Soils of the Waimea Plains: Brightwater to Richmond District

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INTRODUCTION

The eastern portion of the Waimea Plains from Brightwater to Richmond covers about 30% of the total Waimea basin and is dominated by the distinctive Ranzau soil type (total area approximately 1600 ha). The Waimea Plains occupy the eastern margin of the Moutere Depression in the low lying land between the uplifted east and west Nelson Ranges and was formed through the deposition of alluvial sediments through Late Last Glaciation and Recent times. The valley floor sediments that constitute the Waimea Plains have been deposited by the Wai-iti and Wairoa Rivers, which join at Brightwater and flow northwards into Tasman Bay. Covering around 7,500 ha but with the effective area now continually reducing through urban development, the Waimea Plains are a highly important resource for the economy of Nelson Province they it provide the basis for an appreciable portion of the horticultural production of the Province. Its economic value is enhanced in that the soils of the Waimea Plains comprise a significant portion of the more versatile land and soils that are found within the Nelson Province.

Soils of the Waimea Plains were first mapped and described in a report published in 1966 (Soils and Agriculture of the Waimea Plains, Chittenden, Hodgson and Dodson 1966, *New Zealand Soil Bureau Bulletin 30*). Both the soil map at a scale of 1:126,720 (two miles to the inch) and the accompanying report are generalised and provide only a broad picture of the existing soil pattern and the soil properties. Given the inherent soil variations found on fluvial and floodplain surfaces, that report provides little indication of significant soil differences at a scale useful for individual farm management or land-use planning purposes. An even less detailed picture of the soils of the Waimea Plains was given in the General Survey of the Soils of South Island (scale 1:250,000 Soil Bureau staff 1968).

The present soil survey covered the low lying land east of the Wairoa River from just north of Brightwater to the outskirts of Richmond and the Appleby Highway and covers approximately 1900 ha. This is a continuation of recent more detailed soil mapping in the Appleby district to the north (2011/2012), the Waimea West district (2012/2013) to the west and the Brightwater/Spring Grove area (2013/2014) to the south.

Survey Methods

Field work was carried out over 54 days between May and September 2015. Black and white 1938 aerial photographs were used to assist with the identification of landform units and determining changes in river flow patterns, prior to the construction of the existing stopbank system. These as well as grey scale LIDAR maps were useful for looking at micro-topographic variations, which are largely concealed in the modern satellite images where the landscape features are to a large part concealed by tree crop or vine-land types of vegetation.

Soil observations were made mainly from auger borings, up to 1 metre depth where possible, along transect lines that in most cases were short due to the constraints imposed by individual property sizes and long term row crops. Additional observations were made from soil profile pits excavated to around 1 metre where possible as well as from exposures in a few sections. The auger observations provided the basis for assessments of soil depth to gravel, soil horizon formation, soil texture and soil drainage characteristics while the observations from the pits and sections allowed soil structure, soil strength, plant root distribution and nature of underlying materials to be assessed. A total of 981 observations were made, 961 from auger inspections and 20 from soil profile pits and sections.

The Ranzau soil, the most extensive soil type within the existing survey area (76%) is predominantly stony but with loamy upper soil horizon texture and variations in surface stoniness are significant in respect of land management. The percentage of the surface stone content at each observation point was assessed visually to differentiate soil stoniness relative to defined soil stoniness classes (slightly stony, moderately stony, very stony and extremely stony (Milne et al. 1995, Webb and Lilburne 2011). As the visual assessments of the stone content are subjective, assessment of the stone content was periodically checked by carrying out field gravimetric measurements (sieving) to determine the <2mm/>2mm fraction of a 10kg sample of the topsoil. In addition, at 13 sites, surface and some sub soil horizons were sampled for laboratory determination of the fine fraction particle size class.

The soil description criteria used are those described in the Soil Description Handbook (Milne et al. 1995) which gives the official description standards for description of New Zealand soils. Additional and updated criteria are given in Clayden and Webb (1994) and Webb and Lilburne (2011). Field soil data were electronically recorded and included a digital image for the soil at each observation site. Each observation site was located and recorded using GPS and marked on 1:4000 colour photo field sheets onto which soil boundaries were plotted. The field sheets had contours at half-meter intervals and these were useful in assisting with the plotting of the soil boundaries. The soil boundaries were later transferred by TDC staff onto a photogrammetric base for final map compilation. The field data for each soil that was recognised were analysed in respect of the variation in properties for each of the recognized soil types (horizon sequences and thicknesses, colour, texture, drainage, soil depth, stoniness etc.) and the information was used in determining the properties for each soil as well as the variability within the map units. The soil land use ratings (Table 2) are derived from assessments of a range of soil and land attributes as outlined by Webb and Wilson (1995) in a manual of land characteristics for evaluation of rural land. A similar system was previously used by Agriculture New Zealand in the 1994 Classification System for Productive Land in the Tasman District.

The Soil Landscape Environment

The soil landscape of the Brightwater to Richmond district over the majority of the area consists of a surface formed on the upper part of the Hope Gravel Formation (Johnston 1979, 1982). Sediments in the lower part of this formation have been dated at around 48-49 thousand years but the surface gravels, (known locally as the Ranzau gravels) are likely to be much younger and possibly date from the onset of a warming phase during the Last Glaciation maximum about 18,000 years B.P. This gravelly surface has a uniform gradient with the highest elevation approximately 40m above sea level at the Wairoa Gorge entrance and the lowest elevation within the survey area about 7m, the fall being approximately 4.6m/km. At the entrance to the Wairoa Gorge, the surface of the Hope Gravel Formation is separated from the younger alluvial sediments of the Appleby Formation by a prominent scarp 9.5m high. The scarp (known locally

as Burkes Bank) that separates the Hope and Appleby Formation surfaces diminishes from 9.5m at the Wairoa Gorge entrance to approximately 0.5m at the Appleby Highway. The Appleby Formation sediments encompass several low level terraces as well as the modern flood plain and has a fall of approximately 3.6m/km.

The land surface on which the Ranzau soils are formed (Hope Gravel Formation) is unlike that of a typical river terrace. The surface consists of an intensive pattern of weakly defined shallow (<0.50cm) discontinuous channels with occasional deeper (<1m) but more continuous channels that extend over a few hundred metres. The channel alignment toward the east trends in a northeast direction but closer to the Wairoa River, the alignment is northerly. The particle size of the gravels ranges from fine gravel (6-2mm) to very coarse gravel (60-200mm) with very coarse gravel often predominating. Boulders (>200mm) are sometimes present but are generally not extensive. Small patches of fine textured loamy sediment are occasionally present on the surface as well as thin discontinuous lenses of fine sediment within the gravel. At the eastern end of Clover Road, a remnant of an older and higher surface is present with very stony soils, similar to those of the Ranzau Gravel and may represent an early depositional phase of the Hope Gravel Formation. The surface topography and relatively uniform size range of the gravels resembles that of a fan rather than a river terrace, the construction of which may have taken place over a relatively short time interval. Implicit are massive water flows, perhaps related to an early climatic perturbation.

