Soils of the Waimea Plains: Waimea West District

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Introduction

The Waimea Plains comprise a small area of arable land constructed by the deposition of recent alluvial sediments of the Wai-iti and Wairoa Rivers, which join and flow northwards into Tasman Bay. The Waimea Plains is an important area for the economy of Nelson Province as it provides 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.

The existing information about the soils of the Waimea Plains comes chiefly from the soil survey report published nearly 50 years ago (Soils and Agriculture of the Waimea Plains, Chittenden, Hodgson and Dodson 1966, *New Zealand Soil Bureau Bulletin 30*). The soil map accompanying this report is at a generalised scale of 1; 126,720 (two miles to the inch). Given the inherent soil variations found on fluvial and floodplain surfaces, this 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 survey of the Waimea West district covers approximately 1000 ha and is a continuation of recent (2011/2012) more detailed soil mapping in the Appleby district, immediately to the north.

Survey Methods

Soil mapping was carried out over 55 days between October 2012 and June 2013. 1938 black and white 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 structural features, soil strength, plant root distribution and nature of underlying materials to be assessed. A total of 899 observations were made, 851 from auger inspections and 48 from soil profile pits and sections.

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 etc) and the information was used in determining the properties for each soil as well as the variability within the map units. The soil landuse ratings are derived from assessments of a range of soil and land attributes as used by Agriculture New Zealand in the 1994 Classification System for Productive Land in the Tasman District (Table 2).

The Soil Landscape Environment

The Waimea Plains covers an area of around 7,500 ha and comprises deposits of gravels derived chiefly from the catchments of the Wai-iti and the Wairoa Rivers. Alluvium from the Wairoa River forms a distinct slightly elevated terrace surface between the eastern side of the Wairoa River and the Richmond foothills. The remainder of the plains consists predominantly of floodplain and low terrace country.

The principal part of the Waimea Plain occupies an area about 7km wide and extends inland about 10km inland to Brightwater. East of Brightwater, the Wairoa River passes in a southerly direction into steep dissected country of the Bryant, Gordon and Richmond Ranges, with an elevation of over 1700m at Mt Rintoul, while to the west of Brightwater, the Wai-iti River trends southwest through lower altitude country formed by the Gordon Range and the Moutere Hills. While the Wairoa River has a larger catchment than the Wai-iti and receives higher rainfall because of its higher elevation, significant floods are experienced in the Wai-iti resulting from localised directional storm events. The Wairoa and Wai-iti Rivers have somewhat differing compositions of their sedimentary materials, the Wairoa containing some gabro, dunite and limestone together with a variety of siltstones and, sandstones and the Wai-iti predominantly sandstones and reworked sediments from the Moutere Gravel Formation.

Geomorphically, the Waimea West district comprises mainly old river flood plain and low terrace surfaces but also includes a smaller area of older higher terrace remnants on the western

side of the valley adjacent to the Moutere Hills. The main valley floor surface lies, at best, about 2 metres above the floodplain. It has a largely flattish surface, rising from 8 metres above sea level at the Moutere Highway (the northern part of this survey area) to about 37 metres near Teapot Valley, but is in places undulating with shallow channels, probably formed by extensive, but comparatively recent, flood overflows. The channelised areas tend to be somewhat gravelly with shallow soils while the smoother broader areas tend to have deeper fine sediments over gravel. These alluvial sediments have been mapped by Johnston (1982) as Appleby Gravel Formation (Holocene age <11,700 yrs) with radiocarbon dates from Waimea West at a depth of 7.6 m of 4120± 60 and 4620 ± 140 years B.P. but the surface sediments may be much younger.

The floodplain surfaces, now largely flood protected by stopbanks, represent historical and slightly older surfaces formed by recent flooding of the Waimea and Wai-iti Rivers. Some of these surfaces were river channels less than 50 years ago.

The higher terrace remnants on the west side of the Waimea West district are part of the former Late last Glaciation aggradation deposits that presently occupy Eves Valley and Teapot Valley. These gravelly deposits, mapped as Hope Gravel Formation by Johnston (1982) were more extensive and covered the valley floors before being partly excavated during the degradational conditions that prevailed after the commencement of the Holocene Interglacial. Dated at > 48 100 and >49 500 years B.P. from a drill hole at 32 m depth in Wai-iti Valley (Johnston 1982), the upper soil forming materials are likely to be much younger and may represent deposition from the post termination amelioration that followed the late glacial cold climate deposition of the Last Glacial Coldest Period (ca 30k-ca 18k years Barrell et al.2013).

During the formation of the present surface of the Waimea Plain in the Waimea West district, flood overflow waters appear to have been in part directed along the western border of the valley along a shallow channel. Subsequently, drainage waters from Eves Valley stream and other minor gully flows have occupied this channel and deposited predominantly sandy sediments, of recent and post-European age and which have been derived from local erosion within the Moutere Hills.

The western margin of the survey area to the south borders the Moutere Hills and has a landscape comprising foot-slopes composed of re-worked Moutere Gravel materials.

Soils

The existing published soil map (Chittenden et al.) identified four soil types in the Waimea West area. The soils identified in the present survey are listed in table 1 below.

