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Guidance on the sustainable management of 'surplus' soil and subsoil: consultation draft

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Guidance on the sustainable management of 'surplus' soil and subsoil: consultation draft

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Summary

Project and client

- This project has been undertaken with funding from an Envirolink Tools Grant (C09X2206) for the Contaminated Land and Waste Special Interest Group (CLWSIG) and the Land Monitoring Forum (LMF).
- The project involved two components: (1) developing a framework and guidance for implementing ecological soil guideline values that will be appropriate for both existing and future regulation, and (2) drawing on this framework to address the emerging practice of sustainable management of 'surplus soils' to achieve better overall environmental outcomes (this report).

Objective

- To develop a guide for councils, Māori, and industry to enable the sustainable management of surplus soils.

The process

- This project was overseen by an advisory group comprising representatives from territorial and unitary authorities, regional councils (including representation from the CLWSIG and LMF), central government (Ministry for the Environment, Ministry for Primary Industries, Department of Conservation), the WasteMINZ contaminated land special interest group, and a Māori representative.
- The work included:
    - conducting a policy and regulatory review of the proposed application of ecological soil guideline values, which also considered surplus soils
    - exploring the science, terminology, policy, and management of contaminated land and surplus soils from a te ao Māori perspective
    - holding a workshop with selected end-users (in August 2022) to explore the drivers for the generation of surplus soils, and barriers to its beneficial reuse
    - conducting a review of national and international literature on the management of surplus soils
    - holding a workshop (in June 2023) with representatives from different industry sectors (including contaminated land management, waste disposal to land, organic materials and primary production, as well as central and local government) to gain feedback on issues relating to the sustainable management of surplus soils
    - having discussions with industry and central and local government representatives, including at the Australasian Land and Groundwater Association (ALGA) regulators forum in September 2022.

Results

- A high-level definition of surplus soils has been developed: surplus soils are:

  Those that have been disturbed through land and infrastructure development or natural processes (e.g. landslips, silt/sediment) and are unable to be beneficially used on-site.[1]

- Further, for this document, soil has been defined as:

  unconsolidated, naturally occurring mineral particles and other naturally occurring material resulting from the natural breakdown of rock or organic matter by physical, chemical or biological processes, or formed predominantly from organic material in a permanently wet environment, such as a peat bog.

  Soil includes peat, 'mullock'[2], eroded soils, soils mixed with leaf litter and humus, and flood-deposited sediment, but it must also contain no visible contaminants. Soil is broadly categorised into topsoil and subsoil to recognise the different features and purposes for which these soils can be used. A third broad category, manufactured soil (soil deliberately amended to meet a purpose), is also within scope for this document.

- A Māori perspective on 'surplus soils' is provided, noting the long and enduring relationship Māori have with soils in New Zealand, and also their many names for soil, which are often associated with a range of activities and uses (e.g. cropping, gardening, harvest, customary use). Soil was associated with food growing and nurturing life and ecosystems, which is consistent with soil definitions worldwide that refer to the top 1 metre (approximately) of soil. Māori have no definition for what constitutes a surplus soil. Soils are typically regarded *in situ* and intact as part of the whakapapa (ancestral lineage and connection) of an area, location, tribe, and ecosystem. Traditionally, any reworking of a soil (e.g. for pā, papa kāinga – fortifications, gardens) did not produce 'surplus' and was under the auspices of tikanga Māori and kaupapa Māori (customs and policies). Any redesign for another use is therefore determined by Māori needs that view all soil as a treasured resource.
- Anecdotally, challenges associated with the generation of surplus soils, and barriers to their reuse, have been expressed by multiple individuals and sectors. These concerns include the lack of sustainability, unnecessary disposal costs, emissions associated with transporting surplus soil, lack of data on the amount of material encompassed as 'surplus' soil, lack of agreement on what should be measured, and regulatory challenges with reuse, even for low-risk (i.e. lightly contaminated) soils. Perhaps the most tangible evidence – and possibly coincidental – is an increase in the proportion of inert materials disposed to Class 1 landfills since 2012.
- Greenfield residential subdivisions, followed by brownfield residential developments, were considered to be the primary source of surplus soils at a workshop with various stakeholders. The bulk of soil disposed to landfills was considered to have contaminant concentrations above background concentrations but below applicable

[1] Also note that, anecdotally, there can be issues reusing excavated soil on site if concentrations of contaminants are deemed to be above background concentrations.
[2] Organic Soils and organic-enriched soils found in seepages and wetlands.

soil contaminant standards (residential, followed by commercial/industrial) for the protection of human health.

- Geotechnical requirements, clean-fill criteria based on background concentrations, and specific clauses within the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS) were all identified by participants in the June 2023 workshop as contributing to the generation of surplus soils (see Appendix 1).
- In the context of surplus soils and clean-fill criteria, an upper 'threshold' of background concentration typically used is provided, along with a summary of updated background concentrations for trace elements developed by Cavanagh et al. (2023).
- At a national level, drivers for change include the recently released *Te Rautaki Para | Waste Strategy* (MfE 2023b), which has at its core a circular economy approach to reduce carbon emissions. Specific goals for the management of contaminated land include priorities for the sustainable management of contaminated land, and reducing the volume of soil disposed to landfill. *Whenua Parakino | Contaminated Land Guidance* provides national guidance on the management of contaminated land for Waka Kotahi (2023), and raises the profile of the potential reuse of lightly contaminated soils and sustainable soil management practices.
- Reducing carbon emissions (e.g. those associated with excavation and transport of soils) is an obvious driver for the sustainable management of surplus soil, while a greater focus on climate resilience, including enhancing the use of urban soils and greenspace to mitigate stormwater runoff and reduce peak temperatures, provides a different perspective on how these surplus soils can be used.
- International examples to support processes to enhance the reuse of surplus soils include ISO standards for sustainable remediation, and guidance on the characterisation of excavated soil and other materials intended for reuse. The UK and Canada have comprehensive processes for the sustainable use of soils from construction sites (UK) or excavated soils (Canada) that may provide useful insight into approaches that could be adopted in New Zealand. The EU's soil strategy identifies the reuse of urban soils as a key objective.
- Addressing the challenge associated with surplus soils requires that we think differently, and provides a focus on valuing soils and considering soil from both a soil science and a Māori perspective, as distinct from a contaminated land management or geotechnical engineering perspective. Rethinking our approach to sustainably managing soils includes much earlier intervention and even before the design process, and greater understanding of the different beneficial uses that can be achieved. Several case studies outline examples of how thinking differently has contributed to the sustainable reuse of soils as currently undertaken.

Recommendations

A number of steps are required to better enable the sustainable management of surplus soils.

- ***Fill information gaps*** – this includes understanding the amount of surplus soil and fill being generated, from which types of sites, where it is going and why, as well as understanding the demand for virgin materials, and the extent to which this demand could be offset by reused/reprocessed surplus soils. This should be considered in the context of reimagined pathways for reuse rather than reliance on status quo processes. Options for filling these gaps include collating existing information from landfills and available through councils, surveys of major land development agencies, or a greater requirement for the capture of soil movement information in contaminated land remedial action plans and collation of that information (e.g. by regional councils).
- ***Establish principles for developing a surplus soil sustainable management framework*** – these principles are required to enable the right systems and processes to be put in place. They should include:
  - minimising the generation of surplus soils by minimising disturbance of soils and maximising on-site reuse (with a key emphasis on consideration of these factors at the design stage)
  - reusing soils on-site, and at alternative sites, has a clearly defined beneficial use
  - having a clear understanding of the properties of soil to achieve beneficial reuse, and whether soils are fit for purpose
  - making disposal of soil to landfill less cheap and convenient
  - ensuring the regulatory and logistical requirements associated with the movement and reuse of soils at a recipient site are easy to follow, because, as things stand, it is easier to dispose of that material to a landfill, particularly for low-risk soils.
- ***Address regulatory and logistical challenges to enable the sustainable management of surplus soils and fill*** – these aspects are intimately connected, particularly in relation to the management of soils with some level of contamination. Addressing regulatory and logistical challenges should include:
  - requiring clear national enabling processes for soil movement, allowing tracking of soils from source site to recipient, including temporary storage sites
  - scoping the use of 'soil hubs' (e.g. large-scale, multi-site developers, landscape/soil suppliers, including aggregate producers and district councils) for the temporary storage or processing of surplus soils and fill, and establishing key criteria for these hubs, initially drawing on examples of the approaches used in the UK and Canada
  - developing qualitative (e.g. fit for purpose) and/or quantitative, risk-based 'reuse' criteria that include recognition that simply being above background concentrations should not be a reason to regulate against the reuse of soils
  - complementing reuse criteria with risk-based decision-making

    - requiring contracting arrangements to incentivise the reuse of materials at an earlier stage in design and development, including through the use of targets for soil reuse
    - ensuring documenting the quality (contaminant, geotechnical, general) of materials for reuse becomes 'the norm'.
- The development of a national soils strategy would effect higher-level change and generate the impetus and pathway for effectively and sustainably managing our soils to achieve desired outcomes, such as soil security, soil health, economic prosperity, and human well-being. This approach should be based on a broader set of pluralistic societal values, bringing together other values based on the strong relationship and connection New Zealanders have with soils and incorporating te ao Māori. An overarching national soils strategy would form a strong connector for drivers such as climate change, land-use practice, and land development, and their impacts on land, soils, freshwater, groundwater, ecosystem services, and human well-being and values.
- We recommend that the CLWSIG and LMF advocate to the Resource Managers Group and central government (Ministry for the Environment, Ministry for Primary Industries) for the development of a national soils strategy to achieve sustainable soils management and soil health across New Zealand.

1 Introduction

Over the last 2 to 3 years there has been a growing awareness of the widespread extent of soil disturbance, movement, and disposal to landfill, with questions raised about the necessity and sustainability of current practices by multiple sectors in New Zealand. The current project largely arose from a Contaminated Land and Waste Special Interest Group meeting in May 2021, where the extent of and challenges associated with surplus soil generation from land development, movement, and disposal to landfill were recognised by multiple regional councils. Recognition of the connection to decision-making for contaminated land management resulted in a proposal for an Envirolink Tools Grant to explore this issue, alongside consideration of the implementation of ecological soil-guideline values (Eco-SGVs) for contaminated land management.

We define *surplus soils* as those that have been identified as being 'surplus' to on-site requirements as a result of soil disturbance such as land subdivision, or remediation of lightly contaminated sites, and removed off-site.

This project commenced in July 2022. During the project other initiatives to address certain aspects of the issue were identified.

- An Australasian Land and Groundwater Association (ALGA) regulators forum on 'On/off site use of "suitable" soils' was held in September 2022.
- A WasteMINZ sector group, the Soil Disposal Sampling & Reuse Working Group, was formed to develop sampling guidance for surplus soil generators.
- A joint WasteMINZ–Geotechnical Society working group was formed, with the aim of producing a practice note on surplus soils and focusing on geotechnical/contaminant issues.
- The Parliamentary Commissioner for the Environment conducted a short follow-up investigation into the fate of urban soil as part of the subdivision and development process, following on from a report on the importance of urban green spaces (PCE 2023).
- Multiple developer/practitioner-led projects to minimise the disposal of soil to landfill are underway or have been completed (see also case studies section 6.3.1).
- The Ministry for the Environment's Waste Minimisation Strategy identified the goals of reducing disposal of soil to landfill, thereby promoting a circular economy, and getting better data on waste.

This document draws on discussions at the ALGA regulators forum and with industry and central and local government representatives, in addition to specific research undertaken in the course of the project. It is intended to complement the above initiatives and provide a perspective on additional key steps that can be taken to enable the sustainable management of surplus soils and fill.

2 Objective

- To develop a guide for councils, Māori, and industry to enable the sustainable management of surplus soils.

3 The process

This project, including related research on Eco-SGVs (Cavanagh & Harmsworth 2023), was overseen by an advisory group comprising representatives from territorial and unitary authorities and regional councils (including representation from the Contaminated Land and Waste Special Interest Group and the Land Monitoring Forum), central government (Ministry for the Environment, Ministry for Primary Industries, Department of Conservation), the WasteMINZ Contaminated Land Management sector group, and a Māori representative.

The work included:

- a policy and regulatory review of the proposed application of Eco-SGVs, which also considered surplus soils
- exploring the science, terminology, policy, and management of contaminated land and surplus soils from a te ao Māori perspective
- a workshop with selected end-users, held in August 2022, to explore the drivers for the generation of surplus soils and barriers to their beneficial reuse
- a review of national and international literature on the management of surplus soils
- a workshop, in June 2023, with representatives from different industry sectors, including contaminated land management, waste disposal to land, organic materials and primary production, as well as central and local government, to gain feedback on the issues relating to the sustainable management of surplus soils
- discussions with industry and central and local government representatives, including at the ALGA regulators forum in September 2022.

4 What's the problem?

Evidence of the challenges associated with the generation of surplus soils, and barriers to their reuse, is largely anecdotal – albeit from multiple individuals and sectors. The concerns expressed include:

- lack of sustainability
- unnecessary disposal costs
- emissions associated with transporting surplus soil
- lack of data on the amount of material classified as 'surplus' soil

- lack of agreement on what should be measured
- regulatory challenges with reuse, even for low-risk (i.e. lightly contaminated) soils.

Perhaps the most tangible evidence, although possibly coincidental, is an increase in the proportion of inert materials disposed to Class 1 landfills from 2012, shortly after the introduction of the National Environmental Standard for Managing Soil Contaminants for the Protection of Human Health (NES-SC) in 2011 (Figure 1). Inert materials include virgin natural materials such as clay, soil, and rock, but also other materials such as concrete or brick (i.e. not soil). Anecdotally, large volumes of soil are also disposed to other classes of landfills, although data are currently lacking. Obtaining better data on the material disposed to landfills is a key focus for the Ministry for the Environment and is signalled in its Waste Minimisation Strategy.

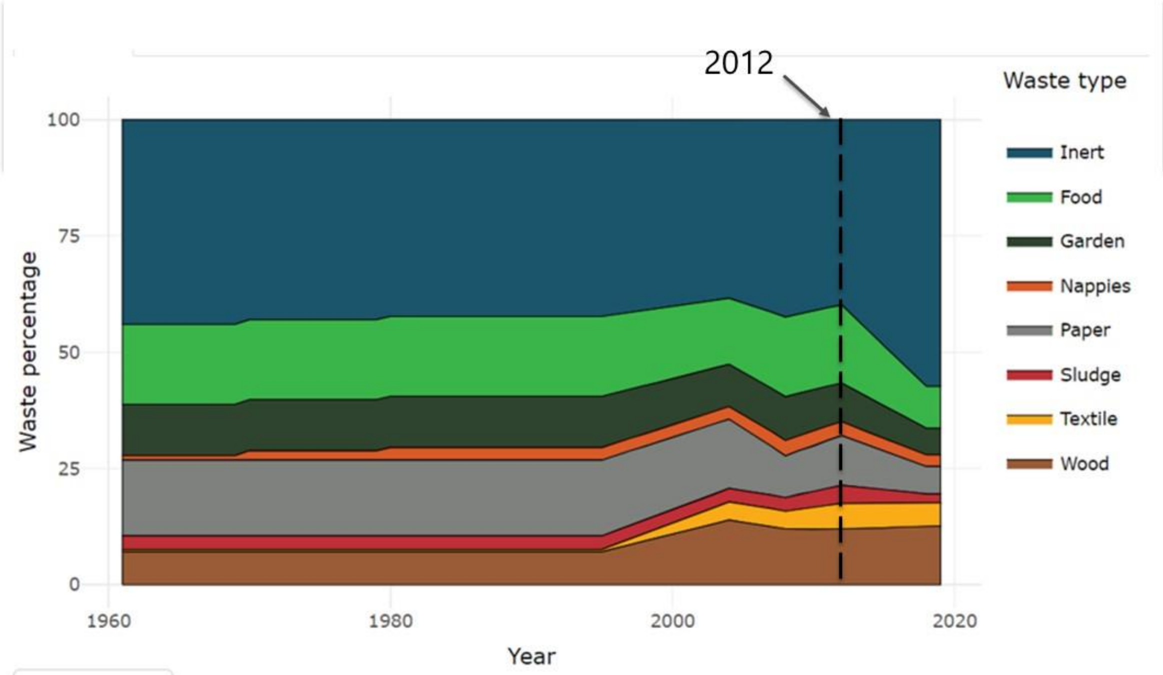


Figure 1. Proportion of different types of waste disposed to Class 1 landfills. The NES-SC was introduced in 2011. (Adapted from Dee & Lidgard 2021)

Workshop discussions grouped drivers for the generation of surplus soils into three types:

- **regulatory** – the NES-SC (in particular regulation of background concentrations/clean-fill criteria), council staff conservatism and/or lack of suitable expertise, individual council plans (which vary across New Zealand with respect to clean-fill criteria or activities)
- **developers** – a desire to avoid legacy risk (i.e. by leaving contamination on site that is noted on LIMs or requires specific ongoing management that may reduce the value of land or general saleability), building preferences, lack of incentives or disincentives to minimise the generation or beneficial reuse of soils
- **other** – geotechnical requirements, engineering standards, differing levels of public scrutiny of public vs private developers; i.e. greater scrutiny is placed on

public developers, such as Kāinga Ora, LINZ, and Waka Kotahi, to operate more sustainably, and these organisations have key performance indicators that support reuse (e.g. carbon accounting), as on-site reuse can reduce carbon emissions from avoided trucking).

Identified **barriers to reuse** included:

- a lack of awareness of reuse options
- regulatory uncertainty
- poor site investigations
- risk aversion to contamination, leading to a preference for virgin materials
- lack of intermediate storage capacity for storing soils, both on and off site, in the development process
- supply and demand of excavated soil not being aligned spatially or temporally
- reuse of soils carrying little economic incentive compared to other solutions (although landfilling costs are changing this)
- the time required to obtain consent for storing excess soil or reusing soil.

Through workshop discussions it also became evident that there is a lack of clarity as to what is really meant by 'soil', as well as variable definitions of 'contamination', despite a regulatory definition of contaminated land as being land that has a hazardous substance in or on it that has, or is more than likely to have, significant adverse effects on the environment.

4.1 Definitions

Through initial workshop discussions, the high-level definition of surplus soils developed is:

> *Those that have been disturbed through land and infrastructure or natural processes (e.g. landslips, silt/sediment) and are unable to be beneficially used on-site.*[3]

This document uses the following definitions of key terms.

> **Soil** is defined as unconsolidated, naturally occurring mineral particles and other naturally occurring material resulting from the natural breakdown of rock or organic matter by physical, chemical or biological processes, or formed predominantly from organic material in a permanently wet environment, such as a peat bog.

[3] Note that, anecdotally, there can be issues related to reusing excavated soil on-site if concentrations of contaminants are deemed to be above background concentrations.

Soil includes peat, 'mullock',[4] eroded soils, soils mixed with leaf litter and humus, and flood-deposited sediment, but it must contain no visible contaminants.

Soil is broadly categorised into topsoil and subsoil to recognise the different features and purposes for which these soils can be used. A third broad category, manufactured soil (soil deliberately amended to meet a purpose) is also within the scope of this document.

Topsoil is the uppermost part of the root zone where organic matter and most of the soil microbial activity are concentrated (Hewitt et al. 2021). For mineral soils, topsoil is termed the 'A-horizon', with darker soil generally indicating a higher organic matter content. Where soil is formed predominantly from organic material in a permanently wet environment, such as a peat bog, an O-horizon is recognised and may be the topsoil. For most purposes these soils should comprise:

- stones (2 mm – 50 mm): stone content must not be more than 35% by dry weight, and the 2 mm – 5 mm fraction must not exceed 20% by dry weight[5]
- Additional criteria for topsoil re-use: 4% – 20% organic matter, with pH and nutrients on an as-fit-for-purpose basis, but with those features that provide specific ecosystem services *not* related to geotechnical support (e.g. water storage, biological life) and those features related to mauri (see also sections 6.3, 7.3, 7.4).

Exceptions are allowed where replaced soil is mimicking pre-existing (i.e. just prior to land development) soil conditions.

Subsoil is defined as unconsolidated, naturally occurring mineral particles and other naturally occurring material resulting from the natural breakdown of rock, and may include soils with low fines content. This includes reused or recycled aggregate products.

Manufactured soils are soils that have been deliberately manufactured by blending combinations of natural or manufactured materials to perform specific soil functions. This includes recycled asphalt, concrete, and compost products.

Materials outside the scope of the above definitions include: mine tailings, wood waste/slash, and soil mixed with debris such as painted wood, ashes, or other refuse.

4.2 Sources of surplus soils

In considering where or how the generation of surplus soils and fill could be minimised or, if unavoidable, beneficially used it is useful to consider the different sources of surplus

[4] Organic Soils and organic-enriched soils found in seepages and wetlands

[5] The density of organics is close to 1 g/cm^3 while mineral particles are usually greater than 1.5 g/cm^3

materials and their potential soil contamination status. Figure 2 provides an illustration of the primary sources of surplus materials and their potential contamination status.

