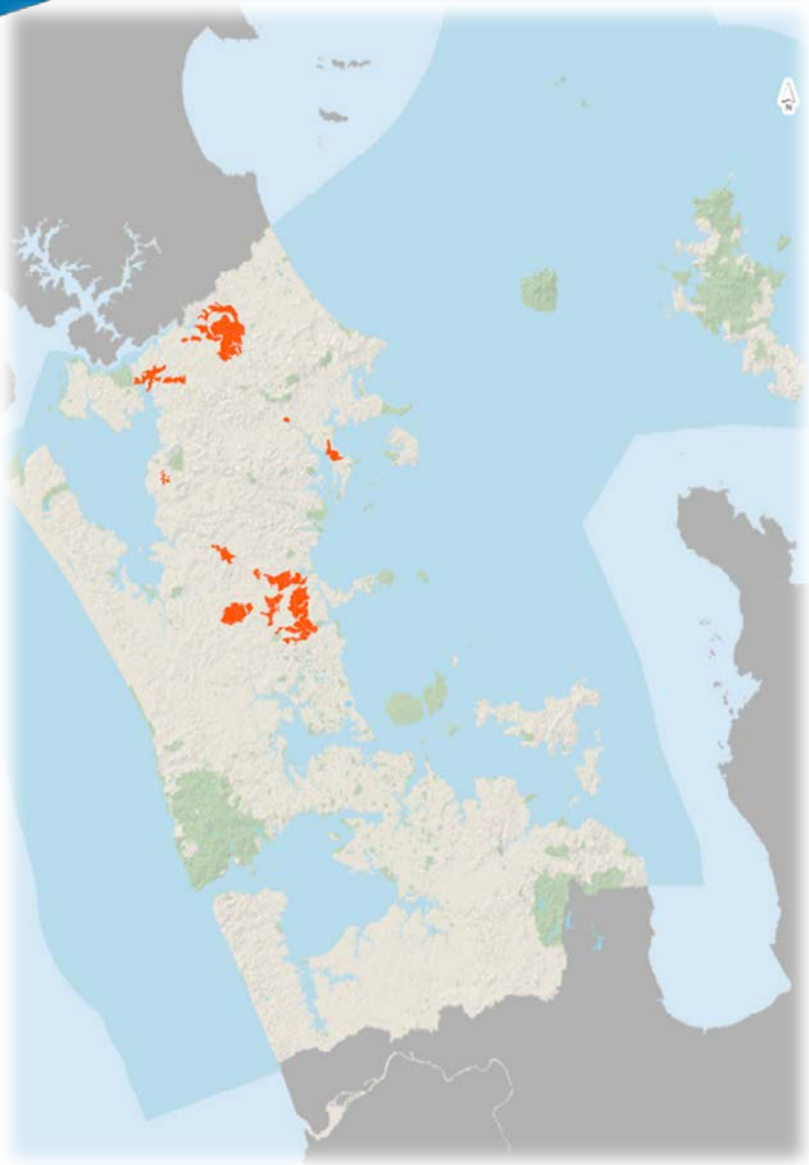
Soil Information Inventory:

Waikare and related soils

October 2018 Soil Information Inventory 24



RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Soil Information Inventory 24:

Waikare and related soils

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1 Introduction

With Auckland's expected growth from 1.7 to 2.0 million people in the next 30 years (The Auckland Plan 2050) and a goal to double New Zealand's agricultural exports by 2025 (Ministry for Primary Industries), an understanding of Auckland's soil resources is essential for planning urban growth, and sustaining if not expanding rural production, while managing the impacts of both on our region's environment.

Existing information on Auckland's soils is difficult to assess and interpret. Electronic versions of soil maps are available on research institute websites. Some have been uploaded into Auckland Council's geographic information system (GIS, GeoMaps) for use by council staff and for public viewing. However, the GIS maps and their attached attribute lists cannot be understood or used without referring to background information which is dispersed across old maps, publications, or unpublished reports. Many of these documents are now hard to find.

Auckland Council has undertaken to compile old information for the region's main soils into single documents called soil information inventories (SIIs). These may be viewed on Knowledge Auckland, www.knowledgeauckland.org.nz council's research and technical publications website, downloaded and printed. It is expected that there will be gaps in each inventory. The gaps will be filled as new information becomes available. Each inventory is a repository for information old and new and will be a "living document".

Their intent is to:

- ease access to soil information
- enable better understanding of the soils' properties
- enhance public awareness about the location of productive or problematical soils
- improve awareness of the soils' potential and limitations, amongst consultants and planners
- help council staff provide better advice, and make more informed decisions.

Our role has been document compilers, not authors. We have selected information which appears useful for landowners, farm, forest, environmental or planning consultants, and the council staff who deal with them. While we regard the selected information as reliable, responsibility for accuracy of contents rests with the organisations which originally collected and published the maps or documents which we cite. Auckland Council makes the information available on the Knowledge Auckland website with this understanding.

Acknowledgments are due principally to old soil surveyors of the DSIR's Soil Bureau, who collected most of the information reproduced here, notably Charles Sutherland, Charles Wright, Norman Taylor, Edward Cox, and Gary Orbell.

Assistance from Mandy Holt (cross-section), Tyana Rowe-Kurene, Tony Edhouse and Linda Wallis (document editing and layout), Fiona Curran-Cournane (internal publication referee) and Malcolm McLeod (external publication referee) is also acknowledged.

Michael Martindale, Douglas Hicks and Peter Singleton
June 2016, October 2018

2 Published maps

On DSIR's published soil maps of North Auckland (1:100,000), soils on mudstone deeply weathered to clay are depicted as three separate series i.e. soils with distinct profiles and parent materials:

YK, YKH	Waikare clay or silt loam
HK, HKH	Hukerenui silt loam
WK, WKH	Wharekohe silt loam

The Waikare label appears on map polygons singly, or combined with less weathered soils from mudstone e.g.

