Manaaki Whenua
Landcare Research

New Zealand soil mapping protocols and guidelines

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Contents

Tables

Summary

This soil mapping protocol document provides standards and guidance to be used nationally for collecting soil map information, and presenting soil maps and their supporting data. This Envirolink tools project was initiated to address the need to provide a framework for consistent soil mapping, identify methods, provide a process that can be used to determine if the work has met minimum standards, and provide guidance on the level of detail required for different applications.

Regional councils requested the protocol for farm-scale soil mapping that could be referenced as a framework standard to meet; this was to overcome the variety of soil maps and differing standards of work that would otherwise be received. Given the generic approach used to prepare the soil mapping protocols it has been expanded to be a New Zealand Soil Mapping Protocol, applicable at a range of scales and applications.

Standards for different soil map applications are established for 6 procedures that are integral to soil mapping (site density, site distribution, soil characterisation, soil variation, provider, and review), and each have 3 levels of detail (low, medium, and high) that are defined with guidance information. This provides a framework to determine what is expected to be conducted to construct a soil map for a particularly application.

Following on from this, the work outputs can be inspected using a listing of what should be provided. Finally, a self-assessment matrix allows for a summary of the level of work detail to be evaluated, this can then be used to compare against what was expected.

This entire framework is contained in 4 tables, with the remaining text providing detailed guidance, rationale and explanation.

This soil mapping protocols and guidelines document is dynamic and developing. It is the first step to establishing standards, and the intention is that the information proposed in this document will be reviewed and updated based on applications and feedback.

1 Introduction

1.1 Purpose of this handbook

The soil mapping protocol presents a framework and guidance to support the preparation of soil maps and supporting documentation, and to facilitate assessment of the soil map quality.

The protocol document aim is to help New Zealand implement a nationally consistent approach to conduct soil mapping. Using the protocol should produce defensible soil maps that are fit for purpose to support land management decisions by providing clarity as to what procedures and level of detail is required, and against which an assessment of the mapped output could then be made. The protocol document is *not intended* to provide instruction on how to construct a soil map.

The protocol is generic and applicable for all soil mapping scales. However, the focus in preparation was for farm-scale soil mapping (about 1:500 to 1:20,000 scales). The approach and guidance provided is also likely to be applicable to other non-farming applications requiring soil maps, e.g. urban and peri-urban development, mine sites, effluent disposal schemes, and industrial sites.

This soil mapping protocols and guidelines document is dynamic and developing. It is the first step to establishing standards, and the intention is that the information proposed in this document will be reviewed and updated based on applications and feedback.

1.2 How do we know the soil map presented is of sufficient quality?

The quality of a soil map could be determined by an independent separate field survey verification process to evaluate the descriptive and predictive outputs of the work. This would be conducted by an experienced soil surveyor using knowledge and structured sample design to check the soil map. In some cases this would be required where the map is to support significant investment decisions or environmental concerns to provide confidence in the soil map generated. However, in most cases this would be considered too much of an overhead expense, particularly for a small area farm soil map.

Therefore, the approach in this protocol is aligned to Quality Assurance/Quality Control process. The quality of the work can be managed by the following:

Procedures for survey work activities have accepted documented guidance (prior to work starting) and when followed provide confidence that the soil map will fulfil requirements for quality and fit for purpose. The process can be referred to as Quality Assurance, making sure you are doing the right things the right way.

Inspecting the soil map outputs and verifying that they satisfy the specified requirements. The process can be referred to as Quality Control, making sure the outputs of what you did are what are expected.

1.3 Structure of this document

This soil mapping protocol is in two parts:

- First, the **key procedures** are identified and the level of detail required for different applications of the map are documented. **See Table 1 and Table 2** for a summary and **Section 4** for detailed guidance.
- Second, the **inspection checklists** ensure that necessary information is provided in the soil map outputs. **See Table 3** for information to be provided and **Table 4** for evaluation of the work conducted.

For easy of extraction, the tables are also provided in Appendix B.

For people using the protocol, a workflow is presented in Figure 1:

- **Clients** can refer to **Table 1** to assist with preparing the survey work scope.
- **Providers** can refer to **Table 2** to help confirm minimum standards for procedures, **Table 3** to determine what is to be provided, and **Table 4** checklist to evaluate what has been provided.
- **Users** can refer to **Table 3** and **Table 4** to help evaluate the soil map outputs and compare this against recommended guidance in **Table 1**.

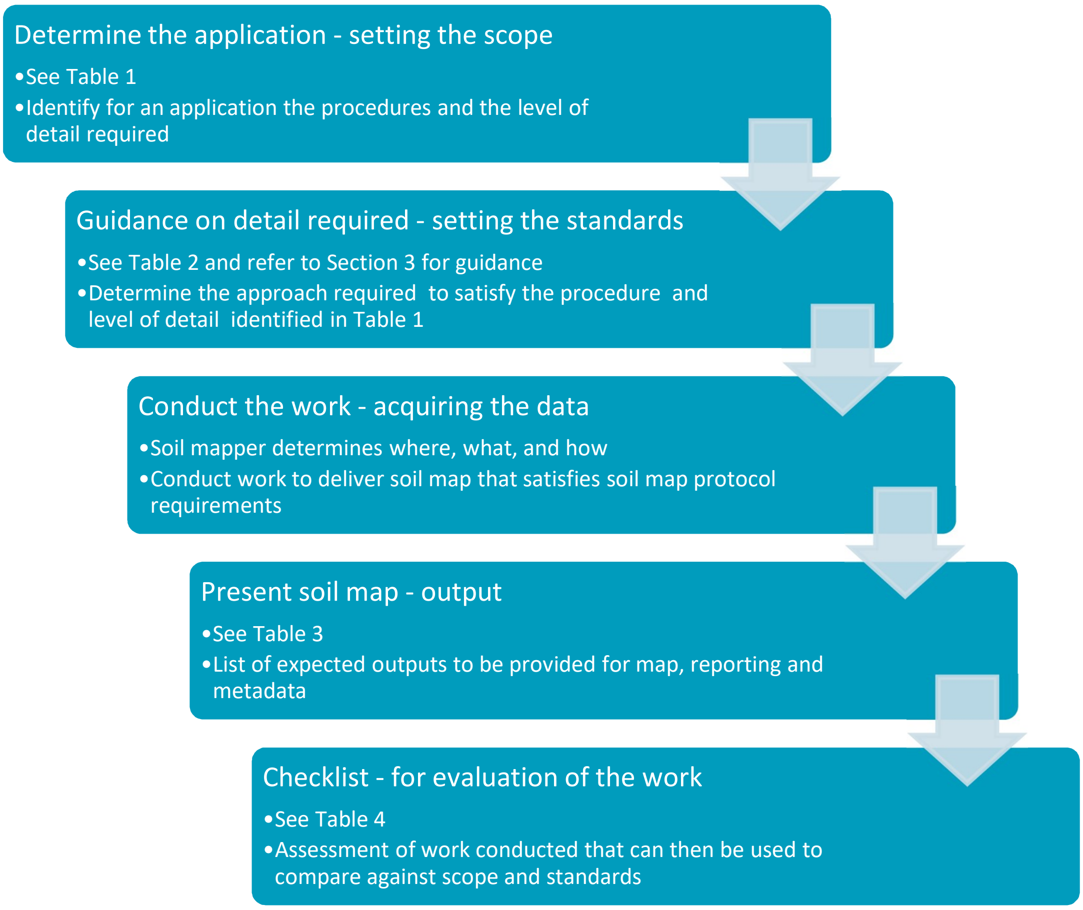

Figure 1. Presents a workflow and identifies protocol tables that provide standards and guidance.