At a workshop held in June 2023 with 81 participants,[6] greenfield residential subdivisions, followed by brownfield residential developments, were considered to be the primary source of surplus soils (Appendix 1). The bulk of soil disposed to landfills was considered to have contaminant concentrations above background concentrations but below applicable soil contaminant standards (residential, followed by commercial/industrial) for the protection of human health.

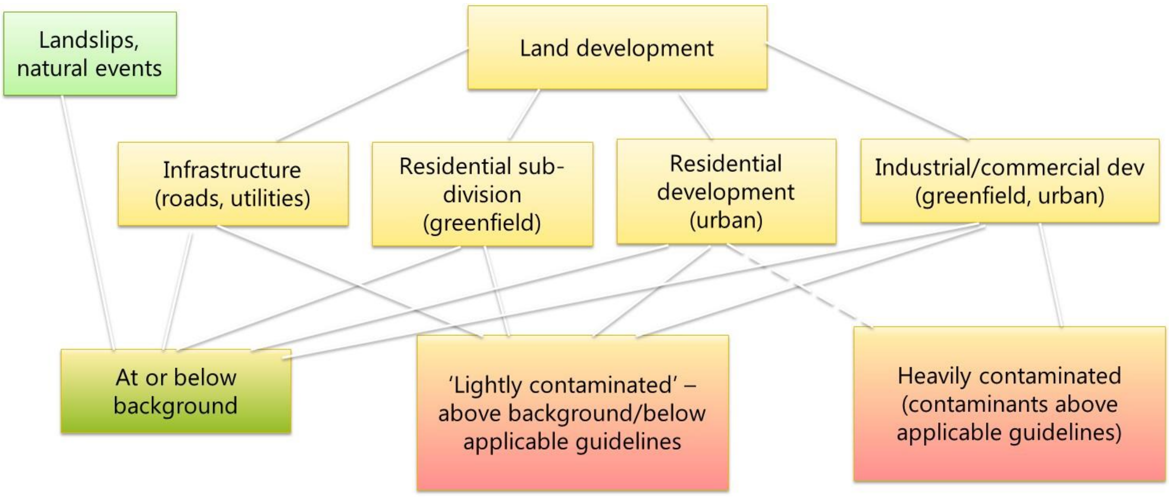


Figure 2. Illustration of primary sources of surplus soil and fill, and potential soil contaminant status.

4.2.1 Te ao Māori definitions

Māori have a long and enduring relationship with soils in New Zealand, going back centuries to Polynesian migration (Harmsworth 2020b). Some of the original knowledge of soils, crops, and climate was from Polynesia, but as knowledge systems evolved in New Zealand an expansive knowledge system (i.e. mātauranga Māori, mohiotanga) developed on land, soils, ecosystems, biodiversity, forests, and wetlands, as well as gardening, horticulture, and cropping (Harmsworth & Roskruge 2014a, b).

This connection and narrative can be traced back to the creation stories of Papatūānuku (the earth mother) and Ranginui (the sky father), when humans first came into being on earth. The stories of interconnection and interdependency with soils and ecosystems often start with the first woman, Hine-ahu-one or Hine-hau-one (the female element), who was formed from the soil (i.e. a clay red earth / red clay – onewhero, of the place Kurawaka), from which human beings originated. This places Māori firmly in the soil ecosystem as part of the ecology (e.g. eco-receptors, including microbes, invertebrates, plants, and higher

[6] The workshop comprised 56% contaminated land practitioners, 21% local authority representatives, 2% waste/disposal and geotechnical engineers, 17% other.

animals) where their well-being and health are dependent on a healthy ecosystem based on continuing and interconnected relationships through whakapapa (Harmsworth & Awatere 2013).

The common generic Māori name for soil is oneone (Harmsworth 2018), which covers size classes from clay, mud, silt, and sand, to gravels. Due to this close connection with the land (whenua) and environment (taiao), a large number of local Māori soil names (Table 1) have been developed over time within specific tribal areas, often associated with different activities and use (e.g. cropping, gardening, harvest, customary use). This naming coincided with exploring and describing most parts of the landscape in detail, which highlighted the close relationships between human, cultural, social, spiritual, and ecological forms.

Soil names express a range of soil characteristics through descriptors (e.g. location, wetness, texture, composition, dryness, hardness, colour, size class, feel, features, and depth) often linked to customary values, interests, and the type of activity and use (Harmsworth 2022). These names and associated Māori values provide a basis for understanding soils and can help find acceptable definitions for types of soil, and solutions for the management of soil, and how Māori might regard anthropogenic impacts on soils and the issue and use of surplus soil.

Table 1. Over 100 indigenous Māori names exist for soil

Māori soil names and English description	Māori soil names and English description
Oneone – general name for soil	One-matua – typically loam
One-pū – sand	Oneware, onemata – dark fertile soil
One hunga – sea sand; sandy beach; sometimes mixed with mud	One paraumu – very dark, fertile, soil; friable
One-pārakiwai – silt	Oneware – greasy soil
Parahua – silt	Onetakataka – a friable soil
Paru, paruparu – mud; dark mud	Onewawata – a lumpy soil
Kere – used as a prefix for some types of clay, including keretū, kerematua, kerewhenua	Pūngorungoru – (soft spongy) a light, loose soil
Kōtore, pākeho – white clay	Rei – peat
Keretū – heavy clay	Onekopuru – an organic soil found in wet situations
Kerewhenua – yellow clay	Pungapunga (also purupuru) – pumice soils
Kenepuru – sandy silt	Pungarehu – volcanic ash
Uku – unctuous clay; white or bluish clay (and ukui used to mean wash or wipe away)	Onekōkopu – gravel or very gravelly soil
Uku whenua – plastic clay (old traditional name)	Tiapu, onetaipu – fertile lands, especially sandy, alluvial soils

Source: Harmsworth 2022

In te ao Māori (the Māori world) all soils have a whakapapa (ancestral lineage, genealogy) that connects humans, terrestrial biota (soil microbes, invertebrates, plants, wildlife, and livestock) to location, soil, and natural environments (Harmsworth & Awatere 2013). Māori contemporary definitions for what constitutes a soil and what is soil health therefore include a strong ecosystem component based on ancestral values, relationships, and connections, consistent with te ao Māori.

An Endeavour programme (C09X1613), 'Soil health and resilience: Oneone ora, tangata ora', gave a working definition for soil health as:

> *The capacity of a soil as a living ecosystem to sustain and support all forms of life (to sustain microbes, plants, animals, humans and complex interconnections), through the maintenance of te mauri and mana, to strengthen and enhance whakapapa, taonga tuku iho, oranga, wairua, and whai rawa.*

This definition was based on important Māori values and symbolises strong connections between ecosystem and human health (Harmsworth 2018; Harmsworth 2020a; Hutchings et al. 2018; Hutchings & Smith 2020).

Māori always explained soil as that cultivatable level of the whenua in which they could grow plants and/or crops, and where forests, shrubs, and wetlands would grow. This describes the more biological, watered, and breathable part of the whenua. Soil was associated with nurturing life and ecosystems, the food-growing part of the whenua, which is consistent with soil definitions worldwide that refer to the top 1 metre (approximately), the skin of the earth, not the rock material below (parent material = whenua). A modern soil definition aligned to te ao Māori therefore could include:

> *The weathered surface of the earth, often the top 1 metre, in which organic matter, minerals, gases, liquids and organisms interact to support life and ecosystems (Te kiri o Papatūānuku, te kiri o te whenua, ngā oneone ō te taiao).*

'Kiri' is the Māori term for skin, which is appropriate for Papatūānuku, in the top 1 metre. 'Pūnaha hauropi', 'whenua hauropi' or 'ngā pūnaha hauropi o te taiao' can all be used to describe an ecosystem. The term 'whenua' is used for land (including soils). Whenua is commonly explained through whakapapa (lineage) as earth or placenta, giving connection, life, nourishment, and existence. The term 'whenua parakino' can be used for contaminated land and soils (Cavanagh & Harmsworth 2023).

Surplus soils

Māori have no definition for surplus soil or what it would look like. Soils are typically regarded *in situ* and intact as part of the whakapapa (ancestral lineage and connection) of an area, location, tribe, and ecosystem. Given this whakapapa, soils can be regarded as family (whānau, hapū, iwi), and when regarded as surplus they are in fact surplus to family, location, and can become disconnected, being regarded through te ao Māori as whangai'ed out, or 'fostered', 'adopted out' to somewhere else (e.g. another recipient location, or to someone else).

This will affect Māori decision-making regarding surplus soil. The notion of dislocation is contrary to kaitiakitanga and values (e.g. whanaungatanga, manaakitanga), and brings into question what is indeed surplus or what is waste. Generally, Māori regarded all soils as a resource and treasure, regardless of condition (taonga tuku iho).

Māori did modify soils and moved them about, but not far from their source. They were typically repurposed and redesigned (whai hanga, whakahouhou) for pā, papa kāinga sites, fortifications, gardens, etc. However, soils and parent materials tended to be retained on-site, while the more fertile soil component (e.g. topsoil = onemata, one matua) was often removed for use on gardens (i.e māra kai, mahinga kai). Traditionally and historically these modified materials and associated soils were not contaminated (except with middens, shell fragments, organic food waste) and still remained relatively pure and had a whakapapa connected to tangata whenua, related back to a site or area. Areas of human waste (under cultural practice and regulation) were separated out and became tapu (sacred, prohibited).

Any reworking of a soil like this was under the auspices of tikanga Māori and kaupapa Māori (customs and protocols), and when soils were reused it was in line with Māori needs at the time and did not constitute waste. However, Māori did create what we now know as *anthropogenic soils*. They transported specific soil components, using them as amendments to improve soil condition (e.g. the use of sand, stones, gravels, and charcoal), increasing productive capacity and adaptability for tropical and temperate crops. These modified 'Māori plaggen soils' are now evidenced as small to large-scale historical earthworks (e.g. gardens, papa kāinga / settlements, and fortified pā on hills) in many regions in New Zealand. All areas show varying degrees of alteration, redesign, reclamation and dumping of organic wastes (notably as Māori middens) (Park 1995; Pawson & Booking 2002; Harmsworth & Roskruge 2014a, b; Harmsworth 2020b).

If we use a definition such as

> *surplus soils are those soils that have been disturbed (and extracted) through natural (e.g. landslips) and anthropogenic activities (e.g. land development, utilities, installation) but are unable to be used or kept onsite, or are excess to requirements (note: excludes quarries)*

the closest equivalent to surplus in te ao Māori is where the soil (oneone) becomes horo, meaning to be removed quickly, such as under natural processes of erosion where the soil can slip away, or be taken away, displaced from one site to another (e.g. Horowhenua, horo oneone). Where soil is excess to what is wanted, the term 'toenga' could be used, meaning remains, additional to requirements, left-overs, or surplus (toenga oneone = surplus soil). Surplus soils can be contaminated or free of contaminants. Where contaminants are involved, the term used is 'toenga tāoke' = toxic residue), and where soils move off-site, 'neke atu' might be used to mean move away from (e.g. neke atu oneone).

4.3 Geotechnical requirements

Geotechnical requirements were identified as being the key driver for the generation of surplus soils by participants at the June 2023 workshop (Appendix 1). NZ4431:2022 *Engineered Fill Construction for Lightweight Structures* and *Field Description of Soil and Rock – Guidelines for the Field Classification and Description of Soil and Rock for Engineering Purposes* NZGS (2005) provide the basis for criteria from a geotechnical perspective, and not surprisingly are focused on the texture and strength attributes of the material.

NZ4431:2022 classifies material based on source type, as follows.

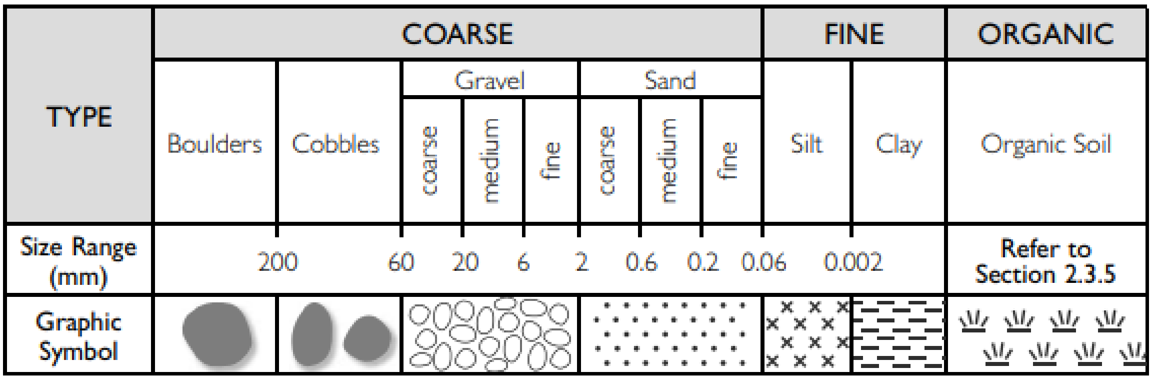
- Topsoil (material type T) – natural material that comprises the 'O' and 'A' horizons as defined in the *Australian Soil and Land Survey Field Handbook* (NCST 2009). Leaf litter can be mixed with the 'O' or 'A' horizons during excavation.
- Fine-grained soil (material type F) – natural soil material that can be described as fine-grained using the method defined in the *Field Description of Soil and Rock – Guidelines for the Field Classification and Description of Soil and Rock for Engineering Purposes* (NZGS 2005) and based on >35% material passing through a 63 μm sieve.
- Intermediate soil (material type I) – natural soil material with between 15 and 35% material passing through a 63 μm sieve.
- Coarse-grained soil or aggregate (material type C) – natural soil material with ≤15% material passing through a 63 μm sieve.
- Rock (material type R) – any natural material that can be described as rock using the method defined in NZGS's *Field Description of Soil and Rock*.
- Manufactured material (material type M) – material created or modified for the purpose of earthworks.

The material condition is also specified, with 'unsuitable' materials based on either physical or chemical (primarily soil contamination) properties. Materials typically considered to be geotechnically unsuitable include peat, material with significant quantities of topsoil, materials from swamps, marshes and bogs, and certain clays, with allophane specifically identified as being unsuitable or at least restricted for use. Many of these materials can have high value for use in green spaces, notably stormwater treatment systems, wetlands, forested areas, and urban farms.

These materials may also be specified for different fill types, although these are not described in NZ4331:2022.

NZGS 2005 provides guidance on the field assessment of soils for geotechnical purposes and broadly groups soils as coarse, fine, and organic, based on grain size (Figure 3). For the classification of soils, because the properties of a coarse soil are closely related to particle size, particle size is the sole criterion used in their classification (Figure 4). However, for fine soils the properties are influenced by both the size and the composition of particles, and other methods are used to describe and classify them (Figure 4).

Silt is intermediate between clay and fine sand. Silt is less plastic and more permeable than clay, and displays 'dilatant' and 'quick' behaviour. Quick behaviour refers to the tendency of silt to liquefy when shaken or vibrated, and dilatancy refers to the tendency to undergo volume increase when deformed. Clay consists of very small particles and exhibits the properties of 'cohesion' (material that sticks together) and 'plasticity' (allowing the material to be deformed without volume change or rebound, and without cracking or crumbling).



TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel			Sand			Silt	Clay	Organic Soil
			coarse	medium	fine	coarse	medium	fine			
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		Refer to Section 2.3.5
Graphic Symbol											

Figure 3. Grain size criteria. (Source: NZGS 2005)

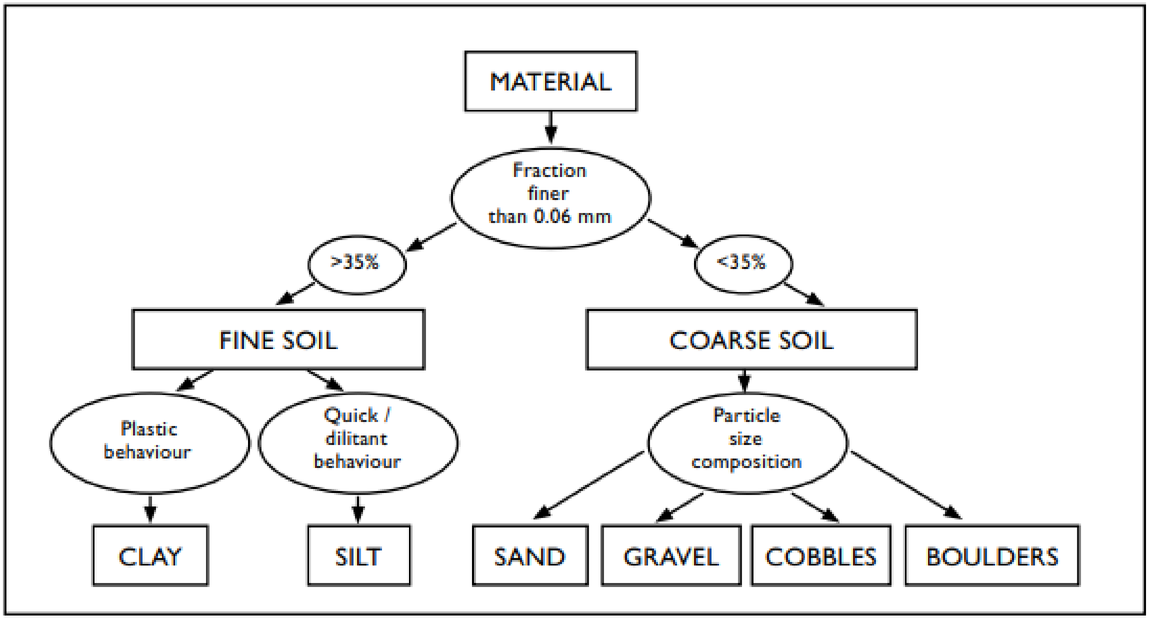


Figure 4. Soil classification, based on NZGS 2005.

Further details on the classification of course and fine soils are given, along with guidance for the description of the state in which a soil is found. This includes aspects such as relative density for coarse soils, soil structure for both coarse and fine soils, and strength and moisture content for fine soils.

4.4 Landfill and waste acceptance criteria

Clean-fill criteria based on background concentrations were identified as the second most-influential factor in generating surplus soils participants in the June 2023 workshop (Appendix 1).

Approaches used by regional councils for clean-fill criteria have been variable, based either on background concentrations alone, or a combination of background concentrations and Eco-SGVs (e.g. Cavanagh 2021, 2013), or on concentrations that are not lower than the 95th percentile of the regional background and not exceeding the lower of protective thresholds for the most sensitive receptor (i.e. the lower of human health or ecological thresholds (Waikato Regional Council 2022).

The latest revision of the *Technical Guidelines for Disposal to Land* (Revision 3, WasteMINZ 2022),[7] which also appears on the Ministry for the Environment website, specifies clean fill or Class 5 landfill waste acceptance criteria based on background concentration, using regional background concentrations for key inorganic elements in Auckland and Wellington as examples. It also specifies criteria for selected organic contaminants, although it is unclear what data they are based on. The revised national background soil concentrations for trace elements determined by Cavanagh et al. (2023) may be useful to consider here.

The technical guidelines provide guidance on siting, design, construction, operation, and monitoring for disposal to land, and classify landfills into five types:

- Class 1 landfill – municipal solid waste landfill or industrial waste landfill.
- Class 2 landfill – construction & demolition landfill or industrial waste landfill
- Class 3 landfill – managed fill
- Class 4 landfill – controlled fill
- Class 5 landfill – clean fill.

For Classes 4 and 5 it is intended that there be unrestricted future land use.[8] No mention is made of future land use for Class 3 landfills, although some constraint on future land use for these landfills is implied in Appendix C in WasteMINZ 2022. This appendix also provides an overview of the development of waste acceptance criteria, which includes consideration of leaching potential, human health exposure, and exposure of ecological receptors. Class 3 managed fill is based only on the protection of groundwater drinking-water and aquatic environment protection pathways. Class 4 waste acceptance criteria include consideration of ecological receptors, using values from Cavanagh 2019 and Cavanagh 2006 (for nickel).

4.5 National Environmental Standard for Managing Contaminants in Soil for the Protection of Human Health (NES-SC)

Clause 5(9) of the NES-SC was also identified as a key driver for the generation of surplus soils by participants at the June 2023 workshop. This clause states: 'These regulations do not apply to a piece of land … about which a detailed site investigation exists that demonstrates that any contaminants in or on the piece of land are at, or below, background concentrations'. There is the requirement that the land must have been

[7] http://www.wasteminz.org.nz/pubs/technical-guidelines-for-disposal-to-land-april-2016/.

[8] The release of the new HAIL guidance (MfE 2023a) and the proposed Natural and Built Environment Act now place a question over whether this will be the case.

identified as having, having had, or is more likely than not to have had a HAIL (Hazardous Activities and Industries List) activity on it, for this clause to apply.

