Soil Properties in the Koromiko Area

Technical Report No: 14-007
November 2014

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MDC Technical Report No: 14-007

ISSN 1179-819X (Online)

ISBN 978-1-927159-51-4 (Online)

File Reference/Record No: E355-004-008-05/14228058

November 2014

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Acknowledgements:

The Marlborough District Council wish to thank the landowners for providing access to their properties to allow soils to be sampled and Dr Iain Campbell for help in location of sampling sites, soil profile descriptions and comments on geomorphology of the catchments.

Executive Summary

Currently Council has detailed information for soils mapped on the Wairau Plain and the lower Awatere Valley. For the rest of Marlborough we have very little or more often no soils information available. An example is the Koromiko area where there is no available information on important soil parameters such as water holding capacity, drainage, soil depth and permeability. This information is critical if we want to help landowners manage their soils for activities such as irrigation scheduling, effluent application, stock management etc. Furthermore, a range of models such as OVERSEER, SPASMO and the Dairy Pond Calculator require accurate soils information to help predict things like nutrient losses from soils, water availability and the suitability of soils for effluent application.

Because soils act as buffers to capture and store nutrients and microbes, treat a range of waste products and store and filter water, accurate soils information is critical. Council, industry and landowners require this information to maintain and enhance water quality, accurately allocate/use water and protect our important soil resources.

The aim of this project was therefore to describe and sample soils from representative sites in the Koromiko area and undertake a range of analysis for both topsoil and subsoils. This information will be summarised into fact sheets and made available to landowners in the region and be available for incorporation into various models used by Council and industry to ensure the most efficient use and protection of our natural resources.

A series of soil auger observations were made across a range of sites in the Koromiko area to identify the dominant soil types. Twenty one soil profiles were described and top and subsoils sampled and analysed for a range of soil physical and chemical properties.

The Koromiko, Manaroa and Kaituna family of soils occurs on the valley floor with some on the fan foot slope. The Rai family and Ronga family occurs on hilslope and stream levee, respectively.

The Kaituna, Rai and Ronga soils were generally well or moderately drained, moderately rapid permeability and have high water storage capacities. capacities. These properties make the soils generally lower risk in terms of direct losses from land application of effluent because of their ability to store and treat effluent The Koromiko and Manaroa soils were poorly or imperfectly drained, slow to moderately slow permeability and have high water storage capacities. These properties make the soils generally higher risk in terms of direct losses from land application of effluent because of their ability to store and treat effluent. Detailed, farm scale soil mapping (i.e. 1:5,000) would help separate soils within the families which aren't as well drained or those with lower permeabilities and should be done on site specific basis when categorising the soil for effluent or irrigation application.

Contents

1. Introduction

Currently Council has detailed information for soils mapped on the Wairau Plain and the lower Awatere Valley. This information has been compiled by Landcare Research into soil fact sheets which summarise key properties (e.g. water holding capacity, soil depth, texture) for a particular soil that can be used to help landowners better manage their soils. For the rest of Marlborough we only have very little or more often no soils information available. An example is the Koromiko and Tuamarina district where there is no available information on important soil parameters such as water holding capacity, drainage, soil depth and permeability. This information is critical if we want to help landowners manage their soils for activities such as irrigation scheduling, effluent application, stock management etc. For example, you need to know how much capacity a soil has to assimilate effluent or irrigation and at what rate you can apply it without it ponding or running offsite. In addition, detailed soil physical information is also central to many models Council and industry use to make decisions on how to manage our natural and physical resources. For example the latest version of the nutrient budget model OVERSEER requires topsoil and subsoil texture information to help predict nutrient (nitrate) losses from soils. The irrigation scheduling tool SPASMO requires a comprehensive set of soil physical and hydraulic properties to calculate a soil water balance including soil texture, bulk density, water holding capacity and drainage class. Likewise the Dairy Pond Calculator being promoted by Dairy NZ and Regional Councils to farmers to help manage dairy effluent application requires information on soils to help determine pond storage requirements.

Because soils act as buffers to capture and store nutrients and microbes, treat a range of waste products and store and filter water, accurate soils information is therefore critical. Council, industry and landowners require this information to maintain and enhance water quality, accurately allocate/use water and protect our important soil resources.

The purpose of the soil investigation in Tuamarina Valley is to obtain data on a range of soil properties to assist both Farmers and Council in the processes of land management. Data from the soil samples that have been collected will provide information on a range of soil chemical properties and also some soil physical properties including bulk density, porosity and water capacity, which are important in respect of stock management and the disposal of effluent by irrigation.

1.1 Aim

The aim of this project is therefore to describe and sample soils from representative sites in the Koromiko area and undertake a range of analysis for both topsoil and subsoils. This information will be summarised into fact sheets and made available to landowners in the region. The information will also be available for incorporation into various models that Council and industry uses to help protect and manage our natural resources.

2. Material and Methods

2.1 Sites

Soil samplings were carried out from 21 sites along the lower lying land of the Tuamarina Valley system (Figure 1). The sites were spread across the district and covered the area from the northern end in the vicinity of Mt Pleasant to the southern end in the vicinity of Para Road while also extending into the small side valleys to the east and west. As well providing a geographical coverage of the area, the sampling sites were chosen to give representation to topographical differences within the valley floor system.

At each sampling locality, the specific sampling site was randomly selected as being representative of the immediate area, while avoiding obvious low or high spots in the landscape. At each site, a series of auger observations were made to confirm a measure of soil uniformity across the immediate landscape, although stony soils or soils with a shallow depth to gravel were avoided in order to ensure satisfactory bulk density ring samples could be obtained.

2.2 Soil Sampling

At each site, a 30m transect was laid out and at the 15m mark, a soil pit was excavated to approximately 1m depth where possible and the soil profile described and photographed. Topsoil (0cm-7.5cm depth) core samples were obtained at 2m intervals along the 30m transect and bulked for soil chemical analyses. At the pit site, a topsoil (0cm-7.5cm depth) ring sample was obtained for physical analyses and a similar subsoil sample (at variable depth depending on the soil horizon position) was obtained, along with a bulk sample (25-35cm depth) for soil chemical analyses. The soil cores were removed as one unit by excavation around the liner, bagged and loaded into padded crates for transport to the laboratory for analysis.

2.3 Soil Analyses

2.3.1 Chemical

All soil chemical analysis was undertaken by Hills Laboratory, Hamilton. Soil pH was measured in water using glass electrodes and a 2:1 water to soil ratio (Blackmore et al., 1987). Total carbon and nitrogen were determined by dry combustion of air-dry soil using a LECO 2000 CNS analyser (Blakemore et al., 1987). Olsen P was determined by extracting soils for 30 min with 0.5 M $NaHCO_3$ at pH 8.5 (Olsen, 1954) and measuring the phosphate concentration by the molybdenum blue method. Exchangeable cations i.e. Ca, Mg, K and Na were determined by extraction in ammonium acetate at pH 7 and analysed by ICP-OES. Anion storage capacity (Phosphate retention) was determined by equilibrium with 0.02 M potassium phosphate and analysis by ICP-OES. Anaerobically mineralisable nitrogen (AMN) was estimated by the anaerobic incubation method. The increase in NH_4-N concentration was measured after incubation for 7 days at 40 ºC and extraction in 2 M KCl (Keeney and Bremner, 1966). Trace element concentrations in soils i.e. total recoverable copper, chromium, cadmium, arsenic, mercury, lead, nickel and zinc were determined by digesting soils in nitric/hydrochloric acid and analysing trace elements in the digest by inductively coupled plasma mass spectrometry (US EPA 200.2).

2.3.2 Physical

Soil physical analysis was undertaken by Landcare Research in Hamilton. Dry bulk density was measured on undisturbed soil cores dried in an oven at 105°C until the weight remained constant and the sample was then weighed (Gradwell and Birrell, 1979). Particle density was measured by the pipette method. Soil water moisture content was determined at -5, -10, -100 and -1500 kPa tensions. This data was used to calculate Total Available Water (TAW) at the 0-30mm and 0-60mm soil depth. Total Available Water is the amount of water (in mm) that can be extracted between field capacity (-10kPa suction) and permanent wilting point (-1500 kPa). Total available water is effectively a measure of the amount of water storage there is in a soil. The capacity is affected by a range of soil properties including soil texture, structure, organic matter content, soil depth, profile layer and stone content.

