available if soil series, order, or group is selected, or S-map returns soil order and profile descriptors. Soil profile descriptor inputs primarily affect soil water estimates and are:

- Top soil texture group. Soil texture classes extracted from the National Soil Database (Wilde and Ross, 1996). Top soil texture can affect runoff, particularly for heavier textured soils. The presence of cracking can also result in higher infiltration rates. This is not included, but selecting a texture class with less clay or silt will increase infiltration rates.

- Top soil is stony. This is defined as a top soil (0-10 cm layer) with greater than 35% stones is a stony topsoil (T Webb, Landcare Research, pers. comm.).

Additional sub-soil descriptors are:

- Soil texture group. Options of light, medium, and heavy are available. These were initially based on generalised descriptions used by the cropping industry, and primarily affect soil water content. Sub-soil texture groups are defined as:
  - ‘Light’ soils where the upper 60 cm is dominantly sand or loamy sand. The soil water contents are based on those for a sandy soil (section 3.2.4).
  - ‘Heavy’ soils where the upper 60 cm is dominantly clay (clay content >35%)
  - ‘Medium’ soils which are not Light or Heavy as defined above.

  Sub-soil texture group can be selected for Brown and Recent soil orders, or if soil order is not selected then only Sedimentary and Recent/YGE/BGE soil groups are available. These soils were considered to be more likely to have variations in sub-soil texture.
- Non-standard layers. Non-standard layers were developed as a means to improve estimation of soil water contents in stony soils. The definitions were based on the soil water data described in section 3.2.4. Available categories are:
  - Sandy — Sub-soils where the whole profile is sand, such as soils found in sand dunes or on sand plains. They are often found on flood plains. Note that these are soils that have a sandy layer in the subsoil, not soils where the whole profile is sand, in which case the sandy soil group should be selected (section 2.1.4).
  - Stony — Sub-soils with a high stone content leading to reduced water holding capacities. Technically defined as a subsoil profile containing 50% or more stones and the fine material is sandy.
  - Stony matrix — Sub-soils with a moderate to high stone content and there is soil matrix between the stones. Water holding capacity is lower than a non-stony soil, but higher than a stony soil. The soil water contents were selected to be intermediate between stony and brown soil, and there soil water contents correspond to a subsoil profile that contains 50% or more stones and the fine material is loamy or clayey.
- Depth to non-standard layer is the depth in the soil profile (cm) that a non-standard layer starts.

2.2.3. Maximum root depth and impeded layers

Maximum rooting depths and depth to impeded layers can be entered. These are define as:

- Maximum rooting depth. This is the maximum depth (cm) that roots penetrate the profile, typically due to a chemical layer, such as a layer that is aluminium or manganese toxic, or anoxic. It is not the depth that roots naturally grow to, and must be less than the depth to the impeded layer. Drainage of water can still occur below this depth.

- Depth to impeded layers is the depth that an impervious layer starts, and hence there is negligible vertical drainage of water past this depth. Roots are also assumed not to penetrate this layer, and hence this factor is included in the N leaching sub-model.

2.3. Soil properties

The default values associated with soil classification inputs (section 2.1), or information entered under the soil water focused input options (section 2.3) are all based on information from databases, and hence are summaries of information. For some soil properties, site-specific information may be available as a result of specialist soil testing and analysis. The option to enter this information has been included. As it is site-specific, it takes precedence over the database-derived information based on soil classification (section 2.1) or soil water focused inputs (section 2.3).

Soil drainage characteristics (section 2.3.1), soil tests (section 2.4) and soil potassium leaching potential settings (section 2.3.1) can also be set as these are all site-specific.

2.3.1. K leaching potential

Potassium (K) leaching potential describes the potential for a site to lose K via leaching, with a value between 0 and 6. It is a multiplicative factor for estimating K leaching (A Metherell, unpublished).

The default K leaching potential is estimated as shown in section 4.11, or a value can be selected by the user.

2.3.2. Soil water contents

The user can enter soil water contents at wilting point, field capacity, and saturation (mm/10 cm) for three depths (0-30 cm, 30-60 cm, and > 60 cm).

2.3.3. Soil chemical and physical parameters

The user can enter the following properties for the 0-10 cm soil layer

- Bulk density (kg/m^3).
- Structural integrity (section 4.4).
- Top soil carbon content (%).
- Top soil clay content (%).

The user can enter the following properties for the 10-60 cm soil layer

- Sub soil clay content (%).
- Saturated conductivity (mm/day).

2.3.4. Soil carbon levels

The change in soil carbon (section 4.12) is used in the acidity sub-model to estimate maintenance lime requirements, and is used to provide a minimum level of N immobilisation in the N sub-model for the pastoral block. The change in carbon is estimated from one of the following inputs:

- Selecting a status, with options of 'Large decrease', 'Small decrease', ‘Use default’, 'Small increase', and 'Large increase'.
- Entering a rate of change in total soil C (kg C/ha/year).
- Entering initial and final soil carbon measures, and the number of years that the change occurred over. Soil carbon measures can be entered as total C mass (kg/kg soil), as content (%), or as hot water extractable C (µg/g soil).

The ‘Use default’ status uses the N immobilisation potential to provide an estimate (section 4.12).

The option to enter soil pH is also available. Soil pH only affects the extent to which changing soil carbon levels affect acidification rates, and hence maintenance lime requirements.

2.3.5. N immobilisation potential

N immobilisation potential is an indicator of the ability of the soil to immobilise excess N and hence can alter the amount of N removed by leaching. The selections are:

- Standard: Recommended selection and is the value that the N leaching sub-model is calibrated against.
- Higher: N immobilisation potential is higher than Standard because of management practices such as recent dairy conversions, or re-development of pasture. Estimated N leaching is typically lower than for the Standard setting.
- None No net N immobilisation occurs. This option typically results in higher estimated N leaching.

It is highly recommended that ‘Standard’ is used as this is the setting that N leaching sub-model has been calibrated against. However, alternatives have been provided to demonstrate the likely effects of higher or lower level of net N immobilisation rates.

2.4. Soil tests

2.4.1. Soil nutrient tests

Soil tests for six major nutrients are compulsory inputs to produce a nutrient budget OVERSEER. These are Olsen P (volumetric, mg/L or µg/ml), MAF Quick Test (QT) K, Ca, Mg, and Na, and a sulphur test. The QT’s are typically reported without units but conversions are detailed in Cornforth and Sinclair (1984). The extraction techniques are described in Cornforth and Sinclair (1984) but individual laboratories these days use different methods that are calibrated back to these original methods. Sampling depth is typically 0-7.5 cm (75 mm) on pastoral soils, and 0-15 cm on crop soils.

The Olsen P and QT test values were used to develop sub-models such as pasture nutrient concentrations, relative yield (Characteristics of pasture chapter), and plant available nutrient levels in soil (7.1). Hence, no alternative test options are included.

For S, one of three tests values can be entered: the phosphate extractable organic S test (Watkinson and Kear, 1996, mg/kg), total S test (Rajendram *et al*., 2008, mg/kg), or the QT SO_4 values are used similarly. The relationship between relative yield and the soil test is better for total S than the phosphate extractable organic S. For other relationships, phosphate extractable organic S is estimated from total S (section 6.5). QT SO_4 was added so phosphate extractable organic S could be estimated (section 6.4) if the other two tests are not available.

There is an option to populate soil test values with default values according to the soil description selected (section 6.7). It is envisaged that they would only be used if the user has no data or only partial data.

Soil pH is only used in the acidity sub-model, where it is used for estimating maintenance lime requirements, and for estimating the change in acidity due to a change in carbon content. Soil pH is important for fertiliser and lime recommendations, and because of its effect on nutrient availability in soils. However, with the exception of the acidity sub-model, pH is not used in any nutrient budget calculations.

2.4.2. Anion storage capacity

Anion storage capacity (ASC) or phosphate retention (PR) is a measure of the soil's ability to retain phosphate and sulphate. Typically, soils with higher ASC will require greater amounts of phosphate fertiliser to raise soil test levels or to overcome phosphorus deficiencies.

A default ASC is displayed or a measured ASC can be entered by the user. The default values for ASC are estimated as outlined in section 3.1.

2.4.3. Reserve K status

The reserve K status is used as an indication of the rate of release of fixed K (McLaren and Cameron, 2004), which is sometimes referred to as slow release K. The reserve K status can be identified by entering a sodium tetraphenylboron (TBK) reserve K test, selecting a K reserve category (section 2.4.3), or using the default status based on soil classification (section 3.1).

The TBK reserve K test is a measure of the amount of K in soil that is fixed, or slowly available, and can be entered directly by the user.

K reserve categories are high, medium, low, very low, and extremely low, with selection guidance shown in Table 2, based on the summary in Campkin (1985). Parent material influences the reserve K levels for Gley and Recent soils. Gley soils range from very low to high and recent soils range from low to high. For sedimentary or Brown soils, it is recommended that either TBK reserve K is entered or a K reserve status is selected due to the high variability of the slow release K status within these groups.

The default value is based on the soil classification as outlined in 3.1 using the method described in section 6.2.

Table 2. Reserve K level category for New Zealand Soil Classification soil groups (basis of original reserve K level classification) or soil orders.

Category	New Zealand Soil Classification soil group	Soil order
High	Brown grey earths (BGE)	Semiarid
	Yellow grey earths (YGE)	Pallic
Medium	Yellow brown earths (YBE)	Brown
	Yellow brown /yellow grey earth intergrades (YBE/YGE)	Brown
	Yellow brown sands (YBS)	Recent
	Rendzinas	Melanic
	Brown granular clays and loams (BGC & L)	Granular, Melanic, or Oxidic
Low	Podsolised YBEs	Podzols or Ultic
	Steepland soils	Brown
Very low	Yellow brown pumices (YBPS)	Pumice
	Yellow brown loams (YBL)	Allophanic
	Red and brown loams (R & B L)	Oxidic
Extremely low	Podzols	Podzol
	Peats	Organic

2.5. Soil drainage/runoff

Soil drainage/runoff is separated into two sections, soil drainage and runoff characteristics which is only shown for the pastoral block, and artificial drainage systems, which is shown for pastoral, cropping, cut and carry and fruit crop blocks.

2.5.1. Soil drainage and runoff characteristics

2.5.1.1. *Naturally high water table*

The occurrence of a naturally high water table is an input option for pastoral blocks with soils that have a natural drainage class of imperfect, poor or very poor. The input is used in the riparian strip sub-model (unpublished). A water table is considered high when it is less than 0.75 m from the soil surface during winter. Note that naturally high water table does not include soils with a perched water table, which are soils with an impeded layer. Selecting a high water table does not affect the hydrology sub-model.

2.5.1.2. *Compacted state*

Top soil is compacted. This is an indicator of whether the soil in the block is compacted due to numerous events causing compaction over time. It is not a measure of a single compaction or pugging event, for instance, due to a paddock grazed in late winter.

2.5.1.3. *Hydrophobicity*

Hydrophobicity, also known as water repellency, describes the susceptibility of water to infiltrate or runoff at the soil surface through selection of a 'hydrophobic condition' (Rutherford *et al*., 2008). Hydrophobicity could be a problem in many New Zealand soils (Müeller *et al*., 2010), especially if they dry out. The options and there definitions are shown in Table 3.

The default option chooses a hydrophobicity factor based on region and rainfall, with higher hydrophobicity expected on the East Coast of New Zealand. Thus, hydrophobicity is 'Never' unless the region is the East Coast or annual rainfall is less than 1000 mm; then if the topography is flat or rolling, hydrophobicity is 'Occasionally', otherwise it is it is 'Frequently'

Table 3. Definition of hydrophobicity options.

Option	Description
Never	Rain always soaks in.
Occasionally	Generally soaks in, occasionally runs easily off slopes.
Frequently	Mostly runs off, unless there is a long period of gentle rain.

Hydrophobicity is used in the hydrology sub-model in the estimation of surface runoff.

2.5.1.4. *Propensity for pugging*

The definition of the profile drainage class includes a statement on the degree of pugging that could occur (Table 16). This definition is used to define the propensity for treading damage (Table 4). Note that this is not a measure of whether pugging has occurred, or the degree of pugging that occurs after a single grazing event. This is then used to estimate the profile drainage status, and in the estimation of denitrification.

Table 4. Definition of pugging occurrence classes.

Pugging occurrence	Definition
Rare	Can be grazed with minimal pugging damage most of the year.
Occasional	Must be grazed with caution during winter to avoid pugging damage.
Winter	Heavy pugging damage occurs if grazed anytime over winter.
Winter or rain	Heavy pugging damage occurs if grazed anytime over winter, and pugging damage occurs after heavy rain events at other times of the year.

2.5.2. Artificial drainage systems

There are two options to select artificial drainage, if present: 'Mole/tile drains' and 'Other'.

If either drainage system is selected, the percentage of the block that has a drainage system is required. Thus, 50% means that only 50% of the block area is covered by the drainage system – the remainder of the block is un-drained. In addition, artificial wetlands at the drain outlets can also be included.

If an 'Other' drainage system is selected, the depth to drains (m) and spacing between drains (m) can be entered. These affect the efficiency of the drainage system, and hence the proportion of flow and nutrients entering the drainage system.

Where there is no artificial drainage, an option to describe a grass filter strip is included. This is defined as a fenced off area containing dense grass, through which runoff passes before reaching a water body. It is assumed that if a block is drained, most of the runoff is captured by the drainage system and hence grass filter strips would be non-functional. Therefore, if a drainage system is selected, grass filter strips cannot be described.

Further details on the use of soil drainage characteristics in sub-model procedures are described in the Hydrology chapter.

3. Obtaining soil property data

3.1. Method

The soil property values used in OBVERSEER are obtained following a hierarchical approach that was developed to take account of:

- The objective of OVERSEER to provide suitable defaults where possible (Introduction chapter).
- Site-specific information overrides other sources of information (Introduction chapter). Thus, for example, entered values of bulk density, ASC, etc. would override default values.
- For different methods of entering data, the assumed quality of the different data is considered. Hence, data based on soil order data overrides data based on soil group.

There are specific methods for clay content (section 4.1), carbon content (section 4.2), structural integrity (section 4.4), and saturated hydraulic conductivity (section 4.8). These methods follow the same general rules as below but have an extra step where other sources of information are considered.

Soil properties listed in section 3.2 are obtained in the following order of preference:

- if a user enters a site-specific soil property then this is used; else
- if a user enters a value in the soil water focused input option, then this is used; else
- if soil series is selected and there is a default value (value >= 0), then the default value associated with soil series is used; else
- if the soil is classified as a sand, then soil group sand data is used (Topsoil texture is sandy, which is only used for N concentrations in runoff water); else
- if soil order is selected then the default value associated with the soil order is used (Table 8 and Table 9); else
- if soil group is selected then the default value associated with the soil group (Table 10) is used.

3.2. Default soil properties

The default soil properties based on soil order or soil group are listed in Table 5. Many of the parameters are used in sub-models that are covered in different sections of the Technical Manual.

The default soil properties values are listed in Table 8 and Table 9 for soil order and Table 10 for soil groups.

Default properties are also listed for top soil texture classes (section 3.5, Table 11 and section 4.2, Table 15) and sub-soil texture group (section 3.6, Table 12).

3.2.1. Description and units

The default soil properties are described in Table 5. The source of the data is detailed in the footnotes to Table 5.

Table 5. Property name, description and source of data for soil-based parameters.

Property	Comment	Notes
P sub-model		
slowP	Slow P release rate (kg P/ha/year).	1
Ploss	Soil P loss factor (kg P/(kg P/year)).	1
olsenf	Parameters for Olsen P-labile P conversion.	1
olseng	Parameters for Olsen P-labile P conversion.	1
hydroclass	Hydrologic drainage class.	2
dispindex	Mean slaking dispersion index.	2
RunoffClass	Propensity for runoff class.	2
K sub-model		
kcurvature	Parameter for estimation K leaching potential.	3
kmaxlevel	Parameter for estimation K leaching potential.	3
Change in soil tests		
Pchange	kg P / unit change Olsen P.	4
Kchange	kg K / unit change QT K.	4
Cation weathering		
CaW	The particular quantity of cations weathered for each soil group before adjustment by the equations for soil temperature and moisture and aerial deposition (kg Ca/ha/year).	5
MgW	See CaW (kg Mg/ha/year).	5
NaW	See CaW (kg Na/ha/year).	5
Dep	Dep is used for the adjustment of base cations weathered for each soil group based on aerial deposition of salts.	5
origBC	The total cations weathered for each soil group based on their original mean composition. This composition changed slightly so a ratio is used to adjust the responses for effects of soil moisture, temperature, and aerial deposition.	5
MC	Same as for Dep but adjusted for soil moisture.	5
Temp	Same as for Dep but adjusted for soil temperature.	5
adjCa	The inherent (or sometimes unexplained) loss of cations from each soil type (kg Ca/ha/year).	5
adjMg	See adjCa (kg Mg/ha/year).	5
adjNa	See adjCa (kg Na/ha/year).	5
Soil test conversions		
QTCaconv	Conversion for QT Ca to kg/ha.	6
QTMgconv	Conversion for QT Mg to kg/ha.	6
QTNaconv	Conversion for QT Na to kg/ha.	6

Soil water contents		
SMwp	Soil water content at wilting point (mm/10 cm).	7
SMfc	Soil water content at field capacity (mm/10 cm).	7
SMsat	Soil water content at saturation (mm/10 cm).	7
Runoff nutrients		
Soil N	Arithmetic mean total soil N content (%).	8
Soil P	Arithmetic mean total soil P content (%).	8
Soil K	Arithmetic mean total soil K content (%).	8
Soil S	Arithmetic mean total soil S content (%).	8
Soil Ca	Arithmetic mean total soil Ca content (%).	8
Soil Mg	Arithmetic mean total soil Mg content (%).	8
Soil Na	Arithmetic mean total soil Na content (%).	8
Default soil properties		
BD	Soil bulk density (kg/m^3).	9
ASC	Anion storage capacity (value between 0 and 100).	9
Carbon	Soil carbon (%).	9
Clay	Subsoil clay content (%).	9
Sand	Subsoil sand content (%).	9
Kc	Nitric acid reserve K test (cmol(+)/100 g soil) – gives the default amount of slow release K (section 6.2).	9
drainageclass	Natural soil drainage class (section 4.6).	9
Macroporosity	Macroporosity (%). Used in the riparian strip sub-model.	9
StrucInt	Structural integrity.	10
group	Most likely soil group soils in given soil order belongs to.	11

Notes:

1 Metherell *et al*. (1995) on a soil group basis. For soil order, used value for soil group that was most representative of that order as described in section 3.2.2.

2 Parameters in P runoff sub-model. Values for mean dispersion/slaking index and hydrologic drainage class are described in sections 4.8 and 4.9 respectively.

3 See section 4.11.

4 Extracted from Morton and Roberts (1993), Roberts and Edmeades (1993), and Roberts *et al*. (1994) and used to estimate change in soil test values (section 6.6).

5 Parameter values supplied by P. Carey for the cation sub-model reported by Carey and Metherell (2002). For soil order, the value for soil group was used that was most representative of that order (section 3.2.2). The weathering rates for the Recent soil order uses a multiplier of 3 (conservative estimate) as it is probably a more realistic weathering rate (although there is no data to validate this).

6 See section 7.1.

7 Soil water contents are described in section 3.2.4.

8 The average total nutrient content (%) in the top horizon was extracted from the National Soils Database (Wilde and Ross 1996) for each order (section 3.2.3) and allocated to soil group (section 3.2.2). Used to estimate nutrient contents in runoff water.

9 As for 8 except the relevant property was extracted. Macroporosity is defined in section 3.2.5.

10 Calculated from data extracted as outlined in section 3.2.2 using the method described in section 4.4.

11 As described in section 3.2.2.

3.2.2. Soil group soil order relationship

The relationship between soil order and soil group used to allocate soil properties is shown in Table 6. For properties based on soil group, the value for a soil order would be the value for the soil group shown in Table 6. For properties based on soil order, the value for soil group would use a combination of values from the soil orders that were associated with the soil group. For sedimentary soil group, the values were weighted towards the brown soils as these made up the largest order.

Table 6. Relationship between soil order and soil groups.