This clause appears to often be interpreted as indicating that the NES-SC does apply to this land with soil concentrations *above* background, even if below any applicable human health criteria (i.e. soil contaminant standard) or environmental guideline. While the clause does not necessarily result in additional excavation of soil, in combination with 8(1)f), which states that to be a permitted activity 'soil taken away in the course of the activity must be disposed of at a facility authorised to receive soil of that kind', it appears to result in the largely unnecessary disposal of soils to landfill, which is obviously an authorised facility. If not a landfill, the 'facility' requires some level of authorisation that may be more or less easily obtained from the relevant council. This requirement contrasts with the discretion allowed in the transport, disposal, and tracking of soil and other materials taken away in the course of the activity under controlled, restricted discretionary, or discretionary activities (Regs 9–11 of the NES-CS).

In a review of policy and regulations surrounding the implementation of Eco-SGVs and surplus soils, Mayhew (2023) suggested that 8(1)f) could be reworded to be 'soil taken away in the course of the activity must be disposed of at a facility authorised to receive soil of that kind or *applied/reused in accordance with a rule in a relevant regional or district plan or resource consent*;' noting that local authority plans would probably still need to change to enable reuse. It is also intriguing to consider whether another option is to simply remove clause 5(9), and thus better enable risk-based assessment of contaminated land.

4.6 Background soil concentrations

National estimates of background soil concentrations of trace elements in topsoils (generally 0–15 cm) were recently updated by Cavanagh et al. (2023), with an example of the final output provided in Figure 5. Specifically, a series of maps was produced that present the rural ambient concentrations of individual trace elements based on the percentile (median, 90th, 95th, and 99th percentiles) of the predicted range. These estimates are produced on a 1 km × 1 km basis, and the data are intended to be available via the Land Resources Information System (LRIS). Significant natural small-scale variations (i.e. less than 1 km × 1 km) may occur for some elements (e.g. arsenic), which may warrant site-specific investigations to determine background concentrations.

The use of background concentrations in the context of surplus soils and clean-fill criteria differs from that described for soil guideline values for the protection of ecological receptors. Notably, in this case an upper 'threshold' for background concentration is more relevant to avoid unnecessarily triggering action as much as reasonably practicable. There is a further argument as to whether background concentrations should be used at all in these contexts, and this is discussed further in section 7.3.3.

However, going with the use of an upper threshold of background concentrations for surplus soils/clean fill, and evaluating the estimates developed by Cavanagh et al. (2023), it should be noted that model estimates in that study under-predict some elements, and in particular arsenic and zinc concentrations, compared to measured concentrations. For this reason, it is recommended that, for these elements, the 99th percentile value should be used as the threshold value for all areas showing as 90th percentile and above. For other areas, the upper estimate should be used as the relevant background concentration (i.e. for areas falling in the 50th–90th percentile, the 90th percentile should be used as the upper limit).

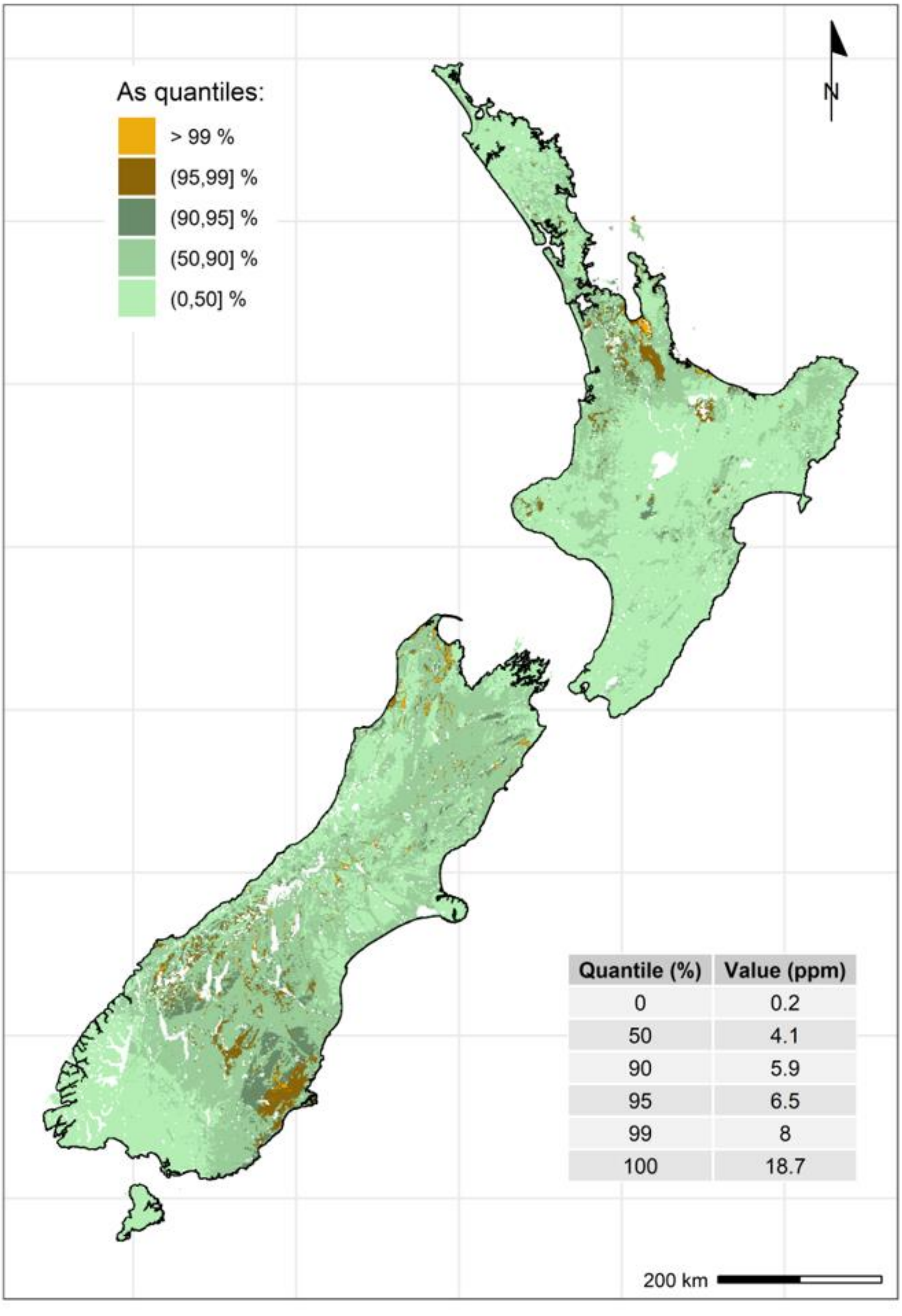


Figure 5. Predicted ambient background concentrations of arsenic across New Zealand. Concentrations are presented as quantile ranges of predicted ambient concentrations.

The full suite of revised background concentrations is shown in Table 2.

Table 2. A summary of relevant statistics for the range in ambient concentrations of selected trace elements using an extended data set

Element	Min	Median	90th	95th	99th*	Max
As	0.22	4.1	5.9	6.5	8.0	18.7
B	0.6	4.6	12	16	23	83
Cd	0.01	0.08	0.2	0.29	0.35	0.58
Cr	1.96	16	25	30	68	765
Cu	3.8	16	24	28	39	76
Ni	1.4	9	14	16	42	590
Pb	1.3	11	17	19	21	30
Zn	11.2	48	63	68	80	100

* It is recommended that the 99th percentile be used as a default value for these areas initially, but it may be appropriate to undertake site-specific determination of background concentrations.

Further work is required to 'merge' or transition information on regional background concentrations in Auckland (ARC 2001), Wellington (URS 2003), and Christchurch[9] (Tonkin & Taylor 2006, 2007), given the current use of these data in regional plans. Data from these regional studies were also included as some of the data used by Cavanagh et al. (2023) to determine background concentrations nationally, and these authors also provide a specific comparison of the nationally predicted concentrations with these regional studies.

The estimates provided by Cavanagh et al. (2023) are based on rural ambient concentrations; urban ambient background concentration of certain trace elements (e.g. lead) may be elevated in specific, generally predictable areas as a result of emissions from diffuse anthropogenic combustion sources (e.g. vehicles) and historical use of leaded petrol. However, there are limited data available to determine urban ambient background concentrations.

Cavanagh et al. (2015) evaluated background concentrations in urban soils and for organic contaminants, specifically polycyclic aromatic hydrocarbon s (PAHs) and DDTs. PAHs are derived from a number of diffuse anthropogenic combustion sources (e.g. vehicles, domestic woodburners). While provisional ambient concentrations for benzo(a)pyrene in urban areas, provincial towns, and rural areas were determined from data from three regions, further sampling and analysis were identified as being required to develop more robust estimates of ambient background concentrations of PAHs and Benzo(a)Pyrene (BaP.

[9] https://opendata.canterburymaps.govt.nz/datasets/ecan::soil-trace-elements-level-2/about

In rural areas the organochlorine pesticide DDT was widely used in pastoral agriculture and horticulture in the 1950s–1960s, and while such use had largely ceased by the mid-1970s (Buckland et al. 1998), residues (primarily pp-dichlorodiphenyldichloroethylene – pp-DDE) still persist in agricultural soils (e.g. Boul 1995; Buckland et al. 1998; Gaw et al. 2006; numerous contaminated land site investigation reports). This historical, widespread use of DDT has resulted in the ubiquitous presence of DDT residues in soil that should be considered as ambient background concentrations of these residues. The challenge is that historical use can be highly variable between sites, making determination of 'the' ambient background concentration problematic (Cavanagh et al. 2015).

More recent examples of likely widespread diffuse contamination of an organic contaminant are per- and polyfluoroalkyl substances (PFAS), which are members of a large, complex group of synthetic chemicals that have been used in consumer products around the world since about the 1950s. In New Zealand, identification of the presence of PFAS contamination in soils and groundwater, largely associated with the use of firefighting products at several New Zealand airforce bases, resulted in an all-of-government approach to understanding the extent and effect of PFAS.[10] Several studies revealed the ubiquitous occurrence of PFAS in different environments (e.g. PDP 2019a, b).

Further discussion on the use of background concentrations of trace elements is provided in Cavanagh et al. 2023.

5 Drivers for change

5.1 National-level drivers

5.1.1 Waste Strategy

The Waste Strategy (MfE 2023) is arguably the strongest existing driver for the reuse of surplus soils. The waste hierarchy has at its core a circular economy approach to reduce emissions (Figure 6):

[10] https://environment.govt.nz/what-government-is-doing/areas-of-work/land/per-and-poly-fluoroalkyl-substances-pfas/latest-updates-on-pfas/

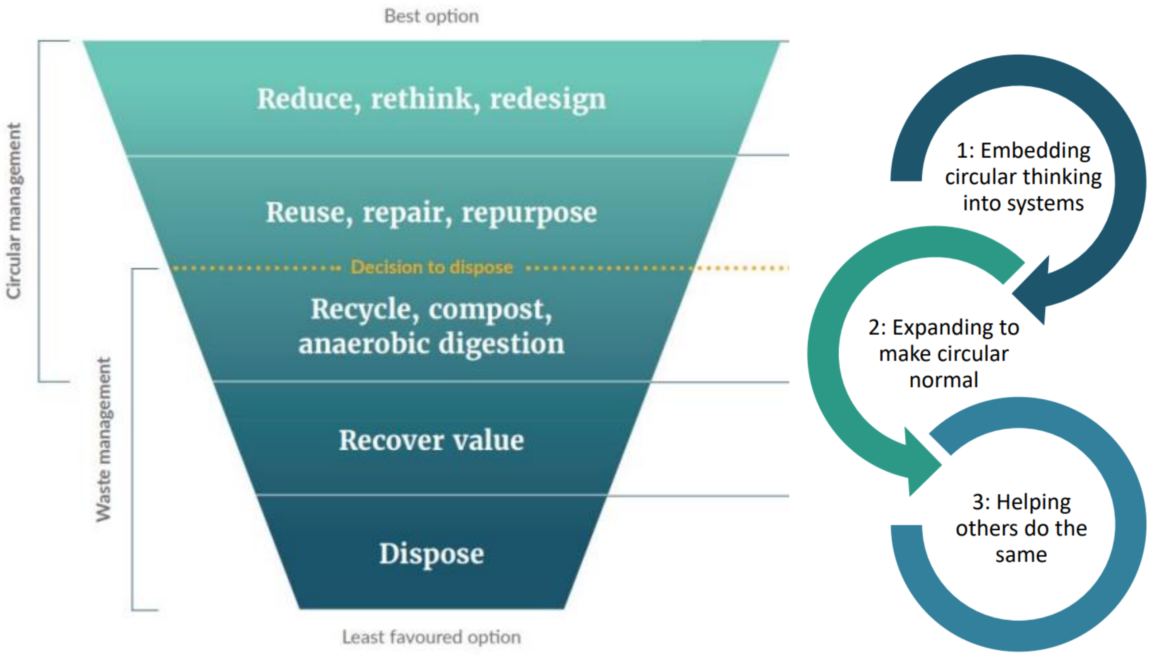


Figure 6. Waste hierarchy and three stages for implementing a circular economy approach. (Source: MfE 2023)

The strategy includes a priority for using the resource management reforms to create a new framework for identifying and sustainably managing contaminated land, and another priority for reducing the volume of soil disposed of at landfills by increasing soil diversion and reuse (8.3), under Goal 8: 'Contaminated land is being remediated and managed to reduce waste and emissions, and enhance the environment'.

Some of the motivation for this priority is recognition of the large volumes of soil transported to landfills as waste during development projects, or when we manage and remediate contaminated land. Transporting soil creates carbon emissions, increases traffic disruption, and prolongs soil exposure to erosion, in addition to the other negative environmental effects.

The strategy calls for a change in approach to recognise the inherent value of soil and to reduce the volume that ends up in landfills using a circular economy approach. Key activities outlined in the strategy are:

- investigate how and why we generate excess soil during construction and demolition
- obtain good data on the volume of soil disposed of at landfills
- promote sustainable remediation of soil as the norm, including treating contaminated soil on site
- explore options to recover and reuse soil when it has been moved off-site.

A limitation of the Waste Strategy's goal is that it doesn't provide any leverage for the reuse of soils not associated with contaminated land. However, the waste hierarchy provides a framework to minimise the generation, and enhance reuse, of surplus soils from non-contaminated land. A further opportunity is to consider separating soils into topsoils and 'other soils', to recognise the special values of topsoils.

5.1.2 Whenua Parakino – Contaminated Land Guidance

For roading projects, the recently released *Whenua Parakino: Contaminated Land Guidance* (Waka Kotahi NZ Transport Agency 2023) emphasises the potential for the beneficial use of lightly contaminated soils. The document also emphasises the importance of considering management options from the outset before undertaking soil disturbance works, applying for consents, or other authorisations, including:

- alterations to road design/route
- reducing soil disturbance
- reusing and/or managing soils on-site.

Examples of low-level contamination soil-reuse options include activities such as the construction of site features (including bunds, hillocks for noise control and visual amenity), and other landscaping features. The encapsulation of contaminated soils on-site, with capping by clean materials, is another example provided, noting that a long-term site management plan would be required.

Soil remediation was also noted as being potentially relevant where appropriate landfills are quite a distance away and there is a significant volume of contaminated soil to manage. Options for soil disposal are provided, noting the different costs associated with disposal to different landfill types.

This document complements NZTA P39: *Standard Specification for Highway Landscape Treatments*, although NZTA P39 isn't mentioned in *Whenua Parakino*. NZTA P39 focuses on the use and management of topsoil, which is defined as 'the top layer of soil characterised by the presence of organic matter'. Greater specification of topsoil is provided in Section F of the document, which outlines characteristics including texture, stone content, and chemical parameters such as pH, nutrient levels, and organic matter content that are required to be met for use as topsoil.

Section C of the document outlines site preparation activities (including identification of topsoil and reuse opportunities), such as soil testing, protection of topsoil, and the identification of unsuitable materials, including:

- soil that is too weak to provide support for new planting
- soil containing rubbish or contaminated materials
- soil containing pest plant material.

5.1.3 Carbon emissions

Transport of soil off-site generates carbon via transport and excavation, particularly when soils are removed to lower classes of landfill because of the longer average trucking distances. In addition, if soil removed needs to be replaced, it will be replaced by soils or aggregates sourced elsewhere. Large earth-moving projects with key performance indicators that include carbon emissions are therefore incentivised to reduce off-site soil disposal and importing virgin materials (e.g. topsoil for landscaping). This is a driver for soil reuse on the O Mahurangi – Penlink Waka Kotahi project. However, it requires soils to be suitable, and planning to create enough storage area and/or synergistic timing of (top)soil stripping and reuse, both spatially and temporally.

5.1.4 Climate resilience

Soils influence climate resilience. Within urban areas, 'sealed' soils (i.e. those covered with buildings and impervious surfaces) exacerbate stormwater runoff and heat generation. In contrast, permeable greenspaces have a major and increasingly important role in mitigating stormwater runoff and reducing peak temperatures. These roles are maximised under deep topsoils and/or deep total root zones, and where trees are present. Deep, well-drained soils with deep topsoil are also the most versatile and agriculturally productive (Hewitt 2004), and although little urban greenspace is used to grow food, interest in urban farming is increasing.

Unfortunately, most New Zealand district and regional councils specify thin topsoils for greenspaces such as berms and parks, which is based on establishing grass: 75 to 150 mm topsoil with unspecified total root zone is typical. The deliberate manipulation of urban soil profiles to maximise stormwater treatment, and versatile vegetation with enhanced drought resilience (in the absence of irrigation), has been generally restricted to designed 'stormwater devices' such as raingardens and tree pits. There appears to be widespread scope to encourage the use of surplus favourable topsoils and subsoils to create extra-deep topsoils and root zones that increase resilience to drought and waterlogging, and increase the potential productivity and versatility of our greenspaces. Perhaps all greenspaces should be designed to support a future tree canopy, within geotechnical constraints.

5.2 International examples

There are a number of examples internationally that illustrate the importance placed on sustainably managing soils and achieving a balance between reuse and protection of human health and the wider environment, with a review by Hale et al (2021) illustrating the extent to which surplus soil reuse is topical internationally. From a contaminated land perspective, sustainable remediation of contaminated soils and groundwater is one driver for the sustainable management of surplus soil.

ISO18504 arose out of the progressive development of sustainable remediation practices and is discussed further below. Processes used in the UK and Canada are discussed to provide specific examples of soil reuse processes in place, which navigate the fine line between beneficial reuse and soil being a waste. The EU soil strategy provides an example of a high-level driver for soil reuse, and it too is discussed.

5.2.1 ISO 18504: soil quality – sustainable remediation

Sustainable remediation was first formally articulated in 2007 when the Sustainable Remediation Forum (SuRF) was established in the US (Smith 2019). Since then a number of sustainable remediation forums have arisen internationally, including in Australia and New Zealand.[11] ISO 18504 represents some formalisation of the process to assess the sustainability of contaminated land remediation by providing a framework for considering the environmental, economic, and social value associated with remediation activities. ISO 18504 is referenced in Contaminated Land Management Guideline #1 (MfE 2021) to consider when assessing remedial options, and can inform the remediation or management of contaminated soil on some sites in New Zealand.

The focus of ISO 18504 is on more highly contaminated soils and large sites, and on sustainable development as being that which results in the return to use of abandoned, derelict, underused, potentially contaminated sites in a way that increases their environmental, economic, and social value. Sustainable remediation is defined as the elimination and/or control of unacceptable risks in a safe and timely manner, while optimising the environmental, social, and economic value of the work. Smith (2019) also provides further discussion on sustainable remediation. The overall approach outlined in ISO 18504 is shown in Figure 7.

