Ministry for Primary Industries
Manatū Ahu Matua

Food safety and animal welfare guidance if spreading rocks and minerals from drilling oil and gas wells on land

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Growing and Protecting New Zealand

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Executive summary

The application of this guidance will ensure there is no risk to food safety or animal welfare as a result of spreading rocks and minerals from drilling oil and gas wells on land.

When wells are drilled to find and develop new oil and gas reserves, rocks and minerals are broken up by the drill bit and removed from the ground. These rocks and minerals can also include residual "mud", which is used to lubricate the drill bit. The prevailing technique is to spread these rocks and minerals onto and cultivate them into land. This process enables microbes in the surface soil to degrade any hydrocarbons faster than historic practices such as "mix-bury-cover". It also enables the rocks and minerals to serve a secondary purpose: to be recycled and used to improve the productivity of soil.

Several concerns have been raised about spreading these rocks and minerals on land, including that they may pose a risk to the welfare of livestock grazed on the land or that the milk or meat from that livestock may pose a risk to food safety.

The Ministry for Primary Industries (MPI) is publishing this document to provide guidance on how to ensure food safety and animal welfare if spreading these rocks and minerals on land.

MPI commissioned Landcare Research to undertake a detailed review and analysis of the related science to help develop this guidance.[1] This analysis of the New Zealand and international science determined there is no risk to food safety or animal welfare as a result of spreading rocks and minerals from drilling oil and gas wells on land, other than potentially from hydrocarbons. The risk from hydrocarbons is extremely low, even immediately after rocks and minerals are spread onto land.

If rocks and minerals are spread onto land at or near the surface, MPI advises that the land is not stocked and crops are not harvested until the concentration of hydrocarbons in the soil are at or below the values specified in Table 1 of this guidance. The Landcare Research analysis has determined that, once these values have been reached, no risk to food safety or animal welfare exists as a result of spreading rocks and minerals on the land, and the land can be used for any purpose, including for stock or crops to produce meat, milk, fruit or vegetables.

This guidance sets out criteria to manage any potential risk to food safety that could arise from spreading these rocks and minerals on production land. MPI advises food producers and processors to consider incorporating the criteria into their risk management and food safety programmes for regular audit through existing audit scheduling under the Animal Products Act 1999 or Food Act 1981 and Food Act 2014 as appropriate.[2] MPI may use its regulatory powers to investigate whether businesses are properly addressing risks to food safety and animal welfare or may impose legislative requirements.

Regional councils and territorial authorities may also impose controls on the spreading of rocks and minerals on land to manage environmental effects under the Resource Management Act 1991. Councils may decide that the criteria identified in this guidance are appropriate for managing effects under the Resource Management Act 1991 or they may impose different controls focused on different effects or tailored to the particular circumstances of the relevant area.

Purpose

This document provides guidance on how to ensure food safety and animal welfare if spreading rocks and minerals from drilling oil and gas wells on land.

The guidance provides the following:

- **Assurance** – the latest scientific analysis confirms no risk to food safety or animal welfare exists as a result of spreading rocks and minerals from drilling oil and gas wells on land, if this guidance is followed.
- **Clarity** – of the roles of territorial authorities, regional councils and central government agencies in regulating the practice of spreading rocks and minerals from drilling oil and gas wells on land.
- **Consistency** – by outlining a national approach to managing risks to food safety and animal welfare if spreading rocks and minerals from drilling oil and gas wells on land.

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Taranaki Regional Council

MPI would also like to acknowledge Dr Jo Cavanagh from Landcare Research for her report, *Land application of waste from oil and gas wells: implications for food safety and animal welfare*, which informed the development of this guidance.

MPI is grateful to others who have shared their experience and expertise of spreading rocks and minerals from drilling oil and gas wells on land, including farmers in Taranaki.

1 Introduction

This publication provides guidance to producers and processors of food, including farmers, on how to ensure food safety and animal welfare if spreading rocks and minerals from drilling oil and gas wells on land.

The document does not include advice on managing environmental effects, beyond those relevant to food safety and animal welfare. This guidance describes the role of local government in managing those environmental effects under the Resource Management Act 1991 and draws on the expertise and experience of Taranaki Regional Council and territorial authorities within the Taranaki region. The Taranaki Regional Council has been issuing resource consents under the Resource Management Act 1991 to manage the environmental effects of spreading rocks and minerals from drilling oil and gas wells on land for almost two decades.

For guidance on managing the environmental effects, see the Ministry for the Environment's guidelines: *Managing environmental effects of onshore petroleum activities (including hydraulic fracturing): guidelines for local government*.[3]

1.1 WHAT ARE COMPONENTS OF ROCKS AND MINERALS FROM DRILLING OIL AND GAS WELLS?

When drilling wells to find and develop new oil and gas reserves, rocks and minerals are broken up by the drill bit and removed from the ground. These rocks and minerals can also include residual "mud". Drilling mud is used to lubricate the drill bit and allows the rocks and minerals to flow back to the surface of the well. Drilling mud can be water based or synthetic to which further compounds are added to modify their physical characteristics.[4] If the well enters a petroleum reservoir, naturally occurring hydrocarbons may also be encountered.

This guidance uses the phrase "rocks and minerals" to describe the material drilled up from the ground, including the salts and metals it may contain, and residues of drilling mud and naturally occurring hydrocarbons.[5]

1.2 DISPOSAL IN NEW ZEALAND: HISTORIC AND PRESENT

A process called "deep well injection" is used to dispose of material from drilling oil and gas wells that has a high liquid content. This liquid is pumped down a well and into a layer of rock capable of absorbing the liquid.[6] Material with a higher solids content (for example, rocks and minerals) cannot generally be disposed of by injecting it down a well because even small particles can block the injection process.

Historically, these rocks and minerals have been placed in lined sumps on the site of a well and covered over. They may also be disposed of in landfills and vermicomposted.[7] More recently, they were mixed with soil or sawdust and then buried ("mix-bury-cover"). This mixture is buried above the water table but below the reach of plant roots. Microbes in the soil degrade the hydrocarbons in the rocks and minerals over time.

However, the greater numbers of microbes present in surface soils enable hydrocarbons to degrade faster. To allow this to happen, the prevailing technique is for a layer of topsoil to be removed and the rocks and minerals spread onto, and cultivated into, land. Topsoil is then usually spread over the top and the land is fertilised, re-sown with ryegrass and/or clover and

sometimes irrigated. This practice is popularly labelled “landfarming” in New Zealand. A more accurate description for it, however, is “surface application”.[8] Livestock are typically excluded from the land until pasture is re-established.

1.3 SURFACE APPLICATION

Internationally, surface application is a common and accepted practice for reducing the concentration of hydrocarbons in soil. Rather than the rocks and minerals being disposed of in a landfill or through practices such as mix-bury-cover, this practice enables the rocks and minerals to serve a secondary purpose: to be recycled and used to improve the productivity of the soil.[9] Spreading rocks and minerals on land can increase the clay content in the soil and improve its ability to retain water and nutrients. Doing so can improve pasture growth and reduce the risk of erosion. In this way, spreading rocks and minerals from drilling oil and gas wells on land may be seen as similar to the application of biosolids.[10]

These benefits are particularly relevant in Taranaki, where sandy coastal farmland has poor water retention and is prone to erosion by wind into the Tasman Sea. Furthermore, as part of the process of spreading the rocks and minerals on land, farmers have had their land levelled. These productivity benefits to the land in Taranaki have contributed to rocks and minerals being transported from drilling wells in the East Coast of the North Island to Taranaki.

The Ministry for Primary Industries (MPI) has conducted targeted milk testing of dairy farms where animals had potentially grazed on land used for surface application and mix-bury-cover. These tests did not identify any risks to food safety or animal welfare.[11] Fonterra has also conducted tests as part of its risk management programme with similar results.