Table 1
Soils of the Waimea West District

Recent River Floodplain	
Well drained soils	Wai-iti soils (Wa)
Older River Overflow and Terrace Surfaces	
Well drained shallow soils	Redwood soils (Rd)
Well drained moderately deep soils	Motupiko soils (Mk)
Well drained deep soils	Waimea soils (Wm)
Moderately well/imperfectly drained soils	Cotterell soils (Ct)
Recent stream alluvium	
Well drained	Eves soils (Ev)
Higher Terrace Remnants	
Well/moderately well drained soils	Dovedale soils (Dv)
Imperfectly drained soils	Braeburn soils (Bn)
Disturbed soils	
Well drained	Anthropic (An)

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

Concept and overview

Wai-iti soils occur on the lowest terrace and floodplain surfaces of the Waimea and Wai-iti Rivers, that were former flow channels and river overflow surfaces until recent times. Occupying 162 ha, Wai-iti soils are now largely protected from severe 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) where were generally identified as Waimea sandy loam but 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 were separated as the recent well drained soils on the floodplain and lowest surfaces of the Waimea River. Wai-iti soils occupy a similar position to Takaka soils in the Golden Bay district.

Landform origin and history

The floodplains of the Waimea and Wai-iti Rivers have formed after river entrenchment following the period of Post Glacial warming. Prior to the stopbank construction and flood protection work carried out by the Nelson Catchment Board in the 1950's and 1960's inundation and changes in river channels commonly occurred. A flood resulting from a severe storm in April 1957 probably covered most of the area that is mapped here as Wai-iti soils. Buried soils recorded in 15% of the observations of Wai-iti soils are indicative of past flooding and river depositional activity. The stopbank system was constructed for a 1 in 50 year flood return period and could be expected to be breached during more severe storms predicted with global climate change.

Key features and physical properties

Wai-iti soils are weakly developed with a brown to dark brown sandy loam A horizon, that averages 14cm thick, a buried A horizon where present that averages 18cm thick. Subsoils are dark yellowish brown to olive brown, and unstructured with texture ranging from sandy loam to silt loam but commonly interspersed with gravelly layers. The depth to gravel averaged 44cm but ranged from 0cm to >100 cm.

Identified variants

Wai-iti shallow soils (Wash <45cm to gravel) were recorded in 60% of observations, Wai-iti moderately deep soils (Wamd 45-100cm to gravel) in 30% of observations and deep soils (>100cm to gravel) 10%. Wai-iti stony soils (Wast, topsoil stoniness; slightly stony 1%-5%, moderately stony 5%-35% and very stony >35% stones by volume) were found at 30% of the observation sites with the majority moderately stony, although in a few locations they are bouldery. Variations in soil depth and stoniness commonly occur within short distances.

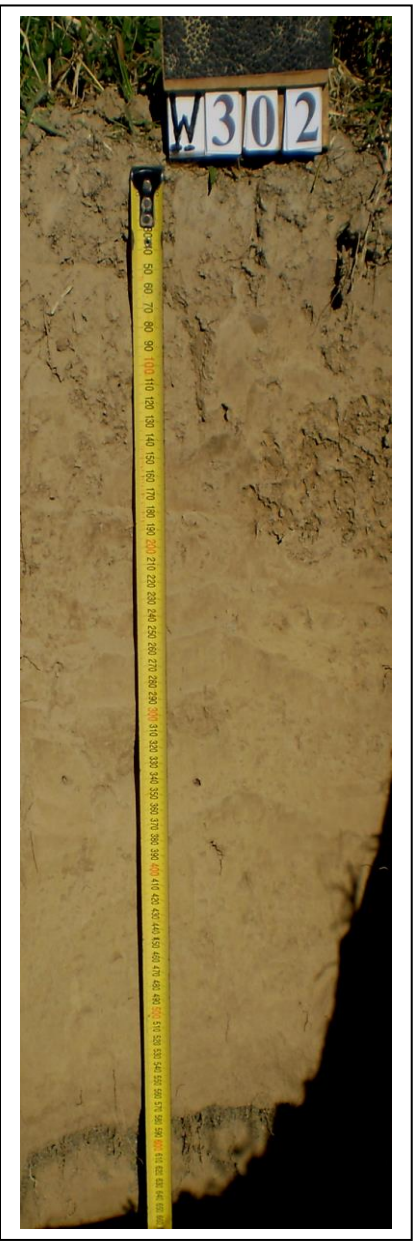
Associated and similar soils

Eves soils, formed from stream alluvium derived from erosion of Moutere Gravel sediments in adjacent Moutere Hills have similar properties to Wai-iti soils.

Versatility and land use rating

Wai-iti moderately deep and deep soils have a moderate to high versatility (1.8 Table 2) while the shallow and stony soils have a moderate to low versatility (2.7 Table 1) owing to stoniness (bouldery in places), somewhat excessive drainage, and lower available water capacity. Both the moderately deep and deep soils and also the shallow

and stony soils are however used successfully for a range of market garden and 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.



Horizon	Depth	Description
A	0-7cm	brown to dark brown (10YR 4/3) silt to silt loam; weakly developed fine polyhedral structure; weak soil strength; 1% fine stones; compact; friable; many fine roots
C	7-14cm	dark yellowish brown (10YR 4/4) silt to silt loam; apedal; weak soil strength; brittle; common fine roots
b A	14-21cm	brown to dark brown (10YR 4/3) silt to silt l loam; weakly developed fine polyhedral structure; weak soil strength; compact; 1% fine stones; few fine roots
b C1	21-45cm	dark yellowish brown (10YR 4/4) silt loam; apedal; slightly firm soil strength; compact; few fine roots
b C2	45-58cm	olive brown to dark yellowish brown (2.5Y 4/4-10YR 4/4) fine sandy loam; apedal; very weak soil strength; compact; few fine roots
C	58-70cm+	olive (5Y 5/3) sand; apedal; loose; 7% fine to medium stones; common fine roots

Soil name and map symbol; Redwood soils (Rd, Rdst)

Concept and overview

Redwood soils are widespread within the present survey area and cover 282 ha. They are formed on surfaces that lie above the present flood plain and a little below the main valley floor level. Redwood soils have a gently undulating topography with a subdued

channelised surface resulting from former overflows during flood conditions. The soils are weakly developed with a weathering depth of between 40-60cm, a depth to gravel that averages 31cm and surface stoniness, which at times is bouldery.

