REGIONAL BIOSOLIDS STRATEGY
LOWER NORTH ISLAND

Report 13: Potential End-Use Options for the Lower North Island

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Regional Biosolids Strategy – Lower North Island

Report 14: Potential End-Use Options for the Lower North Island

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1 EXECUTIVE SUMMARY

Background

A three-year project involving 10 district and regional councils from the lower North Island and supported by the Ministry for the Environment, called the Regional Biosolids Strategy (RBS), has aimed to identify pathways for councils to beneficially use sludge and biosolids. Uptake of the RBS is reliant on feasible end use options being available as alternatives to current biosolids management practices. Council representatives made clear that this information was critical to inform the final biosolids strategy. Whilst there have been several end-use options explored through the strategy development, Council Partners wanted to examine the full list of potential end-use options available specific to the region.

Scope

This report presents the results of an investigation into opportunities for beneficial use that are available in the lower North Island

Key Findings

Key to a successful biosolids use programme are:

- The ability to utilise the total biosolids production from the partner councils, assessed as being approximately 94,400 tonnes of sludge (at 20% solids);
- Suitability for both large, one-off sludge volumes (e.g. pond desludging) and for continuous low volumes of biosolids (e.g. from waste activated processes);
- Compatibility with community and iwi expectations and regulatory requirements; and
- Affordability.

The main ways to dispose of biosolids are:

- Amass and bury (landfill and monofill);
- Apply to land for beneficial use or rehabilitation; and
- Thermally degrade.

Landfill and monofill are presently the most commonly used disposal methods in the study region. These methods are not considered to be sustainable long-term and may not be available in the future. There may be scope to monofill sludge where there is the potential to mine the material for later use. Later use would fall into the category of re-use. It is an aim of the Regional Biosolids Strategy to facilitate the diversion of sludge and biosolids away from landfill. Options considered in this report include landfill as the base option.

Thermal degradation, which may include energy recovery or energy generation, is widely practiced overseas. Typically, these facilities serve large municipalities, greater than the combined population equivalent of the lower North Island. Preliminary investigations into these facilities indicates that they become unaffordable when scaled down. Regulatory approval is challenging due to the potential for air quality impacts. Thermal degradation of biosolids is not considered further in this report.

End use options available to partner councils are dependent on:

- The regulatory environment;
- The characteristics of the material for discharge;
- The availability of target land uses in transportable distance;
- The costs incurred in beneficial use operations including:
    - Processing
    - Transport

- Land application; and
- Consenting costs.

- Consideration of community and iwi concerns and aspirations.

Discharge to land, whether for beneficial use or for land rehabilitation, is considered to be well suited to the lower North Island due to the large amount of potentially available land area. For most councils, suitable land is within a reasonable transport distance and a wide range of land uses are present. End uses considered in this report include:

- Forestry;
- Dairy and drystock (sheep and beef) farms;
- Horticulturalists / orchardists / market gardeners;
- Municipal landscaping;
- Land rehabilitation;
- Road corridors;
- Landfill capping; and
- Commercial enterprises (compost, potting media, etc).

To achieve safe application of sludge and biosolids, meaning low risk to public health and low risk of environmental impacts, the end use of the land must be considered. Table 1.1 shows suitable end uses for different types of biosolids.

Table 1.1: Impact of Sludge Processing on End-Use Options

Suitable for:	Restricted use biosolids	Unrestricted use biosolids	Composted biosolids	Vermi-composted biosolids	Thermally dried biosolids
Forestry	✓	✓	✓	✓	✓
Dairy and Drystock (sheep and beef) Farms	✓	✓	✓	✓	✓
Horticulturalists / Orchardists / Market Gardeners	×	✓	✓	✓	✓
Municipal Landscaping	✓	✓	✓	✓	✓
Land Rehabilitation	✓	✓	✓	✓	✓
Road Corridors	✓	✓	✓	✓	✓
Commercial enterprise	×	✓	✓	✓	✓

✓ Suitable
× Not Suitable

Analysis given in Section 5 shows that it is possible to beneficially use all biosolids produced in the study area. Table 1.2 collates key considerations for a range of feasible options for the study area.

Table 1.2: End Use Option Summary

Option	Minimum processing level required	Total area in land use (ha)	Available area (ha)	Recommended Application Rate (kg N/ha)	Stability of End Use	Constraints on Use	% sludge and biosolids able to be used
Forestry	Bb Biosolids	1,230,000	123,000	200	High/ moderate	Moderate.	>100%
Agriculture	Aa to Bb Biosolids	1,680,000	168,000	200	Moderate	Moderate to high	>100%
Horticulture	Aa biosolids	25,000	500	200	Low	High	12%
Municipal landscaping	Ab biosolids	>6,000	~120	200-1,000	High/ moderate	Moderate	3-14%
Land rehab-ilitation	Bb Biosolids	350	7	1,000	Low/ moderate	Minor	1%
Road corridors	Ab biosolids	958+	106+	1,000	Moderate	Minor	12%
Landfill capping	Bb biosolids	Variable	~4	1,000	Low/ moderate	Minor	0.50%
Commercial enterprise	Composted	NA	NA	200	Moderate	Moderate	Potentially 100%

Section 6 highlights that qualitative costs do not limit the feasibility of any option.

End use options will need to be resilient to manage changes in the ability to discharge the biosolids. This can be achieved by operating multiple end use options which enables biosolids streams to be diverted between end uses.

It is recommended that multiple options are pursued, including site specific evaluations. A staged approach to biosolids beneficial use could be taken to build resilience and avoid system redundancy. The staged approach would result in the initial discharge of biosolids with a lower degree of processing to less sensitive land areas i.e. forestry, low producing farmland and road corridors. This provides capacity to beneficially use all the biosolids produced in the study area in the interim while cost/benefits are refined, and markets are developed with high value users such as for landscaping or within the horticulture industry.

2 INTRODUCTION

2.1 Background

Ten lower North Island councils are working in partnership to develop a biosolids strategy that includes a potential collective approach for sludge management and beneficial end-use. The strategy is led and co-ordinated by a collaborative management team of Lowe Environmental Impact (LEI), Massey University and The Institute of Environmental Science and Research Ltd (ESR).

Initial stages of the project have carried out stock-take and gaps analysis to highlight the scale of the sludge problem in the region1 (Stage 1 Gap analysis; Task 1a Desk top study, and Task 1b Site visits and field investigations). Areas where councils could potentially work together to manage their sludge were identified (Stage 2 Opportunities to Work Together; Task 2a Opportunities to Work Together). Initial 'straw-men' strategies (Stage 4 Scenario Evaluation; Task 4a Development of 'straw men' scenarios and 4b Workshop Discussion) were developed and progressed through discussion to the development of draft strategies for the collective management of biosolids for the Lower North Island (Stage 5 Draft Strategy; Task 5b Development of a Draft Strategy).

2.2 Scope

This report investigates the potential end-use options for biosolids in the lower North Island. At the project Governance Group Meeting on 18th September 2018, the Council representatives determined that this information was critical to inform the final biosolids strategy. Whilst there have been several end-use options explored through the strategy development, Council Partners wanted to examine the full list of potential end-use options available specific to the region.

The purpose of this report is to outline potential end-uses of biosolids in the project region, with a focus on beneficial re-use.

Whilst landfill and monofill are the most commonly used disposal methods presently, these methods are not considered to be sustainable long-term. There may be scope to monofill sludge where there is the potential to mine the material for later use. It is an aim of the Regional Biosolids Strategy to facilitate the diversion of sludge and biosolids away from landfill. However, options considered in this report still include landfill as the base option.

Thermal degradation, which may include energy recovery or energy generation, is widely practiced overseas. Typically, these facilities serve large municipalities, greater than the combined population equivalent of the lower North Island. The evaluation of non land-based beneficial use has been undertaken by the project team members for other projects. It is well understood that the population base and size of the biosolids catchment area will not meet the threshold at which methods such as energy co-generation and thermal hydrolysis is cost effective. In addition, methods such as acid hydrolysis which have been trialled in New Zealand, have not yielded any examples of town or city scale operation, and have little information in the public domain to support the methodology. In all methods involving rapid degradation there remains a high strength wastewater which requires management. Correspondingly, land based beneficial use has been identified as the preferred option for the partner councils and the focus of the regional biosolids strategy. Thermal degradation of biosolids is not considered further in this report.

3 REGULATORY ENVIRONMENT AND LIMITATIONS

3.1 General

The use of sludge and biosolids for land application is regulated through the Resource Management Act (RMA, 1991). The RMA, including relevant national and regional policies is given effect through rules set down by Regional Councils. It has been the experience of stakeholders that the cost and complexity of the RMA process is a deterrent to pursuing land discharge. The Regional Biosolids Strategy includes guidance for navigating the resource consenting process (project fact sheet 3A.1).

This Section provides a brief summary of the key considerations for regulatory compliance.

3.2 Biosolids Classifications and Application Guidelines

A clear and robust definition of sludge and biosolids is central to describing an activity for which regulatory compliance needs to be assessed.

3.2.1 National Biosolids Guidelines

The "*Guidelines for the Safe Application of Biosolids to Land in New Zealand*" (NZWWA, 2003) is the most widely adopted guidance document for biosolids management in New Zealand. These guidelines contain information and recommendations to assist producers, dischargers and regulators (Regional Councils) to plan and assess the discharge of biosolids. The current biosolids guidelines have no legal status. Despite this the guidelines are referenced in many regional plans.

The biosolids guidelines include standard or nationally-agreed criteria for monitoring the contaminant loading of sludges and biosolids and receiving soils. The guidelines use a grading system whereby biosolids are assigned a stabilisation (microbiological and vector attraction reduction (VAR)) grade 'A' or 'B', and a chemical contaminant (i.e. trace metals and organic contaminants) grade 'a' or 'b'.

