PRODUCTION AND USE OF BIOFERTILISERS FROM THE ANAEROBIC DIGESTION OF SOURCE SEPARATED ORGANIC WASTES

BANZ TECHNICAL GUIDE 8

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About this Guide:

1. The compilation of this Technical Guide has been facilitated by contributions and oversight of the relevant expert members of the Bioenergy Association Gaseous Biofuels Interest Group..
2. The aim of the Association's Technical Guides is to encourage delivery of high quality and consistent best practice bioenergy solutions. These Guidelines are voluntary but essentially provide a regulatory framework for the New Zealand bioenergy and biofuels sector.
3. The Guide is an outcome of industry discussion and collaboration. It captures the collective technical knowledge of a range of relevant leading bioenergy sector personnel. In addition, it benefits from the collective review and use by relevant asset owners, guide users, policy makers and regulators.
4. This guide is provided in good faith as an addition to the ongoing body of knowledge relating to the bioenergy and biofuels sector in New Zealand and Australia. However, as the guide is general and not specific to any application the Association and none of those involved with its preparation accept any liability either for the information contained herein, or its application.
5. As with all Bioenergy Association technical guidance documents, this guide is a 'living document' and will be revised from time to time and reissued, as new information comes to our attention. If you have suggested additions to this guide please contact admin@bioenergy.org.nz.
6. This second version of the Guide includes the methods for certification of digestate as a biofertiliser and for the accreditation of certified biofertilizer producers.
7. Any enquiries regarding these guidelines should be referred to:

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Caveat

Bioenergy Association recommends that any party undertaking a project to upgrade or replace a bioenergy facility should undertake a full evaluation of all possible options prior to fixing on a specific new project solution.

As a decision maker, it's important to understand the pros and cons of each option and have them set out by an appropriate expert in a way that ensures they are easily comparable.

These Technical Guides are only a guide and users should ensure that they have engaged an appropriate expert to consider their specific application.

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1 FOREWORD

Anaerobic digestion (AD) of animal manure, organic wastes of industrial or municipal origin, and arable crop residues is gaining substantial interest around the world due to its indisputable economic and socio-environmental benefits; these being the production of renewable energy and fertiliser, reduction of the amount of waste disposed at landfills, improvements of soil fertility, increases in food production and the reduction of greenhouse gas emissions.

Anaerobic digestion converts organic waste material into two economically beneficial products: biogas and digestate.

Biogas can be used as a substitute for natural gas for industrial, commercial and residential use. Using established technologies, biogas can be converted to electricity, or heat, or be upgraded to biomethane for injection into the national gas distribution grid or compressed for use as a transport fuel.

Digestate is the liquid residue from the anaerobic digestion of non-human organic waste. Digestate can also be produced from the anaerobic digestion of human organic waste, however this is known as biosolids. Both materials can be beneficially used as a soil fertiliser and conditioner, however regulatory controls can limit the disposal of biosolids to land.

Digestate contains high levels of macro- and micro-nutrients and as such presents an environmentally sound alternative to mineral and synthetic fertilisers. Nevertheless, the use of digestate as biofertiliser has been limited by the regulatory burden and an unfavourable perception by farmers, food wholesalers, food retailers, politicians, decision makers and the general public.

Due to the high proportion of greenhouse gas emissions associated with organic waste disposal in New Zealand and Australia, anaerobic digestion can play a key role in the countries' ability to meet their greenhouse gas emissions reduction targets. As more and more communities and businesses adopt circular economy principles, the production of digestate biofertilisers is expected to increase. Providing a clear framework to produce fertiliser products from digestate, developing sustainable markets and sharing methods for the beneficial use of digestate is essential for the wider uptake of the AD technology and ultimately the reduction of greenhouse gas emissions and fertiliser use.

2 INTRODUCTION

Under current legislation and industry guidelines, all material applied to land after anaerobic digestion in New Zealand remains a 'waste' and subject to regulatory controls which can be costly and time consuming.

The Ministry for the Environment is keen for New Zealand to join other countries around the world that have established ways to treat and handle digestate from the anaerobic digestion of source separated organic wastes so that it can qualify as a 'product'. However each country has its own criteria for producing fertiliser products from waste organic material based on the risks and controls needed to protect human and animal health and the environment within their borders.

As a result, the Bioenergy Association was funded through the Waste Minimisation Fund to undertake extensive research to understand and identify the risks and controls required to protect human and animal health and the environment from use of digestate from source separated organic waste in New Zealand, and to develop a framework that enables digestate products to be decoupled from waste regulations.

Technical Guidance 8 (TG 8) has been produced to share this knowledge and explain the framework that has been developed to eliminate the barriers to using digestate as a fertiliser product. Aligned with Fertmark[1] the framework details how digestate from the anaerobic digestion of source separated organic wastes can become certified biofertiliser products. This removes the need for costly and time-consuming resource consents for digestate application to land and creates opportunities for the sale of digestate as biofertiliser products.

TG 8 aims to remove a major barrier to wider uptake of AD for recycling of source segregated organic waste by providing a clear specification to plant operators to produce consistently high-quality market-acceptable biofertiliser. With the exception of compost, the application of organic waste material to land is governed by the Biosolids Guidelines (2003) and its successor version, the *Guidelines for Beneficial Use of Organic Materials on Land* [2](awaiting publication). Subsequently the use of digestates is subject to an extensive permitting process.

TG 8 promotes the process-oriented Quality Assurance approach over the product-focused Quality Control approach specified in the Biosolids Guidelines. The QA approach encourages good selection, design and operation of the treatment processes and provides benefit to those that select processes that are inherently more robust and therefore less likely to fail to adequately treat.

Higher emphasis on Quality Assurance increases the reliability of the treatment outcome, while allowing reduction in frequency, extent and consequently the cost of the end product testing currently prescribed in the Guidelines. Conformance with TG 8 provides assurance to consumers, farmers, food producers and retailers that digestate produced from the AD facility is safe for human, animal and plant health and compliant with the regulatory quality requirements.

The framework sets out the quality requirements for digestates from source separated organic wastes to be classified as a certified biofertiliser, and the controls needed to produce a quality biofertiliser that is fit for purpose. It also specifies how producers can become accredited biofertiliser producers. It is designed

[1] https://fertqual.co.nz/fertmark/
[2] https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=3291

for producers whose digestate meets the minimum quality requirements and has been created to ensure producers can easily understand, plan and complete the requirements to produce certified biofertilisers.

It is important to note that following this framework is voluntary and digestate can continue to be classed as a waste and applied to land through resource consents if the producer is unable to meet the minimum quality criteria, or chooses to produce a waste. Ultimately, however, it is hoped that TG 8 will improve the awareness of the social, environmental and monetary benefits of biofertilisers and encourage growth and investment in the industry in the future.

2.1 Scope

This Technical Guide covers the production of biofertilisers from the anaerobic digestion of source separated organic wastes. Please note that the addition of other materials or organic wastes to the process not detailed in the framework will result in the digestate falling outside the scope of TG 8 and subject to relevant waste regulations for application to soils. Specifically, digestate from the anaerobic digestion of municipal sludges of human origin is excluded and is governed by the Biosolids Guidelines 2003.

TG 8 covers:

1. The background to the processing of residual organic materials
2. A review of the anaerobic digestion process
3. An assessment of the anaerobic digestion industry in New Zealand and Australia
4. A review of how the UK decouples digestate from waste regulations
5. The new framework for producing biofertilisers
6. Guidance on industry best practice to assist producers using the framework

Extensive case studies along with examples of facility documentation are located within the Appendices.

2.2 The Processing of Residual Organic Materials

Residual organic waste is the waste remaining after minimisation, recycling and reuse has been maximised. Figure 1 below illustrates the position of anaerobic digestion within the waste hierarchy.

Figure 1: The position of Anaerobic Digestion within the waste hierarchy (Aotearoa New Zealand's First Emissions Reduction Plan, May 2022).

For the purpose of this Technical Guide, there are four types of organic waste:

- Mixed waste (typically municipal liquid or solids)
- Source-segregated industrial, domestic or commercial organic waste (liquid or solid)
- Animal residue (manure, litter)
- Biosolids

While this TG8 is specifically designed for the source-segregated organic waste, it is important to describe the other categories to provide better clarity to the users. Details of these waste categories are explained below and overleaf.

2.2.1 Mixed Organic Waste

Municipal liquid or solid waste streams are generally mixed with other non-specified waste and often have variable compositions. It is often disposed of to landfill where it decomposes to produce biogas and leachate. Only about 60% of biogas is captured from a modern designed landfill so decomposition of organic waste in a landfill is a very inefficient means of processing residual organic waste. It also does not produce a solid residue which can be used as a fertiliser substitute.

2.2.2 Source-segregated organic waste

Source-segregation is a process of separating organic materials from other waste to avoid sending organic materials to landfill. Separating organic waste at its source and treating it helps to reduce the amount of waste that goes to landfill, which reduces emissions from landfill. The separated organic waste material is able to be treated separately by anaerobic digestion (AD) or composting to produce a low emission alternative to landfilling.

Organic waste may be source segregated, and of known consistent composition (although the feedstock may change seasonally), or mixed source in which case the composition of the feedstock cannot be guaranteed as being known and consistent. If a feedstock is known and consistent then the form and frequency of testing of the resulting digestate from AD can be simplified, but if the feedstock composition is not known then more extensive and frequent testing may be necessary.

AD plants can be purpose-built waste processing facilities for a variety of source-segregated organic residues or be part of the waste management and treatment at the originating industrial processing plant.

AD systems located at an originating food-processing site are often designed for removing organic matter from on-site animal, vegetable or fruit processing. They generally do not receive materials from other sites and will only handle their own by- products. These facilities may have the advantage of using co-generation to produce electricity as well as heat, reducing on-site energy costs.

Centralised or non-farm AD systems treating organic wastes are becoming more common outside Europe where they have been used for a number of years. In Europe, centralised AD systems often receive material from many farms and food-processing plants. The digestate is transferred to nearby agricultural fields where the nutrients are needed (away from the original livestock farm sources).

In North America, the current trend is for centralised AD systems to only handle food-processing waste and urban source-separated organics. In some cases, the treated liquid digestate is discharged into municipal sewers for further treatment at the municipal wastewater treatment plant. Centralised systems are often located on the edge of urban areas where there may be opportunities for heat from the centralised AD system to be used at other nearby commercial or industrial facilities.

2.2.3 Animal manure and agricultural waste

Agricultural manure and crop production residual wastes are generally from a single source.

Farm-based processing systems are designed for farm manure, for the manure from several nearby farms, or for the use of residues from crops from local fields. Internationally, because manures may be dilute in organic material many farm-based systems will rely on off-farm feedstocks such as food processing by-products to boost biogas production and increase operational effectiveness. Farm-based systems have the advantage of a local source of inputs and the ability to handle digestate nutrients for self-use. When compared to the management of raw manure, farm-based systems experience the additional benefits of odour reduction, pathogen treatment, improved manure handling and more effective soil conditioning.

In New Zealand farm dairy effluent discharge to land without prior processing is regulated by regional councils under the Resource Management Act and, in addition, there are a number of good management practice guidelines available from the Dairy NZ website.

It should be noted that the 2019 Biogro compost guidelines[3] allow the use of anaerobic digestion residues as input for certified primary producers producing compost on site in the production of anaerobic compost/bokashi as long as manure is not included and as long as the compost is made for own use (i.e. not for sale as a biofertiliser).

2.2.4 Biosolids

Biosolids are treated sewage sludges from a wastewater treatment plant. It is important to distinguish between sewage sludge and biosolids. Biosolids can only be considered as such once they fulfil the requirements of a set of approved biosolids management guidelines[4].

Sewage sludge is the solids that are collected from the wastewater treatment process, but which have not undergone further treatment. Sludge normally contains up to around 3% solids. Sewage sludge is regarded as having become biosolids once it has undergone further treatment to reduce disease causing pathogens and volatile organic matter significantly, producing a stabilised product suitable for beneficial use on soils.

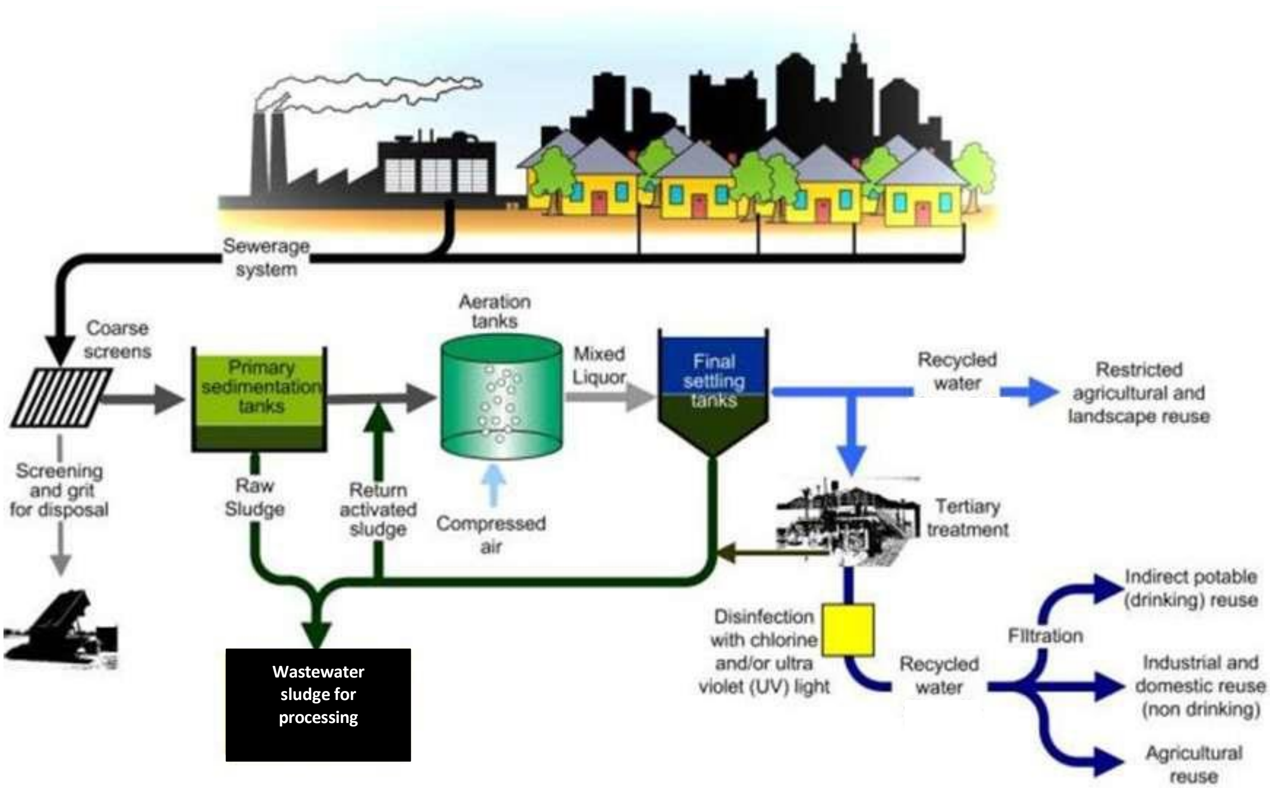

Figure 2: Processes in a typical wastewater treatment plant producing sludge for processing into biosolids
Source: Australian Water Association.

3 https://static1.squarespace.com/static/5783012e1b631b1a87b5f0de/t/5e44601260eb477252c92bd6/1581539348008/BioGro+Compost+Guideline .pdf

4 https://www.biosolids.com.au/info/what-are-biosolids/

Biosolids may contain:

- Macronutrients, such as nitrogen, phosphorus, potassium and sulphur and
- Micronutrients, such as copper, zinc, calcium, magnesium, iron, boron, molybdenum and manganese

Biosolids may also contain traces of emerging organic micropollutants (PFAS, PFOS, others, microplastics), synthetic organic compounds used in the treatment (such as dewatering polymers) and metals, including arsenic, cadmium, chromium, lead, mercury, nickel and selenium. These contaminants limit the extent to which biosolids can be used, with all applications regulated by appropriate regulations. Treatment processes produce a stabilised product suitable for beneficial use on land.

Biosolids, normally contain between 15% to 90% solids. Biosolids are carefully treated and monitored and they must be used in accordance with regulatory requirements.

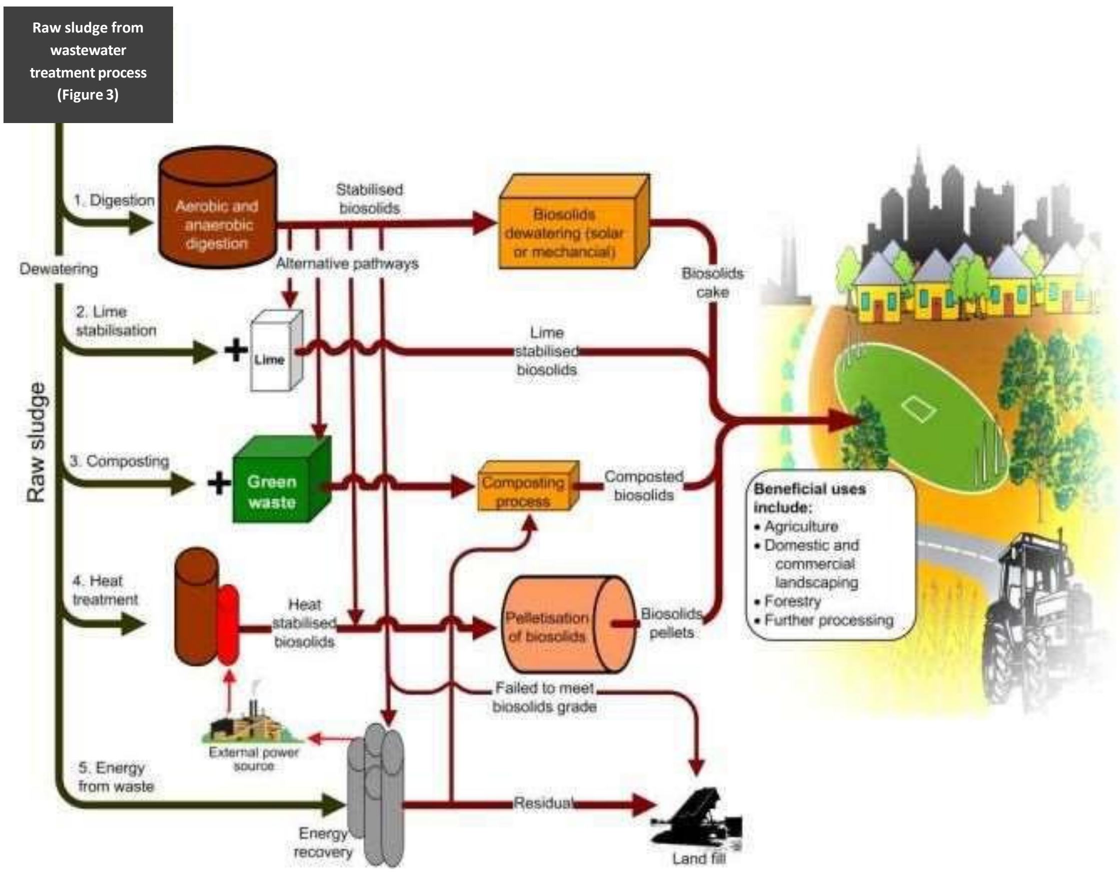

Figure 3: Five typical production systems for biosolids with possible alterative productions pathways
Source: Australian Water Association.

Biosolids are graded according to chemical composition and the level of pathogens remaining after production. Not all biosolids can be used for all applications. Lower qualities are typically used for road bases and mine site rehabilitation. Only the highest grade of biosolids can be used to grow crops for human consumption. In Australia regulators, such as State Departments of Health and Environment strictly control the production, quality and application of biosolids. In New Zealand the regulators follow the *Guidelines for safe application of biosolids to land (2003.)*

In Australia and New Zealand, biosolids have been used for:

- Land application in agriculture (vine, cereal, pasture, olive)
- Co-generation/power production/energy recovery
- Road base
- Land application in forestry operations
- Land rehabilitation (including landfill capping)
- Landscaping and topsoil
- Composting
- Oil from sludge (experimental).

Other uses include:

- Bricks and construction material
- Vitrification (glass manufacture)
- Solid biofuel
- Fuel substitute (cement works)

2.3 A Review of the Anaerobic Digestion Process

Anaerobic digestion (AD) is a collection of naturally occurring processes that convert organic matter, in the absence of oxygen, into energy-rich biogas and liquid residue, known as digestate. Anaerobic digestion has been widely used around the world for the processing of waste organic materials and its popularity is still growing due to its key role in business and communities moving to adopt circular economy principles. In its most important role, anaerobic digestion can facilitate a diversion of large volumes of agro-industrial, domestic and commercial organic material and by-products from landfill disposal and reduce the methane emissions this practice creates.

Biogas produced from residual organic waste typically consists of 35–75% methane, 25–65% carbon dioxide, 1–5% hydrogen along with minor quantities of water vapor, ammonia, hydrogen sulphide and other contaminants. The biogas can be used for generation of heat and/or electricity or purified, compressed and used as vehicle fuel. More recently, biogas has been used for production of renewable carbon dioxide, bio-methanol or other added-value chemicals and bio-based products.

During the AD process, the majority of nutrients contained in the reclaimed wastes are retained in the form of liquid residue digestate. Digestate can provide an alternative supply of nutrients to farmers as a substitute for mineral fertilisers. This can result in energy, fossil fuel and greenhouse gas emissions savings[5]. The use of digestate derived from food waste can save 20-40 kg CO_2e per tonne of digestate in comparison to mineral fertiliser.

Further to the above listed benefits, digestate can improve New Zealand's balance of trade since a large majority of mineral fertilisers or their raw ingredients are currently imported.

Nutrients (N, P, K, etc.) in digestate are present in a more plant-accessible form than in its raw solid organic waste form, hence increasing the nutrients' utilisation efficiency and reducing pollution of the environment from leaching of the non-utilised portion of the nutrients. The nutrient content of digestate is consistent over time, provided it is stored and handled correctly. This makes it easier for farmers to calculate the required fertiliser application rate to meet crop needs (Birkmose, 2007).

In addition to its nutrient value, digestate also provides large quantities of organic carbon to the soil, which is beneficial for soil and crop health. Research has shown that the use of digestate as biofertiliser leads to an increase in yield, protein content of crops and improved soil moisture-retention properties, and consequently increases quality and quantity of food without adverse effects on the environment (Makadi, Tomoscik, & Orosz, 2012, Wager-Baumann, 2011).

[5] https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=3291

2.4 Anaerobic Digestion Feedstocks & Digestate Quality

The quality of digestate is determined by the digestion process used and the composition of the feedstock (Makadi, Tomoscik, & Orosz , 2012). During anaerobic digestion the feedstock biomass is broken down to non-digestible residue (under AD process conditions), water and biogas consisting mainly of methane and carbon dioxide. While this reduces the dry matter concentration of most AD feedstock by up to 70-90%, the nutrient content of most macro and micronutrients is preserved – apart from nitrogen and sulphur, where gaseous losses in the low single digit per cent range have been recorded (Munzert & Hueffmeier, 1998). When applied correctly on land (typically using surface and subsurface application rather than spraying), these nutrients may re-enter the food chain via uptake by plants and crops, creating a closed-loop nutrient cycle (Figure 4). Additionally, the effect of residual organic matter in digestate on soil organic matter is a vital additional aspect. Note the figure below shows an idealised nutrient recovery; significant nutrient loss can occur through volatilisation and run-off through over application, or application to saturated soils.