Relationship to previously named soils

Redwood soils were not mapped in the earlier survey of the soils of Waimea County (Chittenden 1966) and were probably included with Waimea sandy loam. They were mapped in the 2011/12 survey of the Redwood Valley-Appleby portion of the Waimea Plains (Campbell unpublished).

Landform origin and history

Redwood soils are formed from Appleby Gravel Formation deposits (circa 4120$\pm$ 60 Johnston 1982) but the surface materials and soils may be relatively recent as the soil weathering depth is shallow (generally <45cm) and buried soils are sometimes present. There have probably been intermittent climate related cycles of aggradation and degradation in the river systems through the Holocene warming period with Redwood soils representing a relatively recent fluctuation in the river flow pattern.

Key features and physical properties

Redwood soils are well drained, predominantly shallow soils, with a dark brown or brown to dark brown A horizon of about 20cm overlying a dark yellowish brown B horizon of less than 20cm passing into a olive to light olive brown BC or C horizon. Topsoil texture is predominantly silt loam or sandy loam and the subsoil texture sandy loam or silt loam passing into sandy gravel with increasing depth. The average depth to gravel was found to be 31cm but 65% of the soils were stony to the surface with 15% slightly stony (1-5%), 40% moderately stony (6-35%) and 10% very stony (>35%).

Identified variants

The main variant identified was Redwood stony soils (Rdst) with stoniness commonly changing over short distances. In a few areas the surface gravels are bouldery.

Associated and similar soils

Redwood soils are associated with Motupiko soils, which are essentially without surface stones and have a greater depth to underlying gravel. They differ from Wai-iti soils in having more distinct soil horizons with better development of soil structures.

Soil versatility and landuse

Redwood soils have a moderate to high versatility (average 1.8 Table 2) and are widely used for market garden and horticultural crops. Where the soils are very stony or bouldery, the versatility is moderate to low but the soils here are largely used for viticulture. The main restrictions are the shallow depth to gravel and soil stoniness with consequent lower available moisture storage but this limitation is overcome with irrigation. The surface stoniness provides some limitation to the range of horticultural crops that can be grown but allows the soils to be worked throughout the year. Redwood soils are included in class B of the Tasman District Council Classification system for productive land.

Horizon	Depth	Description
A	0-21 cm	brown to dark brown (10YR 4/3) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; 1% medium st stones; abundant fine roots
AB	21-26cm	brown to dark brown and dark yellowish brown (10YR 4/3+10YR 4/4) silt loam; moderately developed fine polyhedral and medium blocky structure; weak soil strength; compact; friable; common fine roots
B	26-41cm	dark yellowish brown (10YR 4/4) fine sandy loam; slightly firm soil strength; compact; brittle; 5% fine and medium stones; few fine roots
BC	41-47cm	dark yellowish brown (10YR 4/4) coarse sandy loam; apedal; compact; 40% fine and medium stones; very few fine roots
C	47-70cm+	olive brown (2.5Y 4/4) coarse sand; apedal; loose; 60% fine to coarse stones; very few fine roots

Soil name and map symbol; Motupiko soils (Mkmd, Mk)

Concept and overview

Motupiko soils occur widely within the Waimea West area covering 247 ha.
They are present on the low terrace that lies between 1-2m above the floodplain system and on a surface that for the most part is smooth although occasionally slightly undulating and broken with former shallow oveflow drainage channels. Motupiko soils

are well drained, have moderately developed profiles and for the most part are moderately deep, have silt loam texture that passes into sandy loam or sand and overlying gravel at less than 1m depth, although some areas with deeper profiles are present.

Relationship to previously named soils

Motupiko soils were earlier mapped in the survey of the soils of Waimea County (Chittenden et al. 1966) as soils formed from Moutere Gravels, greywacke, argillite and sandstone with silt loam to sandy loam textures and overlying gravel. They were mapped within the present Waimea West survey area and also on the lower terraces of the main river systems that draining the Moutere Hills.

Landform origin and history

Motupiko soils are formed from the Appleby Gravel Formation sediments (Johnston 1982) that were deposited in the Late Holocene period. The sedimentary sequence of silt loam over sandy over gravel, sometimes greater than 1m within the soil profiles over broad areas suggests a period of widespread but uniform flooding and sediment accumulation before some degradation, that gave rise to the present floodplain surfaces.

Key features and physical properties

Motupiko soils are well drained and have a brown to dark brown or dark yellowish brown silt loam topsoil that averages 22cm in thickness, a dark yellowish brown silt loam textured B horizon that averages 33cm in thickness, passing into a light olive brown to light yellowish brown sandy loam textured BC horizon, then into a olive or light olive brown sandy textured C horizon. Moderately deep soils (45-100cm depth to gravel) were recorded for 61% of the observations and deep soils at 39% of the observations. The average depth to gravel for moderately deep soils was 65cm.

Identified variants

The main variation for Motupiko soils was in respect of soil depth (moderately deep to deep) while about in about 15% of the observations, stones were present in the upper horizons. In a few occasions, some mottles indicating a slight drainage impediment were noted in the lower horizons.