Biosolids are classified according to their stabilisation and contaminant grades as follows:

- Unrestricted use biosolids: Aa; and
- Restricted use biosolids: Ab, Ba, Bb.

The quality (or grade) of a biosolids products determines potential end-uses based on restrictions for use as outlined under the biosolids guidelines and regulations as outlined in Section 3.2.2 and 3.2.3. If a material does not meet the requirements for grades A, B or a, b then it is considered to be sludge (not biosolids).

Limits for 'a' grade biosolids are based on soil limits determined using a "lowest observed adverse effect concentrations" (LOAEC) methodology where it has been assumed there will be annual application of biosolids at agronomic rates i.e. that long term application should not result in concentrations that cause an adverse effect. The guidelines (NZWWA, 2003) suggest that "Regular monitoring of soil is only recommended for the application of restricted use biosolids, as contaminant limits in unrestricted use biosolids are low enough to prevent the rapid accumulation of contaminants. However, periodic monitoring of soil that has had Aa grade biosolids applied to it would be useful and good management practice. These data should be collected centrally and held as a public record. ", where unrestricted refers to Aa biosolids and restricted refers to Ab, Ba and Bb biosolids as outlined above. For grade 'b' biosolids, the means for ensuring contaminant levels do not reach unacceptable levels is through conditions of consent. These conditions are site and biosolids source specific

3.2.2 Unrestricted Use Biosolids.

Unrestricted use biosolids are those classified as Grade Aa for pathogen, VAR and chemical contaminants. These biosolids are considered to be of sufficiently high quality that they can be safely handled by the public and applied to land without risk of adverse effects.

There are numerous end-use options for high quality (grade Aa) end-products due to these limited restrictions (see Table 5.1 below). Partner Councils have expressed an interest in the potential for beneficial use and possible generation of revenue that this option presents. However, outlay costs are likely to be greater given the level of treatment/stabilisation that would be required.

3.2.3 Restricted Use Biosolids

Restrictions are placed on the use of biosolids that are less than grade A (Grade Bb-Ab). These grades are safe to be applied to land with site-specific controls imposed in accordance with a resource consent (NZWWA, 2003).

There is potential for combined systems to produce biosolids that are of a higher quality, allowing for more potential end-use options (Table 5.1 below). It is possible that the risks presented by grade Bb biosolids could be minimised by combining sludge from multiple sites, or by mixing sludge with other substances (e.g., pumice, sand, sub-soils, bark, sawdust, green waste). i.e. blending contaminated sludge with better quality sludge (or organic waste stream) can dilute contaminants in low quality sludges; biosolids with elevated levels of metal contaminants could be brought within grade Ab, Ba or even grade Aa limits by blending with Grade Aa sludge from another WWTP.

3.2.4 Update of the Biosolids Guidelines

Led by WaterNZ and involving industry (WasteMinz, and New Zealand Land Treatment Collective), research (The Centre for Integrated Biowaste Research) and government ministry (MfE, MoH, MPI) partners, a new technical guide is being drafted that recognises the commonalities of all organic waste, and describes quality criteria for beneficial use. This guideline will supersede, update and reference existing guidelines and standards including the NZ Biosolids Guidelines and the NZS4454 Composting Standards. More information on the new guideline can be found on the WaterNZ website.

3.3 National and Regional Planning Provisions

There are various regulatory instruments that must be considered when planning biosolids re-use or disposal. These include:

- The Resource Management Act; and
- Regional Plans.

In general, the application of wastes to land including sludge and biosolids is controlled by the Resource Management Act 1991 (RMA), with Regional Councils regulating via discharge consents triggered by their Regional Plan rules what is applied, how it is applied and where it is applied.

3.3.1 The Resource Management Act

Under the RMA, Regional Councils have functions to control the use of land for the purposes of maintaining and enhancing water quality (section (30(1)(c)(ii)) and aquatic ecosystems (section

30(1)(c) (iiia)), and to control discharges of contaminants onto land or into water or air (section (30(1)(f) of the RMA).

The application of wastes to land generally requires a resource consent (for discharges of contaminants to land in accordance with section 15 of the RMA), unless the waste poses minimal risks to the environment and is expressly allowed to be applied in accordance with a Regional Plan.

3.3.2 Horizons Regional Rules

Discharges of sludge or biosolids to land are allowed by rules in the Horizons (Manawatu/Whanganui) regional plan. Rules relevant to the discharge of biosolids and sludge are described below.

For Aa biosolids the following applies:

Aa biosolids and compost discharge to land are covered by Rule 14-7, making the discharge a **Permitted** activity, subject to the following conditions;

a. There must be no direct *discharge*^ or run-off into any surface *water body*^ or its *bed*^ or *artificial watercourse**.
b. For *compost** the material must not contain any human or animal pathogens, or any *hazardous substances**.
c. For *grade Aa biosolids** the *discharge*^ must comply with the requirements for *grade Aa biosolids** as included with Chapters 4 and 7 of Volume 1 and Chapters 8 (including monitoring requirements) and 9 of Volume 2 of the Guidelines for the Safe Application of Biosolids to Land in New Zealand (New Zealand Water and Waste Association, August 2003).
d. The *discharge*^ must comply with the following separation distances:
   i. 50 m from *rare habitats**, *threatened habitats** and *at-risk habitats**
   ii. 20 m from *bores**, surface *water bodies*^, *artificial watercourses** and the *coastal marine area*^
   iii. 50 m from any *historic heritage*^ identified in any *district plan*^ or *regional plan*^.
e. A nutrient budget undertaken using the OVERSEER® model, which takes into account all other sources of nitrogen and which is designed to minimise nitrogen leaching rates, must be used to plan and carry out the *discharge*^ of the *grade Aa biosolids** or *compost**. If a *nutrient management plan** is required under Rules 14-1 to 14-4 then the nutrient budget required by this *condition*^ must be consistent with it and the activity must be carried out in accordance with it.
f. The *discharge*^ must not result in any offensive or objectionable odour or dust beyond the *property** boundary.
g. The discharger must keep the following records:
   i. a daily record of the *discharge*^ volume and location
   ii. a monthly (or more frequent) analysis of the nitrogen concentration of a *discharge*^ sample and make these records available to the Regional Council upon request.

For Ab, Ba or Bb biosolids the following applies:

Other biosolids (Ab, Ba, Bb) are covered by Rule 14-8, making the discharge a **Restricted Discretionary** activity, subject to the following conditions;
a. There must be no direct *discharge*^ or run-off into any surface *water body*^ or its *bed*^ or *artificial watercourse**.
b. The material must have undergone stabilisation processes to achieve at least B grade as defined by the Guidelines for the Safe Application of Biosolids to Land in New Zealand (New Zealand Water and Waste Association, August 2003). *Hazardous substances** must not exceed b grade limits as given by the Guidelines for the Safe Application of Biosolids to Land in New Zealand (New Zealand Water and Waste Association, August 2003).
c. The *discharge*^ must comply with the following separation distances:
   i. 150 m from residential buildings, public places and amenity areas where people congregate, education facilities and public roads
   ii. 50 m from *property** boundaries

iii. 50 m from *rare habitats**, *threatened habitats** and *at-risk habitats**
iv. 20 m from *bores**, surface *water bodies*^, *artificial watercourses** and the *coastal marine area*^
v. 50 m from any *historic heritage*^ identified in any *district plan*^ or *regional plan*^.

d. A nutrient budget undertaken using the OVERSEER® model, which takes into account all other sources of nitrogen and which is designed to minimise nitrogen leaching rates, must be used to plan and carry out the *biosolids** *discharge*^. If a *nutrient management plan** is required under Rules 14-1 to 14-4 then the nutrient budget required by this *condition*^ must be consistent with it and the activity must be carried out in accordance with it.

e. The *discharge*^ must not result in any offensive or objectionable odour or dust beyond the *property** boundary.

Matters for discretion for other biosolids are:

a. the rate of *discharge*^ and frequency of *discharge*^ to control nutrient and contaminant loading rates
b. maintenance of vegetative cover in the area of *discharge*^
c. avoiding, remedying or mitigating the effects of odour or dust
d. contingency measures, including for events of mechanical failure and prolonged wet weather
e. monitoring and information requirements
f. duration of consent
g. review of consent *conditions*^
h. compliance monitoring
i. the matters in Policy 14-9 (which relates to pig and poultry farm litter).

If a product doesn't meet the definition of biosolids, it is sludge and resource consent can be sought under a catch-all Rule 14-30 (**discretionary**).

In the Manawatu/Whanganui Region it is likely that a high quality biosolids product can be applied as a permitted activity (no consent required). Sludge and lower quality biosolids will require consent.

3.3.1 Greater Wellington Regional Rules

The Proposed Natural Resources Plan (PNRP) decision version was notified 31 July 2019. While the Plan is not fully operative, the Rules relating to biosolids discharge can be considered to be operative.

The PNRP rules would be given precedence in applying for consent to discharge biosolids and sludge to land in the Greater Wellington Region and are as follows:

For Aa biosolids the following applies:

Aa biosolids, covered by Rule R77 of the Proposed Natural Resources Plan, is a **Permitted** activity, subject to the following;

(a) the biosolids carry the registered Biosolids Quality Mark (BQM) accreditation, and
(b) biosolids application rates shall not exceed a three-year average of 200kg total N/ha/year, or 600kg N/ha/year with no repeat within three years, and
(c) soil pH where the biosolids are discharged is not less than pH 5.5, and
(d) the discharge is not located within 20m of a surface water body, coastal marine area, gully, or bore used for water abstraction for potable supply, and
(e) the discharge is not located within a community drinking water supply protection area as shown on Map 26, Map 27a, Map 27b, or Map 27c, and
iii.(f) the discharge of odour is not offensive or objectionable beyond the boundary of the property.