Soil order	Soil group
Allophanic	Volcanic
Brown	Sedimentary
Gley	Sedimentary
Granular	Volcanic
Melanic	Sedimentary
Organic	Peats
Oxidic	Volcanic
Pallic	Recent/YGE/BGE
Podzols	Podzols
Pumice	Pumice
Recent	Recent/YGE/BGE
Semi-arid	Recent/YGE/BGE
Ultic	Sedimentary

3.2.3. National soils database

Default values were based on soil series data extracted from the National Soils Database (Wilde and Ross 1996). The information extracted was:

- Series name.
- Type qualifier (top soil textural group).
- New Zealand revised soil order.
- New Zealand generic soil group.
- Soil properties: Phosphate retention (ASC, see section 2.4.2), Kc, carbon, bulk density, clay, natural profile drainage category.
- Structural integrity was calculated for each series that had ASC, carbon and clay.
- Hydrology class was assigned a value based on top soil texture.

A subset of the data used for soil series is shown in Appendix 1. Additional data was extracted at the same time. This data was then tabulated to provide mean values for soil orders and soil groups and soil textural classes.

Not all the information was available for a given series, and only series that had soil order and natural drainage class were included.

3.2.4. Soil water content data

McLaren and Cameron (2004) defined:

- wilting point (WP) as the water content at 1500 kPa;
- field capacity (FC) as the water content at 10 kPa;
- saturation (Sat), or total porosity (TP), as the water content at 0 kPa;

With the mode, soil water content is entered or estimated using units of mm/mm soil depth, where the soil depth varies depending on the use. The soil water content at wilting point, field capacity, and saturation are used as direct inputs into the hydrology sub-model, and into other sub-models such as the N leaching sub-model.

Typical soil water contents at wilting point, field capacity, and saturation for each soil order and for sands were supplied by Landcare Research (T Webb, pers. comm.) for three soil categories (Table 7).

Table 7. Soil category and description of data source used for soil water contents.

Soil category	Data source
Standard soil	Average of values for 0-50 and 50-100 cm soil depth
Shallow soil	Average of 0-50 cm depth times 0.8
Stony soil	Shallow values times 0.65

The data clearly indicated that soil water content at 50-100 cm soil depth was not always the same as that at 0-50 cm depth. For pastoral blocks, the bottom of the rooting zone is defined as being at 60 cm. Hence, values for shallow soils would be most relevant (0-50 cm depth). However, as the values for shallow soils where reduced values for 0-50 cm (Table 7), the value for shallow soils was divided by 0.8, and then divided by 6[1] to give default values for a 10 cm layer for soil orders. These were then assigned to soil groups (section 3.2.2).

3.2.5. Profile available water

Profile available water (depth) (PAW_D), previously referred to as available water capacity (AWC), is the rainfall equivalent depth of 'total available water' within a specified depth D in the soil (Irrigation New Zealand, 2014). It is soil specific and independent of plant type or root depth. Total available water is extractable by plants (plant type may be specified); taken as the

[1] This is an error. This should be divided by 5, not 6.

difference between soil water at field capacity and at permanent wilting point (Irrigation New Zealand 2014). Thus:

Air capacity (AC) can be estimated as the difference between total porosity and field capacity. This term is not used but is shown here for completeness.

3.2.6. Total and macro and air-filled porosity, and water-filled pore space

Total porosity (TP) is the same as soil water content at saturation (Sat).

Air-filled porosity is the difference between total porosity and the soil water content.

Water-filled pore space (WFPS) is defined as the ratio of soil water content and soil water content at saturation, and is used in the estimation of nitrous oxide.

Macroporosity is the difference between water content at zero kPa (total porosity or saturation) and at 5 kPa. The macroporosity used in the sub-model follows this definition, expressed as %.

Agronomically, macroporosity is usually the difference between soil water content in pores greater than 30 micron. This is the same as air capacity described in section 3.2.4 with regards to volumetric content.

3.3. Soil property data for soil order

Soil properties for each soil order are shown in Table 8 and Table 9.

Table 8: Soil properties values for seven soil orders. The property and units are described in Table 5.

Property	Allophanic	Brown	Gley	Granular	Melanic	Organic	Oxidic
slowP	3	3	3	3	3	3	3
Ploss	0.05	0.04	0.04	0.05	0.04	0.04	0.05
olsenf	19	25	25	19	25	25	19
olseng	1.2	1.7	1.7	1.2	1.7	1.7	1.2
hydroclass	0.51	0.56	0.64	0.74	0.62	0.58	0.75
dispindex	0.2	0.2	0.4	0.4	0.2	1	0.2
RunoffClass	1	1	2	2	1	4	1
kcurvature	0.00231	0.00183	0.00183	0.00231	0.00183	0.00167	0.00231
kmaxlevel	2	1.5	1.5	2	1.5	3	2
Pchange	11	5	5	11	5	7	11
Kchange	60	60	60	60	60	45	60
CaW	0.068	0.111	0.111	0.068	0.111	0.024	0.068
MgW	0.048	0.174	0.174	0.048	0.174	0.006	0.048
NaW	0.124	0.105	0.105	0.124	0.105	0.043	0.124
Dep	0.1857	0.2384	0.2384	0.1857	0.2384	0.0473	0.1857
origBC	0.314	0.393	0.393	0.314	0.393	0.077	0.314
MC	0.1281	0.1635	0.1635	0.1281	0.1635	0.0326	0.1281
temp	0.1306	0.1666	0.1666	0.1306	0.1666	0.0339	0.1306
adjCa	0	35.2	35.2	0	35.2	42.6	0
adjMg	0	22	22	0	22	26.8	0
adjNa	0	30.3	30.3	0	30.3	10	0
QTCaconv	140	198	180	190	220	80	196
QTMgconv	5.6	7.9	7.2	7.6	8.8	3.2	7.8
QTNaconv	6.7	9.5	8.6	9.1	10.6	3.8	9.4
SMwp	22.0	18.0	18.8	23.3	19.5	15.2	24.8
SMfc	40.2	35.3	39.7	34.0	34.3	48.5	36.0
SMsat	57.5	48.3	50.8	48.3	45.0	68.3	50.8
Soil N	0.315	0.204	0.235	0.187	0.213	0.832	0.184
Soil P	0.087	0.088	0.081	0.044	0.116	0.104	0.078
Soil K	1.277	1.293	1.582	0.529	1.526	0.917	0.056
Soil S	0.104	0.044	0.436	0.061	0.067	0.068	0.000
Soil Ca	1.455	0.934	1.042	0.396	1.153	1.268	0.133
Soil Mg	0.493	0.738	0.657	0.174	0.728	0.465	0.167
Soil Na	1.406	1.668	1.682	0.903	1.919	1.101	0.436
BD	764	1004	859	1010	984	428	961
ASC	83	43	43	49	32	57	59
carbon	9.4	6.1	8.8	9.5	5.5	28.7	6
clay	23	24	33	44	36	24	48
Sand	39	33	19	11	19	31	8
Kc	0.13	0.31	0.32	0.16	0.49	0.1	0.05
drainageclass	2	2	4	2	2	4	2
Macroporosity	13.4	12.2	8.6	6.3	8.4	16.3	11.3
structinteg	0.44	0.66	0.61	0.59	0.68	0.51	0.47
group	2	1	1	2	1	6	2

Table 9: Soil properties values for the other 7soil orders. The property and units are described in Table 5.

Property	Pallic	Podzols	Pumice	Raw	Recent	Semi-arid	Ultic
slowP	3	3	3	3	3	3	3
Ploss	0.04	0.1	0.07	0.04	0.04	0.04	0.04
olsenf	25	21	14	25	25	25	25
olseng	1.7	1.3	1.3	1.7	1.7	1.7	1.7
hydroclass	0.56	0.47	0.31	0.49	0.49	0.45	0.63
dispindex	0.6	1	0.4	0.6	0.6	0.8	0.8
RunoffClass	3	5	5	3	3	4	4
kcurvature	0.00183	0.00116	0.00186	0.00183	0.00183	0.00183	0.00231
kmaxlevel	1.5	4	2.6	1.5	1.5	1.5	2
Pchange	5	5	7	5	5	5	5
Kchange	60	60	45	60	60	60	60
CaW	0.111	0.024	0.024	0.333	0.333	0.111	0.111
MgW	0.174	0.006	0.006	0.522	0.522	0.174	0.174
NaW	0.105	0.043	0.043	0.315	0.315	0.105	0.105
Dep	0.2384	0.0473	0.0473	0.2384	0.2384	0.2384	0.2384
origBC	0.393	0.077	0.077	0.393	0.393	0.393	0.393
MC	0.1635	0.0326	0.0326	0.1635	0.1635	0.1635	0.1635
temp	0.1666	0.0339	0.0339	0.1666	0.1666	0.1666	0.1666
adjCa	35.2	42.6	42.6	35.2	35.2	35.2	35.2
adjMg	22	26.8	26.8	22	22	22	22
adjNa	30.3	10	10	30.3	30.3	30.3	30.3
QTCaconv	244	171	156	228	228	271	215
QTMgconv	9.7	6.8	6.2	9.1	9.1	10.8	8.6
QTNaconv	11.7	8.2	7.5	11	11	13.1	10.3
SMwp	14.2	13.8	8.7	9.7	9.7	9.2	19.3
SMfc	28.5	36.3	29.0	25.0	25.0	24.0	35.2
SMsat	40.0	50.8	54.2	45.0	45.0	35.8	42.5
Soil N	0.113	0.206	0.178	0.143	0.143	0.067	0.103
Soil P	0.058	0.043	0.022	0.074	0.074	0.055	0.032
Soil K	1.611	1.229	1.828	1.826	1.826	1.611	0.443
Soil S	0.019	0.037	0.043	0.036	0.036	0.014	0.015
Soil Ca	0.961	0.751	1.714	1.213	1.213	0.961	0.077
Soil Mg	0.606	0.368	0.444	0.888	0.888	0.606	0.225
Soil Na	2.050	1.249	2.710	2.123	2.123	2.050	0.486
BD	1236	875	866	1110	1110	1373	1064
ASC	21	32	49	23	23	9	26
carbon	3.5	11.1	6.6	4.1	4.1	2	3.8
clay	23	12	19	19	19	17	27
Sand	24	46	65	40	40	48	9
Kc	0.45	0.13	0.12	0.43	0.43	0.54	0.18
drainageclass	3	3	1	1	1	2	3
Macro-porosity	9.5	12.9	24.5	14.8	14.8	10.4	5.6
structinteg	0.81	0.77	0.66	0.84	0.84	0.94	0.76
group	7	4	3	7	7	7	1

3.4. Soil property data for soil group

Most of the soil group parameter values were selected from three groups (Sedimentary, Volcanic, and Pumice). A detailed list of the soil parameter values for each soil group is given in Table 10.

Table 10. Soil property values for soil groups. The property and units are described in Table 5.

Property	Sedimentary	Volcanic	Pumice	Podzols	Sands (High P loss)	Peats	Recent/ YGE/BGE
slowP	3	3	3	3	3	3	3
Ploss	0.04	0.05	0.07	0.1	0.1	0.04	0.04
olsenf	25	19	14	21	21	25	25
olseng	1.7	1.2	1.3	1.3	1.3	1.7	1.7
hydroclass	0.6	0.58	0.31	0.47	0.33	0.58	0.52
dispindex	0.2	0.2	0.4	1	0.6	1	0.6
RunoffClass	1	1	5	5	3	4	3
kcurvature	0.00183	0.00231	0.00186	0.00116	0.00167	0.00167	0.00167
kmaxlevel	1.5	2	2.6	4	3	3	3
Pchange	5	11	7	5	7	7	7
Kchange	60	60	45	60	45	45	45
CaW	0.111	0.068	0.024	0.024	0.024	0.024	0.111
MgW	0.174	0.048	0.006	0.006	0.006	0.006	0.174
NaW	0.105	0.124	0.043	0.043	0.043	0.043	0.105
Dep	0.2384	0.1857	0.0473	0.0473	0.0473	0.0473	0.2384
origBC	0.393	0.314	0.077	0.077	0.077	0.077	0.077
MC	0.1635	0.1281	0.0326	0.0326	0.0326	0.0326	0.1635
temp	0.1666	0.1306	0.0339	0.0339	0.0339	0.0339	0.1666
adjCa	35.2	0	42.6	42.6	42.6	42.6	35.2
adjMg	22	0	26.8	26.8	26.8	26.8	22.0
adjNa	30.3	0	10	10	10	10	30.3
QTCaconv	140	198	180	190	220	80	140
QTMgconv	5.6	7.9	7.2	7.6	8.8	3.2	5.6

Property	Sedimentary	Volcanic	Pumice	Podzols	Sands (High P loss)	Peats	Recent/ YGE/BGE
QTNaconv	6.7	9.5	8.6	9.1	10.6	3.8	6.7
SMwp	18.0	22.0	8.7	13.8	5.0	15.2	11.0
SMfc	35.3	40.2	29.0	36.3	13.3	48.5	25.8
SMsat	48.3	57.5	54.2	50.8	43.3	68.3	40.3
Soil N	0.188	0.315	0.178	0.206	0.065	0.832	0.108
Soil P	0.073	0.087	0.022	0.043	0.056	0.104	0.062
Soil K	0.905	1.277	1.828	1.229	1.423	0.917	1.683
Soil S	0.104	0.104	0.043	0.037	0.055	0.068	0.023
Soil Ca	0.623	1.455	1.714	0.751	1.564	1.268	1.045
Soil Mg	0.448	0.493	0.444	0.368	0.778	0.465	0.700
Soil Na	1.182	1.406	2.710	1.249	1.809	1.101	2.074
BD	943	815	865	884	1073	428	1224
ASC	41	73	49	31	29	57	21
carbon	6.6	8.7	6.5	10.9	4.3	28.7	3.4
clay	28	30	19	12	10	24	21
Sand	33	39	66	49	80	31	25
Kc	0.32	0.13	0.12	0.13	0.17	0.1	0.5
drainageclass	2	2	1	3	1	4	3
Macro-porosity	12.2	13.4	24.5	12.9	15.0	16.3	12.0
structinteg	0.65	0.47	0.66	0.78	0.85	0.51	0.83

3.5. Soil properties for top soil texture classes

Soil texture is the textural class extracted from the New Zealand Soil database. Topsoil clay content was the average value for a soil texture across all soil orders. Hydrologic drainage class (also see section 4.9) for each soil texture was provided by Richard McDowell (pers. comm.) and is used as an input into the P runoff sub-model (McDowell *et al.*, 2005).

Table 11, Clay content and hydrologic drainage class value for each textural class.

Texture	Clay (%)	Hydrologic class
Clay	51	1
Clay loam	38	0.8
Loam	22	0.4
Loamy peat	20	0.4
Loamy sand	16	0.2
Peat	5	0.6
Peaty loam	8	0.6
Peaty sand	6	0.6
Peaty sandy loam	8	0.6
Peaty silt loam	9	0.6
Sand	11	0.2
Sandy clay	40	0.8
Sandy clay loam	30	0.6
Sandy loam	14	0.4
Sandy silt	20	0.4
Silt	20	0.4
Silt loam	25	0.6
Silty clay	50	1
Silty clay loam	45	0.8
Silty peat	15	0.4
Silty sand	5	0.4

3.6. Soil properties for sub soil texture groups

For some soil orders or soil groups, subsoil texture groups of light, medium, or heavy have to be selected (section 2.2). The soil water contents at wilting point, field capacity, and saturation for each layer (mm/10 cm) are shown in Table 12. The soil water properties were based on sands soil group for light soil texture groups. It is unclear what the medium and heavy soil water contents were based on. However, the soil water contents shown in Table 12 were compared with those of soils in the National Soils Database (NSD) (T. Webb, Landcare Research, pers. comm.). The results are shown in Table 13.

Table 13 presents soil water data for OVERSER soil texture groups, and the averaged data for NSD texture classes where the soil water data aligned with the soil water data in Table 12. The following were not included in the analysis – all Pumice soils, pumice horizons and horizons with total available water greater than 24% were removed from the sandy texture class, and all horizons with greater than 78% clay and/or less than 18% wilting point were removed from clayey texture (T. Webb, Landcare Research, pers. comm.). This data was used to align the definition of soil textural groups (section 2.2) with the SM contents used in Table 12 in order to improve the definition of soil texture groups.

Table 12. Subsoil clay content (%), and average soil water contents at wilting point, field capacity and saturation (mm/10 cm) for each soil texture group.

Soil texture group	Clay (%)	Wilting point	Field capacity	Saturation
Light	12	5	11	43
Medium	25	15	31	50
Heavy	38	25	39	58

Table 13. Soil water contents (mm/100 mm soil depth) at wilting point (WP), field capacity (FC), and saturation (Sat) and total available soil water (TAW) data for OVERSER soil texture groups and the averaged data for NSD texture classes with similar soil water contents to the OVERSER soil texture groups. Standard deviations are in parenthesis.

Texture	WP	FC	Sat	TAW	Number
OVERSER light	5	11	43	6	
NSD Sand, loamy sand	6(5)	18 (8)	49(7)	12(5)	67
OVERSER medium	15	31	50	16	
NSD silt loam, sandy loam, clay loam	18(9)	41 (12)	56 (12)	23 (10)	1019
OVERSER heavy	25	39	58	14	
NSD silty clay loam, silty clay, clay	30 (6)	47 (8)	59 (9)	17 (8)	292

Table 14 presents data for Pumice Soils. Sandy Pumice data has a closer association with ‘medium’ texture than with ‘light’ texture, especially for total soil available water (TAW). However, pumice soils are not differentiated by textural class.

Table 14. Soil water contents (mm/100 mm soil depth) at wilting point (WP), field capacity (FC), and saturation (Sat) and total available soil water (TAW) data for OVERSER Medium soil texture groups and the for sandy and loamy pumice soils. Standard deviation are in parenthesis.

Texture	WP	FC	Sat	TAW	Number
OVERSER medium	15	31	39	16	
NSD Sandy Pumice	8 (5)	26 (6)	57 (9)	18 (4)	25
NSD Loamy Pumice	15 (8)	42 (9)	65 (8)	26 (9)	196

4. Calculated or estimated soil properties

The sections below describe soil properties that have specific methodologies.

4.1. Clay

Topsoil (0-10 cm) clay content (%) is estimated as:

- the entered topsoil clay content (%), else
- clay content based on the selected topsoil texture [Table 12, section 3.5], otherwise
- default soil clay content is obtained from the soil classifications selected [section 3.1].

Subsoil clay content (%) is estimated as:

- the entered sub-soil clay content (%), else
- clay content based on selected soil texture group, otherwise
- default soil clay content is obtained from the soil classifications selected [section 3.1].

Note that subsoil texture group can only be selected for a limited range of soil groups or soil orders, whereas topsoil texture may be selected for all soil classifications.

4.2. Carbon

Carbon content (%) top soil is estimated as:

- entered top soil carbon content; else
- based on top soil texture if selected, and that texture is peaty in nature (Table 15); otherwise
- default soil carbon content is obtained from the soil classification selected [section 3.1].

Carbon contents shown in Table 15 where the arithmetic mean carbon levels for type qualifiers that had peat in the name.

Table 15. Carbon content (%) in the topsoil of peaty soil textured soils.

Soil texture	Carbon (%)
Loamy peat	21.00
Peat	31.37
Peaty loam	24.31
Peaty sand	9.10
Peaty sandy loam	13.10
Peaty silt loam	23.69
Silty peat	20.00

4.3. Carbon to organic matter

When required, carbon is converted to organic matter by multiplying by the standard conversion factor 1.72, which dates back to 1864 (Pribyl, 2010). This conversion factor assumes organic matter contains 58% organic carbon. However, this can vary with the type of organic matter, soil type and soil depth. Conversion factors can be as high as 2.50, especially for sub-soils. Recent evidence suggests that a factor of 1.9 to 2.0 is more appropriate (Pribyl 2010), and 1.9 will be adopted in future modelling work.

4.4. Structural integrity

Structural integrity is a measure of soil strength and is based on a modification of the structural vulnerability method of Hewitt and Shepherd (1997), as described by McDowell *et al*. (2005). The formulae in McDowell *et al*. (2005) is incorrect although the use and the variation from Hewitt and Shepherd (1997) in that the drainage term has not be included, still applies. It has a value between 0 and 1.