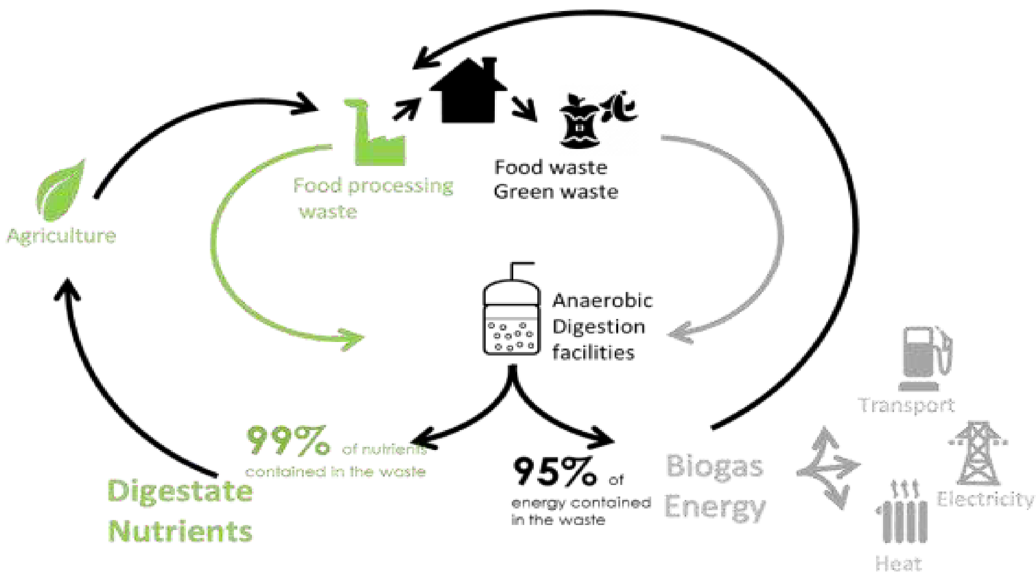

Figure 4: Closed Nutrient Cycle

The mass loss caused by the anaerobic digestion mainly depends on the nature and the proportions of the starting feedstock, where the content of organic solids and their biodegradability are two decisive factors. The AD operating conditions are also important; in particular the retention time and the temperature in the digester have an influence on the degradation rate and on the mass loss. The mass loss equals the amount of biogas produced. Reference values for the mass loss are 3% for manure and 20 to 30% for silage. In the case of food residue, 70 to 80% mass loss may be expected (Wager-Baumann, 2011). For high fat oil and grease substrates such as DAF sludge and grease trap waste 90% mass loss of the organic material has been recorded.

While the total content of most nutrients is preserved, the form and availability of some of these is significantly changed by the AD process. During the decomposition of organic matter, organically bound nitrogen (proteins) and phosphorus are partially oxidised into ammonia and orthophosphates, respectively, hence becoming readily accessible to plants when applied to land. Sulphur is reduced to sulphide and, depending on the pH and presence of suitable metals, it either forms metal sulphide precipitates or becomes hydrogen sulphide.

Besides the above-mentioned nutrients, digestate also supplies slowly decomposable organic materials that stimulate the formation of humus in the soil. Humic substances increase the soil's aggregate stability (friability) and contribute to its ability to retain water and nutrients. Due to the fact that many soils tend to lose organic substances, the use of digestate has proven to favour the development of stable organic matter in the soil (Wager-Baumann, 2011). Poorly degradable or non-degradable organic matter such as lignin and cell debris will remain unchanged during the process of AD.

Table 15 (Appendix A) shows characteristics of feedstock and liquid digestates from different origins. These are mean values and will differ on a case-by-case basis. It is recommended that the quality and composition of digestate is monitored on a regular basis.

Digestate can be mechanically divided into liquid and solid phases and applied separately. Depending on the separation process and its efficiency, the digestate components distribute between the two phases. The majority of the ammonia nitrogen and potassium remain in the liquid phase, while dry matter and phosphorus tend to get separated as the digestate solids (Figure 5).

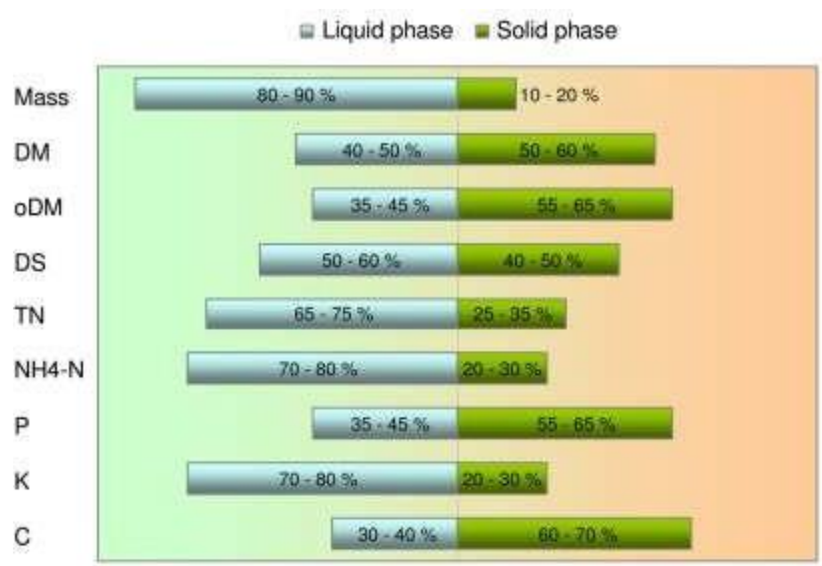

Figure 5: Distribution of digestate components between solid and liquid phase (Wager-Baumann, 2011)

Composition

Feedstocks vary in their biodegradability and content of macro- and micro- nutrients. Biodegradability and nutrient content, along with the efficiency and stability of the digestion process, determine the final fertiliser composition of the digestate. While the organic matter gets degraded in the course of AD by 50-70%, the majority of the nutrients remain in the digestate. For the organic material that does not get fully degraded (typically fibre and ligno-cellulosic compounds) this can provide beneficial carbon to provide structure to soils and improve water retention qualities. Appendix A provides generic information on the composition of common AD feedstocks.

Nutrients

Macronutrients (N, P, S) and micronutrients are essential for life and growth of all plants, animals and all live organisms. Animals absorb nutrients from their feed, but only to a very limited extent and a large majority of the nutrients are excreted. Plants absorb nutrients from soil at the rate required for their growth. Animal manures, plant residues and food waste are therefore an optimum feedstock for biofertiliser production. The elements essential for plant growth get utilised when digestate is applied as biofertiliser, closing the nutrient loop within the food cycle.

From the biogas production perspective, animal manures give relatively low biogas yields and are often co-digested with other biogas-potent materials, such as industrial sludges, waste fat or supplementary agricultural crop material. The AD facility operators are usually limited in selecting feedstocks by their availability within the “catchment”. It is however important to pay attention to the nutrient content of the individual feedstock types since a well-balanced nutrient feedstock mixture positively affects the bacterial activity as well as the value of the digestate product.

Contaminants

Feedstock contamination can be divided into the following categories:

- Heavy metals
- Persistent organic pollutants
- Physical contaminants
- Biological contamination

Along with nutrients, waste materials usually contain a certain level of heavy metals and in some cases, also potentially toxic or non-degradable (persistent) organic compounds. Some heavy metals (so called trace elements such as cobalt, copper, selenium, zinc and others) are in small quantities essential nutrients for healthy life, but most heavy metals have the potential to become toxic at higher concentrations or when metabolised and accumulated in soft tissues (Al Seadi & Lukehurst, 2012).

Persistent organic pollutants (POPs) cannot be degraded in the environment and are often directly toxic to living matter. Heavy metals and POPs will not be removed through AD and will remain in the digestate. While nutrients get utilised when digestate is applied as biofertiliser, heavy metals or persistent organic molecules can also be absorbed.

Herbicides and fungicides may be an issue when supplementary agricultural crop material is being digested. While the probability of transfer of most pesticides through digestate application back to land appears to be relatively low (Al Seadi & Lukehurst, 2012), there is still debate around the persistence of some common herbicides such as glyphosate (Kissane & Shepherd, 2017).

Physical contaminants can be present in the form of large clumps of digestible material or non-biodegradable objects, such as metal, plastic, wood or packaging material.

Feedstocks derived mainly from animal by-products may contain biological risks, such as transmissible bacteria, viruses, intestinal parasites, weed and crop seeds and crop diseases. Although AD has a certain degree of sanitation effect, some additional measures may need to be taken so that the produced digestate is free of these entities. In order to avoid contamination, some feedstock or the resulting digestate may require pasteurisation either at the production site or at the AD site. Digestate is a biologically active biomass and as such requires continuous quality monitoring and rigorous observance of safe production and handling practices.

The presence of chemicals arising from processing (e.g. chemical flocculants and preservatives) and feedstock production (e.g. synthetic fertilisers) may preclude the digestate as being defined as an organic fertiliser. It is not the intention that digestate certification would specify the digestate as “organic”.

The high biological risk, along with heavy metal contamination, is the reason why co-digestion of sewage sludge (i.e. solid residue from treatment of municipal sewage) in AD plants using digestate as biofertiliser is strictly controlled and has been excluded from the scope of TG8.

Feedstock pre-treatment prior to anaerobic digestion will affect the quality and quantity of the digestate. Generally, feedstock is pre-treated in order to:

- Reduce the water content of feedstock
- Increase digestibility of the feedstock
- Sanitise the feedstock material.

In order to reduce the cost of the feedstock transport and treatment, feedstock with low dry matter content (e.g. pig slurry) can be pre-separated into liquid and solid fractions, with the solid fraction being supplied to the AD plant and the liquid fraction being used for irrigation. To some extent, the selection of separation technology also affects the distribution of nutrients between the liquid and solid fraction of the feedstock, which may be an important factor with regards to the expected quality of the digestate (Table 19 in Appendix A).

Digestibility of the feedstock can be improved via several pre-treatment methods, ranging from the basic removal of non-digestible material (contaminants), mashing or homogenisation. The more advanced pre-treatment methods usually target rigid organic structures via maceration, thermal and chemical hydrolysis or ultrasound treatment in order to make them more accessible to anaerobic microorganisms.

Sanitation/Pasteurisation aims to achieve production of pathogen-free digestate. The sanitation/pasteurisation process can be applied to all or selected feedstock or the digestate. In AD plants treating mixed feedstock, it can be more cost-effective to sanitise only specified high-risk feedstock as it reduces the cost of the sanitation process. In such cases, it has to be ensured that cross- contamination of the entire feedstock mixture prior to sanitation is prohibited. The sanitation can also be carried out at the producer's site in order to reduce the biological hazard during the transport of un- sanitised material. Tables 1 and 2 below illustrate the effectiveness of anaerobic digestion in pathogen and weed reduction.

Table 1: Time required for 90% destruction of some pathogenic bacteria in AD systems (Al Seadi & Lukehurst, 2012)

Bacteria	**53°C (hours)**	**35°C (days)**
Salmonella typhimurium	0.7	2.4
Salmonella Dublin	0.6	2.1
Escherichia coli	0.4	1.8
Staphylococcus aureus	0.5	0.9
Mycobacterium paratuberculosis	0.7	6.0
Coliform bacterial	-	3.1
Groups D Streptococci	-	7.1
Streptococcus faecalis	1.0	2.0

Table 2: Survival of weed seeds (% germination) after mesophilic AD expressed in number of days (d) at 37°C (Al Seadi & Lukehurst, 2012)

Plant species	**2d**	**4d**	**7d**	**11d**	**22d**
Brassica Napus (Oil Seed Rape)	1	0	0	0	0
Avena fatua (Wild Oat)	0	0	0	0	0
Sinapsis arvensis (Charlock)	0	0	0	0	0
Fallopia convolvulus (Bindweed)	7	2	2	0	0
Amzinckia micranta (Common Fiddleneck)	1	0	1	0	0

Digestate can be applied directly to land without any treatment once it is removed from the digester and cooled down. However, the low solids content of whole digestate increases the cost of storage and transport. This makes digestate dewatering and volume reduction an attractive option (Al Seadi & Lukehurst, 2012). The common digestate processing and utilisation technologies applied at present to digestate are presented in Figure 6.

Digestate treatment, which has the main purpose of enhancing quality and marketability of the digestate as a useful product is generally called *digestate conditioning*, while the practices aiming to remove nutrients and residual organic matter are called *wastewater treatment*. The water content has a decisive influence on the costs of the treatment of digestate. Whereas most of the solids can be removed by means of simple technologies like a screw press separator, the remaining liquid phase requires much more complex and costly procedures for both, conditioning as well as wastewater treatment (Wager- Baumann, 2011).

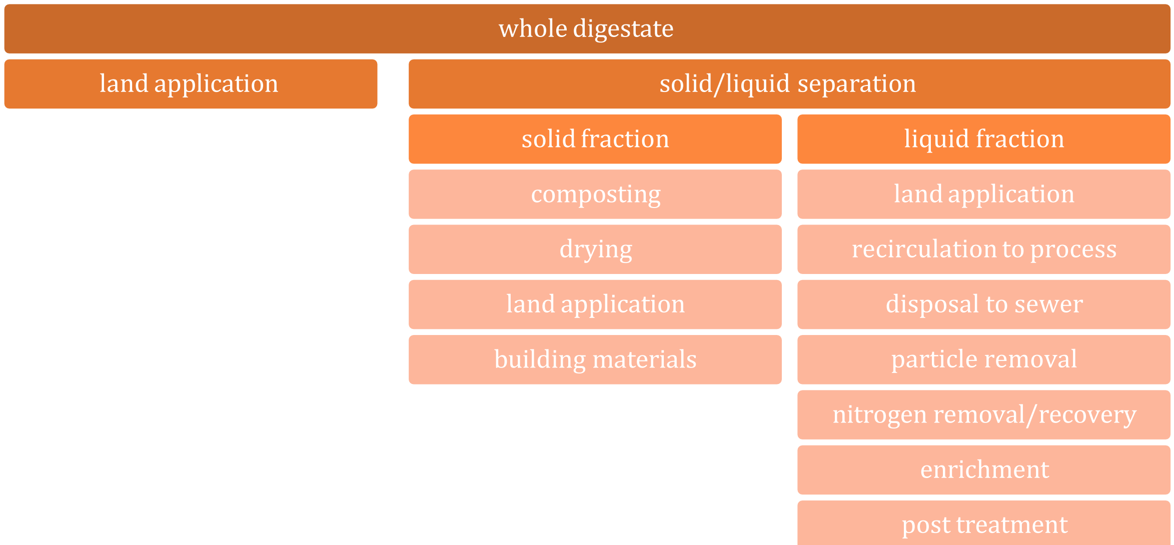

Figure 6: Digestate treatment and utilisation

The selection of a solids-liquid separation technique should be based on the required efficiency, required throughput, capital cost and operating cost of the processing machinery. These aspects are compared for a selection of separation techniques in Table 19 (Appendix A). Particle size of the digestate solids is one of the main factors affecting the efficiency of the equipment. While screw presses are limited to particles larger than 1 mm, decanter centrifuges are efficient in removing solids as small as 0.02 mm.

The solid fraction of the digestate can be directly applied to land as soil conditioner. Alternatively, the solids can be composted or dried and pelletised.

Other non-agricultural uses for digestate also exist. The production of composite construction materials using separated digestate solids is a relatively new application and is still mostly in development stage. Dried digestate solids can also be incinerated for heat or energy production.

The liquid fraction can be directly applied to land or reused within the AD plant for wetting of dry feedstock materials. Advanced filtration technologies (micro-filtration, ultra-filtration, reverse osmosis) or evaporation are used for enrichment of the digestate. Nutrients can be recovered from the digestate in solid form by precipitation (MAP – magnesium ammonium phosphate) or ammonia stripping, or removed using conventional biological treatment methods. In some cases, liquid digestate can also be directly disposed of by discharge to local sewer.

2.5 Anaerobic Digestion in New Zealand & Australia

The use of anaerobic digestion for processing of organic wastes in New Zealand and Australia has been very limited in comparison with other developed countries. This can be mainly attributed to the investors' focus being on the biogas production as a source of energy and little regard being given to the value of digestate. The economic benefits of proposed AD projects have therefore been understated because of the relatively low cost of energy, the majority of which is produced from renewable sources in New Zealand, and the low landfill charges.

Anaerobic digestion, despite the low adoption rates to-date, aligns well with a number of core governing principles and policies of New Zealand and Australia:

- Since 2015, New Zealand and Australia have both been committed to achieving the United Nations 17 Sustainable Development Goals (SDGs) and 169 targets. In both countries this is set to be achieved through a combination of domestic and international actions, including sustainable strategies, policy actions and support programmes. Anaerobic Digestion can make a significant contribution to these targets and goals, not only through generating ultra-low carbon energy and biofertiliser, but also through the reduction of harmful methane emissions from food and farming wastes, providing energy and food security, improving waste management and sanitation, and reducing poverty and hunger.

- As part of ratifying the Paris agreement on climate change, the New Zealand government has committed to reduction of greenhouse gas emissions in the Climate Change Response (Zero Carbon) Amendment Act 2019. With 5.1% of New Zealand's total greenhouse gas emissions and equipped with proven and readily available mitigation technologies such as Anaerobic Digestion, the waste sector plays a key role in New Zealand meeting its emission reduction targets.

- Similarly, in Australia the focus on augmenting diminishing natural gas supply by renewable natural gas is driving a greater interest in the production of biogas from organic waste.

- Anaerobic Digestion has the potential to assist with a reduction in reliance on imported fossil fuels driven by an ever-increasing demand for fuel and energy[6] and declining domestic natural gas reserves. Increasing global competition for fossil fuel resources will require the energy mix to change from predominantly coal, oil and gas to being predominantly based on renewable energy from hydro, geothermal, wind, solar, marine and biomass (Biogas Strategy 2010 to 2040, 2011).

- In New Zealand the Waste Minimisation Act encourages a reduction in disposal and an increase in recycling and reuse of waste in order to protect the environment from harm and provide environmental, social, economic and cultural benefits. In Australia most states have now developed strong waste strategies which include incentives for the production of energy.

- Overseas experience shows that segregation of organic waste at source for AD processing incentivises reduction of waste disposal, and increases recycling and use of waste, which is in line with the waste hierarchy as defined by the New Zealand Waste Minimisation Act.

- The increasing interest in circular economy principles at both a governmental and business level is bringing the utilisation of organic waste, rather than disposal to landfill, into the strategic thinking of communities and businesses[7].

Currently, the most common method of recycling organic waste is by composting. This traditional method dates back many centuries when farmers would leave organic wastes in the open to decompose slowly and naturally on their land. Nowadays, in New Zealand the disposal of compost to land is covered by *NZS 4454:2005, Composts, Soil conditioners and Mulches* which sets out the minimum quality criteria for composting facilities and their products for their beneficial use.

Despite the compost's beneficial soil-conditioning properties and process operational simplicity, composting is not suitable for all organic waste. These are for example animal by-products such as meat which, even composted, cannot be used as a soil conditioner where animals graze. There are also very wet organic wastes which are better suited to anaerobic digestion than composting where drier matter is more appropriate.

Anaerobic digestion and composting should therefore be viewed as complimentary technologies and their merits and risks need to be assessed on a case-by-case basis. Among other factors, consideration needs to be given to the type of waste available, footprint and location of the food processing site and market demand for the product.

[6] 1.2% of annual energy used by mankind is to synthesise N-fertilisers (Wood & Cowie, 2004).

[7] https://www.bioenergy.org.nz/resource/biosolids-guidelines-report-2003

2.6 Digestate within the current New Zealand Regulatory framework

Other than the fish waste digestate product produced by Globe Fisheries in their large on site digester in the 1990's and 2000's which received BioGro certification and was used for many years in pastoral farming, the application of digestate as biofertiliser has not previously been validated in New Zealand due to the scarce utilisation of the AD process to date. The lack of clear regulatory framework for the application of digestate on land has been identified as one of the key barriers for wider utilisation of the technology.

The underlying legislation governing the application of any organic material products (including digestate) to land in New Zealand is the Resource Management Act 1991 (RMA). Apart from direct regulations, the RMA is used as a basis for development of region-specific resource management plans that ultimately define the rules applicable to the use of digestate on land (illustrated below in Figure 7).

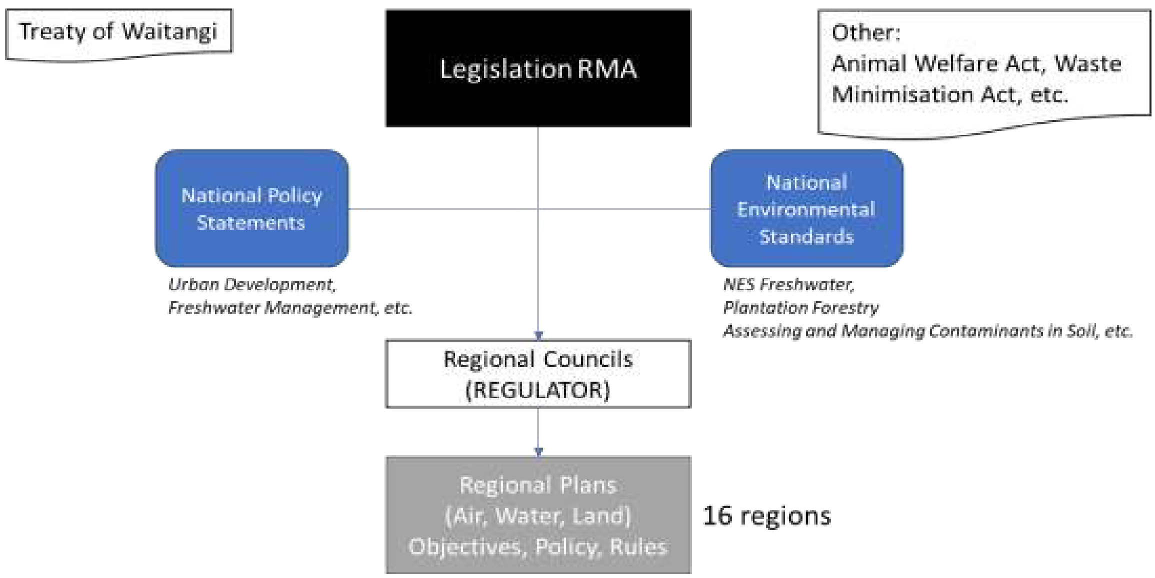

Figure 7: The legislation governing the application of organic materials to land in New Zealand

Further to that, there are currently three key documents that are directly or indirectly related to the use of digestate as fertiliser:

- *Guidelines for safe application of biosolids to land 2003*[8] (Biosolids Guidelines)
- Water NZ - *Guidelines for Beneficial Use of Organic Materials on Productive Land*[9] (The Revised Guidelines - a revision of the Biosolids Guidelines)
- Soil replacement requirements specified for urban and rural areas embedded in individual regional resource management plans[10]

[8] https://www.bioenergy.org.nz/resource/biosolids-guidelines-report-2003

[9] https://www.waternz.org.nz/Projects

[10] Regional Councils acting as consenting authorities operate within the Rules in their Regional Plans. These Rules are only changed when the Regional Plan is reviewed. As a consequence, the certification framework set out in TG8 will only be recognised at the discretion of Council.