1.4 WHAT IS THE PURPOSE OF THIS GUIDANCE?

While no evidence exists that spreading rocks and minerals from drilling oil and gas wells on land poses a risk to food safety or animal welfare, several concerns have been raised. These include:

- concern that spreading rocks and minerals on land may pose a risk to the:
  - welfare of livestock subsequently grazed on the land;
  - safety of food produced from the land (that is, crops, meat and milk);
- a request for greater clarity about who is responsible for regulating which aspects of the practice of spreading rocks and minerals on land;
- a recommendation from the Parliamentary Commissioner for the Environment to:
  - resolve the situation with livestock on landfarmed sites in Taranaki;
  - consider how solid waste from oil and gas wells in the East Coast Basin should be disposed of before wells begin to proliferate.

A working group was established to consider these issues, at the recommendation of the Parliamentary Commissioner for the Environment. The group included relevant industry associations and local and central government agencies.[12]

To inform the working group’s consideration of these issues, MPI commissioned Landcare Research to undertake an analysis of the related science.[13] This analysis of the New Zealand and international science determined that there is no risk to food safety or animal welfare as a result of spreading rocks and minerals from drilling oil and gas wells on land, other than potentially from hydrocarbons. The risk from hydrocarbons is extremely low, even immediately after rocks and minerals are applied to land.

Furthermore, Landcare Research's analysis has determined that no risks exist to food safety or animal welfare if land is not stocked and crops are not harvested until the concentration of hydrocarbons in the soil are at or below the values specified in Table 1 of this guidance. At this point, the land can be used for any purpose, including stocking and cropping to produce meat, milk, fruit and vegetables.

Although there is no evidence of risk to food safety or animal welfare from the existing management practice of spreading rocks and minerals on land, the working group acknowledged that people's concerns persist. The group therefore recommended guidance be published that provides scientific assurance, regulatory clarity and national consistency to ensure food safety and animal welfare.

MPI is therefore publishing this guidance document to provide information on how to ensure food safety and animal welfare if spreading rocks and minerals from drilling oil and gas wells on land.

2 Guidance

2.1 OVERVIEW

There is no risk to food safety or animal welfare as a result of spreading rocks and minerals from drilling oil and gas wells on land, other than potentially from hydrocarbons. Although the risk from hydrocarbons is expected to be extremely low, even immediately after rocks and minerals are spread on land, it is difficult to verify. Moreover, no risk exists to food safety or animal welfare as a result of spreading rocks and minerals on land, if the land is not stocked and crops are not harvested until hydrocarbons have biodegraded to concentrations at or below the values detailed in Table 1.[14]

2.2 RISK MANAGEMENT AND FOOD SAFETY PROGRAMMES

To ensure food safety and animal welfare, MPI invites producers and processors of food (including farmers), who operate from land that has had rocks and minerals spread on it, to incorporate these criteria into their risk management or food safety programmes.

Risk management and food safety programmes are designed to identify and manage any risk factors that arise during the production or processing of food. Food producers and processors may include alternative and/or additional criteria in their risk management and food safety programmes to demonstrate they are appropriately identifying, minimising, eliminating, controlling or managing risks. Incorporating these criteria into their risk management and food safety programmes means compliance may be checked through the existing system of regular auditing of risk management and food safety programmes.

MPI may use its regulatory powers to investigate if businesses are properly addressing risks to food safety and animal welfare, or it may impose legislative requirements (detailed below in the section on regulatory oversight).

The criteria outlined below for ensuring food safety and animal welfare may overlap with requirements from regional councils and territorial authorities under the Resource Management Act 1991. For example, at the date of publication, the hydrocarbon concentration values in Table 1 were the same as those used by Taranaki Regional Council in its resource consents.

Because MPI is responsible for food safety and animal welfare regulation and regional councils and territorial authorities for managing environmental effects, their requirements may not always be the same.

2.3 DOCUMENTATION

Soil sampling of the area intended to be spread with rocks and minerals should be done and documented before rocks and minerals are applied (regardless of the spreading process to be used, for example, mix-bury-cover and surface application). This sampling should establish the baseline concentration values of total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, benzene, toluene, ethylene and xylenes. As noted in section 4.2, other components of the rocks and minerals, such as metals or salts, do not represent a risk to food safety or animal welfare and are therefore not included in this guidance.

Sampling of the soil before rocks and minerals are spread on land enables deficiencies in the soil's fertility to be identified and remedied by supplementing the rocks and minerals with, for example, zinc, lime or copper.

Records should be kept of the rocks and minerals spread on land and the process (for example, mix-bury-cover or surface application) used to spread them, including:

- source of the rocks and minerals (for example, the well);
- land area to which the rocks and minerals are applied (for example, the paddock(s));
- type of rocks and minerals (for example, water-based or synthetic mud);
- volume and weight or density of the rocks and minerals;
- concentrations of hydrocarbons in the rocks and minerals;
- drilling mud additives, and their quantities, included in the rocks and minerals;
- evidence the rocks and minerals do not contain activity concentrations of naturally occurring radioactive materials elevated above background levels (for example, gamma-spectroscopy screening for radionuclide activity from each well-site from which the rocks and minerals originate);
- date(s) the rocks and minerals were spread on the land;
- method used to spread the rocks and minerals on the land, including:
  - depth the rocks and minerals were applied to;
  - depth of any topsoil spread over the rocks and minerals;
  - rate at which the rocks and minerals were applied (for example, tonnes per hectare);
  - whether and/or how the rocks and minerals were cultivated into the soil.

2.4 STOCK AND CROPS

2.4.1 Surface application

Where rocks and minerals from oil and gas wells have been spread at or near the surface (for example, surface application), MPI advises that stock be excluded and crops are not harvested (for example, by restricting access through fencing the area and locking any gates) until the hydrocarbon concentration values in Table 1 have been reached.[15]

Once these hydrocarbon concentration values have been reached, there is no risk to food safety or animal welfare as a result of spreading the rock and minerals on land. The most sensitive hydrocarbon concentration values have been used to ensure the land is safe for any purpose. It is safe, for example, to use the land to graze animals to produce meat and milk and to grow crops, fruit and vegetables.

Less stringent concentration values should not be used without the risk management or food safety programme operator first establishing that they will result in acceptable outcomes for food safety and animal welfare.

Table 1: Hydrocarbon concentration values (milligrams per kilogram)

Soil type/hydrocarbon	Monoaromatic hydrocarbons and polycyclic aromatic hydrocarbons[16]
SAND	
Benzene	1.1 (v)
Toluene	(68) (4,v)
Ethylbenzene	(53) (4,v)
Xylenes	(48) (4,v)
Naphthalene	7.2 (p)
Non-carc. (Pyrene)	(160) (4,p)
Benzo(a)pyrene eq.	0.027 (p)
SANDY SILT	
Benzene	1.1 (v)
Toluene	(82) (4,v)
Ethylbenzene	(59) (4,v)
Xylenes	(59) (4,v)
Naphthalene	7.2 (p)
Non-carc. (Pyrene)	(160) (4,p)
Benzo(a)pyrene eq.	0.027 (p)
SILTY CLAY	
Benzene	1.7 (v)
Toluene	(210) (4,v)
Ethylbenzene	(110) (4,v)
Xylenes	(160) (4,v)
Naphthalene	7.2 (p)
Non-carc. (Pyrene)	(160) (4,p)
Benzo(a)pyrene eq.	0.027 (p)
CLAY	
Benzene	2.7 (v)
Toluene	(320) (4,v)
Ethylbenzene	(160) (4,v)
Xylenes	(250) (4,v)
Naphthalene	7.2 (p)
Non-carc. (Pyrene)	(160) (4,p)
Benzo(a)pyrene eq.	0.027 (p)
PUMICE	
Benzene	1.2 (v)
Toluene	(73) (4,v)
Ethylbenzene	(48) (4,v)
Xylenes	(53) (4,v)
Naphthalene	7.2 (p)
Non-carc. (Pyrene)	(160) (4,p)
Benzo(a)pyrene eq.	0.027 (p)
PEATS AND HIGHLY ORGANIC SOILS	
Benzene	5.7 (v)
Toluene	(2,500) (4,v)
Ethylbenzene	(2,200) (4,v)
Xylenes	(1,700) (4,v)
Naphthalene	7.2 (p)
Non-carc. (Pyrene)	(160) (4,p)
Benzo(a)pyrene eq.	0.027 (p)

	Total petroleum hydrocarbons[17]	
	Fine	Coarse
C7–C9	210	210
C10–C15	150	150
C16–C36	1300	300

Note: Brackets denote values exceed threshold likely to correspond to formation of residual separate phase hydrocarbons; the following notes indicate the limiting pathway for each criterion: v – volatilisation, s - soil ingestion, d – dermal, p – produce, m - maintenance/excavation.