Structural integrity (value 0 – 1) is estimated as:

- the entered structural integrity, else
- if topsoil clay and carbon content are entered, or if both can be determined from default values, then it is calculated (Equation 1), otherwise
- default structural integrity is obtained from the soil classifications selected [section 3.1].

The method for estimating structural integrity (McDowell *et al*., 2005) is:

Equation 1: StructIng = 1 - ((ASC / 100 + Sqrt(clay) / 5 + Sqrt(carbon) / 8.5 - 0.7) / 2.3)
ASC is the anion storage capacity [section 2.4.2].
clay is the top-soil clay content (%) [section 4.1].
carbon is the top-soil clay content (%) [section 4.2].

4.5. Soil pH

As soil pH only affects the effect of changing soil carbon levels on acidification rates, it can be entered when setting carbon inputs (section 2.3.4), or is estimated as:

- if dairy animals are present on the block and soil group is Peat, then pH is 5.7; else
- for other blocks with dairy animals then pH is 5.8; else
- for other farms, pH is 5.7.

4.6. Drainage properties

The generic term 'drainage class' has been applied to three distinct properties, namely:

- Natural profile drainage class (section 2.2.1).
- Current drainage status (section 4.7).
- Drainage class as a term in the P runoff sub-model.

OVERSEER also used runoff propensity, which is related to drainage classes. This section only describes the natural and current drainage status.

4.7. Current drainage status

The current drainage status is the profile drainage class adjusted to take account of the propensity for pugging after drainage. This was done initially to provide a surrogate to determine the effectiveness of the drainage system.

The propensity for pugging is based on the definitions for the profile drainage class (sections 2.2.1 and 2.5.1.4). Thus, the profile drainage class number and propensity for pugging class numbers are aligned (Table 16). These two inputs are used to estimate current drainage status. For example, if a poor drained soil is drained and the propensity for pugging is 'occasional', then the soil is assumed to be drained very well. In contrast, if the propensity for pugging is still 'Winter or rain' then the drainage system is considered to not be fully effective.

The current drainage status is used to estimate saturated conductivity used in the drainage sub-model, in the estimation of leaching and pasture nutrient contents for sulphur (Characteristics of pasture chapter of the Technical Manual), and in the riparian strip and wetland sub-models. Nitrogen denitrification rates, runoff propensity in the P runoff sub-model, and wetland sub-model also use the natural drainage class and propensity for pugging as inputs.

Table 16. Class numbers for natural profile drainage and propensity for pugging classes.

Class number	Profile drainage class	Propensity for pugging
1	Well	Rare
2	Moderately well	Occasional
3	Imperfect	Winter
4	Poor	Winter or rain
5	Very poor	

The current drainage status is estimated as follows:

- Current drainage status class is initially set to the default profile drainage class as outlined in section 3.1.
- If pugging occurrence is selected (pastoral blocks), then
  - if the default natural drainage class is less than pugging occurrence class, then the pugging occurrence is selected, that is, the current drainage status is set to the poorest drainage condition.
  - if a drainage method is selected (section 4.6), the estimated proportion of the area drained is greater than 50% (Hydrology chapter), and the current drainage status class is greater than the propensity for pugging class, then the propensity for pugging class is selected. Thus, if artificial drainage improves the drainage conditions then propensity for pugging class is used to define the current drainage status class.

4.8. Mean slaking/dispersion index

The mean slaking/dispersion index is based on soil order and takes into account the potential for soil damage to influence soil hydrology. Hewitt & Shepherd (1997) present values for the relative slaking and dispersion potential of New Zealand soil orders. The mean of these is used for the default, and are shown in Table 17.

Table 17. Mean slaking/dispersion index for each soil order.

Soil order	Mean slaking/dispersion index
Oxidic, Allophanic, Brown, Melanic	0.2
Granular, Gley, Pumice	0.4
Recent, Pallic	0.6
Ultic, Semi-arid, Organic	0.8
Organic, Podzol	1.0

4.9. Hydrological drainage class

The hydrological drainage class is based on the USDA curve number method for determining soil hydrologic class. Soils with a coarse texture will have less potential for saturation (low drainage class) than fine textured soils, not accounting for their position in the landscape.

The hydrological drainage class is based on a selected top soil texture group (section 3.5, Table 11) or if a top soil texture group is not selected, the hydrological drainage class is based on subsoil clay content. It was considered that this was may give a better indication of a top soil texture than a default value. The relationship between top soil clay and hydrological drainage class used the data in Table 11, excluding peat soils. Thus hydrological drainage class is estimated as:

Equation 2: hydrodrainageclass = 0.0196 * clay

clay is the entered or default subsoil clay content (%) [section 4.1].

such that it has a maximum value of 1 and a minimum value of 0.2.

4.10. Saturated hydraulic conductivity

Saturated hydraulic conductivity (Ksat) is an input used for estimating daily drainage below the root zone in the hydrology sub-model (see Hydrology chapter). Saturated hydraulic conductivity is either a user-entered soil property, or is estimated from current drainage status (section 4.7). The values of Ksat (mm/day) in Table 18 were estimated using the average clay content of soils within each profile drainage class for soils in the National Soils Database (Wilde and Ross 1996). Using the methodology of Rutherford *et al*. 2008), Ksat (m/day) is estimated for each drainage class as:

Equation 3: $\text{Ksat} = 14611\ \text{clay}^{-3.4868}$

clay is the subsoil clay content (%) [section 4.1].

The above method does not take account of the effect of any improvements in drainage, and is therefore not necessarily a good indication of hydraulic conductivity on some soils.

Table 18. Saturated hydraulic conductivity (mm/day) for current drainage status class.

Class number	Saturated hydraulic conductivity
1	508
2	261
3	170
4	103
5	38

4.11. K leaching potential

K leaching categories (Table 19) for a range of New Zealand soil classification soil groups, drainage class and rainfall were defined for the original K sub-model (A. Metherell, pers. comm.).

Table 19: Description of K leaching category

K leaching category [1]	Soil group [2]	Natural drainage class	K retention	Rainfall + Irrigation (mm)
Very low (< 0.6)	BGE	Intermediate-free	High	<600
	YGE	Intermediate	High	<600
	Recent	Intermediate	High	<600
Low (0.7 to 1.2)	Recent	Intermediate	High	600-1000
	YGE	Poor	High	600-1000
	BGE	Intermediate-Free	High	600-1000
	YGE/YBE	Intermediate	Medium	<1000
	Gley	Poor	High	<1000
Medium (1.3 to 1.9)	Recent & Gley	Intermediate	High	>1000
	Podzolised YBE	Poor	Low	>1000
	YBL	Free	Low	<1500
	YBE	Intermediate	Medium	>1000
	BGL & C	Poor	Low	<1500
	R & B L	Intermediate	Low	<1500
	YBPS	Free	Low	<1000
High (2.0 to 2.5)	Peat	Poor-intermediate	Very low	< 1000
	YBL	Free	Low	>1500
	YBPS	Free	Low	1000-1500
Very high (2.6 to 4.1)	YBS	Free	Low	>1000
	YBPS	Free	Low	>1500
Extremely high (> 4.1)	Podzol	Poor vertical free lateral	Very low	>2000

[1] Values in brackets are the range in K leaching indices for each K leaching category.
[2] These refer to abbreviations for the old New Zealand soil classification group names. The abbreviated names and closest soil order are shown in Table 2.

The values in Table 19 were used to construct a series of curves between K leaching potential and rainfall to the maximum rainfall the climate sub-model allows (6000 mm) for soil orders (Figure 1). The curves were defined by two parameters as shown in Equation 4

Equation 4: $Kleachingpot = kmaxlevel_{soil} * (1 - Exp(-kcurvature_{soil} * water))$

water is the annual rainfall and irrigation (mm/year) added.

kmaxlevelsoil is the maximum value and is obtained as outlined in section 3.1.

kcurvaturesoil is a curvature parameter and is obtained as outlined in section 3.1.

The parameter kmaxlevelsoil was based on the range in K leaching indices for each K leaching category shown in Table 19.

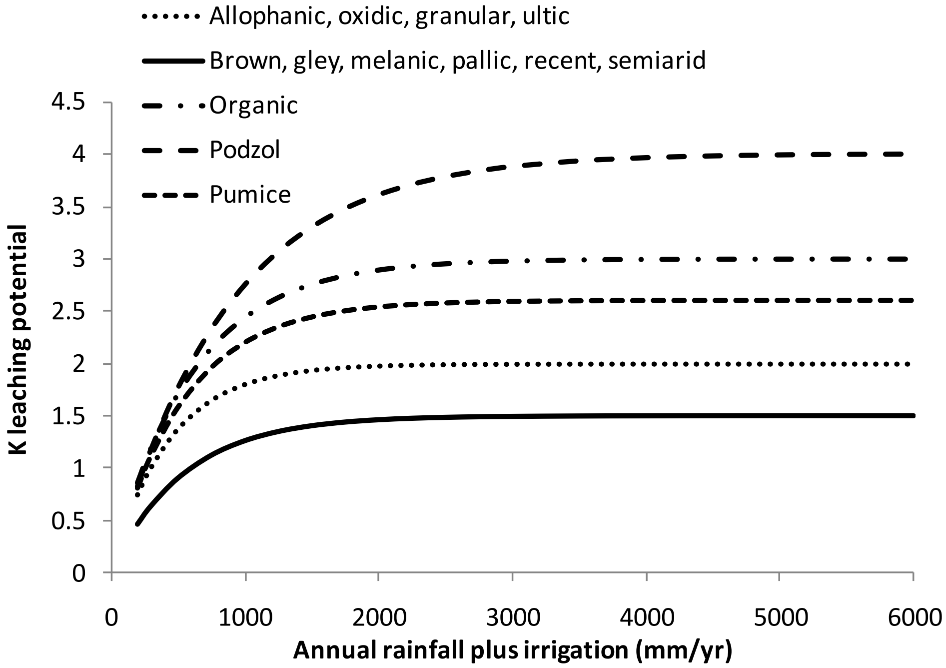

Figure 1: The effect of annual water input on the K leaching potential factor for 13 soil orders.

Parfitt (1992) reported that soils with less preference for K were the Oxidic, Ultic, and Allophanic Soils, and those with the greatest preference were the Granular, Brown, Recent and loess-derived soils. The resultant curves agree with this observation. Parfitt (1992) also reported that the preference decreases as more K is added to the soil. This has not been factored in the estimation of the default leaching potential.

K leaching potential is estimated as:

- user selected value between 0 and 6 (section 2.3.1); else
- zero if annual sum of rainfall plus irrigation is less than 400 mm/year; else
- estimated using Equation 4.

4.12. Sulphur leaching index

The sulphur leaching index (SLI) was derived from Cornforth and Sinclair (1984, Table 7, page 16). The table is categorical, and hence SLI can show a step change when a boundary of a category is crossed. To reduce this step change, a regression equation was fitted to SLI less 0.25 and ASC for the lowest rainfall for the two drainage classes Cornforth and Sinclair (1984) used. A second regression between the mid-point of the 2 middle rainfall bands (500-750 mm, 750-1500 mm) indicated that on average, SLI increased by 0.002 per 1 mm of rainfall for a given ASC and soil drainage class. The average change with rainfall probably underestimates SLI at high rainfall (>1500 mm) and underestimates SLL at low rainfalls (< 750 mm). Rainfall was split between drainage and AET so that site-specific drainage could be used by assuming an average AET for New Zealand of 650 mm/year. Thus SLI is estimated as:

Equation 5: SLI = 0.002 * (drainage + 650) + (-0.0498 * ASC + fdrain)

drainage is the annual drainage (mm/year) [Hydrology chapter].

650 is the average AET for New Zealand (mm/year).

ASC is anion storage capacity.

fdrain is a drainage factor, where fdrain is 5.2051, 4.6151, 4.0251 on soils with a current drainage status of well drained, moderately well drained, and other drainage status respectively.

4.13. Change in soil carbon

The change in soil carbon (kg C/ha/year) is used in estimating the acidification rate and is estimated as:

- if measured initial and final C contents are entered, then this is estimated as shown in Equation 6; else
- if rate of change in C (kg C/ha/year) is entered, then this value is used; else
- if status other than 'Use default' is selected, the rate of change of C is -500, - 250, 250, or 500 kg C/ha/year for status options of 'Large decrease', 'Small decrease', 'Small increase', or 'Large increase' respectively; else
- rate of change is based on the soil N immobilisation status, with rates of change of C of 0, 250 or 100 kg C/ha/year for N immobilisation status of 'None', 'Higher' or 'Standard' respectively. This is the default value.

If measured values are entered then the change in carbon (kg C/ha/year) is estimated as:

Equation 6: ChangeC = SoilAmt * change

change is the change in carbon per year.

SoilAmt is the amount of soil per ha down to the sampling depth (kg soil/ha).

The amount of soil per ha down to the sampling depth (kg soil/ha) is estimated as:

Equation 7: SoilAmt = 0.075 * 10^4 * BD

0.075 is the standard sampling depth (m) of 7.5 cm.

10^4 converts m^2 to ha.

BD is the bulk density (kg/m^3) [section 3.1].

The change in carbon per year is estimated as:

Equation 8: change = (Car2 - Car1) / years

Car2 is the entered final carbon value.

Car1 is the entered initial carbon value.

Years is the number of years between initial and final measurement.

If total C values are entered, the change has values of kg C/kg soil. If percentage carbon is entered, then the change is divided by 100 to give the proportion of carbon in the soil (kg C/kg soil). If hot water carbon values are entered, then the values are first converted to a total carbon percentage using regressions for sedimentary, ash and pumice derived soils supplied by A. Ghani (AgResearch, pers. comm. 1997). It was considered that sands and recent soils behave more similarly to pumice than other soil types. Thus change (Equation 8) is multiplied by the slope of the regression, namely 0.0021 for Volcanic soils, 0.00135 for Pumice, Sands (high P loss) or Recents soil groups, or 0.0027 for other soil groups to give the change as percentage carbon. The result was then divided by 100 to give the proportion of carbon in the soil (kg C/kg soil).

5. Soil water contents

Soil water contents at WP, FC, and saturation, as defined in 3.2.4, are estimated for fifteen 10 cm layers. Data from soil water focused inputs is used in preference (section 5.1); otherwise, a default based on soil descriptors and site-specific inputs is used (section 5.2). The profile soil water contents are then determined to depths dependent on the pasture or crop grown (section 5.3).

5.1. Soil water focused method

Soil water (SM) contents for each layer are assigned a value based on the layer number (1-15) and the depth (0-30 cm, 30-60 cm, and > 60 cm) of the entered data.

The depth (m) at the bottom of a 10 cm layer is calculated as the layer number (z) divided by 10. If a depth to the impeded layer has been entered, then once the depth (m) at the bottom of a layer is greater than the impeded layer, soil water contents are estimated as:

Equation 9: $SMlayfc_z = SMfc * (0.1 – fimped) / 0.1$
Equation 10: $SMlaywp_z = SMwp * (0.1 – fimped) / 0.1$
Equation 11: $SMlaysat_z = SMsat * (0.1 – fimped) / 0.1$
0.1 is the layer thickness (m).

where

Equation 12: fimped = ImpededLayerDepthm - (z / 10 - 0.1)
impededLayerDepthm is the depth to the impeded layer (m) [section 2.2].
z is the layer number.

For subsequent layers below an impeded layer, soil water content is set to zero.

Soil water contents in the top layer (0-10 cm, layer 1) are reduced if top soil is compacted is selected as:

Equation 13: $SMlayfc_1 = (SMlayfc_1 – fcompacted)$
Equation 14: $SMlaysat_1 = (SMlaysat_1 – fcompacted)$
fcompacted is 5 mm if top soil is compacted is selected.

5.2. Soil profile descriptors

5.2.1. Top soil water contents

Top soil water contents are estimated using the method detailed in Wilson and Giltrap (1982) for non-allophanic soils. The same methods are applied to all soils except Organic Soil order or Peat soil group, which use the default values (section 3.1). The soil water contents at wilting point, field capacity and saturation (SMwp, SMwp and SMsat, mm/100 mm soil) in the top 10 cm of soil is initially estimated as:

Equation 15: baseSMwp = 0.05 * silt + 0.5 * clay

Equation 16: baseSMfc = 30.0 + 0.35 * carbon
- 12.0 * BD / 1000
+ 0.230 * silt
+ 0.373 * clay
- 0.0013 * silt * clay

Equation 17: baseSMsat = 59.204 + 0.35 * carbon
- 22.661 * BD / 1000
+ 0.145 * silt
+ 0.263 * clay
- 0.0021 * silt * clay

clay is the top soil clay content (%) [section 4.1], with a minimum value of 5%.
silt is the top soil silt content (%) [Equation 18].
carbon is the top soil carbon content (%) [section 4.2].
BD is the top soil bulk density (kg/m^3) [section 3.1], mulitplied by 1.1 if a stony top soil is selected.

The silt content (%) is estimated as

Equation 18: silt = 100 - clay - sand
clay is the top soil clay content (%) [section 4.1], with a minimum value of 5%.
sand is the top soil sand content (%) [section 3.1].

The conditions on the calculated values were set as:

- baseSMwp is greater than or equal to 5 mm.
- baseSMfc is greater than or equal to baseSMwp + 8
- baseSMsat is greater than or equal to baseSMfc + 1

The base soil water contents se are then adjusted if top soil is compacted or top soil is stony is selected to give soil water contents in layer 1. It was assumed that top soil compaction only reduces field capacity and saturation, not wilting point.

Equation 19: $SMlaywp_1$ = baseSMwp * fstony

Equation 20: $SMlayfc_1$ = (baseSMfc – fcompacted) * fstony

Equation 21: $SMlaysat_1$ = (baseSMsat – fcompacted) * fstony
fstony is 0.65 if top soil is stony is selected, otherwise is 1.
fcompacted is 5 if top soil is stony is selected, otherwise is zero.

The value of fstony is based on the original data supplied for soil order (section 3.2.4).

5.2.2. Subsoil water content

The soil water content of the subsoil layers (mm/10cm soil profile) is based on the site-specific average profile value (section 2.3.2) if these are entered, or are estimated as:

Equation 22: $SMfc = SMfc_{soiltexture}$ if soil texture >0

$= SMfc_{soil}$ otherwise

Equation 23: $SMwp = SMwp_{soiltexture}$ if soil texture >0

$= SMwp_{soil}$ otherwise

Equation 24: $SMsat = SMsat_{soiltexture}$ if soil texture >0

$= SMsat_{soil}$ otherwise

$SMxx_{soiltexture}$ is the soil SM contents (mm/10cm) based on soil texture group [Table 12, section 3.5].

$SMxx_{soil}$ are SM contents (mm/10cm) and are obtained as outlined in section 3.1.

The soil water contents of the subsoil layers (mm/10cm soil profile) for the non-standard layers are estimated using the following values:

Equation 25:	SMNSwp	= 3	if stony
		= 10	if stony matrix
		= 5	if sandy
Equation 26:	SMNSfc	= 7	if stony
		= 23	if stony matrix
		= 13.3	if sandy
Equation 27:	SMNSsat	= 8	if stony
		= 30	if stony matrix
		= 43.3	if sandy

Values for sandy sub-soil are the same as those for a Sand soil group (section 3.4). The derivations of the values used for stony and stony matrix is uncertain.

The soil water contents at each layer can then be estimated as:

Equation 28: $SMlayfc_z = SMfc * forder + SMNSfc * fnonstd$

Equation 29: $SMlaywp_z = SMwp * forder + SMNSwp * fnonstd$

Equation 30: $SMlaysat_z = SMsat * forder + SMNSsat * fnonstd$

z is the zth 10 cm layer of the soil, ranging from 2 to 15.

forder is the proportion of the layer that uses a standard soil water content [Equation 31].

fnonstd is the proportion of the layer that uses a non-standard soil mositure content [Equation 32].

Below the depth that an impeded layer occurs, SM content is considered to be zero and hence is not included in the above.