Other legislation (e.g., the Agricultural Compounds and Veterinary Medicines Act, the Health Act, the Land Transport Act) may have a direct or indirect bearing on a given manufacturing or distribution facility depending on the specific feedstocks and technology used.

The main governing document (Biosolids Guidelines 2003) is currently undergoing a revision with the revised document (The Guidelines for Beneficial Use) expected to be released in the near future[7]. Although the new Guidelines will not have a regulatory status, it is anticipated that all councils will adopt the revised Guidelines when evaluating and consenting the production and use of digestate.

However, in the context of the Revised Guidelines, digestate, regardless of its origin, its beneficial properties or nutrient quality, is considered to be waste. As such, biosolids and/or digestate require testing to prove they possess low risk for the receiving environment. The level of testing is dependent on the source of the feedstock and the form of treatment.

A fundamental premise of the Revised Guidelines is that, rather than focusing only on biosolids, the scope has been widened so that a wide range of organic materials can be beneficially applied to land. Provided that both the process of product manufacture and the process of applying the material to land are subject to adequate management control, and providing the organic material is applied at a rate that does not exceed the agronomic nitrogen requirements of crops.

The relationship between TG8 and the Revised Guidelines is similar to that of the New Zealand Standard 4454:2005 - Composts, Soil Conditioners and Mulches, in that there is a hierarchy of guidelines with the Revised Guidelines being the overarching document. If the methods and limits for protecting soil, the environment, and public health change or differ in the Guidelines then the Guidelines methods and limits will take precedence over TG8. The reason for this hierarchy is that the Revised Guidelines have been developed with and will be endorsed by Government agencies including The Ministry of Health, The Ministry for Primary Industries and The Ministry for the Environment after extensive peer reviewed research, whereas TG8 is an industry document drawing on the same research, but less peer reviewed.

TG8 is an industry specific guide sitting within the research and limits of the Revised Guidelines. It is important that individual industries develop their own specific guidelines that provide tailored solutions for specific materials applied to land as a fertiliser or soil conditioner. The Bioenergy Association works to ensure that TG8 is aligned within the contaminant limits and risk management practices in the Revised Guidelines to ensure the safe and beneficial application of organic material to soils in NZ. Figure 8 illustrates where TG 8 sits within the New Zealand regulatory setting for organic materials applied to land.

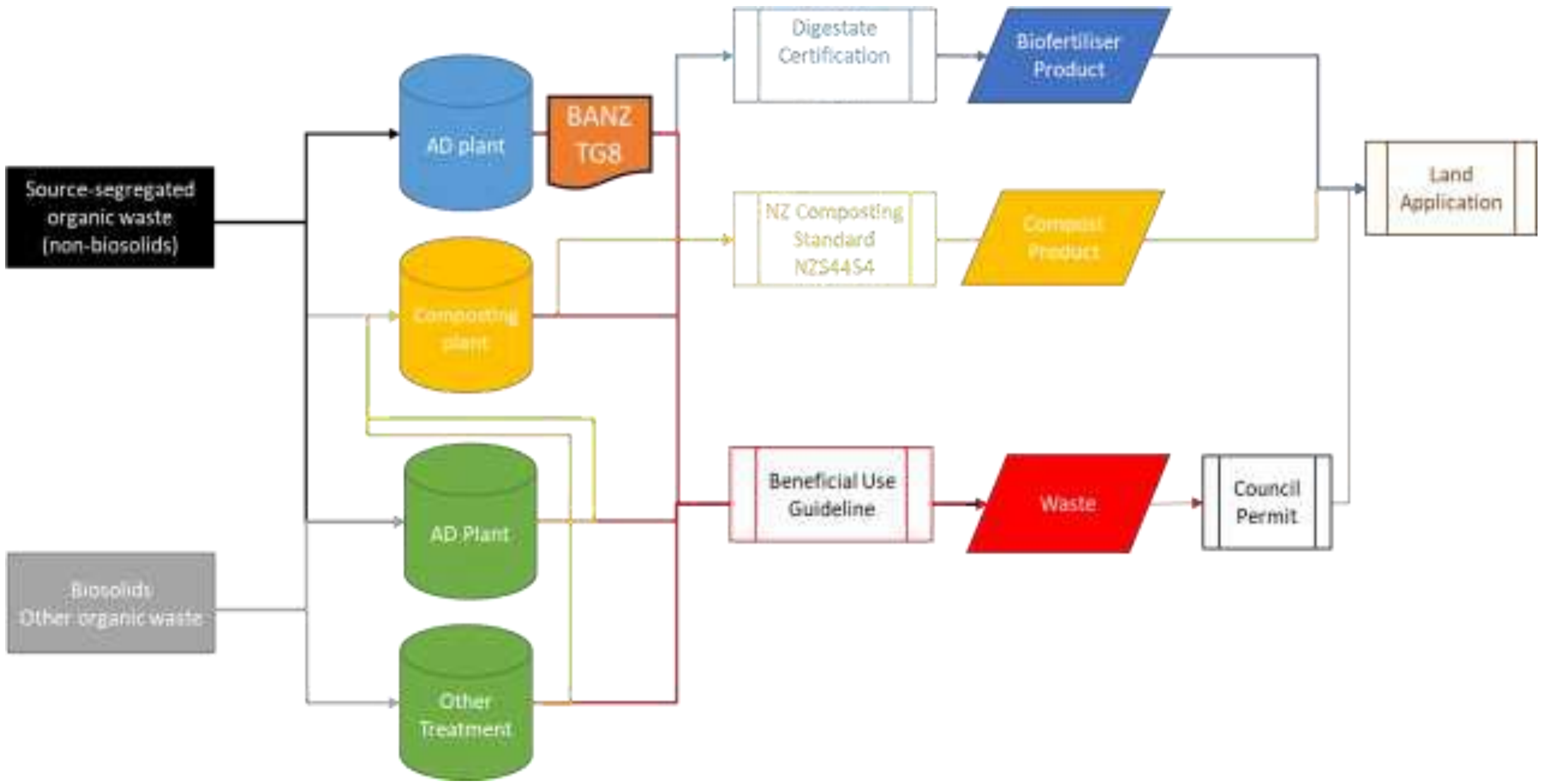

Figure 8: How TG 8 and Biofertiliser products fit within the New Zealand regulatory setting

2.7 Digestate within the Australian Regulatory framework

In the Australian jurisdictions, AD is a recognised treatment method of treating sewage sludge at WWTPs so that it can be applied to land as biosolids. Australian regulations for the use of biosolids are set individually by states. All regulations require the digestate to ensure pathogen and seed elimination, compliance with other legislation as well as set limits on heavy metal concentrations.

There is a lack of consistent national regulation for the digestate from source-segregated organic waste, which prevents the industry from maximising its use. Specifically, the conditions for using it as a commercial product need to be clarified, as well as the specifications of its composition.

2.8 Digestate within the United Kingdom regulatory framework

The use of digestate, derived from source segregated biodegradable waste, as a beneficial source of nutrients has been successfully adopted in the UK via the framework outlined below. This framework is valid for AD plants that process waste of animal or plant origin that can be biologically decomposed. As such, this framework does not apply to AD plants processing biosolids or other waste of human origin.

Within this framework, digestate can be applied on land in two forms:

1) As a biofertiliser product which requires compliance with:
   a) BSI PAS 110 - minimum digestate quality criteria[11]
   b) The Anaerobic Digestate Quality Protocol[12]
   c) Biofertiliser Certification Rules

2) As waste, which requires:
   a) compliance with BSI PAS110 compliant digestate
   b) provision of an EA deployment permit
   c) The AD plant operators may seek Quality Assurance Certification to boost the credibility of their output/digestate

The application of biosolids on agricultural land is regulated by The Sludge (Use in Agriculture) Regulations 1989[13] and the Safe Sludge Matrix[14].

The Biofertiliser Certification Scheme[15] is the only independent scheme in the UK aligned and providing a framework for independent assessment and certification of digestate to BSI PAS 110, the Anaerobic Digestate Quality Protocol, the Scottish Environment Protection Agency's (SEPA's) regulatory position statement, and the BCS Scheme Rules.

Any UK producer can choose to apply for BSI PAS 110 certification, irrespective of the country/ies in which the digestate is used and according to whether it is intended to be supplied as a ‘product' or a ‘waste'.

The Anaerobic Digestate Quality Protocol sets out end of waste criteria for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste. To be Quality Protocol compliant for this material, people will need to be certified against the BSI PAS110 certification scheme, which is managed by the Environment Agency.

BSI PAS 110 - Producing quality anaerobic digestate[16]

The publicly available specification (PAS) BSI PAS 110 aims to remove the major barrier to the development of AD and its markets for digestion process outputs by creating an industry specification against which producers can verify that they produce a product which is of consistent quality, safe and fit for purpose.

BSI PAS 110 covers all AD systems that accept source-segregated biowastes. It specifies:

- Controls on input materials and the management system for the process of anaerobic digestion and associated technologies;
- Minimum quality of whole digestate, separated fibre and separated liquor; and
- Information that is required to be supplied to the digestate recipient.

The Quality Protocol for Anaerobic Digestate[17]

The Anaerobic Digestate Quality Protocol sets out criteria for the production and use of outputs from anaerobic digestion of source-segregated biodegradable waste.

The Quality Protocol (QP) gives official status to the PAS 110 in England, Wales and Northern Ireland.

To be Quality Protocol compliant for this material, people will need to be certified against the BSI PAS110 certification scheme, which is managed by the Environment Agency.

The protocol provides a set of criteria for the production, placement on the market, storage and use of products derived from suitable types and sources of organic waste, such that any risks to the environment and to human and animal health are acceptably low when any such product might, under certain circumstances, be used without waste regulatory controls. The Protocol also sets out how compliance with its criteria should be demonstrated.

Additional information on the processing of residual organic waste in the UK is available from WRAP UK[18].

[11] https://www.wrap.org.uk/content/bsi-pas-110-producing-quality-anaerobic-digestate
[12] http://www.biofertiliser.org.uk/adqp
[13] http://www.legislation.gov.uk/uksi/1989/1263/made
[14] https://www.fas.scot/downloads/safe-sludge-matrix/
[15] https://www.biofertiliser.org.uk/
[16] http://www.wrap.org.uk/content/bsi-pas-110-specification-digestate
[17] https://www.wrap.org.uk/content/bsi-pas-110-producing-quality-anaerobic-digestate
[18] https://www.wrap.org.uk/

3 The Biofertiliser Framework

The New Zealand Biofertiliser Framework is an industry specification that is designed to eliminate the barriers to using digestate as a fertiliser in New Zealand. By following the steps within the Framework, digestate can cease to be classed as waste and become a biofertiliser product. This potentially removes the need for consenting to apply digestate to land and offers opportunities for the sale of digestate as a biofertiliser (the need for consents will be discretionary to consenting authorities until incorporated into Regional Plans).

It is based upon the UK's *BSI PAS110 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials. PAS110* is the general international standard used in many countries and along with the *Quality Protocol for Anaerobic Digestate,* it has been in use for over 10 years and is highly respected.

The framework is voluntary and consists of two stages, Digestate Biofertiliser Certification and Producer Accreditation. It is designed for producers of digestate that meets the minimum quality criteria (input materials and physical, chemical and biological characteristics) set out within this Framework who wish to market their digestate as a quality assured biofertiliser. Figure 9 below illustrates where the framework fits within the processing of source separated organic wastes.

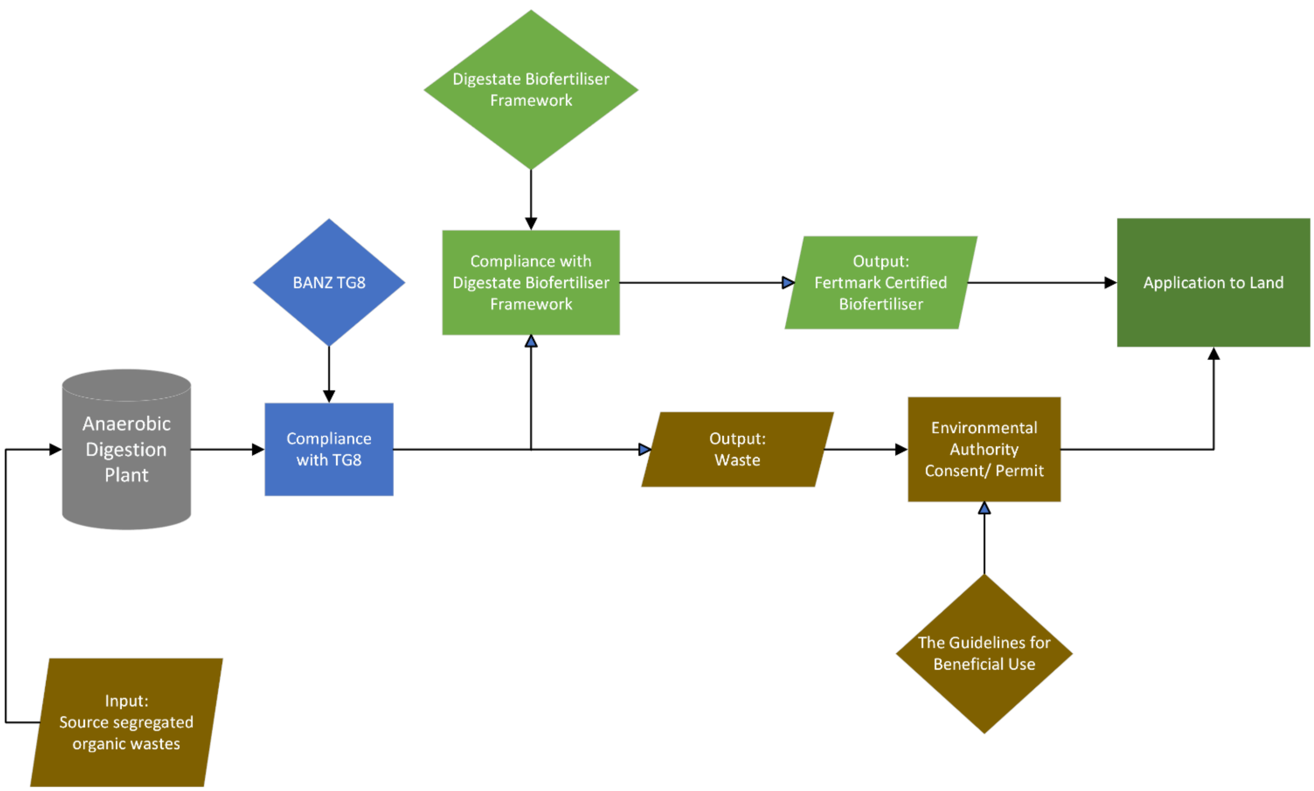

Figure 9: Biofertiliser Framework for use of digestate from anaerobic digestion of source-segregated organic waste

Figure 9 demonstrates source-segregated organic waste can go down either the pathway covered by the framework which results in a product able to be sold as a certified biofertiliser, or the pathway covered by the Guidelines which results in digestate that remains classed as a waste.

The Biofertiliser Framework, like the Composting Standard NZS4454, adopts the same product quality requirements as specified in the Guidelines. With predictable AD plant operation (through quality assurance) and the use of consistent source segregated waste feedstock, an alternative more cost-effective approach can be taken to achieve compliance with The Guidelines.

With the Biofertiliser Framework using the same limits specified in the Guidelines Technical Appendices, biofertiliser users can be confident that the products meet the requirements approved by the Ministry of Health, the Ministry for Primary Industries and the Ministry for the Environment to ensure the safety of humans, animals and plants.

The authors acknowledge that the matters discussed in the TG8 may bear importance to Māori culture and traditions. The governing document, the *Guidelines for beneficial use of organic materials* prepared by Water NZ, has been extensively consulted with iwi authorities. The consultation of the TG8 with iwi authority has taken the form of public announcements and invitations for feedback.

3.1 Certified Biofertiliser Products

Compliance with TG8 and the Biofertiliser Framework ensures consistent and high quality of digestate. To minimise regulatory costs and maximise the revenue attainable from sale of digestate, AD facilities that undergo certification in order to decouple the digestate product from the waste regulatory framework are able to class their digestate as a fertiliser for compliance with the Agricultural Compounds and Veterinary Medicines Act. Furthermore, the Framework offers opportunities for cost saving through its operation of a quality assurance based system in comparison to the Guidelines' quality control approach.

The facilities that choose not to or cannot pursue the biofertiliser certification due to feedstock composition or other reasons, are encouraged to refer to the TG8 for best practice guidance for safe, reliable and stable operation of anaerobic digestion processes.

3.2 Non-certified Digestate

Regional councils in New Zealand regulate the disposal or use of non-certified digestate onto land and this may be a prohibited, permitted or discretionary activity depending on the digestate treatment and quality as specified in the Biosolids Guidelines 2003 (the Guidelines) or its revised version the *Guidelines for Beneficial Use of Organic Residues* (draft). The Guidelines set out extensive quality control testing requirements.

3.3 Biofertiliser Certification

The Biofertiliser Certification Guide explains in detail the requirements for producers seeking to obtain Fertmark certification for their digestate. This Guide and supporting document can be found on the Bioenergy Association's website[19]. A summary of key requirements are included in sections 3.3.1 - 3.3.3 but for details reference should be made the full guidance document.

Compliance with the Biofertiliser Certification Guide requirements enables biofertilisers to be made and supplied in a way that minimises risks to land, food safety and animal welfare.

To obtain certification producers must ensure their digestate can meet the minimum quality criteria set out in the Guide. Furthermore, producers must demonstrate that their product consistently meets the criteria through the establishment of a Risk Management Programme for their facility.

The Risk Management Programme consists of:

- A Quality Management System
- A Hazard Analysis Critical Control Point (HACCP) Plan
- A Facility Management Plan

Certification of the biofertiliser product is then completed through application to and auditing by Fertmark. The process is designed to meet both the requirements of producing a biofertiliser to Fertmark and Bioenergy Association jointly specified performance standards, and the need to demonstrate the facility's ability to safely handle and treat biodegradable organic materials in accordance with the current regulatory controls of:

- The Animal Products Act 1999 and Animal Products Regulations 2021
- The Agricultural Compounds and Veterinary Medicines Act 1997
- The Biosecurity (Ruminant Protein) Regulations 1999

Producers applying for Fertmark certification must be aware of the Fertmark Code of Practice that covers the rules for the use of the Fertmark Trademark, policies and protocols, code and conduct, product classifications, protocols for mixing plants, auditor protocol and industry agreed agronomic trial protocols. Please note that all products are audited by QCONZ on behalf of the Fertiliser Quality Council.

Detailed information on the process of applying for Fertmark certification is located within the Fertmark Code of Practice, found on the Fertiliser Quality Council website:

www.fertqual.co.nz

[19] https://www.biogas.org.nz/biofertiliser

3.3.1 Feedstock Materials

The source segregated biodegradable feedstock materials which an AD facility may accept to produce a certifiable digestate is limited to the materials set out in Table 3 and subject to the conditions in Table 4 overleaf.

Table 3: Input materials able to be feedstocks for digestate biofertiliser

Industry	Approved Materials
Agriculture and Primary Processing Residues	Fruit and/or vegetables from the field not intended for human consumption
	Plant parts like leaves or tops free from clopyralid and aminopyralid herbicides
	Purpose grown supplementary crops free from clopyralid and aminopyralid herbicides
	Abattoir and butchery by-products from healthy animals free from disease and not able to be sold as a higher value product. Must comply with conditions 1 and 2 overleaf (Table 4). These by-products include: paunch grass, carcasses/body parts, hides, skins, hooves, horns, feathers, wool, hair, hatchery by products including eggs and eggshells, unhatched poultry in its shell, aquatic animals, and invertebrates
	Shells from shellfish with soft tissue
Domestic and Commercial Garden waste	Organic materials commonly found when working in a domestic garden or commercial green space such as tree branches, pruning from trees and hedges, weeds, lawn clippings, plants, shrubs, leaves and cut flowers. Must comply with condition 3 overleaf (Table 4).
Food and drink processing residues	Residue and by-product material from the manufacture of food products containing meat, fish, dairy. Must comply with condition 4 overleaf (Table 4). Includes material of animal origin that has been passed as fit for human consumption in an abattoir or butchery but for commercial reasons or due to problems of manufacturing or packaging defects or other defects cause no risk to public or animal health. For example, product is passed its use by date, it is damaged or soiled.
	Residue materials from the manufacture of drinks and other beverages
	Reject fruit and vegetables from commercial pack houses
	Brewers' grain/chaff, grape marc (skins, pulp, stems, seeds left over from grape pressing)
Domestic and commercial food waste Must comply with Condition 4 below	Domestic household kitchens e.g. kerbside food scrap collections
	Retail premises, restaurants, cafes, hotels, catering facilities, commercial kitchens
	Food markets, supermarkets, butchers, and bakers
	Schools and workplaces

Table 4: Conditions for Input Materials

Condition 1	The abattoir by-products have been passed as fit for human consumption but are not intended for human consumption either because they are parts of animals we normally do not eat (e.g., hides, bones) or for commercial reasons.
Condition 2	Only meat from processing facilities that are approved for export to the UK and Europe and are compliant with appropriate MPI and EU legislation such that the spinal cord and brain matter are removed separately prior to further processing will be accepted. These processing facilities have Specific Risk Material (SRM) removal systems in place to meet market requirements. All SRM material is treated as high risk, is separated, and sent to rendering with condemned material.
Condition 3	Lawn clippings carry the risk of containing the herbicide clopyralid. Ideally this feedstock should be free of clopyralid. However, if clopyralid is detected, then markets for the biofertiliser will need to exclude high risk crops.
Condition 4	Only meat and meat products which were once acceptable for human consumption is exempt from the SRM material certification requirement, e.g., originating from butchers, supermarkets, restaurants, food processing factories, and kerbside food scraps collections. For clarity this may include (but not limited to) product which is no longer within its use by date, damaged stock and/or meal leftovers.

3.3.2 Digestate Minimum Quality Criteria

Quality testing for nutrients and chemical, biological and physical characteristics of digestate must be carried out according to the accredited test methodologies in laboratories accredited to NZS ISO/IEC 17025 and/or recognised by IANZ (International Accreditation New Zealand, formerly TELARC). Other tests must be carried out accordingly to the test methodology prescribed in NZS 4454:2005 or according to alternate accredited test methodology in accredited laboratories. Sampling protocols to be followed are specified within Sections 9.1-9.8 within *NZWWA Guidelines for the Safe Application of Biosolids to Land in New Zealand (2003)*.