[11] https://landandgroundwater.com/interest-groups/about-surf-anz

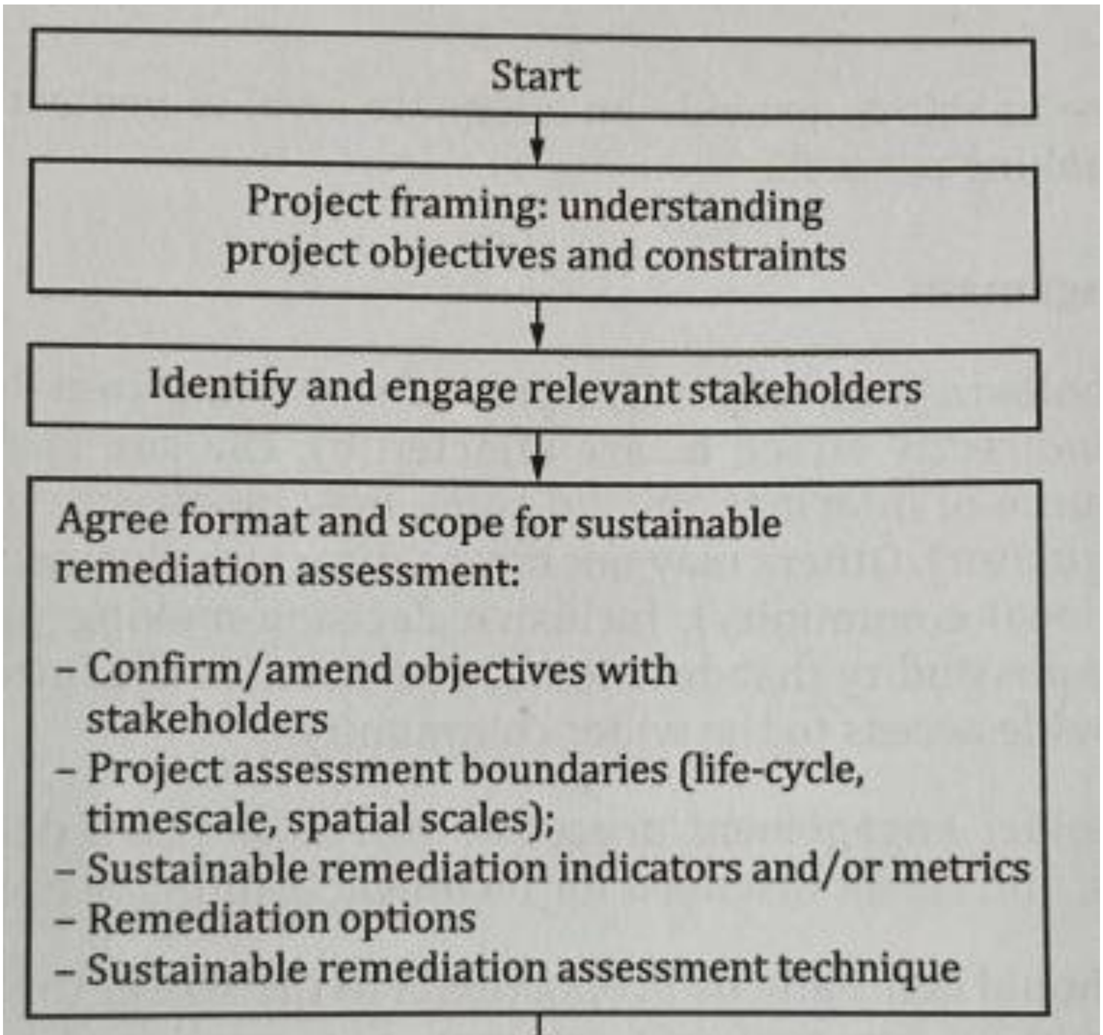


Figure 7. Stages of sustainable remediation strategy assessment, selection, and implementation. (Source: ISO 18504)

Economic indicators can include the costs associated with remediation activities, including waste disposal, as well as job creation and rise in land values. Environmental indicators can include energy used, waste generated / reduction in generation, materials reused, enhancement of ecosystems, while social indicators can include community and worker safety during remediation processes, as well as community health and mental well-being after remediation.

5.2.2 IS0 15176: guidance on the characterisation of excavated soil and other materials intended for reuse

This document provides guidance on the range of tests that could be necessary to characterise soil and other soil materials (e.g. manufactured soils) intended to be reused, with or without preliminary treatment (e.g. screening to remove over-large materials). Specifically, it is intended to assist in determining the suitability of materials for reuse and the assessment of environmental impacts that might arise from reuse, taking into account the different requirements of topsoil, subsoil and other materials such as sediments or treated soils. Soil materials include natural soil and other materials (e.g. fill, 'made ground') excavated, stripped or otherwise removed from their original location in-ground or above-ground (if in a stockpile), dredged materials, manufactured materials, and soil treated to remove or destroy contaminants.

The guidance is intended to be applicable to a wide range of possible end uses, ranging from play areas for children to agriculture, commerical forestry, gardens and other residential areas, restoraton of damaged ecosystems, construction sites, and road and rail construction. The over-riding principle for the document is that when there is to be no change in intended land use at the target site, imported soil materials cannot lead to a permanent reduction in performance of relevant soil functions. When there is to be a change in use, the soil should be suitable for the new use.

The document presents a flow chart that can be followed to characterise soil materials for reuse, which identifies the potential for physical, chemical, and biological tests to be considered. Chemical parameters include basic charactersation (e.g. pH, cation exchange capacity), nutrients, trace elements and potentially harmful substances (e.g. organic contaminants, non-essential trace elements), and considers substances that may be aggressive to construction materials. Physical parameters include soil profile, presence of roots, redox potential, hydraulic conductivity, infiltration rate, as well as other parameters included in geotechnical guidance (eg. plasticity, texture).

Biological characteristics are considered to be most relevant when the soil is to be productive (e.g. agricultural) or used for nature protection and landscape conservation, and are generally not relevant when soil is to be used for non-productive uses (e.g. earthworks). The guidance notes that biological measurements may also be useful to determine toxicity effects (e.g. where complex mixtures of potentially harmful substances are present), and/or for assessing the influence of soil properties (e.g. pH, organic matter, or clay minerals on toxicity effects).

Suggestions about the characteristics of source and target sites that might be determined are also included. Parameters at the source site are those relevant to the extraction process and subsequent storage and handling, and direct observations that can be made on site (e.g. soil pits) relevant to intended use. At the target or recipient site, the parameters are those that are relevant to the placement process, and properties of the existing topsoil and subsoils that are relevant to determining whether imported soil materials can be used without harm.

The following principles apply when soils are to be reused:

- avoidance and/or reduction of excavation of soil or removal of material from the site
- avoidance of damage during handling, storage or placement
- usefulness on the target site
- harmlessness on the target site.

More detail on key aspects are provided in the annexes of the document:

- Annex A – Relevant parameters required for the chemical, physical, and biological characterisation of materials for reuse
- Annex B – Good practice in the reuse of soil materials
- Annex C – Guidance on the scope of investigation needed before excavation of soil materials
- Annex D – Examples of classification and evaluation of soils and other soil materials
- Annex E – Examples of elements and compounds belonging to different contaminant groups.

5.2.3 United Kingdom

The UK *Construction Code of Practice for the Sustainable Use of Soils on Construction Sites* (Defra 2009) provides a useful example of practices used to enable the reuse of soils. Also, the *Sustainable Management of Surplus Soil and Aggregates from Construction* (Berryman et al. 2023) was released at the start of August 2023. These documents work within the UK regulatory framework for managing wastes and soils, which includes avoiding the disposal of soil to landfill (including through less onerous regulation of low-risk waste processes) and creating a circular economy.

The *Code of Practice* is aimed at protecting soils and ensuring adequate soil function (e.g. plant growth, water attenuation, biodiversity) during and after construction, and is intended to provide guidance for people involved at all stages of construction projects, including the developer, designer, contractor, sub-contractor (earthworks, landscape) and regulator. Sitting alongside the *Code of Practice* for sustainable soil management is the *Definition of Waste: Development Industry Code of Practice* and the *UK Site Waste Management Plans Regulations 2008*.

The *Code of Practice* for sustainable soil management covers a range of activities, from preconstruction planning, managing soils during construction and landscaping, and habitat or garden creation, and covers the following specific activities:

- knowing what soils are on site
- on-site soil management
- topsoil stripping
- subsoil stripping
- soil stockpiling
- soil placement
- sourcing and importing topsoil
- topsoil manufacture
- soil aftercare
- uses for surplus topsoil.

A key component of the UK *Code of Practice* is developing a soil resource plan, which is undertaken by a high-quality soil scientist. This is discussed further in section 6.2.2.

5.2.4 Ontario, Canada

In Ontario, the On-site and Excess Soil Management Regulation was enacted in 2019, following release of *Management of Excess Soil – A Guide for Best Management Practices*[12] in 2014, and a subsequent policy review (MOE 2016). The regulations support the proper management of excess soil – defined as soil that has been excavated, mainly during construction activities, that cannot or will not be reused at the site where the soil was excavated and must be moved off-site. This may also include excess soil temporarily stored at another location before it is brought back to be used for a beneficial reuse at the site where the soil was originally excavated.

The aim of the regulation is to 'ensure valuable resources don't go to waste and to provide clear rules on managing and reusing excess soil'. Risk-based standards (soil contaminant concentrations) are used to 'facilitate local beneficial reuse which in turn reduces greenhouse gas emissions from soil transportation, while ensuring strong protection of human health and the environment'. Processes for tracking soil from a 'source' site to a site where the excess soil can be reused for a beneficial purpose (a 'receiving site'), including the nature of use, are a strong feature of the rules.

Key elements of the regulation include:

- clear excess soil reuse rules and clarity on when excess soil is not a waste
- clarity on reusing excess soil and replacing waste-related approvals with regulatory rules for low-risk soil management activities
- enhanced reuse through improved reuse planning for larger (greater than 2,000 cubic metres) and riskier sites (e.g. gas stations and industrial sites), including tracking, registration, an assessment of past uses, and, if necessary, soil sampling and characterisation

[12] https://www.ontario.ca/page/management-excess-soil-guide-best-management-practices

- greater assurance that reuse sites are not receiving waste soil and requiring larger reuse sites (10,000 cubic metres) to register and develop procedures to track and inspect soil received.

In the future (2025), restrictions on landfilling clean soil that is suitable for reuse at a sensitive site (e.g. schools and agricultural sites) will also be included.

A key element of defining when excess soil is not a 'waste' is that there 'is a beneficial use for that excess soil and the quality and quantity of excess soil being taken to that site are consistent with the beneficial use'. Beneficial use is defined as the use of excess soil in an undertaking that requires additional soil in order to complete that undertaking. Examples of beneficial purposes include backfill and raising the grade for a planned development. Another criterion for determining whether excess soil is not waste is that the soil is dry, with liquid soil defined as being that which has a slump of more than 150 mm using a specified test (a specific authorisation is required to use liquid soil).

The types of sites permitted are a Class 1 soil bank storage site or soil processing site (which includes processing to reduce contaminant concentrations) or a Class 2 soil management site, which is a waste disposal site at which excess soil is managed on a temporary basis.

The quality of the soil is a key element, with excess soil quality standards developed based on contaminant concentrations, although the physical characteristics of the excess soil, including soil type and geotechnical suitability, are also to be considered. Principles for management include that soil placement should not degrade the existing conditions at a receiving site (e.g. by introducing a new contaminant or increasing the concentration of an existing contaminant), and that mixture and dilution of contaminated soils to reduce the concentrations of contaminants is not undertaken.

5.2.5 EU soil strategy and mission

The EU soil strategy and related initiatives include several high-level drivers to promote the protection and sustainable management of soil. Two key aims of the EU soils strategy are to ensure that:

- all EU soil ecosystems are healthy and more resilient and can therefore continue to provide their crucial service
- soils are protected and managed sustainably, and that restoring degraded soils is a common standard.

Key actions include:

- investigating streams of excavated soils and assessing the need and potential for a legally binding 'soil passport' to boost a circular economy and enhance reuse of clean soil
- restoring degraded soils and remediating contaminated sites.

The objectives outlined in *EU Mission: A Soil Deal for Europe*[13] also identify the reuse of urban soils (Figure 8).

The 8 Mission objectives

1. reduce desertification
2. conserve soil organic carbon stocks
3. stop soil sealing and increase re-use of urban soils
4. reduce soil pollution and enhance restoration
5. prevent erosion
6. improve soil structure to enhance soil biodiversity
7. reduce the EU global footprint on soils
8. improve soil literacy in society

Figure 8. Key objectives for the *EU Mission: A Soil Deal for Europe.*

6 What can we do differently?

6.1 Value soils!

We are dependent on soil for almost every aspect of our lives. This is well illustrated in Figure 9, which shows the range of ecosystem services provided by soil, and the relationship of soil to the UN Sustainable Development Goals. The topsoil layer is the most biologically active, with soil hosting around a quarter of the planet's biodiversity.

[13] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-health-and-food_en

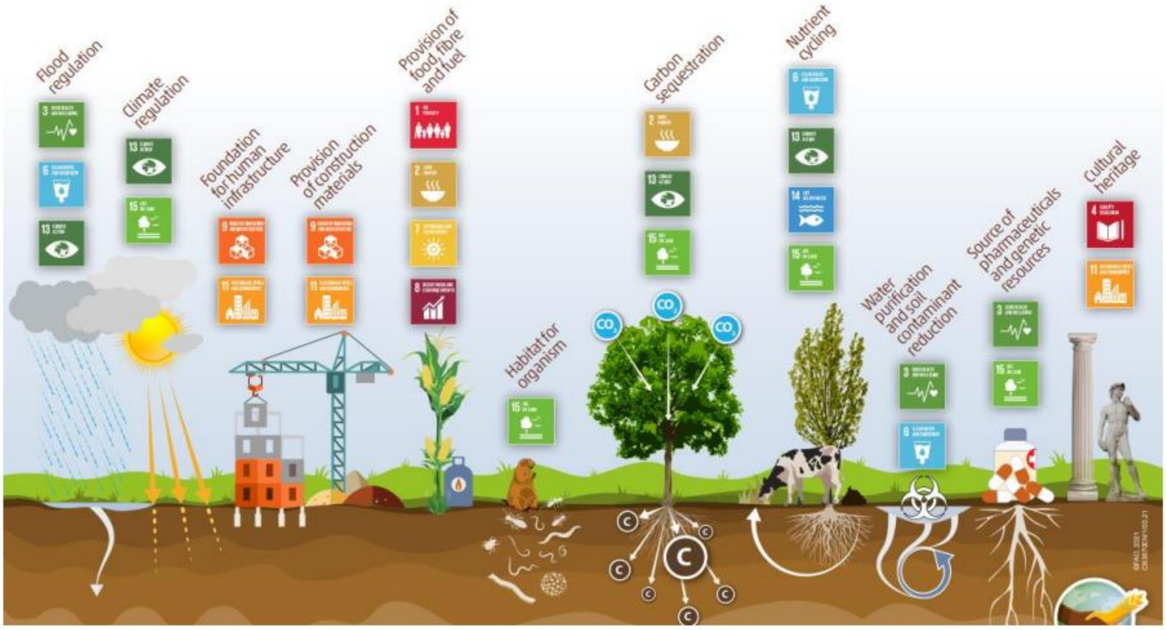


Figure 9. Ecosystem services and Sustainable Development Goals supported by healthy soils. (Source: EC 2021)

The ecological values of New Zealand soils are unique. Many of our soil organisms are unique to New Zealand, but poorly studied. New Zealand native ecosystems have most of their faunal biomass within the leaf litter and soil layers, with some reflecting our Gondwanan heritage (notably native earthworms). While the physical and chemical properties of topsoil may be able to be rebuilt, the recovery of some aspects of soil biology is slower, and some have not been attempted, which means our topsoil is vulnerable, particularly when removed from native ecosystems.

Soil builds up over time through gradual weathering and chemical decay of rock into smaller particles – gravels, sands, silts, and clays. During this process nutrients are released and become part of the soil, combined with soil organic matter developed from plants, fungi, micro-organisms, and fauna. Many New Zealand soils are made from a build-up of fine, wind-blown sediments (loess), volcanic ash or pumice; others are developed from flood-deposited sediments. The diversity of soils across New Zealand is shown in Figure 10; different soil profiles have different properties that can be more or less useful for different purposes (see also Appendix 2).

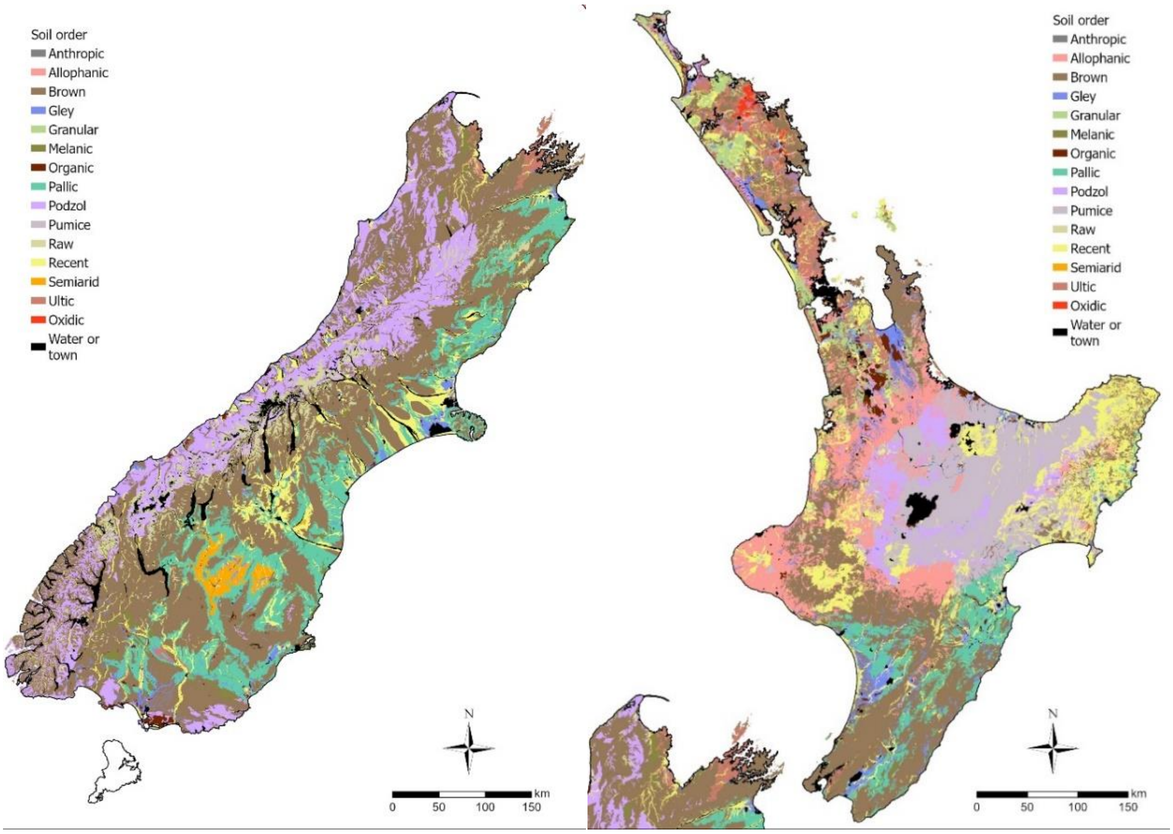


Figure 10. Distribution of soil orders throughout New Zealand's North and South Island.

Most soil descriptions identifying the productive potential of a soil focus on a soil profile, which is the top metre or two of soil exposed when a pit is dug in the ground, and which typically shows different layers or horizons (Figure 11). Where soil is formed predominantly from organic material in a permanently wet environment, such as a peat bog, an O horizon is recognised. For mineral soils, the topsoil or A horizon is the uppermost part of the root zone, where most of the soil microbial activity and organic matter are concentrated.

Underneath this lies the subsoil (with lower organic matter), which is altered such that the parent material is largely no longer readily recognised. This is termed the B horizon and is the lower part of the root zone. Occasionally, an E-horizon, an 'eluviation' zone, may exist between the A and B horizons.

Below the root zone are found weathered parent materials or C horizons, which are essentially unmodified geological materials or deposits, usually only weakly consolidated or unconsolidated and little affected by soil-forming processes. Refer to Hewitt et al. 2021 for more detail.

In contrast, geotechnical assessments extend to 5 m, frequently deeper, with 30 m common for structures over 6 m in height. Boreholes for tunnelling or water abstraction can extend hundreds of metres into the ground. Geotechnical investigations use a different assessment method that covers both soil and rock (NZGS 2005; see also section 4.3). To a geotechnical engineer, all soils above rock are formed soils, with variation described initially on the basis of texture, and thereafter on the various attributes relevant to or useful for engineering purposes.

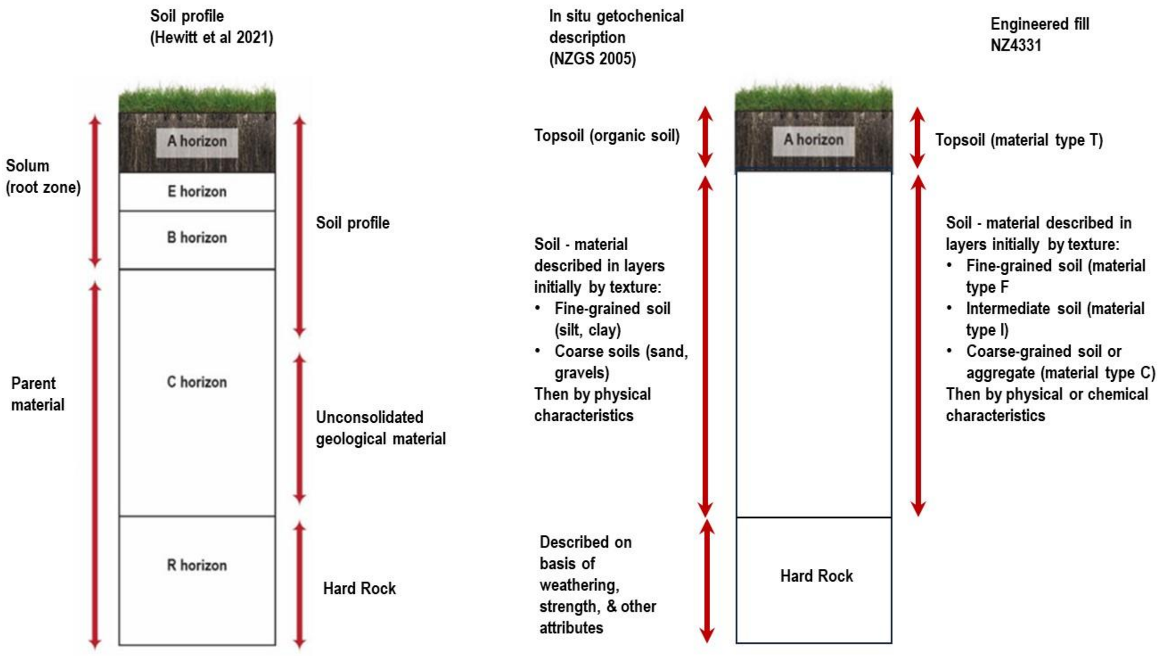


Figure 11. Left: a generalised scheme showing the names and typical arrangement of mineral soil horizons, as classified by soil scientists, with soil profile typically based on the top 1 m (Source Hewitt et al. 2021). This contrasts with the geotechnical engineering description of a soil profile (right), which may extend to 50 m depths depending on the purpose of the investigation (Source Adapted from Hewitt et al. 2021).