It is not possible to comply with this rule since no Biosolids Quality Mark programme exists. The next rule to consider is:

For Ab, Ba or Bb biosolids the following applies:

The discharge of other biosolids (Ab, Ba, Bb) to land are covered by Rule R78 which is a **Restricted Discretionary** activity, subject to the following; (a) the discharge is not located within a community drinking water supply protection area as shown on Map 26, Map 27a, Map 27b, or Map 27c, and (b) the discharge shall not result in the creation of contaminated land. Matters for discretion for these other biosolids are: 1. Application rate, volume and location including in relation to: (i) presence of subsurface drainage (ii)nutrient capacity of the soil 2. Effects on soil health 3. Storage period and volume for deferred application during periods of prolonged wet weather 4. Effects on groundwater quality 5. Set back distances from surface water bodies, coastal marine area, and water supply bores 6. Discharge of odour 7. Methods for the incorporation of biosolids into soil 8. Effects on soil pH 9. Nitrogen loading rate j. Notification: In respect of Rule R78 applications are precluded from public notification (unless special circumstances exist).

If a product doesn't meet the definition of biosolids, it is sludge and resource consent can be sought under a default rule; Rule R92 (**restricted discretionary**, within water supply areas) or R93 (**discretionary**).

In the Greater Wellington Region, resource consent will be required for most discharges to land of biosolids or sludge, or their associated products. However, if a Biosolids Quality Mark programme existed then permitted activity status could be applied and significantly more options may result.

3.4 Consultation

Engaging with potential end-users, hapū and Iwi, and incorporating the wider community's views into waste management decisions is a beneficial part of developing wastewater (and biosolid) solutions. Identifying alternatives to landfilling of biosolids will typically require a consultation process to identify issues, concerns and the potential effects that the discharges may have on affected parties and key stakeholders. This presents both challenges and opportunities for local government, businesses, and communities. Any persons or community group that may be affected by the biosolid application to land should be approached for consultation. This may include interest groups, community groups, individuals and stake holders.

Section 7 below provides additional detail about the role that tangata whenua play in the decision-making process.

3.4.1 End Users

Potential end-users must be directly engaged during consultation to ensure that they are aware of all the pros and cons, management controls, and can guide where and how the sludge could be discharged on their properties. Their knowledge of site-specific conditions, terrain, land productivity variations, environmental constraints, sensitive neighbours, and practicalities of sludge spreading will assist with developing a sludge discharge programme. This information will also be necessary for informing the consent application documentation.

End-users must also be aware of any risks and regulations associated with the practice to be undertaken and the potential future restrictions on the use or development of their land under the NES for protection of human health from contaminated soil.

4 MATERIAL FOR BENEFICIAL USE

4.1 General

The identification of options for beneficial use are dependent on the amount, and consistency of supply of biosolids and sludge. An assessment of the sludge and biosolids volumes from the partner councils is detailed elsewhere (Biosolids Strategy – Report 2). Section 3 gives a brief characterisation of the material for discharge.

4.2 WWTP in Study Area

There are 46 wastewater treatment plants (WWTP) within the partner council area as follows:

- 37 Oxidation pond systems;
- Four small advanced treatment systems; and
- Five advanced treatment systems servicing the larger centres (Paraparaumu, Levin, Palmerston North, Feilding, Whanganui).

Oxidation ponds require infrequent desludging of large volumes of material. Pond sludge is best suited to land uses where a one-off application over a large area is available.

Advanced treatment systems typically produce a continuous supply sludge for treatment and/or discharge. Sludge volumes are low by comparison to desludging a pond but require a discharge situation where frequent applications to small areas is suitable.

4.2.1 Amount of Material

Reports 1 and 2 describe the biosolids and sludge production for the study area and recommend that end use options should be designed for:

- Approximately 80,000 tonnes of sludge (at 20% solids) currently residing in oxidation ponds, assumed to be removed over the first five years of the strategy; and
- Additional sludge from high rate treatment plants, with discharge from the treatment system on a daily basis in the order of 35 to 160 L/person/y dry volume of sludge (Report 1), assumed to equate to 19,600 m^3 dry solids per year for the study area. At a bulk density of 0.8 tonnes/m^3 this equates to 78,400 tonnes/year at 20% solids.

4.2.2 Material Quality

The material available from the partner councils varies in its concentrations of nutrients and contaminants. For the evaluation of end use feasibility, it has been assumed that a range of material concentrations will be available. The degree of processing of the materials will impact the suitability for any land use. Processing may include simply removing from the plant (sludge), through to composting or thermally drying.

For the purpose of this investigation the average nitrogen concentration is taken as 4.5% N on a dry weight basis.

4.3 Area Needed for Land Discharge

In order to apply 94,400 tonnes of biosolids or sludge, the land area needed would be:

- For annual repeat applications – 4,248 ha at a loading of 200 kg N/ha/year
- For one-off applications – 850 ha at a loading of 1,000 kg N/ha.

If a combination of options is selected, the annual area of application will be between 4,250 ha and 850 ha.

5 END-USE OPTIONS FOR THE LOWER NORTH ISLAND

5.1 Identified End Use Options

There are several options for use of biosolids within the lower North Island and many promote sustainable waste management and support Government strategies.

These include:
- Forestry
- Agriculture and horticulture
- Municipal Landscaping
- Land rehabilitation
- Road Corridors
- Landfill capping
- Commercial enterprise

All end-use options outlined can be achieved by Councils working individually or collectively. There may be a benefit to working collectively in many instances (economies of scale). It has been made clear through the strategy development process that determining the preferred end-use is a major driver for deciding on a treatment pathway. By determining end-use first, councils can avoid treating sludge to a higher grade than is necessary, and in turn reduce associated costs. Table 5.1 summarises the potential end uses based on the material processing. Industry restrictions or management of perception may further limit the use of some materials.

Table 5.1: Impact of Sludge Processing on End-Use Options

Suitable for:	Raw sludge	Restricted use biosolids	Unrestricted use biosolids	Composted biosolids	Vermi-composted biosolids	Thermally dried biosolids
Forestry	✓	✓	✓	✓	✓	✓
Dairy and Drystock (sheep and beef) Farms	×	✓	✓	✓	✓	✓
Horticulturalists / Orchardists / Market Gardeners	×	×	✓	✓	✓	✓
Municipal Landscaping	×	✓	✓	✓	✓	✓
Land Rehabilitation	✓	✓	✓	✓	✓	✓
Road Corridors	✓	✓	✓	✓	✓	✓
Commercial enterprise	×	×	✓	✓	✓	✓

✓Suitable
×Not Suitable

The following section outlines potential end-use options for the study region and discusses the feasibility of each based on parameters such as biosolids grade, regional rules, industry standards and guidelines and end user perception.

5.2 Forestry

Forest plantations are often established on land that is highly disturbed or with low soil fertility, consequently there is significant opportunity to use biosolids beneficially in forestry in the study area. There is a depth of research which has established benefits to biosolids application to both exotic and native forest (Esperschuetz *et al.*, 2017a; Esperschuetz *et al.*, 2017b; Gutierrez-Gines *et al.*, 2017; Wang *et al.*, 2013; Xue *et al.*, 2015; Wang *et al.*, 2017).

The benefits of applying biosolids to forest systems rather than agricultural land are:

- Increased timber production;
- Reduced likelihood of contaminants entering the food chain;
- Lowered direct contact with humans; and
- Perennial growth allowing year-round application.

Challenges to forest land application of biosolids typically relate to accessibility, transport distance and method of application. Even distribution of biosolids may be hampered by either the stems or the canopy of the forest.

Community consultation and views (in particular iwi) are also going to be a significant consideration for land application such as this. However, it has been found that in some instances application to forest is in line with Māori values due to the reduced chance for sludge to come into contact with food sources or water bodies.

5.2.1 Forest and Bushland in the Study Area

The study area has an estimated 1,230,000 ha of land currently in forestry, both indigenous and exotic (LCDBv4.1, 2020). In addition to commercial plantations a large area is taken up by the Tararua and Remutaka Forest Parks. An additional 140,000 ha of marginal farmland could also be converted into forestry as noted in Section 5.2.2 below.

In the study area, land that is currently forested typically occupies marginal land, steep slopes and relatively inaccessible areas. This does not exclude these areas from biosolids application but may increase the application costs and deems them less likely to be discharged to.

The catchments which contain Wellingtons water supplies should be excluded from consideration of biosolids discharge. Further, due to transport costs areas that are more than 100 km from the WWTPs are unlikely to be accessed. If 10 % of the land currently under forest (123,000 ha) was targeted for biosolids application at 200 kg N/ha/year, around 29 times the area needed for the current biosolids supply would be available.

5.2.2 One Billion Trees (1BT) New Zealand Government Initiative

The Government has set a goal to plant one billion trees over 10 years (between 2018 and 2027). The Government is incentivising planting by using Crown land for planting, entering into joint ventures or leases with landowners (such as farmers) to plant privately owned blocks, and providing monetary incentives for planting, for example, through a Grants programme.

The 1BT initiative presents a significant opportunity for expansion of forestry in the study area that has a focus on replanting current forestry blocks (business as usual) and converting marginal land into forestry. Around 140,000 ha of marginal farmland exists in the Greater Wellington region. If biosolids were applied at a rate of 600 kg N/ha/year at planting, to 10 % of the available land a 10 year supply of biosolids would be used.