Table 5: Digestate Nutrient Characteristics (minimum nutrient limits for Biofertiliser)

Parameter	Standard	Authorised Analysis Methodology
Nitrogen Phosphorus Potassium Magnesium Calcium Sulphur	Aggregate of all parameters > or equal to 0.6% dry weight	N, P, K, Mg and Ca APHA Nitric Acid Digestion

Source: Fertmark Code of Practice/ BANZ

Note: Calculated using the 6-month rolling average of sampling data. Tolerance limits for these nutrient concentrations is +/-20% on a dry weight basis once production facility reaches steady state (digestion and input feedstocks)

Table 6: Digestate Chemical Characteristics (heavy metal limits for Biofertiliser)

Parameter	Concentration Limit mg/kg dry weight	Authorised Analysis Methodology
Arsenic	30	NZS ISO 17025 (or IANZ) accredited laboratory using accredited test methodologies
Cadmium	10	
Chromium	1500	
Copper	1250	
Lead	300	
Mercury	7.5	
Nickel	1500	
Zinc	135	

Source: Beneficial Use of Organic Materials on Productive Land Vol 1 Guide, 2017 and NZS 4454:2005 Composts, Soil Conditioners and Mulches

Table 7: Digestate Biological Characteristics (pathogen limits for Biofertiliser)

Parameter	Standard	Authorised Analysis Methodology
E coli	Less than 100 MPN/g	Part 9221 F (modified) Standard Methods for the Examination of Water and Wastewater (APHA, 23rd ed. 2017)
Campylobacter	Less than 1/25g	Enumeration of Thermotolerant Campylobacter in Biosolids (A. Donnison, AgResearch Limited) Appendix 1 Biosolids Guidelines
Salmonella	Less than 2 MPN/g	Salmonella sp bacteria: Part 9260 D, Standard Methods for Examination of Water and Wastewater, (APHA, 1988), or Detection and enumeration of salmonella and Pseudomonas aeruginosa (Kenner and Clark, 1974)

Source: PAS 110:2014 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials

Table 8: Digestate Physical Characteristics (allowable physical contaminant limits for Biofertiliser)

Total N of Biofertiliser	Kg/t	<1	1-1.9	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	9 or more
Total Contaminants >2mm	**Kg/t**	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
Total Stones >5mm	**Kg/t**	3.2	6.4	9.6	12.8	16	19.2	22.4	25.6	28.8	32
Authorised Analysis Methodology NRM method JAS-497/001 declared on a fresh weight basis or Accredited methodology at accredited laboratory (NZS ISO/IEC 17025 and/or recognised by IANZ)											

Source: PAS 110:2014 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials

Table 9: Digestate Stability Characteristics (allowable stability limits for Biofertiliser)

Parameter	Standard	Authorised Analysis Methodology
Stability of whole digestate, separated liquor or separated fibre		
Volatile Fatty Acids	0.774g COD / g VS	Gas Chromatography

Source: BANZ

Note: Alternative methods (excluding the alkalinity method) for determining stability as set out in Table 7 may be used, where those alternatives demonstrate an equivalent limit to that set in the table.

3.3.3 Risk Management Programme

To demonstrate the reliability and consistency of digestate production, producers must establish a Risk Management Programme. This is necessary for Fertmark to have confidence that samples taken during certification and routine monitoring are representative of the digestate as a whole. Figure 10 below illustrates how the plans and systems form the facility's Risk Management Programme and Table 10 details the individual components of the Risk Management Programme, detailed guidance on these aspects is found in Section 4.

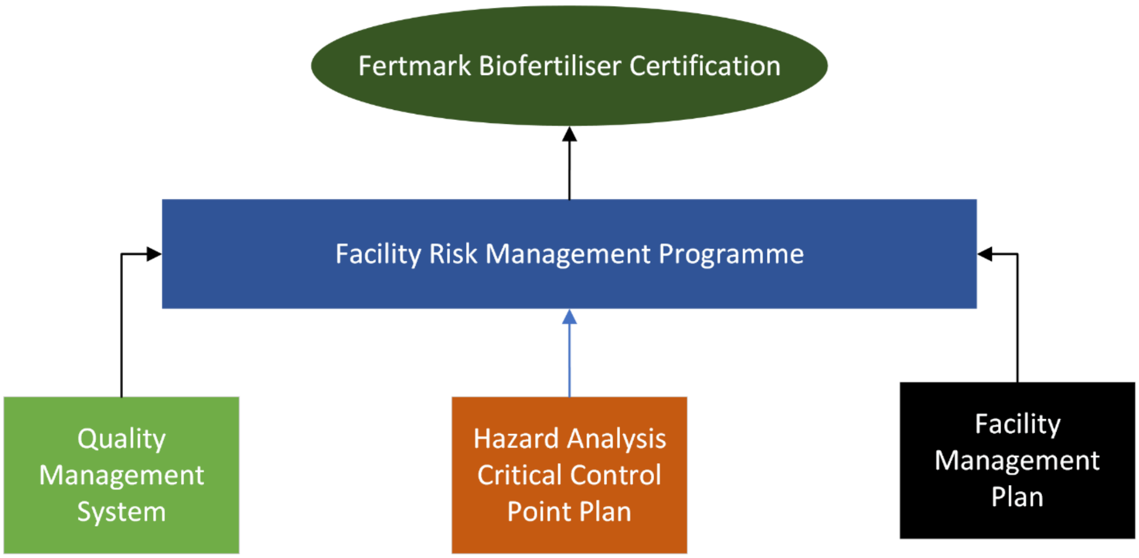

Figure 10: Risk Management Plan requirements for Biofertiliser Certification

Table 10: Components of the Risk Management Programme

Quality Management System	HACCP Plan	Facility Management Plan
1. Management engagement and leadership	1. Hazard analysis	1. Facility details
2. Adequate resourcing, staff training, and contingency planning.	2. Critical control points (CCPs)	2. Process safety management, feedstock separation and storage
3. Clear roles and responsibilities	3. Critical limits	3. Process equipment
4. Quality commitment	4. Monitoring systems to control the CCPs	4. Process monitoring
5. Effective communication	5. Corrective actions when monitoring systems indicate a CCP is not under control	5. Sampling of digestate
6. Regular reviews	6. Verification procedures	6. Actions in the event of test failure
7. Reporting	7. Documenting procedures and records	**7.** Distribution & Storage
8. Document control		

3.4 Producer Accreditation

Once a facility has become a Fertmark certified biofertiliser producer, they can apply to become an accredited producer. Known as the Biofertiliser Producer Accreditation Scheme, it is designed to offer comprehensive support and advocacy to anaerobic digestion facilities within New Zealand and Australia producing Fertmark certified biofertilisers.

Its role is to assist and promote the production of renewable energy and fertilisers from the anaerobic digestion of source segregated biodegradable organic materials. Consisting of annual certification, the Scheme ensures certified biofertiliser producers have demonstrated to an independent party their ability to deliver quality biofertiliser and they have the quality assurance processes and procedures in place to consistently deliver these products.

Administered by the Bioenergy Association, the Scheme provides significant benefits to certified biofertiliser producers (detailed in Figure 9 overleaf) and verifies that facilities producing Fertmark certified biofertilisers are working to industry best practice. Using learning from both national and international experiences and focusing on continuous improvement, the Scheme offers support in relation to training, technology and procedures and informs digestion facility owners of the importance of quality biofertilisers.

Producers must ensure their digestate is produced in line with *the Biofertiliser Certification Guide* and have obtained certification through Fertmark for their biofertiliser product/s. Accreditation requires producers to operate their facilities in full compliance with their Risk Management Programme. Consisting of a Quality Management System, a Hazard Analysis and Critical Control Point Plan and a Facility Management Plan, accreditation of a facility takes place once they are satisfied the facility is operating as documented within its Risk Management Programme and upon receipt of the completed application documentation. Figure 11 overleaf illustrates the benefits of producer accreditation.

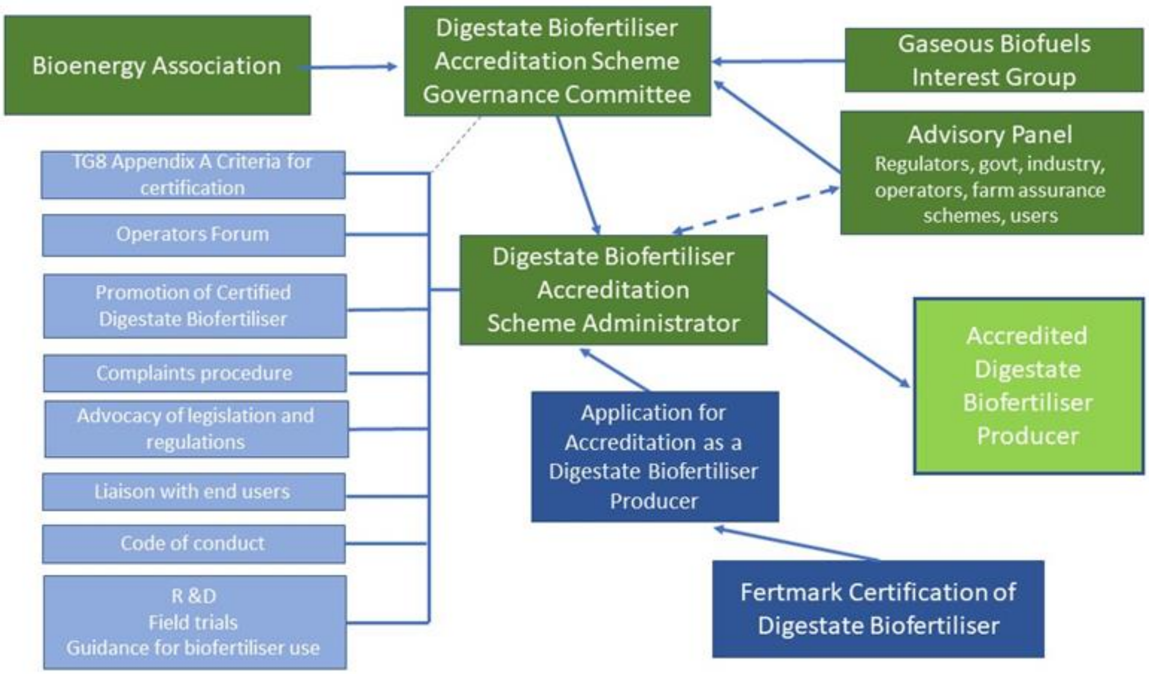

Figure 11: Producer Accreditation Scheme details

4.0 Detailed Guidance: The Biofertiliser Framework

In this section of TG 8, detailed guidance regarding the requirements of the Biofertiliser Framework is presented. It is divided into several sections and is designed to offer supplementary information to support the requirements set out in both the Biofertiliser Certification Guide and the Biofertiliser Accreditation Scheme. It covers:

- The Risk Management Programme
- Health and Safety
- Application Management

4.1 Risk Management Programme

Operators of any AD facility should adopt and implement a Risk Management system in order to ensure that the produced digestate is of consistently high quality. Composed of a Quality Management System, HACCP Plan and Facility Management Plan, the system based on quality assurance is a way of preventing mistakes and defects in manufactured products and avoiding problems when delivering products to customers along with controlling risks to the environment, human and animal health.

Within the context of this Technical Guide, higher emphasis on Quality Assurance increases the reliability of the treatment outcome, while allowing reduction in frequency, extent and consequently the cost of the end product testing currently prescribed in The Guidelines.

4.1.1 Quality Management System

The four main components of a quality management process are Quality Planning, Quality Assurance, Quality Control and Continuous Improvement.

Each AD Facility needs to establish and maintain a specific Quality Management System (QMS). This QMS will be based on EN ISO 9001 and applied to the appropriate and relevant extent to each facility.

The key aspects of QMS for AD facilities are:

1. Management engagement and leadership – senior management needs to demonstrate and communicate commitment to the established quality management system and to continuous improvement.
2. Adequate resourcing – for both, operation and maintenance of the facility as well as of the QMS. This requires securing and/or developing appropriate competence and skills, provision of training and processes and tools for effective knowledge transfer.
3. Clear definition of roles and responsibilities and effective communication of these to the staff.
4. Quality commitment from management to meeting quality standards and customers' requirements in form of quality policy.
5. Effective communication internally and externally of relevant parts of the QMS, including quality standards, processes and results.
6. Regular reviews in form of regular internal audit and management review of the QMS and the HACCP plan. The outcome of the reviews needs to be appropriately recorded, communicated and actioned.
7. Reporting of facility performance and in particular of incidents and accidents or complaints and concerns
8. Document control of documents relevant to the QMS needs to be established and maintained. This includes establishing of document approval, identification, access, storage and archiving processes.

The requirements of each section are explained in detail below.

1. Management Engagement and Leadership

   Senior management must appoint a member of the organisation's management who, irrespective of other responsibilities, must have responsibility and authority that includes:
   - Ensuring that QMS processes are established, implemented and maintained
   - Reporting to senior management on the performance of the QMS and any need for improvement
   - Ensuring the promotion of awareness of customer requirements throughout the organization

2. Adequate resourcing:

Senior management must:
- Ensure sufficient resources for the establishment, implementation, maintenance and improvement of the QMS

3. Clear roles and responsibilities

   Senior management must:
   - Ensure that the responsibilities and authorities are defined, using as a minimum a staff organogram, and that these are communicated throughout the organisation
   - Determine the necessary competencies for personnel performing work affecting digestate quality
   - Ensure that each person whose duties affect digestate quality must be trained, instructed and supervised commensurate with those duties, such that he/she is competent.
   - Ensure training includes the subjects of QMSs and HACCPs, at least for the competent person(s) with overall responsibility for the QMS.
   - Ensures that the individual/s who lead the organisation's training on QMSs and HACCP must receive appropriate training from an experienced training provider.
   - Ensure that contractors are suitably trained regarding site and equipment safety, equipment operation, and that their access on site is controlled.

4. Quality commitment

   The producer must:
   - Establish a quality policy for digestate produced under this QMS

   The producer's quality policy must include:
   - Clear identification of the location of the digestion equipment within the site, the type/s of processes employed, and what digestate output types are produced
   - The producer's commitment to achieving the corresponding minimum quality specified in TG8 for each digestate certified output
   - The producer's commitment to fulfilling customers' requirements regarding its fitness for purpose for each digestate output certified through Fertmark including any additional quality requirements

5. Effective communication

Senior management must:
- Communicate to the organisation that the digestate produced under this QMS must be fit for purpose
- Ensure that the appropriate communication process is established within the organisation and that communication takes place regarding the effectiveness of the QMS
- The quality policy and relevant parts of the QM must be communicated to all personnel whose activities affect digestate quality.
- All personnel whose activities affect digestate quality must be made aware of the relevance and importance of their activities, and how those activities contribute to the achievement of the producer's commitments set out in its quality policy.

6. Regular reviews

The producer must:
- Conduct and record internal audits at planned intervals, at least annually, to determine whether the QMS conforms to its QMS plan for the production of digestates that are fit for purpose and whether the QMS is effectively implemented and maintained.
- Establish and document a procedure that defines the responsibilities and requirements for planning and conducting audits, establishing records and reporting results.
- Review whether the QMS, HACCP plan and FMP continue to be effective.
- Ensure than any necessary corrections and corrective actions are taken without undue delay to eliminate detected nonconformities and their causes.
- Ensure that follow-up activities include verification of the actions taken and reporting and recording of verification results.

In the event of any significant, non-temporary change in input materials, production process management or required digestate quality occurs, producers must:
- Ensure the production process is revalidated
- Review and record the significance and temporary or non-temporary nature of any change including the producer's justification for each decision.
- Sample and test the relevant digestate output types if working towards certification or if operating after certification, as appropriate, to determine the effects of those changes on the digestate(s).

The audit programme must:
- Be planned
- Take into consideration the status and importance of the processes and areas to be audited
- Take into consideration the results of previous audits
- Have a defined audit criteria, scope, frequency and methods
- Ensure the selection of auditors and the conduct of audits are objective and impartial
- Ensure that an auditor does not audit his/her own work

The audit must cover:
- QMS procedures and processes
- The digestate production process
- Operating procedures that describe it
- Digestate quality
- Procedures relating to the allocation of QMS responsibilities, human resources, training, infrastructure, customer-related processes, data handling, communications and improvement of the QMS

Producers must complete regular reviews that include:

- Results of audits by the producer's personnel and any external auditors
- AD process performance
- Digestate quality (i.e. its conformance to the quality policy, including fitness for purpose)
- Status of preventative and corrective actions
- Follow-up actions from previous management review
- The continuing suitability of the QMS including the HACCP plan, CCPs and CLs and the FMP and operating procedures in relation to changing conditions and information
- Any complaints and concerns expressed by interested parties, including personnel, customers, clients and regulatory authorities and their outcomes

The output from the management review must include any decisions and actions relating to:

- Improvement in the effectiveness of the QMS, including its procedures
- Improvement of digestate quality as per customer/user requirements and
- Resource needs

Please note:
Significant change is a matter of interpretation, and can relate to input materials, production process management, required digestate quality of other factors that affect its quality.

7. <u>Reporting</u>

For each person, including the competent person(s) with overall responsibility for the QMS, a record must be kept of the:

- Training topic
- Training date or period
- Name and role of the person who received the training on that topic
- Person and organisation who delivered the training (which can be the producer); and
- Any certificate or qualification achieved

The producer must record:

- All accidents and other incidents that occur at the facility, the known or suspected cause(s) and the actions taken. The need for preventative action must be considered, and any such action taken must be recorded.
- All complaints and concerns, any necessary action in response to any complaints or concerns expressed by interested parties, including personnel, customers, clients and regulatory authorities, about quality or usability of the whole digestate, and any separated liquor and separated fibre fractions.
- The name and contact details of the person who expressed concern or made the complaint
- Specific subject(s) of the concern or complaint
- Date and time the concern or complaint was communicated to the producer and the name of the person to whom it was communicated
- Nature and date(s) of any actions and checks and who carried them out
- Nature and date(s) of any response to the person who expressed a concern or made a complaint; and
- Name of the person who communicated the response

8. Documents and Document Control

Producers must:

- Establish and use documents appropriate to the scope of the QMS
- Ensure these are subject to document control
- Be aware that existing documentation and records may be used as part of the QMS if they meet the requirements of certification
- Ensure any document of external origin in use within the QMS must be identified and its distribution must be controlled.
- Ensure any obsolete document must be promptly removed from all places where it is used and, where appropriate, replaced with the current revised and approved version.
- Ensure any obsolete document retained for any purpose must be identified as obsolete.
- Maintain records specified within this Scheme that demonstrate effective control of input materials, production and storage of digestate.
- Ensure records are readily identifiable, legible, genuine, collated and maintained such that they are readily retrievable
- Ensure records are stored in good condition for at least two years

Each document of internal origin that is in use within the QMS must:

- Be the current version approved as adequate by the person with responsibility for document control.
- Be legible and available at its relevant place(s) for use
- Include a title, version number, date of issues and the name of the person who issued it

Please note:

- Records generated by a weighbridge system that relies on software programming which the producer is not easily or cost-effectively able to change are exempt from the requirements above.
- This exemption is conditional upon each weighbridge system record being assigned a unique record number.

4.1.2 Hazard Analysis Critical Control Point Plan

Hazard analysis forms a key part of the process design and plant operation in order to ensure consistent production of high-quality specified digestate. The hazard analysis aims to identify risks that need to be reduced to acceptable levels, avoided, or eliminated.

The required framework for conducting the analysis is Hazard Analysis and Critical Control Point (HACCP) planning. The main principles of the HACCP planning are:

Principle 1: Conduct a Hazard Analysis - listing the steps in the process and identifying where significant hazards are likely to occur with a focus on hazards that can be prevented, eliminated, or controlled by the HACCP plan. A justification for including or excluding the hazard is reported and possible control measures are identified. These hazards will include:

- Pathogens and toxins that adversely affect human or animal health
- Odours offensive to people who live or work in close proximity to the facility or location of digestate use,
- Inert material such as stones, plastics, wood, glass, etc.
- Sharps that may adversely affect human and animal health.

Principle 2: Determine Critical Control Points - A critical control point (CCP) is a point, step or procedure at which control can be applied and a safety hazard can be prevented, eliminated or reduced to acceptable levels. Acceptable level is equivalent to the minimum digestate quality required in this document. The number of CCP's needed depends on the processing steps and the control needed to assure product safety.

Principle 3: Establish the Critical Limits - A critical limit (CL) is the maximum and/or minimum value to which a biological, chemical, or physical parameter must be controlled at a CCP to prevent, eliminate, or reduce to an acceptable level the occurrence of a product or safety hazard.

Principle 4: Establish Monitoring Procedures - for the measurement of the critical limit at each critical control point. Monitoring procedures should describe how the measurement will be taken, when the measurement is taken, who is responsible for the measurement and how frequently the measurement is taken during operation.

Principle 5: Establish Corrective Actions - procedures that are followed when a deviation in a critical limit occurs to prevent potentially non-compliant digestate from being produced and the steps that are needed to correct the process. This usually includes identification of the problems and the steps taken to assure that the problem will not occur again.

Principle 6: Establish Verification Procedures - Those activities, other than monitoring, that determine the validity of the HACCP plan and that the system is operating according to the plan, such as auditing of CCP's, record review, instrument calibration and product testing as part of the verification activities.

Principle 7: Establish Record-Keeping Procedures – in order to secure information that can be used to prove that the digestate was produced safely. The records also need to include information about the HACCP plan, product description, flow diagrams, the hazard analysis, the CCP's identified, Critical Limits, Monitoring System, Corrective Actions, Recordkeeping Procedures, and Verification Procedures.

The requirements of each section are explained in detail below.

1. Hazard Analysis

Producers must:
- Conduct a Hazard Analysis listing the **steps** in the process and identifying where significant hazards are likely to occur with a focus on hazards that can be prevented, eliminated, or controlled by the HACCP plan.
- Ensure that the Hazard Analysis assesses human, animal and plant (vegetation) health hazards associated with intended uses of the digestate output type(s) for which certification is claimed, conformance is claimed, or is intended to be claimed
- Report the justification for including or excluding the hazard and the possible **control measures** identified

The hazards assessed must include:
- Pathogens and toxins in the biofertiliser that adversely affect human and animal health
- Odours offensive to people who live or work in close proximity to the location of use of the biofertiliser
- Inert materials such as **stones** and any man-made particles that might damage equipment for handling, mixing or applying digestate or blended materials that contain it
- **Sharps** that might adversely affect human and animal health

2. Critical Control Points

For each of the hazards identified above, producers must:
- Identify one CCP in the digestate production process
- Establish the CCLs of the control measure(s) at the CCP
- Ensure the same requirement are applied to each further hazard specified above and any other hazards identified by the producer
- Ensure all whole digestate undergoes the CCP(s) for each hazard applicable to whole digestate

Please note:
- A critical control point (CCP) is a point, step or procedure at which control can be applied and a safety hazard can be prevented, eliminated or reduced to ‘’acceptable’’ levels.
- Acceptable level is equivalent to the minimum digestate quality required in this document.
- The number of CCP's needed depends on the processing steps and the control needed to assure product safety.
- All steps of the digestate production process from input material receipt to digestate dispatch should be considered when identifying the CCP for a specific hazard.
- This does not mean that every step in the production process is a CCP.
- More than one control measure might be required to control a specific hazard.

- The requirements relating to complaints and their review are specified with the QMS section of this document.
- At each CCP, operating conditions must be monitored and maintained within the CCP's CLs.
- Establish procedures for verification that the HACCP plan and its implemented CCPs and CLs are under control and that the HACCP system is working effectively.
- Ensure the HACCP plan and related procedures are documented and reviewed as part of the QMS review as instructed earlier.

3. <u>Critical Limits</u>

Producers must:

- Establish the Critical Limits for each CCP within the process

Please note:

- A critical limit (CL) is the maximum and/or minimum value to which a biological, chemical, or physical parameter must be controlled at a CCP to prevent, eliminate, or reduce to an acceptable level the occurrence of a product or safety hazard.