2 Protocol approach – procedures and inspection

The list of procedures required to construct soil maps will generally remain the same for all soil mapping efforts. The level of detail to be provided and methods to be followed would be determined by the application or purpose that the soil map is to be used for.

2.1 Applications, procedures and minimum level of detail

A selection of applications that soil map information could be used for are listed along with the procedures and their recommended minimum levels of detail required (Table 1). The table is set up so that new applications or subsets of existing ones can be established as needed by adding extra rows for the application and level of detail required for the procedures.

The minimum level of detail required has been determined by expert judgement. However, the client or user of the soil map may specify in their project work scope a higher level of detail. Given one of the purposes of this protocol is to document accepted standards, it is not recommended that work be conducted below the minimum level of detail identified.

2.2 Procedure information required to satisfy a level of detail

The level of detail required for each procedure is described in Table 2, where three categories are described (low, medium, high). Note that the level of detail does not necessarily imply level of quality, but describes the level of information provided to support the procedure, from high (or optimum) level and decreasing to a low level (or minimum).

Discussion and description about the Table 2 criteria are provided in Section 4.

2.3 Inspection check list – requirements for a soil map output

The aim of the check list is to provide guidance as to what a soil map output should provide (Table 3). This guidance is necessary to ensure there is sufficient supporting information: (i) for the soil map, and (ii) to provide data that can be used to evaluate the soil map quality.

2.4 Self-assessment summary list of work conducted

This one-page table allows a self-assessment of the soil map to be summarised and documented (Table 4).

This serves as a guide for quick evaluation of the work conducted. The level of detail identified here can then be used as a check against the original work scope and minimum level of detail requirements for the soil map application (Table 1).

Table 1. Soil map applications and the minimum level of detail required for each procedure (see Table 2 for description of codes).
Note: level of detail is a minimum standard guide and the client or user may vary it to a higher level to match their needs

Application for soil map Level of detail codes: H=high, M=medium, L=low	Procedures to be addressed Site density	Site distribution	Soil characterisation	Mapping method	Provider	Review
S-map online input	M	M	M	M	M	H
General farm management planning	L	L	L	L	M	L
Precision farming; irrigation planning;	H	H	M	M	M	L
Hill country grazing management; forestry establishment	L	L	L	M	L	M
Infrastructure planning, e.g. for storm-water	H	H	M	H	M	M
Determining high value soil areas	H	M	L	M	M	H
Nutrient budget – verification of existing map e.g. Overseer input	L	L	L	L	L	M
Nutrient budget – new farm soil map e.g. for Overseer input	M	M	M	M	M	M
Nutrient budget – measured soil properties e.g. for Overseer input	H	M	H	H	M	M
Land treatment – verification of existing map e.g. for dairy effluent	M	L	L	M	L	M
Land treatment – measured soil properties e.g. for dairy effluent	H	M	H	H	M	M
Land treatment – industrial or municipal wastewater	H	H	H	H	H	H

Table 2. Summary of the levels of detail applied to each procedure (see Section 4 for explanations)

Procedure	**Level of detail** **<<< Increasing – Decreasing >>>** **High (H)**	**Medium (M)**	**Low (L)**
Site density (read in context of map scale)	Total of 1 observation per 1 cm^2 of published map area	Total of 1 observation per 2 cm^2 of published map area	Total of 1 observation per 4 cm^2 of published map area
Site distribution (representativeness)	Explicit (repeatable, reproducible, statistical)	Knowledge-based (environmental gradients, transect, catena, stratified)	Free survey (relies on surveyor judgement)
Soil characterisation (information collected to provide evidence)	Measured (soil properties determined by analysis in the field or laboratory)	Detailed morphological descriptions (for pedotransfer functions and determining NZSC)	Soil type identification (limited description to identify a soil type or soil property)
Mapping method (how soil was mapped)	Described explicitly, numerical or diagrams	Narrative description	No information, accept surveyor judgement
Provider (soil surveyor)	Proven experience and approved	Proven experience	Gaining experience
Review (checked by peer)	Desktop review and site visit	Desktop review	Not required, acknowledge information sources

Table 3. Check list showing information required as part of the soil map output

Item	Information required
Map	***Mandatory to be provided***
Map format	Either as GIS compatible digital data or printed hardcopy. To be determined by client and the end result of the work.
Map base	• Coordinate grid with sufficient information to locate position. • Usually with imagery and/or cadastre background (referencing source and date).
Map information	• Title of the survey. • Date survey conducted. • Scale at which the survey was conducted. • Information used to construct map.
Soil variation	• Shown as map unit polygon boundary lines or coloured raster pixels. • Map units labelled, providing a link to the map legend.
Map legend	Descriptive legend: identifying the soils within each map unit, their relative abundance, predicted location and related landscape information.
Supporting data	***Mandatory to be provided***
Survey scope	• Who was the client that requested the work. • Why the work was conducted, what was the intended application. • Who conducted the work, affiliation, and statement of their experience. • Where did the survey occur, name, and distance to nearest town or roads. • What were the survey area, size, and shape.
Methods	• What standards and guidelines were followed. • What background information considered. • Rationale for selection of survey scale. • Describe approach to select sites. • List field and laboratory measurements, with method code and reference. • Describe how the soil map was constructed. • Quality assurance and quality control procedures conducted.
Results	• Number of sites investigated and types of observation made. • Location of sites investigated – coordinates recorded (NZTM coordinate system recommended), marked on a map. • Description of soil map units – location, landscape, soils, relative abundance of soils within map unit, and difference from other map units. • Descriptions of soil classes and/or soil properties – identify typical sites and present all data. • Soil description and measured data, e.g. laboratory result sheets – provide in appendix or database. • Photographic record – at a minimum one photograph for each map unit and soil type. • Review process – findings and how they were addressed.
Accompanying Information	***Not mandatory but may be requested by client***
Interpretation Conclusion	Project scope will identify if these sections are required and if required what should be considered and evaluated.