YK + OA	Okaka silty clay loam
YK + AP	Aponga clay loam
YK + TF	Te Tio stony clay loam (rare)
YK + OM	Omu clay (rare)

In Northland, Waikare clay or silt loam also appears on map polygons in combination with other soils weathered from mudstone (not listed here because they are not mapped in the Auckland region).

The Hukerenui and Wharekohe labels are common in Northland. They appear on just a few map polygons in North Auckland; either singly or combined with Waikare series or with each other e.g.

YK + HK
YK + WK (rare)
HK + WK

Similar soils do not appear on DSIR's published maps of South Auckland (1:253,840, 1: 63,360, 1: 25,000) because mudstone rocks are absent from the landscape.

Sourced from:
Soil maps of Maungaturoto-Kaipara area; Mangawhai-Warkworth area; Helensville-Waitakere area; Whangaparaoa-Auckland area NZ Soil Bureau maps 189, 190, 220, 221

3 Online maps

Landcare Research's online soil map (S-map, 1: 50,000) re-names and re-labels the soils as follows:

YK	Waikare family sibling 2a, Waikare 2 family sibling 1a, Kimptons family sibling?
HK	No family name or sibling number
WK	No family name or sibling number

Reasons for the basis of S-map can be found in the S-map database manual. The names and numbers were assigned by computer-matching local soil properties with different soils in other parts of the country.

Sourced from S-map Online – Home http://smap.landcareresearch.co.nz/home

4 Farm-scale maps

North of Auckland, any published map polygon labelled YK, HK or WK is a mosaic of the three when investigated in the field by local mappers. All three can be differentiated into distinct types i.e. soils with different textures or other characteristics, when mapping at farm scale. These correspond with two situations:

- Parts of the polygon where the soil has weathered from parent rock or
- Parts where it has weathered from re-deposited material, usually colluvium (slopewash deposit).

On farm-scale soil maps (1:5,000 - 1: 10,000) the types are labelled as:

YK	Waikare silty clay or clay
YKc	Waikare silt loam (colluvial variant)
HK	Hukerenui silt loam
HKg	Hukerenui silt loam with iron nodules (colluvial variant)
WK	Wharekohe silt loam
WKp	Wharekohe silt loam with iron pan (colluvial variant)

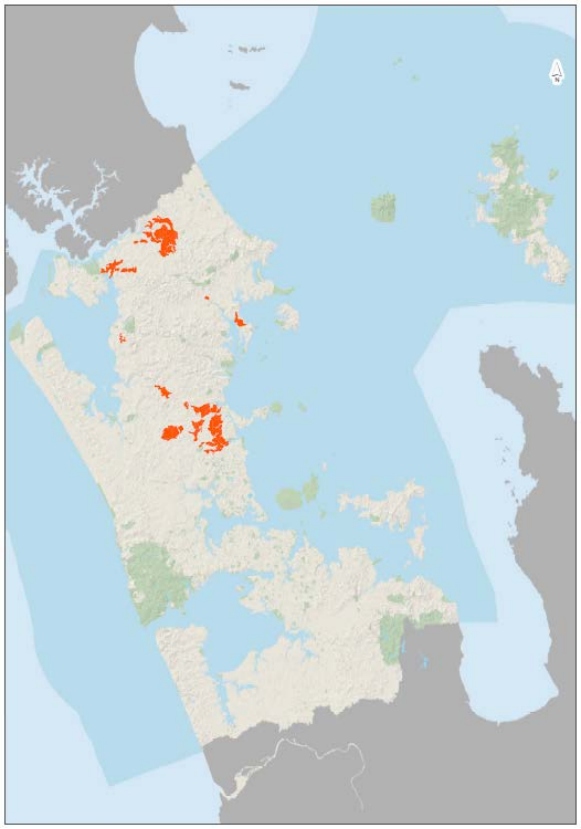
Published map polygons where YK etc. appears as part of a compound label e.g. YK + OA, generally turn out to contain extensive areas of Waikare (including its colluvial variant) as a mosaic with the other named soil. Patches of related soil i.e. Hukerenui or Wharekohe may be present within the areas separable as Waikare, though are rarely large enough to differentiate on a farm-scale map.
Published map polygons labelled solely as associated soils i.e. OA, AP, TF, OM usually contain small areas of Waikare, Hukerenui and Wharekohe. Where large enough to differentiate at farm scale, these are separated and labelled as above.

Sourced from 1995-2015 farm-scale maps and soil notes prepared for private landowners, Auckland Regional Council or Auckland Council

Sourced from 1995-2015 farm-scale maps and soil notes prepared for private landowners, Auckland Regional Council or Auckland Council

5 Where the soils occur

Widespread from Dairy Flat through Waitoki to Wainui; as pockets from Warkworth to Kaipara Flats; extensively from north side of the Hoteo River mouth to the Auckland region's boundary at Te Hana.



Location of Waikare and related soils

Waikare and related soils are mapped on 9,300 hectares (2% of Auckland region). About 6,100 hectares (65% of the area mapped) are in productive use, divided between dairy or drystock pasture and forest plantation (estimated from overlay of Agribase on Fundamental Soils Layer). *http://intermaps.arc.govt/AucklandCouncilViewer/*

Waikare clay on stable parts of a mudstone hillslope near Wellsford, interspersed by Waikare silt loam on colluvium in rushy hollows, and Aponga clay loam on hummocky earthflow terrain. *Photo: D. Hicks*

5.1 On what landform

Rolling downland formed from siliceous mudstone or calcareous mudstone, interspersed with bands of sandstone or limestone. The rocks are marine sediments deposited from end of the Cretaceous period (70 million years ago) through early epochs of the Tertiary period (up till 25 million years ago). These geological formations comprise the Northland Allochthon, emplaced over younger siltstone, sandstone or volcanic rocks of the Waitemata Group by sea-floor landslides during the Miocene epoch (between 25 and 8 million years ago). They alternate from intact blocks rafted in the landslides, through rock with shattered but visible bedding, to crushed rock without visible structure. The allochthon has been eroded away from high ground, where resistant Waitemata Group rocks outcrop, but survives as a mantle over low-lying parts of North Auckland's landscape.