4. <u>Monitoring systems to control the CCPs</u>

Producers must:

- Establish monitoring procedures for the measurement of the critical limit at each critical control point.
- Ensure monitoring procedures describe how the measurement will be taken, when the measurement is taken, who is responsible for the measurement and how frequently the measurement is taken during operation.

5. <u>Corrective actions when monitoring systems indicate a CCP is not under control</u>

Producers must:

- Establish a **Corrective Actions** process
- Ensure that procedures are followed when a **deviation** in a critical limit occurs to prevent potentially non-compliant digestate from being produced
- Ensure that the steps needed to correct the process are taken

Please note:

- This usually includes identification of the problems and the steps taken to assure that the problem will not occur again.

6. <u>Verification procedures</u>

Producers must:

- Maintain monitoring procedures for each CCP to ensure that the facility is operating as designed and that end product is compliant with product limits
- Establish verification procedures to ensure that the monitored results are accurate
- Ensure the timing of verification testing is set out in the HACCP plan
- Ensure that the verification procedures cover activities, other than monitoring that determine the validity of the HACCP plan and that the system is operating according to the plan

Please note:

- Verification activities can include auditing of CCP's, record review, instrument calibration and product testing as part of the verification activities.

7. Documenting procedures and records

Producers must:

- Establish record-keeping procedures in order to secure information that can be used to prove that the digestate was produced safely.
- Ensure the records include information about the HACCP plan, product description, **flow diagrams**, the hazard analysis, the CCP's identified, Critical Limits, monitoring system, corrective actions, record keeping procedures, and verification procedures

4.1.3 Facility Management Plan

To demonstrate compliance producers must establish and maintain a Facility Management Plan (FMP) that is specific to their facility/ digestion process and the resultant whole digestate and any separated liquors and fibre. An FMP must consist of the following sections:

1. Facility details
2. Input controls
3. Process management, separation and storage
4. Process equipment
5. Process monitoring
6. Sampling of digestate
7. Actions in the event of test failure
8. Storage: Storage and use of whole digestate, separated liquor and separated fibre

The requirements of each section are explained in detail below.

1. Facility Details

Producers must:

- Ensure the following information is recorded within their FMP:
  - Producer name
  - Facility address
  - Name of business (if different to Producer)
  - Business description

2. Input Controls

Rigorous selection and quality control of the AD feedstock is the most critical point in the production of digestate. In order to ensure appropriate quality of the digestate, AD plant operators must have complete control over the quality of the feedstock being treated in their facility.

The AD plant operators are responsible for making sure that the feedstock suppliers understand the importance of and the risk associated with the quality of the supplied material on the performance of the plant and quality of the output material. An accredited producer would normally require the feedstock supplier(s) to have their own quality assurance systems so that all parties have confidence in the quality and composition of the feedstocks being delivered to an AD facility.

Producers must:
- Ensure all biodegradable organic material **feedstocks** are source separated or sourced from a single origin
- Ensure a written **Supply Agreement** for feedstock materials is agreed between the Biofertiliser producer and the feedstock supplier
- Work with the supply chain to eliminate or minimise plastic entering the feedstock (public education, visual inspections, de-packing technology)
- Ensure feedstock does not contain any non-biodegradable materials or residues of any toxic substances, e.g. veneer, paint, laminate and wood preservatives
- Ensure each feedstock load is visually inspected for quality prior to storage or processing
- Ensure for every load of feedstock delivered to the AD facility, they record:
    - Weight of each load
    - Type of material
    - Supplier
    - Date delivered
    - Acceptance/ rejection
    - Delivery location on site/where it was sent if rejected
- Ensure rejected materials are stored away from the processing AD facility and removed as soon as practicable
- Ensure the volume/ weight of the rejected material is recorded

Producers must ensure Feedstock Supply Agreements include:

a) Type and source location of all material delivered
b) Product descriptions (odour and colour)
c) Product contaminants (physical, chemical and biological)
d) Amount (volume and weight)
e) Collection, pretreatment and handling practices
f) Handling and storage instructions
g) Date delivered
h) Any additional arrangements associated with actions taken to remove or reduce physical contamination or other unsuitable content prior to digestion
i) Criteria for delivery acceptance (inspections)
j) Criteria that trigger feedstock material rejection and procedure to be followed
k) Declaration that each feedstock material is fit for purpose and is free from any contaminants specified by the AD operator
l) Condition that supplier must notify the Biofertiliser producer of any significant change in the quality of feedstock material

Please note:
- A written feedstock supply agreement is not required where a farm or co-operative produces biofertiliser from material sourced within its own premises
- Where physically and economically viable, feedstock can be pumped to the AD facility using individual pipework

3. Process management, separation and storage

The AD facilities seeking compliance with TG8 are to be designed, constructed and operated in manner to ensure consistent production of appropriate-quality specified product. Such facilities will also effectively minimise odour and gaseous emission that will or may be generated as by-product of the process.

Producers must ensure each **batch or portion of production of digestate**, separated liquor or fibre is:
- assigned a unique product identifier code for quality management purposes
- the quantity produced in each batch or portion of production is recorded
- treatment process and analysis results are recorded for each batch or portion of production

Producers must ensure they have procedures that cover:
- Tracing and recall of out of spec product
- Conducting a simulation recall event
- When and how to recall product
- Notification of Fertmark and customers

Producers must ensure that:
- The site has an **Incident Management Plan** in place to manage pollution incidents and emergencies
- The Incident Management Plan is tested annually
- Staff are fully conversant in the IMP
- Odours are controlled and do not cause a nuisance to adjacent properties
- Pests are controlled and do not cause a nuisance to adjacent properties
- Any other nuisances are controlled and do not cause a nuisance to adjacent properties
- Complaints are registered and appropriate actions are taken to address these

Producers must ensure:
- Digestate handling and storage facilities are ''clean areas'' where no contact with the raw feedstock material or equipment can occur
- Anything used in the storage and handling of digestate that has the potential to been in contact with raw feedstock material is disinfected prior to use (clothing, equipment)
- Cross contamination between customers is prevented by using dedicated trucks and days/times of services
- Trucks are washed down prior to use if it has been used for the transportation of other materials such as feedstocks
- In the event of biosecurity concerns, truck wash down must also include sanitation

Producers must ensure all digestates produced by an AD process includes:
- A pasteurisation step capable of heating all material to at least 70°C for one hour; or
- An equivalent alternative treatment validated for its efficacy at reducing a suitable plant pathogen indicator species
- The process used is documented within the FMP
- Staff are fully conversant in the pasteurisation process

Please note:
Three types of feedstocks are exempt from pasteurisation if the associated conditions can be met (detailed in Table 11).

Table 11: Details of feedstocks exempt from pasteurisation requirements

Feedstock	Condition
Type 1 Digestates made only from unprocessed crops, processed crops, crop residues and/or glycerol that arises within a single or co-operative's premises or holding	After digestion, digestates must be returned to and used entirely within the originating single or co-operative's premises or holding
Type 2 Type 1 digestates mixed with pasteurised biodegradable materials	After digestion, digestates must be returned to and used entirely within the originating single or co-operative's premises or holding.
Type 3 Feedstocks derived from prior processes that include thermal treatment(s) equivalent to at least 70°C for one hour	Product must be labelled and customers notified that product has not been pasteurised.

4. Process equipment

Producers must:
- List all process equipment
- Provide a statement of annual feedstock material throughput quantity (estimate)
- Provide a statement of annual digestate output quantity (estimate)
- Prepare a process flow diagram illustrating the digestate production system (annotated)
- Ensure each treatment and storage vessel/area are clearly labelled as described in the site's documents and flow diagram
- Ensure material flows one way through the system
- Ensure the site and digestate production system is designed and managed to prevent contamination between materials

5. Process monitoring

Producers must:
- Control and monitor all processes within the facility within the acceptable operating levels specified for the critical performance parameters
- Provide pasteurisation of feedstock or digestate product unless exempt
- Provide and maintain equipment in good working order for the processes required
- Specify how often equipment is checked, what checks will be carried out and contingency arrangements in the event of equipment failure
- Avoid cross contamination of the final digestate product with untreated, partially treated, unwanted or rejected material

- Justify and record and changes in the feedstock material, production process or required digestate quality
- Understand any significant change in production that results in products not meeting the specification will trigger re-validation

6. Sampling of digestate

General requirements

Producers must ensure:

- Sampling occurs after digestate has completed the full AD treatment cycle
- Sampling occurs when the product is ready for use (after full separation, treatment or maturation if sampling separated liquors or fibre)
- Samples are taken from storage tank before any new batch of digestate enters the storage vessel (if stored before dispatch from site)
- Each sample is representative of the **batch** or **portion of production**
- Samples are homogenous (storage tanks must be adequately mixed to ensure representative samples can be obtained)
- Sampling and analysis follow the methods detailed in Tables 5-9
- Stability testing occurs at the end of the anaerobic digestion process, prior to dispatch
- For each batch or portion of production which is not sampled for testing, the quality management process is followed (QMS, HACCP, FMP)

Please note facilities that receive domestic and commercial garden residues feedstocks must test biofertilisers for the presence of the herbicides Clopyralid and aminopyralid at the frequencies specified in Tables 12 and 13 found on the following pages. A detection of Clopyralid and/or aminopyralid within the biofertiliser must be addressed according to section 4 of TG 8 'Actions in the event of Test Failure'. In the event that a retest or reprocessing still has clopyralid, this should be noted by the Producer and they must have documented processes to ensure that the biofertiliser affected is not sold for application to sensitive crops.

Sampling requirements

Producers must record for each sample taken:

- Sampling date and time
- Sample type (whole digestate, separated liquor, fibre)
- Product identifier e.g. Batch code
- Prior mixing time
- Digestion facility name
- Name of person who carried out the sampling

Sampling regime

Producers must ensure that **i**nitial product monitoring is completed:

- Before applying for certification
- When a new process is commissioned
- When a change from non-animal product feedstocks to animal product feedstocks occurs
- When changes are made to an existing process
- When any of the routine samples do not meet the requirements set out in Tables 3-7

Table 12 below details the number of samples required to be taken during the initial product monitoring phase.

Table 12: Initial product monitoring frequency

<table>
<tr><th>Parameter</th><th>Facilities accepting feedstocks
with
animal product</th><th>Facilities accepting feedstocks
without
animal products</th></tr>
<tr><td>Nutrients</td><td rowspan="2">The 3 most recent samples meet the quality requirements in Tables 3 & 4</td><td rowspan="5">The 3 most recent samples meet the quality requirements in Tables 3 - 7</td></tr>
<tr><td>Chemicals

Heavy Metals
Clopyralid
Aminopyralid</td></tr>
<tr><td>Biological (Pathogens)</td><td>The 5 most recent samples are below the limits in Table 5</td></tr>
<tr><td>Physical (Contaminants)</td><td rowspan="2">The 3 most recent samples meet the requirements in Tables 6 & 7</td></tr>
<tr><td>Stability</td></tr>
</table>

Please note:

1. Biofertiliser made from feedstock materials arising within a single or co-operative’s premises used entirely within the same premises, biological (pathogen) tests are only required if any feedstock material contains or is at risk of containing human and/or animal pathogens.
2. For digestates made only from unprocessed crops, processed crops, crop residues and/or glycerol that arises within the producer’s/co-operative’s premises or holding no physical (contaminant) testing will be required. The digestate shall be used entirely within the same premises or holding.

After certification has been obtained, digestate must continue to meet the biofertiliser product quality limits. The routine test frequencies for each parameter are shown in Table 13 overleaf. The digestate quality requirements remain the same as previously detailed (Tables 5-9).

Table 13: Routine product monitoring requirements

Parameter	Facilities accepting feedstocks <u>with</u> animal product	Facilities accepting feedstocks <u>without</u> animal products
Nutrients	1 sample per 5,000m^3 digestate produced or 1 sample per 3 months whichever is sooner	
Chemicals Heavy Metals Clopyralid Aminopyralid	1 sample per 5,000m^3 or 1 sample per 3 months whichever is sooner	
Biological (Pathogens)	5 samples per 12 months Samples must not be within 2 months of one another	1 sample per 5,000m^3 or 1 sample per 3 months whichever is soonest
Physical (Contaminants)	1 sample per 5,000m^3 or 1 sample per 3 months whichever is soonest	
Stability	2 samples per 12 months Samples must not be within 3 months of each other	

7. Actions in the event of test failure

Producers must ensure that corrective actions cover:
- Restoring control and preventing recurrence of a loss of control
- Identifying, managing and disposing of affected product
- Managing unforeseen loss of control
- Person(s) to manage incident(s)

If any batch or portion of production fails to meet any of the quality limits, producers must ensure:
- The batch is disposed of as non-complying digestate and not sold as a biofertiliser; or
- The batch is re-processed
- The reprocessed product is re-tested for the failed parameter/s
- If they choose to re-process or take other corrective actions to a non-conforming liquid product (whole digestate, separated liquor) after implementing corrective actions, an additional digestate batch or portion of production can be mixed with the re-processed/ corrected batch provided the additional product has been tested and meets the complying criteria.
- The new mixed batch is re-tested for compliance after thorough mixing
- A re-processed/corrected batch or portion of production of separated fibre is re-tested prior to introduction of a new batch or portion of production

8. Storage: Storage of whole digestate, separated liquor and separated fibre

High quality digestate is a stable product with minimal risk of pathogen transfer. Recontamination from raw feedstock is therefore the main concern during handling, storage and transport of digestate. Correct storage reduces ammonia, methane and unpleasant odour emissions to atmosphere. To achieve correct storage requires a number of precautions at the biogas plant as well as other digestate storage areas, such as:

- Storage facilities can be located at source, i.e. at the biogas plant, or, more conveniently, close to the place of utilisation. In order to eliminate emission of odours or greenhouse gasses into the atmosphere, digestate storage is usually carried out in above ground storage tanks, covered ponds, or storage bags.
- It is important that all digestate storage facilities are gas sealed and appropriately vented through emission-destructing equipment (flare, biofilter, etc.) or combined with biogas collected within the main AD reactors, in order to minimise ammonia volatilisation and greenhouse gas emissions.
- Handling and storage of digestate in a dedicated “clean area” strictly ensuring no contact with the raw feedstock material or equipment that has been in contact with the raw material without prior disinfection (clothing, vehicles, etc.).
- Avoid cross-contamination between farms by using dedicated trucks and days/times of services.
- All transport trucks should be washed down after delivery of each load. Where there are biosecurity concerns this wash down should also include sanitation.
- Where physically and economically viable, feedstock can be pumped to the biogas plant using individual pipework.
- Regular analysis and recording of digestate composition from each truckload.

For the safe storage of biofertilisers, producers must ensure the site has:

- Storage capacity for digestate produced outside the growing season
- Storage facilities that minimise odour
- Storage facilities that are gas sealed and vented through emission-destructing equipment

Please note biofertiliser labelling requirements and end user information is located in section 4.2 overleaf.

4.2 Biofertiliser Labelling & End User Information

For safe labelling of biofertiliser products, producers must ensure:
- They identify and control risks associated with false and misleading labelling
- Products are labelled correctly
- Customers purchasing bulk biofertilisers are given a **Product Information Document** that contains the same information that would appear on the label of a packaged product
- Provide the Product Information Document at the time of collection/delivery
- Ensure transport/storage vessels are adequately marked to minimise the effects of accidents during transportation and storage
- Where appropriate labels should be printed and fixed to containers and remain legible and permanently attached under all climatic, transport and other conditions likely to be experienced
- Complete a **Dispatch Record** for every biofertiliser sale
- Store Dispatch Records in line with the Scheme requirements

The Product Information Document/ label information must include:
- Trade name
- Name and address of producer
- Product Identifier Batch number
- Order number or date of delivery
- Nutrient Content (concentrations of N, P, K) as registered with Fertmark
- Product description (statement of whether whole digestate, separated liquor or separated fibre)
- Particle size range, pH, loss on ignition (volatile solids)
- Information on the product's origins (e.g. if it includes animal products such as ruminant protein)
- Storage and handling information (toxicity, first aid, methods of handling spills)
- As supplied product analysis information
- the 'Precautions for Use' Declaration detailed below

Precautions for Use Declaration

This biofertiliser product may contain a variety of living micro-organisms, some of which on rare occasions can cause illness in humans. Serious infection is rare but can happened for older people and those with reduced immunity. Please take the following precautions:
- *Avoid handling biofertiliser in enclosed areas*
- *Avoid inhaling the emissions to air from the biofertiliser*
- *Always wear gloves and wash hands after use*
- *See your doctor if you develop a high fever, chill, breathlessness or cough*

Notice: Do not feed to sheep, cattle, deer, goats, buffaloes, or other ruminant animals.
This product contains or may contain ruminant protein.

Dispatch Records must include:
- Customer name and contact details
- Delivery address
- Product identifier e.g. batch number
- Date of production
- Quantity dispatched by weight or volume
- Date of dispatch

4.3 Health and safety and Operating Procedures

Production, storage and handling of digestate must be carried out in compliance with the NZ Health and Safety in Employment Act 1992. Several codes of practice are available for waste handling and biogas production, which can provide valuable information regarding safe practices during these activities, such as:

- *WasteMINZ 2012: Liquid and Hazardous Wastes Code of Practice*
- *WasteMINZ 2012: Liquid and Hazardous Wastes (Operators' Handbook)*
- *Technical Guide 13: Design, Construction & Operation of Anaerobic Digestion Equipment for Farm Waste Treatment*

A systematic assessment of human-health hazards associated with production, handling and use of digestate should be carried out for each plant. The hazards should include pathogens and toxins that adversely affect human health and odours offensive to people who live or work in close proximity to the location of production or use.

Safe practices shall be adopted and strictly observed for the transport and pre-treatment of feedstock in order to prevent or minimise the exposure of the staff to potentially hazardous material. Personal Protection Equipment (PPE), such as rubber gloves and respirators should be worn during loading and unloading of the feedstock material and during its handling in enclosed spaces.

Anaerobic digestion of organic material produces large amounts of biogas containing explosive and toxic gases (methane, hydrogen sulphide, etc.). As such, AD plants need to be designed and operated to the highest safety standards. Operating staff should be provided with personal gas detectors and appropriate PPE.

Residual methane producing and other biological processes during storage of digestate may lead to evolution of harmful gases. This needs to be taken into account during the design and operation of the digestate storage facilities, but also during transport of digestate to the location of use. Personal gas detectors and appropriate PPE, combined with safe practice procedures should be developed and used at all times.

Producers are recommended to create and implement a number of SOPs at their site(s) to demonstrate compliance with the requirements of the Scheme. These are shown in Table 14. SOP Templates can also be found on the MPI website[20].

[20] https://www.mpi.govt.nz/food-business/food-safety-codes-standards/good-operating-practice/documents/

Table 14: SOPs recommended by the Scheme

Feedstocks	Biofertilisers	Production	Corrective Actions	Records	Adverse Events	Staffing
Supply Agreements	Sampling Methodologies & Frequency	Process Inspections	Contamination Prevention	Traceability	Pollution Management	Hygiene
Waste Inspections	Sample Locations	Process Controls	Loss of Control	Recall simulation	Incident Management Plan	PPE
Waste Rejections	Sample Analysis, Critical Levels & Acceptable Ranges	Production Steps	Sample Failures	Biofertiliser Recall	Odour Control	Clothing
Feedstock preparation	Biofertiliser Handling	Maintenance & Repairs	Notifications	Labelling & Advice Notes	Pest Control	Equipment
Pasteurisation	Biofertiliser Storage, Conditions and Timescales	Cleaning & Sanitation	Corrective Actions	Dispatch Records	Nuisance Control	Training
Feedstock Handling	Biofertiliser Dispatch	Chemical control		Record keeping	Complaint Handling	Health & Safety
Feedstock Storage	Maturation Steps	Buildings & Facilities				
Reception Areas		Recirculation of Whole Digestate or Separated Liquor				
		Process Management Evaluation				

4.4 Application Management

While the method of use of the digestate is outside the scope of this guide, the application of digestate to land should be done in such a way as to minimise the loss of nutrients to ground and surface waters via run-off and to the air via volatilisation. This requires the product to be applied at suitable hydraulic and agronomic loading rates, and using methods such as direct application to soils to prevent volatilisation.

4.4.1 Characteristics

The main aspects farmers should consider regarding the application of digestate as biofertiliser are:

- Nutrient content – the nutrient profile and fertiliser value of AD digestate is dependent on the feed-stock composition.
- Carbon content – this can help in enhancing soil structure. For most biological materials the carbon content is between 45 to 60 percent of the volatile solids fraction.
- Distance to source – in the majority of cases, the user will need to cover the cost of the transport of digestate to the place of utilisation. This distance to source may have a decisive influence on the economic viability of such practice.
- Price of conventional fertiliser – the cost of digestate fertiliser is made up of the cost associated with transport of the feedstock, biogas plant operation and any digestate treatment (if applied). In order for the use of digestate bio-fertiliser to be economically viable, the digestate “fertiliser” value of the nitrogen, phosphorus or potassium needs to be lower than that of conventional mineral fertilisers when expressed in $/kg.
- Incentives offered by the AD facility such as subsidised cost of digestate.
- Storage – digestate should be applied only during the growing season in order to ensure prompt and high nutrient uptake and in order to eliminate nitrate leaching into the soil with consequent groundwater pollution.
- Farm product users – the use of digestate as biofertiliser must be accepted by the users of the products grown on the farm. Regulatory requirements regarding the digestate quality may differ in different countries, which may create problems during export of the products overseas.

4.4.2 Microplastics

Most household and municipal organic waste is contaminated with plastic, which cannot be completely removed using even the most advanced separation technologies. Processing of these wastes in anaerobic digesters will inevitably result in size reduction and partial breakdown of plastics and presence of residual microplastics (< 5 mm in size) in the digestate.

While the extent of the environmental and health effects of microplastics is not completely clear, studies have found they are detrimental to the health of organisms such as earthworms and rodents, and that they make their way into human food supplies. However, the lack of adequate understanding of the fate of microplastics during and post anaerobic digestions, their health effects and the absence of effective monitoring methodology prevents setting and enforcing plastics concentration limits.

The authors of the Guidelines for Beneficial Use reached an agreement with the New Zealand Ministry of Health and the Ministry for the Environment that no microplastic concentration limits will be set until more knowledge is attained and monitoring methodology developed. Since the TG8 has adopted the same contaminant limits as specified in the Guidelines, it is adequate for the TG8 to adopt the same strategy.

It is important that maximum effort is made along the whole supply chain to eliminate or minimise the amount of plastics entering the feedstock for the AD facility. This includes, but is not limited to:

- public education by local authorities and waste recycling operators on the impact of plastics along the value chain,
- visual inspection of the waste bins by the waste collectors upon collection,
- site acceptance processes – waste inspection upon delivery, and
- processing technologies – de-packaging equipment, etc.

4.4.3 Application of whole digestate to land

The use of digestate must be integrated in the fertilisation plan of the farm in the same way other sources of nutrients would be and it must be applied at even and accurate rates (Al Seadi & Lukehurst, 2012). In New Zealand, the use of the OverseerFM software is promoted within the agriculture sector for a comprehensive science-based nutrient balance analysis.