Because there is no risk to food safety or animal welfare as a result of other components of the rocks and minerals (such as salts or metals) being spread on land, concentration values for those other components are not included in this guidance.

2.4.2 Application at depth

For areas where rocks and minerals are applied at a depth below the root zone of plants (that is, greater than 1 metre), such as mix-bury-cover, there is no need for stock to be excluded or crops not harvested before hydrocarbon concentrations reach the values in Table 1. In these situations, no exposure pathway exists for hydrocarbons to be taken up from soil to plants and animals so there is no risk to food safety or animal welfare as a result of stocking or cropping the land. There is also no risk to food safety or animal welfare as a result of hydrocarbons leaching to ground water[18] because they are present at such low concentrations in the rocks and minerals.[19]

2.5 SAMPLING METHODOLOGY

To ensure the concentration values for hydrocarbon in Table 1 have been reached for surface applications, and that it is safe to stock and crop the land, MPI recommends the following sampling methodology is followed.

Post-application sampling should be conducted to a depth of 15 centimetres to ensure the rooting depths of pasture and crops are covered.

Representative samples should be collected by taking 2.5 centimetre diameter cores at a spacing of 5 metres along a transect of at least 50 metres. Samples from two separate transects should initially be collected to account for any significant variation in the composition of the rocks and minerals. This sampling is sufficiently representative for an area of application of 3000 square metres or less, and additional samples should be taken where the area of application is greater than 3000 square metres on a pro rata basis.

If no significant variation is noted (or expected, based on analyses of the rocks and minerals), then the number of transects can be reduced to one per 3000 square metres. The location of transects should be recorded to enable resampling during subsequent monitoring, and thus provide a measure over time. Any areas with higher concentrations of hydrocarbons should subsequently be sampled to verify that the entire site has concentrations at or below the hydrocarbon concentration values detailed in Table 1.

For further information on sample handling and preservation, please see the Ministry for the Environment's *Contaminated land management guidelines No. 5: site investigation and analysis of soils*.[20]

2.6 STORAGE

If rocks and minerals are stored on site before being spread on land, MPI advises that storage pits are lined with impermeable material to prevent leaching to surface water or ground water.

2.7 MULTIPLE APPLICATIONS

As with a single spreading, if rocks and minerals from oil and gas wells are spread more than once on an area of land at or near the surface (for example, surface application), MPI advises stock are excluded and crops not harvested until the hydrocarbon concentration values in Table 1 have been reached.

2.8 FRACKING RETURN FLUIDS

This guidance does not cover the spreading of fracking return fluids on land. MPI notes it is standard practice in Taranaki for these to be disposed of by deep-well injection.[21] Before considering whether it would be safe for fracking return fluids to be spread on land from a food safety and animal welfare perspective, MPI would need to undertake further analysis.

From an environmental perspective, the Ministry for the Environment does not endorse spreading of fracking return fluids on land. Its guidelines, *Managing environmental effects of onshore petroleum activities (including hydraulic fracturing): guidelines for local government*, recommend deep-well injection, disposal at an industrial waste facility, or that return fluids are recycled (used for subsequent hydraulic fracturing operations).[22]

2.9 FURTHER INFORMATION

Application of this guidance will ensure there is no risk to food safety or animal welfare as a result of rocks and minerals from drilling oil and gas wells being spread on land. In the event that questions or concerns arise about food safety or animal welfare, expert advice should be sought from a local veterinarian or MPI.

For further information on managing the environmental effects of spreading rocks and minerals on land, see the Ministry for the Environment's guidelines on *Managing environmental effects of onshore petroleum development activities (including hydraulic fracturing): guidelines for local government*.[23]

As noted, MPI commissioned Landcare Research to undertake a detailed review and analysis of the science relating to the process of spreading rocks and minerals on land. The report, *Land application of waste from oil and gas wells: implications for food safety and animal welfare*, provides additional information to this guidance, including on the environmental effects of the practice. Regional councils, territorial authorities, waste management contractors, food producers and processors and others interested in, or affected by, this practice may find the report of interest and use.

3 Regulatory oversight

3.1 OVERVIEW

MPI, regional councils and territorial authorities all have a role in managing the effects of spreading rocks and minerals from drilling oil and gas wells on land.

3.2 MINISTRY FOR PRIMARY INDUSTRIES

3.2.1 Food safety

Providing safe food is a priority for New Zealand, which relies on food exports for its economic prosperity. MPI is responsible for the legislation that ensures safe food is available for sale in New Zealand and for export. An overview of New Zealand's food safety system is included in Appendix 1.

The statutory framework for food safety is established by the Food Act 1981 and Food Act 2014,[24] the Animal Products Act 1999,[25] Agricultural Compounds and Veterinary Medicines Act 1997[26] and Wine Act 2003,[27] which work together to form a comprehensive food safety assurance programme.[28]

Animal Products Act 1999

Under the Animal Products Act 1999, all primary processors of animal material and products for human or animal consumption, including dairy farm operators and processors of meat and dairy products, are required to operate a risk management programme.[29] The risk management programme details how the operator will identify and control, manage, eliminate or minimise food safety hazards and other risk factors in relation to the processing.[30] This risk management programme is also required to be independently verified.[31]

The Animal Products (Regulated Control Scheme – Contaminant Monitoring and Surveillance) Regulations 2004 established a scheme to identify chemical and biological contaminants in animal material and products and to address the risks from those hazards to human or animal health.[32] The scheme enables MPI to apply risk management measures to sources of risk.[33] These measures can include:

- placing the material or product on a surveillance list and notifying the affected farmer or processor;
- imposing a sampling regime on the material or product;
- controlling the supply of the material or product;
- any other measures needed to manage the risk.[34]

If MPI puts a risk management measure in place, it must also notify the relevant processors of the details of the material or product at risk.[35]

Food Act 1981 and 2014

The Food Act 1981 and the Food Act 2014[36] require anyone who trades in food to ensure that the food is safe to eat.[37] Operators must also comply with mandatory standards for various products.[38] As under the Animal Products Act 1999,[39] where MPI reasonably suspects that food does not comply with the Act, or there is a hazard or source of contamination that may affect food, it can impose movement or other controls to determine, minimise, manage or control the risk.[40]

Monitoring

MPI operates monitoring programmes that play a crucial role in ensuring food is safe by verifying that the food production systems are managing risks to food safety and establishing safe levels for residues, contaminants and other hazards.[41] Animals from farms that have been spread with rocks and minerals at or near the surface may be randomly selected for testing under these programmes.

3.2.2 Animal welfare

MPI is responsible for managing animal welfare law, policy and practice in New Zealand.