On the eastern margin of the plain, remnants of the Moutere Gravel Formation occur as north sloping ridges separated by small valleys which have fan sediments of the Stoke Fan Gravel Formation (Johnston 1982). These sediments spill out onto the plain surface and post-date the deposition of the Ranzau gravels and may be of Late Quaternary age, possibly coinciding with the Late Glacial cooling reversal 13.5-11.5 yrs B.P. (Barrell et al. 2013). At the toe of the fans, the deposits thin and merge with the Ranzau gravel. The Stoke Fan Gravel deposits differ lithologically from the Ranzau gravels, the former being derived mainly from sediments of the Maitai and Richmond Groups which include greenish and reddish purple siltstones, whereas the latter have a wider range of rock types, including ultramafics from the Dunn Mountain Formation.

In summary, the sequence of depositional and erosional events giving rise to the present geomorphic and soil configuration on the Brightwater to Richmond part of the Waimea Plains is as follows:

- Deposition of early Hope Gravel Formation (represented by the terrace remnant at 48m at the eastern end of Clover Road) in an earlier glacial cycle,
- Extensive removal of this surface by river erosion,
- Construction of the present ‘Ranzau gravel’ plain surface during a rapid fan-forming outwash phase (41.5m near the eastern end of Clover Road) associated with a glacial cooling/warming period,
- Construction of local fan deposits in adjacent eastern side valleys
- River incision and channel widening within the Hope Gravel Formation during climatic warming,
- Low terrace and floodplain sedimentation associated with Post Glacial Holocene climatic fluctuations.

Soils of the Waimea Plains-Brightwater to Richmond District

In this section, the soils occurring between Brightwater and Richmond are described according to their landscape position and drainage class in the order as set out in Table 1.

Table 1
Soils of the Brightwater-Richmond district

Recent River Floodplain and lowest Terraces		
Well drained soils	Wai-iti soils	Wa, Wamd, Waest, Wavst
River Overflow and Low Terrace Surfaces Older		
Well drained shallow soils	Redwood soils	Rd, Rdmd, Rdsh, Rdst
Well drained deep soils	Waimea soils	Wm, Wmmd, Wmsh
Moderately well drained soils	Cotterell soils	Ct
Higher Terrace/fan surface		
Well drained	Ranzau soils	Rz, Rzmst, Rzvst, Rzest
Moderately well drained	Richmond soils	Rm
Other fan surfaces		
Well drained to moderately well drained	Barnicoat soils	Ba
Imperfectly drained soils	Lee soils	Le
Rolling and hilly land	Wakatu soils	Wh
Disturbed soils		
Replaced from gravel extractions	Anthropic soils	An

Soil name and map symbol; Wai-iti soils (Wa, Wash, Wamd, Wast, Wavst)

Concept and overview

Wai-iti soils occur on floodplain surfaces and lowest terrace levels and overflow channels of the Wairoa and Waimea Rivers and are soils that have minimal soil profile development due to the very recent age of the alluvium. They are well drained soils, commonly with some surface stones and with variable depth of fine material over underlying gravel. Some of the surfaces on which Wai-iti soils occur were river flood channels up until the 1930's before management of the river systems took place. Occupying 86 ha, Wai-iti soils are now largely protected from occasional flooding by the stopbank system, which was constructed in the late 1950's and early 1960's.

Relationship to previously named soils

Wai-iti soils were not identified in the earlier surveys (Chittenden et al. 1966) although were included within the Waimea soil family, without being separated on the soil map. In the 2011/12 survey of the Redwood Valley-Appleby portion of the Waimea Plains (Campbell unpublished) Wai-iti soils have been separated as the recent well drained soils on the floodplain and lowest surfaces of the Wairoa and Waimea River in the recent soil surveys of the Waimea Plains.

Landform origin and history

The floodplain of the Wairoa/Waimea River system formed after river entrenchment following the period of Post Glacial warming. Where the Wairoa River exits the Wairoa Gorge, occurrences of Wai-iti soils are predominantly in narrow strips adjacent to the river but closer to the coast where the river gradient diminishes, larger areas of Wai-iti soils occur in response to sedimentation changes associated with Holocene sea level rise. Land surfaces are in places uneven due to flow channelling in times of flood and sediment deposition Buried soils found in 15% of the observations of Wai-iti soils are indicative of the past flooding and river depositional activity. The stopbank system was constructed in the 1950's for a 1 in 50 year flood return period could be expected to be breached during more severe storms predicted with global climate change. Rising sea level associated with global climate change will impact on the Wai-iti soils especially in the lower reaches of the river system.

Key features and physical properties

Wai-iti soils are weakly developed with a dark brown to brown sandy loam or silt loam A horizon that averages 17cm thick. Colour distinction between the A horizon and subsurface is weak, in part due to cultivation and the extensive use of Wai-iti soils in this area for horticulture. Subsoil colours vary, with dark yellowish brown to olive brown colours in deeper silty textured material and olive colours where the soil material is coarse textured. Wai-iti soils are weakly structured, have textures that vary from sandy loam (70%) to silt loam (30%) and range in depth from shallow and stony to deep (>100cm). Underlying gravel, where present within the solum are invariably loose.

Identified variants

Wai-iti soils vary considerably over short distances because of the flood- channelled nature of the land surfaces and sedimentation differences. The mapped variants include Wai-iti (deep 100cm+ 28% of observations) moderately deep (Wamd 45-100cm depth to gravel 32%

of observations), Wai-iti stony (shallow soils with<35% surface stones 35% of observations), Wai-iti very stony (35-70%surface stones 10% of observations). A few un-mapped patches of Wai-iti extremely stony soils (>70% surface stones 5% of observations) are also present. In a few places subsoil mottles indicative of impeded drainage (Appleby soils as mapped elsewhere) were found.

Associated and similar soils

Eves soils, formed from stream alluvium derived from local sources have similar properties to Wai-iti soils but are not present within the present survey area.

Versatility and land use rating

Wai-iti deep soils have a moderate to high versatility rating (1.4 Table 2) while the shallow and very stony soils have a moderate to low versatility owing to stoniness (bouldery in places), somewhat excessive drainage, and lower available water capacity. Both the deep soils and also the stony soils are however used successfully for horticultural crops despite the risk of flooding in extreme weather events. These soils are included in class B of the Tasman District Council system for land management.