Table 4. Self-assessment list; providing a summary of the work level of detail conducted

Background					
	Survey title				
	Location: nearest town and region				
	Date survey conducted				
	Surveyors name and organisation				
	Client				
	Application soil map was prepared for				
Procedure	**Item**	**Details**	**Level of Detail**		
Site density			**H**	**M**	**L**
	Land use				
	Map scale				
	Total number of sites	No. of sites:			
	Area of survey	ha			
	Site density	sites/ha			
Site distribution			**H**	**M**	**L**
	Site selection approach	Statistical / Knowledge / Free survey			
	Base data used and source (e.g. aerial photos, LIDAR, geology, EM, soil map)				
	Site distribution shown on a map	Yes / No			
Soil characterisation			**H**	**M**	**L**
	Measured data	No. of sites:			
	Detailed morphology	No. of sites:			
	Soil type identification	No. of sites:			
	Results provided and methods to obtain them identified	Yes / No			
Mapping method			**H**	**M**	**L**
	Map provided as GIS compatible digital data	Yes / No			
	Map provided as hardcopy	Yes / No			
	Soil map descriptive legend provided (includes map unit composition, soil types, proportion and location of soil types)	Yes / No			
	Models (numerical or diagrams) describing soil landscape relationship provided	Yes / No			
	Written text describing process to construct soil map provided	Yes / No			
Provider			**H**	**M**	**L**
	Surveyor satisfies proven experience requirement	Yes / No			
	Surveyor has approved status	Yes / No			
Review			**H**	**M**	**L**
	Who conducted the review				
	Desktop assessment conducted	Yes / No			
	Site visit assessment conducted	Yes / No			

3 Need for soil mapping protocols

Soil maps are used to support decisions on how to manage land, for example, a farmer determining fertiliser rates for an area; or deciding if an area could be suitable for installing irrigation equipment; or determining if a new crop could be grown at the location. Soil maps and soil measurements provide input data to computer models for predicting nutrient movement, e.g. via Overseer® (Overseer 2015), and for simulating agricultural systems and crop models, e.g. APSIM (APSIM 2017). National standards provide clarity and certainty to those investing in farm-scale soil information, ensuring equitable and consistent outcomes from farm nutrient budgets and farm environmental management plans (Carrick et al. 2014). Additionally, soil maps are increasingly required for regulatory tools, to inform policy decision making and for resource consent applications.

Soil data are required to better manage both agricultural productivity and environmental outcomes. Demand is being driven by the needs to increase New Zealand agriculture primary product exports (MBIE 2015), while minimising the loss of non-point source contaminants from agricultural land to fresh water (NPS-FM 2014) and conserving the soil resource and soil quality (Collins et al. 2014).

Soil properties vary across landscapes and these variations will influence how an area is managed and will perform. A fundamental requirement to help optimise land management is relevant soil information provided at an appropriate resolution.

3.1 What is a soil map?

A soil map shows the spatial distribution of soils for an area. These can be mapped as classified soil types or a single factor map of a soil property. The map is usually constructed from conducting field soil investigations and assessment of other related environmental data such as topography, geology, geomorphology, vegetation, land cover, and climate.

Soil maps can be generated at a range of scales. Map scale is the ratio of the size of a feature on a map compared with the size of the real feature on the ground, for example at 1:20,000, 1 cm on the map represents 200 m on the ground. A detailed scale map (e.g. 1:500 to 1:15,000) enables identification of short-range spatial changes in soil properties that can be used to help with paddock-level farm management. Whereas a broad-scale map shows less detail (e.g. > 1:25,000 scale) and cannot be used for site specific management but is used for catchment and regional planning.

Conventional soil maps typically show the general distribution of the soil type, where differing areas are represented as polygons on a map known as soil map units. Soil classification is used to summarise the soil properties and the identified soil type is used to describe the soil within the soil map unit. Depending on scale and complexity, there may be one or more soil types per map unit. The soil map legend links the map units to the soil types and usually provides some information about the soils position in the landscape. Detailed information about soil types is presented in the accompanying soil report or fact sheets. An introduction to farm soil mapping is described in the booklet by Manderson et al. (2007), where steps to construct a soil map are presented. An example of a soil map is presented in Appendix A.

Digital soil mapping is an approach to predict soil variation by using computers and digital data sets. Construction of these maps use field survey data, and/or measured data from laboratory analysis and digital environmental map data (e.g. landscape derivatives from topographic maps, geology, vegetation, climate) to define a numerical model that is then used to map the soil variation. The output typical shows the variation in raster format. Production of the soil map includes an estimate of the model uncertainty.

Sensor map data may provide spatial information about soil and land variation; these sensors include capture of electromagnetics (EM), gamma radiometrics, LIDAR or spectral data. The maps produced are not soil maps, but if linkages or models can be developed for the area of interest they can assist with predicting soil type or soil property variation.

3.2 Benefits

The soil mapping protocol identifies standards and provides guidance. Outputs based on this protocol will be more consistent in terms of what is presented and how the soil information is obtained, enabling auditing to determine quality of the soil map. Consistency of approach allows repeatability of the work, and different operators should get similar results.

Landowners, industry organisations and investors benefit from a consistent set of standards being followed that assured appropriate soil information was used to construct the map. This provides confidence in using the soil map to help make significant investment decisions, e.g. land purchase, new farm infrastructure or land management changes.

Regional councils benefit from consistency in methods and standards for provision of soil maps, allowing soil maps to be audited and assured that they have been prepared to required levels. Consistency of approach will go some way towards facilitating individual farm data to be combined for broader catchment and regional objectives.

Practitioners who prepare farm-scale soil maps or those who train the soil surveyors benefit through the ability to demonstrate compliance with a national protocol.

3.3 Risks

Without a national protocol to provide acceptable standards for work to be conducted against, there is a risk to the client of getting poor quality soil information due, for example, to insufficient observations being conducted, incorrect assessment methodologies, unsuitable data evaluation, and inexperienced providers. Following from this, clients may have to pay a second time to have their farms mapped, for example to meet regulatory requirements. Alternatively, a client may pay for more detail than is required.

Without a national protocol to help guide mapping approaches, there would be uncertainty for potential users as they would be unable to determine the reliability of the soil information, which diminishes its value.

4 Procedures and descriptions for each level of detail

4.1 Site density (read in context of map scale and proportion of site observation types)

Reason for procedure

Site density provides information on the total number of site observations per mapped area. Site observations provide ground-truth evidence used to construct the soil map, and the higher the density for a stated survey map scale, the more confidence one could have in the produced map. Assuming sites are well placed and described appropriately, and the complexity of the soil-landscape is understood – these are addressed in the following procedures.

The site density required is determined by the application and the survey map scale. See Table 5 and Table 6, along with the accompanying text for guidance to determine this.