5.2.3. Soil water distribution in a layer

In allocating soil water contents between layers, the schematic diagram in Figure 2 was followed. Soil water contents for standard (layers above the depth to non-standard water) and non-standard soils are assigned to each 10 cm layer if that layer is fully within the standard or non-standard zone respectively, and pro-rata allocated between standard and non-standard soil water contents if the depth to a non-standard layer occurs within a layer. An impeded layer has been defined as a layer that water does not move through. Hence, any layer or part of a layer that is below the impeded layer is considered to have zero soil water content.

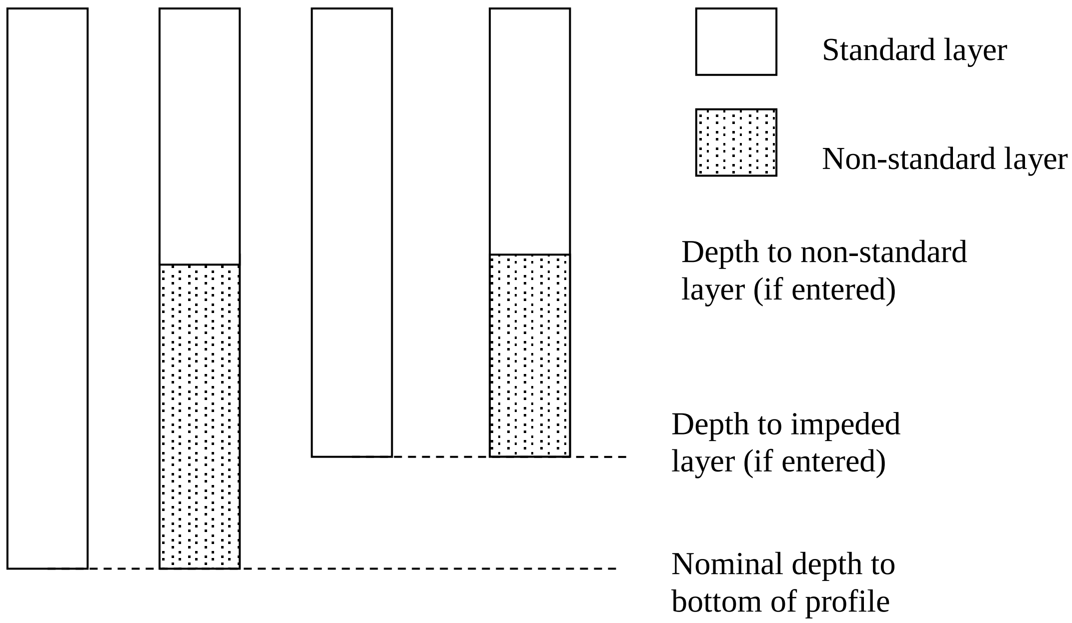

Figure 2. Relationships between soil with standard profile, soil with a non-standard sub-soil, soil with an impeded layer, and soil with both a non-standard and impeded layer.

For each layer:

Equation 31: forder = dorder / 0.1

Equation 32: fnonstd = dnonstd / 0.1

Equation 33: fimped = dimped / 0.1

dorder, dnonstd and dimped is the depth (m) of the layer that is assigned to standard soil layer, non-standard soil layer, of below the depth that an impeded layer occurs respectively.

0.1 is the depth of a layer (m).

The values of dorder, dnonstd and dimped are estimated using the following procedure:

- if depth to impeded layer or depth to non-standard layer is not entered, and there are no non-standard layers or a depth to an impeded layer, then dorder is set to 0.1; else
- if depth to impeded layer has been entered then:

if depth to impeded layer has been exceeded then dimped is set to 0.1; else

if the depth to the bottom of the soil layer (zdepth) is less than the depth to impeded layer and the depth to non-standard layer then dorder is set to 0.1; else

if zdepth is greater than the depth to the impeded layer then method 1 (see below) is followed; else

if the depth to the non-standard layer is entered then method 2 is followed; else

dorder is set to 0.1.

- else if depth to a non-standard layer has been entered then method 2 is followed;
- else dorder is set to 0.1

Method 1 is used if zdepth is greater than the depth to an impeded layer. Then:

- if the depth to the non-standard layer is entered then

  if the depth to the bottom of the soil layer (zdepth) is greater than depth to the non-standard layer then

    dorder = NonStdDepthm - (zdepth - 0.1)
    if the depth to the impedance layer is greater than thedepth to the non-standard layer then
      dnonstd = ImpededLayerDepthm - NonStdDepthm
    dimped = zdepth - NonStdDepthm

  else

    dorder = ImpededLayerDepthm - (zdepth - 0.1)
    dnonstd = 0
    dimped = zdepth - ImpededLayerDepthm

- if the depth to the bottom of the soil layer (zdepth) is greater than depth to the non-standard layer then

    dorder = 0
    dnonstd = ImpededLayerDepthm - (zdepth - 0.1)
    dimped = zdepth - ImpededLayerDepthm

- else

    dorder = AImpededLayerDepthm - (zdepth - 0.1)
    dnonstd = 0
    dimped = zdepth - AImpededLayerDepthm

Method 2 is used when the depth to the non-standard layer has been entered. Then:

- if the depth to the bottom of the soil layer (zdepth) is greater than depth to the non-standard layer then

  if this is the first occurrence then there may be a split layer, hence

    dorder = ANonStdDepthm - (zdepth - 0.1)
    dnonstd = zdepth - ANonStdDepthm

else the non-standard layer has been reached earlier and hence dnonstd is set to 0.1.

- else the non-standard has not been reached and hence dorder is set to 0.1.

5.3. Profile soil water contents

Cumulative wilting point, field capacity or saturation is calculated down to the depth required. For example, for pastoral blocks, values for the first six 10 cm depths are summed, to give water contents to 60 cm.

6. Soil test relationships

6.1. Olsen P by weight

Olsen P is adjusted to a weight basis using the method outlined in Rajendram *et al*. (2003) (Equation 34) as all calibrations were done on a weight basis (µg/g soil), whereas Olsen P is measured in commercial labs on a volume basis (µg/ml soil). Thus:

Equation 34: OlsenPwt = EXP(OlsenFactors / 1.13)

where

Equation 35: OlsenFactors = Ln(OlsenPvol) + 1.69 – (0.0057 * ASC) – (0.895 * BD / 1000)

OlsenPvol is the entered olsen P by volume [section 2.4.1].
ASC is the anion storage capacity [section 2.4.2].
BD is the bulk density (kg/m^3) [section 3.1].
1000 converts bulk density tfrom kg/m^3 to g/ml.

In the method of Rajendram *et al*. (2003), BD is volume weight (g/ml) of a scoop of air-dried soil. It is conceded that bulk density and volume weight are only moderately correlated.

6.2. Estimating TBK reserve K test from kc

The National Soils Database (Wilde and Ross, 1996) contains values for Kc test for a range of soil series. However, OVERSEER uses K reserve category or TBK reserve K test as inputs. Both the Kc and TBK reserve K tests are assigned categories (Excel spreadsheet supplied by A. Metherell for the TBK reserve K test, and Metson 1980 for Kc). The terminology for the categories do not align (Table 20). However, the rankings are considered to be similar. The relationship between TBK reserve soil test and Kc uses the relationship (Figure 3) between the midpoints for the category (Table 20).

To provide default data for a wider range of soil orders, the Kc values in the National Soils Database were used to define default slow release K potentials for a soil series where available, and averaged for soil orders and soil groups.

The Kc values are converted to K reserve values using the relationship shown in Figure 3. This relationship is only used to estimate default values.

Table 20. Category, and the range and midpoints (cmol(+)/100 g soil) for Kc and K reserve categories.

Kc			K reserve		
Category	**Range**	**Midpoint**	**Category**	**Range**	**Midpoint**
Very high	> 0.5	0.7	High	> 2.5	4.15
High	0.35-0.5	0.425	Medium	1-2.5	1.75
Medium	0.2-0.35	0.275	Low	0.2-1	0.6
Low	0.1-0.2	0.15	Very low	0-0.2	0.1
Very low	< 0.1	0.05	Extremely low		0.01

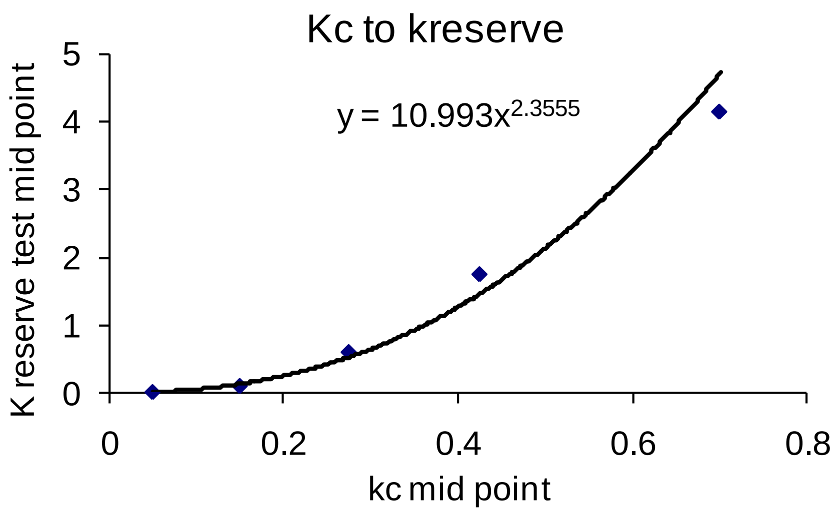

Figure 3. Relationship between Kc and K reserve tests (cmol(+)/100 g soil) using midpoints of categories.

6.3. Camp site soil test conversions

When calculating soil nutrient levels, or other calculations using soil tests, the values for camp sub-blocks are adjusted using the equations shown in Table 21.

Table 21. Conversion of soil tests data for campsites

Nutrient	Conversion for campsites
P	OlsenP * 2.8
K	QT K *3
S	PESo + 3
Ca	QT Ca * 1.1
Mg	QT Mg * 1.5
Na	QT Na *1.1

The conversion rates were based on soil test data from different slope categories in hill country, where flat land was considered camp sites (Gillingham and During 1973) or camp sites in flood irrigated border strips (Saville *et al*., 1997).

6.4. Estimating phosphate-extractable organic S from QT SO_4

The soil sulphate test is only used to estimate the initial organic S test value when the user does not have an organic S soil test value. The phosphate-extractable organic S test (PESO, mg/g soil) is determined as:

- entered value, else
- estimated from total S (section 6.5); else
- estimated from QT SO_4 test (Equation 36); else
- estimated from type soil test value for a given soil group; else
- a default value of 10 is used.

The conversion of QT SO_4 test to PESo assumes that sulphate and organic S are at an equilibrium level at the time of sampling, and is based on a method used in earlier versions of the OVERSEER (source unknown). Thus PESo is estimated as:

Equation 36: $PESO_0 = (QTSO4test + 0.012) / 0.884$

QTSO4test is the entered QT SO_4 test (mg/g soil), with a maximum value of 20.

If the QT SO_4 soil test value is used, it is preferable that no sulphate fertiliser has been applied within six months of soil testing, and soil testing has not been preceded by high rainfall. Within OVERSEER, the QT SO_4 soil test is only used to give an estimate of the organic S test. In practice, it is used in making fertiliser recommendations.

6.5. Relationship between phosphate-extractable organic S and total S tests

The relationship between the phosphate-extractable organic S test (PESo, mg/g soil) and total S test (mg S/kg soil) was based on further analysis of the data in Rajendram *et al*. (2008) by J. Waller (AgResearch, pers. comm.) to give:

Equation 37: PESo = 2.61 + 99.2 * (totalStest / 1000) if pumice
= 9.20 + 36.3 * (totalStest / 1000) if peats
= 5.21 + 97.5 * (totalStest / 1000) if volcanic
= 4.84 + 104.6 * (totalStest / 1000) otherwise

totalStest is the entered total S test (mg S/kg soil).

6.6. Change in soil test

The change in soil test values is based on the quantity of fertiliser nutrient required to be applied to achieve a 1 unit change in soil test (Morton and Roberts (1993), Roberts and Edmeades (1993), and Roberts *et al*. (1994). The rate of change is reported on a soil group basis, and the default is obtained using the method in section 3.1. For Mg, only one value was published (9 kg Mg per unit change in QT Mg).

It is assumed that the change in soil test due to accumulation of nutrients in the soil inorganic P occurs at the same rate as the quantity of fertiliser nutrient required to be applied to achieve a 1 unit change in soil test. This value is used to estimate the change in soil test values.

Thus, the change in soil test (pchange, kchange, mgchange for P, K and Mg respectively) is estimated as:

Equation 38: pchange = ChangeP / $pchange_{soil}$ * ratio
Equation 39: kchange = ChangeK / $kchange_{soil}$ * ratio
Equation 40: mgchange = ChangeMg / 9 * ratio

ChangeP, ChangeK and ChangeMg is the amount of nutrient applied as fertiliser or the accumulation in the soil inorganic pool (kg nutrient/ha).

kchange and pchange are the change is the rate of change in soil test values (kg nutrient per unit change in soil test) [section 3.1].

ratio accounts for different soil depths [Equation 41].

In pastoral soils, the ratio is one. In crop soils when deeper soil samples are typically taken, it was assumed that the rate of change was proportional to the depth of the sample. Thus, if the sampling depth was greater than 7.5 cm, the ratio was estimated as:

Equation 41: ratio = samplingdepth / 7.5

samplingdepth is the depth (cm) that the soil samples are taken.

6.7. Typical soil tests

Typical soil test values are arithmetic means obtained from aggregated data from soil samples submitted to a commercial lab between 1996 and 2001 (Wheeler *et al*. 2004).

Typical soil test values are determined as:

- for pastoral and the pastoral phase of cropping blocks, then if the farm is a dairy farm then the values in Table 22 are used, otherwise the values in
- Table 23 are used.
- if a cut and carry block, then average values from Table 22 and
- Table 23 are used.
- if a fruit crop block, then the values from
- Table 24 are used for P, K, Ca, and Mg, and the values for dairy SO_4 and Na are used (Table 22).
- if a crop block, the default pasture values are used for a the pasture phase. For each crop sown the user can either enter soil test values, or default typical soil test values based on each crop are used (Characteristics of crop chapter).

Table 22. Typical volumetric Olsen P (μg/ml), and QT K, Ca, Mg, and SO_4 soil test values for each soil group for dairy farms.

	P	K	SO_4	Ca	Mg	Na
Sedimentary	30	7	8	9	21	8
Volcanic	32	7	11	8	20	7
Pumice	28	5	6	6	16	5
Podzol	30	7	8	9	23	8
Sand (High P loss)	30	7	8	9	23	8
Peat	36	5	13	10	23	8
Recent/YGE/BGE	30	7	8	9	21	8

Table 23. Typical volumetric Olsen P (μg/ml), and QT K, Ca, Mg, and SO_4 soil test values for each soil group for non-dairy farms.

	P	K	SO_4	Ca	Mg	Na
Sedimentary	16	7	6	7	21	8
Volcanic	16	7	8	6	20	7
Pumice	17	5	4	5	16	5
Podzol	16	7	6	6	23	8
Sand (High P loss)	16	7	6	6	23	8
Peat	18	5	9	8	23	8
Recent/YGE/BGE	16	7	6	7	21	8

Table 24. Typical volumetric Olsen P (μg/ml), and QT K, Ca and Mg soil test values for apples and other (based on kiwifruit) fruit crops.

	P	K	Ca	Mg
Apples	57	12	12	35
Other	53	12	10	29

7. Plant available nutrients in soil

The amount of plant available nutrient in the soil (kg nutrient/ha) to 75 mm is based on soil tests and applied nutrients. These are used to estimate relative yield or pasture nutrient concentrations, as well as leaching losses.

7.1. Soil nutrient levels

Within each of the nutrient sub models, a relationship was developed between a measure of the soil nutrient status, and plant nutrient concentrations and relative yield (Pasture characteristics chapter). The soil nutrient status varied with the sub-model, but its fullest expression had the form of:

Equation 42: $SoilNut_{nut} = soil0_{nut} + solnut_{nut} + Effin_{nut}$

$soil0_{nut}$ is the intial soil level (kg nutrient/ha) [section 7.2].

$solnut_{nut}$ is the amount of soluble nutrients added over a 12 month period (kg nutrient/ha).

$Effsin_{nut}$ is the nutrients added as effluent over a 12 month period (kg nutrient/ha).

Some of the nutrient sub-models (N, P, S, K, and Mg) include fertiliser nutrient inputs in the calculation of soil nutrient levels. Soluble nutrients include nutrients in soluble fertilisers, and those in rainfall inputs or in irrigation.

The inorganic component of nutrients added as farm-derived or imported effluents were expected also to have an effect on soil nutrient levels similar to that for fertiliser nutrients.

7.2. Plant available nutrients based on soil tests

The amount of plant available nutrient in the soil (kg nutrient/ha) is estimated from the MAF QT soil test for samples taken to 75 mm depth. However, OVERSEER requires an estimate of the amount of nutrient in a conceptual soil labile pool for P (Metherell 1994). For cations (K, Ca, Mg and Na), an estimate of total exchangeable cations in kg/ha is required (Carey and Metherell, 2002).

Hence, the amount of plant available nutrients based on soil tests (kg nutrient/ha to 75 mm) is estimated as:

Equation 43: $Soil0_{P} = labileP$

labileP is the soil labile pool (kg P/ha) [Equation 48].

Equation 44: $Soil0_{K}$ = QT_K * QTKconv

QT Kis the user entered soil test value.

QTKconv is a constant of 27 (Metherell, unpublished data).

Equation 45: $Soil0_{Ca}$ = QT_Ca * QTCaconv

QT_Ca is the user entered soil test value.

QTCaconv obtained as outlined in section 3.1.

Equation 46: $Soil0_{Mg}$ = QT_Mg * QTMgconv

QT_Mg is the user entered soil test value.

QTMgconv is obtained as outlined in section 3.1.

Equation 47: $Soil0_{Na}$ = QT_Na * QTNaconv

QT_Na is the user entered soil test value.

QTNaconv is obtained as outlined in section 3.1.

The conversion factors for Ca, Mg and Na were based on conversion factors reported in Cornforth and Sinclair (1984), allowing for differences between QT and standard exchange methods (P. Carey, pers. comm.).

7.3. Labile P

Labile P is a conceptual soil pool of plant available P (Metherell 1994). It is estimated as:

Equation 48: labileP = (OlsenP / laba)^{labb}

OlsenP is the entered volumetric Olsen P value.

The two parameters, laba and labb, are estimated as:

Equation 49: laba = 200$^{(1\text{-olseng})}$ / olsenf

Equation 50: labb = 1 / olseng

where olseng and olsenf are fitting parameters with values shown in Table 8, Table 9, and Table 10 and is determined using the method in section 3.1. These are only available for the four original soil groups, and have been assigned to soil order based on the likely soil group within each soil order (section 3.2.2). The resultant curves are shown in Figure 4.

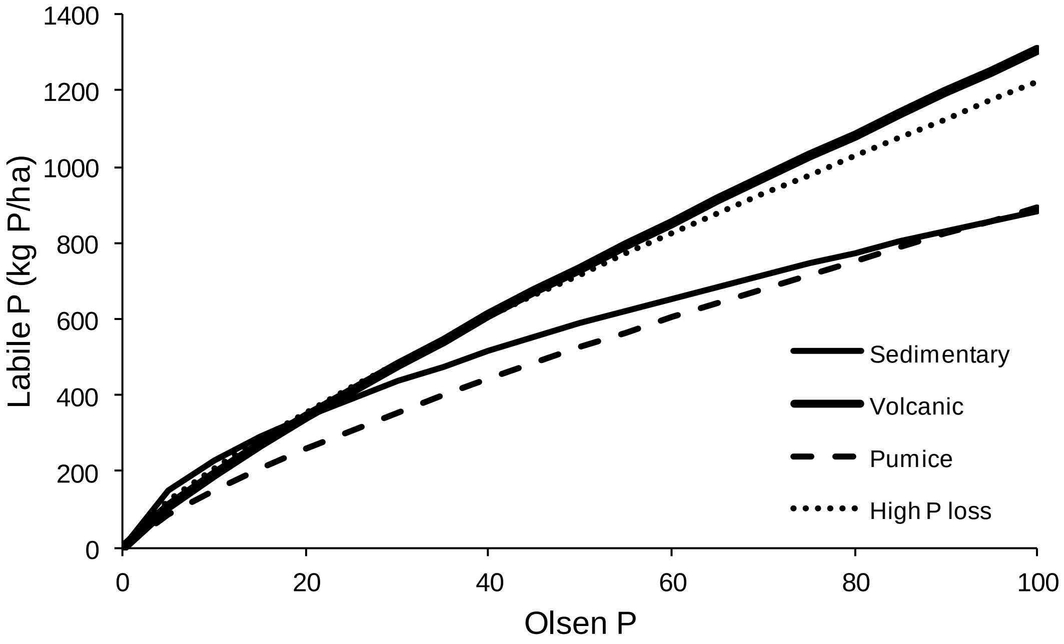

Figure 4. Relationship between volumetric Olsen P (µg/ml) and labile P for four soil groups.