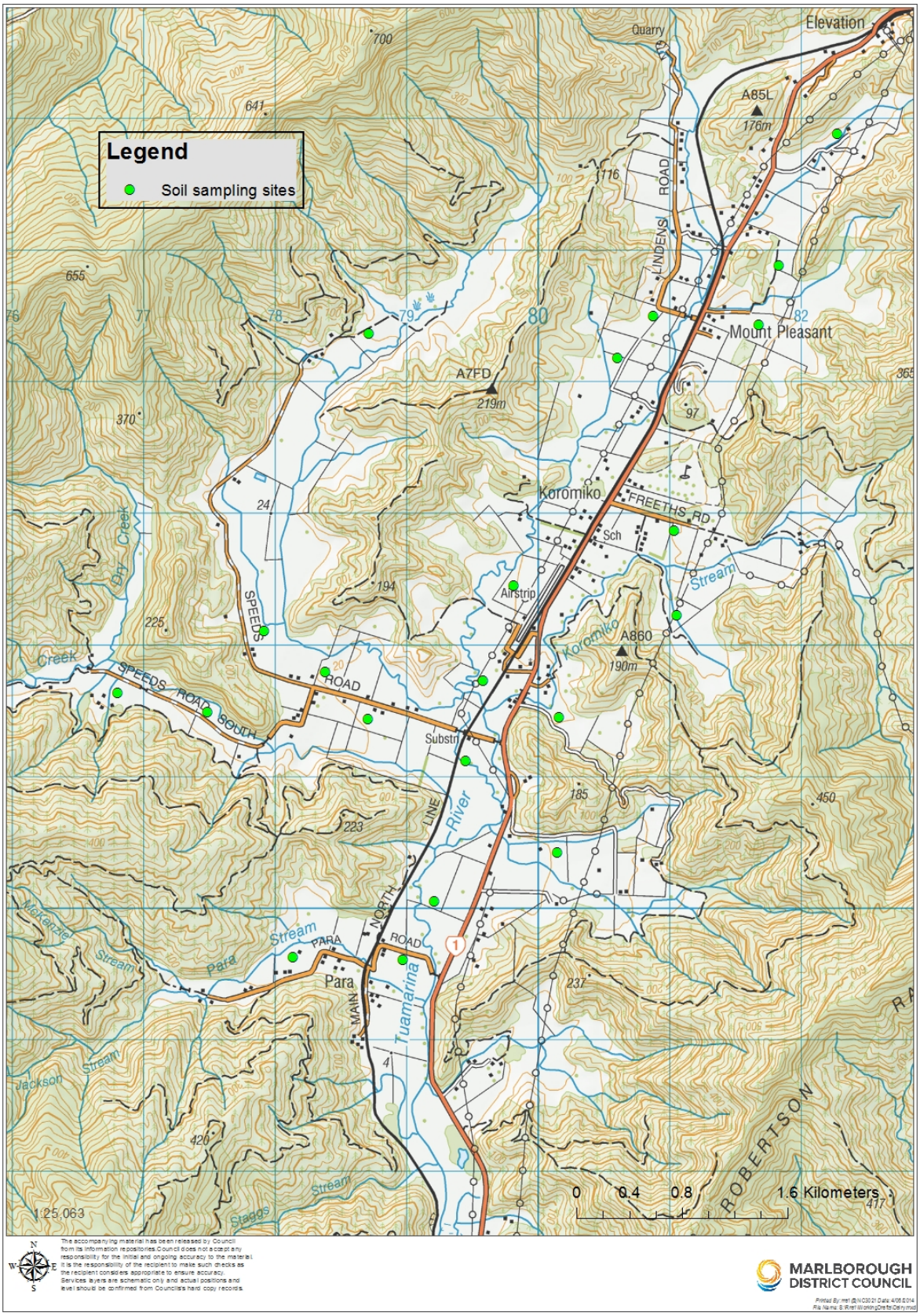

Figure 1. Location of soil sampling sites

3. Results and Discussion

3.1 General setting

The Tuamarina Valley is approximately 15km long with a general north/south alignment that lies between two rows of hills with elevations of between about 600-1000m. The valley bottom is narrow, typically less than 1km wide with small side valleys that extend into a lower elevation partly dissected landscape. The valley floor is for the most part flat with a low angle slope (35m elevation near Mt Pleasant to 4m elevation near Para Road; approximately 0.6º per km). Because of its low lying nature, the valley floor is susceptible to flooding, as evidenced from flood debris along fence lines, which indicates that floodwaters had reached more than 1m above existing ground levels in a recent storm event. The shorter side valleys have a somewhat steeper grade but with relatively little entrenchment of the streams.

Tuamarina Valley differs from other areas in the Marlborough Sounds region in that there is no clearly defined system of terraces and fans present on the lower slopes of the valley sides. In the Linkwater, Kaituna and Rai Valley systems (areas that were studied in recent years) valley side terrace remnants with their gravelly deposits provide evidence of past cycles of climatically related aggradation and subsequent degradation. These higher and older surfaces have soils that are more weathered than those on the valley floors. In contrast, the surface sediments on the Tuamarina Valley floor in places sharply abut against the steeply sloping valley sides, suggesting that the valley floor system represents an aggrading sedimentary phase. Drill log data from some sites on the Tuamarina Valley floor support a similar conclusion. In places, bedrock appears to be present more than 30m below the present ground surface (and below present sea level). Downcutting probably took place during the last glacial period when sea level was 120m lower and with subsequent rising base levels, valley infilling has taken place and seems to be continuing. The drill log records show layers of gravels separated by finer sediments and these sedimentary sequences are probably indicative of the climatic fluctuations that have occurred since the Last Glacial Cold Period beginning about 26,000 yrs BP. The Tuamarina Valley floor sediments therefore appear to represent a period of geologically Recent but continuing sedimentation.

The materials forming the soils on the Tuamarina valley floor have originated either from Pelorus Group greywacke argillite rocks or from Marlborough Schist Group rocks, both of which occur within the Tuamarina catchment. In addition, it is likely that the soil materials would include loessial material, which was widely deposited over landscapes in the Marlborough coastal regions in the last glacial period but which has been largely removed from the steeper slopes by subsequent erosion. The proportions of greywacke and schist in the Tuamarina Valley soils vary according to their proximity to the specific source rocks. Higher-grade schist (chlorite III) occurs on the western side of the catchment and lower grade schist and greywacke argillite on the eastern side. The petrological content of the soil materials thus varies within the Tuamarina Valley.

3.2 Previous soil investigations

There are no known existing soil maps of the Tuamarina Valley, apart from the 1:250 000 soil map (Soils of South Island, New Zealand Soil Bureau Bulletin 27 New Zealand Soil Bureau 1968). This mapping took place at a reconnaissance scale in the 1960s and the soils that were identified are only representative of the general landforms and parent rocks in the district. The existing information gives only a brief description of the key soil forming factors and soil properties and is not definitive enough to allow an accurate assignment of the various soils found in Tuamarina Valley into recognised classes. The existing 1:250 000 soil map identifies just two soils for the soils on the valley floor; Kaituna set 34a, (well to moderately well drained soils from schist/greywacke alluvium on valley floor surfaces) and Koromiko set 34e (imperfectly or poorly drained soils on greywacke/schist alluvium on valley floor surfaces).

The 1:250 000 survey of the Soils of South Island recognised four soil sets on the valley floors and terraces within the Marlborough Sounds area; Ronga soils on recent alluvium on the valley floors, well drained to moderately well drained Kaituna soils on the valley floors and low terraces; imperfectly and poorly drained Manaroa and Koromiko soils on valley floors and low terraces an well drained Rai soil soils on older terraces and fans.

3.3 Soil Characteristics

In this investigation detailed soil profile descriptions were collected at each site (Appendix B). From each soil profile basic soil chemistry, trace elements and soil physical data was also collected from both topsoil and subsoils (Appendix A).

3.4 Tuamarina Valley soils

Detailed soil mapping in Tuamarina Valley (i.e. 1:10 000 scale) would result in a greater subdivision of the soils based on the main parent material differences (schist, greywacke, schist/greywacke mixture), on the soil age or soil weathering differences as expressed by the soil horizon development and depth of weathering (in general terms older terraces and fans, lower terraces and fans and floodplain surfaces) and on drainage differences (well drained, moderately well drained, imperfectly drained and poorly drained soils). Additional subdivisions based on soil depth (shallow depth to gravel, moderately deep and deep soils) would also be recognised.

In the absence of a detailed name system for Tuamarina Valley soils, the soils that were examined and sampled are grouped into the broad classes that were separated in the General Survey of the Soils of South Island as follows: Rai family (1), Ronga family (1) Kaituna family (6) Manaroa family (9) the Koromiko family (4).

3.4.1 Rai soil

The soil at Site 2 is formed on a sloping hill footslope and is probably somewhat older and more weathered than most of the soils on the valley floor. Although it is formed on schist rather than greywacke material, it is tentatively included within the Rai family because of similarities in the weathering profile with Rai soils elsewhere. The soil is deep with strongly to moderately developed structure and dark yellowish brown colour. The Rai soils are derived from schist slope detritus. It is likely that there will be a few other small areas of this soil in the Tuamarina catchment on the low easy sloping hilly areas where schist materials are present.

Figure 2. A sloping hill footslope surface on which the Rai family of soils occur.

The soil physical and chemical properties for the Rai family soils sampled are given in Table 1. **T**he Rai soils are well drained, deep soils with a moderate permeability. Topsoil textures are heavy silt loams to silt loams at depth.

Total available water was calculated for both the 0-30cm and 0-60cm soil depths. The 0-30 cm soil depth is particularly useful for soils where effluent is applied where the aim is to retain effluent within the root zone, while the deeper 0-60cm soil depth is useful for scheduling irrigation. For both soil depths storage capacity was classed as high.

Topsoil phosphate retention for the Rai soil was classed as medium. Phosphate retention is a measure of the ability of the soil to remove phosphorus from solution, holding onto it firmly, tending to make it 'slowly' available to plants. High P-retention values indicate that plants will give a lower response to the same amount of phosphate fertiliser than those plants on a soil with low P-retention.

Topsoil cadmium concentrations were approximately background concentrations (0.16 mg/kg) found in soils (Roberts et al. 1994).