Wai-iti stony sandy loam

Horizon	Depth	Description
A	0-13cm	dark yellowish brown (10YR 4/4) sandy loam; weakly developed fine polyhedral structure; 5% fine and medium stones; very weak soil strength; loose; very friable; abundant fine roots
C	13-34cm	olive (5Y 5/3) sand; apedal; 60% medium to very coarse stones; loose; abundant fine roots
b B	34-45cm	dark olive grey (5Y 3/2) sand; apedal; very weak soil strength loose; 5% fine stones; very friable; loose; many fine roots
b C1	45-60cm+	dark olive grey (5Y 3.2) sand; apedal; 5% fine to medium stones, loose; few fine roots
b C2	60-70cm+	dark olive grey (5Y 3/2) sand; apedal; 75% fine to very coarse stones; loose

Soil name and map symbol; Redwood soils (Rdmd, Rdst, Rdmst, Rdvst)

Concept and overview

Redwood soils are present on a low surface of the Wairoa River near the confluence that becomes the Waimea River. They cover 26 ha on a terrace that lies just above the present flood plain and the presence of distinct soil morphological development within the soil profile suggests that the terrace surface is essentially flood free. Topsoils are distinct but the soil weathering depth is shallow (40-45cm to unweathered subsoil) indicating that the soils have a young age. The depth of fine material over gravel is variable while gravel to the surface is common.

Relationship to previously named soils

Redwood soils were not separated in the survey of the soils of Waimea County (Chittenden 1966) and were included within the Waimea soil type as mapped. In the 2001/12 Appleby-Redwood Valley, 2012/13 Waimea West and 2013/14 Brightwater district surveys (Campbell unpublished), Redwood soils were distinguished from Wai-iti soils on the floodplain and Waimea soils on a higher terrace surface.

Landform origin and history

Redwood soils are formed on young alluvium of the Appleby Gravel formation deposits (Holocene age 4120± 60 BP Johnston 1982) but the surface deposits are much more recent as indicated by the shallow soil weathering depth. The low terrace river system is part of the cycle of post glacial excavation and down-cutting into the cold climate depositional gravels along with more recent depositional events related to global climatic fluctuations.

Key features and physical properties

Redwood soils are well drained with dark brown silt loam to sandy loam topsoils (average 18cm thick) overlying weakly structured thin (average 18cm) olive brown to dark yellowish brown B or BC horizons, passing into unweathered olive to olive brown C horizon subsoil. Soil texture is dominantly silt loam or sandy loam in upper horizons becoming sandy with depth. Most of the Redwood soils are stony (5-35% surface stones) and very stony (35-70% surface stones but some are stoneless with the depth of fine material over gravel sometimes reaching >100cm.

Identified variants

The chief variants of Redwood soils that were mapped are Redwood moderately deep soils, and Redwood stony, moderately stony and very stony soils. The soil characteristics vary over short distances owing to the changing river flow conditions at the time of alluvial sediment deposition.

Associated and similar soils

Redwood soils are associated with Wai-iti soils which occur on adjacent floodplain surfaces. Waimea soils, which also occur on low river terraces are mostly deeper soils with clay loam textures and have more advanced soil horizon and soil structure development.

Soil versatility and land use rating

Redwood moderately deep soils have a moderate to high versatility rating for land use (1.6 table 2) and are used for horticulture and viticulture. The stony to very stony soils have a moderate to low versatility rating (2.1 Table 2) the chief limitations being surface stoniness, lower profile available water and a shallower effective rooting depth. The stony soils are likewise utilised for horticulture and viticulture with the soil moisture deficiency overcome through irrigation which allows a range of crops to be grown throughout the year. The Redwood soils are included in Class B of the Tasman District Council Classification system for productive land.

Waimea moderately deep heavy silt loam

Horizon	Depth	Description
A	0-26cm	dark brown (10YR 3/3) silt loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable,
AB	20-22cm	dark brown and dark yellowish brown (10YR 3/3+ 10YR 4/4) silt loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, many fine and medium roots
B	22-50cm	dark brown to olive brown (10YR 4/4+2.5Y 4/4) fine sandy loam; weakly developed fine polyhedral and fine blocky structure, weak soil strength, compact, very friable, common fine roots
C	50-64cm	olive brown to olive (2.5Y 4/4-5Y 3/2) sand, apedal, very weak soil strength, loose, few fine roots
C(g)	64-90cm	yellowish brown (10YR 5/6 40%) and dark olive grey (5Y 3/2 60%) sand, mottles medium and distinct, apedal, 5% fine stones
C	90cm+	loose gravel

Soil name and map symbol Waimea soils (Wm, Wmmd, Wmst)

Concept and overview

Waimea soils occur on the river terrace system of the Waimea River and cover 114 ha in the northwest part of the current survey area. They are predominantly well drained soils with silt loam to clay loam textures on moderately deep to deep fine textured alluvium although patches of stony soils are sometimes present. Surface elevation is a little higher than for Wai-iti or Redwood soils, although the distinction between the terrace surfaces on which Wai-iti, Redwood and Waimea soils are found has diminished from that further upstream in the river system.

Relationship to previously named soils

Waimea soils were initially mapped in the original survey of the soils of Waimea County (Chittenden 1966) on all of the low terraces of the Wai-iti, Wairoa and Waimea river system below Brightwater. In the recent surveys of the Redwood Valley-Appleby district (2011/2012), the Waimea West district (2012/2013) and the Brightwater district (2013/14) (Campbell unpublished), separations have been made to distinguish Wai-iti soils, the most recent soils that are subject to flooding, Redwood soils, which are predominantly flood free and Waimea soils, with better developed soil profiles and which occur on the higher surfaces within the river terrace system.

Landform origin and history

Waimea soils are formed on Holocene to Recent aged alluvium of the Appleby Gravel Formation, the basal sediments at Waimea West of which date from around 4500± years B.P. (Johnston 1982). Their more or less consistent attribute of around 1m of silty to clayey sediment overlying gravel suggests that river flow and depositional conditions were different from the times when the transport and deposition of gravels predominated. Land surfaces are predominantly smooth but bisected in some places by former overflow channels.

Key features and physical properties

Waimea soils are well drained and dominantly moderately deep (45-100cm) with silt loam, heavy silt loam or clay loam textures overlying gravel. The A horizon is dark brown and 24cm thick and overlies the B horizon of yellowish brown clay loam or silt loam (average thickness 33cm) with moderately developed structure. This merges into an olive brown to yellowish brown clay loam to sandy clay loam textured BC horizon which sometimes has a few mottles. In deeper profiles, textures at the base are commonly sandy before passing into weakly consolidated gravel.

Identified variants

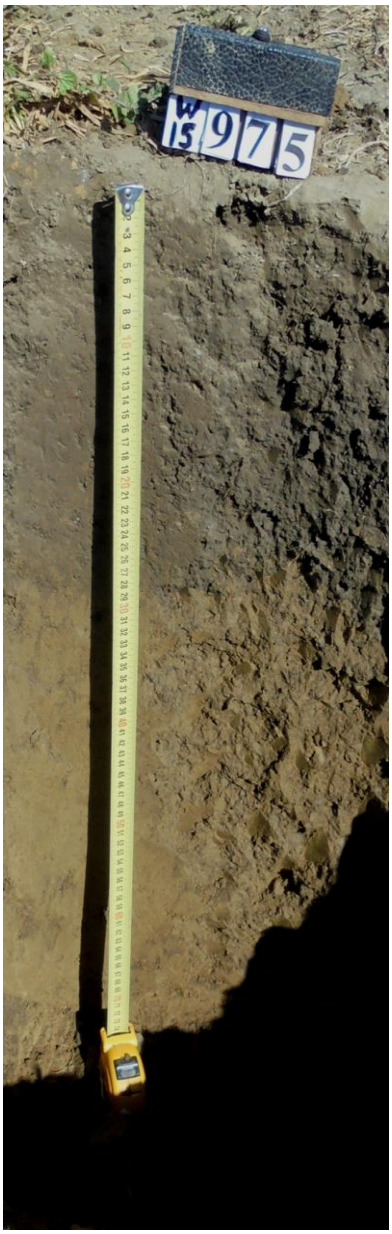
Shallow soils were recorded in 24% of the observations although not mapped separately. Stony soils (slightly stony to moderately stony) were recorded in 18% of the observations (Wmmst). Moderately deep soils (Wmmd, 45-100cm) were recorded in 51% of the observations and deep soils (Wm) in 30% of the observations. Soils with subsoil mottles were noted in 15% of the observations.