Types of site observations normally differ throughout the survey area. Some will be full morphological descriptions usually from pits; some may have measurements taken where samples are analysed in the laboratory for chemical and physical analysis or in situ field measurements; the majority are likely to be rapid auger borings (or from cuttings) making note of only key soil features to classify the soil, or for mapping, or recordings of visual clues to help with mapping, e.g. vegetation type such as rushes that indicate poor drainage. See Table 7 for guidance on the expected proportion of soil site observation types.

High level of detail – total of 1 observation per 1 cm^2

For 1 observation per 1 cm^2, it is expected that there will be:

- An overall site density attaining at least 1 observation per 1 cm^2 of cartographic mapped area. This does not mean 1 site placed in each cm^2 of mapped area. It is the calculated site density for the total number of sites per total number of cm^2 of published mapped area and is equivalent to the survey scale. The distribution of sites will depend on the surveyors sampling strategy (see Section 4.2).

Medium level of detail – total of 1 observation per 2 cm^2

For 1 observation per 2 cm2, it is expected that there will be:

- An overall site density attaining at least 1 observation per 2 cm^2 of cartographic mapped area. This does not mean 1 site placed in each 2 cm^2 of mapped area. It is the calculated site density for the total number of sites per total number of cm^2 of published mapped area and is equivalent to the survey scale. The distribution of sites will depend on the surveyors sampling strategy (see Section 4.2).

Low level of detail – total of 1 observation per 4 cm^2

For 1 observation per 4 cm2, it is expected that there will be:

- An overall site density attaining at least 1 observation per 4 cm^2 of cartographic mapped area. This does not mean 1 site placed in each 4 cm^2 of mapped area. It is the calculated site density for the total number of sites per total number of cm^2 of published mapped area and is equivalent to the survey scale. The distribution of sites will depend on the surveyors sampling strategy (see Section 4.2).

4.1.1 Guidance on selecting survey (cartographic) map scale

The survey map scale (often known as the published cartographic map scale, e.g. 1:5,000, 1:10,000, 1:50,000) of a soil map should be decided by the purposes for which it is required. Survey cost rises sharply with increase in scale (finer detail), so a decision on the degree of detail needed, and hence the scale, is one of the most important decisions to be taken into account during discussions preceding the survey (Dent & Young 1981; Lynn et al. 2009). Map scale refers to the published cartographic scale of the map and indicates the level of survey intensity. More sites are required to produce a more detailed map; doubling a map scale to produce more detail (e.g. 1:20,000 to 1:10,000) will generally require a four times increase in survey effort and the number of observation sites to cover the same area, adding to cost.

Care must also be taken when using maps in a computer geographic information system (GIS), as zooming into a level beyond the survey scale that the map was constructed, will give a false sense of detail, for example viewing 1:50,000 regional scale maps at 1:10,000 farm scale, as the 1:50,000 scale delineations and survey to construct this map would not be good enough to resolve the soil pattern at farm scale. Check the metadata and determine the scale at which the data should be viewed. It is acceptable to view the map at a coarser (less detailed) scale e.g. 1:100,000.

The selected cartographic scale of a soil map will depend on:

- the amount of detail that can be shown on the map, as there are practical limitations. Generally, one square centimetre on the map is about the smallest level of detail. Therefore a 1:10,000 scale equates to a 1 ha area (e.g. 100 m × 100 m), whereas at 1:50,000 the minimum area of one square centimetre is 25 ha (e.g. 500 m × 500 m)
- the soil pattern and variability over a landscape and the level of accuracy required, as a complex soil pattern will require a finer-scale map to accurately show useful soil units
- the application for which the soil map will primarily be used, as this will dictate the smallest area that it is practicable to treat differently, e.g. more intensive land uses such as orchards or market gardens would require information at sub-

hectare level; while less intensive land uses such as sheep grazing may be greater than a hectare even though smaller variations may be known but would be impractical to treat differently

- the resolution of data sources available to assist with mapping (e.g. digital elevation model, geology map, and imagery), as mapping the soils to a finer detail than the supporting datasets provide may require significantly more field work to assist boundary placement
- the project funds dictate the amount of time and resources available to conduct the survey. This determines the number of sites to be investigated, which dictates the survey intensity and area that can practically be covered.

Survey detail is usually described in terms of the published cartographic map scale (e.g. 1:5,000, 1:50,000), but more important is the evidence used to produce the map such as the number of soil sites investigated and their distribution across the study area and quality of the data collected.

Guidance on an appropriate map scale for use in New Zealand is provided in Table 5. This is based on the application as the expectation is that the more intensive land uses will likely require more detailed maps to assist with decision making. However, the final determination of map scale to use will be directed by the project work scope, the purpose for constructing the map, and the available resources (funds) to do the work.

Table 5. Guidance on cartographic map scale, based on application or land use for conventional soil maps (after Manderson & Palmer 2006; Lynn et al. 2009)

Selected applications	Indicative smallest area of interest to identify on map (ha)	Indicative map scale range
Horticulture, market gardens, viticulture, precision farming	0.001 to 0.1	1:500 to 1:5,000
Pastoral, arable	0.1 to 1	1:5,000 to 1:15,000
Pastoral, extensive pastoral, catchment studies, forestry	1 to 10	1:15,000 to 1:50,000
Catchment planning, regional studies	10 to 40	1:50,000 to 1;100,000
Strategic overview, broad planning	40 to 250	1:100,000 to 1:250,000

4.1.2 Guidance on the number of sites required for a given map scale

As a guide for conventional mapping it is generally recommended that there is on average 1 site per one square centimetre of published map and a minimum acceptable limit of 1 site per four square centimetres of published map (Cowie & Leamy 1979; Dent & Young 1981; Schoknecht et al. 2008). The site densities required for different cartographic map scales are provided in Table 6.

Note this does not imply that a grid sampling pattern is required with an observation for each square of the map. Instead, this is a total count that is applied for the entire area and the distribution of sites will depend on the surveyors sampling strategy (see Section 4.2). Also, it does not imply that all observation types are detailed soil profile descriptions, the total count can include a range of observation types from detailed soil profile descriptions through to a record of location and soil type or a relevant soil feature that assists with the mapping (see Section 0).

Table 6. Survey site density guidance provided for conventional soil mapping

Cartographic Scale	Area per one observation			Number of observations per unit area		
	total of 1 observation per 1 cm^2 of mapped area	total of 1 observation per 2 cm^2 of mapped area	total of 1 observation per 4 cm^2 of mapped area	total of 1 observation per 1 cm^2 of mapped area	total of 1 observation per 2 cm^2 of mapped area	total of 1 observation per 4 cm^2 of mapped area
	ha/observation			observation/ha		
1:500	0.0025	0.005	0.01	400	200	100
1:1,000	0.01	0.02	0.04	100	50	25
1:5,000	0.25	0.5	1	4	2	1
1:10,000	1	2	4	1	0.5	0.25
1:15,000	2.25	4.5	9	0.44	0.22	0.11
1:20,000	4	8	16	0.25	0.13	0.06
1:50,000	25	50	100	0.04	0.02	0.01
1:100,000	100	200	400	0.01	0.05	0.025
1:250,000	625	1250	2500	0.0016	0.0008	0.0004

4.1.3 Guidance on the proportion of observation types

For a general purpose soil map it is recommended that the total sites within the study area are proportionally distributed across different observation types as shown in Table 7.