Table 1. Soil properties for the Rai family of soils

Overview	
Family:	Rai
Soil Classification:	Typic Orthic Brown
Parent material origin:	Schist slope detritus
Average Physical properties	
Texture:	Silty
Potential rooting depth:	>90cm
Soil depth:	Deep
Drainage class:	Well
Permeability:	Moderate
Topsoil stones:	Stoneless
Top 30cm available water: (0-30cm)	88mm (range 84– 92mm)
Top 60cm available water: (0-60cm)	127mm
Topsoil bulk density:	1.0 g/cm3
Subsoil bulk density:	1.3 g/cm3
Chemical properties	
Topsoil organic matter:	4.7%
Topsoil P retention:	Medium (37%)
Topsoil cadmium:	0.17 mg/kg

3.4.2 Ronga soil

The soil at site 16 is included with the Ronga family, which embraces the soils formed on recent deposits of stream alluvium within the floodplain system of the streams and rivers within the Marlborough Sounds region. Soils of the Ronga family typically have weakly developed soil profiles, due to the recent nature of the alluvial deposition, commonly with thin topsoils and little weathered subsoils and may have older buried A horizons that provide evidence of the sedimentation history since the time of European settlement. Charcoal fragments are sometimes present in the subsoil and are indicative of early land use management practices when burning was widely used. Soil drainage conditions vary greatly but with deeper well drained soils commonly found on levees near the streams and soils with drainage impediments in the depressions or back-swamps further away.

Soil physical and chemical properties for the Ronga family soils sampled are given in Table 2. The soil at site 16 has a thin, weakly structured topsoil and overlies light olive brown weakly structured silt loam. Beneath is yellowish brown heavy silt loam, which formed the subsoil of an earlier soil prior to its burial with younger alluvium. The yellowish red and brownish grey mottles are indicative of impeded subsoil drainage with water at 90cm being noted at the time of sampling.

Figure 2. A valley floor surface on which the Ronga family of soils occur.

Total available water was calculated for both the 0-30cm and 0-60cm soil depths. The 0-30 cm soil depth is particularly useful for soils where effluent is applied where the aim is to retain effluent within the root zone, while the deeper 0-60cm soil depth is useful for scheduling irrigation. For both soil depths storage capacity was classed as high.

Topsoil phosphate retention for the Ronga soil was classed as low. Phosphate retention is a measure of the ability of the soil to remove phosphorus from solution, holding onto it firmly, tending to make it 'slowly' available to plants. High P-retention values indicate that plants will give a lower response to the same amount of phosphate fertiliser than those plants on a soil with low P-retention.

Average topsoil cadmium concentrations were approximately double typical background concentrations found in soils (Roberts et al. 1994). The source of cadmium is most likely phosphate fertiliser which has been shown to contain cadmium as an incidental impurity.

Table 2. Soil properties for the Ronga family of soils

Overview	
Family:	Ronga
Soil Classification:	Fluvial Recent
Parent material origin:	Greywacke/schist alluvium
Average Physical properties	
Texture:	Silty
Potential rooting depth:	90cm
Soil depth:	Deep
Drainage class:	Moderate
Permeability:	Moderate
Topsoil stones:	Stoneless
Top 30cm available water: (0-30cm)	79mm
Top 60cm available water: (0-60cm)	141mm
Topsoil bulk density:	1.4 g/cm3
Subsoil bulk density:	1.4 g/cm3
Chemical properties	
Topsoil organic matter:	7.9%
Topsoil P retention:	Low (19%)
Topsoil cadmium:	0.32 mg/kg

3.4.3 Kaituna soils

Soils included within the Kaituna family are those at sites 4, 11, 12, 13, 14 and 15. These soils are all formed from schist alluvium or schist colluvium, predominantly in the side valleys where there is a little more slope on the valley floor and drainage is better because of slight entrenchment of the streams. The soils are deep to moderately deep with predominantly well drained profiles. The topsoils are dark yellowish brown with moderately developed polyhedral structure and overlie yellowish brown or light olive brown silt loam or clay loam with moderately blocky developed structure. At around 50-65cm, the soil passes into less weathered light olive brown silt loam with gravel sometimes present. Where subsoil is deep with heavier texture, some mottles may be present indicating a slight drainage impediment. Some of the Kaituna soils appear to be less weathered with predominantly light olive brown subsoil colours and at these sites the soil material is younger alluvium.

Figure 3. A valley floor surface on which the Kaituna family of soils occur.

Some average soil physical and chemical properties for the six Kaituna family soils sampled are given in Table 3. Typically the Koromiko soils are moderately to well drained, moderate to deep soils with a moderate permeability.

Total available water was calculated for both the 0-30cm and 0-60cm soil depths. The 0-30 cm soil depth is particularly useful for soils where effluent is applied where the aim is to retain effluent within the root zone, while the deeper 0-60cm soil depth is useful for scheduling irrigation. For both soil depths storage capacity was classed as high.

Topsoil phosphate retention for the Kaituna soil was classed as low. Phosphate retention is a measure of the ability of the soil to remove phosphorus from solution, holding onto it firmly, tending to make it 'slowly' available to plants. High P-retention values indicate that plants will give a lower response to the same amount of phosphate fertiliser than those plants on a soil with low P-retention.

Average topsoil cadmium concentrations were approximately double typical background concentrations found in soils (Roberts et al. 1994). The source of cadmium is most likely phosphate fertiliser which has been shown to contain cadmium as an incidental impurity. One Kaituna soil had a cadmium concentration approaching the suggested 0.6 mg/kg trigger value outlined in the national strategy for managing risks caused by cadmium in agricultural soils (MAF, 2011).

Table 3. Average soil properties for the Katiuna family of soils

Overview	
Family:	Kaituna
Soil Classification:	Orthic Brown
Parent material origin:	schist alluvium or schist colluvium
Average Physical properties	
Texture:	Silty/clayey-silty/skeletal
Potential rooting depth:	65cm to >1m
Soil depth:	Moderate to Deep
Drainage class:	Moderately to well
Permeability:	Moderate
Topsoil stones:	Stoneless, some with stones
Top 30cm available water: (0-30cm)	98mm (range 74 – 125mm)
Top 60cm available water: (0-60cm)	163mm (range 130 – 206mm)
Topsoil bulk density:	1.0 g/cm3
Subsoil bulk density:	1.3 g/cm3
Chemical properties	
Topsoil organic matter:	1.6 - 8.1%
Topsoil P retention:	Low (28%)
Topsoil cadmium:	0.42 mg/kg

3.4.4 Manaroa soils

Soils included in the Manaroa family are those from sites 1, 3, 6, 7, 8, 9, 17, 19 and 21. They are characterised by their predominantly imperfect drainage, which is indicated by the predominance of grey and reddish or brownish coloured distinct mottles in the lower subsoil horizons. The topsoils are dark yellowish brown to brown with moderately to weakly developed polyhedral structure while the upper subsoils are mainly paler coloured (light yellowish brown, pale yellow or light olive brown) generally with weakly developed blocky structure. The lower subsoils are generally compact and have coarse mottles with contrasting strong brown and greyish colours. Soil textures are mainly clay loam. The Manaroa family includes soils formed from mixed schist/greywacke alluvium as well as those from greywacke alluvium. Some of the differences observed between the Manaroa soils that were sampled may be related to parent material differences but a detailed survey would be needed to confirm this.

Figure 4. A valley floor surface on which the Manaroa family of soils occur.

Some average soil physical and chemical properties for the nine Manaroa family soils sampled are given in Table 4. Typically the Manaroa soils are generally moderately slow to imperfectly drained, moderately deep to deep soils with a slow to moderately slow permeability.

Total available water was calculated for both the 0-30cm and 0-60cm soil depths. The 0-30 cm soil depth is particularly useful for soils where effluent is applied where the aim is to retain effluent within the root zone, while the deeper 0-60cm soil depth is useful for scheduling irrigation. For both soil depths storage capacity was classed as high.

Topsoil phosphate retention for the Manaroa soil was classed as low. Phosphate retention is a measure of the ability of the soil to remove phosphorus from solution, holding onto it firmly, tending to make it 'slowly' available to plants. High P-retention values indicate that plants will give a lower response to the same amount of phosphate fertiliser than those plants on a soil with low P-retention.

Average topsoil cadmium concentrations were approximately double typical background concentrations found in soils (Roberts et al. 1994). The source of cadmium is most likely phosphate fertiliser which has been shown to contain cadmium as an incidental impurity.

Table 4. Average soil properties for the Manaroa family of soils

Overview	
Family:	Manaroa
Soil Classification:	Mottled Orthic Brown
Parent material origin:	schist/greywacke alluvium
Average Physical properties	
Texture:	Silty/clayey, clayey, silty/skeletal
Potential rooting depth:	60 – 75cm
Soil depth:	Moderate to Deep
Drainage class:	Moderately slow to imperfect
Permeability:	Slow to moderately slow
Topsoil stones:	Stoneless, some with stones
Top 30cm available water: (0-30cm)	85mm (range 39 – 126mm)
Top 60cm available water: (0-60cm)	137mm (range 99 – 185mm)
Topsoil bulk density:	1.1 g/cm3
Subsoil bulk density:	1.4 g/cm3
Chemical properties	
Topsoil organic matter:	2.8 - 10.3%
Topsoil P retention:	Low (27%)
Topsoil cadmium:	0.3 mg/kg

3.4.5 Koromiko soils

Soils included within the Koromiko family are those from sites 5, 10, 18 and 20. Koromiko soils were mapped in the 1:250 000 survey in low lying areas of the valleys in the Marlborough Sounds region where water tables are higher and drainage impeded because of low elevation. The Koromiko soils are derived from schist alluvium. They are characterised by a predominance of pale soil profile colours with brownish or reddish mottles that may extend into the topsoil. The topsoils are very dark greyish brown with weakly developed polyhedral structure, sometimes mottled, while subsoils are pale olive to light olive grey coloured with yellowish brown to strong brown coarse mottles. Soil textures vary from heavy silt loam to clay loam and at the time of sampling, water was present in the profiles at most sites.