Animal Welfare Act 1999

The Animal Welfare Act 1999 sets out the obligations on people who own or are in charge of animals.[42] These obligations include meeting an animal's physical, health and behavioural needs and alleviating pain or distress.[43]

The needs that could be impacted by spreading rocks and minerals on land are "proper and sufficient food and water" and "protection from, and rapid diagnosis of, injury and disease". Further details on what these obligations mean are provided in minimum standards in a range of codes of animal welfare.[44]

It is an offence for the owner or the person in charge of an animal not to meet their obligations for care of, and conduct towards, animals.[45]

3.3 MINISTRY FOR THE ENVIRONMENT

The Ministry for the Environment is responsible for administering the Resource Management Act 1991.[46] It provides national direction in the form of national environmental standards[47] and national policy statements. It also issues several binding and non-binding guidelines on environmental issues.[48] While the Ministry for the Environment administers this Act, regional councils and territorial authorities are generally responsible for its implementation and enforcement.

3.4 REGIONAL COUNCILS

Under section 30 of the Resource Management Act 1991, regional councils' functions include establishing objectives, policies and methods to achieve the integrated management of the natural and physical resources of their region. They have a role in controlling the use of land to address soil conservation and maintaining water quality, as well as controlling discharges of contaminants into the environment. Certain land use activities and discharges may require resource consent from a regional council, and a council may impose conditions to manage environmental effects, including conditions that require the consent holder to adopt the best practicable option to prevent or minimise any actual or likely adverse effect on the environment.

For example, MPI was advised that Taranaki Regional Council has classified mix-bury-cover and "landfarming" (or surface application) as controlled activities in its Regional Plan, which means a resource consent is required to undertake this activity. The council issued 17 resource consents for "landfarming" and 42 for mix-bury-cover between 1998 and 2015. Not all of these consents have been exercised.

The council has applied various conditions on its resource consents. These include restrictions on proximity to ground water, concentration and depth of application and monitoring and

notification protocols. Taranaki Regional Council's consent conditions are based on those used by a range of domestic and international authorities.[49] At the date of publication, the concentration values for hydrocarbons used by the Taranaki Regional Council were the same as those used in this guidance (see Table 1). The Taranaki Regional Council undertakes extensive compliance, monitoring and enforcement of its resource consents, the results of which are available on its website.

3.5 TERRITORIAL AUTHORITIES

Under section 31 of the Resource Management Act 1991, the functions of territorial authorities[50] include implementing objectives, policies and methods that achieve the integrated management of the effects of the use, development or protection of land and associated natural and physical resources of the district. In the event that a particular land use is restricted by the relevant district plan,[51] resource consent from the territorial authorities will be required. As with regional councils, a territorial authority may impose conditions on a resource consent to avoid, remedy or mitigate adverse effects of the activity.

Territorial authorities also administer and grant consents under the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011. These regulations apply to land that has or is likely to have had an activity or industry listed in the Hazardous Activities and Industries List undertaken on it.[52] The regulations cover five activities, including "soil disturbance" and "change of land use". If an activity covered by the regulations is undertaken on a site that is on the Hazardous Activities and Industries List, the regulations prescribe certain requirements that must be met.[53]

Regional and district councils in Taranaki are in regular contact to ensure they have an integrated approach to the management of the environmental effects of the process of spreading rocks and minerals on land.

4 Analysis of the science

4.1 OVERVIEW

As noted in previous sections, there is no risk to food safety or animal welfare as a result of rocks and minerals being spread on land, other than potentially from hydrocarbons. The risk from hydrocarbons is expected to be extremely low, even immediately after the rocks and minerals are spread on the land, but this is difficult to verify. Moreover, there is no risk to food safety or animal welfare if the land spread with the rocks and minerals is not stocked or crops not harvested until hydrocarbons have biodegraded to or below the concentration values detailed in Table 1.[54]

4.2 COMPONENTS OF ROCKS AND MINERALS

The risks from spreading rocks and minerals on land depend on the components in the rocks and minerals, and whether there are any pathways of exposure for receptors (for example, people and livestock). If a component is safe or there is no exposure pathway, no risk exists.

Rocks and minerals predominantly comprise rock cuttings with some drilling mud residue. The major components are:

- Bentonite – used in drilling mud as gelling agents or viscosifiers:

  Bentonite does not pose a food safety or animal welfare risk because it is not toxic.

- Barite – used in drilling mud to increase their density:

  Barite (barium sulphate) does not pose a risk to food safety or animal welfare because it is practicably insoluble and therefore not toxic.[55]

- Salts (typically sodium or potassium chloride) – used in drilling mud as emulsifiers and shale inhibitors:

  Salts do not pose a food safety or animal welfare risk in the concentrations present in the rocks and minerals.

- Hydrocarbons – naturally occurring and used in synthetic drilling muds:

  The hydrocarbons present in rocks and minerals are typically grouped as total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and benzene, toluene, ethylene and xylenes.

  Water-based muds are used for most drilling operations. Synthetic muds are often used closer to hydrocarbon reserves and are therefore likely to contain higher naturally occurring concentrations of hydrocarbons than water-based muds. Synthetic muds also contain low levels of hydrocarbons themselves.

  People are exposed daily to various hydrocarbons from different sources in the modern environment, including by: consuming soft drinks[56] or coffee; inhaling smoke from cigarettes, breathing fumes from forest fires or vehicle exhausts; and eating grilled, smoked or barbequed food. Some hydrocarbons also occur naturally in plant waxes.[57] Exposure to these sources of hydrocarbons, which are abundant in modern society, is considered to be safe when within acceptable levels.[58]

Similarly, as noted, the risk from hydrocarbons is expected to be extremely low in the concentrations present in rocks and minerals from drilling oil and gas wells, even immediately after they are spread on land, but is difficult to verify.[59] The primary hydrocarbons of concern are polycyclic aromatic hydrocarbons, which are typically present at low concentrations in rocks and minerals. To avoid a risk to food safety or animal welfare, the soil should be tested to ensure it meets or is below the concentration values in Table 1 before it is stocked or crops are harvested.

These values have been developed to protect the health of the ecological environment; human health from direct ingestion of soil; food safety and animal welfare; and to avoid any uptake from the soil to plants or animals.[60] The concentration values for hydrocarbons required to protect the ecological environment and human health are lower than those required to ensure food safety or animal welfare. As such, the use of these values is a highly conservative approach to ensuring food safety and animal welfare from any subsequent use of the land.[61]

- Metals – naturally occurring in rock cuttings and drilling additives:

  Metals are naturally occurring at low levels in the rocks and minerals and do not represent a risk to food safety or animal welfare when spread on land. Copper and zinc, which are the metals most likely to be slightly elevated in the rocks and minerals, are deficient in some New Zealand soils and any increase in their levels may therefore improve the fertility of the soil they are spread on.[62] Test results from soil applied with rocks and minerals verify that concentrations of metals are comparable to levels found in New Zealand soil generally.[63]

- Minor drilling additives – used in drilling muds:

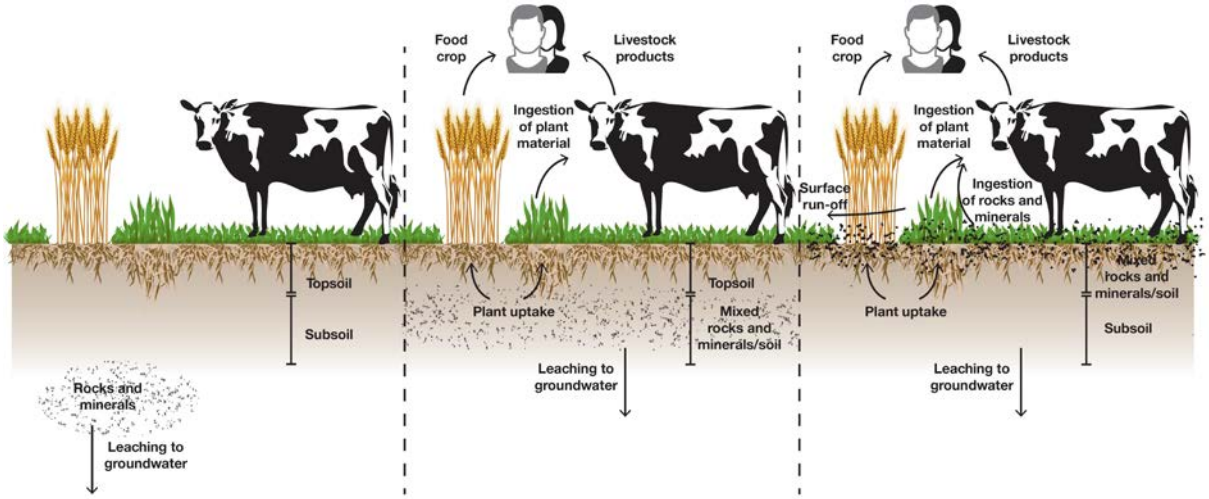
  Various minor additives may be used in drilling muds, such as thinners, corrosion inhibitors and lubricants. Based on real-use data and modelling of worst case scenarios, Landcare Research has determined that these components do not pose a risk to food safety or animal welfare. This is because they are either non-toxic, present at concentrations that are not toxic, or will not be transferred from soil to crops or livestock.[64]

- Other:

  When drilling oil and gas wells, naturally occurring radioactive materials may also be encountered, depending on the site's geology. However, evidence has not shown elevation of these materials in rocks and minerals from New Zealand sites.[65]

4.3 POTENTIAL EXPOSURE PATHWAYS

The figure below shows potential exposure pathways.



4.3.1 Crops

The potential for plants to absorb components of rocks and minerals arises predominantly from components present in water retained in soil, which is only a fraction of the total potential quantity of the component in the soil. Furthermore, even if taken up by plants, the transfer of organic components from the roots of plants to their leaves is limited.

As noted above, pasture yields can improve when land is spread with these rocks and minerals. This is because the rocks and minerals increase the soil's capacity to retain water and nutrients.[66]

4.3.2 Livestock (including milk and meat)

The primary pathway through which livestock could be exposed to components of rocks and minerals is through the ingestion of soil, plants or water. However, if rocks and minerals are applied below the root zone, there is no exposure pathway for livestock from soil or plants.

If the rocks and minerals are applied to the shallow subsoil, plant uptake is the primary potential pathway for livestock. If rocks and minerals are applied to the surface, and stock are grazed on the land before the components of rocks and minerals have biodegraded or attenuated, the primary potential pathway for livestock is through direct ingestion of soil.

However, once the hydrocarbon concentration values in Table 1 have been reached, analysis of the exposure pathways shows there is no risk that hydrocarbons could be transferred from soil and/or plants to animals (and then into their meat and milk) from spreading rocks and minerals on land. This has been verified by MPI milk testing[67] on dairy farms that had rocks and minerals spread on their grazing land.[68] Milk testing is an appropriate process for verifying that hydrocarbons have not transferred from soil and/or plants to the meat of animals, because milk is a particularly sensitive indicator of the presence of organic components such as hydrocarbons. These tests identified four minerals or compounds of interest at very low levels, which did not represent a risk to food safety or animal welfare.[69] Furthermore, no hydrocarbons were detected in milk that could be attributed to rocks and minerals having been spread on the land. Indeed, the sources of exposure to hydrocarbons for livestock and crops are numerous, including exhaust fumes from traffic on nearby roads, their

natural occurrence in plant waxes[70] and smoke from forest fires.[71] Fonterra has also conducted tests as part of its risk management programme with similar results.

As stated above, MPI operates several programmes that monitor for chemical residues and environmental contaminants in different foods, with extensive sampling and testing programmes focused on milk, dairy products, meat and other animal products.[72] Farms spread with rocks and minerals from drilling oil and gas wells are included in these programmes.

4.3.3 Soil health

No effects on soil health (such as impacts on earthworms or soil microbes) that may be caused by spreading rocks and minerals on land pose any risk to food safety or animal welfare.[73]

4.3.4 Ground water and surface water

In the event that hydrocarbons[74] leach to ground water, there is no risk to food safety or animal welfare as a result of spreading rocks and minerals on the land, because the hydrocarbons are present at such low concentrations.[75]

If rocks and minerals are stored on site before being applied, storage pits should be lined with impermeable material to prevent hydrocarbons from leaching to ground water.

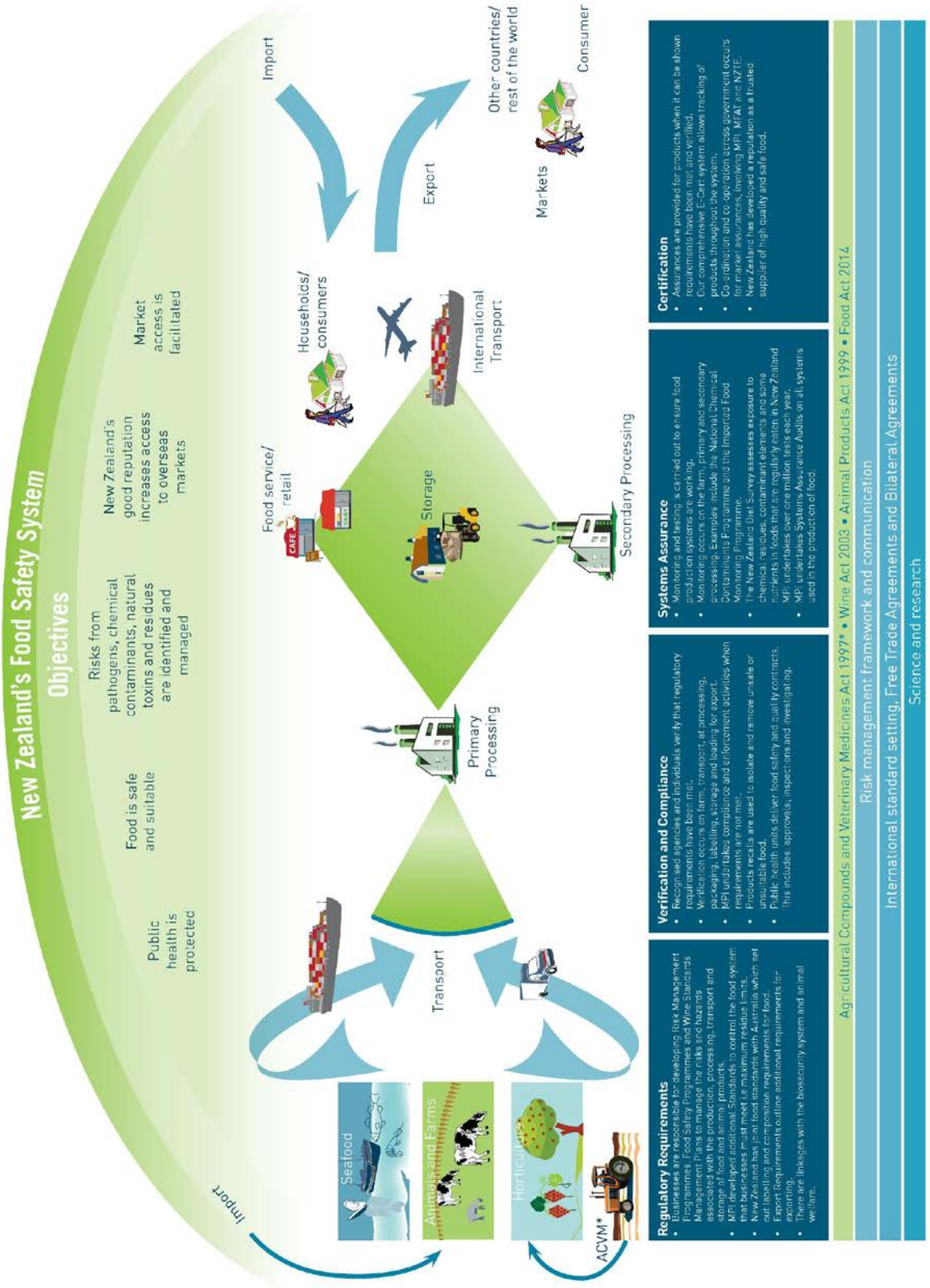
In the event that storm water run-off results in hydrocarbons[76] entering the surface water, there is no risk to food safety or animal welfare from spreading rocks and minerals on land, because the hydrocarbons are present at such low concentrations.[77]