5.2.3 Forestry Summary

Table 5.2 summarises the potential end use for forestry.

Table 5.2: Summary of End Use for Forestry

Forestry	Description
Minimum processing level required	Sludge
Total area in land use (ha)	1,230,000
Available area (ha)	123,000
Recommended Application Rate (kg N/ha)	200
Stability of End Use	High/moderate – relies on third party ownership, but large number of potential owners to negotiate with can assist to manage risk.
Constraints on Use (industry requirements, perception, etc)	Accessibility of sites for discharge and avoidance of sensitive sites required.
% sludge and biosolids able to be used	>100%

5.3 Agriculture and Horticulture

Previous research and surveys indicate that application of biosolids to land that will be used to produce food crops such as fruit and vegetables, is not supported by local communities or local iwi. It is recommended that consultation with local iwi be undertaken before any potential discharge near food intended for human consumption be considered. This does not mean that the use of biosolids in farming or horticultural systems cannot be considered. There are still many potential end-uses in this area within the study region.

5.3.1 Agriculture

The use of biosolids as a soil conditioner may be of particular value to non-dairy pastoral farmers in the lower North Island, where soil types from alluvial sediments and coastal sands are present. Biosolids have the potential to increase nutrients and improve moisture retention and soil structure through the addition of organic matter, therefore increasing the resilience of the land and improving crop/pasture performance. There is potential to use biosolids on drystock farms where application could occur prior to pasture development and subsequently at regrassing or pasture renewal. In addition, biosolids can be used as a fertiliser or soil conditioner to improve the growth of non-food crops such as maize and ryegrass, as exhibited by the Regional Biosolids Strategy biosolids field trial (Report 10).

The use of biosolids on farms is not controlled by New Zealand Food Safety Authority (NZFSA) or the Agricultural Compounds and Veterinary Medicines (ACVM) Group which states that:

> *"Soil conditioners that are raw or composted biological wastes should be regulated via the Resource Management Act 1991 (RMA) as is the case for fertilisers and fertiliser additives that are raw or composed biological wastes."*

The biggest risk to the feasibility of this option is likely to be due to requirements for resource consent as described for the relevant authorities in Section 3. However, generating a grade Aa material would overcome many of these obstacles.

Fonterra maintains a position on the use of biosolids and wastewater for fertilisation and/or soil conditioning that makes application to dairy farms challenging. The restrictions applied to biosolids application limit the grazing or feeding of material grown in sludge or biosolids amended soils to lactating and non-lactating cows.

In the study area there is around 1,680,000 ha of high and low producing farmland. It is anticipated that some landowners would not be interested in biosolids use, land may be excluded through buffer requirements (to streams, boundaries, sensitive sites). If 10% of the farmed land was able to be used for biosolids application (168,000 ha) there would be around 40 times the land needed at an application rate of 200 kg N/ha/year.

5.3.2 Horticulture

Rapid turn-over of crops occurs in horticultural applications. In particular the high tillage requirements of market gardens is known to result in loss of soil carbon, mineralisation and potential loss of nitrogen from the soil, and degradation of soil structure. The use of biosolids as a soil conditioner can assist to ameliorate both the carbon and nitrogen loss and assist with maintaining soil structure.

Supply of produce to most end markets requires the producer to be able to demonstrate the safety of the produce. Application to land used for horticultural crops must comply with the Horticulture NZ Approved Supplier Programme. A certificate of analysis (COA) would be required by end users of the biosolids. Aa grade biosolids with a COA can be re-used in horticultural situations. Biosolids cannot be used in certified organic farming systems.

Due to the negative perception of biosolids products some horticultural industry organisations consider biosolids containing soil conditioners to be inappropriate for use. In particular, this stance has been taken by Zespri for Kiwifruit crops.

If 2% of the around 25,000 ha of horticultural land in the study area was available for biosolids application (500 ha) at 200 kg N/ha/year, around 12% of the calculated biosolids supply would be used.

5.3.3 Agricultural and Horticultural Summary

Tables 5.3 and 5.4 summarise the potential end use for agriculture or horticulture.

Table 5.3: Summary of End Use for Agriculture

Agriculture	Description
Minimum processing level required	Aa to Bb Biosolids
Total area in land use (ha)	1,680,000
Available area (ha)	168,000
Recommended Application Rate (kg N/ha)	200
Stability of End Use	Moderate – relies on third party ownership.
Constraints on Use (industry requirements, perception, etc)	Industry requirements for dairy land.
% sludge and biosolids able to be used	>100%

Table 5.4: Summary of End Use for Horticulture

Horticulture	Description
Minimum processing level required	Aa biosolids
Total area in land use (ha)	25,000
Available area (ha)	500
Recommended Application Rate (kg N/ha)	200
Stability of End Use	Low – relies on third party ownership and subject to changing industry and regulatory requirements
Constraints on Use (industry requirements, perception, etc)	Industry restrictions Proximity to food chain
% sludge and biosolids able to be used	12%

5.4 Municipal Landscaping

Biosolids could potentially be used by the city and district councils and landscaping contractors as a soil conditioner in amenity areas and large-scale landscaping. The product would most likely be used as a compost or growing medium to enrich soil and improve soil moisture holding characteristics. More than 6,000 ha of grounds are managed by councils in the study area, although this includes sports grounds which are not suited to biosolids application due to their use and management. If 2% of the land was able to have biosolids applied (~120 ha) there would be capacity to annually receive 3% of the current biosolids available (at 200 kg N/ha/year) or 14% for a one off application (1,000 kg N/ha).

Due to potential public access to areas where biosolids have been applied a high grade of biosolids will be required (grade Aa) or controls will need to be in place to restrict access to areas where the product has been applied for a length of time.

In areas where substantial soil disturbance has occurred, such as new subdivisions, biosolids can be used to assist establishment of vegetation in common areas. In particular, sites where topsoil has been disturbed or removed. There is also potential to utilise biosolids for reducing erosion.

To comply with potential restrictions on nitrogen loadings, the method of application of biosolids would require an even surface application. Biosolids would not be suitable for applications at depth or for infilling. Applications of biosolids in subdivision situations may occur as a one-off application, or several applications over the development of the site.

The feasibility for biosolids to be used in this manner would need to be assessed on a case by case basis. The setup and administration of a system for tracking application location, volume and date may affect the feasibility. As well as general public perception, local/wider iwi views and economic factors would need to be considered. The largest issue for use in a landscaping situation is likely to be obtaining resource consent unless Grade Aa can be applied as a permitted activity. The most likely situations for biosolids use in municipal landscaping are:

- Establishment of new subdivisions;
- Maintenance of existing parks and gardens (as a soil amendment/compost);
- Areas of plant re-vegetation i.e. new parks and reserves; and
- In plant nursery production as a potting media amendment.

5.4.1 Municipal Landscaping Summary

Table 5.5 summarises the potential end use for municipal landscaping applications.

Table 5.5: Summary of End Use for Municipal Landscaping

Municipal Landscaping	Description
Minimum processing level required	Ab biosolids
Total area in land use (ha)	>6,000
Available area (ha)	~120
Recommended Application Rate (kg N/ha)	200-1,000
Stability of End Use	High/moderate – able to be applied to land in council ownership
Constraints on Use (industry requirements, perception, etc)	Management of public access to application sites
% sludge and biosolids able to be used	3-14%

5.5 Road Corridors

Application of biosolids to planting sites along road corridors is a viable option for use. As with municipal landscaping, the product would be used to enrich soil for planting, providing nutrients and improving soil moisture holding characteristics. There is the potential for use to be on-going, over long periods of time (months to years).

In this situation biosolids would likely be surface applied in quantities according to guidelines for application of biosolids to land, usually based on total nitrogen but also limited by heavy metal and pathogenic contaminants (NZWWA 2003). As with municipal landscaping there is potential for public access to areas where biosolids have been applied so a high grade of biosolids may be required (grade Aa) or controls will need to be in place to restrict access. Restriction of access by public should not be a problem during the construction of a new roadway, however, additional safety protocols would need to be put in place for construction staff.

The largest issues for use on roadside corridors are likely to be obtaining resource consent unless Grade Aa can be applied as a permitted activity. In addition, contractor reluctance may play a big part; there is potential for commercial contractors to be hesitant to apply biosolids due to potential liability, in-experience with the product (negative perception) and potential health and safety issues that may arise.

The Project Region currently has major new roading developments underway and projected to continue for several years. As communities grow there will be further roading projects developed.

5.5.1 Levin Expressway

The Levin expressway is the last section of the new Wellington Northern Motorway (Figure 5.1). Local authorities have been finalising the route of a new two-lane highway between Otaki and Levin scheduled to begin in 2021. At present the project is going under re-evaluation and as such, construction timing and the form of this new route is uncertain and will depend on nationwide growth and funding priorities. However, the long-term plan to develop an expressway in the region is still likely and presents an opportunity for large-scale biosolids use. Biosolids for roadside planting would have the potential to be applied to approximately 44 ha of land (likely more) along the length of the expressway, not considering possible flyovers and road convergences. In addition, the location is easy access to the Regions WWTPs by main highway (State Highway 1).

Figure 5.1: Levin Expressway as Provided by the NZ Transport Agency Website (November 2018)

5.5.2 Transmission Gully

Transmission gully is a 27 km four-lane motorway under construction North of Wellington (Figure 5.2). Construction officially began on 8 September 2014 and completion is scheduled for 2020. The motorway will run from Mackays Crossing to Linden, through Transmission Gully.