Sourced from Edbrooke, S. W., 2001, Geology of the Auckland Area, Institute of Geological and Nuclear Sciences 1: 250,000 map 3 and accompanying bulletin

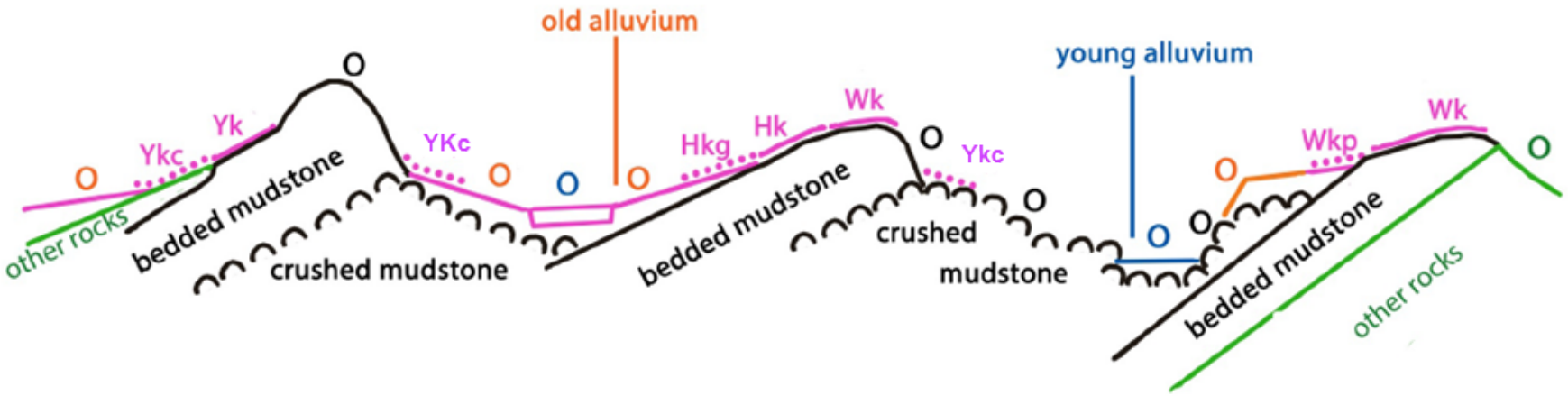
5.2 How they differ from other soils

Waikare and related soils are underlain by a layer of clay which has weathered from the same marine sedimentary rocks as are exposed on hillslopes. These ridges and footslopes are the most stable parts of the landscape, so there has been sufficient time for clay illuviation to occur in upper subsoil; also, for a layer of fine sandy silt to form on top of the clay i.e. for podsols to develop. Under generations of kauri forest, nutrients are leached from the topmost clay, while percolating soil water washes the clay itself downwards through soil pores and cracks, depositing it in the upper subsoil. Initially a silty topsoil develops over a clay-rich upper subsoil which seals once wet. This is mapped as Waikare clay or Waikare silt loam. With time, a distinct eluvial (leached) horizon of silt develops

between topsoil and subsoil. This is Hukerenui silt loam. Finally, the eluvial horizon compacts into a pan, parts of which may cement. The end-stage is mapped as Wharekohe silt loam.

Sourced from: Wilson, A.D. and Cox, J.E., Soils of Rodney County, Unpublished report, Soil Bureau DSIR

Cross section showing Waikare and related soils' position in the landscape



<u>On broad ridges and stable upper slopes:</u>

Yk Waikare silty clay or clay
Hk Hukerenui silt loam
Wk Wharekohe silt loam

<u>On slope hollows and stable footslopes:</u>

Ykc Waikare silt loam
Hkg Hukerenui silt loam with iron nodules
Wkp Wharekohe silt loam with iron pan

o, o, o, o Other soils (refer to relevant soil information inventory)

Soil type labels on the cross-section are sourced from Auckland Council's farm-scale maps.

6 Classifications

NZ genetic (NZG):	Yellow-brown earth, podzolised yellow-brown earth, or podzol
NZ soil (NZSC):	Perch-gley albic ultic, mottled densipan ultic, perch-gley densipan ultic *http://soils.landcareresearch.co.nz/contents/SoilNames_NZSoilClassification_SoilOrders.aspx*
Soil Taxonomy (USDA):	Aquic, aeric or typic albaquult *http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051544.pdf*
World Soils (FAO):	Cambisol or podsol *http://www.fao.org/3/a-i3794e.pdf*

DSIR replaced the New Zealand genetic classification dating from 1930s with the New Zealand soil classification in 1990s. DSIR's soil scientists considered that Soil Taxonomy did not work well in New Zealand, nor did World Soils. Soil Taxonomy and World Soils remain internationally accepted classifications.

7 Soil profile descriptions

DSIR prepared numerous unpublished type profiles for variants of Waikare series. The first (MF103) corresponds with Waikare clay as mapped on weathered siliceous mudstone. It was located on “deeply weathered grey-white shattered claystones of the Onerahi Beds” near Wellsford. Originally labelled Waikare clay, silty clay loam and silt loam; hand-annotated as Waikare silt loam + Okaka clay and silty clay.