4.4 FUTURE WORK

The Ministry of Business, Innovation and Employment has funded an Envirolink Tools project to develop an agreed methodology for deriving New Zealand soil guideline values for the protection of ecological receptors (soil microbial, soil biota, plants, livestock, wildlife).[78] The project intends to then derive soil guideline values for several priority contaminants, including hydrocarbons, during 2016.

Because this guidance has adopted the most conservative hydrocarbon concentration values in soil, it is not expected that the values generated through the Envirolink Tools project will be more stringent than those detailed here. However, this guidance will be reviewed periodically to ensure it continues to reflect the latest scientific knowledge.

Appendix 1: New Zealand's food safety system



Endnotes

[1] Cavanagh, JC (2015) *Land application of waste from oil and gas wells: implications for food safety and animal welfare*. Landcare Research; Lincoln.

[2] Note that, while the risk-based measure in the Food Act 1981 is called a food safety programme, in the Food Act 2014 the relevant measure is called a food control plan.

[3] Ministry for the Environment (2014) *Managing environmental effects of onshore petroleum activities (including hydraulic fracturing): guidelines for local government*. Ministry for the Environment; Wellington. http://www.mfe.govt.nz/sites/default/files/managing-environmental-effects-of-onshore-petroleum-development-activities-pdf.pdf. Accessed 5 July 2015.

[4] These compounds include weighting agents, viscosifiers, thinners, loss circulation materials, pH control additives, dispersants, corrosion inhibitors, bactericides, filtrate reducers, flocculants and lubricants. Bentonite clay is a common constituent as are barite (barium sulphate) and salts (sodium, potassium, calcium, chloride).

[5] Other components include those generated from hydrocarbon exploration and production activities such as: sludge and wax removed from tanks and separators, slop oil from wellhead cellars, oily formation sand, and contaminated soil from leaks and spills. These are typically only a small component of the total volume of rocks and minerals.

[6] A suitable reservoir will be porous and permeable, and isolated from ground water by cap rock. Depleted production wells can be used or a disposal well can be drilled for this purpose near a production well.

[7] Vermicompost is the process of composting using various worms to create a heterogeneous mixture of decomposing waste, bedding materials and vermicast.

[8] This also includes shallow sub-surface application as well.

[9] Edmeades, DC (2013) *The Taranaki landfarms; are they "fit for purpose"*. Taranaki Regional Council; Stratford.

[10] The *Guidelines for the safe application of biosolids to land in New Zealand* are available at: https://www.waternz.org.nz/Folder?Action=View%20File&Folder_id=101&File=biosolids_guidelines.pdf. Accessed 5 July 2015.

[11] *Report on the targeted surveillance of milk from animals potentially exposed to petrochemical mining wastes*, MPI Technical Paper No: 2014/24, August 2014. Barium, toluene, longer chain saturated hydrocarbons and polybrominated diphenyl ethers were identified at very low levels that did not represent a risk. There was also no evidence that the presence of these minerals and compounds was due to the farmland having been spread with rocks and minerals.

[12] The working group included: Beef + Lamb New Zealand; Dairy Companies Association of New Zealand; Federated Farmers of New Zealand; Hawke's Bay Regional Council; Horizons Regional Council; Local Government New Zealand; Meat Industry Association of New Zealand; Ministry of Business, Innovation and Employment; Ministry for the Environment; Ministry for Primary Industries (MPI); Petroleum Exploration and Production Association New Zealand; South Taranaki District Council and Taranaki Regional Council.
[13] Cavanagh, JC (2015) *Land application of waste from oil and gas wells: implications for food safety and animal welfare*. Landcare Research; Lincoln.

[14] Ministry for the Environment (2011) *Guidance for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand*. Ministry for the Environment; Wellington; and Canadian Council of Ministers of the Environment (2008) *Canada-wide standard for petroleum hydrocarbons (PHC) in soil: scientific rationale*. Canadian Council of Ministers of the Environment; Winnipeg, MB, Canada.

[15] The concentration values for monoaromatic hydrocarbons and polycyclic aromatic hydrocarbons are from the Ministry for the Environment's 2011 *Guidance for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand* and for total petroleum hydrocarbons from the Canadian Council of Ministers of the Environment 2008 *Canada-wide standard for petroleum hydrocarbons in soil*.

[16] Ministry for the Environment (2011) *Guidance for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand*. Ministry for the Environment; Wellington.

[17] *Canada-wide standard for petroleum hydrocarbons in soil* (Canadian Council of Ministers of the Environment, 2008). These values for total petroleum hydrocarbons are used because they provide the most recent comprehensive evaluation of the toxicity of these hydrocarbons, are more relevant, and generally more stringent, than those in the Ministry for the Environment's *Guidance for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand* (Ministry for the Environment, 2011).

[18] There is a risk of other components of rocks and minerals from oil and gas wells leaching into ground water (such as salts). However, none of these components pose any risk to food safety or animal welfare as a result of spreading rocks and minerals on land.

[19] Cavanagh, JC (2015) *Land application of waste from oil and gas wells: implications for food safety and animal welfare*. Landcare Research; Lincoln.

[20] Ministry for the Environment (2004) *Contaminated land management guidelines No. 5: site investigation and analysis of soils*. Ministry for the Environment; Wellington.
http://www.mfe.govt.nz/sites/default/files/media/Land/Contaminated%20Land%20Management%20Guidelines%205.pdf. Accessed 5 July 2015.

[21] Historically, one "landfarm" facility was granted consent by Taranaki Regional Council to apply fracking return fluids. Use of that facility has now concluded.

[22] Ministry for the Environment (2014) *Managing environmental effects of onshore petroleum activities (including hydraulic fracturing): guidelines for local government*. Ministry for the Environment; Wellington. http://www.mfe.govt.nz/sites/default/files/managing-environmental-effects-of-onshore-petroleum-development-activities-pdf.pdf. Accessed 5 July 2015.

[23] Ministry for the Environment, ibid.

[24] The Food Act 1981 is available at: http://www.legislation.govt.nz/act/public/1981/0045/latest/DLM48687.html.

[25] The Animal Products Act 1999 is available at: http://www.legislation.govt.nz/act/public/1999/0093/latest/DLM33502.html.

[26] The Agricultural Compounds and Veterinary Medicines Act 1997 is not relevant in this context because the rocks and minerals are not an agricultural compound. The Act's purpose is to ensure the safe use of agricultural compounds in New Zealand (without undue risk to public health, trade, animal welfare or agricultural security) and that use does not result in breaches of the food residue standards. An agricultural compound is any substance used for various agricultural purposes, such as pest control, animal nutrition or veterinary medicines. No

agricultural compound may be used in New Zealand unless that use is authorised by or under the Act. The Agricultural Compounds and Veterinary Medicines Act 1997 is available at: http://www.legislation.govt.nz/act/public/1997/0087/latest/DLM414577.html.

[27] The Wine Act 2003 is available at: http://www.legislation.govt.nz/act/public/2003/0114/latest/DLM222447.html.