Associated and similar soils

Motupiko soils are associated with Redwood soils, which occur where the depth of fine material over gravel is less than 45cm. Motupiko soils are similar to Waimea soils, which are deep but with clay loam texture. In lower lying areas and depressions of former overflow channels, moderately well drained Cotterell soils are present.

Soil versatility and landuse

Motupiko soils have a moderate to high versatility (1.6 Table 2) and are used for orcharding, vineyards and some horticultural crops. The chief limitations are their low nutrient status, slight winter limitations for trafficability and workability. They are included in class B of the Tasman District Council Classification system for productive land.

Horizon	Depth	Description
A	0-23cm	dark brown (10YR 3/3) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; many fine and few coarse roots
AB	23-31cm	dark brown and dark yellowish brown (10YR 4/6) silt loam; moderately developed fine polyhedral and weak blocky structure; weak soil strength; friable; common fine and few medium roots
Bw	31-53cm	dark yellowish brown (10YR 4.6) silt loam; moderately developed medium blocky structure; slightly firm soil strength; brittle; few fine roots
BC	53-70cm	yellowish brown (10YR 5/6) sandy loam; weakly developed fine blocky structure; compact; very few fine roots
C	70-60+cm	light olive brown (2,5Y 5/6) sandy gravel; apedal; 45% fine and medium stones; loose; very few fine roots

Soil name and map symbol; Waimea soils (Wm)

Concept and overview

Waimea soils cover 57 ha and occur in the northern part of the present survey area. They are formed on a relatively even surface, which although lying and only 1-2m above the Waimea River floodplain, constitutes the uppermost surface of the valley floor fluvial system. Waimea are deep soils with clay loam subsoils textures passing into coarser texture or gravel at greater depth. They are occasionally gravelly in the

topsoil horizon where they have been modified by the addition of gravel during early Maori cultivation.

Relationship to previously named soils

In the survey of the soils of Waimea County (Chittenden et al. 1966) all of the soils on the lower valley floor surfaces were mapped as Waimea soils As in the 2011/12 survey of the Redwood Valley-Appleby portion of the Waimea Plains (Campbell unpublished) Waimea soils are restricted to the deeper and heavier textured soils on the older recent fluvial surfaces of the Waimea Plains while the soils earlier mapped as Waimea silt loam and sandy loam were separated as Wai-iti and Redwood soils.

Landform origin and history

Waimea soils are formed on the Appleby Gravel Formation (Johnston 1982) with deposition occurring in the Late Holocene, judged by the C^{14} dates of 4120$\pm$ 60 and 4620 $\pm$ 140 years B.P from samples at Waimea West. The uppermost sediments are likely to be much younger however with the deep finer textured relatively uniform surface sediments representing widespread deposition under low velocity conditions.

Key features and physical properties

Waimea soils have a topsoil that averages 23cm thick and is dark brown, dark brown to brown or dark yellowish brown with moderately developed structure and silt loam or clay loam texture. The B horizon has an average thickness of 45cm and is predominantly dark brown blocky structured clay loam and passes into a BC horizon (average thickness 25cm) of weakly structured dark brown to light olive brown sandy clay loam, then into olive to olive brown material of varied texture. Some gravel may occasionally be encountered within the subsoil as well as a few mottles, generally at greater depth.

Identified variants

In 20% of the observations, the A horizon was found to be moderately gravelly without stones present in the underlying B horizon and probably represents additions of sandy gravel during early Polynesian soil cultivation. A few mottles, indicative of a slight drainage impediment are occasionally present in the lower subsoil.

Associated and similar soils

Motupiko deep soils are similar to Waimea soils but the former have silt loam rather than clay loam subsoil textures which pass into sandy loam and sand with increasing soil depth. Motupiko soils are predominantly moderately deep soils whereas Waimea soils are deep. (greater than 100cm).

Soil versatility and landuse

Waimea soils have a moderate to high versatility (1.6 Table 2) their main limitations being somewhat slow permeability along with seasonally restricted workability and trafficability due to their heavier texture and slower drainage. They are used for orcharding horticulture and nursery propagation. Waimea soils are included in Class B of the Tasman District Council Classification system for land management.

Horizon	Depth	Description
Ap	0-23 cm	very dark greyish brown (10YR 3/2) sandy silt loam; moderately developed fine polyhedral structure; 15% fine and medium stones; weak soil strength; compact; friable; common fine and few coarse roots; few small charcoal fragments; stones and charcoal resulting from additions to the soil from Maori cultivation
AB	23-32cm	very dark greyish brown and dark yellowish brown (10YR 3/2+10YR 4/4) silt loam; moderately developed fine polyhedral and medium blocky structure; slightly firm soil strength; compact; friable; few fine roots
Bw	32-52cm	dark yellowish brown (10YR 4/4) clay loam; weakly developed medium blocky structure; slightly firm soil strength; compact; brittle; few fine and few coarse roots
BC	52-95cm	dark yellowish brown to olive (10YR 4/4-2.5Y 4/4) sandy silt loam; weakly; developed medium blocky structure; slightly firm soil strength; compact; brittle
C	95cm+	olive (2.5Y 4/4) sand; apedal; loose; 15% medium stones

developed fine

Soil name and map symbol; Cotterell soils (Ct)

Concept and overview

Cotterell soils cover 73 ha and occur predominantly on the western side of the Waimea West district on land that is slightly lower lying. They are also present in some smaller lower lying areas that were former river overflow channels. They are moderately well drained to imperfectly drained soils with subsurface wetness resulting from slow subsoil permeability and low-lying topography. Their distinctive feature is the presence of reddish and grey coloured mottles usually below 50cm depth. Included with Cotterell

soils are some small areas of imperfectly drained soils formed from sediments deposited by Eves Valley Stream.