Figure 5. A valley floor surface on which the Koromiko family of soils occur.

Some average soil physical and chemical properties for the four Koromiko family soils sampled are given in Table 1. Typically the Koromiko soils are generally poorly drained, deep soils with a slow to moderately slow permeability. Topsoil textures are typically silt loams or heavy silt loams and textures very variable at depth ranging from heavy silt loams to heavy clay loams.

Total available water was calculated for both the 0-30cm and 0-60cm soil depths. The 0-30 cm soil depth is particularly useful for soils where effluent is applied where the aim is to retain effluent within the root zone, while the deeper 0-60cm soil depth is useful for scheduling irrigation. For both soil depths storage capacity was classed as high.

Topsoil phosphate retention for the Koromiko soil was classed as medium. Phosphate retention is a measure of the ability of the soil to remove phosphorus from solution, holding onto it firmly, tending to make it 'slowly' available to plants. High P-retention values indicate that plants will give a lower response to the same amount of phosphate fertiliser than those plants on a soil with low P-retention.

Average topsoil cadmium concentrations were approximately double typical background concentrations found in soils (Roberts et al. 1994). The source of cadmium is most likely phosphate fertiliser which has been shown to contain cadmium as an incidental impurity.

Table 5. Average soil properties for the Koromiko family of soils

Overview	
Family:	Koromiko
Soil Classification:	Mottled Orthic Brown
Parent material origin:	Greywacke/Schist alluvium
Average Physical properties	
Texture:	Silty, clayey
Potential rooting depth:	>65cm
Soil depth:	Deep
Drainage class:	Poor
Permeability:	Slow to moderately slow
Topsoil stones:	Stoneless
Top 30cm available water: (0-30cm)	106mm (range 93 – 115mm)
Top 60cm available water: (0-60cm)	164mm (range 139 – 194mm)
Topsoil bulk density:	1.0 g/cm3
Subsoil bulk density:	1.3 g/cm3
Chemical properties	
Topsoil organic matter:	5.4 - 9.4%
Topsoil P retention:	Medium (34%)
Topsoil cadmium:	0.4 mg/kg

4. Summary

- Five soil families were identified in the Koromiko area i.e. Rai, Ronga, Koromiko, Manaroa and Kaituna soils.
- The Koromiko, Manaroa and Kaituna family of soils occurs on the valley floor with some on the fan foot slope. The Rai family and Ronga family occurs on hilslope and stream levee, respectively.
- The Kaituna, Rai and Ronga soils were generally well or moderately drained, moderately rapid permeability and have high water storage capacities. capacities. These properties make the soils generally lower risk in terms of direct losses from land application of effluent because of their ability to store and treat effluent The Koromiko and Manaroa soils were poorly or imperfectly drained, slow to moderately slow permeability and have high water storage capacities. These properties make the soils generally higher risk in terms of direct losses from land application of effluent because of their ability to store and treat effluent.
- Detailed, farm scale soil mapping (i.e. 1:5,000) would help separate soils within the families which aren't as well drained or those with lower permeabilities and should be done on site specific basis when categorising the soil for effluent or irrigation application.

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Appendix A

Table A1 Soil chemical analysis from soil sampling pits

Site No.	Depth	pH	Olsen P	ASC	AMN	OM	Total C	Total N	C/N	K	Ca	Mg	Na	CEC	BS
			mg/L	%	µg/g	%	%	%		me/100g	me/100g	me/100g	me/100g	me/100g	%
Site 1	0 - 7.5 cm	5.5	17	28	192	10.3	6	0.58	10.3	9	11	28	5	26	55
	25-30 cm	6	6	37	85	4.7	2.7	0.23	11.7	3	10	22	5	18	62
Site 2	0 - 7.5 cm	5.7	53	20	251	13.4	7.8	0.72	10.8	19	12	41	3	28	62
	25-30 cm	5.3	14	78	109	7.3	4.3	0.39	11.0	12	4	16	2	19	29
Site 3	0 - 7.5 cm	5.6	33	20	270	8.3	4.8	0.53	9.1	7	10	24	3	23	58
	25-30 cm	5.3	1	49	24	3.1	1.8	0.13	13.8	1	5	13	2	18	30
Site 4	0 - 7.5 cm	5.4	76	23	224	8.3	4.8	0.49	9.8	12	11	17	2	24	54
	25-30 cm	5.6	9	46	58	3.2	1.9	0.22	8.6	< 1	2	3	< 2	12	19
Site 5	0 - 7.5 cm	5.4	39	27	226	7.6	4.4	0.58	7.6	6	9	18	4	26	53
	25-30 cm	6	11	28	28	3	1.8	0.17	10.6	< 1	5	9	< 2	13	48
Site 6	0 - 7.5 cm	5.3	6	30	278	10.3	6	0.63	9.5	4	7	18	4	25	40
	25-30 cm	5.5	< 1	54	30	1.3	0.8	0.06	13.3	1	2	14	5	18	16
Site 7	0 - 7.5 cm	6.2	7	18	268	9.2	5.4	0.43	12.6	7	14	23	4	23	71
	25-30 cm	5.4	< 1	47	34	1.3	0.7	0.07	10.0	11	3	5	< 2	16	21
Site 8	0 - 7.5 cm	5.5	27	20	266	8.5	4.9	0.53	9.2	11	10	45	5	25	58
	25-30 cm	5.9	3	38	42	3.8	2.2	0.16	13.8	2	9	15	5	21	46
Site 9	0 - 7.5 cm	5.7	22	19	242	8.9	5.2	0.56	9.3	7	12	42	4	23	66
	25-30 cm	5.7	1	37	40	2.8	1.6	0.13	12.3	2	8	57	5	19	55
Site 10	0 - 7.5 cm	5.9	20	23	184	5.4	3.1	0.4	7.8	7	11	38	6	23	60
	25-30 cm	5.8	2	30	34	2.2	1.2	0.17	7.1	2	7	22	5	17	48
Site 11	0 - 7.5 cm	5.4	33	22	153	8	4.6	0.42	11.0	18	7	17	3	21	52
	25-30 cm	5.3	4	29	29	3	1.8	0.15	12.0	6	2	4	3	13	23
Site 12	0 - 7.5 cm	5.9	35	< 15	138	8.1	4.7	0.47	10.0	9	9	29	5	21	65
	25-30 cm	5.9	8	22	37	2.5	1.4	0.1	14.0	< 1	3	5	3	10	37
Site 13	0 - 7.5 cm	5.5	2	41	44	1.6	1	0.09	11.1	7	2	8	< 2	13	21
	25-30 cm	5.4	4	30	218	10.8	6.3	0.53	11.9	8	4	20	2	20	32
Site 14	0 - 7.5 cm	5.9	34	36	211	8.4	4.9	0.54	9.1	7	13	24	3	23	67
	25-30 cm	5.4	3	41	50	2.8	1.6	0.12	13.3	1	10	21	< 2	20	53
Site 15	0 - 7.5 cm	5.4	46	18	167	7.9	4.6	0.49	9.4	15	7	18	3	18	50
	25-30 cm	5.1	9	46	40	4.1	2.4	0.22	10.9	3	1	3	< 2	14	12
Site 16	0 - 7.5 cm	6	38	19	165	7.9	4.6	0.44	10.5	6	9	22	3	20	61

Site No.	Depth	pH	Olsen P	ASC	AMN	OM	Total C	Total N	C/N	K	Ca	Mg	Na	CEC	BS
	25-30 cm	4.8	4	44	61	4.2	2.4	0.29	8.3	7	3	6	< 2	19	22
Site 17	0 - 7.5 cm	5.6	2	41	31	2.8	1.6	0.12	13.3	2	9	23	< 2	20	50
	25-30 cm	5.3	18	36	265	8.7	5	0.5	10.0	6	8	27	3	26	45
Site 18	0 - 7.5 cm	5.3	30	42	324	9.4	5.4	0.53	10.2	6	8	31	4	24	47
	25-30 cm	5.7	2	30	44	1.7	1	0.13	7.7	5	6	37	5	12	63
Site 19	0 - 7.5 cm	5.5	26	32	216	9.7	5.6	0.57	9.8	5	9	31	4	21	55
	25-30 cm	5.9	1	< 15	41	3.1	1.8	0.16	11.3	2	8	34	4	13	70
Site 20	0 - 7.5 cm	5.6	40	31	176	7.4	4.3	0.48	9.0	5	7	24	4	22	53
	25-30 cm	6	3	30	60	2.7	1.6	0.23	7.0	2	10	17	4	19	61
Site 21	0 - 7.5 cm	5.3	24	31	156	7.9	4.6	0.41	11.2	5	5	21	3	23	40
	25-30 cm	5.5	2	27	49	2.8	1.6	0.21	7.6	1	5	19	3	16	37