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Appendix 1. Soil properties for soil series

Data for each series was extracted from the National Soils Database (Wilde and Ross 1996). Note that for most soil series, there were gaps in the data. However, all series listed in the model have soil order, and this is used to determine default values as outlined in section 3.1.

Table 25. Soil order, soil group, anion storage capacity (ASC), bulk density (BD, kg/m^3), sub soil clay content (%), top soil carbon content (%), structural integrity (section 4.4), nitric acid extractable K (Kc), hydrological class and natural drainage class (section 2.2.1). Blanks mean that there was no data available.

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Aan	6	6				49.0			0.6	4
Abbotsford	8									3
Abrahams	9									1
Absolum	11	1	48		11	7.4	0.69	0.27	0.6	3
Acheron	2	1	38		21	3.5	0.74	0.64	0.5	1
Acton	11									1
Addington	11									1
Addison	9	4			2	25.5		0.01	0.45	4
Admiralty	2									1
Ahaura	2	1	48	898	18	11.8	0.58	0.23	0.4	1
Ahikouka	3	7	17	1180	15	3.1	0.88	0.52	0.6	4
Ahuriri	3	1	17			1.8		0.54	0.4	4
Ahuroa	3									4
Ailsa	6	6	15			0.6			0.6	4
Airedale	8									1
Akaroa	2	1	28	1125	17	3.9	0.80	0.43	0.6	1
Akatarawa	2									1
Akatea	2									1
Akatore	2									1
Akeake	6									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Akitio	2									1
Alexandra	12	7								1
Alford Forest	2									1
Allanton	8									1
Allendale	2	1	34		28	6.3	0.67	0.50	0.6	1
Alpine	2									1
Altimarlock	5	2	30		26	3.9	0.74	0.54	0.6	1
Alton	11									3
Amberley	8	1	21			3.3		0.72	0.4	2
Amokura	3									4
Amuri	5									1
Anakiwa	11									1
Anakoha	2									1
Anaura	2									1
Andrews	6	6		140		48.0			0.6	4
Anglem	2	4	73			13.8		0.08	0.6	3
Angus	9	4				20.2			0.6	4
Apanui	3	1	50		40	5.6	0.56	0.49	0.6	4
Aparima	8									3
Aponga	13									3
Apotu	7									1
Arahiwi	9									1
Arahura	2	1	56		26	5.7	0.59	0.17	0.6	1
Aramoana	8									3
Aranga	4									1
Aranui	3									4
Arapawa	2	1	25		33	2.9	0.75	0.98	0.8	1
Arapohue	5									1
Ararimu	4									1
Aratora	11									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Arawa	10	2	59			7.2		0.09	0.4	1
Ardgour	12									1
Ardgowan	11									1
Ardlui	3									4
Ardlussa	2									1
Ardmore	6	6	90			27.5		0.02	0.6	4
Argyll	11									1
Aria	1									1
Arlington	3									4
Arnold	2	1							0.6	1
Aroha	2									1
Aroronga	2									1
Arowhana	11									1
Arrow	8	7	14		13	2.6	0.92	0.50	0.6	1
Arthurton	2	1	44			3.9		0.30	0.6	2
Ashcott	2									1
Ashers	9									2
Ashhurst	2	1	34	1660	28	4.6	0.70	0.26	0.6	1
Ashley	8	7	20	1295	20	2.6	0.85	0.37	0.6	3
Ashley Dene	8									2
Ashton	2									1
Ashwick	2									1
Atapo	2									1
Atarau	2									1
Atawhai	2									1
Athol	8									4
Atiamuri	10	3	47	635	53	8.1	0.48	0.09	0.2	2
Atua	8	7	26	940	24	5.6	0.74	0.36		3
Atuanui	11									1
Auripo	12									2

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Autea	3									4
Avoca	2									1
Awadale	3	1	64		59	14.8	0.30	0.35	0.6	4
Awahou	2	5	13		5	3.4	0.98	0.10	0.2	3
Awaiti	11									1
Awakaponga	11	1				16.7			0.6	3
Awakeri	10									4
Awamate	11									3
Awamoko	11									3
Awana	6									4
Awapuku	4	2	46			6.8		0.16	1	3
Awapuni	8	1	11			3.9		1.10	0.6	2
Awaroa	6									4
Awarua	4									3
Awatere	11	7	3		10	1.3	1.03	0.58	0.2	1
Awatiko	1									1
Awatoto	11									1
Awatuna	1	2	95	700	16	10.5	0.40	0.19	0.4	4
Ayreburn	3									4
Backholm	2									3
Bald Hill	2									1
Balfour	8									4
Ballarat	9									1
Balmoral	2	1	28	1161	22	3.6	0.78	0.62	0.5	1
Bannockburn	11									1
Barrhill	8									1
Barron	5									1
Barry	11									1
Batty	2									1
Bealey	9									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Beaton	2	4	15	1125	6	5.5	0.91	0.20	0.4	1
Beaumont	8									3
Becks	12	7	13	1410	25	2.3	0.86	0.62	0.8	2
Belmont	2									1
Benbecula	2									1
Bendhu	2									1
Bendrose	11									1
Benio	2									2
Benmore	2	1	30		13	3.1	0.84	0.68	0.4	1
Benneydale	10	3	45		2	8.2	0.79	0.05	0.4	1
Berwick	3									4
Bickerstaffe	3									4
Bideford	8									4
Bidois	3	1	70			8.2		0.09	0.4	4
Birchfield	2									1
Bishopdale	5	1	42	932	43	5.9	0.58	0.16	0.6	1
Black Point	11									1
Blackball	2	1	77		25	7.5	0.48	0.23	0.4	1
Blackmans	12	7	6	1410	11	2.4	0.98	0.57	0.4	2
Blackmount	2									1
Blackridge	5									1
Blackstone	8	7	32			5.4			0.4	1
Blackwater	2									1
Blairch	5									3
Blairgowrie	2									1
Blue Bottle	2	1							0.6	3
Blueduck	2									1
Bluff	2									1
Bombay	4									1
Borland	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Bortons	11									1
Bossu	2	1	54	920	16	5.0	0.67	0.41	0.6	1
Bourke	2									1
Bowenvale	8									1
Bradshaw	3	1	57	610	11	14.0	0.57	0.15	0.4	4
Braeburn	11									1
Braemar	3									4
Branch	2	1	36			3.8		0.37	0.6	1
Brancott	5	7	14	1286	27	2.6	0.84	0.59	0.6	1
Brassknocker	11									1
Braxton	3									4
Breaksea	2									1
Bream	4									3
Brighton	2									1
Broad Bay	5									3
Broadbridge	8	7	21	1247	27	2.4	0.81	0.55	0.6	2
Bromielaw	9									1
Brookby	13									1
Brooklyn	2									1
Brookstead	11									1
Bruntwood	1	2	90	810	24	10.0	0.39	0.13	0.6	4
Bryneira	2									3
Buccleugh	2									1
Buckland	8									3
Bucks	2	1	47	1090	37	4.5	0.61	0.20	0.9	1
Budle	2									1
Bulwer	2	1	37		35	3.5	0.68	0.22	0.8	1
Bungaree	2									1
Bungtown	6	6				39.0			0.6	4
Burley	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Burnside	5									1
Burrell	11									1
Burwood	2									1
Buscot	8									3
Cadzow	11									1
Cairnside	12	7	12			2.2			0.4	2
Callaghans	2	1	65		16	9.8	0.54	0.12	0.6	1
Camp Stream	2									1
Camphill	5									1
Capleston	2									1
Cargill	2									1
Carnarvon	3	5	43	1053	15	5.1	0.72	0.18	0.3	4
Caroline	8									4
Carrick	2	1	29			3.8		0.36		3
Carterton	8									3
Carton	9	4	7		0	4.4	1.09	0.09	0.4	3
Cascade	2	1	49			8.5		0.16	0.6	1
Cashmere	5	1	41	945	18	6.2	0.69	0.42	0.6	1
Casolis	9	4	18		4	14.0	0.80	0.09	0.4	3
Cass	2	1	37			6.6		0.56	0.6	1
Castle	5									1
Castlebrae	11	7	10	1272	19	2.7	0.89	0.70	0.4	1
Castlecllff	11									1
Cattle Creek	11									1
Caversham	3	1	85			12.8		0.24	0.8	4
Chalky	5									1
Chalmers	5	1	29			5.7				1
Chapman	12									2
Charleston	9	4	5	1315	3	2.7	1.05	0.08	0.3	4
Charlton	2	7	24			4.5		0.23	0.6	3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Charwell	2									3
Chaslands	2									3
Chasm	8									2
Chatto	12									1
Chatton	2									2
Chertsey	8									1
Cheviot	8									4
Chewings	3									4
Christmas	11									1
Churchill	2	7	33			4.9		0.06	0.8	1
Claddagh	2	1							0.6	1
Clare	12	7								1
Claremont	8									4
Clarence	11									1
Clarendon	5									1
Clayton	8									4
Clevedon	3									4
Clifton	8	7	31		28	3.6	0.73			2
Clinton	2									1
Cluden	8	7	9			2.5		0.57	0.4	2
Clutha	11	7	15		11	3.4	0.91	0.61	0.4	1
Clyde	12	7							0.4	1
Clydevale	8									3
Cockabulla	2	1	40		23	3.8	0.72	0.20	0.6	3
Cockneys	2									1
Colac	6									4
Cone	2									1
Conical Hill	5									1
Conroy	12	7	5			2.0		0.66	0.4	1
Cookson	5									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Coopers Creek	3									4
Cornwallis	4									1
Cox	2									3
Craigdale	2									1
Craigieburn	2									1
Crofton	8									3
Croiselles	2									1
Cromwell	12	1	12	1147	10	2.5	0.95	0.23	0.4	1
Crookston	8	7	27	1215	21	3.9	0.78	0.25	0.6	3
Crownthorpe	8									2
Cullen	2									1
Culverden	8	7	16		23	3.6	0.83	0.56	0.7	2
Curraghmore	8	7	14		40	3.0	0.77	0.75	0.8	2
Cuvier	13									3
Dacre	3	1	50			11.8		0.14	0.6	4
Dalgety	8	7	19			2.1		0.59	0.6	2
Dalmore	2									1
Danby	2									1
Dannevirke	1	2	91		29	10.2	0.36	0.23	0.6	1
Darkeys	2									3
Darnley	8									2
Dashwood	8	7	23	1132	24	2.3	0.82	0.57	0.6	1
Deadman	2	1	69		25	8.0	0.51	0.16	0.6	1
Dean	5									1
Deceit	2									3
Denniston	9									4
Devonshire	8									2
Dicksons	11									1
Dilemma	2	1							0.6	3
Dilston	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Dip	11									3
Dipton	8	7	21	1311	27	3.1	0.80	0.25	0.6	4
Disturbed	2									1
Dobson	3	1	35			6.6		0.44	0.6	4
Dome	11									1
Dome Valley	4									1
Domett	3									4
Dovedale	11									1
Dredgings	2									1
Drummond	2	1	60	950	35	5.5	0.54	0.31	0.6	1
Drybread	12	7	15	1520	20	1.4	0.91	0.48	0.4	1
Dryden	11	7	22	1200	26	2.7	0.81	0.57	0.4	1
Dublin	2									1
Duffers	11									1
Dukes	3	1	49	983	40	4.9	0.58	0.62	0.8	4
Dukeshead	2									1
Dumpling	11									1
Dun	2	1	49			3.7		0.04	0.6	1
Duncan	11									1
Dunedin	2	1	41			3.5		0.29	0.6	3
Dungree	11									1
Dunmore	1	2	82			8.0		0.10	0.6	1
Dunstan	2									1
Dunton	2									1
Dusky	9									1
Earnscleugh	12									1
Eden	12									2
Edendale	2	1	54	1090	28	5.4	0.60	0.28	0.6	1
Edwards	8									2
Eely	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Eglinton	2									1
Egmont	1	2	88	750		9.1		0.19	0.6	1
Elbow	8									1
Elliot	9	4	15		4	3.6	0.98	0.11	0.6	3
Elmwood	2									1
Elsthorpe	8									3
Elstow	3	1	67	840	58	5.2	0.43	0.37		4
Eltham	6	6	94	534		23.2		0.14	0.6	4
Endeavour	13									1
Enfield	8									3
Esk	11									1
Euclid	9									3
Eureka	3	1	40			4.0		0.16	0.8	4
Evans	5									1
Evansdale	3									4
Eweburn	11									1
Excelsior	2	1	78	858	29	7.7	0.45	0.18	0.6	1
Eyre	11	1	18	1314	21	3.3	0.84	0.56	0.5	1
Fairdown	3									4
Fairfax	2									1
Fairhall	3	7	21	1319	19	3.5	0.83	0.55	0.6	4
Fairlight	2									1
Farndon	11	7	20	1195	21	2.0	0.86	0.75	0.6	1
Felton	2									1
Ferndale	2									3
Ferndunlaw	2									1
Finegand	8									4
Fiordland	9									1
Flagstaff	3	1	16		5	28.2	0.66	0.18	0.6	4
Flaxbourne	8									2