As discussed throughout this document, the application of digestate to arable land is beneficial in various aspects from providing macro- and micronutrients to plants, reducing soil acidification, enhancing moisture retention and improving microbiological activity of soil (Makadi, Tomoscik, & Orosz, 2012). However, hydrolysis of organic nitrogen to ammonia during AD accompanied by a higher pH in the digestate may induce ammonia volatilisation and nitrogen losses due to gaseous emissions during handling and application. This is of relevance to the famers for two reasons.

a) Emissions during application - Ammonia losses and odour emissions are the main risk factors as far as digestate application method is concerned. In general, equipment used for application of raw slurry can be used for digestate with the exception of splash plate application, which has been banned in some countries due to the high ammonia volatilisation effect. On the other hand, trailing hose, trailing shoe and shallow soil injection have proven to be the most efficient (Table 9, Appendix A).

b) Reduction of digestate nutrient content due to ammonia volatilisation. Where digestate is used as the sole source of nutrients, this may lead to under-fertilising. It is therefore essential that the receiving soil nutrient properties are monitored through regular testing.

Other potential issues associated with the use of digestate as biofertiliser is the risk of phytotoxicity, nitrate leaching and odour evolution during and after application. The risk of phytotoxicity can be minimised by careful evaluation of digestate quality and quantity applied. Nitrate leaching can be reduced or eliminated by a high control of the application rates based on soil quality and crops requirement and by careful selection of most suitable application time.

Figure 12: Tanker fed sub-soil injection system

Figure 13: View of injector system mounted on the tanker rear

5.0 GLOSSARY

Anaerobic digestion - process of controlled decomposition of biodegradable materials under managed conditions where free oxygen is absent, at temperatures suitable for naturally occurring mesophilic or thermophilic anaerobic and facultative bacteria species, that convert the inputs to biogas and whole digestate.

Biodegradable - capable of undergoing biologically mediated decomposition

Biofertiliser - Digestate derived from organic matter which is produced by AD facilities that are designed and operated with this Technical Guide 8 and have been certified according to the Biofertiliser Certification Scheme (TBA).

Biosolids- sewage or sewage sludge derived from a sewage treatment plant that has been treated and/or stabilised to the extent that it is able to be safely and beneficially applied to land. Biosolid is a Biowaste Product that contains waste material of human origin.

Certification – third-party attestation of products, processes, systems or persons.

Control - <noun> state wherein correct procedures are being followed and criteria are being met; <verb> take all necessary actions to ensure and maintain compliance with criteria established in the HACCP plan.

Control measure - action and activity that can be used to prevent or eliminate a digestate safety hazard or reduce it to an acceptable level

Co-operative - natural or legal persons who form a group under a written agreement, who exercise only agricultural, soil-/field-grown horticultural or forestry activities and who, as a group, carry out one AD process at one location within the cooperative’s holdings

Corrective action - action to be taken when the results of monitoring at the critical control point (CCP) indicate a loss of control

Critical control point (CCP) - last step at which control can be applied and is essential to prevent or eliminate a hazard or reduce it to an acceptable level of risk

Critical limit (CL) - criterion which separates acceptability from unacceptability

Deviation - failure to meet a critical limit

Digestate (or whole digestate) - whole digestate resulting from an AD process, and any subsequently separated fibre or liquor fractions. NOTE Includes any separated fibre that undergoes a subsequent aerobic maturation step, without addition of further materials.

Digester - closed vessel system in which biodegradable materials decompose under anaerobic conditions

Exemption - exemption from the need to hold an authorization.

Feedstock – see input material

Harm - physical injury to, or damage to, the health of people, or damage to property, or to the environment. NOTE In the context of this Technical Guide, “harm” also includes injury or damage to the health of animals and plants. Harm can be caused by one or more unwanted biological, chemical or physical agents in, or by misuse of, whole digestate, separated liquor or separated fibre.

Hazard - potential source of harm

Hazard analysis - process of collecting and evaluating information on hazards and conditions leading to their presence, to decide which are significant in relation to the production of digestates that can be used without harm. NOTE This should be addressed in the HACCP plan.

Hazard analysis and critical control point (HACCP) - system used for the identification, evaluation and control of hazards that are significant in relation to the production of digestates that can be used without harm

HACCP plan - document prepared in accordance with HACCP principles, to ensure control of hazards that are significant in relation to the production, storage, supply and use of digestates that can be used without harm

Holding - all the land units managed by a farmer/land manager within New Zealand

Hydraulic retention time (HRT) - average time that material stays in the digester vessel, determined by the loading rate and operational digester capacity. NOTE Hydraulic retention time can be calculated by dividing the digester working volume by the rate of flow of input materials into the digester, i.e. HRT (days) = digester volume (m^3) / influent flow rate (m^3 per day).

Input material - biodegradable material intended for feeding, or fed, into an AD process. In the context of this Technical Guide, Input material is source-segregated organic material, fit for anaerobic digestion.

Manures - slurries and solid manures, including farmyard manures and dairy shed effluent.

Maceration - to make biodegradable input materials into a more consistent and readily flowing and pumpable mixture by means of shredding, chopping, crushing or mincing the input materials and/or soaking them in a liquid

Maturation - optional period of treatment or storage of separated fibre under predominantly aerobic conditions

Mesophilic - organisms for which optimum growth temperatures are within the temperature range 30 ºC to 43 ºC

Method of test - procedure for testing a sample of digestate. NOTE Where available for any one or more parameters, this Technical Guide specifies recognized international standards

Monitor - act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control

Operating procedures - carried out and documented procedures for producing digestates

Organic loading rate (OLR) - weight of organic matter fed to a unit volume of the digester per unit time NOTE OLR = kg COD m^{-3} day^{-1} or kg VS m^{-3} day^{-1}, where COD is chemical oxygen demand and VS is volatile solids. A similar way to describe OLR is weight of organic dry matter added per day (kg VS d^{-1}) divided by digester volume (m^3).

Pasteurisation - process step during which the numbers of pathogenic bacteria, viruses and other harmful organisms in material undergoing AD are significantly reduced or eliminated by heating the material to a critical temperature for a minimum specified period of time or by other appropriate methods. NOTE 1 Pasteurization could occur either as part of the AD process or as a separate step. Pasteurization does not aim to achieve sterilization, which destroys all life forms. NOTE 2 Pasteurized material might contain beneficial and other, non-harmful, microorganisms.

Personal Protective Equipment (PPE) - any garments of clothing or equipment that is used to guard you and your employees against hazards in the workplace. For details of required PPE refer to the adequate H&S legislative documentation.

Producer - business enterprise, organization, community initiative or person(s) responsible for the production of digestates

Putrescible - material that has the capability to become putrid. NOTE In this context, those fractions of organic waste or biodegradable material with relatively high proportions of readily biodegradable carbon-based molecules and moisture.

Quality control - part of quality management focused on fulfilling quality requirements NOTE Implemented through a series of systems and activities, which are integrated in daily work, and enable frequent, or continuous, verification of product quality. Examples are checks on process conditions throughout every processing step, digestate sample test results and the effects of any corrective actions taken.

Quality management system (QMS) - management system to direct and control an organization with regard to quality [SOURCE: ISO 9000:2005] NOTE In the context of AD, it is a system for planning, achieving and demonstrating effective control of all operations and associated quality management activities necessary to achieve digestates that are fit for purpose. Where specific controls are applied, they should be monitored and recorded, and their efficacy evaluated both during and after process validation. Corrective actions should be defined.

Quality Protocol (QP) - set of criteria for the production, placement on the market, storage and use of products derived from suitable types and sources of waste, such that any risks to the environment and to human and animal health are acceptably low when any such product might, under certain circumstances, be used without waste regulatory controls, in those countries in which the protocol applies. NOTE A Quality Protocol also sets out how compliance with its criteria should be demonstrated. Products should be used in accordance with good practice, and appropriate guidance is referred to where available and suitable for use of those products in end markets allowed by that specific QP.

Risk - combination of the probability of occurrence of harm and the severity of that harm [derived from ISO/IEC Guide 51] NOTE It can mean the potential realization of unwanted, adverse consequences to human life and health, property or the environment associated with a hazard.

Separated fibre (SF) - fibrous fraction of material derived by separating the coarse fibres from whole digestate. NOTE At least 15% of its mass should be dry matter in order that the sample is suitable for laboratory tests as a "solid" material. It should contain sufficient dry matter to be capable of being stacked in a heap if it undergoes an aerobic maturation step; a mass fraction of 23% dry matter is a guideline figure.

Separated liquor (SL) - liquid fraction of material remaining after separating coarse fibres from whole digestate. NOTE It is normally the fraction remaining following the use of a separator or centrifuge to remove coarse fibres. Less than 15% of its mass should be dry matter in order that the sample is suitable for laboratory tests as a "liquid" material. It should contain sufficient moisture to be pumpable; a suitable mass fraction percentage of dry matter content should be determined in practice and the dry matter result declared for any tested portion of production. If the user desires that no significant solids residue remains on crop leaves after applying separated liquor, it should contain no more than a mass fraction of 4% dry matter.

Specified digestate or biofertiliser – A digestate or biofertiliser where the physical and fertiliser characteristics are known and identified.

Sharps - man-made contaminants that are greater than 2 mm in any dimension that might cause physical injury to a person who handles digestates without protective gloves or to a person or animal who comes into contact with these materials. NOTE Organic components such as twigs and woody fragments can puncture skin but this risk is considered acceptably low and so has been omitted from this "sharps" definition. Omitted also are rock-derived "mineral" particles and aggregated particles of all sizes, including, for example, gravel and stones.

Soil improver/conditioner - material added to soil in situ primarily to maintain or improve its physical properties, and which may improve its chemical and/or biological properties or activity

Source-segregated - materials or biowastes that are stored, collected and not subsequently combined with any nonbiodegradable wastes, or any potentially polluting or toxic materials or products, during treatment or storage (whether storage is before or after treatment). NOTE Source-segregated materials can include collection of a mixture of biowaste/biodegradable material types, from more than one source. Such materials do not include sewage sludges and their derivatives. It is acknowledged that low levels of physical contamination might occur, which might trigger rejection of an input material load or physical contaminant removal prior to loading the biowaste/biodegradable material into the working digester

Stability - quality of being stable

Stable - point at which the rate of biological activity has slowed to an acceptably low and consistent level and will not significantly increase under favourable, altered conditions. NOTE Stable digestate should not be attractive to vermin or wild animals and should not be so odorous that its storage or use causes nuisance to humans. In a stable but immature state, it might still contain insufficiently biodegraded natural or man-made substances that exert phytotoxic effects in some applications; this should be taken into account in guidelines for digestate use.

Stabilization - biological and chemical processes that, together with conditions in the material being treated, aim to achieve stable, treated material NOTE after stabilization, biodegradation will continue to occur, albeit at a slower rate.

Step - point, procedure, or operation in the digestate chain, including raw materials, from primary production to final use of digestates and the consumption of food or fodder grown on land that has received such material

Thermophilic - organisms for which optimum growth temperatures are typically within the temperature range 45 ºC to 80 ºC

Total Solids (TS) - those solids in a sample of material that remain after the drying of the sample at 105 ºC, to the point such that they lose no more moisture. NOTE also referred to as ”Dry Solids”, or “dry matter (DM)”.

User - individual or organization that obtains digestates from a producer or third party with the intention of using them

Validation, validate - obtaining and evaluating evidence that the elements of the HACCP plan are effective. NOTE 1 In the context of this Technical Guide, this includes obtaining and evaluating evidence that the QMS is effective for producing digestates of the quality to which the producer has committed in the quality policy.

Verification, verify - application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine compliance with the HACCP plan and other relevant quality requirements.

Volatile fatty acids (VFA) - fatty acids, or organic acids, with a carbon chain of six carbons or fewer

Volatile solids (VS) - those solids in a sample of material that are lost on ignition of the dry solids at 550 ºC NOTE 1 Volatile solids are also referred to as “loss on ignition (LOI)”, which is a measure of organic matter (OM).

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APPENDIX A: FEEDSTOCK CHARACTERISTICS

Table 15: Typical nutrient concentration of selected AD feedstock (in kg/m3 or kg/t of fresh weight). 1 – (Longhurst 2017), 2 – (Lukehurst, Frost, & Al Seadi, 2011)

Feedstock	TS (%)	Total N	$N\text{-}NH_4$	P	K	S	Mg
Dairy shed effluent[1]	0.5-1.2	0.15-0.3	0.05	0.07	0.4	0.07	0.04
Dairy cow manure slurry (housed)[1]	11	3.1		0. 7	5.8	0.6	0.9
Pig slurry[2]	4.0	4.0	2.5	0.9	2.1	0.4	0.2
Poultry: [2]							
Layer manure	30	16	3.2	5.7	7.5	1.5	1.3
Broiler/turkey litter	60	30	12	10.9	15	3.3	2.5
Grass silage[2]	25-28		3.5-6.9	0.4-0.8			
Maize silage[2]	20-35	1.1-2	0.15-0.3	0.2-0.3	4.2		
Dairy waste[2]	3.7	1.0	0.1	0.4	0.2		
Stomach contents[2]	10.1	3.1	0.3	0.7	0.5		
Blood[2]	10.9	11.7	1.0	0.4	0.6		
Food leftovers[2]	9-18	0.8-3	2.4	0.7			

TS = Total solids, N = nitrogen, $N\text{-}NH_4$ = Ammoniacal nitrogen , P = Phosphorus, S = Sulphur, Mg = Magnesium

Table 16: Approximate trace elements and heavy metals concentrations (mg/kg dry matter) in some feedstock types (Lukehurst, Frost, & Al Seadi, 2011).

Feedstock	Zn	Cu	Ni	Pb	Cr	Cd	Hg
Animals							
Dairy slurry	176	51.0	5.5	4.79	5.13	0.20	
Pig slurry	403	364	7.8	<1.0	2.44	0.30	
Poultry (egg layers)	423	65.6	6.1	9.77	4.79	1.03	
Crops							
Grass silage	38-53	8.1-9.5	2.1	3.0		0.2	
Maize silage	35-56	4.5-5.0	5.0	2.0	0.5	0.2	
Agri-food products							
Dairy waste	3.7	1.4	<1.0	<1.0	<1.0	<0.25	<0.01
Stomach contents	4.1	1.2	<1.0	<1.0	<1.0	<0.25	<0.01
Blood	6.1	1.6	<1.0	<1.0	<1.0	<0.25	<0.01
Brewing wastes	3.8	3.7	<1.0	<1.0	<1.0	<0.25	<0.01

Table 17: Time required for 90% destruction of some pathogenic bacteria in AD systems (Al Seadi & Lukehurst, 2012)

Bacteria	**53°C (hours)**	**35°C (days)**
Salmonella typhimurium	0.7	2.4
Salmonella Dublin	0.6	2.1
Escherichia coli	0.4	1.8
Staphylococcus aureus	0.5	0.9
Mycobacterium paratuberculosis	0.7	6.0
Coliform bacterial	-	3.1
Groups D Streptococci	-	7.1
Streptococcus faecalis	1.0	2.0

Table 18: Survival of weed seeds (% germination) after mesophilic AD expressed in number of days (d) at 37°C (Al Seadi & Lukehurst, 2012)

Plant species	**2d**	**4d**	**7d**	**11d**	**22d**
Brassica Napus (Oil Seed Rape)	1	0	0	0	0
Avena fatua (Wild Oat)	0	0	0	0	0
Sinapsis arvensis (Charlock)	0	0	0	0	0
Fallopia convolvulus (Bindweed)	7	2	2	0	0
Amzinckia micranta (Common Fiddleneck)	1	0	1	0	0

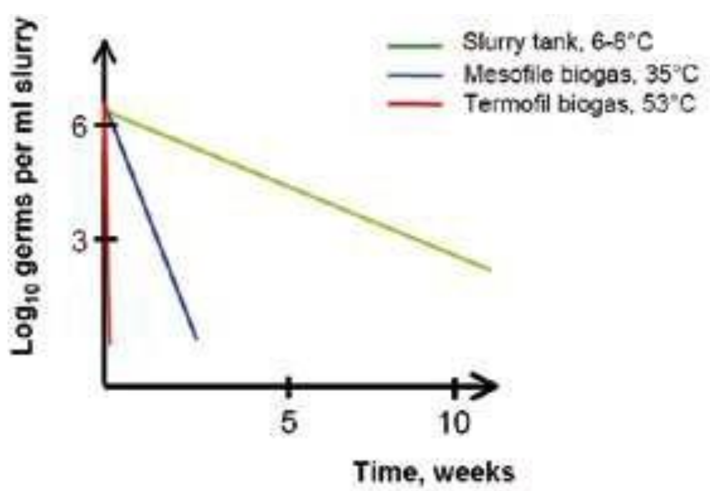

Figure 14: Comparative rates of pathogen reduction in digestate and undigested slurry measured by the log 10 FS (Streptococcus faecalis) method (Al Seadi & Lukehurst, 2012)

Table 19: Separator efficiency (%) of some common mechanical manure separators for dry matter (DM), nitrogen (N), phosphorus (P), potassium (K) and volume reduction (VR). Without polymer addition unless otherwise stated. Values expressed as percentage of component in total slurry input that was partitioned to solid fraction. (Lukehurst, Frost, & Al Seadi, 2011)

Technology	**DM**	**N**	**P**	**K**
Belt press	65	32	29	27
Centrifuge	54-68	20-40	52-78	5-20
Screw press	20-65	5-28	7-33	5-18
Sieve centrifuge	13-52	6-30	6-24	6-36
Brushed screen (cattle slurry)	36	18	26	15
Brushed screen (pig slurry)	19	6	7	5
Decanter centrifuge (pig slurry) no polymer with polymer	 53 71	 21 34	 79 93	 9 11
Decanter centrifuge (cattle slurry) no polymer with polymer	 51 65	 25 41	 64 82	 13 13

Table 20: Comparison of analysis results for undigested and digested feedstock (ADAS UK Ltd, 2007)

	TN	**NH_4-N**	**P_2O_5**	**K_2O**	**DM**	**pH**	**feedstock**
	kg/m^3	kg/m^3	kg/m^3	kg/m^3	%	-	
Feedstock Digestate Change %	3.0 3.4 +13	2.0 2.3 +15	1.4 1.6 +18	3.5 3.2 -7	4.7 4.2 -10	7.3 7.75 -	dairy cattle/pig slurry (Suffolk, UK)
Feedstock Digestate Change %	7.6 nr -	3.5 4.9 +40	0.65 0.61 -6.2	1.3 nr -	2.33 1.84 -21	7.6 8.1 -	pig slurry (Yorkshire, UK)
Feedstock Digestate Change %	4.9 4.2 -14.3	2.3 2.5 +8.7	Nr Nr -	nr nr -	8.8 6.5 -26.1	7.2 7.7 -	beef cattle slurry, beef housed on slats (Northern Ireland)
Feedstock Digestate Change %	4.63 5.11 +10.4	2.16 2.88 +33.3	1.86 1.92 +3.2	nr nr -	11.32 67.2 -25.2	7.4 7.9 -	Beef cattle slurry (New York State, USA)
Feedstock Digestate Change %	3.48 3.25 -6.6	1.70 2.12 +24.9	1.79 1.64 -8.4	nr nr -	8.81 5.69 -35.4	7.6 8.2 -	Beef cattle slurry (Wisconsin, USA)

Note: TN – total nitrogen, DM – dry matter, nr – no record.

Table 21: Efficiency of main solid-separation techniques used for processing of digestate (Williams & Esteves, 2011)

Technology	**Input DM (%)**	**Output DM (%) Solid fraction**	**Energy consumption (kWh/t)**	**Typical throughput (m^3/h)**
Sedimentation	0.5	5		
Flotation	0.5	5		
Screen sieves	0.5-5	10	0.2-0.9	10
Belt press	3-7	21-25	0.08-0.12	10-40
Centrifuge	1.7-8.1	18-30	1.8-7	0.7-40
Screw press	1-16	25-40	0.24-1.1	2-100

Table 22: Example from Denmark summarising the characteristics of four digestate and raw slurry application methods (Lukehurst, Frost, & Al Seadi, 2011)

	Trailing hose	**Trailing shoe**	**Injection**	**Splash plate**
Distribution of slurry	Even	Even	Even	Very uneven
Risk of ammonia volatilisation	Medium	Low	Low or none	High
Risk of contamination of crop	Low	Low	Very low	High
Risk of wind drift	Minimal after application	Minimal after application	No risk	High
Risk of smell	Medium	Low	Very low	High
Spreading capacity	High	Low	Low	High
Working width	12-28 metres	6-12 metres	6-12 metres	6-10 metres
Mechanical damage of crop	None	None	High	Low
Cost of application	Medium	Medium	High	Low
Amount of slurry visible	Some	Some	Very little	most

APPENDIX B - CASE STUDY - REGIONAL ANAEROBIC DIGESTION FACILITY TREATING RESIDENTIAL AND COMMERCIAL FOOD WASTE

1 OVERVIEW

This case study demonstrates the application of the TG8 validation framework for the use of digestate, from anaerobic digestion facilities treating organic waste, as a fertiliser and soil conditioner substitute. The case study considers a regional anaerobic digestion facility treating source-segregated residential and commercial food waste. The facility is designed and operated to meet the requirements specified in the BANZ Technical Guide 8 and Digestate Biofertiliser Certification Scheme The digestate will be supplied as biofertiliser to local farmers for application on pastural or arable land.

The proposed facility as a system promotes the principles of sustainable development and circular economy. The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such a transition is the opportunity to transform our economy and generate new and sustainable competitive advantages[21].

1.1 Situation

1.1.1 Feedstock

The anaerobic digestion facility is designed to process up to 70,000 tonnes of source segregated organic waste, consisting of:

- kerbside-collected residential kitchen waste,
- unsold de-packaged food waste from supermarkets,
- food and kitchen waste from restaurants and cafes.

The waste is collected and delivered to the facility by a contracted waste company based on long- term supply contracts.

1.1.2 Process

The process shown in Figure 15 consists of the following steps:

[21] Closing the Loop – an EU action plan for a circular economy; 2015

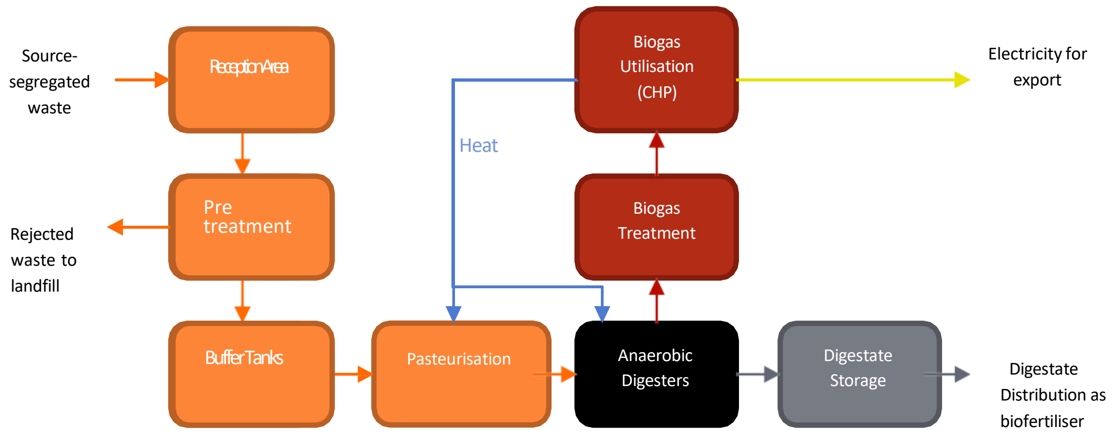

Figure 15: Facility waste processing components

The raw waste is pre-treated in a series of steps, consisting of grit-removal, shredding and homogenisation. Pasteurisation comprises heat treatment of the waste mixture for 1 hour at 70°C. Anaerobic digesters operate at mesophilic temperature (37°C) and Hydraulic Residence Time of 35 days. Digestate is stored on site in covered storage tanks for up to 50 days prior to distribution to the end users. Biogas is conditioned and used in Combined Heat and Power (CHP) units to generate heat for pasteurisation and digester heating and electricity for on-site use and distribution to the grid.