Table A2 Soil physical analysis from soil sampling pits

Site No.	Depth	Dry Bulk	Particle	Total	Macro	Air	VoM. WC	VoM. WC	VoM. WC	VoM. WC	Readily	Total
		Density	Density	Porosity	Porosity	Filled Porosity	-5kPa	-10kPa	-100kPa	-1500kPa	Available	Available
		(t/m3)	(t/m3)	(%, v/v)	(%, v/v)	(%, v/v)	(%, v/v)	(%, v/v)	(%, v/v)	(%, v/v)	(%, v/v)	(%, v/v)
Site 1	0 - 7.5 cm	1.161	2.6	55.4	2.5	4.8	52.8	50.6	40.9	26	9.6	24.6
	0 - 7.5 cm	1.186	2.6	54.4	9.2	11.6	45.1	42.8	34.5	23.8	8.3	19
	22-29.5 cm	1.421	2.7	47.4	5.4	6.5	41.9	40.9	36.1	29.7	4.7	11.2
Site 2	0 - 7.5 cm	1.015	2.44	58.4	2.7	4.8	55.7	53.6	46	25.6	7.6	28
	0 - 7.5 cm	1.043	2.52	58.6	5.4	7.8	53.2	50.8	43.5	20.1	7.3	30.7
	17-24.5 cm	1.328	2.66	50.1	14.3	16.4	35.8	33.7	28.2	20.8	5.5	12.9
Site 3	0 - 7.5 cm	1.064	2.59	58.9	4.3	6.1	54.6	52.8	44.4	22	8.4	30.8
	0 - 7.5 cm	1.328	2.66	50.1	14.3	16.4	35.8	33.7	28.2	20.8	5.5	12.9
	18 - 25.5 cm	1.185	2.6	54.4	2.2	3.9	52.2	50.5	44.5	24.8	6	25.7
Site 4	0 - 7.5 cm	1.242	2.64	53	4.4	6.1	48.6	46.9	38.3	22.1	8.5	24.8
	18 - 25.5 cm	1.291	2.7	52.2	10.3	12	41.9	40.2	32.3	21.8	8	18.4
Site 5	0 - 7.5 cm	1.003	2.57	61	1.1	2.7	59.9	58.3	49.5	27.5	8.8	30.9
	25 - 32.5 cm	1.172	2.71	56.8	7.3	8.6	49.5	48.2	42.7	28	5.4	20.2
Site 6	0 - 7.5 cm	0.831	2.51	66.9	1.8	5.1	65.1	61.8	49.4	20	12.4	41.8
	13 - 20.5 cm	1.294	2.65	51.2	6.8	8.6	44.4	42.6	34.6	22.7	8	20
Site 7	0 - 7.5 cm	1.144	2.59	55.8	4.2	5.4	51.6	50.4	43.5	19.1	6.8	31.3
	23- 30.5 cm	1.562	2.71	42.4	4.5	5.5	37.9	36.9	33	25.3	4	11.6
Site 8	0 - 7.5 cm	1.081	2.58	58.1	<1	2.1	58	56	46.8	23.9	9.2	32.1
	28- 35.5 cm	1.184	2.69	56	13.9	15.7	42	40.3	33.8	22.3	6.5	18

Site No.	Depth	Dry Bulk	Particle	Total	Macro	Air	VoM. WC	VoM. WC	VoM. WC	VoM. WC	Readily	Total
Site 9	0 - 10 cm	1.104	2.54	56.5	5	6.9	51.6	49.6	40.8	23.7	8.8	25.9
	20 - 27.5cm	1.469	2.68	45.2	5.7	6.7	39.5	38.5	34.5	28.9	4	9.5
Site 10	0 - 10 cm	0.976	2.61	62.6	<1	1.4	62.8	61.2	51.9	22.7	9.3	38.4
	20 - 27.5 cm	1.381	2.73	49.4	6.9	8.3	42.5	41.1	34.9	22.6	6.2	18.4
Site 11	0 - 7.5 cm	1.051	2.63	60	3.1	4.5	57	55.5	49.6	22.5	5.9	33
	22 - 29.5 cm	1.293	2.76	53.1	7	8.6	46.1	44.5	36.2	18.9	8.3	25.6
Site 12	0 - 7.5 cm	0.968	2.63	63.2	<1	2.5	62.8	60.7	48.8	19.2	11.9	41.5
	16 - 23.5cm	1.265	2.75	54	8.4	10.2	45.6	43.8	35	16.6	8.9	27.3
Site 13	0 - 7.5 cm	0.902	2.62	65.6	7.6	10.7	58	54.9	44.4	20.8	10.4	34.1
	25 - 32.5 cm	1.383	2.73	49.3	3.3	4.3	46.1	45	38.6	27.7	6.4	17.3
Site 14	0 - 7.5 cm	1.032	2.63	60.8	1.7	3.7	59	57.1	47.6	25.8	9.5	31.3
	26 - 33.4 cm	1.344	2.76	51.3	6.3	7.7	45	43.6	38.1	27.9	5.5	15.6
Site 15	0 - 7.5 cm	1.033	2.62	60.6	5.2	7.2	55.4	53.4	46.8	21.8	6.6	31.5
	23 - 30.5 cm	1.256	2.74	54.2	8.3	10.1	45.8	44.1	35	18.7	9.1	25.4
Site 16	0 - 7.5 cm	1.385	2.63	47.4	<1	<1	48.3	47.3	38.9	20.9	8.5	26.4
	17 - 24.5 cm	1.351	2.72	50.3	11.8	13.5	38.6	36.8	27.8	16.2	9	20.6
Site 17	0 - 7.5 cm	1.086	2.56	57.6	2	3.6	55.6	54	46.3	26.2	7.7	27.9
	30 - 37.5 cm	1.422	2.7	47.3	5.7	6.9	41.6	40.4	36	30.9	4.4	9.5
Site 18	0 - 7.5 cm	0.901	2.57	64.9	2.9	6.1	62	58.8	48	24.7	10.8	34.1
	22 - 29.5 cm	1.376	2.71	49.2	4.9	6.3	44.3	42.9	36.7	30.8	6.1	12.1
Site 19	0 - 7.5 cm	0.983	2.56	61.6	4	6.4	57.6	55.2	44.8	22.4	10.4	32.8
	29 - 36.5 cm	1.564	2.69	41.9	2.6	3.7	39.3	38.2	32.7	26.3	5.5	11.9
Site 20	0 - 7.5 cm	0.981	2.64	62.8	1.3	2.6	61.6	60.2	51.6	22.1	8.5	38.1

Site No.	Depth	Dry Bulk	Particle	Total	Macro	Air	VoM. WC	VoM. WC	VoM. WC	VoM. WC	Readily	Total
	25 - 32.5 cm	1.162	2.73	57.5	10	12.1	47.4	45.4	34.5	18.9	10.9	26.4
Site 21	0 - 7.5 cm	1.004	2.65	62.1	5	6.9	57.1	55.2	47.3	22.8	8	32.4
	20 - 27.5 cm	1.155	2.73	57.7	10.9	13	46.8	44.7	33.4	18.9	11.4	25.8

Table A3 Soil trace element concentrations (mg/kg) from soil sampling pits

Site No.	Depth	Zn	Cu	Cr	As	Pb	Ni	Hg	Cd
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site 1	0 - 7.5 cm	63	26	24	3.5	11.8	12.1	0.06	0.35
	25-30 cm	64	12	25	3.8	12.4	12.1	0.1	0.17
Site 2	0 - 7.5 cm	62	14	16.6	2.5	8.8	8.7	0.09	0.39
	25-30 cm	85	26	35	4.5	10.9	19.4	0.34	0.11
Site 3	0 - 7.5 cm	59	14	23	4.1	13.3	11.2	0.04	0.44
	25-30 cm	52	12	25	2.3	11.3	11.8	0.04	0.04
Site 4	0 - 7.5 cm	60	13	16.9	5.3	8.9	8.4	0.05	0.43
	25-30 cm	55	11	23	4.7	9.7	11.6	0.08	0.04
Site 5	0 - 7.5 cm	82	26	26	13.4	15	15.6	0.17	0.51
	25-30 cm	79	17	30	11.8	15.7	16.6	0.15	0.08
Site 6	0 - 7.5 cm	43	11	27	2.4	9.2	11.5	0.04	0.3
	25-30 cm	49	13	34	1.8	10.3	13.8	0.06	0.04
Site 7	0 - 7.5 cm	44	11	29	2.1	8.2	12.7	0.03	0.38
	25-30 cm	51	13	46	2.4	9.6	18.7	0.04	0.07
Site 8	0 - 7.5 cm	57	13	33	3.4	12.8	13.1	0.04	0.36
	25-30 cm	52	13	31	4.7	18.3	12	0.06	0.07
Site 9	0 - 7.5 cm	40	10	21	4.1	13.9	9.8	0.04	0.32
	25-30 cm	37	11	29	2.9	14.1	11.8	0.06	< 0.02
Site 10	0 - 7.5 cm	72	15	28	4	16.4	15	0.07	0.29
	25-30 cm	64	17	24	3.9	13.7	14.1	0.06	0.05
Site 11	0 - 7.5 cm	63	16	18.6	4.7	9.5	11	0.07	0.43
	25-30 cm	59	23	22	5	10.6	13.8	0.07	0.08
Site 12	0 - 7.5 cm	70	22	20	5.3	10.5	14.5	0.06	0.53
	25-30 cm	63	23	28	5.5	9.9	19.2	0.11	0.1
Site 13	0 - 7.5 cm	75	19	22	3.4	9.8	12.2	0.3	0.06
	25-30 cm	61	17	19	3.2	8.9	10.9	0.19	0.13
Site 14	0 - 7.5 cm	78	23	49	3.8	8.7	25	0.4	0.54
	25-30 cm	75	26	57	4.5	9.5	29	0.34	0.09
Site 15	0 - 7.5 cm	61	19	17.4	5.6	10.3	11.3	0.06	0.52
	25-30 cm	55	18	17.3	5	10.2	10.7	0.08	0.07
Site 16	0 - 7.5 cm	60	18	16.3	5.5	10.5	11.3	0.06	0.32
	25-30 cm	72	25	22	7.1	12.5	15.9	0.1	0.07
Site 17	0 - 7.5 cm	55	15	22	2.1	11.5	10	0.06	0.05
	25-30 cm	56	13	21	2.4	10.9	10.3	0.06	0.34
Site 18	0 - 7.5 cm	37	7	19.7	2.8	9.9	9	0.06	0.34
	25-30 cm	38	8	14.3	4.3	12.1	4.6	0.07	0.03
Site 19	0 - 7.5 cm	38	8	18.6	2.1	7	8.7	0.06	0.3
	25-30 cm	28	5	13.5	1.9	6.7	5.6	0.07	0.03
Site 20	0 - 7.5 cm	67	22	20	5.4	10.6	14.3	0.06	0.38
	25-30 cm	74	22	26	5.5	12.7	18.3	0.1	0.11
Site 21	0 - 7.5 cm	78	24	22	5.5	12.3	14.5	0.13	0.19
	25-30 cm	66	22	19.6	5	11.8	13.9	0.13	0.05