Figure 5.2: The Transmission Gully Route Map as Provided by the NZ Transport Agency Website (November 2018)

Four interchanges and two new link roads will connect the route to Mackays, SH58, eastern Porirua and Kenepuru. Landscaping and planting is going to occur across the whole 27 kilometre alignment, as well as the new interchanges and link roads. This planting has already begun and will be ongoing for the length of the project, occurring in phases as each section of road is complete. It has been approximated (based on 20 m roadside and 2 ha/interchange) that the area available for planting would be some 62 ha. A detailed evaluation is necessary to confirm these figures and it is likely that more will be available (unlikely to be less). This presents a significant land area for potential application of biosolids.

The contract to build the Transmission Gully motorway is held by Wellington Gateway Partnership (WGP), who are responsible for designing, constructing, financing, and operating/maintaining the motorway. WGP has contracted a joint venture of CPB Contractors and HEB Construction (CPB HEB JV) to undertake the motorway design and construction. Any future plan for roadside biosolids use at Transmission Gully would need to be presented to and approved by the WGP.

5.5.3 Road Corridor Summary

Table 5.6 summarises the potential end use for road corridors.

Table 5.6: Summary of End Use for Road Corridors

Road Corridors	Description
Minimum processing level required	Sludge (with exclusion) Ab biosolids (accessed by workers)
Total area in land use (ha)	958+
Available area (ha)	106+
Recommended Application Rate (kg N/ha)	1,000
Stability of End Use	Moderate – new roading projects are scheduled for the next decade. Relies of negotiation with a consortium of interests.
Constraints on Use (industry requirements, perception, etc)	Minor
% sludge and biosolids able to be used	12%

5.6 Land Rehabilitation

The study region covers a significant amount of land containing alluvial sediments and coastal sands, particularly along the Kapiti Coast, that are considered non-productive. Biosolids application has the potential to increase nutrient and moisture retention in sandy soils and improve soil structure through the addition of organic matter, improving the fertility and potential land use. Council partners indicated that rehabilitation of unproductive sand dunes in western coastal parts of the region (i.e. Foxton) would be an option that they would be interested in. Biosolids can also be used to improve erosion in zones of sandy soils.

5.6.1 Land Rehabilitation Summary

Table 5.6 summarises the potential end use for rehabilitation of land such as dune erosion and contaminated or mined land.

Table 5.6: Summary of End Use for Land Rehabilitation

Land rehabilitation	Description
Minimum processing level required	Sludge
Total area in land use (ha)	350
Available area (ha)	7
Recommended Application Rate (kg N/ha)	1,000
Stability of End Use	Low/moderate – relies on third party owners, only requires one-off application in most cases
Constraints on Use (industry requirements, perception, etc)	Minor
% sludge and biosolids able to be used	1%

5.7 Landfill Capping for Closure

Biosolids are commonly used for capping of landfills since they provide a good planting media and typically approved for use at these sites. Capping is likely to be a one-off application and so an application rate of 1,000 kg N/ha is considered to be appropriate for plant establishment.

Composted biosolids is currently being used to cap the Awapuni landfill in Palmerston North which closed in 2004. The sludge from the PNCC WWTP is transferred from the plant to the Awapuni composting site where it is composted with green waste before transport to the landfill for use as capping. The use of the compost in this way has been a valuable means to recycle the sludge, and it has been the sole end-use for the Palmerston North City sludge for some time. There is estimated to be a further five years of space at this site (PNCC Harley Arnopp, Pers Comm). The use of sludge as landfill capping is considered a good option given the lesser requirements for sludge treatment (grade Aa would not be required) and likely less public concern given that the sludge is being applied to an 'already contaminated' site, however initial consenting requirements may be prohibitive.

There are 6 landfills in the study region and a further one in the neighbouring Taranaki District. These are listed in Table 5.7, showing information regarding the location and expected capacity remaining for these sites.

Table 5.7. Landfills in the Lower North Island, New Zealand

Landfill	Location	Territorial Authority	Consent expiry/fill date
Awapuni Landfill	Palmerston North	Palmerston North City Council	Closed in 2004. Currently undergoing capping via biosolids compost from the Awapuni composting facilities
Bonny Glen Landfill	8km west of Marton	Privately owned by Mid West Disposals – service primarily Whanganui and Rangitikei districts	Consented to 2050, Current cell capacity near limit, a new site is expected to have 40 year capacity.
Colson Road Landfill	New Plymouth	Privately owned by EnviroWaste Limited (Taranaki Region)	Estimated to reach full capacity in 2019. Plans are in place to develop a new Central Landfill in Eltham
Levin Landfill	Levin	Horowhenua District Council	Consented to 2037
Silverstream Landfill	Upper Hutt	Hutt City Council	Consented to 2055
Southern Landfill	Happy Valley, Wellington	Wellington Coty Council	Current cell capacity to approx. 2025. Valley capacity for100yrs
Spicers Landfill	Porirua	Porirua City Council	Consented to 2030, capacity to 2045

The Wellington region is possibly the best equipped for landfill space and it is evident that at current fill rates this space is not estimated to run out for 30-100 years. However, the locations of the three wellington landfills (Southern landfill, Silverstream and Spicers) make access to these landfills by nearby regions difficult.

5.7.1 Landfill Capping Summary

Table 5.8 summarises the potential end use for capping of landfills in the study area.

Table 5.8: Summary of End Use for Landfill Capping

Landfill capping	Description
Minimum processing level required	Bb biosolids
Total area in land use (ha)	Variable
Available area (ha)	~4
Recommended Application Rate (kg N/ha)	1,000
Stability of End Use	Low/moderate – ownership is with councils. Site life is expected to be reached rapidly.
Constraints on Use (industry requirements, perception, etc)	Minor
% sludge and biosolids able to be used	0.5%

5.8 Commercial Enterprise

High quality biosolids, Grade Aa, can be treated like other fertilisers or soil conditioners and distributed or sold in a retail setting. In this case individual users do not need to obtain a resource consent, allowing for a wide range of potentially beneficial uses. Some potential commercial enterprise ideas that have been discussed include as a planting media in nurseries, composted biosolids, or as a bio-fertiliser.

5.8.1 Council Run Plant Nurseries

Council expressed interest in the idea of using biosolids as a medium for growing seedling in council run plant nurseries. Research carried out by Project Partners (ESR, LEI, Massey) addressing earlier stages of the project (Regional Biosolids Strategy Report 6: Biosolids Processing Trials; Trial for assessing the reuse of biosolids as a growing substrate for nursery plants) have shown that biosolids can effectively be used as an additive to seedling growth mediums to enhance plant growth.

The growth of shrubs and trees in nursery situations are well suited to using biosolids since:

- They are not directly linked to the human food chain;
- They commonly use growing media which requires frequent replacement; and
- These types of plants, especially native trees and shrubs are often slow growing and may benefit from a slow release fertiliser such as biosolids.

There is a current drive to plant trees through government initiatives such as '1 billion trees' (The Government has set a goal to plant one billion trees over 10 years between 2018 and 2027), this will require the increase in current output of seedlings from Council run nurseries and as such may be a viable end-use option for higher grade biosolids, especially given that the time between potting up the seedlings and planting out would allow for some further stabilisation (and attenuation of microbial contaminants) of the product. This end-use would not be viable for biosolids containing high levels of HM such as Cr which may disrupt plant growth.

5.8.2 Commercial composting

Two Council's currently carry out composting of biosolids (PNCC and MDC). At present these products are not available for commercial sale due to elevated HM concentrations. PNCC currently use their composted biosolids to cap the closed Awapuni Landfill (Palmerstone North) but this space is expected to run out within five years (Harley Arnopp, pers. Comm.). There is potential to expand both the MDC and PNCC facilities to accept biosolids from other sites, however the lack of end-use is one main reason for not investigating this further. If the composted product was deemed suitable to sell in a retail setting this would make composting a more favourable option. One option to improve the quality of the compost would be to pre-blend the sludge with other sludges/products with lesser contaminants to further dilute levels to below guideline limits.

The facilities are already fully equipped and therefore outlay costs are low. Transport costs and movement of sludge between Rohe are likely to be the biggest road blocks to this becoming a viable option for Councils. It may have potential for smaller WWTP within the region of the two composting sites (smaller travel distances and within the same Rohe), and if a commercial retailer is identified then there is potential for a financial return.

5.8.3 Bio-fertilisers

A specific interest of one of the Council Partners was the potential to use sludge as a bio-fertiliser by combining it with commercial fertiliser. This process is said to to kill the pathogens by means of osmotic pressure, the product can then be used or if necessary diluted with ordinary compost to bring HM levels within guidelines limits for general use. The final product would be far removed from the original product (positive in terms of public perceptions), and by meeting grade Aa could be used around public facilities such as council parks and gardens. The initial outlay of an end-use option such as this would be great given that there are no facilities currently available, however the long-term financial gains may make it a viable option.

5.8.1 Commercial Enterprise Summary

Table 5.9 summarises the potential end use for commercial enterprises.

Table 5.9: Summary of End Use for Commercial Enterprise

Commercial enterprise	Description
Minimum processing level required	Composted
Total area in land use (ha)	NA
Available area (ha)	NA
Recommended Application Rate (kg N/ha)	200
Stability of End Use	Moderate – councils have the opportunity to produce the end product. Uncertainty exists about a market to supply to.
Constraints on Use (industry requirements, perception, etc)	Management of public contact with product
% sludge and biosolids able to be used	Potentially 100%

5.9 End Use Summary

Table 5.10 collates key considerations for a range of feasible options for the study area.