Table 7. Proportion of sites and their level of soil characterisation required for a survey area

Observation type and soil characterisation required	%Proportion of total sites	Use
Soil type identification (limited description to identify a soil type or soil property e.g. depth to gravel)	65–90	To help with map unit boundary placement; determine the distribution of soil types or a soil property in a map unit; help understand soil distribution.
Detailed morphological description (detailed descriptions often from pits, sufficient data collected to be used for pedotransfer functions or determining New Zealand Soil Classification)	10–30	To help characterise soil type; place site in a soil landscape context to help develop mapping models; provide information to estimate important soil properties via pedotransfer functions.
Measured (soil properties determined by analysis in the field or laboratory)	0–5	To provide quantitative measurement of soil properties to help determine how a soil will perform when managed. Often conducted to characterise the dominant soil types, or to link with observable morphological features to develop pedotransfer functions.

4.2 Site distribution (representativeness)

Reason for procedure

The distribution of site locations throughout the survey area provides an indication of the representativeness of the data collected to support the construction of the soil map. Site locations and the information about the soil and landscape are used to i) characterise a soil, ii) determine the variability of soil within a map unit delineation, and iii) help with placement of the map unit boundary. The approach used to choose where to place the site observations will therefore impact on the map accuracy.

Different sample design approaches can be used to determine site locations. Some are statistical, others rely on knowledge of the relationship between soil and landscapes, while yet others rely on the surveyor's experience; each approach has limitations and benefits. It should be noted that a more explicit statistical approach *does not* necessarily imply that a better map will be produced, e.g. free survey versus statistical. But the more explicit the approach used to determine the site locations and describing the thinking sitting behind it, the easier it is to understand, replicate, and test.

High level of detail – Explicit (repeatable, statistical)

For explicit, the approach to determine the site distribution should acknowledge that:

- The sample design is a process that can be reproduced and tested
- The sample site locations are selected generally without bias
- Examples of an explicit approach could include:
    - Predetermined structured approach to cover an area, e.g. grid, or two sites per field, or every x metres along a compass bearing, or every x rows in a crop
    - A statistical approach that characterise soils and soil variation, but note that this is likely to be less valuable for assisting with placement of map unit boundaries

Medium level of detail – Knowledge-base (environmental gradients, transects, catenas, stratification)

For knowledge-base, the approach to determine the site distribution uses:

- Prior knowledge to assist with the sample design. Examples of prior knowledge to place site locations could include:
    - Soil landscape models (e.g. developed from previous work that explains the linkages and can be used as guidance)
    - Along environmental gradients (e.g. topographic position, distance from river channel, elevation, geological differences, chronological differences, landforms or land use changes)
    - Focused on localised windows (e.g. selected parts of the landform to represent larger similar areas)
    - Stratified according to digital data covariates (e.g. from electromagnetic (EM) survey, gamma radiometrics data, or digital terrain models).

Low level of detail – Free survey (relies on surveyor judgement)

For free survey, the approach to determine the site distribution depends on:

- The skill of the soil surveyor and their ability to make a judgement to select appropriate locations for soil investigations
- The surveyor's experience and prior knowledge about the landscape and soils likely to be found in the area. These are difficult to quantify

A limitation of this approach is that the survey design cannot be described, making it difficult for another surveyor to repeat and understand. Rarely would any two surveyors select identical site locations for soil investigations, therefore a different set of site data would be used to construct the soil map, and may lead to differing maps.

A benefit of this approach is that the surveyor is able to conceptualise the soil and landscape relationship by mentally compiling many pieces of information some of which are not necessarily explicit. From this, judgements can be made to test, develop and reinforce the soil mapping conceptual model by selecting sites that would best assist. This may be an efficient approach, but likely to be bias towards that surveyor understanding of the area, as it is likely they would select sites to support their model rather than test it properly.

4.3 Soil characterisation (information collected to provide evidence)

Reason for procedure

Soil characterisation provides on-ground evidence data (compared with remotely observed or predicted data) that is used to guide soil mapping and also provides information about soil properties and their distribution.

Measuring the soil properties of interest such as soil water movement directly throughout the mapped area is the ideal, but regular or extensive measurement is constrained by the time and cost involved. Therefore approaches are used to infer the likely soil property data value based either on a pedotransfer function where observable features of the soil are related to the soil property (e.g. a sandy texture could indicate likely free water movement; or a clayey texture may infer good nutrient holding capacity). Or where the soil type is identified and an assumption is then made about the soil property value based on knowledge about that soil type by extrapolating data collected from similar soil type profile elsewhere.

High level of detail – Measured (soil properties determined by analysis in the field or laboratory)

For measured, the soil characterisation information would include:

- Soil properties measured in the field (e.g. water infiltration rate, bulk density) or from laboratory analysis of a collected soil sample (e.g. cation exchange capacity, clay percentage).

- It is expected that at selected sites, the soil morphology (e.g. depth; texture; structure; colour) and site (e.g. landform; slope; land use) data would also be collected to determine their New Zealand Soil Classification (Hewitt 2010; Webb & Lilburne 2011).
- Guidance on what information should be measured and suitable methods are provided in Table 8, and for producing a photographic record are provided in Table 9.

Medium level of detail – Detailed morphological description (for pedotransfer functions and determining NZ Soil Classification)

For detailed morphological description the soil characterisation information would include:

- Soil profile morphological data along with site data that would allow pedotransfer functions to be used, e.g. soil texture assessment can provide a field estimate of percent sand and clay.
- Detailed soil morphological information to support the classification of the soil type to the New Zealand Soil Classification (Hewitt 2010; Webb & Lilburne 2011).
- Guidance on what information should be measured and suitable methods are provided in Table 8, and for producing a photographic record are provided in Table 9.