Appendix B

Sample name: Site 1
Soil Name: Manaroa S-map sibling: Flax_88.2.2
GPS: 1682290.325 E 5426081.345 N
Land use: Deer grazing
Elevation: 53m
Slope: 0º
Soil material: greywacke colluvium
Landscape: main valley floor
Soil drainage: moderate

Horizon	Depth	Description
A	0-18cm	dark yellowish brown (10YR 4/4) clay loam; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; 2% fine and medium stones; many fine roots
AB	18-22cm	dark yellowish brown (10YR 4/4) and light yellowish brown (10YR 6/6) clay loam; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; 2% fine stones; common fine roots
B	22-36cm	light yellowish brown (10YR 6/6) clay loam; moderately developed fine polyhedral and medium blocky structure; weak soil strength; compact; friable; 2% fine to medium stones; few fine dark brown concretions
B(g)_	36-60cm	dark yellowish brown (10YR 4/6) clay to clay loam; 25% strong brown (7.5YR 5/6) and 15% pale olive (5Y 6/3) medium mottles; moderately developed medium blocky structure; weak soil strength; compact; friable; 1% fine dark brown concretions; few fine roots
Bg	60-80cm+	dark yellowish brown (10YR 4/6) clay loam; 20% strong brown (7.5YR 5/8) and 50% light grey 2.5Y 7/2) medium and coarse mottles; weakly developed coarse blocky structure; slightly firm soil strength; compact; brittle failure

Sample name: Site 2

Soil Name: Rai S-map sibling: Orono_121.1.1
GPS: 1681867.588 E 5426950.346 N
Land use: Dairy
Elevation: 40m
Slope: 7º
Soil material: schist slope detritus
Landscape: hill footslope
Soil drainage: well

Horizon	Depth	Description
A	0-19	dark yellowish brown (10YR 4/4) heavy silt loam; strongly developed fine polyhedral structure; weak soil strength; compact; very friable; 5% fine stones; abundant fine roots
AB	19-30cm	dark yellowish brown and yellowish brown (10YR 4/4 + 10YR 5/6) silt loam; strongly developed fine polyhedral structure; very weak soil strength; compact; very friable; 5% fine stones; many fine roots
Bw1	30-55cm	dark yellowish brown (10YR 5/6) silt loam; strongly developed fine and medium polyhedral structure; very weak soil strength; compact; friable; common fine roots
Bw2	55-90cm+	dark yellowish brown (10YR 5/6) silt loam; moderately developed fine polyhedral and blocky structure; weak soil strength; compact; friable; few fine roots

Sample name: Site 3
Soil Name: Manaroa S-map sibling: Parah_8.1.1
GPS: 1681745.158 E 5426487.227 N
Land use: Dairy
Elevation: 40m
Slope: 0º
Soil material: greywacke/schist alluvium
Landscape: Valley floor
Soil drainage: imperfect

Horizon	Depth	Description
A	0-18cm	brown (10YR 5/3) heavy silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; common fine roots
AB	18-22cm	brown (10YR 5/3) and pale yellow (2.5Y 7/4) clay loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; few fine roots
Bw(g)1	22-50cm	pale yellow (2.5Y 7/4) clay loam; 30% strong brown (7.5YR 5/6) fine distinct mottles; moderately developed medium polyhedral and fine blocky structure; weak soil strength; compact; friable; few fine roots
Bw(g)2	50-75cm	pale yellow (2.5Y 7/2) clay loam; 40% strong brown (7.5YR 5/6) distinct mottles; weakly developed medium blocky and polyhedral structure; slightly firm soil strength; compact; friable
BC(g)	75-90cm+	light yellowish brown (2.5Y 6/4) sandy clay loam; apedal; dense; 20% fine to medium stones

Sample name: Site 4

Soil Name: Kaituna S-map sibling: Utik_12.1.1
GPS: 1678715.821 E 5424551.671 N
Land use: Dairy
Elevation: 45m
Slope: 5º
Soil material: schist collivium
Landscape: fan upper midslope
Soil drainage: well

Horizon	Depth	Description
A	0-15cm	dark yellowish brown (10YR 4/4) silt loam; strongly developed fine polyhedral structure; weak soil strength; compact; very friable; <10% fine stones; common roots
AB	15-25cm	dark yellowish brown (10YR 5/4) and yellowish brown (10YR 5/8) silt loam; strongly developed fine polyhedral structure; very weak soil strength; compact; very friable; <10% fine stones few roots
Bw	25-42 cm	yellowish brown (10YR 5/8) silt loam; strongly developed fine polyhedral structure; weak soil strength; compact; friable; <10% fine stones; few fine roots
BC	42-66cm	yellowish brown (10YR 5/4) fine sandy loam; weakly developed medium blocky structure; weak soil strength; compact; friable; few fine roots
C	66-80cm+	dark olive (5YR 3/4) coarse sand; apedal; compact; 60% fine to coarse stones

Sample name: Site 5

Soil Name: Koromiko Hast_28.2.1
GPS: 1677932.999 E 5422320.926 N
Land use: Dairy
Elevation: 24m
Slope: 0º
Soil material: schist alluvium
Landscape: Valley floor
Soil drainage: Poor

Horizon	Depth	Description
A	0-25cm	very dark greyish brown (10YR 3/3) heavy silt loam; weakly developed fine polyhedral structure; weak soil strength; compact; friable; common fine roots
Bg1	25-35cm	pale yellow (2.5Y 7/4) heavy silt loam; 15% dark yellowish brown (10YR 3/6) fine distinct mottles; weakly developed fine blocky and polyhedral structure; weak soil strength; compact; friable; few roots
Bg2	35-50cm	pale olive (5Y 4/3) heavy silt loam; 35% strong brown (7.5YR 5/6) fine distinct mottles; moderately developed medium blocky structure; slightly firm; compact; semi-deformable failure
Bg3	50-80cm	pale olive (5Y 4/3) heavy silt loam; 25% strong brown (7.5YR 5/6) medium mottles with light grey (2.5Y N7/) down cracks; moderately developed coarse blocky and prismatic structure; slightly firm soil strength; compact; semi-deformable water at 75cm

Sample name: Site 6

Soil Name: Koromiko S-map sibling: Hast 5.2.2
GPS: 1681060.847 E 5422438.402 N
Land use: Dairy
Elevation: 41m
Slope: 2º
Soil material: greywacke/schist alluvium
Landscape: Valley floor
Soil drainage: imperfect

Horizon	Depth	Description
A	0-15cm	dark greyish brown (10YR 4/2) clay loam; 10% strong brown (7.5YR 5/6) and 10% pale yellow (10YR 7/4) fine mottles; weakly developed fine polyhedral structure; weak soil strength; compact; friable; common fine roots
B(g)1	15-30cm	pale olive (5Y 4/3) clay loam; 20% brown to dark brown (7.5YR 4/4) and 15% light grey (5Y 7/2) fine mottles; weakly developed fine polyhedral structure; weak soil strength; compact; friable; few fine roots
B(g)2	30-50cm	pale yellow (2.5Y 7/4) clay loam; 20% strong brown (7.5YR 5/6) and 15% pale olive fine mottles; moderately developed medium blocky structure; slightly firm soil strength; compact; brittle failure; few fine roots
BCg	50-85cm+	light grey (5Y 7/1) clay loam; 40% strong brown (7.5YR 5/8) medium mottles; with light grey to grey (2.5Y 6/1) in cracks; moderately developed medium blocky and prismatic structure; firm soil strength; dense; brittle failure water at 80cm