Waikare clay *Photo: D Hicks*

Waikare silty clay loam = Waikare clay

Horizon	Depth (cm)	Description
Ah	0-8	Dark grey and grey (10YR 5/1) silty clay loam; friable when moist; massive in this wet condition; many scrub roots; distinct wavy boundary.
Br	8-16	Intermingled colours mottled effect, grey, white and pale brown (10YR 6/1-8/1-7/3) silty clay; few faint fine and very fine, strong brown and dark brown (7.5YR 5/6 and 4/4) mottles mainly as coatings along root channels; firm; massive and brittle when moist, poor porosity; contains many earthworms, many casts; many scrub roots; distinct wavy boundary.

Btg	16-29	Intermingled colours mottled effect, light grey, very pale brown, yellow and white (10YR 7/2-7/3-8/6 and 8/1) clay; common very fine and medium, reddish yellow (7.5YR 6/6) mottles; massive; faint imprint of coarse and medium subangular polyhedral structure with distinct grey brown clay skins along the faces of the prisms; very firm and brittle; poor porosity; contains many native earthworms and worm casts; many scrub roots; distinct wavy boundary.
Bt(g)	29-79	Intermingling colours mottled effect, varied very pale brown, varied yellow and speckles of white (10YR 8/4-7/4; 8/6-7/6; + 8/1) clay; common fine to medium, reddish yellow (7.5YR 6/6 and 5YR 6/6) mottles; moderately developed coarse, very coarse and medium subangular polyhedral structure, more tightly packed in place with increasing depth; moderately developed prismatic structure with light brownish grey and dark gray clay coatings along the faces of the prisms; very firm; very poor porosity; common casts; many scrub roots along the faces of the prisms; distinct irregular boundary.
Btr	79-99	White (2.5Y 8/2) clay; common medium and fine, reddish yellow (7.5YR 6/8) mottles; very firm; moderately developed coarse and medium subangular polyhedral structure, very poor porosity; horizon fissured with faint grey clay coatings along the faces of the fissures; distinct irregular boundary.
R	on	Soft and hard shattered grey-white claystone with prominent yellowish red and pale brown coatings on the faces of the claystone; no scrub roots.

Another type profile (MF106 a) corresponds with Waikare silt loam, a variant mapped where sheetwash (erosion of soil by overland runoff) has deposited colluvium in slope hollows or on footslopes. This type profile was located on “strongly and deeply weathered, shattered, grey-white and grey brown cretaceous (calcareous) claystone” between Silverdale and Redvale.

Waikare silt loam (colluvial variant) *Photo D Hicks*

There are two type profile descriptions for Hukerenui silt loam; the first (MF16a) beneath scrub, the second (MF 16b) under pasture. They were located “on deeply weathered claystone” near Tikipunga in Northland. DSIR’s soil mappers described the second as a good modal profile:

Hukerenui silt loam *Photo: D Hicks*

Hukerenui silt loam

Horizon	Depth (cm)	Description
Ap	0-9	Dark grey (10YR 4/1) silt loam; friable; moderately and weakly developed very fine and fine subangular polyhedral and extremely fine subrounded polyhedral casts, some single grain; many worms; abundant grass roots; diffuse boundary.
E	9-18	Grey and dark grey (10YR 5/1- 10YR 4/1) silt loam; friable; massive in place but with weakly developed fine and very fine subangular polyhedral structure, some very fine and extremely fine subrounded polyhedral casts; common worms and many grass roots; abrupt boundary.
E(x)	18-31	Light grey and grey (10YR 7/1 - 10YR 6/1) silt loam; many fine and very fine light yellowish brown mottles and few dark grey mottles; massive in place with a very weakly developed fine and very fine blocky structure; high packing; brittle; many grass roots; diffuse boundary.
Bt(f)1	31-68	Yellow and light brownish grey (10YR 8/6 + 8/3 + 6/2) clay; slightly sticky; many fine reddish brown and yellowish red (5YR 5/3 and 5/6) mottles; massive in place with moderately developed very coarse medium blocky structure; light brownish grey clay coatings along the faces of fissures and on some aggregates; many grass roots; diffuse boundary.
Bt(f)2	68-83	Very pale brown (10YR 7/3 - 10YR 7/4) clay; faint, very fine and fine yellowish mottles; very firm; moderately developed medium and fine subangular polyhedral structure, the lower part is well developed prismatic structure, with light brown grey to grey clay coatings along the faces of the prisms and on some aggregates; many fine grass roots; diffuse boundary.
C	On	Pale yellow (10YR 8/6-8/4) clays; faint, very fine reddish brown mottles; firm; moderately developed medium and fine subangular polyhedral structure; few grass roots

Hukerenui silt loam with iron nodules (colluvial variant) *Photo: D. Hicks*

There does not appear to be a DSIR type profile corresponding to the colluvial variant of Hukerenui silt loam. MF19 (Hukerenui gravelly silt loam) is similar in some respects, except that it contains silica nodules ("1/8 to 3/4 inch white silicified gravels ... very hard, flint-like") in its A and E horizons and is described as occurring on moderate or steep short slopes. It is mapped in Northland but not Auckland. A local soil mapper (DLH) has prepared a provisional profile description for Hukerenui silt loam with iron nodules, as mapped on colluvial (slopewash-deposit) hollows or footslopes in North Auckland:

Hukerenui silt loam with iron nodules (colluvial variant)