[28] The Animal Products Act 1999 establishes a regulatory regime that requires all animal products traded and used to be "fit for intended purpose" (section 5). Food businesses do this by complying with the following types of controls: standards – these are issued under the Act as regulations or notices; risk management programmes – these are implemented by businesses processing animal material to manage food safety hazards and ensure the resulting animal products meet relevant standards; regulated control schemes – these are imposed and managed by MPI in circumstances where it is more efficient to control food-related risks, such as contaminants and residues, through a national programme; export controls – these are issued by MPI and include Overseas Market Access Requirements, General Requirements for Export and official assurances.

[29] Section 13 of the Animal Products Act 1999. Dairy farmers may adopt into their risk management programme, and therefore comply with the Code of Practice for the Design and Operation of Farm Dairies. Under this code, dairy farmers can only spread rocks and minerals from drilling oil and gas wells to land when: they have advised their dairy company, that company has given written approval, the date at which the land may be returned to feed dairy animals is specified; and records are permanently held that identify the nature of the waste, where it was applied and how much was applied. The code of practice also requires livestock to be precluded from known contaminated sites such as industrial waste dumps. The Code of Practice for the Design and Operation of Farm Dairies is available at: http://www.foodsafety.govt.nz/elibrary/industry/dairy-nzcp1-design-code-of-practice/amdt-2.pdf.

[30] All traded animal products must be "fit for intended purpose" and meet the appropriate New Zealand animal product and food legislation.

[31] Section 17 of the Animal Products Act 1999.

[32] Regulation 3 of the Animal Products (Regulated Control Scheme – Contaminant Monitoring and Surveillance) Regulations 2004. The regulations are available at: http://www.legislation.govt.nz/regulation/public/2004/0396/latest/096be8ed803a6cf2.pdf.

[33] If it has reasonable grounds to suspect there is a risk of contamination of animal material or product. Regulation 14 of the Animal Products (Regulated Control Scheme – Contaminant Monitoring and Surveillance) Regulations 2004.

[34] These measures can also include: investigating and reporting on the risk and potential for wider contamination; verifying whether the person in charge of the animal material or product is complying with risk management measures in place. Regulations 14 and 23 of the Animal Products (Regulated Control Scheme – Contaminant Monitoring and Surveillance) Regulations 2004.

[35] Regulation 15 of the Animal Products (Regulated Control Scheme – Contaminant Monitoring and Surveillance) Regulations 2004.

[36] The Food Act 2014 will come into force by 1 March 2016, but some sections are in force already.

[37] MPI administers and enforces the Act. Verifiers (who may be employees of MPI or contracted agencies) and food safety officers (note, food safety officers are officers in the 2014 Act) work in the community to ensure compliance with the Act and adherence to regulatory measures. The Act covers all food including crops, plant material and animal products intended for human consumption, including when these are sold for processing into other food products.

[38] The New Zealand (Maximum Residue Limits of Agricultural Compounds) Food Standards 2015 are one such standard and set the maximum residue limits for all food products. The Australia New Zealand Food Standards Code – Standard 1.4.1 – Contaminants and Natural Toxicants sets out maximum levels of specified metal and non-metal contaminants and natural toxicants in nominated foods.

[39] Specifically the Animal Products (Regulated Control Scheme – Contaminant Monitoring and Surveillance) Regulations 2004.

[40] Section 282 of the Food Act 2014.

[41] These programmes include: the National Microbiological Database – monitors meat and poultry; the National Chemical Residues Programme – monitors cattle, sheep, goats, deer, horses, pigs, ostrich, wild animals, poultry, salmon and honey for residues and contaminants; the National Chemical Contaminants Programme – monitors food safety hazards in dairy products and milk; and the Food Residues Surveillance Programme – surveys food available on the domestic market, including imported food that is not included in other programmes. The following, more general, monitoring programmes are also in place: the New Zealand Total Diet Study – every five years measures residues and contaminants in the average diet, that, when combined with model diets, allows an estimation of exposure to these residues and contaminants relative to the acceptable daily intake; and the Imported Food Monitoring Programme – monitors food safety hazards in imported foods.

[42] Includes a body of persons, whether incorporated or unincorporated.

[43] Section 10 of the Animal Welfare Act 1999. Section 4 of the Act defines physical, health and behavioural needs as: proper and sufficient food and water; adequate shelter; the opportunity to display normal patterns of behaviour; physical handling in a manner that minimises the likelihood of unreasonable or unnecessary pain or distress; and protection from, and rapid diagnosis of, injury and disease, being a need which, in each case, is appropriate to the species, environment and circumstances of the animal. The owner of an animal that is ill or injured, and every person in charge of such an animal, must, where practicable, ensure that the animal receives treatment that alleviates any unreasonable or unnecessary pain or distress being suffered by the animal (section 11).

[44] These standards vary, depending on the species, environment and circumstances of the animal. There are, amongst others, specific codes of welfare for dairy cattle and for sheep and beef cattle. For instance, the minimum standards for the Dairy Cattle Code of Welfare 2014 require: dairy cattle of all ages to receive sufficient quantities of food and nutrients to enable each animal to maintain good health, meet their physiological requirements and minimise metabolic and nutritional disorder; all dairy cattle to have access to a daily supply of drinking water sufficient for their needs and that is not harmful to their health; and that those responsible for the welfare of the dairy cattle must be competent at recognising ill-health or injury and take remedial action as appropriate. The codes of welfare are available at: http://www.biosecurity.govt.nz/regs/animal-welfare/codes/alphabetically.

[45] Section 12 of the Animal Welfare Act 1999. Complaints made about non-compliance with the Animal Welfare Act 1999 are investigated by MPI and the Royal New Zealand Society for the Prevention of Cruelty to Animals. MPI's verification services at slaughter premises and other animal products premises also record animal welfare offences. Enforcement is undertaken through education, warning letters, prosecutions and district court orders. The Animal Welfare Amendment Act 2015 also provides for regulations to be developed, which will be enforceable through infringement notices.

[46] The Resource Management Act 1991 is available at: http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html.

[47] Relevant to this topic are the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011, which are available at: http://www.legislation.govt.nz/regulation/public/2011/0361/latest/DLM4052228.html?search=ts_regulation_contaminants_resel&p=1&sr=1.

[48] Relevant to this topic are the Ministry for the Environment's 2011 *Guidelines for managing environmental effects of onshore petroleum activities (including hydraulic fracturing): guidelines for local government*. http://www.mfe.govt.nz/sites/default/files/managing-environmental-effects-of-onshore-petroleum-development-activities-pdf.pdf.

[49] These include: the Ministry for the Environment *Guidelines for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand* (2011); the Ministry for the Environment and New Zealand Water and Wastes Association's *Guidelines for the safe application of biosolids to land in New Zealand* (2003); the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations (2011); and the Canadian Council of Ministers of the Environment *Canada-wide standard for petroleum hydrocarbons in soil* (2008).

[50] Territorial authorities are defined in the Local Government Act 2002 as a city council or a district council named in Part 2 of Schedule 2 of that Act.

[51] For example, the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 prohibit soil disturbance beyond a minimum level without a resource consent.

[52] The Hazardous Activities and Industries List is available at: http://www.mfe.govt.nz/sites/default/files/laws/standards/contaminants-in-soil/hail-contaminants.pdf.

[53] Further guidance on the National Environmental Standard for assessing and managing contaminants in soil to protect human health (NESCS) can be found in the *Users' guide: National Environmental Standard for assessing and managing contaminants in soil to protect human health* at: http://www.mfe.govt.nz/publications/rma-land-hazards/users-guide-national-environmental-standard-assessing-and-managing.