Table 23: Anaerobic Digestion facility design capacity

Parameter	Unit	Value
Waste capacity	t/year	70,000
Digester volume	m^3	3 x 3,500
Heat production	MW_{th}	2.2
Electricity production	MW_{el}	2.0
Digestate production	t/year	92,000
Nitrogen load in digestate	t/year	361
Phosphorus load in digestate	t/year	58
Potassium load in digestate	t/year	171

1.1.3 Digestate Validation and Utilisation

The facility is designed, validated and operated in compliance with the Bioenergy Association *Technical Guide 8: The Production and Use of Digestate as Fertiliser*. The management adopts a robust Quality Management System, governing the areas of feedstock quality control, process management based on HACCP (Hazard Analysis and Critical Control Point) Plan and product (digestate) management and control.

The quality of the digestate produced at the facility meets the A1 class quality requirements specified in The Guidelines for Beneficial Use of Organic material and the additional criteria specified in the Technical Guide 8 relating to physical contaminant and residual biogas production. The facility therefore has three main options for digestate validation as shown in Figure 16:

1. apply digestate on land as organic material under the Permitted Activity planning control,
2. apply digestate on land as biofertiliser by securing accreditation under the Digestate Biofertiliser Certification Scheme, or
3. apply digestate on land as compost by supplying digestate (whole or as separated fibre only) to a certified composting facility.

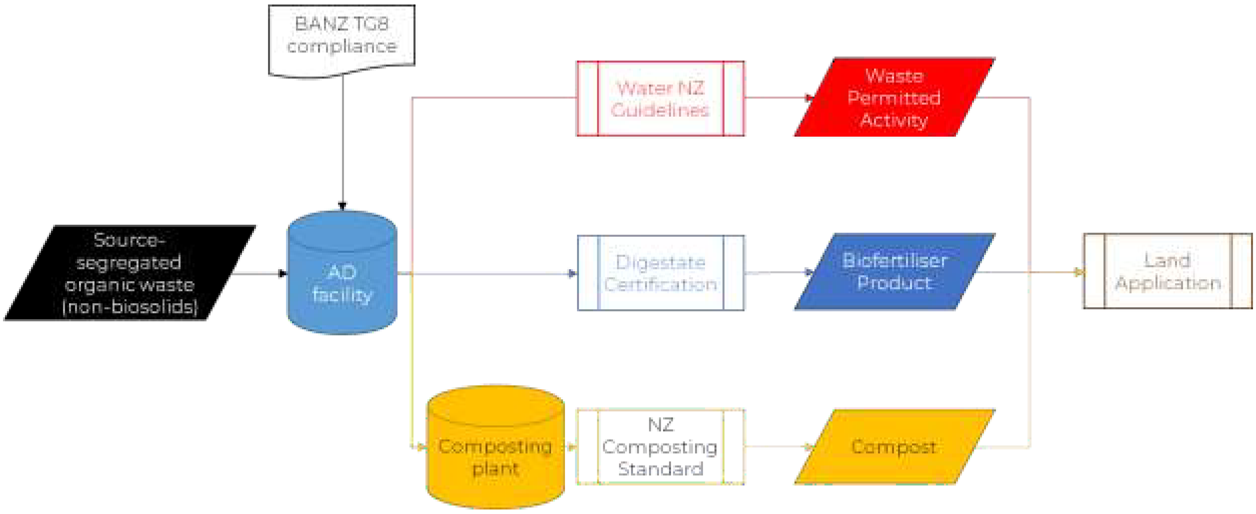

Figure 16: Alternative pathways for digestate validation

1.2 Solution

The facility management carried out a cost-benefit and risk analysis of the three product options available:

Table 24: Product options

Option	Benefits	Risks/Drawbacks
1 – waste	Low cost - no permit required (subject to local regional authority)	Subject to change in legislation
		Low product credibility
		Relies on long-term contracts
		Extensive product testing required
2 – biofertiliser	Highest value product	Cost of certification
	Recognition in agriculture, horticulture	Rigorous Input/Feedstock quality control required
	Customer/User's confidence in safe and of consistent quality	High emphasis on Quality Assurance
3 – compost	Low set-up cost	Relies on long term availability of composting plant
		Generates low value product

1.2.1 Option 1 – Waste

Under this option, the facility is expected to meet the requirements of The Guidelines *for Beneficial Use of Organic Products on Land* (2020). The owner of the facility needs to seek confirmation from the local Regional Authority that application of the produced digestate is considered a Permitted Activity and does not require any further permits.

Figure 17: Tanker fed sub-soil injection system

The Guidelines (2020) require that the operators establish a rigorous product quality testing programme to demonstrate ongoing compliance with the quality criteria specified in the Guidelines.

The digestate leaves the facility as a waste product and as such its use is subject to legislation governing waste management. It carries low product credibility despite its high nutrient content. Due to the perceived low value of the product, the producer is recommended to seek long-term supply contracts with local farmers to reduce the risk associated with product sale.

This option has a low set-up cost, yet the cost of frequent product compliance testing is high. The producer is unlikely to receive any revenue from the supply of digestate. In fact, in more AD- saturated markets, producers are required to pay farmers for the offtake of the digestate (up to $10/tonne)[22]. For the purpose of this case study, it is assumed that the offtake of digestate is cost-neutral.

1.2.2 Option 2 – Biofertiliser

Certified Biofertiliser in terms of Technical Guide 8 signifies that the digestate was produced using an effective quality management system. This provides an assurance that the materials have a consistent quality and are safe and reliable to use.

Under the certification scheme, the Biofertiliser is recognised by local authorities and potential users for its nutrient value. The monetary value of the digestate depends upon what mineral fertiliser

[22] http://www.organics-recycling.org.uk/uploads/category1060/Financial_impact_assessment_for_anaerobic_digestate.pdf

pricing benchmark is adopted. Digestate typically replaces a broad based NPK fertiliser containing all three of the primary macronutrients: Nitrogen (N), Phosphorus (P) and Potassium (K).

Based on its current market prices of mineral fertiliser, the equivalent price for digestate is $10-$20 NZD/tonne. This price factors in the increased cost of transport and spreading compared to mineral fertilisers. A conservative price of $5/tonne is assumed for the purpose of this case study to reflect the low maturity of the current digestate market.

This analysis does not quantify the monetary value of the other benefits of applying digestate that do not apply with mineral fertilisers, such as an increase in soil fertility, through the addition of organic matter, ultimately leading to maintaining soil nitrogen (N), enhancing fertility and productivity, increasing soil biodiversity, and reducing erosion, leaching and water pollution.

The higher perceived value of the Biofertiliser product, in comparison to digestate as waste or compost, increases the size of the market and reduces the risks associated with the offtake of digestate from the facility.

The annual cost of maintaining the Certification for this facility is estimated to be in the order of $10,000 – $15,000 NZD[23].

The facility needs to adopt a Quality Assurance System and carry out a hazard analysis that is conducted to define critical performance parameters for process control. The management needs to establish rigorous quality control for the received input waste. Feedstock quality requirements will form an essential part of the feedstock supply agreement with a condition to inform the AD operators of any substantial deviation in the feedstock quality or composition.

1.2.3 Option 3 - Compost

Under this option, the facility is expected to comply with NZS 4454:2005, Composts, Soil conditioners and Mulches NZS. The digestate quality and testing will be subject to the requirements of the receiving Composting facility.

The supply cost of digestate to the Composting facility is likely to be negotiated individually but may be as high as $50-$100/tonne based on current commercial rates. This is due to the relatively high operating cost of composting facilities and low value of compost as a marketable product.

The highest risk of this solution lies in the reliance on a long-term offtake contract with the receiving composting facility.

For the purpose of this case study, it is assumed that a favourable rate of $5/tonne can be negotiated with the composting facility and the product quality monitoring cost will be similar to lower than those required in the other two options.

[23] https://www.biofertiliser.org.uk/pdf/BCS-cost-benefit-analysis.pdf

1.3 Option Comparison

1.3.1 Commercial model

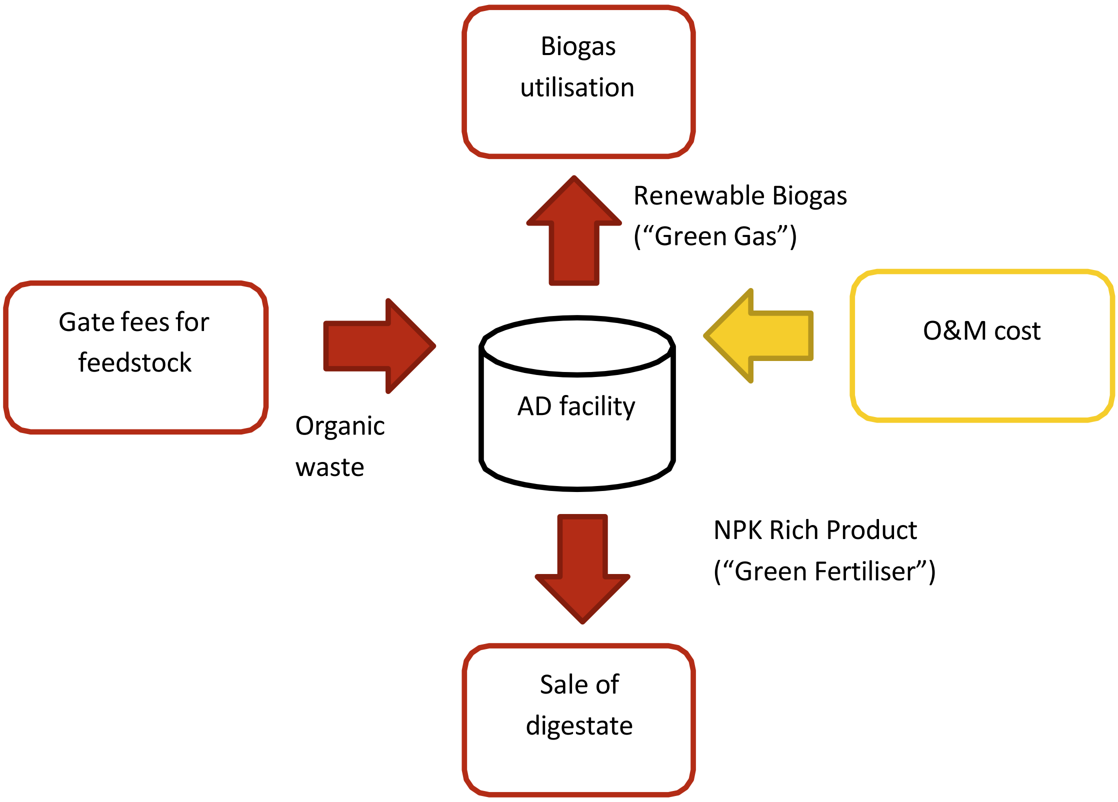

Figure 18: Commercial model for an AD facility

A typical business model for a commercial AD facility treating source segregated organic waste draws on revenue from gate fees (collected from feedstock suppliers or as avoided disposal cost), revenue from biogas utilisation (in form of heat, energy, CO_2), and the sale of digestate as biofertiliser, compost or for direct use.

Construction of an AD facility involves a large capital investment, which presents a substantial risk to the project developer/owner. Therefore, the contractual commitments for waste supply, biogas and fertiliser sales need to be long-term (> 10 years) to justify the investment.

The (feedstock/biogas/biofertiliser) customers' key risk during this period is whether the negotiated price becomes expensive compared to future alternative options for waste disposal, fertiliser and energy supply.

It should be acknowledged that policy decisions introducing a cost of carbon to reduce emissions (from waste disposal, industrial heat and fertiliser usage) suggest that the cost of traditional alternative options will increase in real terms over time.

1.3.2 Options comparison

It is assumed that the revenue from feedstock gate fees and sale of biogas will be the same for all three options. Similarly, the operation and maintenance cost of the facility is the same for all three options. Option 1 will comply with The Guidelines and Option 2 with TG8. Option 3 will comply with NZS 4454:2005.

Table 25 lists the variable cost and revenue for the three presented options. The facility selling digestate (@ $5/tonne) as a certified biofertiliser has an opportunity to generate substantial revenue.

Table 25: Evaluation of digestate sale options

Option	Annual Cost		Annual Revenue	
1 – waste	Monitoring	$10,000	Sale of digestate	$0
2 - biofertiliser	Certification	$12,000	Sale of digestate	$460,000
3 - compost	Monitoring	$5,000	Sale of digestate	-$460,000

Based on the equivalent nutrient value (as kg N/ha applied), the assumed Biofertiliser price needs to be competitive with commercial mineral fertiliser and other biofertilisers to provide financial incentive to its users. Detailed feasibility assessment of potential AD projects demonstrate that the digestate sale value can be as high as $20/tonne, depending on the digestate composition.

1.4 Conclusions

This case study explains the application of the proposed validation framework for the use of digestate from anaerobic digestion facilities treating organic waste. The risk and cost-benefit analysis of the three proposed options demonstrates the value of obtaining Biofertiliser Certification for the produced digestate due to the larger market potential for high-quality product and a potential revenue that may be generated from its sale.

The Certification scheme for digestates to standardise and increase their quality is expected to stimulate the development of the anaerobic digestion option and the available markets for the products. This will provide more certainty in the marketplace and consequently reduce costs and improve the public acceptance of the products. The Certification scheme is also expected to reduce the costs of marketing by providing users with information/knowledge about the product and thereby stimulate confidence.

APPENDIX C - CASE STUDY - ANAEROBIC DIGESTION FACILITY TREATING FARM WASTE

1 OVERVIEW

This case study relates to a farm digester treating manures and/or crop residues. The facility is designed and operated to meet the requirements specified in Technical Guide 8 and a Digestate Certification Scheme for manures (to be developed). The digestate is applied to arable land that is part of the farm holding or sold to neighbouring farms.

1.1 Situation

1.1.1 Feedstock

The anaerobic digestion facility is designed to process up to 70 m^3/day of dairy farm effluent from a 750 head herd. The cows are milked twice a day and kept indoors on a covered feed pad for 12 hours a day. The equivalent herd size for the same organic load where the cows are on the feed pad for only 4 hours would be about 1,800 cows.

1.1.2 Process

The digestion process is set out in Figure 19.

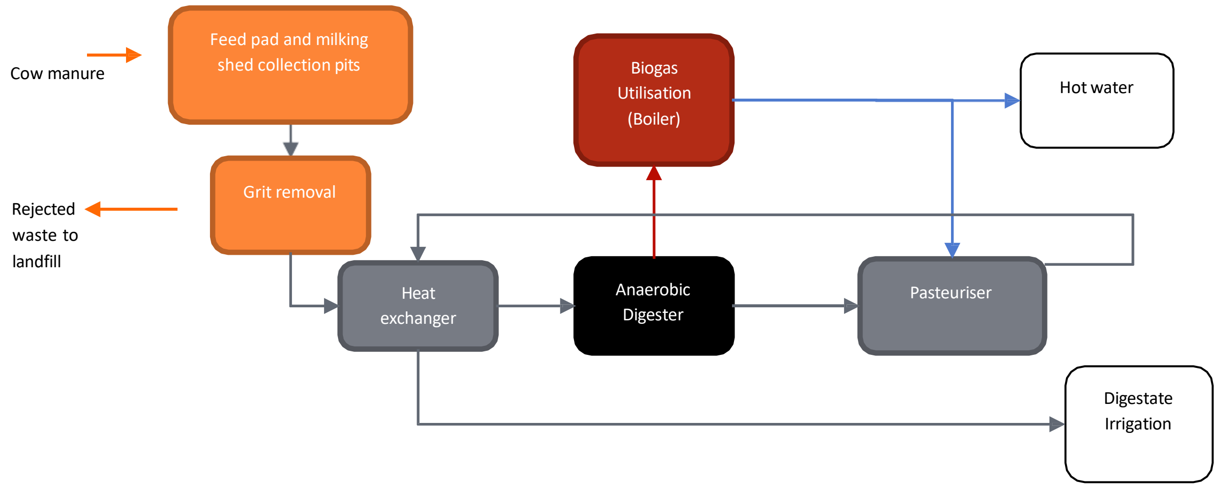

Figure 19: Farm digester process

The raw waste from the milking shed is washed down to collection pits for each milking. The manure from the feed pad is scraped down daily followed by a washdown. From the collection pits it flows through grit removal traps to a holding sump. The contents of the holding sump are pumped into the bottom of a covered lagoon digester. The lagoon has been designed and built to the DairyNZ /IPENZ guide[24]. The mesophilic digesters operate at 35°C and with a Hydraulic Residence Time of 60 days. Digestate is stored in the storage ponds for up to 50 days prior to irrigation on to pasture. The biogas can be used directly to generate heat for pasteurisation of the digestate (if required) and heating of

[24] https://www.dairynz.co.nz/publications/environment/ipenz-21-farm-dairy-effluent-pond-design-and-construction/

milk tank wash-down water. Heat from the digestate is recovered in a heat exchanger to heat the incoming effluent.

Table 26: Anaerobic Digestion facility design capacity

Parameter	Unit	Value
Waste capacity	t/year	21,000
Digester volume	m^3	1 x 5,000
Heat production	MW_{th}	0.365
Digestate production	t/year	21,000
Nitrogen load in digestate	t/year	73
Phosphorus load in digestate	t/year	8.5
Potassium load in digestate	t/year	75

1.1.3 Digestate Validation and Utilisation

The facility is designed, validated and operated in compliance with the Bioenergy Association *Technical Guide 8: The Production and Use of Digestate as Fertiliser*. The management adopts a robust Quality Management System, governing the areas of feedstock quality control, process management based on HACCP (Hazard Analysis and Critical Control Point) Plan and product (digestate) management and control.

The quality of the digestate produced at the facility meets the A1 class quality requirements specified in The Guidelines *for Beneficial Use of Organic material* and the additional criteria specified in the Technical Guide 8 relating to physical contaminant and residual biogas production.

As shown in Figure 20 the facility has two (2) main options for the beneficial use of their digestate:

1. Business as usual; apply digestate on land as waste organic material under the existing effluent discharge consent,
2. Apply digestate on land as certified Biofertiliser by securing accreditation under the Digestate Certification Scheme (under development).

Option 1 meets the requirements of The Guidelines and has 2 options which is for use as a fertiliser on the on-site farm (Option 1a), or for sale to neighbouring farms (Option 1b)

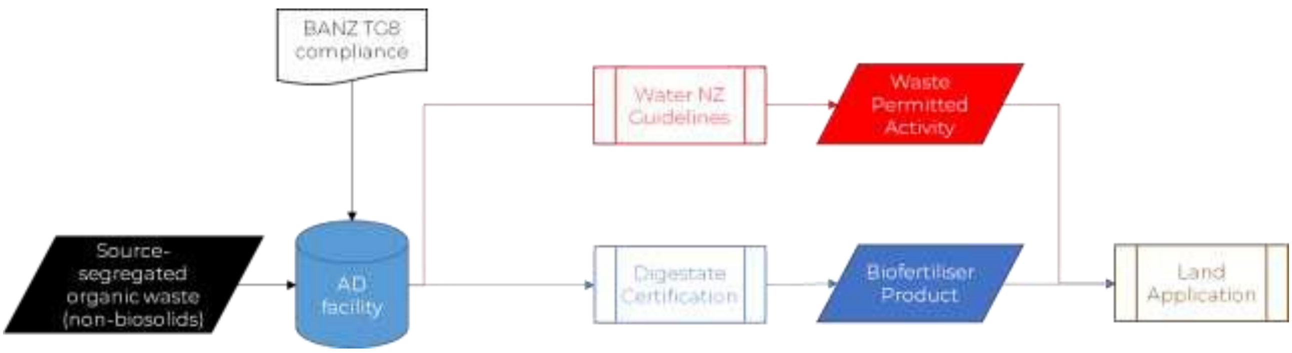

Figure 20: Options for processing and selling digestate

In option 2 the biofertiliser is produced to the requirements of TG8 and is assumed to be sold in a liquid form as it is for on-farm use. The option of drying the biofertiliser for sale to other parties could be possible but with the underdeveloped state of the biofertiliser market the option of drying and selling the biofertiliser would not generally be economic. This could be a future option.

1.2 SOLUTION

The facility management carried out a cost-benefit and risk analysis of the two options available as shown in Table 27:

Table 27: Benefits and Risks of Options

Option	Benefits	Risks/drawback
1 – Discharge to land as waste	Low cost – standard consent required	Subject to change in legislation
	Nutrient benefit when applied to own land	Low product credibility and low/negative return when applied to off-farm sites
2 – Certified Biofertiliser	Higher value product	Cost of certification
	Recognition in agriculture, horticulture	Additional cost for pasteurisation
	Customer/User confidence as safe and of consistent quality	Additional cost for delivery

1.2.1 Option 1 – Discharge to land (Business as usual).

Under this option, the facility is expected to comply with The Guidelines *for Beneficial Use of Organic Products on Land* (2020). The owner of the facility needs to seek confirmation from the local Regional Authority that application of the produced digestate is considered a Permitted Activity and does not require any further permits. If the regional plan has provision for digestate to be applied as a permitted activity then this can be done otherwise the dairy farm would discharge under their existing effluent consent. In either case there would be no need for pasteurisation.

The digestate could be applied to neighbouring land without pasteurisation (Option 1b) provided a controlled activity discharge consent were obtained. The digestate would leave the facility as a waste product and as such its use would be subject to legislation governing waste management. It carries low product credibility despite its high nutrient content. Due to the perceived low value of the product, the producer is recommended to seek long-term supply contracts with local farmers to reduce the risk associated with product sale. Assuming the application to land is consented as a controlled activity, this consent will apply to a particular land area so security of access to that land for discharge is also important.

The producer is unlikely to receive any revenue from the supply of digestate. In fact, in more AD-saturated markets, producers are required to pay farmers for the offtake of the digestate (up to

$10/tonne)[25] due to its perception as a waste product. In addition to this there would be significant transport or reticulation costs to get the digestate to the neighbouring farms.

1.2.2 Option 2 – Certified Biofertiliser

Certified Biofertiliser signifies that the digestate was produced using an effective quality management system. This provides an assurance that the pathogen free materials have a consistent quality and are safe and reliable to use.

Under the certification scheme, the Biofertiliser is recognised by local authorities and potential users for its nutrient value. In some markets, this is sufficient for the producer to generate revenue from the sale of digestate. Based on its estimated nutrient value, the equivalent price for digestate from a dairy effluent digester is $10.25 NZD/tonne. A conservative price of $5/tonne is assumed for the purpose of this case study to reflect the low maturity of the current digestate market.