Low level of detail – Soil identification (limited description to identify a soil type or soil property)

For soil type identification, it is expected that soil profile morphology and site information would allow the described location to be allocated to a soil type or soil property of interest. This should include the following:

- For identification of a soil type:
  - The soil type has been predefined, either from the literature (e.g. previous nearby soil survey report or existing work for the area) or has been established as part of a new survey (e.g. detailed description and supporting data confirming its characteristics). The reference source should be documented in the survey report and map.
  - Pit profile descriptions in the survey area have been made, and the site location correlated to a known referenced soil type.
  - From this the key features are identified that allow separation of the soil type for the study area. This would form part of the working soil mapping legend. Examples of the feature to recognise could be depth to stone layer, colour of subsoil, presence of mottles above or below a certain depth.
  - Using soil auger holes (and shallow pits when required) would allow many sites to be rapidly visited with only a limited set of information recorded that would confirm the soil type at each site.
  - Guidance on what information should be measured and suitable methods are provided in Table 8, and for producing a photographic record are provided in Table 9.
- For identification of a soil property:
  - The information collected may be for just one (or more) soil property of interest, e.g. or depth to gravels, topsoil texture, soil field pH.

4.3.1 Guidance on measurements required and their methods

For each level of soil characterisation the soil attributes that must be measured as a minimum data set for a site location are identified in Table 8, along with those that are optional depending on the survey and map requirements.

The method for assessment is referenced. It would be expected for site and soil morphology attributes that Milne et al. (1995) would be followed. For soil chemical, physical and biological analysis, at this stage it is assumed Blakemore et al. (1987), Gradwell & Birrell (1979) and McKenzie et al. (2002) would be followed. But it is likely there are updates that need to be considered and, if used, these methods should be recognised as appropriate, referenced and noted in the soil map report.

Table 8. Guidance on soil attributes to be measured for each level of detail. Key: X always record; (X) optional

Attribute	High – Measured	Medium – Detailed morphology	Low – Soil property or soil type identification	Method*
REFERENCE DATA				
Profile identifier	X	X	X	Unique site ID
Project ID	X	X	X	Survey name or code
Author	X	X	X	M p9
Date	X	X	X	M p9
Soil name (common name or soil series or survey soil code)	(X)	(X)	(X)	M p9
Soil classification – NZSC to Level 3 (subgroup)	X	X	(X)	H
Soil classification – NZSC to Level 4 and 5 (family, sibling)	X	X	(X)	W
SITE				
Location (coordinates, datum, projection)	X	X	X	M p10
Geomorphic position (landform, component or element, microtopography)	X	X	(X)	M p11
Slope (angle, aspect)	X	X	(X)	M p12
Rock outcrops and surface boulders (abundance, lithology)	X	X		M p13
Vegetation	(X)	(X)		M p25
Land use	X	X	(X)	M p32
Land management practices (leading to soil modifications)	X	X		M p33
Depth to impeded drainage	X	X		
Depth to free water	X	X		M p41
Soil drainage class	X	X	(X)	
Selected soil attribute			X Identify soil property of interest.	Includes any one or more of the following listed soil attributes

Attribute	High – Measured	Medium – Detailed morphology	Low – Soil property or soil type identification	Method*
SOIL MORPHOLOGY				
Observation type	X	X	X	M p35
Layer depth (upper, lower)	X	X	X	M p36
Horizon designation	X	X		M p132
Horizon boundary (distinctness, shape)	X	(X)		M p36
Moisture status	X			M p40
Matrix colour	X	X		M p42
Mottles (abundance, size, contrast, colour)	X	X		M p44
Texture (class, %sand, %clay)	X	X		M p47
Coarse fraction (abundance, size, roundness)	X	X		M p45,67
Consistence (soil strength)	X	X		M p83
Structure aggregates (pedality, size, shape)	X	X		M p57
Structure voids (abundance, size, pattern)	(X)	(X)		M p61
Surface features (kind)	(X)	(X)		M p73
Concentrations (abundance, type)	(X)	(X)		M p64
Plant roots (abundance, size)	X	X		M p65
Substrate type	(X)	(X)		M p94
CHEMICAL PROPERTIES				
pH	(X)	(X)		B or R
Electrical conductivity	(X)	(X)		B or R
Organic carbon	(X)			B or R
Exchangeable Ca, Mg, K, Na	(X)			B or R
Cation exchange capacity	(X)			B or R
P retention	(X)			B or R
Available plant nutrients (N, P, K, S, micronutrients)	(X)			B or R
Other chemical characterisation	(X)			B or R
PHYSICAL PROPERTIES				
Bulk density and porosity	(X)			K or G
Particle size analysis	(X)			K or G
Water stability of soil aggregates	(X)			K or G
Moisture release characteristic	(X)			K or G
Hydraulic conductivity (saturated and unsaturated)	(X)			K or G
Field infiltration rates	(X)			K or G
Other physical characterisation	(X)			K or G
BIOLOGICAL PROPERTIES				
Other biological characterisation	(X)			TBD
MINERALOGICAL PROPERTIES				
XRD, XRF	(X)			TBD
Allophane field test (NaF)	(X)	(X)		M
Other mineralogical characterisation				TBD

*References: M = Milne et al. 1995; H = Hewitt 2010; W = Webb & Liburne 2011; B = Blakemore et al. 1987; R = Rayment and Lyons 2011; K = McKenzie et al. 2002; G = Gradwell & Birrell 1979; TBD=to be determined.

4.3.2 Guidance on producing a photographic record

Photographs of the soil or landscape provide visual evidence to support observations made during the soil mapping survey. Information to be provided with photographs should include what is listed in Table 9. The table also presents guidance on what a good photograph should include. Examples of soil profile photographs are presented in Figure 2.

Photographs should be taken to cover all soil types encountered, all soil units mapped, and general landscape and land use.

Table 9. Photographs and the information required to be included to support them

Type of photograph	Minimum information required with the photograph	A good photograph should include
Soil profile, soil core, or samples	Location coordinates and site number; soil name, classification, or description of soil feature shown; date photograph was taken.	Photograph taken perpendicular to the soil face; a legible reference scale; proper lighting to show soil colour and contrast features; sharp focus; if shadows occur these are minimised and do not mask important soil features; cropped to focus on the soil; the soil should be prepared to bring out the features and structure, remove spade marks and smearing, possible moisten with a spray to bring out colours; take the photograph as close as possible to the soil and include the soil of interest within the field of view
Landscape, map unit, land use, soil location	Description of what is presented, linking to soil and landscape.	Good lighting and contrast to highlight features of interest; only include features of interest, don't clutter the photograph;

Figure 2. Examples of soil profile photographs, with prepared soil face and tape for scale (photographs sourced from Soils Portal of Landcare Research).

4.4 Mapping method (how soil was mapped)

Reason for procedure

Representing spatial variation of the soil types or soil properties is what soil mapping does. There are many approaches to do this, such as a computer-generated output from statistical analysis of data through to someone drawing lines as to where they understand change occurs, or a two-dimension cross-section diagram showing soil and landform relationships. Every approach has its benefits and limitations. Documenting the approach provides an understanding of the methods used to construct the soil map to show soil variation and for others to follow and replicate if necessary (which is part of the scientific process).

The more explicit the soil mapping process described, the more confidence there is in the approach taken and therefore in the soil map outputs.