Table 5.10: End Use Option Summary

Option	Forestry	Agriculture	Horticulture	Municipal landscaping	Land rehabilitation	Road corridors	Landfill capping	Commercial enterprise
Minimum processing level required	Sludge	Aa to Bb biosolids	Aa biosolids	Ab biosolids	Sludge	Sludge or Ab biosolids	Bb biosolids	Composted
Total area in land use (ha)	1,230,000	1,680,000	25,000	>6,000	350	958+	Variable	NA
Available area (ha)	123,000	168,000	500	~120	7	106+	~4	NA
Recommended Application Rate (kg N/ha)	200	200	200	200-1,000	1,000	1,000	1,000	200
Stability of End Use	High/ moderate	Moderate	Low	High/ moderate	Low/ moderate	Moderate	Low/ moderate	Moderate
Constraints on Use	Moderate	Moderate to high	High	Moderate	Minor	Minor	Minor	Moderate
% sludge and biosolids able to be used	>100%	>100%	12%	3-14%	1%	12%	0.5%	Potentially 100%

6 COST CONSIDERATIONS

6.1 General

An assessment of the costs of any end use forms part of the option evaluation. This section summarises cost categories associated with biosolids management which should be considered in an evaluation of options.

6.2 Processing Costs

Processing costs have been evaluated for the Regional Biosolids Strategy. A summary memo for costings is included as Appendix A. Appendix A focusses on the costs for removing sludge and preparing it to be taken away for end uses.

As indicated in Table 5.1 the level of processing recommended differs for end uses. In general, a greater degree of processing increases the options available for end use. This provides more resilience for the discharge of biosolids. Costs increases with increased processing and so a full cost/benefit analysis is recommended to determine if the resilience provided warrants the additional costs.

6.3 Costs Associated with End Use

As noted above a key component of the costs associated with any end use relates to processing of the material. The processing costs need to be included in an evaluation of end use costs. A minimum set of costs for consideration include:

- Capital costs such as:
    - Land area for processing activities;
    - Land area for storage/stockpiling;
    - Physical infrastructure for sludge removal, dewatering, stabilisation (drying, composting, geobags, etc); and
    - Land application infrastructure (machinery, application site storage, etc).
- Operational costs such as:
    - Repair and maintenance for processing and application infrastructure;
    - Operational time;
    - Fees.
- Transport costs including:
    - Mileage;
    - Time; and
    - Fuel and road user charges.
- Consenting costs including:
    - Technical advice and consent application preparation;
    - Consultation;
    - Monitoring and mitigation.

These categories form the basis of a matrix for assessing the costs for any end use. In order to compare options, a detailed cost evaluation is needed to capture the finer details of the activity. For instance, composting may require a large land area at the processing facility and a high operational input, but may have lower transport costs due to more options for use closer to the processing facility i.e. a less processed material may need to be transported further for use. Or, a composted material may require more transport trips than a Bb biosolids due to the increased bulk of the compost product and additionally its use in smaller scale applications.

6.4 Cost Evaluation of End Use Options

A comparative assessment of the costs for the options described in Section 5 is as follows. A qualitative rating of high (H), moderate (M) or minimal (L) is given for each cost category. Table 6.1 shows the cost assessment for the following range of end use options.

1. Bb biosolids to exotic forestry;
2. Bb biosolids to marginal pasture for drystock grazing;
3. Vermicomposted biosolids for maize growth;
4. Composted biosolids for municipal landscaping;
5. Bb biosolids for establishing vegetation at erosion site;
6. Bb biosolids for establishing vegetation along highway margins;
7. Bb biosolids to landfill final cap;
8. Composted biosolids for sale; and
9. Landfilling (current practice)

Table 6.1: Comparative Costs for End Use Options

Option	1	2	3	4	5	6	7	8	9
Capital costs									
Process land	L	L	H	M	L	L	L	H	L
Storage land	L	L	M	H	L	L	L	H	L
Process infrastructure	L	L	L	M	L	L	L	M	L
Land application infrastructure	H	M	M	L	M	M	M	L	L
Operational costs									
Maintenance	M	L	M	M	L	L	L	H	L
Operational time	M	M	H	H	M	M	M	H	L
Fees	L	L	L	L	L	L	L	L	H
Transport costs									
Mileage;	H	M	M	M	H	M	H	NA	H
Time; and	H	M	M	M	H	M	H	NA	H
Fuel and road user charges.	H	M	M	M	H	M	H	NA	H
Consenting costs									
Consent application	M	M	M	M	M	M	L	M*	L
Consultation	L	L	L	M	M	H	L	H	L
Monitoring and mitigation	M	M	M	M	M	M	L	H	L

*Global consent may be required for use of the material. A high level of testing may be needed due to inability to restrict contact with material

Table 6.1 indicates that on a comparative basis, all options presented are feasible based on costs, and should be carried forward for site specific cost assessments where they are not ruled out by other end use sensitivities (available land, stability, constraints). The same exercise as given in Table 6.1 can be carried out with qualitative ratings replaced by numerical values. Guidance for costing values is given in Appendix A.

7 COMMUNITY/IWI VIEWS AND PERCEPTIONS

7.1 General

The preceding sections show that the end use options presented are technically feasible. However, any option must have the support of the wider community to proceed. This section discusses the importance of consulting the community and in particular, iwi representatives, and summarises some key considerations for biosolids and sludge discharges.

7.2 Community and Stakeholder Engagement

New Zealand has unique central and local government drivers for consultation and public engagement. These include the Local Government Act (year) and the resource Management Act (1991/2013). Amongst other issues, consultation is seen as a recommended action for any development and infrastructure project, and in the case of Tangata Whenua there is a need to consider the obligations within the Act regarding the Treaty of Waitangi.

It is preferable to have early community buy-in to new projects, especially when they have the potential to result in environmental effects and expenditure of rate payer's money. Best practice should observe the following principles:

1. Early Consultation. Consult as soon as possible when there is still the flexibility to make changes to address issues raised by interested and affected persons.
2. Transparency. Be open about what the project wants to achieve, what scope there is within the project to change certain aspects of the proposal, and why there might be elements that may not be able to change.
3. Open Mind. Keep views open to the responses people make and the benefits that might arise from consultation.
4. Two-Way Process. Consultation is intended as an exchange of information and requires both the project team and those consulted to put forward their points of view and to listen to and consider other perspectives.
5. Not a Means to an End. While consultation is not an open-ended, never-ending process, it should not be seen merely as an item on a list of things to do that should be crossed off as soon as possible.
6. On-Going. It may be that consultation, or at least communication, will continue after the consent application has been lodged, or even after a decision has been made.
7. Agreement Not Necessary. Consultation does not mean that all parties have to agree to a proposal, although it is expected that all parties will make a genuine effort. While agreement may not be reached on all issues, points of difference will become clearer or more specific.

Further, effective communication is about ensuring that information is provided in a way that is clear and concise and reaches its target audience. Effective communication should follow these principles:

1. Relevant. It is important to make sure that all information provided is necessary and relevant.
2. Clear and Concise. Information needs to get key messages across clearly and efficiently.
3. Targeted. Information needs to be targeted to its intended audience.

4. Accessible. Innovative methods of information dissemination should be considered. In addition to more traditional methods such as newspaper and radio advertising, other methods may be appropriate, such as a project website and email updates.
5. Appropriately timed. Communication to the wider public should be timed so that people who are generally at work can attend public presentations and meetings.

7.3 Cultural Impact Assessment

A Cultural Impact Assessment (CIA) is often carried out as a way of documenting Māori cultural values, interests and associations with an area or a resource, and the potential impacts of a proposed activity on these.

A CIA is a planning tool that helps to facilitate Māori participation in the planning process. Like other technical reports, a resource consent applicant may commission a CIA and the report is regarded as technical advice. The CIA may contain a cultural framework which is a tool used to identify the effects of a proposed activity on tangata whenua cultural associations with the environment (see section 7.4).

There are a number of cultural health frameworks in New Zealand. These have been developed by academic researchers, scientists, Iwi and other individuals, both Māori and non-Māori, with the intentions of communicating the needs, intentions and beliefs of Māori which must be considered during project planning and execution. A good resource for assessing the frameworks available has been developed by LEI (Flutey, 2018; Regional Biosolids Strategy: report 8) and is briefly discussed below.

7.4 Iwi Engagement Framework

Flutey (2018) assessed eight cultural health frameworks commonly used for iwi consultation in New Zealand, selected for their appropriateness to the topic of biosolids management.
These cultural health frameworks are based on atua (Māori beliefs and custom, and values); Tikanga (customary protocols and traditions) or mana whenua perspectives.

The most commonly used frameworks include:

1. Using mātauranga Māori to inform freshwater management – Tikanga based;
2. Mauri-Ometer Indigenous Maori Knowledge and Perspectives of Ecosystems – mana whenua and tikanga based;
3. Mauri Compass – mana whenua and tikanga based;
4. Nga Mahi: Kaupapa Māori Outcomes and Indicators Kete – mana whenua and tikanga based;
5. Cultural flows – mana whenua and tikanga based;
6. Treaty-Based Planning Framework - mana whenua and tikanga based;
7. A Cultural Health Index for Streams and Waterways: a tool for nationwide use - mana whenua and tikanga based.

Each framework presents a unique guide for users to follow to better understand, gauge and determine the needs, values and cultural beliefs of Māori people and Māoritanga. Paramount to correct use of each framework is the need for consultation with tangata whenua, iwi, and hapū groups alongside the frameworks. Each region, iwi, hapū and individual may hold specific and unique views and understandings of their environment and concepts, which must be communicated and included to produce meaningful outcomes for all.

It is likely that many concepts are translatable across groups such as the importance of mauri to a region and its people; however, other values may exist unique to a particular area or group. It should not be assumed that a single framework will meet the expectations of all iwi and hapū groups; instead robust consultation and communication with tangata whenua needs to be maintained throughout the whole process to ensure the cultural relevance and responsiveness of any Cultural Impact Assessment Framework to Māori.