6.1.1 Māori values

Te ao Māori belief systems, Māori values, concepts and knowledge, and Māori customary traditions and practice provide the basis for describing and understanding soils, soil health, and connections between ecosystems and human health and well-being (Harmsworth 2020a; Hutchings & Smith 2020). This world view places Māori within the biosphere, the land, and its natural ecosystems (Harmsworth & Awatere 2013). It is underpinned by a continuum of knowledge from the ancient to the traditional, historical, and contemporary, where core Māori values and principles have been derived from Māori knowledge (Harmsworth 2021). Some of the core values for soil health are given in Table 3. Knowledge and values are then used, alongside other knowledge such as science, to inform decision-making and management, and to find solutions to many complex issues (e.g. sustainable soil management).

Table 3. Core indigenous values/principles integral to understanding soil health

Māori core value/principle	Description
Whakapapa	Recognising the ancestral links or lineage of the soil originating from the Māori belief system (Papatūānuku and Ranginui, te ao mārama, and atua (gods, deities, domains)) and links to tangata whenua (e.g. whānau, hapū, iwi). Strengthens understanding of interdependencies and interconnections between ecosystems, plants, animals, and humans.
Mana	Power, prestige, and authority. Giving respect to the soil resource, elevating the importance and prestige of soils, thereby giving them mana. Also the mana, authority, and responsibilities of human beings to care for, govern, protect, and manage the soil resource in accordance with local tikanga and kawa (customs and values). Recognises the Treaty of Waitangi as an overarching framework to reinforce this mana.
Mauri	Life force or energy, vitality and continued capacity of a soil to sustain/support healthy living ecosystems, including the basis or support for human well-being. A well-functioning soil ecosystem has the capacity to maintain interconnections between the physical, chemical, and biological components of soil, plants, animals, microbes, and people and to restore balance in the system to sustain health and well-being.
Wairua	The spiritual dimension/soul/connection to soil and land – helps provide the glue to maintain and strengthen mana and mauri to achieve a healthy soil and human well-being through spiritual endeavour and practice.
Taonga tuku iho	Soil is a treasure passed down through the generations and has an ancestral lineage and connection. Soil health can be maintained by building inter-generational capacity to care for the soil resource through kaitiakitanga (e.g. values-driven guardianship to give wise land-use options that sustain soil health and well-being).
Maramataka	Based on the Māori lunar calendar, climate, weather, and seasonal variations, guiding cultivation, and planting and harvesting activities.
Māra kai / māhinga kai	The ability of soil to provide healthy food (kai) for sustenance and well-being.
Oranga, hauora, waiora, toiora	The ability of a soil to provide and ensure the health and well-being of the whenua (land), plants, animals, and humans. A well-functioning soil free of harmful pollutants, contaminants, pathogens, and toxicity.
Tau utuutu	Giving back what you take, an active exercise of benefit to the resource (e.g. soil) through environmental guardianship (kaitiakitanga), shown through careful management and practice.
Kaitiakitanga	Cultural and environmental guardianship, as a responsibility, to protect and manage the environment, embracing all the values above.

(Source: Harmsworth 2022)

Māori consider and understand soil within the key concept of whakapapa (ancestral lineage of all parts of nature, where nature, including natural resources, water, air, forests, has senior status to humans), reinforcing interconnections and interdependencies with the ecosystem, soils, and tribal area, location, and site. This belief stresses family or kinship ties (whānau, whanaungatanga) and kaitiakitanga responsibilities (Harmsworth & Awatere 2013). Māori therefore consider soil disposal, the mixing of soils, and soil replacement within the context of Māori beliefs, values, and mātauranga Māori (Harmsworth 2021, 2022).

This alignment and agreement with Māori values, or otherwise, can generate or resolve issues. It can also provide a source of agreement to find solutions to inform decision-making consistent with correct process (tika, tikanga) and management, or to develop best practice (under ritenga = rules, regulation; tikanga and kawa = customary protocols) regarding the sustainable use and management of soils. It will also guide collaboration and engagement with councils and other agencies in terms of best practice (tikanga, process) to achieve agreed goals and best outcomes.

In regard to surplus soils, te ao Māori fashions the thinking and guides local Māori (iwi and hapū) on this topic and issue. Therefore, acceptance criteria will be considered in relation to cultural values and assessed and perceived in terms of cultural impact. This has ramifications for and specific application to the context of waste acceptance criteria for different landfills, but also where soil is imported onto sites as part of a remediation process.

The general te ao Māori perspective for soil management is that all soils are a treasured resource that should be passed down in a healthy condition for use by future generations and to support ecosystems (the principle of taonga tuku iho). There is a prioritisation that soils should be treated on-site to improve soil health, rather than being transported elsewhere, and that all soils have a whakapapa (lineage, provenance). This implies recommending and giving preference to the healing of Papatūānuku (the earth mother) and whenua (land) on-site, *in situ*, before transporting soil or waste off-site.

It would also contravene good cultural practice to move soil from one tribal area (rohe) to another, irrespective of the condition of that soil, especially if the soil were deemed to be or defined as contaminated (Cavanagh & Harmsworth 2023). Development of explicit soil reuse criteria, rather than a heavy reliance on background concentrations, would therefore be a preference for most Māori (e.g. iwi, hapū). It would also be difficult for many Māori to regard a soil as 'surplus' (when fitting the definition of soil) within their rohe in terms of whakapapa, Papatūānuku, and whenua, as explained earlier.

6.1.2 The management of surplus soil based on Māori values

Many suggestions for best practice are based on Māori values and customary practice through tikanga, kawa (protocols, standards) and ritenga (e.g. rules and regulations). Most current practices do not take into account te ao Māori, and many current practices for dealing with waste, surplus soil, and contaminants violate customary approaches. There are regulatory challenges and current standard practices that may inhibit uptake of te ao Māori.

Current practices

Following is a summary of some of the issues identified that act as a barrier to te ao Māori approaches being taken into account and implemented. Lowering these barriers and addressing these issues, would improve the management of surplus soil and facilitate the uptake of te ao Māori in current practices.

- There is a general high level of risk averseness to retaining any waste (surplus soil) by councils and developers as a result of requiring soil to be removed due to contamination by the council, a developer not being keen to leave contamination on-site, or the requirements of long-term management. Generally there is no corresponding averseness to generating waste.
- Geotechnical aspects are often influenced by scale (e.g. large vs small developments, assessments on individual lots within a large development vs whole development).
- Geotechnical/engineering standards are currently geared towards virgin materials, and there is a 'requirement for disposal to a facility authorised to accept "excavated material"'.
- Individual council plans and policies governing the excavation and handling of soils vary markedly around the country. Iwi and hapū concerns, values, and plans are often not considered in council plans. Policies and practice range from very good to poor around the country.
- Consenting includes storage of excavated soils, but at the moment has little regard for Māori approaches and customary practice. A cultural impact assessment (CIA) is often required under consent, which will comprehensively state local Māori values and issues. CIAs need to be fully understood and interpreted correctly to translate into best practice and approaches for managing surplus soils and waste.

Suggestions for best practice with Māori

When engaging with Māori, be ready to explain where the soils are coming from, when they are being disposed of (wā = time), and where (wāhi, takiwā) they are being disposed to (e.g. recipient sites, landfills, culturally significant sites). This again highlights the need to understand concepts such as whakapapa, and issues such as the mixing of the mauri (vitality, life essence) of different soils from different areas.

There is a need to include Māori early in decision-making and to recognise te ao Māori concepts and mātauranga Māori as important. Working with local mana whenua, iwi, and hapū can help determine what is waste or surplus and what to do with these soils. Parties can use a combination of background concentrations, Eco-SGVs, and human health values, plus cultural values to determine how to manage these soils.

Processes for dealing with waste and surplus soils are often different within a te ao Māori perspective. More culturally based approaches for management could be adopted in some circumstances (e.g. when dealing with asbestos).

There is a need to build capacity, capability, and resources within councils and other agencies to engage with mana whenua, iwi, and hapū in order to more fully understand te ao Māori concepts of soils and materials and how to manage them, and to work collectively to find solutions. For example, engineering, technical, and scientific definitions are often very different from Māori concepts (e.g. 'soils' vs 'materials'), and if they are regarded as materials this affects managing soils in the long term and their viability and suitability for specific end uses, and can exacerbate the soils being defined as 'waste' and 'surplus'.

Working with Māori to classify different types of beneficial use, it is essential to examine from a te ao Māori perspective what are beneficial attributes of soil for different uses. There is also a need to raise awareness and determine the acceptability of options for beneficial use – by all parties (including local mana whenua, iwi, and/or hapū. Determining acceptability must consider cultural values, mana whenua, iwi, and hapū.

Māori would like to minimise the transportation of soil off-site, and those classified as surplus, with the preferred option being to enact a healing process for soils with elevated levels of contaminants and trace elements on-site. This involves determining an end-use activity (e.g. industrial, commercial development, subdivision) for these soils in line with customary values (as opposed to culturally significant high health areas, such as papa kāinga, mahinga kai, and māra kai). This might require a better te ao Māori description of what constitutes 'greenfield' and 'brownfield' developments.

There is varying terminology relating to, and definitions of, clean fill and the use of 'hazardous substances', and what councils accept as standard. Definitions need to involve and be accepted by Māori. A te ao Māori definition of clean fill could be quite different from that, for example, of a council or private consultant. Standards, targets, and limits need to be set in conjunction with these definitions, and some standards could recognise cultural values and protocols relating to, for example, whakapapa (provenance), kaitiakitanga, mana, and mauri.

Consenting for the storage of excavated soils, and the mixing and/or treatment of soils at central 'hubs', needs to include Māori protocols and standards from area to area.

Māori need to be included in designing a waste hierarchy and classifying waste categories. Currently soils are defined as waste without considering te ao Māori. Some of these are very important issues for Māori, such as moving soils from one area to another and mixing (e.g. diluting) and dislocation of whakapapa, mixing the mauri and mana of soil.

Māori also need to be included in designing a soil reuse hierarchy. This could be an extension of current practice for specific cultural soils that are identified during site investigations, such as middens and archaeological features found in some historical kūmara gardens (e.g. characteristic black ash patterns in pumice terraces in Waikato). It could be that topsoils with high productive value are prioritised for reuse in māra kai, or soils removed from native forests or wetlands are used in the rehabilitation of ecosystems in parks or for the establishment of pā harakeke (flax).

Background concentrations

Background concentrations for New Zealand have been studied, modelled, and updated by Cavanagh et al. (2023). They show background concentrations primarily based on parent material related to rock type, with great variations throughout the country and across iwi/hapū tribal areas (rohe, takiwā). In relation to Māori values and belief systems, and from discussions and findings during this Envirolink project, the following perspectives were revealed.

- Māori are very interested in accessing and understanding information on background soil concentrations to provide a historical and spatial geographical context to support their decision-making, especially over long time-lines (e.g.100 years). It is important to know the natural background concentrations of a specific area, and the variability of concentrations, before deciding on the use and management of soils (e.g. especially in terms of impacts on health and well-being). Iwi and hapū particularly want to know when their soils are above a nominal background concentration but below any relevant (ecological or human health) soil guideline value.

- Māori are supportive of moving to a more risk-management type of approach (e.g. to identify low-risk and high-risk soils) to manage soils, and of developing criteria using both mātauranga Māori (e.g. cultural impact assessment, cultural indicators) and science (e.g. ecological or human health values).
- Māori are interested in using ecological and human health values to help develop waste acceptance and reuse criteria. Māori should also be involved in decisions for selecting the type of receiving areas and facilities that can take and manage surplus soils and waste. This engagement can include agreements on the disposal of an excavated soil to 'an authorised facility' to accept 'material' (although critical issues may arise when concentrations are above the nominal background concentration). These sites should be authorised and defined by mana whenua, iwi, and hapū, in conjunction with councils and other agencies, to develop holistic criteria that take into account cultural values, potential impacts, and off-site effects (e.g. to water, groundwater, estuarine/coastal).

6.2 Redesign and rethink our approach

6.2.1 Redesign

Redesign includes full consideration of the material flows associated with the design of the development or infrastructure to both minimise excavation of soil and enhance reuse of excavated materials. This could include using alternative construction methods, reconfiguring the design, or enhancing the quality of greenspace (e.g. through landscaping bunds, improved permeability of soils). A key aim should be to minimise the import of new materials and maximise the use of on-site materials, including through smaller volumes of amendments (e.g. compost to improve the quality of on-site soils, or lime or cement in contaminated C horizon soils to immobilise leachable components, where needed). A critical component of redesign is identifying the soil resource.

6.2.2 Identifying the soil resource

Identifying the soil resource is a critical part of sustainably managing soils during construction. The UK *Code of Practice* for sustainable construction provides a useful illustration of such an approach. Specifically, the *Code of Practice* identifies that a soil resource survey should:

- delineate and provide descriptions of the different soil types, including the thickness and characteristics of the surface and subsurface layers within each type, and the results of laboratory analyses

- assess the suitability of the different soil resources for reuse on- or off-site, matching soil types to landscaping requirements
- detail good practice for soil handling, soil management, and the remediation of any soil damage (e.g. compaction) caused during site working.

Figure 12 shows how the soil resource plan fits with the mandated Site Waste Management Plan and voluntary Materials Management Plan in the UK context.

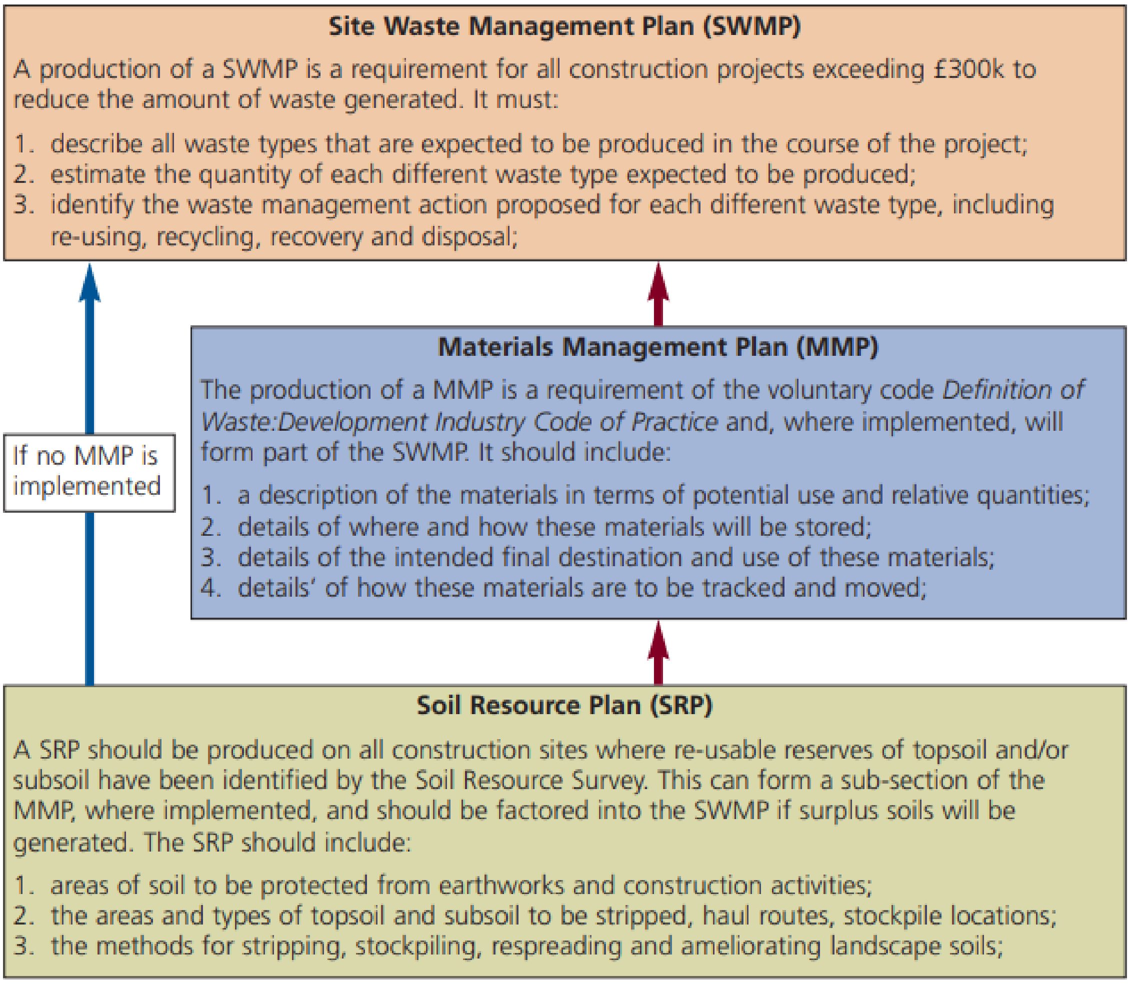


Figure 12. The Soil Resource Plan is the first step in the UK *Code of Practice*. (Source: Defra 2009)

The *Code of Practice* also specifies that a soil resource survey should be carried out by a suitably qualified and experienced soil scientist or practitioner, and that a geotechnical survey or contamination survey should not be relied on for detailed information on topsoil or subsoil resources.

In a New Zealand context, this focus on soil and a good understanding of the full potential of soil is perhaps a missing pillar – or, arguably, soil science is a missing profession – in land development activities. At present soils in most projects are primarily assessed for geotechnical characteristics and (frequently) contamination. In addition to using soil science consultants, another option is upskilling key personnel already involved in planning and development at an early-stage, including:

- surveyors
- stormwater engineers (soil infiltration and hydrological class are used to calculate stormwater treatment and runoff volumes)
- landscape architects, arborists, or ecologists
- geotechnical engineers.

A fundamental requirement to facilitate this upskilling is educating the developer or client on the value of reusing soils and how this can be achieved.

6.3 Understand the options for beneficial use

In both the UK and Canadian examples of sustainable use, documents explicitly specify the beneficial use of excavated material. A key beneficial use is simply offsetting the need to import materials, and reuse on-site should be encouraged in all instances. In some cases, improvement of on-site soils (e.g. through the importation of amendments such as compost or drainage materials) might be required to achieve better outcomes for soils intended for growing trees or plants. In this context, these soils can be considered as a 'landscape soil', which is 'an anthropic soil profile that is either modified from natural *in situ* soil or manufactured and installed using artificial components for the purpose of sustaining vegetation chosen for the landscape design or land rehabilitation' (Leake & Haege 2014).

Beneficial uses for topsoil (as described in section 2.1 of this report) include the following.

- ***Surface soil.*** This is used for gardening or landscaping, urban agriculture or horticulture, noting that different plants and ecosystems require different soil properties (e.g. forests vs urban gardens vs wetlands). Standards for areas in which rongoā (medicinal plants) or food are harvested may be different from those for harvesting above-ground fibres.
- ***Deeper topsoil layers.*** If topsoil is in excess, then deeper layers of topsoil should be encouraged and allowed for in council specifications (e.g. by annotating diagrams as 'minimum depths' and specifying a maximum where this may be relevant , such as above specific slopes where deeper topsoil depths may be unstable).
- ***Increasing water storage and release***. Peat and Pumice Soils and subsoils have a higher ability to store water than other New Zealand subsoils, and these layers can be used to boost water storage. Topsoils and peat hold water due to their high organic matter content.
- ***Bunds.*** Bunding, particularly combined with slope and 'rough' surface treatments and vegetation that encourage infiltration of water into bunds (Figures 13 & 14) (except for flood protection bunds), is valuable adjacent to roads to reduce the impacts of noise and car-lights on adjacent areas. Gently sloping bunds are also valuable to add surface variety when modernising traditionally flat parks, and can enhance the survival and growth of planted trees (Figures 14 & 15).