High level of detail – Described explicitly (numerical or diagrams)

For described explicitly, most of the following should be provided:

- List of steps taken to portray soil variation on the map.
- Rationale as to why the soil map is presented as polygons or in raster form.
- How map unit boundaries were located on the map or soil variation shown in raster form.
- Description of the soil map units, including identifying the soils that occur within the map unit and how the map unit differs from other map units, relationships with landscape and other environmental features.
- If more than one soil per map unit, indicate the relative percent of each soil and likely location within the map unit.
- If a conceptual model is used, information about the surveyor concept and understanding should be provided; this could also include use of topographic diagrams and marked up landscape photographs.
- If a numerical model is used, provide the code to generate the model.
- Information on variance between and within map units should be provided.
- An assessment of the model's ability to describe the soil variation should be provided. For a conceptual model this could be a separate survey validation or a map unit purity analysis or some other justification. For a numerical model this could be from a statistical assessment or similar.

Medium level of detail – Narrative description

For narrative description, sufficient information should be provided to allow the user to broadly understand the approach used to construct the soil map. It is expected that the following information would be provided:

- Identify if a conceptual or numerical approach was used. Include discussion on the approach.

- Describe the soil map units including identifying the soils that occur within the map unit and how the map unit differs from other map units, relationships with landscape and other environmental features.
- If more than one soil per map unit, indicate the relative percent of each soil and likely location within the map unit.

Low level of detail – No information, accept surveyor judgement

For no information, accept surveyor judgement; the map produced is accepted as is. The map produced should have a map legend and acknowledge the sources of information used.

4.5 Provider (soil surveyor)

Reason for procedure

The provider (a soil surveyor, or a team) and their level of experience will influence the quality of the soil mapping conducted and the soil map outputs. Therefore understanding the competency of the person in charge is important.

High level of detail – Proven experience and approved

For proven experience, all of the following would need to be satisfied:

- Demonstrated capability for describing the minimum soil profile description requirements, according to Appendix 8 in Milne et al. (1995) – examples to be provided.
- Demonstrated capability for classifying soils according to Hewitt (2010) and Webb and Lilburne (2011) – examples to be provided.
- Understands the principles of survey design.
- Understands the principles that cause soil variation.
- Constructed soil maps according to standard formats with accompanying map legend (can provide at least 5 maps as examples).
- Carried out soil survey where their work has undergone peer review (can provide at least 3 survey projects that have been reviewed as examples).

For approved, one of the following would need to be satisfied:

- Recognised by the New Zealand soil science society as a practicing soil surveyor.
- Recognised by a New Zealand regulatory body or authority as having satisfied their requirements to conduct soil survey in their region of jurisdiction, and that corresponds with the same area that the survey was conducted in.
- Accredited as a Certified Professional Soil Scientist and with competency in Soil Survey (e.g. www.cpssaccrediatation.com.au; or www.soils.org/certifications)

Medium level of detail – Proven experience

For proven experience, all the following would need to be satisfied (as for High level of detail):

- Demonstrated capability for describing the minimum soil profile description requirements, according to Appendix 8 in Milne et al. (1995) – examples to be provided.
- Demonstrated capability for classifying soils according to Hewitt (2010) and Webb and Lilburne (2011) – examples to be provided.
- Understands the principles of survey design.
- Understands the principles that cause soil variation.
- Constructed soil maps according to standard formats with accompanying map legend (can provide at least 5 maps as examples).
- Carried out soil survey where their work has undergone peer review (can provide at least 3 survey projects that have been reviewed as examples).

Low level of detail – Gaining experience

For gaining experience, the following would need to be satisfied:

- Tertiary qualification that includes methods of soil mapping, soil description, soil genesis, soil properties, and environmental factors influencing soil development.
- Capable of describing the minimum soil profile description requirements, according to Appendix 8 in Milne et al. (1995) – examples to be provided.
- Understands the principles that cause soil variation.
- Capable of constructing soil maps according to standard formats with accompanying map legend – examples to be provided.
- Carried out soil survey field work – examples to be provided.

4.6 Review (checked by peer)

Reason for procedure

Review by peers provides the opportunity for a professional and critical evaluation of the soil map outputs. During this process the technical detail is checked, errors to rectify identified, scientific approach verified, correct presentation of results reviewed, and the author's interpretations examined. Following on from this, the author would address all concerns and update the outputs where feasible and appropriate, thereby improving the soil map output quality.

If the work has been conducted by a provider with the level 'gaining experience', then it is recommended that a higher level of review is conducted.

Review provides confidence in the final outputs. The more comprehensive and transparent the review process, the more confidence there will be in the outputs. Some of the questions to consider when conducting the review are listed in Section 4.6.1.

High level of detail – Desktop review and site visit

For desktop review and site visit, the following would be expected:

- The person (or panel of people) should be from an organisation external to the provider.
- The person or panel of people should collectively have expertise to cover the range of technical detail presented, that would include a soil scientist with soil survey and pedology background. The lead reviewer would satisfy provider credentials level of 'High' or 'Medium'.
- All concerns during the review should be documented and presented to the author (provider).
- The provider should address all concerns and make changes to what is feasible and appropriate, documenting separately how all of the concerns were addressed (and provide this to the client if requested).
- A site visit is to be conducted by the reviewer; including documentation on the survey design of how the map was checked and findings commenting on the mapped work.

Medium level of detail – Desktop review

For desktop review, the person should be:

- A soil scientist, preferably with soil survey and pedology background. Satisfy provider credentials level of 'High' or 'Medium'. The person can be external or internal to the provider's organisation.
- Considered by colleagues as someone knowledgeable in soil mapping for the general area in which the work was conducted.

Low level of detail – Not required

For not required, a review of the work does not need to occur.

4.6.1 Questions about soil maps when evaluating

When conducting a review the following questions should be asked, as they provide an understanding of the construction of the map and help determine its quality:

- Was the map scale appropriate for the application, land use or management purpose that the information will be applied to?
- Were a sufficient number of site observations made to support the soil map information presented?
- Were the sites distributed appropriately throughout the survey area to provide sufficient evidence to support the soil map?
- What properties of the soil need to be recorded?

- Were appropriate methods used to classify, describe and measure the soil properties?
- What is the level of uncertainty of the soils occurring in the map unit and the probability of other soils occurring in the map unit?
- Was information (metadata) provided that describes how the soil variation was mapped?
- Did the people who constructed the soil map have the necessary expertise?

5 Glossary

A glossary for New Zealand soils can be found accompanying the S-map Online website at https://smap.landcareresearch.co.nz/glossary-for-abc

Below are some additional words or phrases used in this document

Map unit: An area delineated on the map that defines part of the landscape as having a similar set of soils and landforms.