7.5 Consultation

As mentioned, engaging with hapū and Iwi is essential when discussing alternatives to landfilling of biosolids.

There are twenty two (22) identified iwi areas of interest within the study region, typically relating to a specific hapu or runanga:

Finalised by The Office of Treaty Settlements (OTS)

- Rangitane
- Wairarapa;
- Ngati Kahungunu;
- Heretaunga Tamatea;
- Taranaki Whanui ki Te Ika;
- Ngati Toa Rangitira;
- Rangitane o Manawatu;
- Ngati Apa;
- Ngati Tuwharetoa;
- Ngati Rangi;
- Whanganui Land Settlement;
- Whanganui River Catchment;
- Te Korowai o Wainuiarua;
- Ngati Haua;
- Ngati Maru;
- Ngati Tama;
- Raukawa Area of Association;
- Maniapoto; and
- Maraeroa A and B.

In Process with The Office of Treaty Settlements (OTS):

- Muaupoko;
- Ngati Tama (Wellington);
- Ngati Kauwhata; and
- Ngati Raukawa ki Te Tonga.

In some cases these spatial regions overlap, highlighting the fact that in certain areas more than one group is likely to have an interest in any activities taking place.

7.6 Iwi Perceptions and Views

It has been previously noted that each region, iwi, hapū and individual may hold specific and unique views and understandings of their environment and concepts, however, some similarities have been noted through various investigations into iwi views and perceptions of biosolids management (references: Karaitiana, 2019; Baker et al., 2018 (Regional Biosolids Strategy:

Report 5); Ataria et al., 2016; Baker et al., 2016; Goven et al., 2015; Goven, 2012; Goven et al., 2015; Prosser et al., 2020 (Regonal Biosolids Strategy: Report 9). Some similarities include:

- The sole focus should not be on biosolids waste without the inclusion of related water, wastewater and land-use issues when engaging with iwi as for Māori these issues tend to be viewed as interconnected;
- Iwi are in favour of beneficial re-use and reject landfilling of biosolids based on both environmental and cultural concerns;
- The application of biosolids for food production, around waterways and near wahi tapu is not acceptable;
- Non-food producing locations such as forestry, during restoration projects or biodiversity regeneration are more strongly supported;
- Some, but not all, iwi object to the transfer of biosolids (or other human waste) across Rohe (boundaries);
- There is evidence that in some cases plants transfer the tapu around biosolids into noa;
    - However, some are uncomfortable with animals gazing on land containing biosolids, or 'cut and carry' where produce is grown and fed to animals that will then be consumed by people; and
- The length of time is an important factor for lifting tapu, fully transitioning the tapu of biosolids into noa can take a long time (ie forest/tree regeneration over decades).

Based on these factors the most favourable end-use options for biosolids or biosolids containing products would be forestry or land regeneration/restoration, in particular where indigenous biodiversity is supported.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 End Use Options - Conclusions

End use options available to partner councils are dependent on:

- The regulatory environment;
- The characteristics of the material for discharge;
- The availability of target land uses in transportable distance;
- The costs incurred in beneficial use operations including:
  - Processing
  - Transport
  - Land application; and
  - Consenting costs.
- Consideration of community and iwi concerns and aspirations.

This report identifies a number of end use options available within the study area. Analysis given in Section 5 shows that it is possible to beneficially use all biosolids produced in the study area. Section 6 highlights that qualitative costs do not limit the feasibility of any option.

8.2 End Use Options – Recommendations

It is recommended that multiple options are pursued, including site specific evaluations. A staged approach to biosolids beneficial use could be taken to build resilience and avoid system redundancy. The staged approach would result in the initial discharge of biosolids with a lower degree of processing to less sensitive land areas i.e. forestry, low producing farmland and road corridors. This provides capacity to beneficially use all the biosolids produced in the study area in the interim while cost/benefits are refined, and markets are developed with high value users such as for landscaping or within the horticulture industry.

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10 APPENDICES

Appendix A: Biosolids Management Costing Memo for the Lower North Island

APPENDIX A

Biosolids Management Costing Memo for the Lower North Island

MEMORANDUM **Job 10416 Y3M1:3A**

To: Biosolids Partner Councils

From: Hamish Lowe, LEI

Date: 29 January 2020

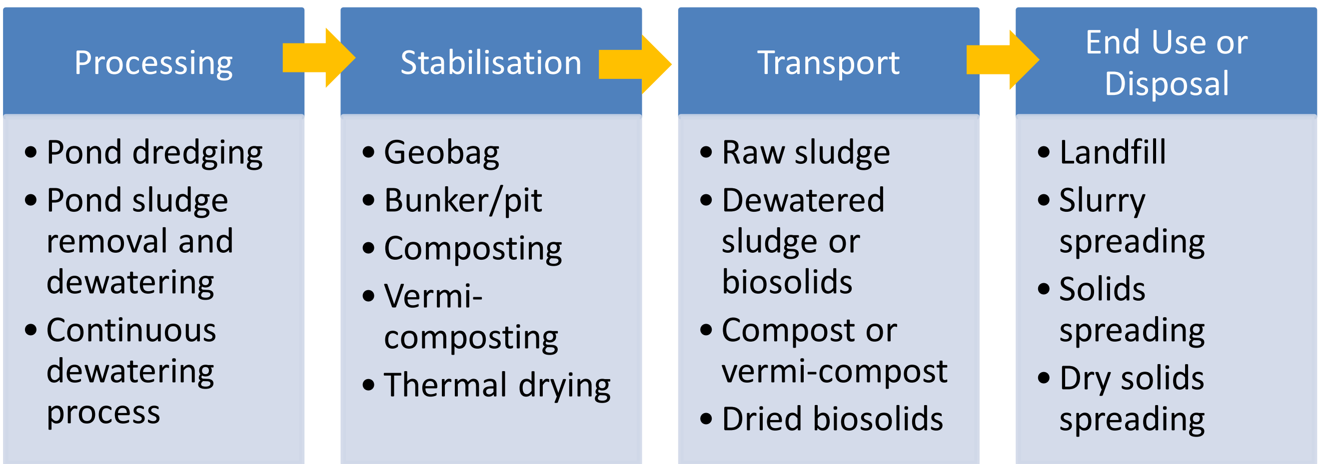
Subject: A cost analysis summary for end-use options in the Lower North Island.

SUMMARY

This memorandum provides a review of biosolids costs from a range of processes and locations around New Zealand. Costs have been adjusted to net present value (NPV, as at November 2019). Data from the review is presented in this memorandum for use to develop high level costings for planning of biosolids end use options. Steps to prepare costs for biosolids end use options are as follows:

1. Determine the amount of material to be processed

2. Assign costs from the tables provided below for each stage as follows



3. Sum and assess the NPV of the option for comparison and decision making

OVERVIEW

A series of biosolids end-use scenarios have been developed for communities in the lower North Island. Options for each component of the processing, stabilising and discharge of biosolids have been evaluated and pathways identified which lead to an end-use option.

Preferred scenarios have been identified for more detailed investigation. Additional investigation includes comparative costing of options for various components in the extraction and management of sludges.

A key consideration of the investigation has been to identify possibilities for and benefits of shared resources. This may include equipment in common, facilities in common or simply procedures in common.

The communities covered by the various councils produce a mix of sludge types (oxidation pond, continuous belt press, digestor), rates of production (<1,500 persons serviced to ~80,000 persons serviced) and required frequency for sludge removal (1 per 10 y to daily). Correspondingly a range of desludging and stabilisation options and scales should be considered.

This work presents a costing exercise that incorporates reuse and disposal options and essentially provides a high-level costing summary for a tool box of options associated with biosolids end use scenarios.

METHODOLOGY

Lowe Environmental Impact (LEI) has engaged with Beca to compile actual costs associated with a range of biosolids management processes for systems in use around New Zealand. Costs have been adjusted to reflect present day value (inflation rate of 5 % and a discount rate of 6 %). This includes material from oxidation ponds and higher rate treatment processes.

In order to develop a costing model which can be used for the scenarios identified for the lower North Island, the following costs have been considered:

- Capital costs such as:
    - Land area for processing activities;
    - Land area for storage/stockpiling;
    - Physical infrastructure for sludge removal, dewatering, stabilisation (drying, composting, geobags, etc); and
    - Land application infrastructure (machinery, application site storage, etc).
- Operational costs such as:
    - Repair and maintenance for processing and application infrastructure;
    - Operational time;
    - Fees.
- Transport costs including:
    - Mileage;
    - Time; and
    - Fuel and road user charges.
- Consenting costs including:
    - Technical advice and consent application preparation;
    - Consultation;
    - Monitoring and mitigation.

Costings are highly variable, being technology, site and material specific. The costings consider the feed material being:

- One-off (1 in 10 year) desludging (oxidation pond); or
- Continuous process (digestor, belt press, etc).

The costs also consider the material to be discharged i.e.:

- Undewatered sludge (5% dry solids);
- Dewatered sludge (20% dry solids, no stabilisation);

- Restricted biosolids (20% solids, stabilised);
- Aa biosolids (20% solids, stabilised, may include dilution with clean fill material);
- Composted biosolids (20% solids, stabilised and combined at 1:4 with greenwaste and woody material);
- Vermi-composted biosolids (20% solids, stabilised and combined at 1:1 with carbon rich material); or
- Thermally dried biosolids (90% solids, stabilised).

As noted above, the final material for discharge varies substantially both in moisture content and in discharge volume where additional material is added e.g. for compost. For this memo the costs have been determined for the material as supplied and as discharged and then presented on a dry solids basis to enable the options to be compared.