- ***Increasing carbon sequestration using Allophanic subsoils.*** These soils can store more carbon than other soils, or increase the nutrient contaminant attenuation capacity of soils receiving such inputs, using Allophanic or Granular Soils over Ultic Soils to reduce bypass/preferential flow (because Ultic Soils are more vulnerable to cracking) and to increase surface area.
- ***Replacement for eroded soil.*** Surface replacement can be used to avoid further erosion or to raise the surface above flood levels, where this does not impinge on flood paths or capacity, or to raise the surface of effluent treatment beds to deliver a greater distance to vulnerable water tables.
- ***Landfill covers.*** This may involve several layers, with compactable subsoils used to restrict root penetration underlying rooting layers (see WasteMINZ 2022 for more detail on landfill covers). Deeper landfill cover layers provide greater flexibility with plant selection (e.g. greater use of shrubs) while not affecting the integrity of the cover and enabling 'mowing in perpetuity' to be avoided.
- ***Habitat restoration.*** There is potential to use soil translocation (with leaf litter layers and attached plants and logs) to inoculate and/or accelerate the rehabilitation of native ecosystems. Such methods have been shown to successfully translocate a range of soil invertebrates along with plant propagules, although the effects on soil mycorrhizae and fungi are unknown. The method also has potential for wetland restoration, notably peat restoration (e.g. Torohape, Waikato region).
- ***Culturally specific*** options may require criteria such as proximity to the source area, or retaining to a degree the provenance and characteristics of the original soil (e.g. granular soils placed in areas with natural granular soils).
- ***Off-setting import of materials.*** This can include the use of manufactured soils developed and amended as required for on-site use (thus requiring a smaller volume of materials to be brought on-site)

The key criteria depend on the type of beneficial reuse. In a 'productive' or habitat restoration, generic tests would be similar to those used for landscaping soils (NZTA P39): contaminants, texture, total carbon, total nitrogen, pH, total phosphorus (P), Olsen P, and phosphorus retention. Source and receiving soil profiles should also be assessed using Hewitt 2004, which includes soil drainage and identification of root-limiting layers. Further, depending on the use, the properties of soil will differ; for example, if native species are to be grown, lower soil nutrient levels are likely to be suitable. If soil is to be used in stormwater devices, low copper and zinc concentrations will be required, along with specific ranges of carbon (organic matter) content.

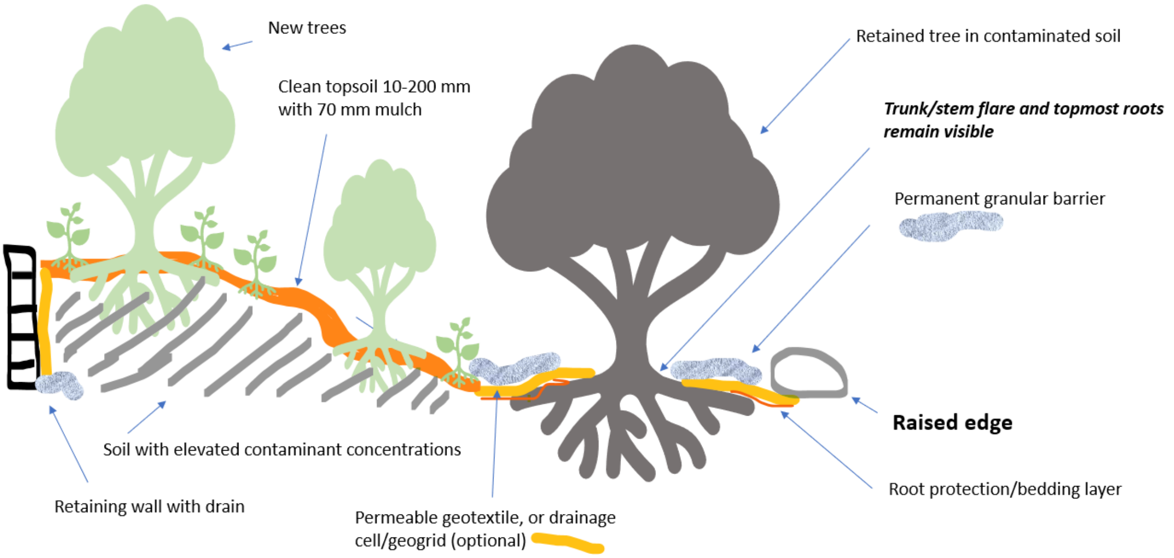


Figure 13. Illustration of the beneficial use of soils with elevated contaminants in landscaping bunds.

Figure 14. Left: New trees in raised bunds. Some places can beneficially use contaminated topsoil as a deeper root zone for healthier trees. Hard edges and taller perennial groundcover are better at reducing access and damage. Right: Rocks and taller, permanent groundcover reduce the likelihood of contact/excavation.

Figure 15. Without mounding, trees can be more likely to die in compacted, shallow, water-logged conditions.

Beneficial uses for subsoil, as described in section 2.1 of this report, include the following.

- ***Subsoil root zones.*** To ensure filled areas have suitable drainage and aeration that support deep rooting, subsoils within the surface 600 to 900 mm would generally be coarser-textured, and could be stony. They could also include subsoils from Allophanic or Granular Soils, despite being fine-textured if treated after placement (e.g. ripping or subsoiling).
- ***Bunds.*** Bunds may be created as described above and shown in (Figures 13–15). Larger bunds may require greater use of subsoil, such as flood protection bunds or those adjacent to roads to reduce the impacts of noise and car-lights on surrounding areas, or to create alternative landforms.

- ***Off-setting import of materials.*** This includes through the use of manufactured soils developed and amended as required for on-site use.

As above, the key criteria depend on the type of beneficial reuse. In the case of subsoils, greater emphasis is likely to be placed on properties that reflect geotechnical requirements from an engineering strength perspective, but also soil drainage characteristics to enhance or minimise the movement of water to groundwater, as appropriate for the site in question.

6.3.1 Case studies

There are various examples of the sustainable management of soils and fill across New Zealand, with sustainability drivers (including minimising waste generations) being key. Other key 'enablers' are space, or access to space, for the storage of excavated materials (e.g. on-site or at a neighbouring site, and where councils have been supportive of reuse). Some case studies are illustrated below.

CASE STUDY 1: TE KORI SCOTT POINT SPORTS PARK, AUCKLAND

Auckland Council is building a new public park to meet the growing needs of the Hobsonville Point community. Te Kori Scott Point site was formerly commercial/industrial land use, including stainless steel manufacture and a nursery site. Te Kori will be New Zealand's first fully sustainably designed and constructed sports park (under the Infrastructure Sustainability Council [ISC] framework). Consent was granted for the project in March 2020, and it is currently in the construction phase.

Site layout and features prior to development

This 16.4 ha park will be made up of three main areas:

- sports and active recreation (4.4 ha, 27% of the original site)
- informal recreation (4.4 ha, 27% of the original site)
- ecological restoration and conservation (7.5 ha, 46% of the original site).

Proposed site layout and features indicating distribution of recreation and conservation spaces

Te Kori has been designed in partnership with the local community and iwi to provide benefit to current and future generations, as well as the environment. The project has already been awarded a 'Leading Design' rating from the ISC.

Drivers for reuse	Obstacles to reuse
• The sustainability values of Auckland Council and use of this as a 'flagship project' to pave the way for others. • Council-led development where 'net zero' carbon emission targets are required to be met sooner than others (i.e. 2030). • Achievement of sustainability-in-design targets within the ISC framework (i.e. 95% of topsoil retains productivity and is beneficially reused). • Site material suitability was fit for end use (i.e. the level and type of conditioning improvements were available and cost-effective within the current market).	• Historical ground contamination sources – horticultural use, uncontrolled filling, fly-tipping, presence of asbestos/asbestos containing material. • The geotechnical suitability of soils used for building platforms. • The site requires detailed planning to support the use of available space for soil reuse purposes. Available areas of the site where disturbance was permitted could be extended laterally to incorporate additional materials.
Tools employed to support reuse	

Tools include:

- a comprehensive understanding of critical design issues to determine feasibility, involving site investigations (PSI & DSI) to determine the type and extent of contaminated land impacts, and detailed soil investigation and logging to determine the type and extent of geological units present at the site, and where development constraints were focused on-site.
- a detailed options assessment for contaminant remediation and geotechnical conditioning/improvements (i.e. blending/mixing) to create fit-for-purpose soil products suitable for end-use; contaminant and geotechnical constraints (type and extent of impacts/materials) were able to be overcome
- sustainable design, in line with the accredited ISC framework – sustainable reuse was incorporated into the design elements of the project to allow for the relevant reuse and retention of thousands of cubic metres of surplus soils, and to offset the importation of thousands of cubic metres of top- and subsoil (to date) by:
  - increasing the volume of earth bunds by thousands of cubic metres via lateral extension to accommodate more 'landscape fill' (geotechnically unsuitable) materials, which has allowed for the on-site retention of more geotechnically 'unsuitable' soil materials
  - exploring excavating and mixing/blending thousands of cubic metres of soil affected by heavy metals with site-sourced (virgin excavated natural materials, VENM to dilute contaminant concentrations, and, backfilling as engineered fill to meet geotechnical requirements fit for future land-use
  - increased frequency of geotechnical and contamination testing to ensure materials are appropriate to be retained on-site, with or without mixing/conditioning, and increased frequency of validation sampling to confirm that construction specifications are met from a geotechnical and contamination point of view, and, to ensure compliance with Auckland Unitary Plan Permitted Activity requirements for contaminated land management (Rule E30)
- education/awareness raising through a flagship project for both community and industry focused on the perception of value of the reuse or retention of soils onsite (i.e. not contributing to waste volumes and/or increased emissions as a result of surplus soils removal and landfilling, etc.).

Site soil investigation to determine reuse potential.
(Case study provided by Rod Lidgard, PDP Limited)

Case Study 2: FORMER THREE KINGS QUARRY DEVELOPMENT, AUCKLAND

Fletcher Residential Limited is developing the former Three Kings Quarry site into an inner-city residential development comprising 1,200 homes, landscaped reserves, playgrounds, playing fields, and community areas. The site is Auckland's second-largest brownfield site at 15.1 ha. The site requires up to 15 m raise in ground level to increase the floor level of the former quarry in line with surrounding site levels.

Reused, engineered surplus soil material in place

In parts of the site, development partners Fletcher and Auckland Council have worked together to support the development potential of the site, and the wider Three Kings area, in line with the local Puketāpapa Local Board plans for the area.
Resource consent for these key areas was granted in February 2018, and it is currently nearing the end of the ground preparation works phase (i.e. ground raise and engineering specifications achieved) in the south of the site.

Works included the excavation, sorting, and partial removal prior to placement and compaction of controlled-fill type materials containing heavy metals, asbestos (etc.) within the development parcel.

Drivers for reuse	**Obstacles to reuse**
• Source/receiving site link available and established. • Cost improvements due to soil reuse and partnered reduction in cartage and disposal costs. • Shared sustainability values of the developer partnership (Auckland Council and Fletcher).	• Historical ground contamination sources – uncontrolled filling, fly-tipping, presence of heavy metals, hydrocarbons, pesticides, and asbestos/ACM above guideline criteria. • Geotechnical/contaminant suitability of soils for building platforms – large waste materials such as boulders, fence posts, and drums (totalling c. 30% of waste volume) require sorting and removal. • Future site use – reused contaminated materials need to be located in specific areas and barriered from future features (e.g. stormwater soakage zones).

Tools employed to support reuse

Tools include:

- a comprehensive understanding of the critical design issues (i.e. the type and extent of contaminated land impacts, the type and extent of geotechnical conditioning required to meet construction specifications)
- contaminant and geotechnical constraints (type and extent of impacts/materials) being able to be overcome by sorting and removing large or contaminated items (rocks, fenceposts, etc), and blending/mixing the balance of soil materials to meet Auckland Council Permitted Activity criteria (AUP-OP Rule E30) and geotechnical specifications for construction
- pioneering sustainable design – prior to established sustainability frameworks (i.e. ISC, ISO18504, etc), sustainability factors for soil reuse and retention for contamination/geotechnical were

incorporated into the design elements of the project to allow for the relevant reuse and retention of c. 8,000 m^3 of surplus soils by:

  - incorporating 'managed fill'-type materials (post-conditioning) as an additional designed component to support the raising of the floor level of the former quarry
  - designing additional areas to house 'landscape fill'-specification soils to optimise topsoil reuse and retention

- increased frequency of geotechnical and contamination testing to ensure the maximum amount of materials are appropriate to be retained on-site; increased frequency of validation sampling to confirm construction specifications are met from a geotechnical and contamination point of view; and preparation of a long-term site management plan (to ensure safe management during any future disturbance) for key areas of the site where the soil material is characterised by contaminant concentrations greater than background but below Auckland Council Permitted Activity criteria (AUP-OP Rule E30)
- community and iwi stakeholder engagement – holding community meetings and including local groups in the design and enhancement plans for the site and the wider area; sustainable factors such as reuse and appropriate risk management discussion helped understanding and support of reuse concepts.

Proposed site development plan, showing the approximate former extent of the quarry.
(Case study provided by Rod Lidgard, PDP Limited)

CASE STUDY 3: WALTHAM RAIL YARD, CHRISTCHURCH

HEB Construction Ltd (HEB) is undertaking a major redevelopment of the 4 ha KiwiRail Waltham Rail Yard in Christchurch. The ongoing development involves constructing a new mechanical hub and load bank building, infrastructure, and amenities; refurbishment of the existing maintenance building into an inventory building; and constructing new track, signalling, pavements, landscaping, site features, and site works.

Stockpile of material generated through works

Works included hardstand stripping and earthworks across the majority of the site, which is on Environment Canterbury's Listed Land Use Register based on use as a rail yard since at least the 1930s, and for having asbestos in a deteriorated condition.

Reuse of c. 8000 tonnes of fill was calculated to save KiwiRail over $2 million in disposal and associated transportation costs, kept over 800 truck-and-trailer heavy vehicles off the roads, and avoided the importation of 8,000 tonnes of clean fill.

The project won the HEB Circular Economy (Reduce/Reuse/Recycle) of Construction Materials award in 2023 and was a finalist in the 2023 WasteMINZ Conference, Expo + Workshop Awards for Excellence in the contaminated land management category.

Ongoing sustainable management approaches include investigations to reduce the remaining cut excavation quantities, and keeping excess stockpiled fill on-site through landscaping and filling additional areas.

Drivers for reuse	**Obstacles to reuse**
• Cost improvements. • Sustainable practice.	• Site contamination – hotspots of arsenic contamination and some soils containing asbestos above human health criteria and thresholds for Class B asbestos removal works disposed to landfill. • Regulatory practice – all excavated material above background concentration assumed to pose unacceptable environmental risks until demonstrated otherwise.

Tools to support reuse

Tool included:

- a comprehensive understanding of the type and extent of contaminated land impacts through multiple site contamination investigations, which demonstrated that contaminants of concern in the proposed work areas were above background concentrations but significantly below applicable commercial/industrial soil contaminant standard (SCS).
- synthetic precipitation leaching procedure (SPLP) testing, which demonstrated low risk of contaminant migration into groundwater from reused material, and enabled consent for reuse of fill to be obtained.

Reuse of fill in the formation of the new rail lines reconfiguration, specifically as backfilling between the tracks, rails, and sleepers and within an electrical line trench, and compacted to meet geotechnical requirements. Geotextile is used to delineate fill, which is then covered with gravel of grade AP20. (Case study provided by Regan Knapp, HAIL Environment)

CASE STUDY 4: WESTERN BAY OF PLENTY RESIDENTIAL DEVELOPMENT – PRIVATE LAND DEVELOPMENT CLIENT

To meet the growing need for residential land in the western Bay of Plenty, a leading residential land developer and house builder recently completed earthworks ahead of plan change and subdivision within an identified urban growth area. The subdivision development comprised an area of 6 ha, providing a combination of low- and medium-density residential dwellings.

Previous investigation by others had confirmed the development site as a typical horticultural property with a combination of potential contamination sources affecting near-surface soils. This included treated timber posts and former superphosphate application to the wider topsoil (former dairy land prior to horticulture).

The investigation confirmed that soils would struggle to meet accepted definitions of clean fill, with anticipated disposal costs exceeding $5,000,000 if materials were required to be disposed at a local Class A landfill.

A reimagined approach to surplus soil management was able to dramatically reduce the amount of topsoil moved to landfill. Of the original 20,000 m^3 of topsoil, 1,200 m^3 of the most severely contaminated soils were reused at an alternative area of production land, with 269 m^3 topsoil from localised asbestos and hydrocarbon hotspots disposed to a Class A landfill. The balance of topsoil was conditioned and recycled for reuse as clean fill at other development properties. This project was a finalist in an international awards programme for outstanding environmental achievements.

Initial site investigations showing presence of treated timber posts

Drivers for reuse	**Obstacles to reuse**
• The drivers for a sustainable solution ultimately came from a need to reduce unsustainable landfill disposal costs in an area where there are limited local disposal options. • Engagement with mana whenua partners through the consenting process showed there was a strong local preference for retaining soils on-site within the rohe, and	• At the point of engagement, the client had a well-developed construction programme that did not allow for retention of topsoil on site. • House building programmes in tightly packed, low-density residential developments with limited garden areas typically result in all topsoil being stripped at the point of house building (due to builders preference for raft or slab foundations). While the majority of topsoil could have been retained on the subdivision site, it

early engagement with mana whenua was a significant positive factor. • Achieving a sustainable outcome aligned with the developer client's brand and reputation for sustainable and environmental beneficial management practices.	would have ended up in a landfill when building commenced. • Subdivision yield assessments and detailed scheme layout design completed ahead of consultant engagement restricted the opportunity to re-purpose some of the site for reserve or public open space for a permanent encapsulation within a less sensitive land use. • Delayed or incomplete plan change processes associated with the development site meant that the issue of managing widespread contamination in horticultural soils had not been discussed or recognised, and so appropriate planning controls encouraging sustainable reuse (urban design, density, form, use of public open space) had not been implemented. • Some stigma and commercial sensitivity remain in the market regarding the retention of low-impact soils for use in residential development, despite suitability for that purpose.

Tools employed to support reuse

- An additional detailed site investigation was completed that appropriately characterised the site and the contamination risks. Bioaccessibility and leachate testing were completed to characterise the extent and mobility of heavy metal contamination in orchard soils, informing a detailed risk assessment and providing confidence to the client and project stakeholders, including iwi partners, that the risk of soil contamination could be managed and options to reuse elsewhere were feasible.
- Orchard soils were segregated into two portions. The first, smaller, portion, identified as those soils directly impacted by CCA timber posts, was segregated and repurposed at an alternative site designated for horticultural production. The reuse of these soils (arsenic UCL95 >250 mg/kg) was subject to resource consent informed by an appropriate conceptual site model and Tier 2 risk assessment to satisfy regulator and mana whenua concerns. The identification of a donor site required early widespread engagement with the community, utilising client and contractor networks.
- The second, larger, portion of orchard soil was characterised as being typically representative of accepted local background, but with approximately 25% of samples reporting heavy metal concentrations exceeding the NES-CS standard for residential land use. These soils were stripped and blended using best-practice techniques in well-managed, *ex situ* stockpiles. The blended stockpiles were confirmed by subsequent validation processes to be diluted to the point of representing regional background.
- All testing undertaken through investigation, delineation, and validation was undertaken with sufficient density and frequency to have confidence in the outcomes utilising statistically robust data sets. With limited remaining space on site, discrete dig and dump was undertaken for small hotspots with acute risk exposure associated with fuel tanks and asbestos in buildings.

Ex-situ stockpiles of blended soils. (Case study provided by Richard Griffiths, Aurecon)

CASE STUDY 5: WESTERN BAY OF PLENTY SUBDIVISION DEVELOPMENT – PRIVATE DEVELOPER / GOVERNMENT CLIENT JOINT VENTURE

The development comprised a joint venture by a private developer and a partner public sector organisation to develop new residential land under the Special Housing Accord.

During landform construction, a large, infilled gully full of construction debris was encountered by contractors. This gully was missed in original investigations completed by a third party. The waste material was identified as containing asbestos debris and fibres, with the amount of affected soil totalling c. 50,000 m^3. This material was unacceptable from both a human health risk and engineering perspective, so a remediation solution was required.

The preferred solution adopted for the site involved encapsulating the entire body of asbestos- containing soil material within an area of reserve located at the centre of the development. To facilitate construction of the encapsulation cell, clean natural soils were over-excavated from within the reserve area. This area was then backfilled to form an engineered slope batter at the edge of a stormwater pond, and encapsulated with geotextile and a 1 m clean soil cap.

Encapsulation of asbestos-containing materials

Geotechnical analyses demonstrated the structure to be stable at a 1 in 2,500-year earthquake event (in line with Building Code requirements for an important Level 4 structure containing hazardous materials).

All material was retained on-site with no soils disposed to landfill. The excavated natural soils were reused for engineering purposes within the wider development. The encapsulation cell is now vested with local territorial authority under an Ongoing Management and Maintenance Plan.

Drivers for reuse	**Obstacles to reuse**
• Off-site disposal of material would have represented a significant budget variance that was perceived to have represented significant reputational risk for the public sector party, noting the project had a number of external private and public stakeholders. Retention of the materials on-site represented an immediate cost benefit and allowed the project to stay within budget. • Encapsulation within an engineer-designed seismically resilient cell represented a safer and more resilient management approach than dumping at a local landfill site. • Alternative options considered for the remediation would have represented a greater health and safety risk to site personnel and the public, through additional handling processes and transport through built-up urban areas.	• A reputational risk for the public sector organisation with a public interface was identified, given the cell was to be designed in an area of residential development and public open space, for what represented a landmark project. • Additional commercial concerns were raised that the encapsulation cell may reduce the commercial viability of adjoining residential lots (either a reduced value or take more time to sell).