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Fleming	8	7	20	1193	20	3.1	0.84	0.35	0.6	4
Forbury	3									4
Fork	2	1	23		9	2.7	0.91	0.60	0.4	1
Fortification	1									1
Fortrose	2									3
Foxton	2	5	23	1089	14	4.5	0.83	0.28	0.2	1
Fraser	11									3
Freestone	2									1
Freeth	2									1
Freshwater	3	6				36.0		0.07	0.6	4
Galatea	10									1
Galloway	3									4
Galtymore	11									1
Garnock	9	4	37			20.1		0.12	0.4	1
Georgetown	8									2
German	11									1
Gibsons	11	7	9	1366	16	1.2	0.97	0.72	0.4	1
Gisborne	10									1
Gladbrook	11									1
Gladstone	8									2
Glasnevin	8	7	29			4.3		0.58		1
Glen Eyrie	2	1	31		19	3.4	0.79	0.53	0.6	1
Glenavy	3									4
Glenbrae	3									4
Glencairn	8									3
Glendhu	8									3
Glenelg	2									2
Glenhope	2									1
Glenkenich	8	7	33			3.5		0.23	0.6	4
Glenlea	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Glenmark	8	7	5			2.8		0.60	0.4	2
Glenn	1	2	98	720	23	9.8	0.37	0.11	0.6	4
Glenrock	8									1
Glenroy	2									3
Glenure	3									4
Godley	8	7	21		21	3.1	0.83		0.6	2
Gollans	3									4
Gore	2	1	31	1402	22	4.4	0.75	0.28	0.6	1
Gorge	2									1
Gower	8									3
Graham	2									1
Grampians	8									2
Grant	9									1
Granville	2	1	6			2.9		0.10	0.4	1
Grasmere	3									4
Grassington	11	7	9		20	2.6	0.90	0.61	0.6	1
Gravesend	3									4
Grays	3									4
Greenburn	8									3
Greenfield	2									1
Greenland	3	1	39		8	3.3	0.83	0.62	0.6	4
Greenvale	2									1
Greville	6									4
Greytown	11									1
Grove Burn	2									1
Grovetown	3	1	20	1135	19	2.8	0.85	0.89	0.8	4
Gwavas	11									1
Haast	9									1
Hakataramea	8									3
Hakowai	8									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Halcombe	8	7	22		20	8.9	0.72	0.21	0.6	4
Haldane	2									3
Haldon	8	7	23		31	3.7	0.75	0.62	0.6	1
Halkett	2									1
Hamama	2									1
Hamilton	2	2	39	1133	30	4.7	0.67	0.08	0.7	1
Hanaia	3	1	56		38	4.9	0.55	0.19	0.6	4
Hangaroa	2									1
Hangatahua	11	1	81	868	9	7.3	0.57	0.15	0.6	1
Hangatuha	11									1
Hangawera	13	1	27		7	3.8	0.89	0.10	0.6	4
Haparangi	10	3	62			8.0		0.09	0.4	1
Hapuatuna	9	6				51.5			0.6	1
Hapuku	2									1
Harapepe	1									1
Harata	9	4	13		16	2.7	0.90	0.16	0.4	3
Harbour Cone	11									1
Harihari	11	1	16	900	5	4.2	0.94	0.54	0.4	3
Haroharo	10									1
Hastings	3	7	24	1218	36	3.5	0.73	0.86	0.6	4
Hatfield	8	7	21	1285	21	2.5	0.84	0.58	0.6	1
Hau	2									1
Hauhungaroa	1									1
Hauiti	2	5	37		7	4.3	0.83	0.33	0.2	1
Haumi	11									1
Haunga	4									1
Haupeehi	1									1
Haupiri	9	4	18			39.8				4
Hauraki	3	1	29	885	59	6.7	0.56	0.37	1	4
Hauroko	2	1				7.8			0.6	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Hauroto	1									1
Hautere	2	1	45	1020	33	4.8	0.63	0.27	0.6	1
Hauturu	1									1
Havelock	8									4
Hawarden	2									3
Hawkesbury	3									4
Hawksburn	12									2
Haycocks	2									1
Haylands	3									4
Hazlett	2									3
Heathcote	8									3
Hedgehope	2									1
Helvetia	4									4
Henley	8									1
Henniker	3	1							0.6	4
Heretaunga	2	1	48	1009	36	5.7	0.58	0.37	0.6	3
Heslington	2									1
Highbank	11									1
Highcliff	5	1	39			4.5		0.43	0.6	1
Hightop	2									3
Hihi	3									4
Hikuwai	2	1	49		13	4.5	0.73	0.41	0.4	1
Hilderthorpe	8									2
Hillersden	2									1
Himatangi	2	5	35	865	18	6.4	0.72	0.25	0.2	3
Hinahina	9									1
Hinau	9	1			41	10.3		0.29	0.6	1
Hinemaiaia	10									1
Hingarae	1	3	81			5.0		0.12	0.2	2
Hiwi	1									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Hoata	11	7	51			4.9		0.36	0.6	1
Hochstetter	2	1	63		20	5.2	0.60	0.18	0.5	1
Hoe-O-Tainui	13	1	23		8	3.8	0.89	0.08	0.6	4
Hohonu	9									1
Hokio	11	1				1.3		0.14	0.2	3
Hokitika	11	7	17		0	9.3	0.97	0.36	0.4	1
Hokonui	8	1	30	888	50	5.0	0.62	0.30	1	4
Holbrook	11	1	21		10	2.3	0.92	0.60	0.3	1
Hollyford	2									1
Honeywood	2									3
Hopai	3	1	38	748	69	6.6	0.49	0.44	1	4
Hope	9	4	39		15	5.8	0.73	0.18	0.5	3
Hopes Creek	3									4
Horea	2									1
Horomanga	10									1
Hororata	2									1
Horotane	3									4
Horotiiu	1									1
Horsham	2									1
Houhora	2									1
Howard	2									1
Howe	11									1
Hui Hui	5									1
Huia	2									1
Huka	11									1
Hukarere	9	4	19		12	8.6	0.79	0.12	0.6	4
Hukawai	11									1
Hukerenui	13	4	9	1133	30	4.0	0.81	0.11	0.4	3
Hundalee	8									1
Hungahunga	3									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Hunoke	4									3
Hunterville	2									1
Hunua	4									1
Hurakaia	9									1
Hurewai	13									4
Hurunui	2	7	19	1200	25	2.6	0.82	0.63		1
Hururua	2									1
Ikamatua	2	1	47		20	18.3	0.50	0.25	0.6	1
Inangahua	2	1	62		31	5.1	0.55	0.19	0.6	1
Inglewood	1									1
Invercargill	6									4
Invermay	3	7	45	1061	44	3.7	0.60	0.59	0.8	4
Irirangi	1									1
Isla Bank	8									3
Iwiroa	3									4
Iwirua	2	1	49		30	1.3	0.71	0.15		1
Jacobs	3									4
Jacobstown	3									4
Janefield	11	1	11	1135	5	3.3	0.98	0.32	0.4	1
Jones	9									4
Jordan	8	7	26	1219	18	3.1	0.82	0.37	0.6	2
Josephville	2									1
Judgeford	2	1	73	946	25	6.8	0.50	0.24	0.6	1
Kaama	9									1
Kaawa	13									1
Kaharoa	10									1
Kaherekoau	6	6	25			14.8			0.6	4
Kahui	1	2	96	658	25	12.1	0.33	0.13	0.6	1
Kahui Hill	1									1
Kahutara	2									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Kaiapo	3	1	27	1270	39	3.8	0.70	0.86	0.8	4
Kaiapoi	11	1			28	3.1			0.6	3
Kaiata	5	1							0.6	1
Kaihere	1									1
Kaihiku	5	1	38	1165	38	5.1	0.63	0.51	0.8	1
Kaihuka	2									3
Kai-Iwi	2									1
Kaikarangi	3									4
Kaikino	9									4
Kaikorai	3									4
Kaikoura	11									1
Kaikouta	2									1
Kaimanawa	10									1
Kaimata	2									1
Kaimua	13									1
Kaingaroa	10	3	68	608	2	15.6	0.59	0.07	0.2	2
Kainui	4	1	25	1190	30	3.2	0.76	0.08	0.6	1
Kaipaki	6	6	60	508		23.6		0.10	0.6	4
Kaipara	3	1	31			3.9			1	4
Kaipo	3									4
Kairaki	11									1
Kairanga	3	1	28	974	42	4.1	0.67	0.66	0.4	4
Kairua	9	4	23	905	0	4.0	1.03	0.07	0.2	3
Kairuru	5	1	44	1061	30	5.8	0.63		0.6	1
Kaitaia	3									4
Kaitala	3									4
Kaitangata	8									1
Kaiteriteri	13	1	21			2.0		0.08	0.4	1
Kaiti	3	1	43		45	7.3	0.54	0.43	0.6	4
Kaitieke	1									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Kaitoa	5									1
Kaitoke	2									1
Kaituna	2	1	40	961	27	4.1	0.69	0.23	0.6	1
Kaiwera	2	1	67	965	41	5.9	0.48	0.18	0.8	1
Kaka	9									2
Kakahi	1									1
Kakahu	2									3
Kakapo	3									4
Kakapuku	2									1
Kakaramea	10									1
Kakatahi	1	2	90			8.7		0.23	0.4	1
Kakepuku	2									1
Kakerangi	3	1	81			13.5		0.06	0.6	4
Kamaka	3	1	43	145	19	21.2	0.49	0.25	0.6	4
Kamiko	2									1
Kamo	3									4
Kaniere	2	1	64		3	3.6	0.78	0.25	0.5	3
Kaniwhaniwha	11									1
Kapamahunga	11									1
Kapu	2	1	33			6.1		0.12	0.6	1
Kapuka	9									2
Kara	3									4
Karaka	1	2	86			7.8		0.06	0.6	2
Karamea	11	1	24	1312	13	2.6	0.88	0.33	0.5	1
Karamu	11									3
Karangarua	3									4
Karapoti	11	7	29	1189	36	4.6	0.69	0.38	0.5	1
Karioi	2									1
Karitane	5	1	23			4.7		0.38		1
Karito	2									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Karoro	2	1							0.2	1
Katlkati	1									1
Katrine	2									1
Katui	4									3
Kauaeranga	4									1
Kauana	5									1
Kauri	4									1
Kauroa	1									1
Kauru	8	7	8			4.8		0.40	0.4	2
Kawarau	11									1
Kawatiri	2									1
Kaweka	10									1
Kaweku	13	1	37	1215	42	4.0	0.64	0.26	0.8	1
Kawerau	10									1
Kawhatau	2	1	57	1600	29	9.9	0.51	0.24	0.6	1
Kawhatiwhati	10									1
Keepa	9									2
Kehu	11									1
Kekerengu	8	1	6		30	3.2	0.84	0.64	0.6	2
Kenepuru	2									1
Kepler	9									1
Kereone	1	2	91		20	9.9	0.41	0.11	0.6	1
Kerikeri	7	2	59	894	52	6.8	0.45	0.07	1	1
Ketu	2	1	28		35	3.3	0.73	0.49	0.7	1
Kidnappers	8									1
Kikiwa	2									1
Kilbride	2									1
Kilmarnock	12									2
Kini	6	6	66			21.0		0.17	0.4	4
Kinohaku	1	1	89			17.3		0.08	0.6	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Kirikiriroa	1									1
Kiripaka	1	1	62		40	7.1	0.48	0.33		1
Kiritaki	2									1
Kirkliston	2	1	32		9	6.4	0.79	0.57		1
Kiteroa	2									1
Kitto	9									3
Kiwi	8	7	21		23	3.1	0.81			2
Kiwitahi	1									1
Kiwitea	2	1	61			6.0		0.17	0.5	3
Knapdale	8									3
Koau	3	1	39		32	4.6	0.66	0.55	0.8	4
Kohemarere	2									1
Koheroa	1									2
Kohine	12									1
Kohinui	2									1
Kohuka	5	2	27			5.4		0.20	0.6	1
Kohumaru	4									4
Kohuratahi	2									1
Koikoi	2									1
Koinga	11									1
Kokau	11									1
Kokiri	2	1							0.6	1
Kokomiko	10									1
Kokotau	8	7	27	1258	36	3.4	0.72	0.57	0.8	4
Komako	3									4
Komata	4									1
Kongahu	9									4
Konin	2									3
Kononi	8									3
Konoti	5									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Kopeka	2	1	28			18.0		0.15	0.6	3
Kopeopeo	9	4	18			4.7		0.17	0.2	3
Kopua	2	1	79	768	42	10.3	0.35	0.24	0.6	3
Kopuawhara	1	1	57	802	10	6.3	0.68	0.09	0.4	3
Kopuriki	10									1
Kopuroa	11									1
Koputaroa	2	5	11	1375	12	2.5	0.95	0.27	0.4	1
Korakonui	11									1
Koranui	2	1							0.4	1
Korari	2									1
Korere	2	1			22	3.9			0.6	1
Korokoro	2	1				5.1			0.6	1
Koromiko	2									1
Kotare	3									4
Kotinga	9									4
Kotiro	2									1
Kourarau	5	1	33			8.7		1.02	1	1
Kouratahi	2									1
Kowai	11									1
Kukumoa	11	7	53		13	3.8	0.72	0.58	0.4	3
Kumara	9	4	25		8	10.8	0.77	0.15	0.6	4
Kumenga	11									3
Kumurau	2									1
Kuranui	2									1
Kuratau	10	3	50	1070	22	7.9	0.60	0.08	0.4	1
Kuri	8									4
Kuripapanga	10									1
Kuriwao	2									1
Kurow	8									1
Lagoon	3									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Lammerlaw	2	1	48		16	7.9	0.65	0.29	0.6	3
Landon	8									4
Landslip	2									1
Larbreck	11									1
Larnach	5	2	65			10.0		0.24	0.6	1
Lawrence	8									3
Leader	8									3
Lee	2									1
Leith	2									3
Leith-Cargill	2									3
Leithen	2									1
Letts	12									1
Levin	2	1	65	973	27	10.5	0.47	0.32	0.6	1
Lewis	9	4	47	906	23	17.7	0.49	0.18		1
Liberton	2	1	59			5.8		0.32	0.6	1
Ligar	2									1
Lillburn	2									1
Lindis	8									1
Linkwater	11									1
Linnburn	12	7	7	1425	16	1.4	0.96	0.54	0.6	2
Lintley	2									1
Lismore	2	7	23	1200	20	3.5	0.81	0.52	0.6	2
Lithosol	11									1
Lochaber	8									4
Lochar	12	1	8		12	2.3	0.96		0.4	2
Lockington	3									4
Longridge	3									4
Longwood	9									3
Lottery	8									4
Lowburn	12									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Lowcliffe	8									3
Lowgarth	10	3	81	1005	34	6.7	0.43	0.16		1
Luggate	2									1
Lumsden	3									4
Luna	11									1
Luxmore	2									3
Lyndhurst	2									1
Lynwood	2	1	75	898	27	8.4	0.46	0.13	0.6	2
Lyoncross	2									1
Macandrew	5	1	62			4.3		0.30		1
Mackenzie	11	1	17		10	2.2	0.94	0.55	0.3	1
Mackley	2	1							0.6	1
Maero	11									1
Mahakipawa	3									4
Mahara	2									1
Maharahara	2									1
Mahia	10									1
Mahinapua	2	5	13	1200	5	2.8	0.98	0.21	0.4	1
Mahinerangi	2	1	55		14	6.7	0.65	0.32	0.6	3
Mahoenui	11	1	25			4.4				1
Mahoneys	2	1	53		15	12.9	0.56	0.21	0.55	1
Mahorehore	1									2
Mahurangi	13									1
Mahuta	4									1
Maihiihi	1	2	96			13.6		0.10	0.6	1
Maimai	3	4	15		9	7.0	0.86	0.15	0.6	4
Mairaki	8									4
Mairoa	1	2	85			16.0		0.09	0.6	1
Maitland	2									2
Makahu	9									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Makara	2									3
Makaraka	3	1	26		24	3.8	0.77	0.36	0.6	4
Makaretu	2	2	88			7.6		0.19	0.6	1
Makarewa	3	1	68	745	35	7.0	0.47	0.18	0.8	4
Makauri	11	1	29		35	3.9	0.70	0.44	0.6	3
Makeretu	8									1
Makerikeri	8									3
Makerua	6	6	52	100	25	22.5	0.41	0.33	0.6	4
Maketu	6									4
Maketu Complex	6									4
Makiekie	10	3	29			4.5		0.34	0.4	1
Makotuku	2	7	20			4.2		0.21		1
Makuri	2									1
Malakoff	5									1
Mamaku	9	4	17	630	2	4.3	0.99	0.07	0.3	1
Manapouri	3									4
Manaroa	2									1
Manawahe	10									1
Manawatu	11	7	15	1221	19	2.8	0.87	0.61	0.4	3
Mandamus	2	1			22	2.9			0.6	3
Mandeville	2									1
Mangaheia	2	7	23	953	22	4.3	0.79	0.48		3
Mangaiti	1									1
Mangakahia	11									1
Mangamahu	2	1	25			3.4				1
Mangamaungaroa	3									4
Mangaomeko	2									1
Mangaotaki	2									1
Mangapiri	2									3
Mangapohue	1									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Mangaroa	6	6		212		52.0			0.6	4
Mangatahi	8									4
Mangatarata	8									1
Mangatawhiri	13									4
Mangatea	2	1	35			3.5		0.44		1
Mangatepopo	9	3	73	523	46	10.2	0.37	0.08	0.2	1
Mangaterata	8									1
Mangatoro	8									1
Mangatu	2									1
Mangatutu	3									4
Mangaweka	2									3
Mangawheau	13									3
Mangawhero	1	2	94	683	42	9.4	0.30	0.20		4
Mangonui	4									1
Mangoreia	11	1	44			3.1		0.56	0.6	3
Mangorewa	9	4	46		0	8.4	0.85	0.05	0.4	1
Manihera	11									1
Man-Made	2									1
Manoeka	11	1	65	833	22	4.7	0.59	0.18	0.5	1
Manorburn	12									2
Manuherikia	12	7			18				0.3	1
Manukaiapu	1									1
Manunui	10	3	45			7.2		0.07	0.4	1
Manurewa	13	1	28			4.1		0.10	0.6	3
Maori	11									1
Mapara	10									1
Mapiu	1									1
Mapua	13	1	18	1421	10	2.0	0.94	0.14	0.4	3
Maraeroa	10									1
Maraetotara	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Marama	11									1
Maramarua	13	1	29	1015	24	3.8	0.76	0.16		3
Marangairoa	11									1
Mararoa	2									1
Marathon	8									1
Mardon	3									4
Maroa	9	4	35	798	24	7.0	0.67	0.11	0.4	1
Marokopa	2									1
Marotiri	13	1	13			7.5		0.30		3
Marris	9	4	3	805	3	9.2	0.94	0.05	0.4	4
Marsden	11									1
Martinborough	8									2
Marton	8	7	21		26	4.0	0.78	0.19	0.6	4
Marua	2									1
Mary	11									1
Masons	5									3
Mata	13									1
Matahina	10									1
Matakanui	8									1
Matakaoa	1	2	87			8.8		0.20	0.4	1
Matakawau	4									1
Matamau	2	7	31		36	3.8	0.69	0.30	0.6	1
Matao	6	6	59		14	7.0	0.63	0.09	0.6	4
Matapiro	8	7	28	1100	25	4.2	0.75	0.19	0.6	4
Matapiro Complex	8									4
Matarae	8									1
Matarau	7									1
Matariki	2									1
Matata	11									3
Matau	3	1	28	1020	27	3.4	0.75	0.61	0.6	4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Matauira	9	4				18.5		0.04	0.5	1
Mataura	11	1	13	1269	18	2.3	0.90	0.65	0.6	1
Matawai	9									3
Matawhero	11	7	23		24	2.2	0.83	0.58	0.6	1
Matiere	1									1
Matiri	2	1	45		19	17.9	0.52	0.11	0.5	1
Matukituki	11									1
Matuku	3									4
Maude	2									1
Maukoro	2	1	31		29	2.6	0.76	0.08	0.6	1
Mauku	1	2	83			8.3		0.02	0.6	1
Maumahaka	9									1
Maungahaumia	11									1
Maungakahia	11									1
Maungakakaramea	2									1
Maungakawa	11									1
Maungakohatu	7									1
Maungapakeha	2									1
Maungarei	13									1
Maungatapu	1									1
Maungatoroto	5									1
Maungatua	9	4	36		9	13.9	0.67	0.20	0.6	4
Maungawera	11									1
Maunu	7									1
Mauriceville	5									1
Mavora	2									1
Mawhera	9	1	10		7	17.4	0.77	0.21	0.6	4
Maxwell	2	5	25			4.5		0.14	0.4	1
Mayfield	8									2
Mcgaw	2									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Mcivor	5									1
Mckerchar	3									4
Mckerrow	9	4	36			9.0		0.25		4
Mcleish	3									4
Mcmurray	2	1	43			21.8		0.21	0.6	1
Mcnab	2	1	43	1165	30	4.3	0.66	0.35	0.8	1
Mcpherson	11									1
Medina	8									3
Medway	8									3
Meeanee	3									4
Meikleburn	2									1
Mercer	3									4
Merrivale	2									1
Merton	8									4
Mesopotamia	11									1
Meyer	11									1
Middlehurst	5	1	25		22	2.5	0.82	0.32	0.6	1
Middlemarch	8									2
Mihiwaka	2	1	62			7.1		0.27	0.6	1
Mikimiki	2									1
Milburn	8									2
Millerton	9	4	4	1280	4	2.3	1.06	0.07	0.4	1
Milson	8	7				4.4			0.6	4
Mine Tailings	2									1
Mine Workings	2									1
Miranda	11									1
Mitchells	2	1	65		14	7.8	0.59	0.26	0.6	1
Moana	9									3
Moawhango	1									1
Moeatoa	1									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Moehau	2									1
Moenui	13	1	28		41	4.9	0.66	0.39		1
Moerangi	10									2
Mohaka	3	1	42	805	9	5.0	0.78	0.11	0.2	4
Mohakatino	2									1
Mokai	6	6				34.0			0.6	4
Mokamoka	2									1
Mokapeka	8									3
Mokau	2									1
Moke	2									1
Mokihinui	2									1
Mokoreta	9	4	81	585	26	16.0	0.34	0.17	0.6	4
Mokotua	2									3
Molesworth	2	1	26		25	3.5	0.77	0.73	0.4	1
Molyneux	12	7	8	1420	8	2.0	1.00	0.49	0.4	1
Monowai	2	1	63		15	8.3	0.58		0.6	1
Montgomery	5									1
Moonlight	2									1
Morley	2									1
Morrinsville	4	2	41		28	3.5	0.69	0.22	0.6	1
Morrisey	2									1
Morrison	2									3
Morven	8									3
Mosgiel	3	7	32	1195	25	3.3	0.75	0.52	0.8	4
Mossburn	8									3
Mosston	11	5			3	2.7		0.14	0.2	1
Motatau	5									1
Moteo	3									4
Motuara	13									1
Motuiti	2	7	12	1305	4	2.5	1.01	0.45	1	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Motukarara	3									4
Motumaoho	6	6	82	596	18	17.8	0.37	0.09	0.5	4
Motumoa	10									1
Motunau	5									3
Motupiko	11	1	27			4.1		0.28	0.4	1
Motuwaureka	3									4
Moumahaki	2									1
Mount Misery	2									3
Mount Mistake	2									1
Mount Rex	13									1
Mount Somers	2									3
Mowbray	2									1
Mt Misery	2									3
Muaiwai	2									4
Muller	8	1	22		19	3.3	0.83	0.62	0.2	1
Murimotu	6									4
Muritai	11	7	13		17	2.5	0.90	0.58	0.4	1
Muriwai	2	1	41	765	20	8.1	0.65	0.20	0.6	4
Murray	2									3
Murrays	11									1
Muturangi	11									1
Naike	4	2	52	881	52	6.6	0.49	0.07	0.6	1
Nardoo	2									1
Narrowdale	2									3
Naseby	8									1
Nemona	3	1							0.4	4
Nenthorn	8									3
Netherton	3	1	34	890	42	4.2	0.65	0.26	0.7	4
Nevis	2	1	33			3.6		0.49	0.6	1
New Plymouth	1	2	85	858	17	10.3	0.44	0.10	0.6	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Newall	1									1
Newstead	8									3
Ngaere	1									3
Ngahere	2	4							0.6	1
Ngahewa	2									1
Ngaio	8									3
Ngakawau	2	1							0.8	3
Ngakuru	1	2	78	832	39	6.6	0.43	0.11	0.4	1
Ngakuta	2									1
Ngamatea	1									1
Ngamoka	8	7				5.9				3
Ngapara	8	7	18			3.4		0.71	0.4	2
Ngapouri	10									1
Ngaroma	9									1
Ngarua	3									4
Ngatarawa	11	7	18		21	2.9	0.85	0.42	0.4	1
Ngatea	6	1	6	495	60	33.0	0.38	0.10	0.6	4
Ngatiawa	11	1				4.4				1
Ngatimoti	5									1
Ngaumu	2									1
Ngauruhoe	11	2	59	1070	7	3.9	0.74		0.4	1
Ngongotaha	9	3	76			6.9		0.04	0.2	1
Niagara	2									3
Nithdale	2	1	71	765	33	7.9	0.46	0.16	0.6	1
Nokomai	8									3
Northope	8									3
Oamaru	5	1	23			9.1		0.41	0.4	1
Obelisk	2	1	1			15.2		0.37		1
Ohaeawai	1	2	97		28	12.9	0.30		0.4	1
Ohaewai	7									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Ohai	8									4
Ohakea	3	1	34			4.8		0.21	0.6	4
Ohakune	2	2	84	780	17	8.2	0.48		0.4	1
Ohau	2	1	27		20	3.2	0.81	0.51	0.6	1
Ohaupo	1	2	87			9.4		0.15	0.6	1
Ohautira	4									1
Ohia	9									3
Ohikanui	11									1
Ohineangaanga	3									4
Ohinemoa	11	1	20			2.2		0.27	1	1
Ohinemuri	3									4
Ohinepanea	10	3	26	1105	4	3.2	0.93	0.10	0.2	1
Ohingaiti	2									1
Ohope	2	1	9		0	1.5	1.16	0.10	1	1
Ohotu	2									3
Okaihau	7	2	62	1105	48	6.4	0.46	0.05	1	1
Okaka	13									4
Okapua	11									3
Okareka	11									1
Okari	2	1	4	839	2	2.0	1.09	0.30	1	1
Okarito	9	4	9	722	7	10.5	0.85	0.09	0.6	4
Okaro	10									1
Okato	1	1	73	770	12	10.2	0.53	0.18	0.6	3
Okawa	8									4
Okeefe	2									1
Okete	3									4
Okia	2									1
Okiwi	2									1
Okoha	2									1
Okoia	8	1	27			5.4		0.51		3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Okowhao	3									4
Okuku	2									3
Okupata	3									4
Okuri	13									1
Old Workings	2									1
Olivine	2	1				10.8				1
Olrig	11									1
Omahuta	13									1
Omaiko	13									3
Omaka	11	7	10		17	2.4	0.92	0.56	0.4	1
Omakau	12									2
Omalley	3									4
Omanaia	2									3
Omanu	9									4
Omanuka	6	6	43	383		25.8		0.08	0.6	4
Omarama	11	7	13		18	1.7	0.92	0.71	0.4	1
Omaranui	11									3
Omarumutu	3	5	42		14	5.3	0.73	0.20	0.4	4
Omaui	9	4	68		6	7.8	0.64		0.6	2
Omeheu	3									4
Omeo	12									1
Omihi	5	1	12			7.3		1.23		3
Omimi	8									3
Omoto	2	1							0.6	1
Omu	13									4
Onahau	9	4	2	1171	3	3.5	1.04		0.4	4
Onamalutu	2									1
One Tree Point	9	4	27	705	6	6.9	0.83		0.6	3
Onekaka	2									1
Onepu	3									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Onepunga	2									1
Onetai	3									4
Onewhero	4									1
Ongarue	1									1
Ongawhao	1									1
Oniao	1									1
Onoke	3									4
Opaheke	13									3
Opaki	2									1
Opani	3	1	29			4.4		0.34	0.8	4
Oparure	1									1
Opawa	11									3
Opawe	2									1
Opiki	6	6	79	695	73	18.7	0.15		0.6	4
Opita	4									1
Opoho	8	1	17			3.9		0.51		3
Oporo	3									4
Opotiki	10	2	65		10	5.5	0.66	0.12	0.4	1
Opouawe	11	1	20	1074	40	6.8	0.67	0.39		1
Opouri	13	1	54		39	3.7	0.58	0.48	0.6	1
Opouriao	11	7	38		19	5.0	0.72	0.53	0.4	3
Opoutama	2	5	20		8	3.2	0.92	0.27	0.2	1
Opuatia	4									1
Opuha	8									4
Orangihewa	10	2	65		7	6.2	0.67	0.14	0.2	1
Orawia	2									1
Orepuki	2									1
Orere	4									1
Oreti	2									1
Organic Soils	6									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Oriental	2	1	4		8	2.6	1.01	0.08	0.4	3
Orikaka	9	4							0.4	3
Oringi	3									4
Orini	11	1				5.0			0.4	1
Orinoco	2									1
Ormond	2	7	30	882	13	5.1	0.79	0.21		3
Oropi	10	3	51	920	6	5.4	0.76	0.12	0.4	1
Oroua	2	1	37			6.4		0.26		1
Orowaiti	3									4
Oruanui	10	3	40	655	3	9.1	0.78	0.08	0.2	1
Oswald	3									4
Otaha	7	2	56	978	33	6.5	0.55	0.04	0.8	4
Otahu	3									4
Otahuti	2									1
Otaika	13									4
Otaitai	3									4
Otakairangi	6									4
Otakau	3									4
Otaki	11	7	20		12	5.0	0.84	0.55	0.4	1
Otakou	2									1
Otama	8	7	17	1221	15	2.9	0.88	0.31	0.6	2
Otamangakau	1									2
Otamatea	10	3	58	1065	29	5.5	0.57	0.13	0.2	1
Otamauri	1	1	41	745	10	3.4	0.80	0.12		1
Otamawairua	9									1
Otane	8									3
Otanewainuku	10									1
Otanga	3									4
Otangaroa	13									4
Otangiwai	3									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Otanomomo	6									4
Otao	1									2
Otapiri	8									3
Otara	11	7	35		22	3.7	0.74	0.41	0.6	3
Otaraia	2	1	59	1085	35	3.7	0.58	0.20	0.8	1
Otarawao	2									1
Otatara	2									1
Otautangi	3									4
Otautari	3									4
Otawhaio	13									3
Otematata	8									2
Otepuni	3									4
Oteramika	2									1
Oteramlka	2									1
Otere	2									1
Otiake	8									2
Otikerama	11									1
Otira	9									1
Otokia	8	7	14		22	3.3	0.85	0.34	0.6	4
Otonga	6									4
Otonomomo	6									4
Otorohanga	1	2	93	640	15	10.7	0.42	0.17	0.6	1
Otu	5									1
Otukura	3									4
Otupae	1									1
Oturehua	8									2
Oturoa	10	2	87			10.1		0.11	0.2	1
Otututu	2	1	11		6	24.9	0.70	0.06	0.4	3
Otway	6									4
Oughton	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Ounu	1									1
Owaka	2	1	36	973	32	4.3	0.68	0.28	0.6	1
Owawenga	9									1
Oweka	11	7	31		26	3.4	0.75	0.57	0.4	1
Owhai	5	1	16		34	2.7	0.80	0.17		1
Owhakura	2									1
Owhango	10									1
Owhata	10	7	47			4.5		0.50	0.4	1
Oxford	8	7	32	1108	24	4.2	0.74	0.32	0.6	4
Paengaroa	10	3	51	1015	8	7.5	0.70	0.15	0.4	1
Paerata	3	1	65		26	13.0	0.45	0.12	0.6	4
Paeratotara	11									1
Paerau	3									4
Paeroa	1									1
Pahaoa	2									1
Pahau	8	7	18	1231	23	2.9	0.83	0.63	0.6	3
Pahiatua	2									1
Pahoia	3	1	61	727	29	12.1	0.46	0.12	0.6	4
Pakarae	8									1
Pakaroa	2									1
Pakau	11									1
Pakawau	9									3
Pakipaki	3	1	20	785	21	5.4	0.78	0.23	0.2	4
Pakira	2									1
Pakotai	4									1
Pakowhai	11	1	24	1050	28	2.7	0.79	0.79	0.6	3
Papakaio	2	7	13			3.4		0.44	0.5	1
Papakauri	1	2	95	730	26	11.6	0.33	0.09	0.6	1
Papamoa	2	3	26	1110	5	3.4	0.92	0.21	0.2	1
Paparoa	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Paparua	8									1
Papatapu	2									1
Papatotara	2	1	58	975	39	5.9	0.52	0.20	0.6	1
Papawera	3	1	47			5.8		0.34	0.8	4
Paradise	2									1
Paraha	8	7	33	1200	31	2.7	0.73	0.40	0.6	3
Parahaki	13									4
Parakao	13									4
Parakino	2	1	61			6.4		0.27	0.4	1
Parakiore	11									1
Paraparaumu	6									4
Parata	6									4
Parataiko	4									1
Parau	4									1
Parawai	11									1
Parawhenuamea	10	3	50	900	10	6.6	0.70	0.18	0.4	1
Paremata	8									3
Paretai	3									4
Paretotara	11									1
Parewanui	3	1	30	1085	23	3.5	0.77	0.69	0.6	4
Paroa	3	1				10.8			0.6	4
Parore	6									4
Parton	6	6	53	910	10	7.0	0.68	0.13	0.4	4
Patea	2	5	12		6	3.5	0.97	0.14	1	1
Patearoa	11									3
Paterson	9	4	34			12.7		0.20		3
Patetonga	3									4
Patience	9									1
Patiki	1									4
Patoka	10									1