Sample name: Site 7
Soil Name: Manaroa S-map sibling: Bushc_44.1.1
GPS: 1681044.235 E 5423073.341 N
Land use: Dairy
Elevation: 40m
Slope: 0º
Soil material: greywacke/schist alluvium
Landscape: Valley floor
Soil drainage: imperfect

Horizon	Depth	Description
A	0-20cm	dark yellowish brown (10YR 4/4) silt loam; weakly developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots; <10% fine stones
AB	20-24cm	dark yellowish brown (10YR 4/4 and 6/4) heavy silt loam; weakly developed fine polyhedral and blocky structure; weak soil strength; compact; friable; <10% fine-medium stones; common fine roots
B(g)	24-41cm	dark yellowish brown (10YR 6/4) heavy silt loam; 30% strong brown (7.5YR 5/8) and 15% pale yellow (2.5Y 7/4) fine mottles; moderately developed medium blocky structure; slightly firm soil strength; compact;; brittle failure; <10% fine stones; few fine roots
BC	41-65cm	light olive brown (2.5Y 5/6) sandy silt loam; 20% strong brown (7.5YR 5/8) and 10% pale olive (2.5Y 7/4) distinct mottles; weakly developed medium blocky structure; slightly firm soil strength; compact; 20% fine to medium stones;
C	65-75+	light olive brown (2.5Y 5/6) sandy silt loam; dense

Sample name: Site 8

Soil Name: Koromiko S-map sibling: Wood_27.1.1
GPS: 1681063.164 E 5422645.642 N
Land use: Dairy
Elevation: 22m
Slope: 0º
Soil material: greywacke/schist alluvium
Landscape: Valley floor
Soil drainage: imperfect

Horizon	Depth	Description
A	0-22cm	dark yellowish brown (10YR 4/4) heavy silt loam; weakly developed fine polyhedral structure; slightly firm soil strength; compact; friable; many fine roots
AB	22-32cm	dark yellowish brown (10YR 4/4) and light olive brown (2.5Y 5/4) clay loam; weakly developed fine polyhedral structure; slightly firm soil strength; compact; semi-deformable; common roots
B(g)1	32-45cm	light yellowish brown (2.5Y 5/4) clay loam; 5% yellowish red (7.5YR 6/8) mottles and 15% black (10YR 2/1) soft concretions; weakly developed medium blocky structure; slightly firm soil strength; compact; semi-deformable; few fine roots
B(g)2	45-60cm	light yellowish brown (2.5Y 6/4) clay loam; 15% strong brown (7.5YR 5/8) medium mottles and >5% black soft concretions; moderately developed medium blocky structure; slightly firm soil strength; semi-deformable;
B(g)3	60-85cm+	light yellowish brown (2.5Y 6/4) clay loam; 40% strong brown (7.5YR 5/8) coarse mottles and >5% fine concretions with reddish centres; moderately developed medium blocky and prismatic structure; firm consistence; compact; brittle failure

Sample name: Site 9
Soil Name: Koromiko S-map sibling: Mangu_9.1.1
GPS: 1680163.375 E 5421611.906 N
Land use: Dairy
Elevation: 22m
Slope: 6º
Soil material: greywacke colluvium
Landscape: Fan foot slope
Soil drainage: imperfect

Horizon	Depth	Description
A	0-20cm	dark brown to brown (10YR 4/3-5/3) clay loam; <2% yellowish brown (10YR 6/8) and light grey (10YR 6/2) fine mottles; weakly developed fine polyhedral structure; weak soil strength; compact; friable; common roots
B	20-28cm	pale yellow (2.5Y 7/4)clay loam; 10% strong brown (7.5YR 5/6) fine mottles; weakly developed fine polyhedral structure; slightly firm soil strength; compact; friable; 5% fine and medium stones; few fine roots
B(g)	28-70cm	pale yellow (2.5Y 7/4) clay; 40% strong brown (7.5YR 5/8) and 25% light grey (2.5Y 7/2) medium mottles; moderately developed medium blocky structure; firm soil strength; compact; brittle failure; 5% fine and medium stones; few fine roots
BC(g)	70-85cm+	strong brown (7.5YR 5/8) and very pale brown coarsely mottled (10YR 7/3) clay; moderately developed coarse blocky structure; very firm; dense; semi-deformable failure

Sample name: Site 10
Soil Name: Koromiko S-map sibling: Hast 5.1.1
GPS: 1680163.375 E 5421611.906 N
Land use: Dairy
Elevation: 22m
Slope: 0º
Soil material: greywacke/schist alluvium
Landscape: Valley floor
Soil drainage: poor

Horizon	Depth	Description
A	0-22cm	dark greyish brown (2.5Y 4/2) heavy silt loam; weakly developed fine polyhedral structure; weak soil strength; compact; friable; common roots
Bg1	22-38cm	olive (5Y 5/3) heavy silt loam; <5% brown (7.5YR 5/4) fine mottles; weakly developed medium blocky structure; structure; weak soil strength; compact; friable; few fine roots
Bg2	38-70cm	light olive grey (5Y 6/2) clay loam; 25% dark brown (7.5YR 3/4) medium mottles; weakly developed medium blocky structure; slightly firm soil strength; compact; semi-deformable failure;
BC(g)	70-85cm+	75% yellowish brown (10YR 5/4), strong brown (7.5YR 5/8) and 35% light grey to grey (10YR 6/1) coarsely mottled clay; weakly developed coarse blocky structure; slightly firm; dense; brittle failure water at 70cm

Sample name: Site 11
Soil Name: Kaituna Waim 61.2.2
GPS 162 8378 E 542 1794 N
Land use: Dairy
Elevation: 29m
Slope: 0º
Soil material: schistose alluvium
Landscape: Valley floor
Soil drainage: well

Horizon	Depth	Description
A	0-20cm	dark yellowish brown (10YR 4/4) silt loam; weakly developed fine and medium polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	20-24cm	dark yellowish brown (10YR 4/4) and light olive brown (2.5Y 5/4) silt loam; weakly developed fine and medium polyhedral structure; weak soil strength; compact; friable; few fine stones; common fine roots
Bw	24-65cm	light olive brown (2.5Y 5/4) silt loam; few faint mottles; weakly developed medium blocky structure; slightly firm soil strength; compact; friable; few fine roots
BC	65-80cm+	light olive brown (2.5Y 5/4) loamy sand; apedal; 40% fine and medium stones; loose

Sample name: Site 12

Soil Name: Katuna S-map sibling: Hast_28.2.1
GPS: 177 8700 E 542 1436 N
Land use: Dairy
Elevation: 19m
Slope: 0º
Soil material: young fine textured schist alluvium
Landscape: valley floor
Soil drainage: well

Horizon	Depth	Description
A	0-16cm	dark yellowish brown (10YR 4/4) silt loam; weakly developed fine polyhedral and blocky structure; weak soil strength; compact; friable; common fine roots
B	16-65cm	light olive brown (2.5Y 5/6) silt loam; weakly developed fine polyhedral and medium blocky structure; weak soil strength; compact; friable; few fine roots
BC	65-95cm+	light olive brown (2.5Y 5/4) silt loam; weakly developed fine medium blocky structure; slightly firm soil strength; compact; friable; few fine roots

Sample name: Site 13

Soil Name: Kaituna Orono 122.1.1
GPS: E167 8120 N 541 9621
Land use: Cattle grazing
Elevation: 29m
Slope: 2º
Soil material: schistose alluvium
Landscape: valley floor
Soil drainage: well

Horizon	Depth	Description
A	0-22cm	dark yellowish brown (10YR 4/4) silt loam; moderately developed fine and medium polyhedral structure; slightly firm soil strength; compact; friable; many fine roots
AB	22-28cm	dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) heavy silt loam; moderately developed fine polyhedral structure; slightly firm soil strength; compact; friable; common fine roots;
Bw	28-68cm	yellowish brown (10YR 5/6) heavy silt loam; moderately developed coarse blocky structure; slightly firm soil strength; compact; brittle failure; few fine and medium stones; few fine roots
BC	68-80cm	yellowish brown to light olive brown (10YR 5/6-2.5Y 5/6) silt loam; weakly developed coarse blocky structure; weak soil strength; compact; friable; few fine roots
C	80-95cm+	light olive brown (2.5Y 5/4) sandy silt loam; apedal; 15% fine and medium stones; loose

Sample name: Site 14

Soil Name: Kaituna S-map sibling: Gorg 8.1.1
GPS: 1676826.046 E 5421821.976 N
Land use: Dairy
Elevation: 29m
Slope: 6º
Soil material: schist colluvium
Landscape: fan mid slope
Soil drainage: moderate

Horizon	Depth	Description
A	0-18cm	dark yellowish brown (10YR 4/6) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; common fine roots
AB	18-28cm	dark yellowish brown (10YR 4/6) and yellowish brown 10YR 5/6) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; 2% fine stones; few fine roots
Bw	28-45cm	yellowish brown (10YR 5/6) clay loam; moderately coarse blocky structure; slightly firm soil strength; compact; very friable; 2% fine stones; few fine roots
B(g)	45-100cm	yellowish brown (10YR 5/6) clay loam; 30% light yellowish brown (2.5Y 6/4) and 30% light yellowish brown (10YR 6/4) medium mottles; moderately developed coarse blocky structure; slightly firm soil strength;compact; brittle failure; 2% fine stones; very few fine roots