• The additional truck movements associated with carting large volumes of soil material to landfill represented a large increase in truck movements off-site, which may have exceeded those allowed by consent, and represented a greater carbon footprint. • In discussion with cultural partners, the preferred solution allowed soils to be retained within the rohe.	

Tools employed to support reuse

- An immediate recommendation was implemented to make the site safe to ensure future soil disturbance did not result in exposure of site personnel, members of the public, and adjacent property owners. A detailed site investigation was then carried out on the site to delineate the extent of soils affected by asbestos, and to ensure the affected soils had not be inadvertently disturbed or tracked around the wider development site.
- Once the site was made safe and contaminated areas clearly delineated, a detailed remediation options appraisal was undertaken. The appraisal was developed looking at three options, developed in collaboration with client organisations: on-site encapsulation, off-site disposal, or a screening exercise to remove asbestos materials from the soil mass.
- The preferred solution was developed utilising a customised multi-criteria analysis (MCA) tool that focused on key aspects considered a priority by client organisations and external project partners, including mana whenua. The MCA looked at economic risks and benefits; environmental risks and benefits; cultural risks and benefits; and practical elements such as feasibility of the programme and likelihood of success.
- The cultural element of the MCA was developed and led with mana whenua partners, driven by the objective of retaining as much mauri over the land as could be achieved. While it was initially considered that off-site disposal represented a better short-term outcome for the land in question, this was tempered by impacts to health, safety, and the environment arising from further handling processes, and it was felt that disposal of affected soils transferred the problem rather than solving it.

Re-established native planting over encapsulation cell.
(Case study provided by Richard Griffiths, Aurecon)

7 Enabling sustainable management of surplus soils

Arising from discussions with central and local government representatives, practitioners, and a review of the literature, the following recommendations are made with regard to the next steps towards enabling the sustainable management of surplus soils.

7.1 Filling information gaps

There is currently an incomplete understanding of the amounts of surplus soil and fill being generated, from which 'types' of sites, where it is going, and why. Gaining a better understanding of these material flows is critical to identifying the key points of intervention, and what those interventions should be.

Some current work is underway to build a better understanding of these flows (A. Pezaro, pers. comm., Ministry for the Environment; R. Lidgard, pers. comm., PDP Limited), although it is likely that further work will be required. Other options for filling these gaps include surveys of major land development agencies, and a greater requirement for the capture of soil movement information in contaminated land remedial action plans and collation of that information (e.g. by regional councils).

As noted earlier, a workshop of predominantly local authority representatives and contaminated land practitioners identified that greenfield residential developments were probably the primary source of surplus soils, especially topsoil, and that soil (and fill) disposed to landfill predominantly had contaminant concentrations between background and applicable contaminant standards (i.e. a low contaminant risk). A further observation was that landform and geotechnical considerations were the primary driver for the generation of surplus soils and fill. While these observations need to be validated, they do point towards key areas in which to develop systems and processes to minimise generation and enable reuse.

Clarity is also required to understand the demand for virgin materials, and the extent to which this demand could be offset by reused or re-processed surplus subsoil or manufactured soils. This should be considered in the context of 'reimagined' pathways for reuse rather than status quo processes.

7.2 Surplus soil and fill sustainable management framework

To enable the right systems and processes to be put in place, the principles underlying sustainable management need to be developed, as follows.

1 The generation of surplus soil and fill should be minimised by minimising the disturbance of soils and maximising on-site reuse.
    - This requires design that more clearly places greater weight on minimising soil disturbance through alternative construction methods, or the design of large-scale developments to maximise on-site reuse. Critically, it also requires gaining an understanding of the on-site soil resource.

- On-site soil resources need to be identified in order to identify areas that should be protected from disturbance and soils (and fill) that can be reused on-site
- Where soil contamination is identified as being an issue, a clear, risk-based approach should be used to identify when an unacceptable risk is present and remediation or management is required.
- Where remediation is required, priority should be given to *in situ* remediation or long-term management. Remedial options assessment should include an evaluation of the sustainability of different remediation options (e.g. along the lines of SuRF –UK 2010, ISO18504).

2 Reuse of soils on-site, and at alternative sites, needs to have a clearly defined beneficial use, which includes:

- offsetting the importation of new materials, particularly virgin materials, onto a site
- offsetting the use of virgin materials at other sites
- enhancing environmental outcomes, including:
  - increased amenity value through landscaping / noise reduction bunds
  - improvement of stormwater management through increased permeability or water-holding capacity of the soil, and through deeper topsoil layers and flood protection bunds
  - improved vegetation outcomes – carbon sequestration, and amenity value (trees vs grass).

3 There should be a clear understanding of the properties of soil required to achieve beneficial reuse, and that soils are fit for purpose.

- 'Fit for purpose' includes geotechnical and non-contaminant soil properties.
- Soil placement should not degrade the existing conditions at a receiving site (e.g. by introducing a new contaminant or increasing the concentration of an existing contaminant).
- Mixture and dilution of contaminated soils to reduce the concentrations of contaminants should *not* be undertaken.

4 Disposal of soil to landfill should be made less cheap and convenient. This could include:

- A higher disposal charge on these materials, especially if they are not contaminated
- requiring a resource consent to dispose of soils

7.3 Addressing regulatory and logistical challenges

Regulatory and logistical challenges to enabling the sustainable management of surplus soils and fill are intimately connected, particularly in relation to the management of soils with some level of contamination. A key principle to facilitate beneficial reuse is that the regulatory and economic requirements associated with the movement and reuse of soils at a recipient site should be as easy as, if not easier than, it currently is to dispose of that material to a landfill – particularly for low-risk soils. Some key aspects relating to processes for moving and storing or placing soil and reuse criteria are discussed below.

7.3.1 Redesign

Early planning and design is a critical first step in minimising the generation of surplus soils and enhancing reuse. This design should also draw on a clear understanding of the soil resource at a site, and have clarity about the nature of the materials required for beneficial reuse. Stipulating the amount of soil to be targeted for reuse – including, at a national level, to provide as targets for individual projects or within agencies (e.g. Kāinga Ora, Education, Health, LINZ, NZTA or large developers) – could provide a focus for minimising the excavation of soils and enhancing reuse at an early stage in the design.

Linked to targets for reuse or minimised generation are contracting arrangements. Design-build contracts are seen as one mechanism to enhance soil reuse (Hale et al 2021). In these, the contractor is responsible for both design and construction, and therefore for making decisions about mass flows and management. This contrasts with a traditional build contract, where the developer plans the design before the contractor is engaged. Alternatively, early contractor involvement contracts could be used to help inform the design by identifying non-traditional opportunities, unique to the contractor's supply chain or the local market. Combined with this, requirements could be included for how much excavated soil is reused in tenders and subsequent contracts for major construction projects, which could also increase the level of reuse.

7.3.2 Development of clear national processes for soil movement and handling, and 'soil hubs'

Development of clear national processes for the movement of surplus soils that allows tracking of soils from source sites to recipient sites, including temporary storage sites, would be one step to facilitate reuse. For controlled or restricted-discretionary or discretionary activity activities under the NES-CS, control or discretion is reserved on the transport, disposal, and tracking of soil and other materials associated with disturbing the soil. Best-practice examples of these arrangements could be used to inform national processes, with examples from the UK, Ontario, and in Hale et al. 2021 also useful to illustrate key considerations.

Clear conditions for the required assessments at the source site, and the nature of use at the recipient sites, drawing on the principles outlined in section 7.2, aided by the development of explicit reuse criteria (section 7.3.3) would enhance reuse. Nationally developed processes would help to achieve consistency across regions, which is currently lacking.

Processes to facilitate movement and use should include guidance for sampling and testing regimes to ensure an appropriate quality of soil or fill is being moved, and should outline the appropriate documentation. Some of this may be covered by the WasteMINZ Soil Disposal Sampling & Reuse Working Group during their development of guidance on sampling requirements for surplus soil generators. ISO15176 also provides useful guidance on characterising excavated soil intended for reuse.

The development of 'soil hubs' (e.g. https://www.claire.co.uk/rom-soil-treatment-facilities) that might alleviate temporary storage requirements or allow processing of surplus soils and fill, including the conditions under which these facilities operate (e.g. OMECP 2022), should be scoped. Soil hubs can provide a more transparent market that regulates supply and demand for excavated soil (i.e. the excavated soil is stored and then sold to projects with a deficit; Hale et al. 2021). In a New Zealand context, regional/district-level soil hubs could be created for high-class (as defined under the National Policy Statement for Highly Productive Soils) soils that could be used to create high-class soils, and also wetland soils (materials that are often considered geotechnically unsuitable).

At a regional or district scale, proactive steps could be taken to identify areas that would benefit from additional topsoil; for example

- closed landfills with thin covers that don't allow for growth of trees
- old, grassed playing fields whose cover is too thin to have trees and would benefit from variation in contour or binding to increase separation and safety from traffic
- areas that are suitable to fill to ensure playgrounds remain above flood level in future
- areas for new community gardens that need deep, horticultural-quality soils.

Such sites could be on a register as receiving sites for when sufficient material of the right quality becomes available.

Finally, improved documentation – and associated testing to demonstrate soil or fill is fit for the intended reuse – and tracking of those material needs to be viewed as 'the norm' rather than optional or costly extras providing no value. Without documentation to show the soil has acceptable geotechnical and geo-environmental properties to be reused, virgin materials will be the preferred option (Hale et al. 2021). Equally, a balance needs to be struck with the time, cost, and effort associated with testing and documentation to ensure the principle of being as easy to reuse soil as it is to dispose of it to landfill is met.

7.3.3 Development of explicit soil reuse criteria

From a soil contaminant perspective, a shift from a heavy reliance on background concentrations for determining management requirements to a more risk-based approach would be beneficial for facilitating greater reuse while ensuring protection of the human health and the environment. This risk-based approach could be on a site-specific basis or could utilise generic, risk-based default criteria (that are not background concentrations).

Such default criteria could be similar in concept to the permitted activity criteria of Auckland Council, which are used to indicate a no greater than minor effect. However, whereas the permitted activity criteria are based on protection of surface water sediments,[14] reuse criteria should be protective of soil ecological receptors, human health, and ground and surface-waters. In this regard they would be similar to the Class 4 – controlled fill waste acceptance criteria. Conceptual site models could be used to determine when movement into surface waters or leaching to groundwater is a potential pathway for the site of beneficial reuse, in which case consideration of protection of these receiving environments should be factored into the reuse criteria.

Such reuse criteria could also build in some contaminant-specific considerations where elevated concentrations are present. For example, copper and zinc are essential elements, and so where elevated concentrations are present, encouraging plant growth, which slowly reduces elevated concentrations over time, may yield better outcomes than digging and dumping this soil. Consideration of other soil properties (e.g. pH, carbon content, cation-exchange capacity) also enables assessment of the relative benefit of soil vs associated contamination. Nonetheless, there needs to be careful consideration of risk in relation to use; for example, if soils are to be used for stormwater management, these should not have elevated copper or zinc concentrations, given a higher risk of leaching to waterways.

Risk-based decision making should ultimately be used and identify where tier 1 criteria may be exceeded. For example, active management of soils and/or ensuring a healthy soil could enhance acceptance of elevated concentrations of some essential trace elements (copper, zinc) and organic contaminants, which have the potential for further degradation over time. Conversely, elevated concentrations of arsenic and lead would need to be managed or remediated more directly as there are no mechanisms for natural attenuation.

Criteria for beneficial reuse need to go beyond contaminant criteria to include the key attributes of soil that influence beneficial reuse for the specific purpose they are to be used for. Specifically, we suggest that for use as topsoils, soil should have an organic matter content between 4% and 20%, and pH and nutrients on a fit-for-purpose basis. Reuse criteria should extend to geotechnical criteria (particularly for subsoil materials) associated with the relevant beneficial use.

7.4 Te ao Māori

Māori involvement in this project, some of which is outlined in this report and in Cavanagh & Harmsworth 2022, along with associated Eco-SGV work (Cavanagh & Harmsworth 2023), has provided an essential te ao Māori perspective and guidelines for thinking about the sustainable management of surplus soils. Many points were raised at hui, during workshops and presentations throughout this project, from a literature review, current and previous engagement with iwi, hapū, and whānau representatives, and dialogue and participation with associated Māori researchers and consultants. Following are some of the main points and actions highlighted by this work.

[14] These values are based on ANZECC (2000) sediment quality criteria, assuming that 20% of sediment is derived (i.e. the sediment quality criterion is divided by 5), with the exception of zinc, for which greater protection is afforded

- Māori involvement in researching and managing surplus soils is currently lacking, and there is a need to build Māori capacity and capability in this area.
- It is important to provide Māori with meaningful information on surplus soils for decision-making and co-management (e.g. employing iwi and hapū perspectives, mātauranga Māori alongside scientific and technical data, and developing explicit soil reuse criteria, iwi plans, and resource plans).
- Māori cultural values and practices are not presently used to manage surplus soils (especially in accordance with local tikanga and kawa Cavanagh & Harmsworth 2023).
- Māori would like to have more information on surplus soils and to understand more about the origins (whakapapa) of surplus soils and their likely destination (source to disposal/recipient sites).
- Māori wish to be involved from initial to final stages of management regarding this issue in recognition of the importance of soil as a taonga/resource. For example, Māori should be involved in national standards and processes, and in identifying/selecting recipient sites (especially in local iwi and hapū areas).
- Māori have different perspectives on what constitutes 'surplus'. It is important to understand Māori cultural values and key concepts in soil and land management to help set criteria of culturally acceptable standards and practice to meet 'Māori aspirations and needs and to reflect values'. This might include co-management, co-design to minimise soil disturbance, and taking into account *in situ* factors (valuable soils, culturally important soils with distinct whakapapa).
- Different levels/grades of contamination (e.g. using key concepts such as tapu, rahui, noa; Cavanagh & Harmsworth 2023) should be considered to help inform decision-making with Māori as the best course of action, in line with agreed goals/outcomes.
- A cultural issue raised at previous workshops is the potential mixing of soils (i.e. contaminated soils with uncontaminated soils, or soils from two different geographical locations with different whakapapa and characteristics).

Solutions

More standardised national approaches to managing surplus soils should be adopted, and should include recognition of te ao Māori, Māori values and mātauranga Māori, including the following.

- More collective (including Māori) definitions and criteria describing contaminated land, contaminated soils, surplus soils, and wastes should be developed and adopted. Some of this discussion and an outline of te ao Māori issues and cultural perspectives and practices has commenced in this report.
- A waste minimisation approach and philosophy should be adopted, which may reduce what is effectively defined as a 'surplus soil' or 'surplus material'.
- Te ao Māori concepts and approaches for managing contaminated soil and land (e.g. asbestos, and elevated or additional trace element levels in soil) and surplus soils should be documented for incorporation into mainstream practices and national standards, based on other knowledge systems such as mātauranga Māori and Māori cultural values.

- Systems for managing excavated soil for both small and large sites, such as soil tracking, provenance tracking, and minimising waste to landfill, would fit well with te ao Māori concepts and approaches for minimising the mixing of soils and retaining whakapapa in distinct locations or takiwā. These are essential for building systems to achieve improved management of excavated soil and to promote the reduction of waste. Alongside this, it is important for mana whenua, iwi, and hapū to know when these materials, waste, and surplus soils are above a nominal background concentration, but below any relevant (ecological or human health) soil guideline value.

7.5 Altering policy and regulatory settings

As noted earlier, the NES-CS 'default' provisions need to be amended with respect to soil disposal to an authorised facility (8(3(e)) to promote/enable alternative options in the transition of the NES-CS, while recognising that this may need to be further enabled within regional (or NBE) plans in the future.

Mayhew (2023) also proposed the development of a national policy statement (NPS), or equivalent direction in the National Planning Framework, to guide outcomes and expectations for decision-making on contaminated land and surplus soils and fill. This would enable the 'principles' associated with the sustainable management of surplus soils and fill to be clearly identified, including support and direction that recognises the beneficial attributes of the soil as a resource, and promotes its reuse where possible in preference to removal and disposal.

In turn, this would provide direction for current and future (NBE) plans. Accordingly, the promotion of low-level contaminated soils as a resource would also benefit from national direction that both promotes the beneficial reuse of these soils and, ideally, discourages their disposal to landfill as a default option. This would complement the move to a more circular soil economy, a goal of the New Zealand Waste Strategy, which seeks to reduce the volume of soil (from contaminated land) disposed of at landfills, including by increasing soil diversion and reuse.

An alternative to an NPS for contaminated land could be a National Soils Strategy that encompasses contaminated land in a higher-level strategic approach. The aim would be to generate impetus and clear objectives for managing soils, such that soils are more protected and valued, and improved soil health and environmental outcomes are realised.

There are multiple current activities that highlight the need for a strategic approach to improving environmental outcomes centred around soil. One such, as noted above, is the recently released Waste Strategy, which includes a goal that contaminated land be remediated and managed to reduce waste and emission and to enhance the environment, with a specific priority being to reduce the volume of soil disposed to landfill[15] (MfE 2023b). The PCE is also undertaking further investigation of the use of urban soils

[15] https://environment.govt.nz/assets/publications/Te-rautaki-para-Waste-strategy.pdf

following an assessment of urban greenspace (PCE 2023), in recognition of the lack of improvement achieved through state of the environment monitoring of soil quality (MfE 2023; Cavanagh et al. 2023). This approach should be based on a broader set of pluralistic societal values, bringing together values based on the strong relationship and connection New Zealanders have with soils and incorporating te ao Māori (Stronge et al. 2023). An overarching national soils strategy would form a strong connector for drivers such as climate change, land-use practice, and land development, and their impacts on land, soils, freshwater, groundwater, ecosystem services, and human well-being and values.

We therefore recommend that CLWSIG and LMF advocate to the Resource Managers Group and central government (Ministry for the Environment, Ministry for Primary Industries) for the development of a national soils strategy to achieve sustainable soils management and soil health across New Zealand.