Relationship to previously named soils

Soils on the floodplain and terraces with a drainage impediment were not separated in the earlier survey of the soils of Waimea County (Chittenden et al.1966) but were separated in the 2011/12 survey of the Redwood Valley-Appleby portion of the Waimea Plains (Campbell unpublished).

Landform origin and history

Construction of the lower terrace surfaces of the plains in the Waimea West district occurred in the Late Holocene period (post 4120- 4620 yrs BP judged by ^{14}C obtained from within buried sediments at 7.6m at Waimea West, Johnston 1982). The surface topography indicates a meandering river system with undulating, mostly indistinct and discontinuous channels, probably formed by river overflows during flood periods. As sediment accumulation was greatest near the river system, surfaces beyond remained slightly lower lying and consequently suffer from some degree of wetness. Surface runoff waters during heavy rainfall events accumulate in some of the old flow channels giving rise to intermittent flows and wetness in some of the drainage channels.

Key features and physical properties

Cotterell soils have a moderately deep (average 22cm) very dark greyish brown to dark brown silt loam topsoil overlying dark yellowish brown, sometimes mottled, silt loam (average 28cm thick) which in turn overlies distinctly mottled silt loam to clay loam with variable mottle colours ranging from light grey to yellowish red or reddish brown. With increasing depth, textures are commonly sandier while soil colour is olive to olive grey. Cotterell soils are predominantly deep, 56% of observations >100cm, with moderately deep accounting for 37% of observations and shallow soils 7% of observations. The average depth to gravel for shallow and moderately deep soils was 54cm. The majority of Cotterell soils are moderately well drained (60%) with the remainder imperfectly drained.

Identified variants

Apart from differences in drainage (moderately well drained and imperfectly drained; which are not mapped separately) variation in Cotterell soils is mainly due to soil depth variation with 37% of observations recorded as moderately deep soils (45-100cm to gravel) and 7% shallow (<45cm to gravel) or gravelly at the soil surface.)

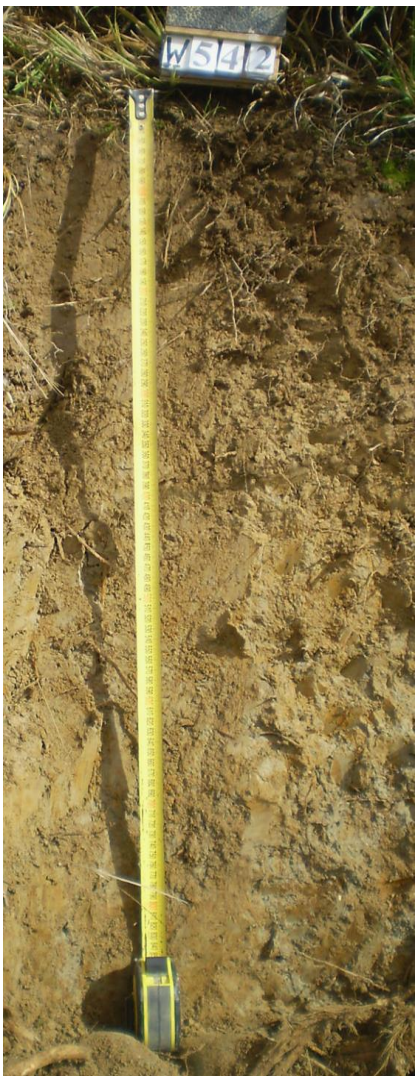
Associated and similar soils

Cotterell soils occur within the same landform units as Waimea, Motupiko and Redwood soils but typically in lower lying channels or backslopes where drainage is impeded.

Soil versatility and landuse rating

Cotterell soils have a moderate to low versatility and moderate limitations for use (2.4 Table 2). The main limitation is drainage and slow permeability in the lower soil horizons but periodic waterlogging and soil wetness restrict trafficability and workability. Larger areas of this soil type are used mainly for grazing rather than for horticulture but smaller areas in some depressions and channels are used for

horticulture alongside adjacent horticultural production. Cotterell soils are included in Class C of the Tasman District Council Classification system for productive land.



Horizon	Depth	Description
A	0-21cm	dark yellowish brown (10YR 4/4) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; very friable; many fine and few coarse roots
AB	21-30cm	dark yellowish brown and yellowish red (10YR 4/4+5YR 5/6) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; 5% light grey (10YR 7/2) fine distinct mottles; many fine and few coarse roots
B(g)	30-52cm	yellowish red (5YR 5/6 55%) and light grey (10YR 7/2 45%) silt loam; weakly developed fine blocky structure; weak soil strength; compact; brittle; medium distinct mottles; common fine and few medium roots
BC(g)	52-92cm	yellowish red (5YR 5/6 40%) and light brownish grey (10YR 6/2 60%) sandy silt loam; moderately developed medium blocky and fine prismatic structure; weak soil strength; compact; brittle; mottles fine to medium and distinct; few fine and few coarse roots
C	92cm+	light olive grey sandy gravel

Soil name and map symbol Eves soils (Ev)

Concept and overview

Eves soils are formed from the alluvium deposited by Eves Stream and cover 54 ha. They are well drained soils of variable depth and occur mainly within a narrow strip associated with the secondary stream system that drains Eves Valley. The alluvial sediments from which they are formed are derived from erosion of Moutere Gravel materials within the Eves Valley catchment. Deforestation and land use changes within the Eves Valley catchment have resulted in increased runoff and sediment deposition and the soils commonly have buried A horizons which highlight past periodic flooding events. The

effects of contemporary flooding are now largely limited by channel deepening and realignments.