Horizon	Depth (cm)	Description
A	0-15	Dark grey silt loam; friable consistence and earthy structure when moist, powdery and subangular polyhedral when dry; distinct boundary.
E(x)	15-45	Pale grey loamy silt; loose consistence and massive when moist, firm and massive when dry; non-indurated; distinct boundary.
Brc	45-75	Pale brownish grey silty clay or clay (may contain some sand washed down cracks); sticky and earthy structure when moist, firm and subangular polyhedral when dry; dark brown or black iron oxide flecks and nodules; sharp boundary.
Bt(g)	on	Grey and yellow mottled clay

Wharekohe silt loam *Photo: D. Hicks*

DSIR's unpublished type profiles for Wharekohe series include the silt loam. Its type profile (labelled MF134) was located on "deeply weathered thinly banded sandstone" interspersed with "softened blue grey calcareous mudstone" at Omahuta forest in Northland. A hand-written note (by JEC) is "very doubtful about the descriptions of parent material ... deep-augered and collected samples ... at a bit less than 2 m reached grey to dark grey silty clay loam containing sulphides and this continued to below 4 m" suggesting the parent material is mudstone. The type profile description is far too detailed (page 20) to be used as a guide for field recognition. This profile is too complicated, unlike a field soil, and needs to be replaced, according to a former Landcare Research soil mapper, (Peter Singleton).

Wharekohe silt loam

Horizon	Depth (cm)	Description
H	0-13	Reddish black well decomposed leaf litter; earthy; friable; fragments of bark and kauri gum; distinct boundary.
Ah	13-20	Dark reddish brown to reddish grey (5YR 3/2- 5YR 5/2) silt; friable; weakly developed fine subangular polyhedral structure grading to massive; many roots; distinct wavy boundary.
E(x)	20-34	Greyish brown (10YR 5/2) silt with many pale brownish grey (10YR 6/2) fine speckles; firm and brittle; massive with a few fissures; surfaces stained dark reddish grey; on drying, this horizon is very hard and bleaches white; many fine pores; abundant fine roots and few vertical large roots (peg roots); indistinct irregular boundary.
E	34-44	Pale brownish grey and greyish brown mottled heavy silt loam with many white (10YR 8/2) speckles; firm; massive with fissures coated reddish black; kauri peg roots and many fine lateral roots; distinct irregular boundary.
Bg	44-56	Pale grey (10YR 6/1) clay; many distinct fine pale brown, brownish yellow, dark reddish brown and dark red mottles; firm and slightly sticky; weakly developed fine subangular polyhedral structure with tendency to form coarse prisms, which are coated reddish black and black; peg roots but fewer laterals; distinct irregular boundary.
Bw(g)	56-81	Yellow, brownish yellow, pale brown and pale grey mottled clay; many fine reddish mottles; very firm; sticky; moderately developed fine subangular polyhedral structure combined into extremely coarse prisms; distinct dusky red coating to prisms; few peg roots, many fine rootlets; indistinct boundary.
B'g	81-98	Pale yellow and pale grey clay; few reddish yellow, strong brown and red mottles; very firm; moderately developed coarse subangular polyhedral structure combined into prisms with thin red coatings; few small pieces sandstone; distinct irregular boundary.
CRg	on	Pale yellow and pale grey silty clay; mottled pale brown and yellowish red; very firm; massive (weathered feldspathic sandstone).

A local mapper (DLH) who has been to the type profile site, observes that its topsoil and eluvial horizon are stained by organic matter; its B horizons moist and soft i.e. influenced by standing kauri forest. Under scrub or pasture, a more typical Wharekohe silt loam's diagnostic features are pale grey or white A2 horizon which alternates from uncemented to cemented (or even silicified) over a short distance, above a hard compact upper B which is

stained by humus and contains iron oxide laminae but has not formed a distinct humus pan or iron pan.

There does not appear to be a DSIR type profile for Wharekohe silt loam with pan (WKp), despite its widespread occurrence in Northland. This type does not appear on the published soil maps of North Auckland as a map polygon label, but it is present at farm scale within polygons labelled Waikare (YK) or Hukerenui (HK) silt loam, on colluvial (slopewash-deposit) footslopes. A provisional profile description (prepared by DLH) is:

Wharekohe silt loam with iron pan (colluvial variant)

Horizon	Depth (cm)	Description
A	0-10	Dark grey silt loam; friable consistence and crumbly structure when moist, powdery and subangular polyhedral when dry; distinct boundary.
E	10-35	Pale grey loamy silt, loose consistence and massive when moist, compact and massive when dry; non-indurated; sharp boundary.
Bfm	35-45	Dark brown or black iron pan; hard consistence and massive structure; dark brown or black iron oxide nodules cemented by thin coatings and bands of hydrated iron oxide; sharp boundary to
Bw(f)	45-57	Pale brownish grey silty clay or clay; sticky consistence and crumbly structure when moist, subangular polyhedral when dry; firm; upper part contains dark brown or black coatings and bands of iron oxide, particularly down fissures; sharp boundary.
Bg	on	Grey and yellow mottled clay (as described for Wharekohe silt loam)

Wharekohe silt loam with iron pan is not widespread in Auckland's landscape. It typically occurs as small patches in hollows or on footslopes. Diagnostic features are A and E horizons often thicker than described (possibly an artefact of deposition by sheetwash), the E horizon uncemented, over a hard but brittle iron pan.

Sourced from:
Sutherland C.F., Cox, J.E., various dates, Type profile descriptions for North Auckland Soil Survey, Unpublished documents, Soil Bureau, DSIR
Fieldes, M. (ed.), 1968, Soils of New Zealand, Bulletin 26, Soil Bureau, DSIR

8 Properties of typical profile

These are best indicated by analysis results for the type profiles i.e. sites where Waikare, Hukerenui or Wharekohe series were defined and described. Data for other sites will vary somewhat, particularly where different types within the series are found.