Associated and similar soils

Waimea soils merge into adjacent Cotterell soils (imperfect to poor drainage) which become more extensive in the northern part of the survey area, where the land is lower lying and the watertable is higher, Waimea soils are similar to Motupiko soils (not mapped in the present survey area), the later also being well drained, but have silt loam to sandy loam rather than clayey texture and are derived from alluvium from the Wai-iti river system and are also derived from differing rock materials.

Soil versatility and land use rating

Waimea soils have a moderate to high versatility for use (1.5 Table 2), the chief limitations being moderately slow permeability which may cause water ponding after intense rainfall. The clay loam texture gives rise to periods of trafficability and workability restrictions during winter months. Waimea soils in this survey area are used intensively and continuously throughout the year for market garden crops and under intensive use, structural breakdown with re-aggregation into clods can be observed. It is likely that fertilisers are leaching from the soils because of their extensive use. Waimea soils are included in Class B of the Tasman District Council system for land management.



Waimea moderately deep heavy silt loam

Horizon	Depth	Description
A	0-20cm	dark brown (10YR 3/3) heavy silt loam, weakly developed fine polyhedral structure, slightly firm soil strength, compact, friable, common fine roots
AB	26-30cm	dark brown and dark yellowish brown (10YR 3/3+ 10YR 4/4) heavy silt loam, weakly developed fine polyhedral and medium blocky structure, slightly firm soil strength, compact, friable, few fine roots
B	30-65cm	dark yellowish brown (10YR 4/4) silt loam, moderately developed medium blocky structure, slightly firm soil strength, compact, friable, very few fine roots
BC	65-75cm	olive brown to dark yellowish brown (2.5Y 5/6-10YR 4/6) silt loam, 50% brownish yellow (10YR 5/6) and 5% light yellowish brown (2.5Y 6/4) fine mottles, weakly developed medium blocky structure, compact, very friable, very few roots
C	70-85+cm	olive brown (2.5Y 5/6) silt loam, apedal, 20% coarse stones, compact

Soil name and map symbol Cotterell (Ct, Ctmd)

Concept and overview

Cotterell soils have been mapped over 56 ha and occur in the northwest of the survey area in some broad patches of slightly low lying land beyond the Waimea River and along some narrow old river overflow channels. They are imperfectly to moderately well drained soils, distinguished by diffuse reddish brown and grey mottle patterns, which vary in intensity, depending on soil drainage conditions. Textures are predominantly clay loam and soil depth is mainly moderately deep or deep but occasionally shallow.

Relationship to previously named soils

Cotterell soils were not separated in the Survey of the soils of the Waimea Plains (Chittenden 1966) but were included within the Waimea Clay loam map unit. They have been mapped separately in the earlier surveys of the Redwood Valley-Appleby district (2011/2012), the Waimea West district (2012/2013) and the Brightwater district (2013/14) (Campbell unpublished).

Landform origin and history

Cotterell soils are a part of the river depositional system, in which Post Glacial river entrenchment and channel widening took place within the Hope Gravel Formation, along with subsequent deposition of Appleby gravels and fine textured sediments within the Wai-iti, Wairoa and Waimea Rivers. Cotterell soils are on slightly lower lying ground that was the river back-swamp at the time of sediment deposition where natural drainage is restricted. Their finer textures are attributed to deposition in a lower energy environment, typical of the lower reaches of a river system where deltaic conditions exist.

Key features and physical properties

Cotterell soils have a dark brown, moderately deep (24cm) clay loam to silt loam topsoil with moderately developed soil structure. Where the soil is moderately well drained, a yellowish brown to olive brown B horizon may be present but where drainage is imperfect, the A horizon overlies clay loam horizons (Bg) characterised by brownish or reddish brown and light grey distinct mottles. In deeper profiles, a sandy clay loam (BCg) horizon may be present with predominantly greyish colours and reddish mottles.

Identified variants

Small scattered patches of slightly stony to moderately stony soils are present (15% of observations) while moderately deep soils with an average depth of 71cm accounted for 47% of the observations to gravel and deep soils (>100cm deep) accounted for 40 % of observations. Moderately well drained soils were recorded at forty observation sites and imperfectly drained soils at 58% of observation sites.

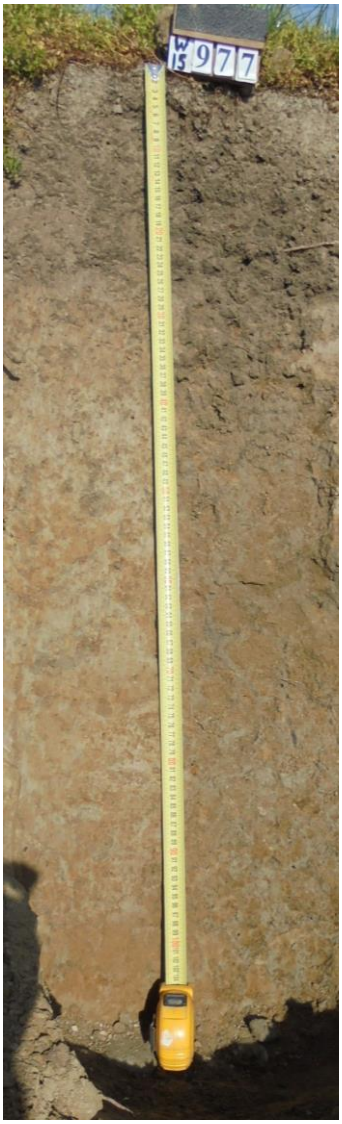
Associated and similar soils

Cotterell soils are associated with Waimea soils which both occur on the same landform and sediment formation, the former being well drained. Moderately well drained to imperfectly drained soils associated with the less developed Wai-iti and Redwood soils are Appleby soils.

Soil versatility and land use rating

Imperfectly drained Cotterell soils have a moderate to low versatility (2.1 Table 2; moderately well drained soils 1.9 Table 2) with moderate limitations for intensive use. The main limitations are slow permeability in lower horizons and restricted trafficability and workability resulting from heavier textures and soil wetness. Cotterell soils are largely used for horticulture but under intensive use, structural breakdown and severe cloddiness has been observed. Cotterell soils are included in Class C of the Tasman District Council Classification system for productive land.