Relationship to previously named soils

Eves soils were not separated in the earlier survey of the soils of Waimea County (Chittenden et al. 1966) however they were mapped in the 2011/12 survey of the Redwood Valley-Appleby portion of the Waimea Plains (Campbell unpublished). Small areas of poorly drained soils associated with Eves soils were separated as Mahana soils.

Landform origin and history

Within Eves Valley, the stream is largely confined within the sediments of the older Harakeke Formation (Johnston 1982) and after degradation in the Wairoa/Wai-iti river system, a small fan was constructed at the mouth of Eves Valley. Eves Valley stream subsequently followed a course in close proximity to the eastern edge of the Moutere Hills, occupying what may have been an earlier overflow channel of the Wairoa River. Eves soils are thus restricted to this confined depositional zone.

Key features and properties

Eve soils are predominantly moderately deep with a dark yellowish brown sandy loam topsoil (average 18cm thick) overlying a weakly developed dark yellowish brown to yellowish brown B horizon (average 26cm thick) with texture varying from sand to silt loam. This passes into brownish yellow to olive coloured sandy to sandy loam (BC or C horizon average 25cm thick). Buried A and B horizons indicative of recent flood history were observed in 37% of the observations. Eves soils are well drained and the depth ranges from deep to shallow.

Identified variants

Shallow soils (<45 cm to gravel) were found in 18% of the observations with 25% of the soils being slightly stony (<5%) or moderately stony (5-35%) and deep soils were found in 35% of the observations. In a few places, the soils are moderately well drained.

Associated and similar soils

Eves soils are similar to Wai-iti soils, both being formed from recent alluvial deposits and having weak soil development with periodic flooding. Wai-iti soils however, are formed from a variety of rock materials while Eves soils are formed from reworked Moutere Gravel sediments and are likely to have somewhat lower fertility.

Soil versatility and landuse

Eves soils have a moderate versatility (2 Table 2) with moderate limitations for intensive use. The chief limitations are susceptibility to flooding and low nutrient status. They are used along with adjacent soils predominantly for grazing but also for horticultural tree and vine crops. They are included in Class B of the Tasman District Council Classification for productive land.

Horizon	Depth	Description
A	0-18cm	brown to dark brown (10YR 4/3) silt loam; weakly developed fine polyhedral structure; compact; slightly firm; 2% medium stones; abundant fine roots
AB	18-22cm	brown to dark brown and dark yellowish brown (10YR 4/3+10YR 4/6) silt loam; moderately developed fine polyhedral and medium blocky structure; slightly firm soil strength; 2% fine stones; compact; brittle; common fine roots
BC	22-35cm	brownish yellow to yellowish brown (10YR4/6-10YR 5/6) silt loam; weakly developed medium blocky structure; 2% fine stones; compact; brittle; few fine roots
b B	35-42cm	brownish yellow (10YR 4/6) sandy silt loam; weakly developed fine blocky structure; 20% fine and medium to coarse stones; weak soil strength; compact; friable; few roots
C	42-60cm+	light olive brown to olive (2.5Y 5/4-4/4) sand; apedal; loose; 45% medium to coarse stones

Soil name and map symbol Dovedale (Dv)

Concept and overview

Dovedale soils are mapped over 56 ha in the southwest part of the Waimea West district. They are well drained, or sometimes moderately well drained, shallow to moderately deep soils formed from fluvial deposits derived from eroded Moutere Gravel materials. They occur on intermediate terrace remnants that lie several metres above and the Waimea Plain at its border with the Moutere Hills.

Relationship to previously named soils

In the survey of the soils of Waimea County (Chittenden et al 1966) Dovedale soils were mapped on most of the narrow valley floors within the dissected Moutere Hills and on terrace remnants of the larger valleys (Chittenden et al.1966). Dovedale soils were described as gravelly loams with silt loam to sandy loam textures and generally shallow soils with gravel mostly at the surface and of somewhat low fertility.

Landform origin and history

The terrace remnants on which Dovedale soils are mapped in the Waimea West district are formed from deposits mapped as Hope Gravel Formation (Johnstone 1982). During the Late Last Glaciation, aggradation from increased cold climate erosion resulted in valley filling within the Waimea Plains area and formation of terraces that have subsequently been largely removed by river excavation in the later Holocene period. The terrace remnants in the Waimea West district lie about five metres above the main valley floor surface, rising from about 25m above sea level at Eves Valley to 40m above sea level at Teapot Valley. The surface is flattish and there is a only a thin veneer of fine material over gravel.

Key features and physical properties

Dovedale soils are mostly well drained with an A horizon (average 20cm thick) which is predominantly dark brown silt loam overlying brownish yellow or yellowish brown silt loam to sandy loam (average 23 cm) overlying compact brownish yellow gravelly sandy loam, with the weathering depth extending to around 1m. The underlying gravels are mainly brownish in colour and partly weathered and have probably been derived as a consequence of erosion of the previously weathered Moutere Gravel Formation. The average depth to gravel is 39cm and generally compact gravels may at times restrict the soil drainage.

Identified variants

50% of the observations were shallow soils (<45cm to gravel) and 50% moderately deep. Stony soils were found in 44% of the observations (<5% slightly stony 26%, 5-35% moderately stony 63%, and >35% very stony 11%). Moderately well drained soils with subsoil mottle colours ranging from strong brown to pale yellow were noted in 25% of the observations.