8.1 Chemical http://soils.tfrec.wsu.edu/mg/chemical.htm

An incomplete chemical analysis appears in the online version of National Soils Database (NSD). The following data are sourced from Soil Bureau Bulletin 5 or Soil Bureau Bulletin 26.

Waikare clay

Property	Topsoil	Subsoil	Units
Acidity	5.2-5.9	5.0-5.0	pH
Total carbon	0.8-3.8	0.2-0.4	%
Total nitrogen	0.09-0.23	0.03-0.06	%
Available phosphorus	1-2	1-1	mg %
P retention	23-30	46-54	%
Available sulphur	1-2	2-5	%
Cation exchange capacity	15.2-18.3	21.2-21.7	me %
Base saturation	16-51	9-10	%
Calcium	0.5-5.2	0.4-0.4	me %
Magnesium	1.6-3.4	1.1-1.1	me %
Potassium	0.18-0.45	0.18-0.21	me %
Sodium	0.2-0.4	0.2-0.2	me %

Sourced from laboratory analysis SB07654, DSIR Soil Bureau

Hukerenui silt loam

Property	Topsoil	Subsoil	Units
Acidity	5.0	5.0	pH
Total carbon	3.0	-	%
Total nitrogen	0.27	-	%
Available phosphorus	0.005	0.002	mg %
P retention	-	-	%
Available sulphur	-	-	%
Cation exchange capacity	16.0	16.5	me %
Base saturation	14	5	%
Calcium	1.3	0.9	me %
Magnesium	1.4	0.7	me %
Potassium	-	-	me %
Sodium	-	-	me %

Sourced from laboratory analysis SB01464, DSIR Soil Bureau

Wahrekohe silt loam

Property	Topsoil	Subsoil	Units
Acidity	4.6-5.1	4.8-4.9	pH
Total carbon	2.0-14.6	1.0-1.8	%
Total nitrogen	0.07-0.34	0.08-0.11	%
Available phosphorus	1-2	1-1	mg %
P retention	0-56	93-95	%
Available sulphur	<1-2	1-9	%
Cation exchange capacity	9.0-28.4	37.5-41.6	me %
Base saturation	6-32	6-6	%
Calcium	0-6.6	0.1-0.5	me %
Magnesium	0.2-2.3	0.1-1.0	me %
Potassium	0.1-0.2	0.3-0.5	me %
Sodium	0.1-0.2	0.3-0.4	me %

Sourced from laboratory analysis SB07644, DSIR Soil Bureau

8.2 Physical

http://soils.tfrec.wsu.edu/mg/chemical.htm

No physical analysis appears in the online version of National Soils Database (NSD). For Waikare and Wharekohe soils the following data are sourced from Soil Bureau Bulletin 26. For Hukerenui soil estimates are sourced from the Fundamental Soils Layer (FSL) plus a relevant S-map factsheet.

Waikare clay

Property	Topsoil	Subsoil	Units
Stones	0	0	%
Sand	2-17	10-16	%
Silt	37-38	24-25	%
Clay	45-61	60-65	%
Dry bulk density	1.12-1.30	1.27-1.36	g/cm³
Total porosity	50-55	49-51	%
Macroporosity	2-3	2-3	%

Sourced from laboratory analysis SB07654, DSIR Soil Bureau

Hukerenui silt loam

Property	Topsoil	Subsoil	Units
Stones	0-4	-	%
Sand			%
Silt			%
Clay			%
Dry bulk density			g/cm³
Total porosity			%
Macroporosity	7.5-25.0		%

Sourced from FSL table and S-map factsheet, Landcare Research

Wharekohe silt loam

Property	Topsoil	Subsoil	Units
Stones	0	0	%
Sand	12-24	1-10	%
Silt	55-75	24-39	%
Clay	5-33	51-75	%
Dry bulk density	0.96-1.27	0.76-0.84	g/cm³
Total porosity	49-62	68-71	%
Macroporosity	2-4	<1	%

Sourced from laboratory analysis SB07644, DSIR Soil Bureau

8.3 Irrigation and drainage

http://irrigationefficiency.co.nz/assets/Uploads/Farmers-Guide.pdf

No soil moisture analysis appears in the online version of National Soils Database (NSD). For Waikare and Wharekohe soils the following data are sourced from Soil Bureau Bulletin 26. For Hukerenui soil estimates are sourced from the Fundamental Soils Layer (FSL) plus a relevant S-map factsheet.

Waikare clay

Property	Topsoil	Subsoil	Units
Field capacity	36-51	35-37	% w/w
Wilting point	20-21	24-27	% w/w
Plant-available water	19-35	13-15	% w/w
Plant-available water	25-49	-	mm
Depth to slowly permeable layer	-	0.45-1.19	m
Perm. at slowly permeable layer	-	<4	mm/hr

Sourced from laboratory analysis SB07654, DSIR Soil Bureau

Hukerenui silt loam

Property	Topsoil	Subsoil	Units
Field capacity			% w/w
Wilting point			% w/w
Plant-available water			% w/w
Plant-available water			mm
Depth to slowly permeable layer	-	0.90-1.49	m
Perm. at slowly permeable layer	-	<4	mm/hr

Sourced from FSL table and S-map factsheet, Landcare Research

Wharekohe silt loam

Property	Topsoil	Subsoil	Units
Field capacity	28-81	84	% w/w
Wilting point	8-27	48	% w/w
Plant-available water	18-56	30	% w/w
Plant-available water	-	-	mm
Depth to slowly permeable layer	-	-	m
Perm. at slowly permeable layer	0-0.89		mm/hr

Sourced from laboratory analysis SB07644, DSIR Soil Bureau

8.4 Topsoil properties under different uses

Local management practices affect the properties of soil, so the history of land use needs to be considered. For many Auckland soils, an indication is provided by soil test results collected by Auckland Council from sites known to have been under the same use long-term. These sites are being re-sampled at five to ten-year intervals to detect any trends. Three were located on Waikare soils during the initial 1995-2000 sampling round; two on the main uses which are dairy and drystock pasture; a third under natural cover as a control. There could be a case for establishing additional sites under scrub (a more widespread natural cover on Waikare soil) and tree plantations (the third extensive land use).