Cotterell deep silt loam



Horizon	Depth	Description
A	0-27cm	dark brown (10YR 3/3) heavy silt loam, strongly developed fine polyhedral structure, weak soil strength, compact, friable, common fine roots
AB	27-38cm	dark brown and brown to dark brown (10YR 3/3+ 7.5YR 4/4) clay loam, strongly developed fine and medium blocky structure, slightly firm soil strength, compact, friable, few fine roots
B(g)1	30-60cm	brown to dark brown (7.5YR 4/4 55%) and light brownish grey (2.5Y 6/2 45%) mottled clay loam; moderately developed medium blocky structure, firm soil strength, compact, brittle failure, few fine roots
B(g)2	60-80cm	yellowish brown (10YR 5/4 65%) and 2.5Y 6/4 35%) mottled clay loam, moderately developed medium blocky and weakly developed coarse prismatic structure, firm to very firm soil strength, compact, brittle failure
BC(g)	80-120cm	brown to dark brown (7.5YR 4/4 45%) and light olive Brown (2.5Y 6/4 55%) mottled clay loam, moderately developed medium blocky structure, firm soil strength, compact, semi deformable failure,
C	120cm+	olive brown (2.5Y 5/4) silt loam, apedal, 30% coarse stones, dense

Soil name and map symbol Ranzau (Rzmst, Rzvst)

Concept and overview

Ranzau soils are the most extensive soils on the Waimea Plains and cover 1434 ha in the present survey area. They are distinguished by their surface and subsurface stoniness and a loamy upper horizon fine fraction texture. They are formed from Wairoa River outwash gravels derived from the rock assemblages of the Richmond Range. Unlike the comparatively weakly weathered lower terrace alluvial soils of the Wairoa and Waimea Rivers, Ranzau soils have a weathering depth that extends to around 1m.

Relationships to previously named soils

In the survey of the soils of Waimea County (Chittenden 1966) Ranzau soils were mapped on the Waimea Plains as Ranzau stony clay loam and Ranzau gravelly silt loam on the smaller areas of the fan surfaces of the foothills and valleys between Hope and Stoke.

Landform origin and history

Ranzau soils occur on fluvial deposits of the Hope Gravel Formation (Johnstone 1982) which accumulated as outwash, following cold climate Late Otirian periglacial conditions in the nearby Richmond Range. Cold climate denudation provided a large quantity of detritus which was probably removed by fluvial action in a high rainfall climate transition period following the end of the glacial cooling event. The remnant of a higher elevation fan or terrace surface at the eastern end of Clover Road indicates that there was an earlier cycle of extensive gravel aggradation followed by river entrenchment and surface stripping. The land surface on which Ranzau soils are found has the form of a low angle fan with the highest point near the Wairoa Gorge entrance (about 52 m above sea level) and a northwards slope that is uniform. The ground surface, as revealed by 50cm spaced contours shows an intricate pattern of short, shallow channels consistent with a fan surface topography surface. The loamy textured surface horizons of the Ranzau soils have probably resulted from discontinuous extensive overland flows, rather than channel flows in which fine sediments can be discharged. Occasional patches of finer sediments are present at the surface and also within the Ranzau gravels as short discontinuous lenses. Surface stoniness varies from slightly stony to exceedingly stony often over short distances and is probably a reflection of the highly variable fluvial flows as the fan surface built up.

Key features and physical properties

Ranzau soils are predominantly very stony (35-70% surface stones and commonly at the higher end of this stoniness class) with a dark brown or very dark greyish brown A horizon that averages 27cm thick while the topsoil texture varies from clay loam to sandy loam. The stone size is variable but typically ranges from fine gravel (2-6mm) through to very coarse gravel (60-200mm) with boulders sometimes present. The B and BC horizons are dark yellowish brown and also very stony with the fine fraction grading to sandy loam or sand while with the weathering depth extends to around 1m.

Identified variants

Ranzau very stony soils (Rzvst, 35-70% stones) were recorded in 56% of the observations and Ranzau moderately stony soils (Rzmst) in 25% of the observations but there is a high degree

of variability over short distances. Ranzau extremely stony soils (greater than 75% surface stones) were recorded in 12% of the observations. Non stony to slightly stony soils (Ranzau moderately deep soils) were recorded in 7% of observations and with these soils, a loamy textured B horizon is present with the average depth to gravel reaching 46cm.

Associated and similar soils

Brightwater soils are similar to Ranzau soils in having very stony profiles but they occur on a younger river terrace and the soil weathering depth is shallower than that for Ranzau soils.
Barnicoat soils (identified in the present survey) are similar but have shallower weathering profiles, stones in the soil profile are fine to medium sized and parent material layering in the subsoil is common.

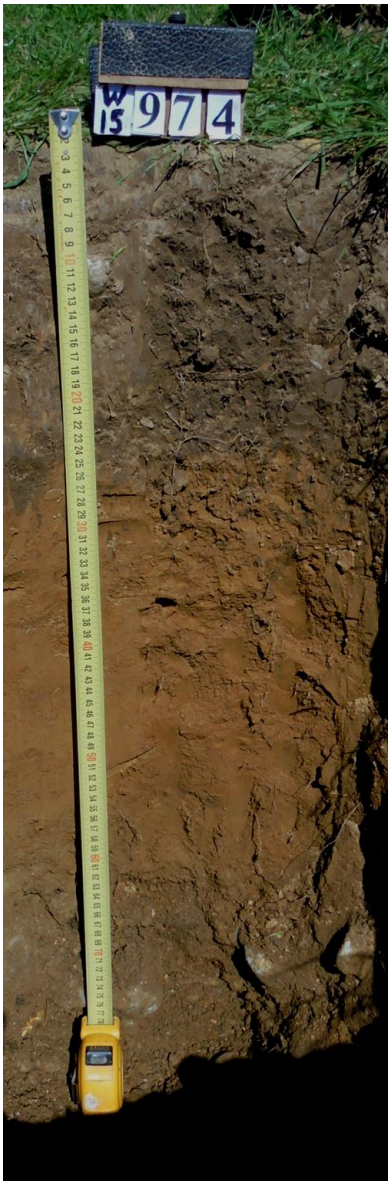
Soil Versatility and land use rating

Ranzau very stony soils has a high to moderate versatility rating (1.9 Table 2; Ranzau moderately deep 1.4 Table 2) The main limitations are their stoniness and low profile available water. In spite of their stoniness, irrigation allows their extensive use for a wide range of horticultural and market garden crops. Under continuous cultivation, however, breakdown of surface soil structure with clod formation has been observed. In places, mechanical sorting has been used to bring the finer gravel fractions to the surface and facilitate seed bed and surface soil management. Ranzau soils are included in Class A of the Tasman District Council system for land management.