Sample name: Site 15
Soil Name: Kaituna S-map sibling: Orono 47.2.1
GPS: 1677486.575 E 5421690.962 N
Land use: Dairy
Elevation: 7m
Slope: 3º
Soil material: schist alluvium
Landscape: terrace
Soil drainage: well

Horizon	Depth	Description
A	0-19cm	dark yellowish brown (10YR 4/4) heavy silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	19-23cm	dark yellowish brown and light olive brown (10YR 4/4 + 2.5Y 5/4) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; common fine roots
Bw	23-50cm	light olive brown (2.5Y 5/4) silt loam; <5% yellowish brown (10YR 5/6) and <5% pale yellow (2.5Y 7/4) fine mottles; moderately developed fine polyhedral and coarse blocky structure; weak soil strength; compact; friable; few fine roots
BC	50-100cm	light olive brown (2.5Y 5/4) heavy silt loam; weakly developed coarse blocky structure; weak soil strength; compact; very friable; few fine roots

Sample name: Site 16
Soil Name: Ronga S-map sibling: Hind 41.1.1
GPS: 1680163.375 E 5421611.906 N
Land use: Dairy
Elevation: 14m
Slope: 0º
Soil material: recent greywacke/schist alluvium
Landscape: stream levee
Soil drainage: moderate

Horizon	Depth	Description
A	0-10cm	dark yellowish brown (10YR 3/4) sandy loam; weakly developed fine polyhedral structure; very weak soil strength; compact; very friable; <10% fine stones; common roots
BC	10-22cm	light olive brown (2.5Y 5/4) silt loam; weakly developed fine polyhedral structure; very weak soil strength; compact; very friable; <10% fine stones; common roots;
C(g)	22-38cm	light brownish grey (2.5Y 6/2) silt loam; 40% yellowish red (5YR 5/6) fine mottles; moderately developed fine polyhedral and blocky structure; weak soil strength; compact; very friable; few fine charcoal fragments; few fine roots
b B(g)	38-95cm	yellowish brown (10YR 5/6) heavy silt loam; 35% light brownish grey (2.5Y 6/2) medium mottles; weakly developed coarse blocky structure; slightly firm soil strength; compact; friable; few fine roots
		water at 90cm

Sample name: Site 17
Soil Name: Koromiko S-map sibling: Oakl 11.1.1
GPS: 1680163.375 E 5421611.906 N
Land use: Dairy
Elevation: 15m
Slope: 0º
Soil material: greywacke alluvium
Landscape: valley floor
Soil drainage: moderate

Horizon	Depth	Description
A	0-20cm	dark yellowish brown (10YR 4/4) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	20-26cm	dark yellowish brown (10YR 4/4) and light olive brown (2.5Y 5/6) silt loam; weakly developed fine polyhedral and medium blocky structure; weak soil strength; compact; friable; common fine roots
Bw	26-40cm	light olive brown (2.5Y 5/4-5/6) clay loam; few faint brown and greyish fine mottles; weakly developed fine polyhedral and coarse blocky structure; slightly firm soil strength; compact; friable; 2% black soft concretions; few fine roots
B(g)	40-66cm	light olive brown (2.5Y 5/6) clay loam; 35% strong brown (7.5YR 5/6) and 30% light yellowish brown (2.5Y 6/2) medium mottles; slightly firm soil strength; compact; very friable; <5% fine black soft concretions; few fine roots
BC(g)	66-90+	light olive brown (2.5Y 5/4) sandy clay loam; 40% strong brown (7.5YR 5/8) and 35% light brownish grey (2.5YR 6/2) medium mottles; <5% black soft concretions; apedal; dense

Sample name: Site 18
Soil Name: Koromiko S-map sibling: Athol 22.1.1
GPS: 1680872.792 E 5424709.324 N
Land use: Dairy
Elevation:27m
Slope: 0º
Soil material: greywacke alluvium
Landscape: valley floor
Soil drainage: poor

Horizon	Depth	Description
A(g)	0-16cm	dark brown (10YR 3/3) heavy silt loam; 35% light olive brown (2.5Y 3/4) and 15% greenish grey (5GY 6/1) fine mottles; moderately developed fine polyhedral structure; very weak soil strength; very friable; abundant roots
AB(g)	16-26cm	pale olive (5Y 6/3) and light olive brown (2.5Y 3/4) clay loam; moderately developed fine polyhedral structure; very weak soil strength; compact; very friable; common fine roots
Bg	26-42cm	brownish yellow (10YR 6/8) clay loam; 65% light brownish grey 2.5Y 6/2) medium and coarse mottles; moderately developed medium polyhedral and coarse blocky structure; weak soil strength; friable; few fine roots
B(g)	42-80cm	strong brown (7.5YR 5/8) clay loam; 30% light brownish grey (2.5Y 6/2) medium and coarse mottles; moderately developed coarse blocky structure; slightly firm soil strength; compact; brittle failure; few fine roots
BC(g)	80-95cm	strong brown (7.5YR 5/8) sandy clay loam; 15% yellowish red (5YR 5/8) and light olive grey (5Y 6/2) medium mottles; weakly developed coarse blocky structure; slightly firm soil strength; compact; brittle failure
		water at 90cm

Sample name: Site 19
Soil Name: Manaroa S-map sibling: Athol 22.1.1
GPS: 1680608.137 E 5424368.058 N
Land use: Dairy
Elevation: 36m
Slope: 4º
Soil material: greywacke colluvium
Landscape: fan toe slope
Soil drainage: imperfect

Horizon	Depth	Description
A(g)	0-15cm	brown (10YR 5/3) heavy silt loam; 30% red (2.5YR 5/6) fine mottles; weakly developed fine polyhedral structure; very weak soil strength; compact; very friable;
A	15-32cm	brown (10YR 5/3) heavy silt loam; 5% strong brown (7.5YR 5/6) fine mottles; developed fine polyhedral structure; very weak soil strength; compact; very friable; many fine roots
Bg	32-65cm	60% strong brown (7.5YR 5/8) and 40% light brownish grey (2.5Y 6/2) clay loam; weakly developed coarse blocky structure; slightly firm soil strength; brittle failure; 15% fine to medium stones in a layer; few fine roots
BC(g)		strong brown (7.5YR 5/8) sandy clay loam; 25% reddish brown (5YR 5/3) and 10% light grey (5Y 7/2) medium mottles; moderately developed very coarse blocky structure; slightly firm soil strength; compact; semi-deformable;

Sample name: Site 20
Soil Name: Koromiko S-map sibling: Hast_28.2.1
GPS: 1679225.186 E 5420230.574 N
Land use: Dairy
Elevation: 10m
Slope: 0º
Soil material: greywacke/schist alluvium
Landscape: valley floor
Soil drainage: poor

Horizon	Depth	Description
A(g)	0-17cm	very dark greyish brown (10YR 3/2) silt loam; 25% yellowish red (2.5YR 4/6) fine mottles; weakly developed fine polyhedral structure; weak soil strength; compact; friable; many fine roots
AB	17-33cm	brownish yellow to light olive brown (10YR 5/4-2.5Y 5/4) heavy silt loam; 2% fine yellowish red (2.5Y 4/6) mottles; moderately developed fine polyhedral structure; very weak soil strength; compact; very friable; many roots
BC	33-42cm	pale olive (2.5Y 6/4) heavy silt loam; weakly developed fine polyhedral and coarse blocky structure; weak soil strength; compact; friable; few roots
BC(g)1	42-65cm	pale olive (2.5Y 6/4) heavy silt loam; 40% yellowish brown (10YR 5/6) medium mottles with yellowish red (2.5Y 5/6) centres; weakly developed coarse blocky structure; weak soil strength; compact; friable; few fine roots
BC(g)2	65-95cm	pale olive (2.5Y 6/4) heavy silt loam; 30% yellowish brown (10YR 5/6) and 25% light grey (10YR 7/3) medium mottles; weakly developed coarse blocky structure; weak soil strength; compact; semi-deformable

Sample name: Site 21
Soil Name: Manaroa S-map sibling: Wood 27.2.3
GPS: 1678990.241 E 5419779.743 N
Land use: Cattle grazing
Elevation: 9m
Slope: 0º
Soil material: schistose colluvium
Landscape: valley floor
Soil drainage: imperfect

Horizon	Depth	Description
A(g)	0-17cm	pale brown (10YR 6/3) silt loam; 15% yellowish red (2.5YR 5/4) and 20% light olive brown (2.5Y 5/4) fine mottles; weakly developed fine polyhedral structure; slightly firm soil strength; compact; friable; abundant fine roots
BC	17-29cm	light yellowish brown (10YR 5/4) heavy silt loam; 2% fine light olive brown (2.5Y 5/6) mottles; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; many fine roots
BC	29-60cm	light olive brown (10YR 5/4) clay loam; 5% yellowish brown (10YR 5/8) and 5% light yellowish brown 2.5Y 6/4) fine mottles; moderately developed fine polyhedral and coarse blocky structure; slightly firm soil strength; compact; friable; common roots
BC(g)	60-95cm+	yellowish brown (10YR 5/6) clay loam; 40% strong brown (7.5YR 5/8 and 40% light yellowish brown (2.5Y 6/4) medium mottles; weakly developed coarse blocky structure; slightly firm soil strength; compact; brittle failure; few fine roots