Land Use		**Natural Cover**		**Pasture**		**Forest**	
Type:		**Bush**	**Scrub**	**Drystock**	**Dairy**	**Mature**	**Logged**
Sample number-		**98/14**	**-**	**98/15**	**98/16**	**-**	-
Acidity	pH	5.5	-	5.6	6.1	-	-
Total carbon	%	6.4	-	8.5	7.6	-	-
Total nitrogen	%	0.48	-	0.77	0.65	-	-
Available nitrogen	µg/ cm³	123	-	137	174	-	-
Available phosphorus	µg/ cm³	6	-	9	19	-	-
Cation exchange capacity	cmol/cm³	38.1	-	27.5	40.0	-	-
Base saturation	%	75	-	79	88	-	-
Calcium	cmol/ cm³	18.9	-	17.7	32.1	-	-
Magnesium	cmol/ cm³	7.8	-	3.3	2.4	-	-
Potassium	cmol/ cm³	1.3	-	0.5	0.4	-	-
Sodium	cmol/ cm³	0.6	-	0.2	0.3	-	-
Bulk density	t/ m³	0.87	-	0.64	0.94	-	-
Particle density	t/ m³	2.48	-	2.35	2.43	-	-
Aggregate stability	mm mwd	1.97	-	2.49	2.56	-	-
Total porosity	%	64.9	-	72.8	61.3	-	-
Macroporosity	%	7.4	-	11.2	11.8	-	-
Total available water	%	22.8	-	33.1	20.0	-	-
Readily available water	%	6.7	-	10.6	6.4	-	-

Sourced from: Sparling, G. et al, various dates, 500 Soils Project, Landcare Research Reports to Auckland Council

Soil Quality of Dairy Sites in the Auckland Region in 2009),Soil Quality of Drystock Sites in the Auckland Region in 2010

9 Land use capability

Land use capability is a classification of land according to properties that determine its capacity for sustained primary production. Classes 1 to 4 are arable, classes 5 to 8 non-arable. Class 1 is versatile i.e. capable of many uses, with negligible limitations to any use. Class 8 is land with extreme limitations that preclude productive use.
http://www.landcareresearch.co.nz/publications/books/luc

Three factors - geology, soil and slope - are taken into account when assigning land use capability classes. Another two - erosion and vegetation - may be recorded but rarely affect the decision. On regional-scale maps, notably the 1: 50,000 New Zealand Land Resource Inventory (NZLRI), limitations to use are indicated by four subclasses, c (climate), w (wetness), s (soil) or e (erosion). Unit numbers (1, 1b etc.) are used as labels for areas of land (map polygons) with the same geology, soil and slope, which are considered to have similar productive potential and management needs. General descriptions of productive potential and management needs are attached to NZLRI unit numbers.

NZLRI sub-classes and unit numbers were used for farm-scale land use capability maps (1:5,000 - 1: 10,000) prepared by Auckland Regional Authority or Auckland Regional Council between 1979 and 2010. On farm-scale soil maps prepared for Auckland Council since 2011, the four sub-classes are now replaced by twenty specific limitations. NZLRI unit numbers and their attached general descriptions are replaced by farm-specific tables.

Landform	NZLRI	Farm	Main limitation	Sustainable uses
Footslopes with perch-gley layer, iron nodules or iron pan	4w4 or incl. in 4w7	3p+w, 4p+w	Poor structure + perch-gley layer causes seasonal wetness	Occasional fodder crops, improved pasture
Upper slopes and ridges with uncemented silica pan	4s4 or incl. in 4e3	3p, 4p	Pan difficult to cultivate	Occasional fodder crops, improved pasture.
Mid-slopes with perch-gley layer or uncemented silica pan	4e12 or incl. in 4e3	3p+t, 4p+t	Poor structure or pan difficult to cultivate + risk of topsoil loss	Occasional fodder crops, improved pasture, woodlots
Any slope position with cemented silica pan	6s5 or not def.	5p	Pan precludes cultivation	Semi-improved pasture

Sourced from: Harmsworth, G.R. 1996, Land use capability classification of the Northland region, Publication 9, Landcare Research; Anonymous 1979, NZLRI Waikato region land use capability extended legend, Water and Soil Division, MWD; Jessen, M.R. 1984, Additions to NZLRI Waikato Region land use capability extended legend, Water and Soil Division, MWD; Hicks, D.L. and Vujcich, V. 2017, Farm-scale land use capability classification for Auckland. Auckland Council technical report TR2017/016

10 Past and present land uses

Waikare and related soils were not cultivated by Maori. Polynesian immigrants would have quickly discovered that root crops such as kumara or taro did not thrive on infertile soils which were saturated in winter but bone-dry in summer. European settlers found out the hard way, that if these soils were cleared from scrub and sown to grass, neither pasture nor stock thrived. They quickly reverted to manuka scrub, or exotic shrubby weeds such as gorse, brush wattle and tobacco tree. For a hundred years, the chief use of the soils was as gum-diggings. The quantity and value of kauri gum extracted, were such as to render them productive in an economic sense.