Ranzau very stony clay loam

Horizon	Depth	Description
A	0-27cm	very dark brown (10YR 3/2) clay loam, moderately developed fine polyhedral structure, compact, friable, 60% fine to coarse stones, common fine roots
B	27-60cm	dark yellowish brown (10YR 3/6) sandy clay loam, weakly developed fine polyhedral structure, weak soil strength, compact, friable, 70% fine to coarse stones, common fine roots
BC	60-96cm	dark yellowish brown (10YR 3/6) sandy loam, apedal, loose, very friable, 75% fine to coarse stones
C	96-120cm	dark yellowish brown to olive brown (10YR 4/4-2.5Y 4/4) coarse sand, apedal, loose, very friable, 80% fine to very coarse stones

C(g)



Ranzau moderately deep clay loam

Horizon	Depth	Description
A	0-24cm	dark brown to dark yellowish brown (10YR 3/3-3/4) clay loam, moderately developed fine polyhedral structure, slightly firm soil strength, compact, friable, <5% fine to coarse stones, many fine roots
AB	24-28cm	dark brown and dark yellowish brown (10YR 3/3+ 10YR 4/6) clay loam, moderately developed fine polyhedral and blocky structure, slightly firm soil strength, friable, <5% fine stones, common fine roots
B	28-57cm	dark yellowish brown (10YR 4/6) clay loam, weakly developed coarse blocky structure, slightly firm soil strength, compact, brittle failure, common fine roots
BC1	57-70cm	dark yellowish brown to olive brown (10YR 4/4-2.5Y 4/4) sandy clay loam, weakly developed fine polyhedral and blocky structure, weak soil strength, compact, friable, 10% medium to coarse stones, few fine roots
BC2	70-85cm+	light olive brown (2.5Y 5/6) sand, apedal, compact, 60% fine to very coarse stones

Soil name and map symbol Richmond (Rm)

Concept and overview

Richmond soils occur in a few small patches and occupy 21 ha in the north east and the northern fringe of the present survey area. They are imperfectly drained soils that are formed on the same land surface as the Ranzau soils and they have a thin cover of fine textured sediment derived from the nearby hills (colluvium) overlying the Ranzau gravels.

Relationship to previously named soils

Richmond soils were mapped in the survey of the soils of Waimea County (Chittenden 1966) With three soil types being separated, Richmond peaty clay loam, Richmond clay loam and Richmond silt loam. They were identified as moderately deep soils from alluvium and with a drainage impediment. In the present survey, Richmond clay loam is the only soil typed mapped.

Landform origin and history

In the present survey, Richmond soils are mapped at the margin of the Waimea Plains adjacent to the eastern hills. Here, sediments from adjacent small valley fan deposits merge with Hope Formation deposits (Ranzau gravels) at the fan toe-slopes and the edge of the foothills. The clay loam textured sediment of the Richmond soils is derived from the adjacent Richmond hills and overlies coarse Ranzau gravels. The impeded drainage conditions are due to the low lying foot slope landscape position where runoff from the nearby hills accumulates. On the northern fringe of the survey area adjacent to the Appleby Highway, two small patches of imperfectly drained soils are formed from the Ranzau gravels and are mapped as Richmond soils.

Key features and physical properties

Richmond soils are moderately deep soils with the average depth to gravel found to be 63cm. They have a brown to dark brown clay loam A horizon (25cm thick) overlying a clay to clay loam Bg horizons that are blocky structured and strongly mottled with reddish brown, strong brown, pale gray or olive grey colours, and overlie imperfectly drained coarse gravel. In places, Richmond soils are moderately well drained with a B horizon that is less strongly mottled than the imperfectly drained soil.

Identified variants

Richmond shallow clay loam (<45cm to gravel and moderately stony to very stony) was found in 32% of the observations and Richmond moderately well drained soils in 30% of the observations.

Associated and similar soils

Richmond soils are associated with Ranzau soils, with which they merge as the cover of colluvium diminishes and under freer draining conditions. Richmond soils also merge with Barnicoat soils as the topography passes from flat lying foot slope to lower fan surface in adjacent small valleys. Richmond soils are similar to the imperfectly drained Lee soils which have deep clayey textures and occur on small fan foot-slopes of adjacent hills.

Soil versatility and land use rating

Richmond soils have moderate to low versatility (2.5 Table 2) for intensive use, their main limitations being Imperfect drainage, slow permeability, low nutrients and restricted

workability and trafficability due to seasonal wetness. They are used for grazing and are included in Class B of the Tasman District Council system for land management.

Richmond moderately deep clay loam

Horizon	Depth	Description
A	0-28cm	dark brown (10YR 3/3) clay loam, moderately developed fine polyhedral structure, weak soil strength, compact, friable, 5% medium stones, many fine roots
B(g)1	28-40cm	dark brown (10YR 3/3 25%) clay loam, 35% strong brown (7.5YR 5/8) and 25% pale brown (10YR 6/3) distinct medium mottles, moderately developed medium blocky structure, slightly firm soil strength, compact, brittle failure, 10% medium to coarse stones, common fine roots
B(g)2	40-65cm	strong brown (7.5YR 5/6 15%), pale brown (10YR 6/3 25%) and very pale brown (10YR 7/3 20%) mottled clay loam, moderately developed coarse blocky structure, firm soil strength, dense, 45% medium and coarse stones, few fine roots
BC(g)	65-70+ cm	very pale brown (10YR 7/3) clay loam, apedal, 65% medium to coarse stones

Soil name and map symbol Barnicoat (Ba)

Concept and overview

Barnicoat soils are mapped in small valleys that originate in the Richmond Hills-Barnicoat Range and are formed colluvial sediments derived from indurated grey, greenish and reddish rocks of the Maitai and Richmond Groups (Johnstone 1982). They cover 90 ha and are formed on layered clayey to gravelly fan deposits on sloping surfaces of the valley floors. They are predominantly slightly to moderately stony moderately deep and well drained soils.

Relationship to previously named soils

Barnicoat soils were not previously identified as a different soil type but were included within the Ranzau family in the survey of the soils of Waimea Plains (Chittenden 1966) where they were mapped as Ranzau gravelly silt loam. In the present survey they are separated from Ranzau soils because of different genetic features including a sloping fan topography, dissimilar parent material and morphological features including a shallower weathering depth.

Landform origin and history

Barnicoat soils are formed on colluvial sediments that originated in the nearby Richmond Hills and Barnicoat Range. The sediments belong to the Stoke Fan Gravel Formation (Johnstone 1982) of Early Holocene in age. The fan sediments and the soils that are formed on them clearly post-date Hope Gravel and formation of the Ranzau soils as the fan sediments spill out onto and overlie the coarser textured Ranzau gravels. Exposures in sections reveal layers of fine and coarse sediments and indicate that deposition has taken place during multiple flood events, probably during a moist climatic cycle following the end of the Last Glaciation.