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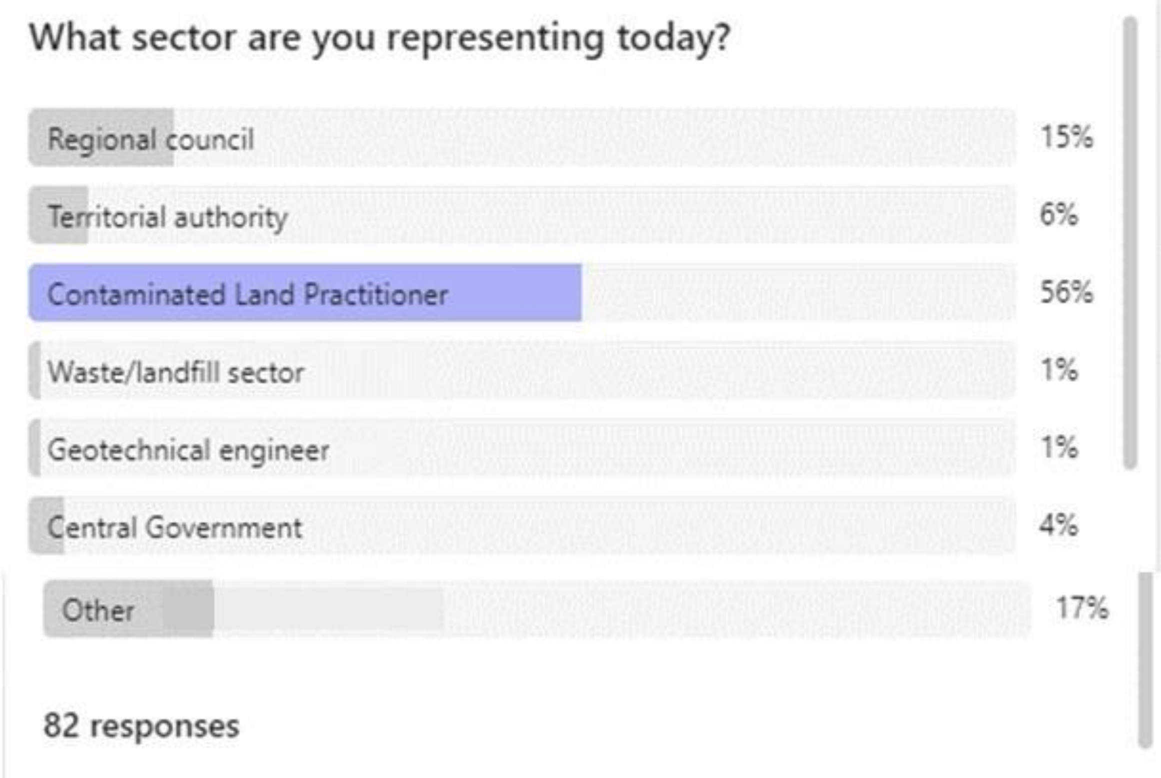
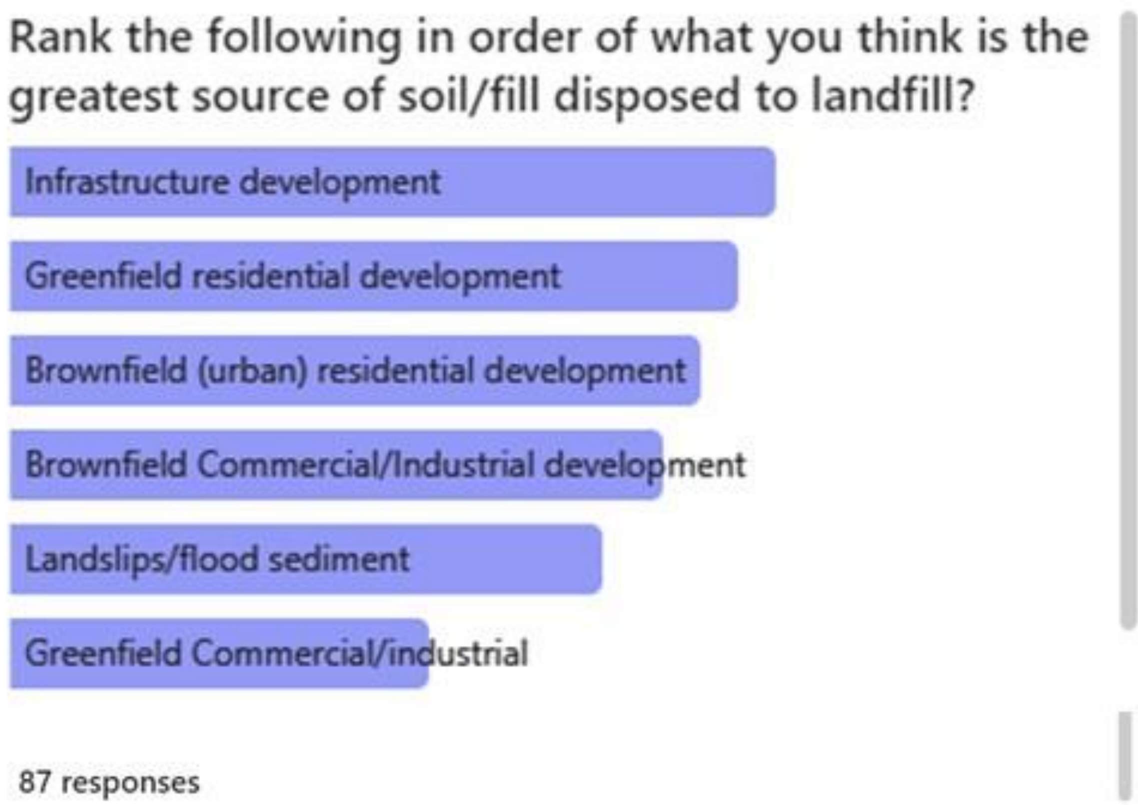
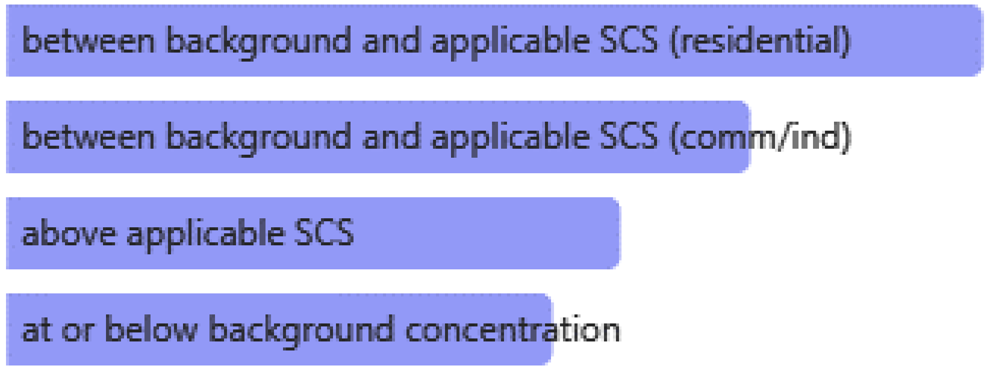
Appendix 1 – June 2023 workshop polls

A virtual workshop on surplus soils was held with 102 participants. The results of questions asked during the workshop, and the response rates, are provided below.



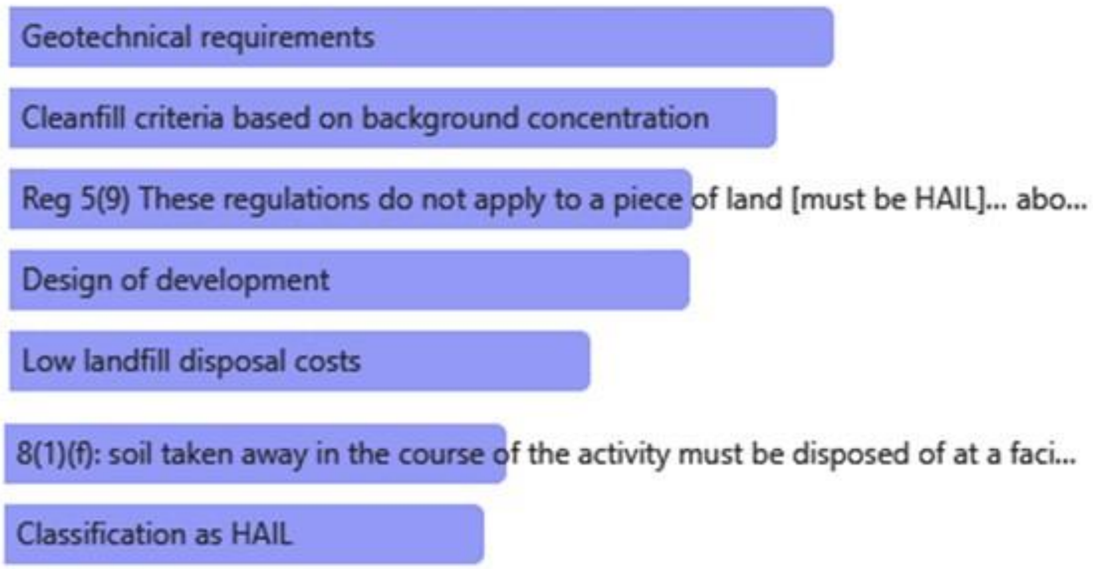


Rank the following in order of what you think is the contamination status of the greatest amount of soil disposed to landfill

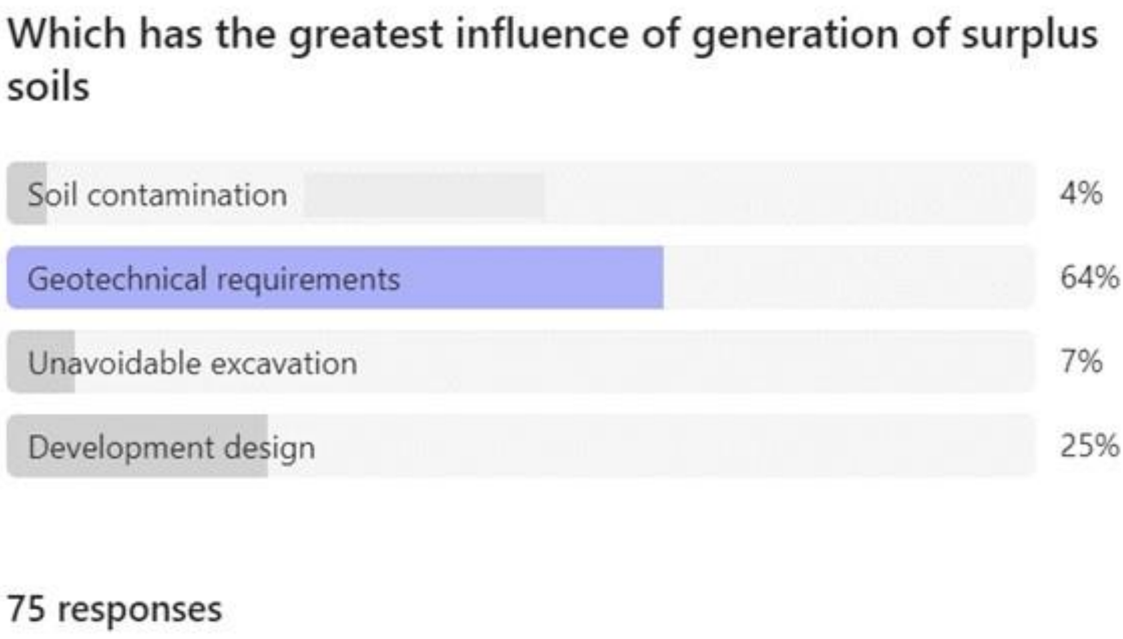


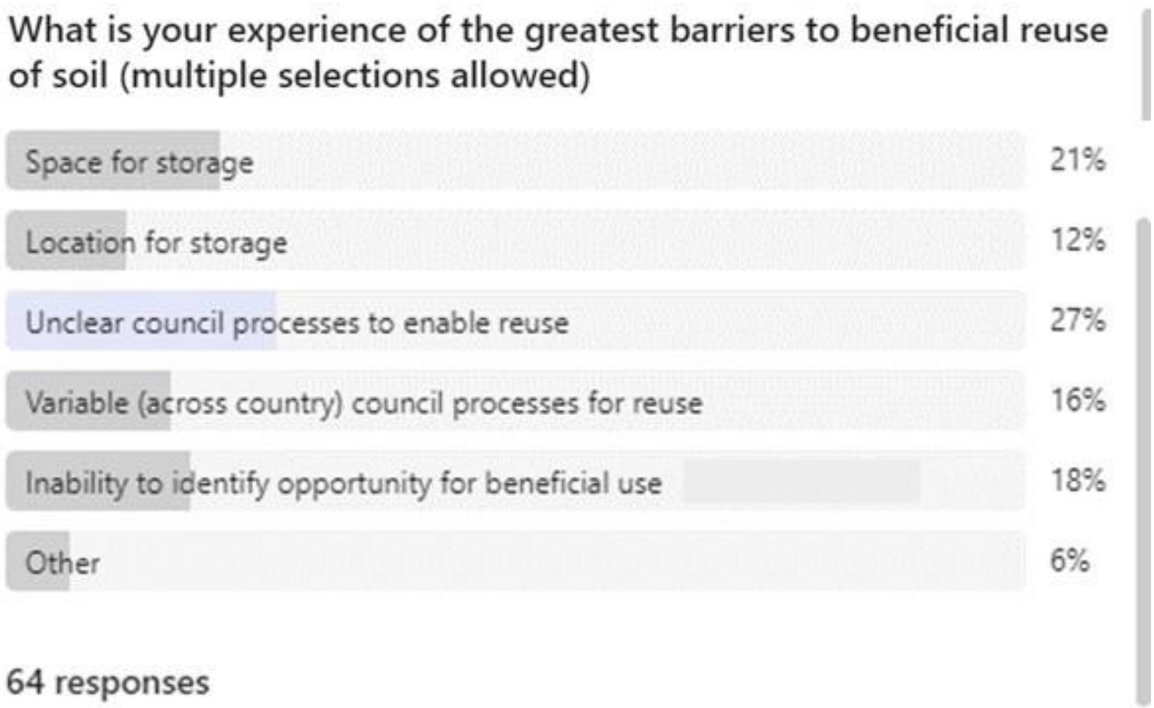
81 responses

Rank the importance of the following factors in the generation of surplus soils?



74 responses


Which has the greatest influence of generation of surplus soils
Soil contamination
4%
Geotechnical requirements
64%
Unavoidable excavation
7%
Development design
25%
75 responses


What is your experience of the greatest barriers to beneficial reuse of soil (multiple selections allowed)
Space for storage
21%
Location for storage
12%
Unclear council processes to enable reuse
27%
Variable (across country) council processes for reuse
16%
Inability to identify opportunity for beneficial use
18%
Other
6%
64 responses

Appendix 2 – Characteristics and suitability for use of soils from different soil orders

New Zealand's landscapes incorporate a diverse range of soils (see also Figure 10 in the main text). At the highest level these are grouped by soil order (Hewitt 2010). Soils of different soil orders have broad properties that make them more or less useful for different purposes (although the properties of an individual soil may vary).

Table A1 provides a summary of the relevant properties of each soil order, along with comments on their suitability (or unsuitability) for reuse in greenspace and geotech development, along with considerations, where relevant, for the handling and storage of soils. These are general guidelines only and may not apply to every soil from a particular order. Sources of information include Hewitt 2010, Hewitt et al. 2021, McLaren & Cameron 1996, Molloy & Christie 1993, and Simcock 2009.

Table A1. Summary of the characteristics of different soil orders, and generalised suitability/unsuitability for different purposes.

Soil order	Characteristics	Suitability for greenspace and geotech uses
Allophanic (5% of New Zealand)	Low bulk density (BD); high microporosity; weak ped strength; topsoils resistant to compaction when wet; low penetration resistance; high P (phosphorus) retention; low natural fertility; A horizons contain large populations of soil organisms, usually well drained with high permeability	Greenspace: physical properties appropriate for supporting plant growth. Suitable for stormwater infiltration, grassed areas, amenity plantings, etc. Wheel traffic and handling should be minimised, and rejuvenated through cultivation to retain permeability. Geotech: need to be mixed with higher-strength soils to be used for geotech foundations. Drying changes soil structure. Loss of strength when remoulded. Sensitivity – saturation following manipulation can result in loss of bearing strength.
Brown (43% of New Zealand)	Well-developed structure; moderate-high BD; moderate-high water-holding capacity; low-moderate natural base saturation (BS); large populations of soil organisms	Greenspace: productive soils.
Gley (3% of New Zealand)	Chemically reduced; affected by waterlogging; anaerobic conditions restrict soil organisms; shallow potential rooting depth; high BD, high organic matter (OM), high subsoil cation exchange capacity (CEC), low-med P retention.	Greenspace: Generally fertile; highly productive once drained; water-tolerant plants may survive better in gleysols (e.g. harakeke, tī kōuka, kahikatea, pukatea). Drainage required for most agricultural use (*in situ*). Geotech: Trafficability limited when wet.
Granular (1% of New Zealand)	Dominated by clay minerals; high penetration resistance – limited rooting depth; moderately permeable; well-developed fine structure; friable; low plasticity; low nutrient reserves; low P and SO_4^{2-} in B horizons	Greenspace: highly productive; limited workability and trafficability when wet; resistant to degradation by ploughing. Suitable for stormwater infiltration, grassed areas, amenity plantings, etc. Wheel trafficking and handling should be minimised, and rejuvenated through cultivation, to retain permeability. Geotech: adequate substrate for road and building construction. However, may need to be treated

Soil order	Characteristics	Suitability for greenspace and geotech uses
		depending on specific soil properties (e.g. mixed with higher-strength soils) to be used for geotech foundations.
Melanic (1% of New Zealand)	Naturally fertile; biologically active; high BS, exchangeable calcium, magnesium and CEC; high OM content; stable topsoil; clay fraction dominated by smectite – soil shrinks on drying and swells on wetting; sticky and plastic; sensitive to water content	Greenspace: resistant to structural degradation (e.g. from continuous cultivation); versatile and sought after for grape and truffle production. Used for cricket pitches due to shrink–swell capacity. Geotech: may not be suitable for foundation works.
Organic (1% of New Zealand)	Very low BD; low bearing strength; high shrinkage when dried; very low thermal conductivity; high available-water capacity; high CEC; acidic; common nutrient deficiencies; high carbon:nitrogen ratios; soil organisms restricted by anaerobic conditions	Greenspace: supports unique flora & fauna; used in potting mixes and composts; provides carbon storage. Suitable for effluent irrigation when not saturated. Degraded by agricultural production; low trafficability; high fire risk. Geotech: generally unsuitable for building infrastructure: can compress unevenly and corrode concrete and steel.
Oxidic (<1% of New Zealand)	Limited rooting depth; moderate-rapid infiltration rates; soil water deficits common in summer; clay content 50–90%; low CEC (at natural pH); high P retention; friable; low plasticity; fine stable structure; low potassium, magnesium, calcium and phosphorus reserves; acidic	Greenspace: challenging soil for plant growth without amendments. Sheet erosion risk without vegetation cover; rill and gully erosion risk when topsoil is removed.
Pallic (12% of New Zealand)	Weak structure; med-high BD; slow permeability; limited rooting depth; high BS; low OM; med-high nutrient content (except sulphur); low P retention; biological activity and plant root growth often limited by anaerobic conditions in winter; often high silt content	Greenspace: suited to podocarp, beech and tussock cover. Immature, Argillic and Laminar Pallics are highly versatile and may support a range of productive uses, though generally unsuitable for use as subsoil. High potential for slaking and dispersion (erosion-susceptible), particularly with added sodium. Unsuitable for wastewater/effluent application. Geotech: cracks due to shrinkage when dry. Not suitable for foundation work.
Podzol (13% of New Zealand)	B and E horizons weakly or apedal; cemented/compacted B horizon; slow permeability; limited rooting depth; low fertility; low BS; strongly acidic; low biological activity	Greenspace: usability as subsoil depends largely on texture – poorly suited to subsoil use if poorly drained. Limited nutrient availability, and aluminium toxicity to plants is common without lime. Fertilisers and ripping generally required for agricultural production.
Pumice (7% of New Zealand)	Sandy/gravelly – apedal earthy to single grain; rapid drainage; clay content <10% and dominated by allophane, imogolite, ferrihydrite; weak ped strength; sensitive; low BD; high macroporosity; deep rooting depth; low major nutrient and trace element reserves; medium P retention; low soil macroinvertebrate populations	Greenspace: wastewater has been successfully irrigated onto Pumice Soils, but there is risk of nitrate leaching without nitrate removal (e.g. by pasture or other vegetation). Suitable for use as subsoil. Susceptible to gully erosion, particularly when soil is left exposed. Low nutrient/TE reserves mean additions are required for most production, particularly cobalt if used for stock grazing. Geotech: resistant to light compaction but low strength when disturbed (sensitive).

Soil order	Characteristics	Suitability for greenspace and geotech uses
Raw (3% of New Zealand)	Very young soils; no distinct topsoil; no B horizon; may be very fluid with high water-table; lacks OM, nitrogen.	Greenspace: Sandy Raw soils are suitable for use as subsoil, but are susceptible to erosion as topsoil. Fertility limited by lack of OM and nitrogen, generally not suitable for food production. Some invasive weeds will readily establish on Raw Soils and need to be managed. Geotech: fluid Gley Raw Soils may be drained and reclaimed for infrastructure (or agricultural) use, though there is a risk they will form acid sulphate soils. Gley Raw Soils have very low bearing strength and are not suitable for foundations or heavy traffic. Other: iron- and titanium-rich raw sands can be used to manufacture steel, while quartz-rich Raw Soils can be used to manufacture glass.
Recent (6% of New Zealand)	Weakly developed; spatially variable; absent or weakly expressed B horizon; deep rooting; high plant-available water capacity; variable texture; high natural fertility; high BS; low P retention	Greenspace: usually covered by vascular plants; productive and versatile soils; Sandy Recent soils suitable for use as subsoil; risk of wind erosion on Sandy Recent Soils, particularly with ploughing and vegetation removal. Geotech: liquefaction risk during earthquakes on Recent Soils.
Semiarid (1% of New Zealand)	Dry for most of the growing season; lime and salt accumulation in lower subsoil; high nutrient levels; high slaking and dispersion potential; moderate-high BD; weakly developed structure; low P retention; low OM; low CEC; weakly buffered; low biological activity	Greenspace: Solonetzic Semiarid Soils are an endangered habitat to specialist native plants adapted to grow on Semiarid Soils (e.g. *Lepidium kirkii*). Topsoil structure degraded by heavy machinery and tillage, particularly when wet. Erodible, high slaking and dispersion potential. Requirse irrigation for crop production, though flood irrigation leads to bypass flow.
Ultic (3% of New Zealand)	Clayey subsoil (includes swelling clays); low permeability; dispersible surface horizons; strongly acidic; low nutrient reserves; topsoils have large active soil organism populations	Greenspace: some Ultic soils support pakihi or gumland ecosystems, which are now threatened (modified by additions of lime or P) and important to conserve. Generally suited to native forest cover, including mānuka and kānuka. Drainage and physical properties are highly spatially variable. May be suitable for urban and peri-urban development, but lime and compost needed (mechanically incorporated) and often ripping/drainage required to develop urban gardens. Impermeable when compacted, meaning perched water tables can form on compacted subsoil and run-off can occur on compacted topsoil, so not well suited for use as subsoil and not suited to stormwater or wastewater discharge. Also susceptible to earthflows on slopes, and to cracking when dry. Failure can occur on slopes of 15–20°. Topsoils are susceptible to livestock treading damage and erosion, especially when left bare. Geotech: subsoils have strength suitable for geotech foundations.

Notes: BD – bulk density; BS – base saturation; CEC – cation exchange capacity; OM – organic matter

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