By the 1940s most gumfields had been exhausted, left a wilderness of holes and spoil-heaps covered by reverting scrub. Advent of machinery for scrub clearance, drainage and cultivation, together with scientific understanding of what fertilisers were needed to establish pasture, initiated a spurt of land development that extended over forty years till the mid-1980s. When the soils were heavily fertilised fodder crops such as chou, turnips, and even maize, could be sown and grown as part of the initial pasture mix. Improved ryegrass-clover pasture were subsequently sustained by heavy fertilisation and liming. Open or subsoil drains, plus deep-ripping to break up compact perch-gley layers and pans, reduced winter wetness. Heavy stocking and dunging helped build up organic matter, which washed down into the infertile silica layer between topsoil and subsoil.

Most areas of Waikare and related soils have now been productive pasture for between 70 and 30 years. They equally support dairy and drystock fattening farms. Crops are grown just for supplementary feed when pasture is renewed.

There are local instances where the silty-textured Hukerenui and Wharekohe soils are planted in drought-tolerant tree or vine crops, and even vegetables (if irrigated). However, these developments have entailed substantial initial expenditure, and will require ongoing heavy fertilisation to maintain yield. So, it would be premature to regard intensive food production as sustainable.

Farm woodlots and shelterbelts are a common feature of the developed farm landscape. Commercial forest plantations planted on some former gumfields 1920s-1940s, notably Riverhead Forest, are now into a third rotation of pines. Foresters recognise the ongoing management of these soils as somewhat problematical. Fertilisation of the second and third rotations is usually needed, to correct nutrient deficiencies and maintain growth form. Trees tend to be shallow-rooted, so are subject to windthrow by gales.

Little of the Waikare and related soils' area now remains in natural cover. Many farms retain patches of gumland vegetation on corners cut off by streams or swamps, which the owners regard as too intractable to develop. Extensive gumland can still be seen on some larger areas of crown land - now DOC reserve - or land in customary Maori title, which for

one reason or another was not developed 1940s-1980s. Although disturbed by gum-digging and fires for a hundred years beforehand, vegetation has had some seventy years to recover. It is now recognised as a distinct ecosystem - opportunistic scrub and wetland plants which co-exist on infertile, seasonally wet and dry sites - providing habitat for several rare plant and animal species.

Sourced from:
Smallfield, P.W., 1969, The Grasslands Revolution in New Zealand, Hodder and Stoughton
Anonymous, 1974, Land Development in Northland, Department of Lands and Survey

10.1 Typical crop, pasture and timber yields

Crop	Yield	Units
Maize	?	t/ha
Forage brassica	?	t/ha
Forage turnips	?	t/ha

Source: local growers

Pasture	Yield	Units
Improved pasture (dairy)	9.7 - 11.4	t dm/ha/yr
Improved pasture (drystock)	8.0 - 10.6	t dm/ha/yr
Semi-improved pasture	6.3 - 7.0	t dm/ha/yr
Un-improved pasture	4.6 - 5.0	t dm/ha/yr

Source: MAF and Dexcel trials cited in Lincoln Farm Technical Manual 2008; various papers in NZ Journal of Agricultural Research

Timber	Yield	Units
Radiata pine (clearwood regime)	?	t/ha
Radiata pine (unpruned pulpwood)	?	t/ha
Macrocarpa cypress (woodlot)	?	t/ha
Eucalypt (woodlot)	?	t/ha
Acacia (woodlot)	?	t/ha

Source: FRI trials cited by SCION; various papers in NZ Journal of Forestry or NZ Farm Forestry

11 Information about soil management

Waikare and related soils are not versatile, though can be made productive if developed into pasture or planted with timber trees. Small-scale horticultural development of the silty-textured Hukerenui and Wharekohe soils - olive groves, vineyards, and even market gardens - is possible, though to maintain commercial yields, requires ongoing inputs which may prove unsustainable. The old soils' key features - poor subsoil structure which is difficult to alter, rapid leaching of nutrients down and out the profile, topsoil's seasonal alternation between winter-spring saturation and summer-autumn water deficit - necessitate somewhat more careful management than younger, more tractable soils.

Key management issues that may arise are:

- Adequately fertilising to replace crop, grass and tree uptake
- Opening drains through perch-gley layers and pans
- Deep-ripping perch-gley layers and pans
- Sustaining crop and grass growth through dry summers
- Maintaining dense sward (particularly on slopes) to avoid topsoil loss in runoff
- Avoiding pugging (particularly on footslopes and ridges) in winter and spring
- Scheduling irrigation/effluent spraying so as to minimise nutrient loss towards, and faecal contamination of, drains
- Installing farm and forest tracks that don't rill or gully
- Establishing temporary ground cover between forest harvest and re-planting

Tips for improving fertility and structure, for minimising stock impact on structure, also for controlling sediment, nutrient and faecal matter losses to runoff, are contained in:

- *Gumland soils* *Soil Information Sheet 11, Auckland Council*
- *Code of Practice for Nutrient Management* *Fertiliser Association*
  Code of Practice for Nutrient Management
  Streamside planting guide *Auckland Council*
- *Native forest restoration guide* *Auckland Council*
- Soil structural breakdown and compaction in New Zealand soils Technical Paper 95/5, MAF Policy
  http://maxa.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/soil-structure/soilcomp.htm
- *Drainage construction and maintenance:* *TP10, Auckland Regional Council*
- *A guide to managing farm dairy effluent (Auckland)* *Dairy NZ*
  http://www.dairynz.co.nz/media/880785/auckland_guide_to_managing_farm_dairy_effluent.pdf
- *Forest harvest guidelines* *TP223, Auckland Regional Council*
- *Control of soil erosion in farmland* *Technical Paper 95/4, MAF Policy*
  http://maxa.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/erosion-risks/

Find out more: phone 09 301 0101, email rimu@aucklandcouncil.govt.nz or visit aucklandcouncil.govt.nz **and knowledgeauckland.org.nz**

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