Key features and physical properties

Barnicoat soils are well drained to moderately well drained (sometimes imperfectly drained) and moderately deep with an average depth to gravel of 58cm. The A horizon is very dark brown to dark brown clay loam (25cm thick) that is commonly stony. It overlies B and BC horizons that have clay loam or clay texture, few-to many distinct yellowish brown, strong brown, reddish brown, pale brown or light brownish grey mottles. Subsoil stoniness varies from slightly to moderately stony.

Identified variants

Barnicoat shallow soils (average depth to gravel 34cm) were recorded in 34% of the observations and Barnicoat deep soils (>100cm depth to gravel) in 6% of the observations. Barnicoat well drained soils were found in 50% of the observations, moderately well drained soils in 30% of the observations and imperfectly drained soils in 25% of the observations. The moderately well drained and imperfectly drained soils were found more especially on the lower parts of the fan surfaces.

Associated and similar soils

Wantwood soils have similarities with Barnicoat soils but are have deeper profiles, are better drained and have fine gritty rock fragments rather than coarser stone fragments in their profiles. Barnicoat soils merge with Richmond soils at the fan toe slopes where the colluvial sediments is thin and overlies coarser Ranzau gravel material.

Soil versatility and land use

Barnicoat soils have a moderate to high versatility for intensive use (1.7 Table 2) their chief limitations being somewhat impeded drainage slight to moderate stoniness and a moderately deep effective rooting depth. Ground surface slope is an additional limitation that would be significant under intensive horticultural cropping. They are extensively used for orchards and horticulture (boysenberry cultivation) while some areas are under grazing. These soils were included within class A (Ranzau soils) of the Tasman District Council Classification system for land management.

Barnicoat moderately deep clay loam

Horizon	Depth	Description
A	0-28cm	very dark greyish brown to dark brown (10YR 3/2-3/3) clay loam, weakly developed fine polyhedral and medium blocky structure, slightly firm soil strength, compact, brittle failure, 2% fine to medium stones, common fine roots
AB	28-35cm	dark brown and brown to dark brown (10YR 3/3+ 7.5YR 4/2) clay loam, moderately developed fine polyhedral and coarse blocky structure, slightly firm soil strength, compact, brittle failure, 10% fine to medium stones, few fine roots
B	35-52cm	brown to dark brown (7.5YR 4/2) clay loam, moderately developed fine polyhedral structure, slightly firm soil strength, compact, friable, few fine roots
BC(g)	52-90cm	yellowish brown (10YR 5/6 50%) and brown (10YR 5/3 50%) clay to clay loam, weakly developed coarse blocky and prismatic structure, firm soil strength, compact, brittle failure, few fine roots
BC2	90cm+	light olive brown (2.5Y 5/4) sandy clay loam, apedal, dense, 60% fine to medium stones

Soil name and map symbol Lee (Le)

Concept and overview

Lee soils occupy 15 ha and occur on the eastern margin of the survey area on sloping land that forms toe slopes of the Richmond Hills. The parent material comprises fine textured colluvial sediment deposited on small fans, originating from within minor gullies within the Richmond Range foothills. The soils are deep, heavy textured and imperfectly to moderately well drained.

Relationship to previously named soils

Lee soils were mapped in the Brightwater district (2013/14 Campbell unpublished) where, in association with Wantwood soils, where they were distinguished as imperfectly drained, heavy textured soils lying at the toe slopes of small fans. In the survey of the soils of Waimea County (Chittenden 1966), Lee soils in the present survey area were included with Richmond soils.

Landform origin and history

The fan deposits on which Lee soils are formed are mapped as Stoke Fan Gravel formation (Johnstone 1982) and are considered to date from the Early Holocene period. The sedimentary materials, derived from erosion of nearby Jenkins Group and Richmond Group siltstone and sandstone rocks come from small catchments and have accumulated as fine textured colluvium during a period of intensive rainfalls when erosion on nearby sloping land was more active than at present. Towards the toe of the fans, the sediments thin and overlie the gravel formation of the Ranzau soils.

Key features and physical properties

Lee soils are deep and imperfectly drained with strongly mottled brown and light grey subsurface horizons. The A horizon is dark brown or very dark brown clay or clay loam, with an average thickness of 26cm while the underlying clay textured B(g) horizons are differentiated by variation in the mottle patterns. The subsoil structures are coarse and compact. A watertable at around 90cm was observed at several observation sites.

Identified variants

Lee soils are sometimes (10%) moderately deep (around 90cm deep) and moderately well drained (30%) with less intensive subsoil mottling. A few stones are occasionally present.

Associated and similar soils

At the toe slopes of the fans where the sediments thin, Lee soils merge into Richmond soils. Lee soils have similarities with Cotterell soils but the later are moderately deep with clay loam to silt loam texture and predominantly moderately well drained. Barnicoat soils also merge into Lee soils in toe slopes where deep fine textured alluvium is present.

Soil versatility and land use

Lee soils have a moderate to low versatility (2.6 Table 2) with significant limitations for intensive use. Included are imperfect soil drainage, slow permeability, limited trafficability and workability due to soil wetness, low nutrient status and a slight erosion risk due to land surface

slope. Lee soils are used for grazing and are included in class D of the Tasman District Council classification system for land management.

Lee clay loam

Horizon	Depth	Description
A	0-27cm	dark greyish brown to dark brown (10YR 4/2) clay loam, 15% reddish brown (5YR 4/4) fine mottles, moderately developed fine polyhedral structure, weak soil strength, compact, friable, many fine roots
Bg1	27-43cm	brownish yellow (10YR 6/8) clay, 35% yellowish red (5YR 5/6) and 15% light grey (10YR 7/2) medium mottles, and pinkish red (5YR 6/2) veined infills, strongly developed coarse blocky and prismatic structure, firm soil strength, compact, semi deformable failure, common fine roots
Bg2	43-70cm	strong brown (7.5YR 6/2 50%) and light brownish grey (2.5Y 6/2 50%) mottled clay, strongly developed coarse blocky and prismatic structure, firm soil strength, compact, semi deformable failure, 2% fine stones, few medium roots
BC(g)	70-95cm	yellowish red (5YR 5/8 50%) and light grey (10YR 7/2 50%) coarsely mottled clay, moderately developed coarse blocky and structure, firm soil strength, compact, semi deformable failure, <2% fine stones, water table at 90cm

Soil name and map symbol Wakatu (Wh)

Concept and overview

Wakatu soils are mapped on the eastern margin of the present survey area in small patches totalling 4 ha and which forms part of the adjacent strongly rolling to hilly foothills landscape. Wakatu soils are formed on weathered Moutere Gravel (Johnstone 1982) on predominantly sloping surfaces and have deep to moderately deep profiles that are moderately well drained.

Relationship to previously named soils

The soils on the Moutere Gravel Formation on the eastern foothills of the Waimea Plain were mapped as Wakatu soils in the Soil Survey of Waimea County (Chittenden 1966). They resemble the Mapua soils which occur extensively to the west of the Waimea Plains.