[54] Ministry for the Environment (2011) *Guidance for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand*. Ministry for the Environment; Wellington; and Canadian Council of Ministers of the Environment (2008) *Canada-wide standard for petroleum hydrocarbons (PHC) in soil: scientific rationale*. Canadian Council of Ministers of the Environment; Winnipeg, MB, Canada.

[55] This is in contrast to other barium salts (such as barium chloride and nitrate). Menzies, C A; Southworth, B; Stephenson, G; Feisthauer, N (2008) The importance of understanding the chemical form of a metal in the environment: The case of barium sulfate (barite). *Human and Ecological Risk Assessment* 14(5): 974–991.

[56] See the MPI analysis of benzene in beverages at: http://www.foodsmart.govt.nz/whats-in-our-food/chemicals-nutrients-additives-toxins/specific-chemicals/benzene. Accessed 5 July 2015.

[57] Wang, YV; Larsen, T; Leduc, G; Andersen, N; Blanz, T; Schneider, RR (2013) What does leaf wax δD from a mixed C3/C4 vegetation region tell us? *Geochimica et Cosmochinica Acta* 111: 128–139.

[58] See, for example, the European Food Safety Authority's review of all sources of polycyclic aromatic hydrocarbons in people's diets or the MPI analysis of benzene in beverages: http://www.efsa.europa.eu/en/efsajournal/doc/724.pdf and http://www.foodsmart.govt.nz/whats-in-our-food/chemicals-nutrients-additives-toxins/specific-chemicals/benzene. Accessed 5 July 2015.

[59] If present at high enough concentrations, hydrocarbons can cause adverse environmental effects on soil invertebrates and plants. On the other hand, microbial populations are likely to be stimulated by the presence of hydrocarbons, because of the use of the hydrocarbon by microbes as a source of carbon.

[60] Ministry for the Environment (2011) *Guidance for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand*. Ministry for the Environment; Wellington; and Canadian Council of Ministers of the Environment (2008) *Canada-wide standard for petroleum hydrocarbons (PHC) in soil: scientific rationale*. Canadian Council of Ministers of the Environment; Winnipeg, MB, Canada

[61] Cavanagh, JC (2015) *Land application of waste from oil and gas wells: implications for food safety and animal welfare*. Landcare Research; Lincoln.

[62] Taranaki Regional Council (2014a) *BTW Company Ltd Brown-Road-Wellington Landfarm monitoring programme. Biennial report July 2011–July 2013. Technical Report 2013-62*. Taranaki Regional Council; Stratford. Available at: http://www.trc.govt.nz/oil-and-gas-compliance-monitoring-reports/#oil. Accessed 6 July 2015. Taranaki Regional Council (2014b) *Boyd – Drilling Waste Disposal Monitoring Programme Biennial Report 2011–2013 Biennial report July 2011–July 2013. Technical Report 2013-63*. Taranaki Regional Council; Stratford. Available at: http://www.trc.govt.nz/oil-and-gas-compliance-monitoring-reports/#oil. Accessed 6 July 2015. Grace, N; Knowles, S; Sykes, A (2010) *Managing mineral deficiencies in grazing livestock. Occasional Publication No. 15*. New Zealand Society of Animal Protection.

[63] Edmeades, DC (2013) The Taranaki landfarms; are they "fit for purpose". Taranaki Regional Council; Stratford.

[64] Cavanagh, JC (2015) *Land application of waste from oil and gas wells: implications for food safety and animal welfare*. Landcare Research; Lincoln.

[65] Cavanagh (2015) ibid.

[66] Edmeades, DC (2013) The Taranaki landfarms; are they "fit for purpose". Taranaki Regional Council; Stratford.

[67] Because milk is a sensitive indicator for the presence of any introduced chemicals, there is no need to conduct further studies for meat.

[68] Ministry for Primary Industries (2014) *Report on the targeted surveillance of milk from animals potentially exposed to petrochemical mining wastes*, MPI Technical Paper No: 2014/24. Ministry for Primary Industries; Wellington.

[69] Barium, toluene, longer chain saturated hydrocarbons, and polybrominated diphenyl ethers were identified at very low levels, which did not represent a risk. There was also no evidence that the presence of these minerals and compounds was due to the area having been applied with rocks and minerals.

[70] Wang, YV; Larsen, T; Leduc, G; Andersen, N; Blanz, T; Schneider, RR (2013) What does leaf wax δD from a mixed C3/C4 vegetation region tell us? *Geochimica et Cosmochinica Acta* 111: 128–139.

[71] Such exposure generally does not represent a food safety or animal welfare risk. See, for example, the European Food Safety Authority's review of all sources of polycyclic aromatic hydrocarbons in people's diets or the MPI analysis of benzene in beverages at: http://www.efsa.europa.eu/en/efsajournal/doc/724.pdf and http://www.foodsmart.govt.nz/whats-in-our-food/chemicals-nutrients-additives-toxins/specific-chemicals/benzene. Accessed 5 July 2015.

[72] These programmes include: the National Microbiological Database – monitors meat and poultry; the National Chemical Residues Programme – monitors cattle, sheep, goats, deer, horses, pigs, ostrich, wild animals, poultry, salmon and honey for residues and contaminants; the National Chemical Contaminants Programme – monitors food safety hazards in dairy products and milk; and the Food Residues Surveillance Programme – surveys food available on the domestic market, including imported food that is not included in other programmes. The following, more general, monitoring programmes are also in place: the New Zealand Total Diet Study – every five years

measures residues and contaminants in the average diet that, when combined with model diets, allows an estimation of exposure to these residues and contaminants relative to the acceptable daily intake; and the Imported Food Monitoring Programme – monitors food safety hazards in imported foods.

[73] Studies on nematodes, microbes, soil chemistry and pasture yield have found the effects on soil biodiversity due to surface application are likely to be subtle, with no effects on pasture yield or earthworms observed. Taranaki Regional Council (2011) *Land farming of drilling wastes: impacts on soil biota within sandy soils in Taranaki (year 1 of 3)*. Taranaki Regional Council Technical Report 2011-35. Taranaki Regional Council; Stratford. High concentrations of drilling muds (salts and hydrocarbons, in particular) are detrimental to earthworms and can initially cause some stress to microbes. However, over time, the microbial population increases and the concentration of hydrocarbons decreases, resulting in biodegradation. Cavanagh, JE; Booth, L; Stevenson, B; McGill, A; Campion, M (2014) *Biological response of earthworms and soil microbes associated with drilling mud wastes in the Taranaki Region*. Landcare Research Contract Report LC1897 for Taranaki Regional Council; Stratford. Insufficient mixing of rocks and minerals with sub-soils could result in the formation of an impermeable layer that leads to water-logging of soil. This in turn may lead to negative effects on pasture or plant growth, most likely in a patchy fashion. Ineffective mixing could also limit access for soil microorganisms to degrade hydrocarbons and create a chemical and physical barrier for earthworms, also slowing hydrocarbon degradation.

[74] There is a risk of other components of rocks and minerals from oil and gas wells leaching into ground water (such as salts). However, none of these components pose any risk to food safety or animal welfare as a result of spreading rocks and minerals on land.

[75] Cavanagh, JC (2015) *Land application of waste from oil and gas wells: implications for food safety and animal welfare*. Landcare Research; Lincoln.

[76] No other components of rocks and minerals from oil and gas wells pose any risk to food safety or animal welfare as a result of spreading rocks and minerals on land.

[77] For example, it would still be safe to use the surface water for livestock drinking water, irrigation or to clean dairy sheds. Historically, ground-water contamination has been found in the proximity of unlined storage pits in Taranaki. Resource consents from the Taranaki Regional Council now require storage pits to be lined with high-quality synthetic liners (or equivalent) and the installation of water bores around the areas where the storage and application of rocks and minerals takes place.

[78] Further information about the Envirolink Tools project can be found at: www.envirolink.govt.nz/envirolink-tools.