Series Name	**Soil order**	**Soil group**	**ASC**	**BD**	**Clay**	**Carbon**	**Structural integrity**	**Kc**	**Hydrological class**	**Drainage Class**
Patons	5	1	63			4.0		0.31		1
Patriarch	2									1
Patua	1	2	95	655	25	13.7	0.31	0.16	0.5	1
Patuki	2									1
Patumahoe	4	2	61	1016	67	5.3	0.42	0.09	0.6	1
Paturau	5									1
Patutu	2									1
Pauatahanui	3	1	8			5.0		0.29	0.4	4
Pawson	8	7	26	1060	25	3.7	0.77	0.51	0.6	3
Paynter	3									4
Pearl	6									4
Pebbly Hills	2									1
Peebles	11									1
Peel Forest	2									3
Pegasus	6	6								4
Pekepeke	10									1
Pelichet	11	5				4.5		0.07	0.2	1
Pelorus	2	4	68		51	14.0	0.32	0.27	0.7	1
Pembroke	2									1
Peria	1									1
Petekuku	11									1
Phoebe	8									3
Piako	6									4
Piarere	1	2	90	807	24	6.6	0.44	0.17	0.6	1
Pidgeon	9									3
Pigburn	12	7	3	1063	12	2.6	0.97	0.40	0.4	2
Pigeon	9	1			27					3
Pihama	1	2	39	1140	7	6.0	0.79	0.17	0.4	1
Pihanga	10									1
Pikikiruna	5	1	32		28	4.0	0.72	0.22		1

Series Name	**Soil order**	**Soil group**	**ASC**	**BD**	**Clay**	**Carbon**	**Structural integrity**	**Kc**	**Hydrological class**	**Drainage Class**
Pikowai	2	1	7			5.3		0.28	1	1
Pinaki	2									1
Pinedale	11									3
Pinehaven	2									3
Pinelheugh	2	1	42		22	3.7	0.71	0.47	0.6	2
Pinohia	13									1
Pioneer	3									4
Piopiotea	3									4
Pipikaretu	5	2	53			4.9		0.34	0.6	1
Piriaka	1									1
Pirinoa	8									3
Piripai	2	5				1.0			0.2	1
Piripiri	3									4
Piroa	13									1
Pirongia	2									1
Piropiro	9									1
Plkaroro	9									1
Pohangina	8	7				2.5		0.37	0.4	3
Pohaturoa	10									1
Pokaka	9									1
Pokapu	13									3
Pokororo	2									1
Pollock	4									3
Polnoon	9									1
Pomahaka	11	7	15		13	1.8	0.94	0.57	0.4	1
Pomarangai	1									1
Pomare	2	1	43			6.2		0.27	0.6	1
Pongakawa	6	1				11.3			0.6	4
Pongaroa	2									1
Poolburn	12									2

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Poporangi	8	7	24		22	2.9	0.81	0.42	0.4	4
Popotunoa	8									1
Porarari	3									4
Porewa	2									1
Porirua	2	1				4.8			0.4	1
Poronui	10	3	67	730	29	7.2	0.51	0.12	0.2	1
Poroporo	11									3
Porteous	2	1	46			4.3		0.29	0.6	3
Portobello	5	2	42			5.1		0.27	0.6	1
Poteriteri	9	4				44.0			0.6	4
Potikirua	11									1
Potton	1									1
Pouawa	8	7	25	901	20	5.7	0.76	0.38		1
Poukawa	3	6				31.0			0.6	4
Pourakino	2									1
Pouwhakaura	3									4
Princess	2									1
Princhester	2	1	81	923	36	7.8	0.40	0.17	0.6	1
Prydes	8									2
Puaroa	3									4
Puerua	3									4
Puhipuhi	2									3
Puhoi	13									3
Puhunga	11	7	40			4.7		0.58	0.6	3
Pukaki	2	1	17		17	3.9	0.85	0.60	0.5	1
Pukawa	10	3	54	850	45	6.2	0.51	0.10	0.2	1
Pukeamuru	2									1
Pukeawa	8									1
Pukehina	3	1	55	735	16	9.0	0.60	0.10	0.6	4
Pukehou	8									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Pukekapia	4									3
Pukekaroro	13									3
Pukekohe	4	2	60			2.7			0.6	1
Pukekoma	2									1
Pukemaku	10									1
Pukemiro	13									1
Pukemutu	8									3
Pukenamu	13									4
Pukeo	3									4
Pukeokahu	5									1
Pukepahi	9	4	64	780	37	9.0	0.45	0.23	0.8	3
Pukepuke	3	5	34	861	12	5.5	0.77	0.17	0.4	4
Pukerangi	8									2
Pukerata	2	1	29			7.1		0.44	0.6	1
Pukerau	1	1	81	675	31	8.8	0.41	0.30	0.8	1
Pukerimu	10									1
Pukeroa	10	3	35	985	4	4.5	0.86	0.12	0.4	1
Pukerua	2									3
Puketaha	3	1	87			10.8		0.08	0.5	4
Puketeraki	2	1	71			9.1		0.45		1
Puketitiri	10									1
Puketitoi	13									1
Puketui	4									1
Pukeuri	8	1							0.6	3
Pukewaenga	13									1
Pu-Mo-Ot	11									3
Punakaiki	2	1							0.6	1
Punehu	1	2	95	620	19	10.8	0.38	0.18	0.4	4
Pungaere	7	2	61		47	3.9	0.52	0.03	0.6	1
Pungapunga	10									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Puniu	11	1	46	975		6.5		0.24	0.6	3
Puponga	9									3
Purakanui	2									1
Puramahoi	2									3
Pureora	9	4	3			14.4		0.06	0.4	1
Purimu	8	1				6.1				3
Puriri	4									1
Purua	13									4
Putangirua	2									1
Putataka	2									1
Putiki	10	3	45			8.2		0.12	0.4	1
Puwera	13									3
Pyramid	2									2
Pyramids	2									1
Quailburn	2	1	47		27	3.9	0.66	0.70	0.6	1
Queensberry	2									1
Queenstown	2									1
Quoin	2									1
Raglan	3									4
Rahotu	1	1	71	735	8	10.6	0.56	0.15	0.6	4
Rahui	3									4
Rai	2									1
Rakauni	2									1
Rakaunui	2									1
Rakiura	2	1	83			18.3		0.15	0.6	1
Rameka	2	1	44	972	41	5.7	0.58		0.6	1
Ramiha	2	1	89		35	10.2	0.34	0.24	0.6	1
Ranfurly	12	7	8	1405	28	1.8	0.88	0.50	0.6	2
Rangiora	2	1	14		22	3.5	0.84	0.16	1	3
Rangipo	10	3	71	940	38	6.4	0.46	0.08	0.4	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Rangiriri	11									1
Rangitaiki	11	7	38		17	2.6	0.79	0.54	0.4	1
Rangitikei	11	7	8	1452	18	1.1	0.96	0.58	0.3	1
Rangitoto	11									1
Rangitumau	5									1
Rangiuru	4									4
Rangiwaea	2									1
Raniera	11									3
Ranzau	2	1	32			4.1		0.30	0.6	1
Rapaki	5	2	31	850	25	6.7	0.69	0.42	0.6	1
Raparapahoe	3	1	48	780	20	6.9	0.64	0.13	0.6	4
Rapaura	11	7	15	1263	17	4.2	0.85	0.63	0.5	1
Rapuwai	2									1
Rataroa	9									1
Raukawa	8									3
Raukumara	11									1
Raumai	2	7	14			2.8		0.27	0.4	1
Raumati	3	1	61			8.9		0.17	0.6	4
Raurekau	2									3
Raurimu	9									1
Rautawiri	10									1
Rawea	2									1
Rawerawe	3	1	48	640	53	9.4	0.46	0.24	0.7	4
Recent Soils	11									1
Red Hill	2	5	40			3.7		0.07	0.4	1
Redcliff	5									1
Redcliffs	3									4
Renata	2	4	79			10.2		0.11	0.6	3
Renwick	2									1
Repanga	13	1	29			5.5		0.17	0.8	3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Reporoa	11									3
Resolution	9									1
Retford	2									1
Rewatu	3									4
Rhoboro	11	7	13			4.0		0.74	0.6	1
Riariaki	1									1
Richmond	3									4
Rimutaka	2									1
Riponui	13									1
Ripponvale	12									1
Riverlea	1	2	90	845	44	8.5	0.32	0.17		1
Riversdale	11									1
Riverton	2	5	8			2.9		0.19	0.2	1
Riwaka	11									1
Roa	2									3
Rochfort	9									4
Rock Land	2									1
Rockvale	13									1
Ronga	11									1
Rongotea	6	6	66			28.5		0.05	0.6	4
Roseberry	5									1
Rosedale	2									1
Rosemarkie	2	1	82	670	41	9.4	0.36	0.17	0.8	1
Rotherham	8									3
Rotoaira	10									1
Rotoatara	6									4
Rotoiti	10	3	36			4.7		0.38	0.2	1
Rotokauri	3									4
Rotokohu	6	6							0.6	4
Rotomahana	11	2	26	1031	20	3.4	0.80	0.63	0.4	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Rotomanu	11									3
Rotongaro	6									4
Rototahi	2									1
Rotowaro	2									1
Rowallan	9	4				10.6			0.6	4
Rowan	1	2	94	810	45	8.6	0.30	0.18		1
Roxburgh	12									1
Ruahine	2	1	45			4.2		0.41		1
Ruakaka	6									4
Ruakaka Complex	6									4
Ruakituri	10	4			6	19.2			0.4	1
Ruakiwi	2									1
Ruapuna	2	1	30	1019	25	3.3	0.76	0.43	0.6	1
Ruaroa	11									1
Ruatangata	7									1
Ruataniwha	11	1	40		45	5.5	0.58	0.09	0.6	3
Ruatoki	11									1
Ruatoria	11									1
Ruawaro	13									1
Rukuhia	6	6		209		49.5			0.6	4
Rukuruku	13									1
Rumahanga	11									1
Runanga	2	1							0.6	1
Ruru	2	1								3
Rutherglen	9	4	8	485	4	9.4	0.90	0.04	0.6	4
Ryans	5									1
Saddle	5									1
Saddle Hill	2									1
Salix	8	7	18	1220	26	2.1	0.84	0.57	0.6	3
Sanatorium	9	4	3	590	2	7.9	0.97	0.05	0.4	4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Sandymount	5									1
Sawdon	11									1
Scarborough	8	7	19		24	3.5	0.81			2
Scotland Point	12									2
Scott Burn	3	1				57.0			0.6	4
Scree	2									1
Scrubby Hill	2									3
Seaforth	11	1	11			8.8		0.14	0.3	1
Seaton	3									4
Seaview	8	7	26		23	2.7	0.80	0.56	0.6	2
Seddon	8	7	14	1345	19	2.3	0.89	0.65	0.5	2
Sedgemere	8	7	24	1407	22	2.7	0.82	0.49	0.6	2
Selwyn	11	7	10			1.3		0.65	0.2	1
Serpentine	3									4
Shaftesbury	3									4
Shagree	3									4
Shamrock	3	1							0.6	4
Shannon	8	7	22	1184	22	4.3	0.79	0.28	0.6	3
Sherry	11									1
Sherwood	2									3
Shotover	11	7	10	1197	16	2.5	0.92	0.61	0.6	1
Silver	8									1
Silver Peaks	2									1
Silverdale	2	1	34	1150	26	3.9	0.72	0.26	0.8	3
Silverstream	11									1
Sim	3	1	72	490	52	7.3	0.39	0.32	0.8	4
Simons	8	7	12		19	2.6	0.89	0.59	0.6	1
Skeletal Soils	11									1
Skipton	2									3
Smedley	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Snowdon	2									1
Sobig	3									4
Soldiers	2	1	43		35	3.5	0.66	0.28	0.6	1
Sonora	12	7								2
Southdown	2	1	56			4.6		0.22	0.6	3
Sowburn	6									4
Speargrass	11									1
Spenser	9	4	65	631	31	8.1	0.49	0.41		1
Spooner	2									1
Spottis	3									4
Spring Creek	3	1	21	1058	40	2.5	0.76	0.84	0.8	4
Springburn	11									3
Springdale	3									4
Springvale	12									1
Spylaw	8									1
Stafford	8									1
Stanley	2									1
Starborough	11	7	10		18	3.6	0.88	0.74	0.4	1
Staveley	2									1
Steward	2									2
Stewart	2	1	62		24	14.5	0.45	0.17	0.6	1
Stillwater	2	1							0.6	1
Stirling	6									4
Stokes	8	7	29	1065	18	3.7	0.80	0.24	0.6	4
Stonycreek	5									3
Stonyhurst	5									1
Stormont	8									3
Stratford	1	2	91	819	18	8.7	0.43	0.16	0.5	1
Streamlands	8	7	10			1.5		0.53	0.4	2
Struan	8									2