Associated and similar soils

Dovedale soils are associated with the imperfectly drained Braeburn soils which also occur on the intermediate terraces, but on toeslopes and sloping surfaces that lie adjacent to the western hills.

Soil versatility and landuse

Dovedale soils have a moderate to low versatility (2.3 Table 2) and moderate limitations to intensive use. Their chief limitations are low nutrient status and the shallow to moderately deep profiles, with the underlying compact gravels restricting the rooting depth and giving rise to impeded drainage in places. They are used for grazing and also in part for orcharding and some horticulture. Dovedale soils are included in Class C of the Tasman District Council Classification system for productive land.

Depth	Horizon	Description
	A	0-20cm dark yellowish brown (10YR 4/4) silt loam; weakly developed fine polyhedral structure; slightly firm soil strength; compact; friable; 2% fine and medium stones; common fine roots
	AB	20-29cm dark yellowish brown and yellowish brown (10YR 4/4+10YR 5/6) silt loam; weakly developed fine polyhedral and fine blocky structure; slightly firm soil strength; compact; friable; 2% fine stones; few fine roots
	Bw	29-60cm yellowish brown (10YR 5/6) fine sandy loam; moderately developed medium blocky structure; slightly firm soil strength; compact; brittle fracture; 5% fine and medium stones; 2% strong brown (7.5YR 5/8) and light grey (2.5Y 7/2) distinct mottles near the horizon base; few fine roots
	BC	60-75cm+ yellowish brown (10YR 5/8) fine sandy loam; weakly developed fine blocky structure; firm; dense; 20% fine and medium stones

Soil name and map symbol Braeburn (Bn)

Concept and overview

Braeburn soils cover 37 ha and are mapped in several small areas in the southwest part of the Waimea West district. They are formed on footslopes that form the margins of the Moutere Hills and also on intermediate terrace remnants or surfaces that have received accessions of locally derived colluvial sediments from adjacent Moutere Gravel materials. Braeburn soils have heavy textures and imperfectly drained with strongly mottles subsoils characterised by reddish and whitish hues.

Relationship to previously named soils

Braeburn soils were first mapped in the survey of the soils of Waimea County (Chittenden et al. 1966) as the soils from poorly sorted alluvium derived from the weathered Moutere Gravels and occurring within the valleys and terraces associated with the Moutere Hills. They were mapped within the Redwood Valley area of 2011/12 survey of the lower part of the Waimea Plains (Campbell unpublished).

Landform origin and history

Braeburn soils occur on the terrace surfaces with underlying deposits of the Hope Gravel and Harakeke Formations but are also mapped several locations on some younger surfaces. For the most part, they are on gently sloping ground that forms toeslopes transitional between the hills and adjacent terraces but are also found on terrace surfaces where drainage is impeded by underlying compact gravel or the presence of an iron pan. The soil material is essentially colluvial slope deposit Moutere Gravel material that has been eroded from the adjacent hills in late glacial times.

Key features and physical properties

Braeburn soils have a moderately deep (24cm thick) dark brown silt loam or clay loam A horizon overlying clay loam or clay (average 42cm thick) that is distinctly mottled with soil colours between pale brown, olive yellow, strong brown and yellowish red. This overlies clay loam, sometimes gravelly and with light grey or whitish and strong brown or reddish coarse mottles. The average depth to weathered gravel was 56cm and the soils are for the most part imperfectly drained.

Identified variants

Most of the Braeburn soils mapped are moderately deep (45-100cm; average 56cm) but in 33% of the observations the soil was deep (>100cm depth to gravel). Poorly drained Braeburn soils were occasionally noted. Some small patches of Mapua soils on moderately steep land on the western margin of the survey are not mapped separately but are included within the Braeburn map units

Associated and similar soils

Braeburn soils occur within the same land system as Dovedale soils, the latter being formed from reworked Moutere Gravel alluvium rather than accessions of materials from adjacent hills. Braeburn soils merge with Mapua soils on the more strongly sloping land that borders the survey area with Mapua soils being formed essentially from in situ weathered Moutere Gravel material.

Soil versatility and landuse

Braeburn soils have a moderate to low versatility with moderate limitations for intensive use (2.9 Table 2). These include heavy texture and imperfect drainage which restricts permability and workability. Some of the Braeburn soils in this survey area occur on sloping terrain which is also a restriction for intensive use. They have in part been used for orcharding in the past but are now only used for grazing. Braeburn soils are included in Class D of the Tasman District Council Classification system for productive land.

Horizon	Depth	Description
A	0-26cm	brown to dark brown (10YR 4/3)_silt loam; weakly developed fine polyhedral structure; weak soil strength; friable; 5% fine distinct dark reddish brown (2.5YR 3/4) mottles; common fine roots
AB(g)	23-37cm	greyish brown (10YR 5/2) and light grey 10YR 7/2) silt loam; weakly developed fine polyhedral and blocky structure; weak soil strength; compact; common fine roots
Bg1	32-52cm	pale yellow (5Y 7/3) heavy silt loam; weakly developed fine blocky structure; weak soil strength; compact; 10% strong brown (7.5YR5/8) medium distinct strongly oxidised stones; common fine roots
Bg2	52-80cm+	light grey and pale yellow (2.5Y 7/2+ 2.5Y 7/4) sandy clay loam; weakly developed medium blocky structure; slightly firm soil strength; compact; brittle fracture; 20% strong brown and yellowish red (7.5YR 5/8+ 5YR 4/6) strongly oxidised stones; few fine roots

Soil name and map symbol **Anthrophic (An)**

Concept and overview

Anthropic soils cover 28 ha and occurring as one large area near the southeast side of Challies Road and in a few very small patches elsewhere. Anthropic soils are soils that have been made by the truncation of natural soil by earth-moving machinery or by truncation and reinstatement after removal of subsoil material, commonly gravel. Anthropic soils are more widely distributed than is usually portrayed on soil maps, as the process of truncation and or reinstatement on a small scale is common on many farm properties, with terrace edges and small channels often being smoothed or infilled

to facilitate land management. The Anthropic soils shown in this survey have been formed by gravel extraction for aggregate with (in most cases) soil and land restoration to a degree that agricultural use can be continued.