NZSC: New Zealand Soil Classification is a national soil classification based on the current state of knowledge and developed to classify New Zealand soils (Hewitt 2010). The objectives of the NZSC are: to provide a better means of communication; to provide an efficient vehicle for soil identification; to enable stratification of soil database information; and to draw together knowledge of the properties of new Zealand soils.

Site: A georeferenced location.

Soil map: Shows spatial variation for area of interest of a soil type or soil property.

Soil morphology: Soil features that can be described by visually seeing them or by touch or by smell, such as: soil structure, texture, colour, consistence, voids, and coarse fragment content.

Soil type: The basic unit of soil mapping, a unique combination of chemical, physical, biological, and mineralogical characteristics and site features.

Pedotransfer functions (PTF): Predictive functions of certain soil properties using data from soil surveys, e.g. using field morphology data (such as texture and structure and consistence) to estimate a difficult or costly measurement (such as water retention, hydraulic conductivity).

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Appendix 1 –

Following are the four key tables necessary for using the New Zealand Soil Mapping Protocols. They are repeats of Tables 1–4 in the document body, and placed here for ease of use and extraction.

Table 1. Soil map applications and the minimum level of detail required for each procedure (see Table 2 for description of codes).
Note: level of detail is a minimum standard guide and the client or user may vary it to a higher level to match their needs

Application for soil map	**Procedures to be addressed**					
Level of detail codes: H=high, M=medium, L=low	**Site density**	**Site distribution**	**Soil characterisation**	**Mapping method**	**Provider**	**Review**
S-map online input	M	M	M	M	M	H
General farm management planning	L	L	L	L	M	L
Precision farming; irrigation planning;	H	H	M	M	M	L
Hill country grazing management; forestry establishment	L	L	L	M	L	M
Infrastructure planning, e.g. for storm-water	H	H	M	H	M	M
Determining high value soil areas	H	M	L	M	M	H
Nutrient budget – verification of existing map e.g. Overseer input	L	L	L	L	L	M
Nutrient budget – new farm soil map e.g. for Overseer input	M	M	M	M	M	M
Nutrient budget – measured soil properties e.g. for Overseer input	H	M	H	H	M	M
Land treatment – verification of existing map e.g. for dairy effluent	M	L	L	M	L	M
Land treatment – measured soil properties e.g. for dairy effluent	H	M	H	H	M	M
Land treatment – industrial or municipal wastewater	H	H	H	H	H	H

Table 2. Summary of the levels of detail applied to each procedure (see Section 4 for explanations)

Procedure	**Level of detail** **<<< Increasing – Decreasing >>>**		
	High (H)	**Medium (M)**	**Low (L)**
Site density (read in context of map scale)	Total of 1 observation per 1 cm^2 of published map area	Total of 1 observation per 2 cm^2 of published map area	Total of 1 observation per 4 cm^2 of published map area
Site distribution (representativeness)	Explicit (repeatable, reproducible, statistical)	Knowledge-based (environmental gradients, transect, catena, stratified)	Free survey (relies on surveyor judgement)
Soil characterisation (information collected to provide evidence)	Measured (soil properties determined by analysis in the field or laboratory)	Detailed morphological descriptions (for pedotransfer functions and determining NZSC)	Soil type identification (limited description to identify a soil type or soil property)
Mapping method (how soil was mapped)	Described explicitly, numerical or diagrams	Narrative description	No information, accept surveyor judgement
Provider (soil surveyor)	Proven experience and approved	Proven experience	Gaining experience
Review (checked by peer)	Desktop review and site visit	Desktop review	Not required, acknowledge information sources

Table 3. Check list showing information required as part of the soil map output

Item	Information required
Map	***Mandatory to be provided***
Map format	Either as GIS compatible digital data or printed hardcopy. To be determined by client and the end result of the work.
Map base	Coordinate grid with sufficient information to locate position. Usually with imagery and/or cadastre background (referencing source and date).
Map information	Title of the survey. Date survey conducted. Scale at which the survey was conducted. Information used to construct map.
Soil variation	Shown as map unit polygon boundary lines or coloured raster pixels. Map units labelled, providing a link to the map legend.
Map legend	Descriptive legend: identifying the soils within each map unit, their relative abundance, predicted location and related landscape information.
Supporting data	***Mandatory to be provided***
Survey scope	Who was the client that requested the work. Why the work was conducted, what was the intended application. Who conducted the work, affiliation, and statement of their experience. Where did the survey occur, name, and distance to nearest town or roads. What were the survey area, size, and shape.
Methods	What standards and guidelines were followed. What background information considered. Rationale for selection of survey scale. Describe approach to select sites. List field and laboratory measurements, with method code and reference. Describe how the soil map was constructed. Quality assurance and quality control procedures conducted.
Results	Number of sites investigated and types of observation made. Location of sites investigated – coordinates recorded (NZTM coordinate system recommended), marked on a map. Description of soil map units – location, landscape, soils, relative abundance of soils within map unit, and difference from other map units. Descriptions of soil classes and/or soil properties – identify typical sites and present all data. Soil description and measured data, e.g. laboratory result sheets – provide in appendix or database. Photographic record – at a minimum one photograph for each map unit and soil type. Review process – findings and how they were addressed.
Accompanying Information	***Not mandatory but may be requested by client***
Interpretation Conclusion	Project scope will identify if these sections are required and if required what should be considered and evaluated.

Table4. Self-assessment list; providing a summary of the work level of detail conducted

Background			
	Survey title		
	Location: nearest town and region		
	Date survey conducted		
	Surveyors name and organisation		
	Client		
	Application soil map was prepared for		
Procedure	**Item**	**Details**	**Level of Detail**
Site density			**H M L**
	Land use		
	Map scale		
	Total number of sites	No. of sites:	
	Area of survey	ha	
	Site density	sites/ha	
Site distribution			**H M L**
	Site selection approach	Statistical / Knowledge / Free survey	
	Base data used and source (e.g. aerial photos, LIDAR, geology, EM, soil map)		
	Site distribution shown on a map	Yes / No	
Soil characterisation			**H M L**
	Measured data	No. of sites:	
	Detailed morphology	No. of sites:	
	Soil type identification	No. of sites:	
	Results provided and methods to obtain them identified	Yes / No	
Mapping method			**H M L**
	Map provided as GIS compatible digital data	Yes / No	
	Map provided as hardcopy	Yes / No	
	Soil map descriptive legend provided (includes map unit composition, soil types, proportion and location of soil types)	Yes / No	
	Models (numerical or diagrams) describing soil landscape relationship provided	Yes / No	
	Written text describing process to construct soil map provided	Yes / No	
Provider			**H M L**
	Surveyor satisfies proven experience requirement	Yes / No	
	Surveyor has approved status	Yes / No	
Review			**H M L**
	Who conducted the review		
	Desktop assessment conducted	Yes / No	
	Site visit assessment conducted	Yes / No	