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Summit	2	1	46		28	4.3	0.65		0.6	1
Sunnybank	5									1
Swampy	2									1
Table Flat	1	2	96			11.8		0.15	0.6	1
Tadmor	2									1
Tahiki	2	1	27	801	13	4.6	0.82	0.24		1
Taho	3	1	34		14	3.6	0.80	0.09	0.6	4
Tahora	2	1	64	895	37	4.9	0.52	0.56	0.6	1
Tahuna	4	1	34		27	3.6	0.73	0.15	0.6	3
Tahunanui	11									1
Tahurangi	11									1
Taiaroa	5	1	36			3.4		0.35	0.6	1
Taieri	3									4
Taihaia	6									4
Taihape	2	7	19	1402	26	2.8	0.82	0.51		1
Taikitao	9									4
Taiko	8	7	9			3.6		0.70	0.4	1
Tailings	2									1
Taioma	2									1
Taipare	11									1
Taipoiti	9	4	7		11	4.1	0.93	0.16	0.4	1
Tairua	4									1
Taita	13	1	39	1018	29	4.9	0.67	0.36	0.9	3
Taitapu	3	1			48	12.6			0.8	4
Taiwhati	2									1
Takahe	8	7	27		23	2.8	0.80		0.6	3
Takahiwai	3	1	39			4.4		0.27	0.9	4
Takamore	11	7	36			4.9		0.67	0.4	1
Takapari	3	1	16			24.2		0.23	0.6	4
Takapau	2	2	68		17	6.5	0.57	0.26	0.5	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Takarangi	10	7	51	1035	6	4.2	0.78	0.37	0.6	1
Takihiwai	3									4
Takitao	9									4
Takitimu	2									1
Takitu	2									1
Tamahere	1	2	20			5.2		0.13	1	2
Tamaki	2									1
Tangatara	2									1
Tangitiki	13									4
Tangitu	1									1
Tangoio	11									1
Tanoa	13									1
Tapanui	8									3
Tapawera	11									1
Tapuwae	9									1
Taraire	7									1
Tarakaipa	2									1
Tarakohe	5									1
Taramakau	2									1
Tararua Complex	2									3
Tarata	2									1
Taratahi	3									4
Taratu	2									1
Tarauku	13									4
Tarawera	11									1
Taringamotu	10									1
Taringatura	2									1
Tarras	11									1
Taruarau	10									1
Tasman	11									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Tate	9									4
Taueru	2									1
Tauhara	10									1
Tauhei	13	1	17	935	26	4.2	0.79	0.31	0.6	3
Taumarunui	10									1
Taumata	13									1
Taumutu	11									1
Taupahi	11									1
Taupo	10	3	45	783	3	4.8	0.83	0.10	0.3	1
Taurewa	9									1
Tauterei	3									4
Tautoro	11									1
Tautuku	9	4	54		29	17.1	0.44		0.6	2
Tauwhare	11									3
Tauwhareparae	1									1
Tawaha	8									4
Tawai	13									4
Tawanui	2									1
Tawharanui	3									4
Tawhia	10									1
Tawhiti	2	1	38		17	3.7	0.76	0.50	0.6	1
Tawhitinui	13	1	24		55	2.4	0.69	0.13	0.8	1
Taylors Mistake	2									1
Te Anau	2	1	81		19	10.7	0.45		0.6	2
Te Aneraki	5	1	21			4.8		1.20	0.8	1
Te Apiti	8									3
Te Arakura	3	1	20			3.8		0.48	0.5	4
Te Aute	5									1
Te Hapara	2									1
Te Hapua	9									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Te Harapa	2									1
Te Hihi	13	1	26		20	6.2	0.75	0.17	0.6	1
Te Hoe	4									1
Te Horo	2									3
Te Houka	8	7	21		21	2.7	0.84	0.26	0.6	3
Te Kaha	1									1
Te Kakahi	3									4
Te Kauwhata	4									1
Te Kie	2									1
Te Kopuru	9	4		995	3	5.3		0.01	0.2	3
Te Kowhai	3	1	36	1040	34	5.9	0.64	0.23	0.6	4
Te Kuiti	1	2	93			14.2		0.08	0.6	1
Te Manaia	1									1
Te Mara	5									3
Te Mata	11	1				13.9			0.4	1
Te Matai	3	1	71	613	26	7.9	0.49	0.16	0.6	4
Te Ngae	11	7	31			3.1		0.35	0.2	1
Te Onepu	5									1
Te Pari	2									1
Te Piki	3									4
Te Pohue	10									1
Te Puke	1	3	45		3	6.0	0.81	0.15	0.4	1
Te Puna	3	1	64	824	14	9.7	0.57	0.08	0.6	4
Te Puninga	1	2	86	707	24	9.8	0.41	0.08	0.6	2
Te Rahu	10	1	25			4.7		0.16	0.4	1
Te Ranga	2									1
Te Rangiita	11	1	53	790	71	5.7	0.44	0.28	0.2	1
Te Ranui	2	1	30	963	19	4.0	0.78	0.38		2
Te Rapa	9	4	88	560	11	25.0	0.32	0.03	0.6	1
Te Rauamoa	9									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Te Rere	10									1
Te Teki	9									1
Te Teko	10									1
Te Tio	13									1
Te Tua	2									3
Te Tuhi	1									1
Te Waewae	2									3
Te Waitere	1									1
Te Wharau	2									1
Teal	2									1
Tekapo	2	1	20			4.9		0.54	0.4	1
Tekoa	2	2	41	922	26	6.1	0.65	0.40	0.4	1
Templeton	8	7	18	1286	22	2.9	0.84	0.66	0.6	2
Temuka	3	1	14	1010	47	3.9	0.72	0.67	1	4
Tengawai	8									1
Teranga	2									1
Terawhiti	2									3
Teviot	2	1	46		16	4.5	0.72	0.45	0.6	1
Thomas	8									2
Thornbury	3									4
Tihia	1									1
Tihoi	9	4	31	890	2	12.0	0.79	0.10	0.2	1
Tikipunga	7									1
Tikirau	1									1
Tikitere	2									1
Tikitiki	11									1
Tikitohe	2									3
Tikotatahi	11									1
Tima	8	7	17		19	2.2	0.88	0.55	0.5	2
Timahanga	1									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Timahau	2	1	65		42	8.5	0.44	0.28	0.4	1
Timaru	8	7	13			4.9		0.59	0.6	3
Timi	1									1
Timpendean	8	7	13			3.4		0.89	0.2	1
Tiniroto	10									1
Tinopai	9									1
Tinui	2									1
Tipapa	8									3
Tipoka	1	2	94	680	18	11.5	0.38	0.17	0.4	3
Tirangi	11									1
Tirau	1	2	88	745	14	8.3	0.48	0.12	0.6	1
Tirohanga	2									1
Tiroiti	8									2
Tiropahi	2									3
Tiroroa	2									1
Tisbury	9									4
Titahi	2									3
Titapu	1									1
Titiokura	10									1
Titipua	2									2
Titiraurangi	2	1	47		8	23.7	0.53	0.05		3
Titiroa	2	1	46	989	16	5.7	0.69	0.20	0.5	1
Tiwai	9									2
Toetoes	9									1
Toi	3									4
Toitoi	2									1
Tokaanu	6	6				33.0			0.6	4
Tokanui	2									1
Tokarahi	5									1
Tokata	11									3

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Tokawhero	2									1
Tokeawa	11									1
Tokiaminga	6									4
Toko	3									4
Tokoiti	2									1
Tokoiti Complex	2									1
Tokomairiro	8									4
Tokomaru	8	7	18		21	3.3	0.83	0.31	0.6	4
Tokorangi	8	7				5.1		0.34	0.4	3
Tokoroa	10									1
Tolson	2	4	18			16.6		0.11	0.2	1
Tomahawk	2									1
Tomoporakau	8									4
Tongaporutu	11									1
Topehaehae	3									4
Topehahae	3									4
Topeheti	11	6				44.0		0.03	0.6	1
Tophouse	2									1
Tora	2									1
Torea	13									1
Torehape	1	2	62			5.2		0.10	0.6	1
Totaranui	11	1	34		27	3.7	0.72	0.31		1
Trail	9									3
Tramline	3	1	83	730	81	11.6	0.19	0.36	0.6	4
Traquair	2	1	44		30	3.5	0.67	0.46	0.6	1
Trent	3									4
Trotter	11									1
Tuahu	2									1
Tuai	10									1
Tuakitoto	6									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Tuamarina	8									1
Tuapaka	8									3
Tuapeka	2									1
Tuatapere	11	1	53	893	43	5.5	0.54	0.17	1	1
Tuhiraki	2									3
Tuhitarata	2									1
Tukituki	11									3
Tukura	11									3
Tulituki	11									3
Tumai	5									4
Tumutumu	1	2							0.6	1
Tuna	2	1	51		60	4.4	0.50	0.23	0.6	1
Tuparoa	11									1
Turakina	2	1	25			4.7		0.57		1
Turakirae	11									1
Turamoe	6									4
Turangi	10	3	59	860	35	5.6	0.54	0.11	0.4	1
Turiwhate	11									1
Tutaetoko	1									1
Tutaki	2									1
Tutamoe	8									2
Tutanekai	3	6	59			19.0			0.6	4
Tutira	10									1
Tuturau	2	1	47	1195	32	3.3	0.65	0.25	0.8	1
Twinlaw	2									1
Twyford	11	7	15	1281	21	2.8	0.86	0.73	0.5	1
Tyneholm	2									1
Uawa	3	1	27		13	4.1	0.83	0.37	0.4	4
Ugbrooke	8	7	29	1325	22	3.3	0.78	0.64	0.6	1
Uia	1									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Umutoi	1	2	92			10.6		0.30		1
Unnamed Subalpine	2									1
Upokonui	2	1	20			3.4				1
Upukerora	11									1
Urewera	10									1
Utawai	11									3
Utiku	2									1
Utopia	9	4	15	1258	7	3.7	0.94	0.18	0.4	3
Utuhina	6									4
Uxbridge	11									1
Vee Forty	11									1
Venlaw	1	2	55	430	45	28.1	0.26	0.23	0.8	1
Vernon	11									1
Victoria	8									1
Victory	2									1
Virgin	3	1	19	1465	8	2.9	0.93	0.34	0.2	4
Von	11									1
Waenga	12	7	15	1330	12	2.0	0.94	0.62	0.4	1
Waianiwa	6									4
Waiapu	11	7	18			2.5		0.50	0.4	1
Waiareka	5	2	36	1020	66	4.0	0.56	0.88	1	2
Waiari	11	1	74	750	17	9.8	0.50	0.20	0.6	3
Waiarikiki	2	1	79	640	35	11.7	0.36	0.21	0.8	1
Waiaruhe	2	1	20			3.2		0.48		1
Waiau	11									1
Waihi	1									1
Waihirere	11	1	25		27	4.4	0.75	0.50	0.6	1
Waihoaka	9									2
Waihoata	11	1	58			4.8		0.42	0.8	3
Waihopai	8									2

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Waihou	1	2	86	775	26	8.1	0.43	0.13	0.6	1
Waihua	1									1
Waihuka	1									1
Waihurua	10									1
Waiiti	9	1	7		7	3.0	0.99	0.14	0.4	3
Waikaia	2									1
Waikairo	2									1
Waikaka	2	1	52			4.5		0.24	0.6	1
Waikakahi	5									1
Waikanae	11	1	20			3.8		0.26	0.6	1
Waikarara	3									4
Waikare	13	1	29		57	3.5	0.63	0.19	0.9	4
Waikaremoana	11									1
Waikari	5	1	25			7.1		0.74	0.4	1
Waikato	11	3	17			2.6		0.14	1	1
Waikerikeri	12									1
Waikino	11									3
Waikiwi	2	1	59		24	4.1	0.62	0.21	0.6	3
Waikoau	10									1
Waikoikoi	8	7	23		23	3.1	0.81	0.25	0.6	3
Waikokomuka	2									1
Waikokowai	1									1
Waikonini	8									4
Waikuku	2									1
Waikumete	1	2	95	720	26	7.4	0.40	0.10	0.6	2
Waikune	6									4
Waikura	2									1
Waimahaka	2									1
Waimai	11									1
Waimairi	6									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Waimakariri	11	7	15	1209	19	3.0	0.87	0.65	0.5	1
Waimamaku	2									1
Waimana	10									1
Waimangarara	11									1
Waimangaroa	3	1	43	745	33	6.4	0.60	0.38	0.6	4
Waimangu	10									1
Waimarama	2									1
Waimarino	9	3	56	818	20	5.4	0.63	0.08	0.2	1
Waimate North	7	2	64	840	53	7.9	0.41	0.05	0.6	1
Waimatenui	4									3
Waimatuku	2	1	47		31	3.1	0.66	0.18	0.6	1
Waimea	11									1
Waimiha	10	3	70		3	9.3	0.65	0.07	0.4	1
Waimonga	2	1	31		9	2.9	0.87	0.56	0.6	1
Waimumu	8	7	39			5.5		0.18	0.6	3
Waingaro	2									1
Wainui	2	7	33		25	4.7	0.72	0.42	0.6	1
Waioeka	3									4
Waioho	3									4
Waiohotu	1	2	91	545	14	10.8	0.43	0.08	0.6	1
Waione	10									1
Waiora	9									1
Waiotaka	3									4
Waiotapu	2									1
Waiotira	2									3
Waiotu	7									1
Waiouru	1									1
Waiowhiro	11									3
Waipa	11									1
Waipahihi	10	3	53	790	24	6.0	0.61	0.08	0.2	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Waipaoa	11	7	18		23	3.0	0.83	0.59	0.6	1
Waipapa	3	1	70	865	47	9.0	0.39	0.06	0.8	4
Waipara	8	7	18	1160	14	2.1	0.91	0.39	0.6	3
Waipatiki	2									1
Waipawa	8									2
Waipikaho	9									1
Waipori	2	1	44		13	4.7	0.74	0.33	0.6	3
Waipoua	4	2	63			47.5		0.02	1	1
Waipu	3									4
Waipukurau	8									4
Waipumuka	10	3	41	945	8	5.2	0.78	0.12	0.4	3
Waipuna	3									4
Waipunga	11									1
Wairakau	1									1
Wairakei	10									1
Wairaki	2									1
Wairama	2									1
Wairangi	2	1	58		37	3.2	0.58	0.47	0.8	1
Wairau	11	7	11	1298	20	1.8	0.91	0.67	0.2	1
Wairere	1									1
Wairiki	13									1
Wairongoa	3									4
Wairua	3									4
Waita	9	4	25	1370	6	9.8	0.80	0.06	0.2	3
Waitaha	2									1
Waitahanui	2									1
Waitahuna	8									3
Waitaia	11	1	32			7.6		0.44	0.6	3
Waitakaruru	2									4
Waitakere	4									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Waitaki	8									2
Waitanguru	1									1
Waitarere	11	7	19	827	5	9.2	0.84	0.35	1	1
Waitaria	11									1
Waitata	2	1	45		37	3.9	0.63	0.43	0.7	1
Waitataura	11									1
Waitati	11									1
Waitawa	2									3
Waitekauri	10									1
Waitemata	1									1
Waitemokia	4									1
Waitepeka	6									4
Waiterere	11									1
Waites	9	1	9	853	11	12.9	0.79	0.10	0.6	4
Waiteti	9									1
Waitetuna	1									1
Waiti	11									1
Waitoa	3	1	58	829	25	6.5	0.57	0.13	0.6	4
Waitohi	8									4
Waitohu	2	1	49	1081	27	4.2	0.65	0.24	0.6	3
Waitomo	5									1
Waitomokia	4	2	38		31	4.2	0.68	0.40	0.6	1
Waituna	11									1
Waitutu	9	4				37.5			0.53	4
Waiuta	9	4	5		7	4.6	0.96	0.08	0.5	3
Waiwhare	10									1
Waiwhetu	3	1	31			3.2		0.34	0.5	4
Wakamarama	2	1	73		29	6.7	0.49	0.25	0.6	1
Wakanui	8	7	22	1210	28	3.0	0.79	0.68	0.6	3
Wakapuaka	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Wakarara	2									1
Wakatu	2									1
Waldronville	3									4
Wallaby	9									3
Wanaka	8									2
Wandle	8									3
Wangaloa	2									1
Wangapeka	11									1
Wangara	1									1
Wanstead	8									3
Wantwood	2	1	26	985	41	4.8	0.67	0.52	0.8	1
Waratah	5									1
Ward	5									3
Warea	1	2	95	650	26	11.4	0.34	0.16	0.4	1
Warepa	8	1	28			3.7		0.28	0.6	4
Warkworth	13									1
Warrington	8									3
Warwick	8	7	8		17	2.7	0.91	0.63	0.6	2
Waterfalls	11									1
Waterloo	2									1
Waterton	3									4
Weber	2	1	46	870	18	4.0	0.72	0.21		1
Wehenga	2	1	46		15	4.9	0.71	0.29	0.6	3
Weka	11									1
Weld	8									1
Wendon	2									1
Wendonside	2									2
Weraroa	1									1
Wesport	11									3
Westmere	5	1	36	1041	28	4.7	0.69	0.23	0.4	1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Weston	11									3
Wetherburn	12									1
Wetherston	5									1
Weydon	3									4
Weymouth	4	1	58		41	4.4	0.54	0.35	0.8	1
Whaka	2									1
Whakaki	3									4
Whakamarama	9	4	72	734	8	9.2	0.59	0.04	0.4	1
Whakapai	4									1
Whakapapa	9									1
Whakarewarewa	10									1
Whakaroro	2									1
Whakatane	10	2				4.2				1
Whakawai	2									1
Whananaki	2									1
Whangaehu	8	7	16			2.9		0.41		3
Whangai	2									1
Whangamaire	3									4
Whangamarino	6									4
Whangamata	1									2
Whangamoa	2									1
Whangamomona	11									1
Whangaparaoa	11									1
Whangape	2									3
Whangapoua	1									1
Whangaripo	13									3
Wharangi	13									1
Wharanui	8									1
Whareama	2									2
Whareatea	2									1

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Wharekahlka	2									1
Wharekaka	8	7	17			3.2		0.25	0.6	2
Wharekohe	13	4	5	862	11	5.2	0.92	0.04	0.4	4
Wharenui	10									1
Whareora	2									3
Wharepaina	3	1	41	760	86	4.6	0.46	0.11	0.6	4
Wharepuhunga	2									1
Wharerata	11									1
Wharere	3	1	56	724	14	10.9	0.59	0.07	0.5	4
Wharetoa	8									3
Whatapaka	3	1	77			9.6		0.34	0.6	4
Whatatiri	2									1
Whatawhata	2									1
Whatitiri	2	2	42			4.6		0.02	0.6	1
Whatoro	4									1
Wheadons	2									1
Whenuaroa	10	3	40	740	28	7.5	0.62	0.10	0.2	1
Whetukura	2	1	29			4.4		0.17		1
Whirinaki	2									3
Whitcombe	2	1	40		41	6.8	0.58	0.36		3
White Cone	11									1
Whiterig	2	1	38	579	24	12.0	0.59	0.17	0.6	1
Whitestone	2									1
Whitianga	1									1
Wickliffe	3									4
Wilder	2									1
Wilford	8	7	14			5.0		0.56		3
Williton	3									4
Willowbridge	11									1
Willowburn	6									4

Series Name	Soil order	Soil group	ASC	BD	Clay	Carbon	Structural integrity	Kc	Hydrological class	Drainage Class
Willowby	3									4
Windermere	6									4
Windley	2									1
Wingate	8	1	17	869	18	5.8	0.80	0.29	0.6	4
Wingatui	11	7	34	1135	25	3.0	0.76	0.59	0.6	1
Winton	8									1
Wiremu	1									1
Witako	3									4
Wither	8									2
Wolds	8	7	11		23	4.6	0.82	0.64	0.4	1
Woodbank	8									3
Woodbourne	8	7	17	1314	24	2.3	0.85	0.61	0.6	2
Woodhaugh	11									3
Woodhen	3									4
Woodlands	2									3
Woodlaw	2									1
Woodpecker	2									1
Workings	2									1
Wyndham	2									3
Yankee	2									3
Yncyca	2									1
Younghill	12									2