Relationship to previously named soils

No anthropic soils have been specifically mapped in earlier soil survey of Waimea County (Chittenden et al. 1966). Prior to their disturbance, they were considered to belong to the Waimea soil type (Waimea silt and sandy loam and Waimea gravelly loam).

Landform origin and history

The anthropic soils shown in the present Waimea West soil survey were previously formed on the low terrace and floodplain system of the Waimea River. The soil materials are the alluvial sediments of the Appleby Formation which date from the Late Holocene period (Johnston 1982) to the present day and had weakly developed soil profiles. Prior to the erection of the Waimea River stopbank system, the area near Challies Road was subject to periodic short term or long term flooding.

Key feature and physical properties

The anthropic soils are predominantly shallow with an indistinct, moderately stony, structureless sandy loam or silt loam textured surface horizon overlying similar, slightly lighter coloured moderately stony sandy loam. Underlying material is gravelly and variable, in places includes foreign substances such as clayey gravel, concrete clasts and a variety of organics which have been introduced for infilling. While earliest reinstatement of these anthropic soils dates from the 1970's there is little evidence yet of reformation of an A horizon.

Identified variants

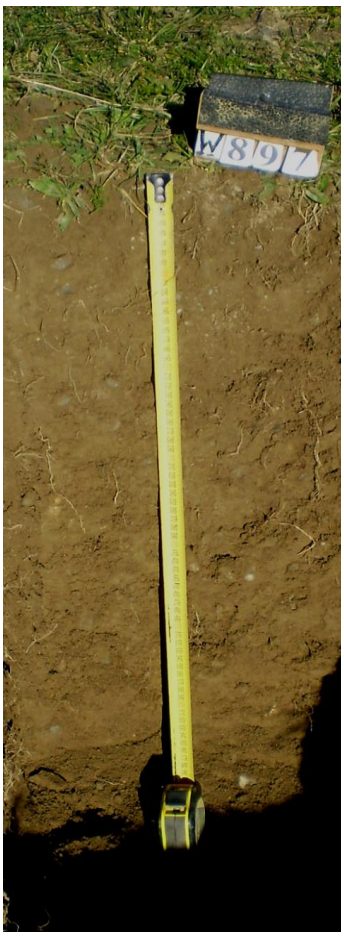
At two locations, small areas at gravel extraction pits have disturbed soil materials that have not been reinstated.

Associated and similar soils

The soils most similar to the anthropic soils are the Wai-iti soils which are formed on the most recently deposited sediments of the Waimea River and which display little soil development.

Soil versatility and landuse

The Anthropic soils have a low to moderate versatility (2.3 Table 2) and moderate limitations for intensive use. The limitations include moderate available water capacity, stoniness, and rooting depth, low nutrients and increased flood risk due to ground level lowering. The soil disturbance due to its removal and replacement has resulted in a loss of soil structure and soil horizons, in particular, an A horizon with its associated nutrient pool and has probably diminished the soil moisture storage capacity and increased the soil moisture infiltration rate. The addition of a range of foreign materials during soil replacement is largely detrimental in respect of enhancing the productive capacity of the restored soil. The potential of the Anthropic soils has probably been downgraded by one unit compared with the original soil condition.



Horizon	Depth	Description
An1	0-40cm	brown to dark brown (10YR 4/3) sandy loam; apedal; slightly firm soil strength; friable; 7% fine to coarse stones; common fine roots
An2	40-70cm	brown to dark yellowish brown (10YR 4/3-4/4) coarse sandy loam; apedal; slightly firm soil strength; compact; friable; 7% fine to coarse stones; common fine and few medium roots;
An3	70cm+	light olive brown (2.5Y 5/4) sandy gravel

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Table 2
Soil versatility ratings, Waimea West soils

Soil Name	Motupiko	Wai-iti	Redwood	Waimea	Cotterell	Eves	Dovedale	Braeburn	Anorthic
Topography	1	1	1	1	2	1	1	2	1
Irrigability	1	2	2	2	3	2	3	4	2
Drainage	1	1	1	1	3	1	1	3	1
AWC	2	3	3	1	2	2	3	2	3
Stoniness	1	1	3	1	1	2	3	2	3
Permeability	2	1	3	2	3	2	2	4	2
Nutrients	3	2	2	2	3	4	4	4	4
Trafficability	2	2	1	3	3	2	2	4	2
Workability	2	2	1	3	3	2	2	4	2
Rooting Depth	1	2	2	1	2	2	3	3	3
Erosion/flooding	1	3	2	1	1	3	1	1	3
Waterlogging	1	1	1	2	3	2	1	3	2
Average	1.6	1.8	1.8	1.7	2.4	2.1	2.2	3	2.3

0-1	Highly versatile	Few limitations
1-2	Moderate to high versatility	Slight limitations
2-3	Moderate to low versatility	Moderate limitations
3-4	Low versatility	Significant limitations