Landform origin and history

The Moutere Gravel Formation is widespread deposit, in the Moutere Depression, of coarse outwash gravels that were laid down towards the end of the Tertiary period. Subsequent deep weathering and landscape dissection have resulted in an intricate pattern of ridges and small valleys. The Moutere Gravel was excavated by the Wai-iti, Wairoa and Waimea River systems leaving the broad expanse of the Waimea Plains. The Moutere Gravel occurrences within the present survey area are remnants of the former Moutere Gravel Formation landscape and include rocks derived from the nearby Maitai and Richmond Groups. They have the same attribute of deep weathering indicating that they are part of the former old landscape system.

Key features and physical properties

Wakatu soils have a shallow (<20cm) clay loam topsoil that overlies a firm blocky structured subsoil that overlies a B horizon with brown or reddish brown mottles. The lower B horizons have a sandy clay loam texture, coarse blocky and prismatic structure, very firm soil strength and prominent grey mottles. There are some firm stones through the profile and in the lower horizons, soft weathered stones that are relic from the former period of deep weathering.

Identified variants

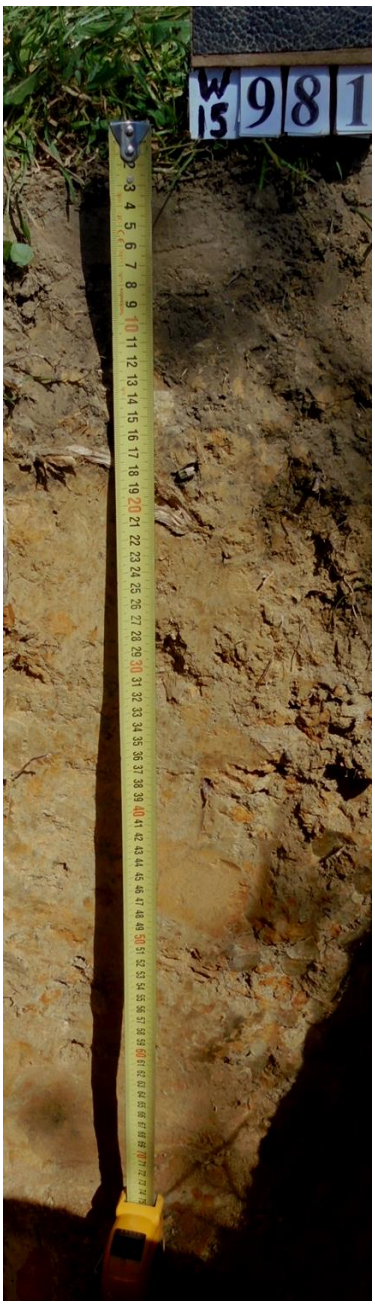
On lower slopes soils with more intense mottling and thick very dark greyish brown topsoils were observed.

Associated and similar soils

Wakatu soils are similar to Mapua soils which are found elsewhere in the district. They have somewhat higher fertility, most probably due to the inclusion of rocks from the Richmond and Maitai Groups within the gravels.

Soil Versatility and land use rating

Wakatu soils have a moderate to low versatility for land use (2.4 Table 2). A rolling topography and sloping ground as well as a potential for soil erosion are significant limitations for various forms of intensive, use but they are successfully used for orchards, which requires minimal cultivation. Wakatu soils are included in class B of the Tasman District Council system for land management.



Wakatu clay loam

Horizon	Depth	Description
A	0-12cm	dark brown (10YR 3/3) clay loam, moderately developed medium polyhedral structure, slightly firm soil strength, compact, friable, <2% medium stones, many fine and few coarse roots
AB	12-20cm	dark brown (10YR 3/3) and brownish yellow (10YR 6/6) clay loam, strongly developed coarse blocky structure, firm soil strength, compact, brittle failure, <2% medium stones, common fine and few coarse roots
B	20-35cm	brownish yellow (10YR 6/6) clay loam, 15% brown (7.5YR 5/8) distinct mottles, strongly developed coarse blocky structure, firm soil strength, compact, brittle failure, 2% fine stones, common fine and few coarse roots
BC(g)1	35-65cm	strong brown (7.5YR 5/8 50%) white (10YR 8/2 10%) and very pale brown (10YR 7/2 35%) coarsely mottled sandy clay loam, moderately developed coarse blocky and prismatic structure, very firm soil strength, compact, brittle failure, 52% medium stones, few fine roots
BC(g)2	65-80cm+	strong brown (7.5YR 5/8 65%) and white (10YR 8/2 35%) coarsely mottled sandy silt loam, weakly developed coarse prismatic structure, very firm, dense, brittle failure, 5% medium stones and some coarse ghosts

Soil name and map symbol Anthropic (An)

Concept and overview

Anthropic soils occur in several places and cover 34 ha within the present survey. They are soils that are formed on materials that have been replaced following land disturbance, primarily as a result of excavations for the extraction of underlying gravels. Anthropic soils may be more widely distributed than as shown on the soil map as in the process of fam land development, smoothing of terrace edges and infilling of small channels commonly occurs but is largely unrecognised.

Relationship to previously named soils

No anthropic soils have been specifically identified in earlier surveys of the district (Chittenden et al. 1966). In the present survey area, the Anthropic soils formed part of former Waimea, Redwood and Ranzau soils.

Landform origin and history

The removal of the upper soil horizons, extraction of subsurface gravel and soil replacement took place on Waimea soils between 19… and 19…in an area close to the Waimea River and the Appleby Highway. At the north west end of Eden Road, an area of Redwood soils was removed and replaced between 19… and 19… and near the east end of Eden Road, a small area of Ranzau soils were removed and replaced following gravel extraction between 19.. and 19..? Before mining the gravel, the surface soil horizon (A) and subsurface (B) horizons are usually removed and stockpiled for later replacement, with attempts being made to minimise compaction with the use of heavy machinery. In the Waimea and Redwood soils, thin topsoils with inconsistent depths and minimal subsoil development in practice means that topsoil and C horizon material are invariably mixed, while respread seldom results in a uniform depth distribution of the replaced soil material. In the Ranzau soil gravel extraction, the more distinct B horizon was removed separately from the A horizon and replaced with minimal compaction before returning the topsoil. Subsequent crop experiments showed that there was a significant low in productivity between the undisturbed and the disturbed Ranzau soil.

Key features and physical properties

The Anthropic soils were found to have thin stony to very stony topsoils (average 14cm depth) but occasionally depths of 45-60cm were recorded. The topsoil colour is variable, sometimes dark brown but more commonly pale olive reflecting the mixing of subsurface material with A horizons during the removal and replacement processes. The average depth to very stony gravel was 35cm. Soil texture is likewise variable and where a silt loam texture was observed, soil compaction and impeded drainage were noted.

Associated and similar soils

The soils most related to the Anthropic soils are Wai-iti soils from recent alluvial deposits and which have little soil profile development.

Soil versatility and landuse

The anthropic soils have a low to moderate versatility for intensive use (2.5 Table 2). The limitations include low profile available water, stoniness, low nutrients, a shallow effective rooting depth and increased flood risk due to ground lowering. The process of soil removal, gravel extraction and soil replacement inevitably results in a loss of productive potential.

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