A key consideration for the costings is the impact of scale. From the range of examples assessed, a relationship has been developed between the equivalent dry solids amount and each parameter. This acknowledges that economies of scale exist and through basing the costings on a wide range of actual projects enables this to be quantified.

Costings were correct at November 2019. Use of net present value (NPV) analysis is recommended when these costs are applied to scenario costings. The costing tables developed are suitable for high level analyses for the purpose of planning and comparison. Detailed, site specific costs should be sought for design purposes.

RESULTS

Processing

One-Off or Infrequent Large Volumes

Oxidation pond desluging typically occurs as a one-off or one in ten-year events. A large volume of sludge requires handling over a brief period. Commonly, a desludging rig is mobilised to the site for the length of time it takes to desludge the pond(s). The process includes removal of sludge from the pond, dewatering and potentially storage. Additional options would include direct removal of undewatered sludge to an off-site facility for further processing. This has been examined in earlier collaboration scenarios but is unlikely to be adopted due to high transport costs (see transport discussion below).

Costs for processing of one-off events have been evaluated as follows.

- Removal only
  In some cases where handling and dewatering infrastructure already exists, there may only be a need to remove the sludge (dredge).

- Oxidation pond sludge removal and dewatering
  Most sludges removed from oxidation ponds undergo some form of dewatering. The extent of dewatering depends on the extraction technique and the targeted moisture content for further handling. Most plants used are mobile and the service is offered by contractors, with costs being inclusive of removal and processing. Costs typically cover set up, operation, chemical and testing.

The following table tracks the cost per dry tonne of solids for processing of a one-off event. The costs include the CAPEX and OPEX combined but exclude the cost of additional land for dewatering or storage (discussed below). Due to the one-off nature of this activity separation of OPEX and CAPEX is not useful.

Dry tonnes of solids	Sludge for transport (wet tonnes)	Processing cost per tonne dry solids		
		Dredging only	Dredge and geotube	Dredge, dewater, bunker/pit
200	1,000	$386	$946	$1,322
500	2,500	$198	$831	$795

1,000	5,000	$135	$793	$619
3,200	16,000	$92	$792	$498
16,000	80,000	$76	$819	$454
18,880	94,400	$76	$820	$453
100,000	500,000	$73	$825	$445

The table above shows a variation in cost based on the total amount of dry solids to be processed. A mass of 3,200 t/y over five years is anticipated if the oxidation ponds in the investigation area are progressively desludged. If all ponds were desludged in one year around 16,000 dry tonnes (80,000 tonnes at 20% dry solids) would be processed.

Continuous dewatering
Where there is a continuous production of sludge that requires dewatering, permeant infrastructure can be established. There are a range of technologies including belt presses and centrifuges, but most typically utilise some form of chemical dosing to assist with removing water. Included in the infrastructure are facilities to handle and in some cases store material prior to removal off site.

There are existing facilities of this nature in the investigation area. Costings provided here allow for full replacement or establishment of a new facility.

Dry tonnes processed	CAPEX	OPEX
	Cost per tonne dry solids	
100	$5,273	$507
2,000	$2,135	$79
10,000	$2,003	$61
15,680[1]	$1,991	$60
18,880[2]	$1,988	$59

[1] Currently processed
[2] Total annual sludge for processing in the investigation area

The total amount of sludge for processing has an impact on the cost but only at low sludge volumes.

<u>Stabilisation</u>

As discussed in previous reporting, there are a number of methods for stabilising sludges and assisting with improving the biosolid grade. Composting, vermicomposting and solar drying are options. It should be noted that once stabilised the material is ready for end use, but stabilisation is not an end use in itself. [JP1]

Composting is a process used internationally and at a number of sites around NZ to stabilise sludges. One of the biggest limitations is managing the supply of green waste to enable the appropriate ratio for effective compositing. In a number of instances sludges are additions to an existing compositing operation, while others are dedicated sludge compost facilities; and this variation contributes to a price variance.

Vermicomposting is similar to composting but is typically using a dedicated site.

Solar or thermal drying uses passive processes such as lined shallow beds that allow water/leachate (including stormwater) to be collected and returned to the treatment system; or active processes such as passing sludge through a heated bed or through a glasshouse type facility. In some cases, it can use existing ponds within a treatment system, with the ponds taken off line for a period of time to allow the moisture content to be reduced. For this investigation active processing units have been used to develop costs.

The table below summarises costs associated with facilities developed throughout New Zealand. The per tonne dry solids cost did not tend to vary by total sludge volume and so a single value has been chosen which represents the geomean for the costed examples.

Stabilisation costs	Land for storage and stabilisation	CAPEX	OPEX
	Cost per tonne dry solids		
Geobag	$25	Included in processing costs	Minimal
Bunker/pit (continuous process)	$4	$100	$20
Composting	$21	$50	$60
Vermi-composting	$13	$130	$80
Thermal Drying	$6	$7,800	$205

Land required for stabilisation and storage of the material has been determined based on the expected footprint of the stabilisation method and takes into account the effect of adding material i.e. greenwaste addition to biosolids for composting. Purchase of land for these operations has been assumed. Costs for the geobags and preparation of a storage area is included in the costs given in the processing table earlier.

Transport

Transport costs for trucking sludge are significantly influenced by two factors – moisture content (or dilution with other materials) and distance. Trucking water is expensive, so dewatering is critical. Distance results in a sliding cost scale with longer distances being cheaper per kilometre, as loading and unloading costs are effectively fixed costs irrespective of the distance. Relationships with the trucking firm and the potential for back loading can also influence costs, but this is predominately a factor should long haul options be considered.

While there may be volume limitations with trucks, the biggest limitation is typically weight. Consequently, costs are expressed on a weight basis, and have been corrected to being cost per dry tonne. The table below gives the costs of moving a range of different materials which reflect the varied moisture contents and the addition of other materials. A slurry tanker is required for transport of raw sludge while truck trailers can be used

Distance to travel (km)	10	20	50	80	100
	Cost per tonne dry solids for transport				
Raw sludge (not dewatered)	$32.52	$34.88	$41.98	$49.09	$53.82
Dewatered sludge, restricted use or Aa biosolids	$6.47	$6.94	$8.35	$9.76	$10.70
Composted biosolids	$10.78	$11.56	$13.92	$16.27	$17.84
Vermi-composted biosolids	$6.47	$6.94	$8.35	$9.76	$10.7
Thermally dried biosolids	$1.62	$1.73	$2.09	$2.44	$2.68

Landfill Disposal

The vast majority of sludge disposal in NZ is to landfills. Landfill costs are variable and often reflect negotiated rates which may be influenced by refuse disposal contracts. The costs are essentially a tipping fee, which covers placement, spreading and any levies. The table below gives landfilling fees for dewatered sludge (20% solids) based on the geomean of fees from five NZ landfills ($185 per wet tonne).

Dry tonnes landfilled	Fees ($)
3,200[1]	$2,967,000
15,680[2]	$14,539,000
18,880[3]	$17,506,000

[1] Annual mass from 20% of oxidation ponds in investigation area
[2] Annual mass from continuous process
[3] Total annual sludge for processing in the investigation area

As with transport, the drier the material the more that can be deposited for the same cost.

End use

As noted in previous reporting, a large volume of sludge material goes to landfill. A key objective of the biosolids strategy is to facilitate beneficial use of biosolids. The end use options available are typically dependent on the material produced by the stabilisation process (maturing, composting, thermal drying, etc).

In some cases decisions about end use are stalled at the dewatering/stabilisation stage, with Councils intentionally choosing to leave the material in the dewatering/stabilisation facility e.g. leave the dried sludge in solar drying beds or geobags. Examples of beneficial use and their costs are not readily available. The table below gives costs for a mine rehabilitation project and spreading of a biosolids slurry to forest.

	CAPEX	OPEX
Stockton (transport and spreading)	Minimal	$105 / wT (3,600 dT / y)
Rabbit Island – slurry (pipeline, storage and spreading)	$ 1,900 / dT (1,100 dT / y)	$31 / wT (1,100 dT / y)

Given similarity in material handling, there is the opportunity to draw on experience with agricultural wastes, with land spreading of solids and slurries from dairy and poultry operations being more common. Often such operations see material generated on the farm and spread on the same farm, and the transport is undertaken by the same wagon as doing the spreading. Costs below are for spreading alone and include transport within a farm operation and do not include resource consents and other approvals.

It is assumed that a contractor will be engaged to undertaking the spreading. However, there is potential for a cost/benefit analysis to favour in-house purchase of equipment and operational control for a combined option between councils.

Discharge	Method	Cost per dry tonne ($)
Slurry spreading (< 4% solids)[1]	Tank and splash plate	$220
Solids spreading (> 15% solids)[2]	Muck spreader	$70
Dry solids spreading (> 80% solids)[3]	Fertiliser spreader	$15

[1] Minimally dewatered biosolids/sludge
[2] Dewatered sludge, restricted use or Aa biosolids, compost or vermi-compost
[3] Thermally dried

WHOLE OF BIOSOLIDS PROCESS COSTS

Using the preceding tables the appropriate costs for each stage of the biosolids management process (processing, stabilisation, transport and end use) can be combined to determine comparative costs for a land based end use.

Ministry for the Environment
Manatū Mō Te Taiao

LOWE Environmental Impact

E/S/R
Science for Communities

Kāpiti Coast District Council
Me Huri Whakamuri, Ka Titiro Whakamua

Manawatu District Council

Whanganui District Council
Te Kaunihera a Rohe o Whanganui

horizons regional council

Palmerston North City Council

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