The cost of transport needs to be considered. It is unlikely that trucking of 70 m^3/day of digestate would be a viable option so the most likely scenario would be reticulation of the digestate to the receiving farm within 5 km. The cost of this reticulation could range from $50,000 to $500,000 depending on the distance and terrain. A typical set up cost of $300,000 spread over ten years has been assumed giving an annual cost of $30,000. The cost of delivery also limits the available market for the product as the end user needs to be in reasonable proximity to the digestion facility.

The higher perceived value of the product increases the size of the market and reduces the risks associated with the offtake of digestate from the facility.

The annual cost of maintaining the Certification for this facility is estimated to be in the order of $10,000 – $15,000 NZD[26].

The facility needs to adopt a Quality Assurance System and carry out a hazard analysis that is conducted to define critical performance parameters for process control. The management needs to establish rigorous quality control for the received input waste. Feedstock quality requirements will form an essential part of the feedstock supply agreement with a condition to inform the AD operators of any substantial deviation in the feedstock quality or composition.

In order to be supplied to farms outside the holding the product would need to undergo pasteurisation. This would require the input of an additional 84kW of heating. While the heating can be provided by the burning of the biogas this might result in lost opportunity to use the gas for other purposes. 84 kW represents about $30,000 assuming $0.05 per kWh commercial gas rates.

For this option it is assumed that Regional Councils will apply a permitted activity rule based on the application of a certified fertiliser.

Securing the facility certification also enables the facility to receive and treat wastes other than manure provided these comply with the source-segregated waste specification of the accreditation

[25] http://www.organics-recycling.org.uk/uploads/category1060/Financial_impact_assessment_for_anaerobic_digestate.pdf

[26] https://www.biofertiliser.org.uk/pdf/BCS-cost-benefit-analysis.pdf

scheme and the TG8, and do not compromise the quality of the digestate. Typical drivers for treating other wastes are:

- Improving the digestate nutrients content,
- Generating more biogas energy for use on farm or for export, and/or
- Improving the project economic viability through additional revenue from gate fees and increased output volumes.

1.2.3 Option Comparison

The business case comparison of the two options is presented in Table 28. It is assumed that the operation and maintenance cost of the facility is the same for all options as all will need to comply with the requirements specified in the Technical Guide 8. Note the business case is limited to the use of digestate; additional revenues such as power savings/income and potential carbon credits are not included.

Table 28: Cost, Revenue and Gross Profits for Options

Option	Annual Cost		Annual Revenue	
1a – Discharge to own land as waste	Consent costs and monitoring	$5,000	Sale of digestate	$0
			Gross Profit (1a)	**-$5000**
1b – Discharge to neighbouring land as waste	Consent costs and monitoring	$5,000	Sale of digestate	$0
	Reticulation	$30,000		
			Gross Profit (1b)	**-$35,000**
2 – Sale as Certified Biofertiliser	Certification	$12,000	Sale of digestate	$105,000
	Reticulation	$30,000		
	Pasteurisation	$30,000		
			Gross Profit (2)	**$33,000**

1.3 Conclusions

This case study examines the options for the use of digestate from anaerobic digestion facilities treating dairy shed and feed pad waste. The risk and cost-benefit analysis of the three options demonstrates that while there may be little benefit in obtaining biofertiliser certification when applying digestate to one's own land, there could be value in obtaining Biofertiliser Certification when providing digestate to outside users, due to the larger market potential for a high-quality product and the potential revenue that may be generated from its sale. However the analysis is sensitive to the price the product can command and the cost of delivery to the end user, and it is these factors which will most likely determine the viability of obtaining Biofertiliser Certification.

APPENDIX D - CASE STUDY - REGIONAL ANAEROBIC DIGESTION FACILITY CO-TREATING FOOD INDUSTRY LIQUID WASTE WITH MUNICIPAL BIOSOLIDS

1 OVERVIEW

"The biogas plant is the hub in the future circular economy. Streams of excess materials, previously regarded as waste, from industrial processes, agriculture and other human activity can be processed through biogas digesters and converted to useful energy carriers, nutrient-rich organic fertiliser and novel materials" (International Energy Agency, 2018)[27].

Consistent with these international developments, primary production industries (dairy, meat, viticulture, food products) have a unique advantage through treating available liquid waste within existing municipal wastewater treatment digester capacities. This has been shown to achieve full treatment and stabilisation of selected source-segregated liquid organic waste materials from food processing industries and of fat, oil and grease rich liquid waste[28] from urban sources.

One key for success of these municipal WWTP infrastructure upgrades towards a circular economy transition is the selection of concentrated liquid waste that are rich in biochemical oxygen demand (BOD), fat oil and grease (FOG) and are low in N,P.K nutrients[29]. This maximises the treatment benefit, the production of useful energy carriers, carbon mitigation and further supports nutrient capture while reducing nutrient release to waterways. Further improvements are feasible with improved N-nutrient recovery.

This case study demonstrates the application of the Bioenergy Association proposed validation framework for the use of digestate from anaerobic digestion facilities treating organic waste within municipal wastewater treatment plants (WWTP's). It relates to a regional anaerobic digestion facility treating source-segregated food processing industry liquid organic waste (DAF sludge), grease trap waste from regional commercial food processors and restaurants and cheese whey from the region.

This facility is an upgrade of an existing municipal WWTP digester for dual purpose use (co-digestion of plant biosolids and imported organic liquid waste) and is designed and operated to meet the requirements specified in Technical Guide 8 and Digestate Certification Scheme for biosolids (to be developed).

Due to the unique digestion process conditions (trade waste co-digestion), optimised to reduce treatment costs in the regional facility, the food waste digestate becomes mixed with WWTP biosolids digestate and is then processed in the WWTP into treated wastewater and dewatered digestate biosolids. The digestate will therefore not be supplied to local farmers for application on pastural or arable land.

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[27] The role of anaerobic digestion and biogas in the circular economy. IEA Bioenergy Task 37:2018:8

[28] JH Thiele (2012). Future proofing our wastewater treatment infrastructure. Proceedings of the Water New Zealand Annual Conference. 2012. Rotorua Energy Events Centre, 26 – 28 September 2012

[29] JH Thiele (2011). The Secret is in the Sludge. Proceedings of the Water New Zealand Annual Conference. 2011. Convention Centre, Rotorua, New Zealand.

The proposed facility as a system promotes the principles of sustainable development and circular economy. The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages[30].

1.1 SITUATION

1.1.1 Feedstock

The anaerobic digestion facility is designed to co-process pre-thickened municipal biosolids (up to 60,000 tonnes per annum, tpa, 3-4 % dry matter) with up to 13,000 tpa of source segregated high strength liquid organic waste (12-15 % dry matter), consisting of:

- Dairy factory wastewater DAF sludge,
- Cheese factory whey,
- Grease trap waste from commercial catering and food processing.

The waste is collected and delivered to the facility by a contracted waste company based on long- term supply contracts.

1.1.2 Process

The process consists of the steps set out in Figure 21.

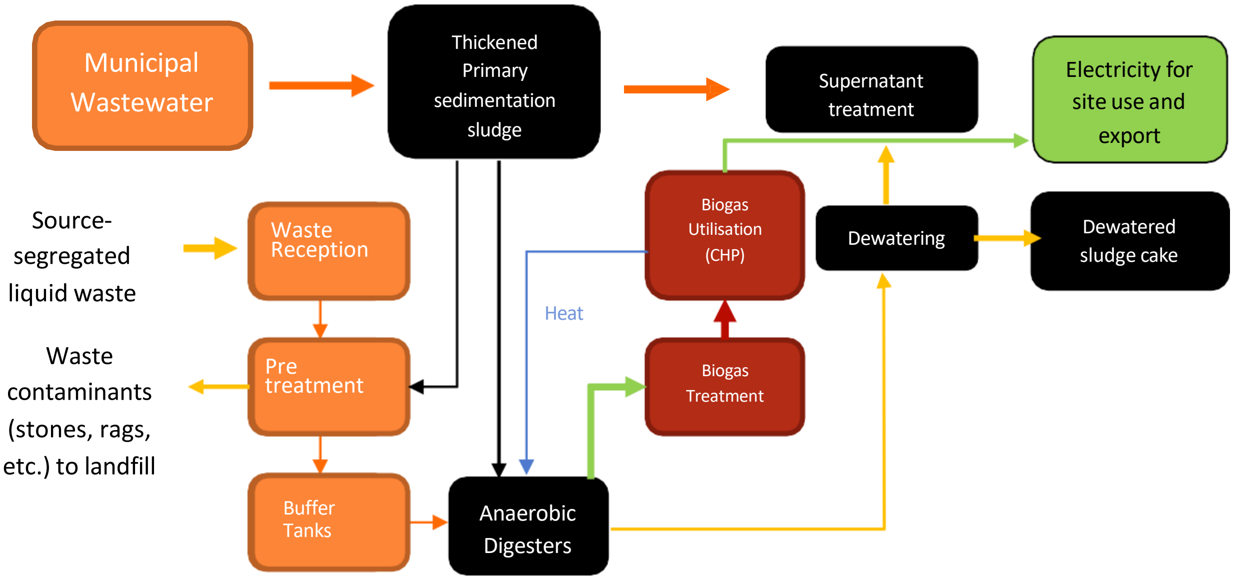


Figure 21: Wastewater Treatment Plant processing of source segregated organic wastes

The raw waste is pre-conditioned in a series of steps, consisting of grit-removal and contaminant removal. The two anaerobic digesters operate in co-digestion mode at a mesophilic temperature (37°C) and Hydraulic Residence Times (HRT) of 12-15 days. Biogas is conditioned with activated

[30] Closing the Loop – an EU action plan for a circular economy; 2015

carbon, blended with natural gas and used in a Combined Heat and Power (CHP) unit to generate power (3-4 times increased output compared to wastewater treatment sludge alone) and digester heating. Electricity is for on-site use and distribution to the grid.

Table 29: Anaerobic Co-Digestion facility design capacity

Parameter	**Unit**	**Value**
Waste capacity	t/year	73,000
Digester volume	m^3	2 x 1,350
Heat production	MW_{th}	approx. 1
Electricity production	MW_{el}	0.7
Digestate production	t/year	N/A
Nitrogen load in digestate	t/year	N/A
Phosphorus load in digestate	t/year	N/A
Potassium load in digestate	t/year	N/A

1.1.3 Digestate Validation and Utilisation

The facility is designed, validated and operated in compliance with The Guidelines. While the management adopts a robust Quality Management System, governing the areas of feedstock quality control, process management based on HACCP (Hazard Analysis and Critical Control Point) Plan and product (digestate) management and control, the quality of the digestate produced at the facility is rated as a biosolid product. It does not meet the A1 class quality requirements specified in the 2017 DRAFT The Guidelines for Beneficial Use of Organic material[6]. It also does not meet the additional criteria specified in the Technical Guide 8 (physical contaminant and residual biogas production).

As the quality of the digestate produced at the facility is rated as a biosolid product, in order to sell the digestate the facility management should carry out an analysis of the main digestate quality criteria laid down in the 2020 The Guidelines for Beneficial Use of Organic Materials on Productive Land:

1. **Pathogen destruction**
   The digestion process has no process stage that is dedicated to an effective pathogen destruction (Table 5.2 in The Guidelines.)
2. **Vector attraction reduction**
   The digestion process has a process stage that is dedicated to an effective vector attraction reduction (> 50 % VS destruction achieved; Table 5.3 in The Guidelines.)
3. **Product pathogen standard**
   The digestion process has no process stage that is dedicated to achieve effective pathogen reduction to meet product pathogen standards (Table 5.4 in The Guidelines.)
4. **Contaminant limits**
   The digestion process has no process stage that is dedicated to reduce digestion product contaminant levels. Based on historical data[31] the metal content for the anaerobic co-

[31] NZWWA (1998). National Study of the Composition of Sewage Sludge. ISBN 1-877134-17-1

digestion digestate is likely to exceed the product contaminant concentration limits for most of the key monitored metal contaminants (Table 5.4 in The Guidelines.). This will need targeted verification of current metal contaminant levels in the digestate from the co-digestion process.

To be able to supply the digestate for disposal to land The Guidelines[32] require that the operators establish a rigorous product quality testing programme to demonstrate ongoing compliance with the quality criteria specified in the Guidelines.

The design and implementation of co-digestion process modifications to meet criteria 1 and 3 above would be cost prohibitive. The digestate leaves the facility as a waste product and as such its use is subject to legislation governing waste management.

Unless significant co-digestion process changes are implemented (see the case study in Appendix E), the production of biofertiliser or compost from the digestate is not possible.

1.1.4 Commercial model

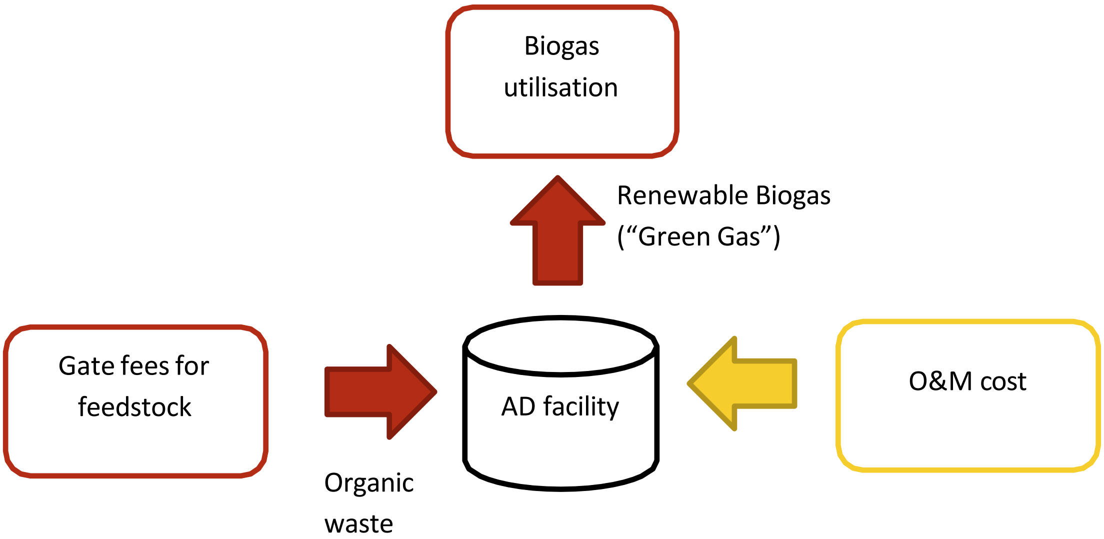


Figure 22: Commercial model with no revenue from fertiliser sales

Where revenue cannot be achieved from sale of digestate as a fertiliser a typical business model for a commercial AD facility treating source segregated organic waste draws on revenue from gate fees (collected from feedstock suppliers or as avoided disposal cost), revenue from biogas utilisation (in form of heat, energy, CO_2), and the sale of biosolid for non-land disposal uses. As detailed in Figure 22, the sale of biofertiliser is not realised in this liquid organic waste co-digestion business model.

However, a multiyear performance analysis of this plant[33] has shown that the added liquid trade waste with high FOG content had a neutral effect on the dry matter amount of digestate solids when compared with the digester plant operation without addition of trade waste. In general, the addition

[32] Guidelines for beneficial use of organic materials on productive land (WaterNZ, 2017, DRAFT)

[33] JH Thiele et al (2016). Improved Trade Waste Co-digestion. Water e-journal Vol 1 No 3. On-line journal of the Australian Water Association. ISSN 2206-1991

of easily digestible organics to primary sludge digesters does improve the sewage sludge digestion efficiency, so there is no sludge disposal penalty incurred when co-digesting trade waste.

Construction of an AD facility typically involves a large capital investment, which presents a substantial risk to the project developer/owner. For example, for the situation described in the case study in Appendix D, construction costs of $30 million are estimated. Therefore, the contractual commitments for waste supply, and biogas sales need to be long-term (> 10 years) to justify the investment.

In case of the construction costs of added infrastructure for this case study, the construction costs were less than 1/10th of the Appendix B case study (Regional Anaerobic Digestion Facility treating Residential and Commercial Food Waste) construction costs and a simple payback of less than 4 years was calculated[7]. In this case, the waste supply contract with one supplier (dairy company) was sufficient and gate fees of the co-digestion facility during a 5 year period could be kept below 50 % of corresponding landfill gate fees. Table 30 shows the relative economics at two gate fee levels.

The (feedstock/biogas/biofertiliser) customers' key risk during this period is whether the negotiated price becomes expensive compared to future alternative options for waste disposal, fertiliser and energy supply.

Table 30: Anaerobic Co-Digestion facility expected business performance

	Construction costs (incl. waste reception)	Operating cost	Revenue from trade waste gate fees	Revenue from biogas sales as genset fuel	Simple Payback Period
Gate fee: 30 $/m^3	$ 1.1 million	$ 0.2 million/ annum	$ 0.38 million/ annum	$ 0.15 million/ annum	3.3 year **(30 % ROI)**
Gate fee: 50 $/m^3	$ 1.1 million	$ 0.2 million/ annum	$ 0.63 million/ annum	$ 0.15 million/ annum	1.9 year **(53 % ROI)**

Electricity: 0.15 $/kwh. **Polymer:** 10 $/kg and 6 kg polymer/t DS.
Value of biogas: 0.025 $/kwhbiogas. **Trade waste processing capacity:** 13,000 wet t/annum

It should be acknowledged that policy decisions introducing a cost of carbon to reduce emissions (from waste disposal, industrial heat and fertiliser usage) suggest that the cost of traditional alternative options will increase in real terms over time.

1.2 Conclusions

This case study explains the application of the proposed validation framework for the use of digestate from anaerobic digestion facilities treating liquid organic waste by co-digestion on municipal wastewater treatment plants when biosolids cannot be sold as a fertiliser. Key conclusions include:

- Co-digestion of liquid organic waste with municipal biosolids waste at a wastewater treatment plant does not produce digestate of the required quality to achieve certification as a biofertiliser

- Only 1 of the four standards of The Guidelines are achieved so the A1 or B1 classification is not met – specifically speaking the vector attraction reduction standard.
- Achieving the required biofertiliser certification would require process modification to achieve standards for pathogens and other contaminant limits adding business risk (through additional investment costs) particularly given the uncertainty associated with the sale of biofertilizer.
- The benefits of co-digestion however include:
    - minimising capital costs and integrating the organic waste digestion into operating premises.
    - increase energy production at wastewater treatment plans offsetting energy costs and provide carbon mitigation.
    - Collecting gate fees for the treatment of the imported organic waste
- When the biosolids processing is separated from the organic waste processing (see case study in Appendix E), the financial risks are reduced due to the larger market potential for high-quality digestate product and potential additional revenue that may be generated from its sale.

Introducing the Biofertiliser Certification scheme for biosolids to standardise and increase their quality is expected to diversify the development of the anaerobic digestion option and the available markets for the products. This will provide more certainty for digestate sales in the marketplace and consequently reduce costs and improve the public acceptance of the products.

The Biofertiliser Certification scheme is also expected to reduce the costs of marketing by providing users with information/knowledge about the product and thereby stimulate confidence. However, this case study demonstrates that the transition to circular economy based liquid organic waste management is possible in either case.

Appendix E – Case Study - Regional Anaerobic Digestion Facility Producing Biofertiliser from Food Industry Liquid Waste, Food Residuals and Biosolids

1 Overview

This document presents one of four case studies demonstrating the application of the Bioenergy Association (BANZ) proposed validation framework for the use of digestate from anaerobic digestion facilities treating organic waste to produce fertiliser and soil conditioner substitute.

Recent cost reductions in municipal sludge digester technology (recuperative thickening) on municipal wastewater treatment plants (WWTP) have enabled councils, waste processors and utilities to upgrade existing sludge digesters to increase sludge solids treatment capacity 2-3 fold without significant CAPEX for construction of new digester tanks or ancillary plant[34&35]. This has been also adopted internationally (Sydney Water, Melbourne Water, others).

Consistent with these developments, New Zealand has now a proven unique advantage in utilising potentially added solids digestion capacities (about 18 sites) to process additional organic waste in municipal WWTP[36].

Prudent use of this "new normal" for organic waste co-digestion (see biofertiliser case 3) achieves

i. full stabilisation of selected source-segregated industrial organic waste, source segregated food residuals and of fat, oil and grease rich liquid waste[35] (about 13,000 tonnes per annum (tpa) per 100,000 population);
ii. 3-4 fold improved daily biogas production. Gas saleable as genset or boiler fuel;
iii. credits for reduced GHG emissions by diverting organic waste from landfills to digesters;
iv. production of nutrient-rich organic biofertilizer.

Key for success in point (iv) is the separation of the biosolids digestion train from the organic waste digestion train at the digester plant. Ideally, concentrated liquid waste and source segregated food waste slurry rich in biochemical oxygen demand (BOD), fat oil and grease (FOG) and N,P.K nutrients[37] are treated in one dedicated digester plant process train, WWTP biosolids are treated in another avoiding biofertiliser contamination with biosolids constituents. Further improvements are feasible at a later stage with improved N-nutrient recovery from the biosolids processing train.

This case study demonstrates the application of the Bioenergy Association (BANZ) proposed validation framework for the use of digestate from anaerobic digestion facilities treating organic waste in a dual train WWTP digester process. It relates to a regional anaerobic digestion facility

[34] C Hearn and JH Thiele (2004). Design and Implementation of a large Digester Facility for Putrescible Waste – Process Implementation and Lessons Learned. 2004 Annual Conference, NZ Waste Management Institute.

[35] JH Thiele (2010). Municipal Sludge Digesters for Co-digestion of Primary Sludge and High Fat Industrial Waste. Proceedings of the Water New Zealand Annual Conference. 21-24 September 2009.

[36] JH Thiele (2012). Future proofing our wastewater treatment infrastructure. Proceedings of the Water New Zealand Annual Conference. 2012. Rotorua Energy Events Centre, 26 – 28 September 2012

[37] JH Thiele (2011). The Secret is in the Sludge. Proceedings of the Water New Zealand Annual Conference. 2011. Convention Centre, Rotorua, New Zealand.

treating source-segregated food industry liquid organic waste (DAFF sludge), grease trap waste from regional commercial food processors and restaurants, source segregated food residuals and cheese whey from the region. We also demonstrate options to optimise the business model for this.

The proposed facility as a system promotes the principles of sustainable development and circular economy. The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages[38]*.*

1.1 SITUATION

1.1.1 Feedstock

The anaerobic digestion facility is designed to separately process pre-thickened municipal biosolids (up to 60,000tpa, 3-4 % dry matter) with up to 13,000 tpa of source segregated high strength liquid organic waste (3-15 % dry matter), consisting of:

- Dairy factory wastewater DAFF sludge,
- Cheese factory whey,
- Slurries of macerated source segregated food waste (8-10 % dry matter),
- Grease trap waste from commercial catering and food processing (1-5 % dry matter).

The organic waste is collected and delivered to the facility by a contracted waste company based on long-term supply contracts. The biosolids are produced from the sewage treatment operations at the site.

Note: In the real-life scenario, **no solid food waste** supply contract was able to be established as the AD facility was in direct competition with the adjacent composting plant and any solid food waste gate fees collected at the AD facility would have taken away from the adjacent composting facility that is owned by the council as well ("zero sums game").

1.1.2 Process

The process consists of the following steps:

[38] Closing the Loop – an EU action plan for a circular economy; 2015

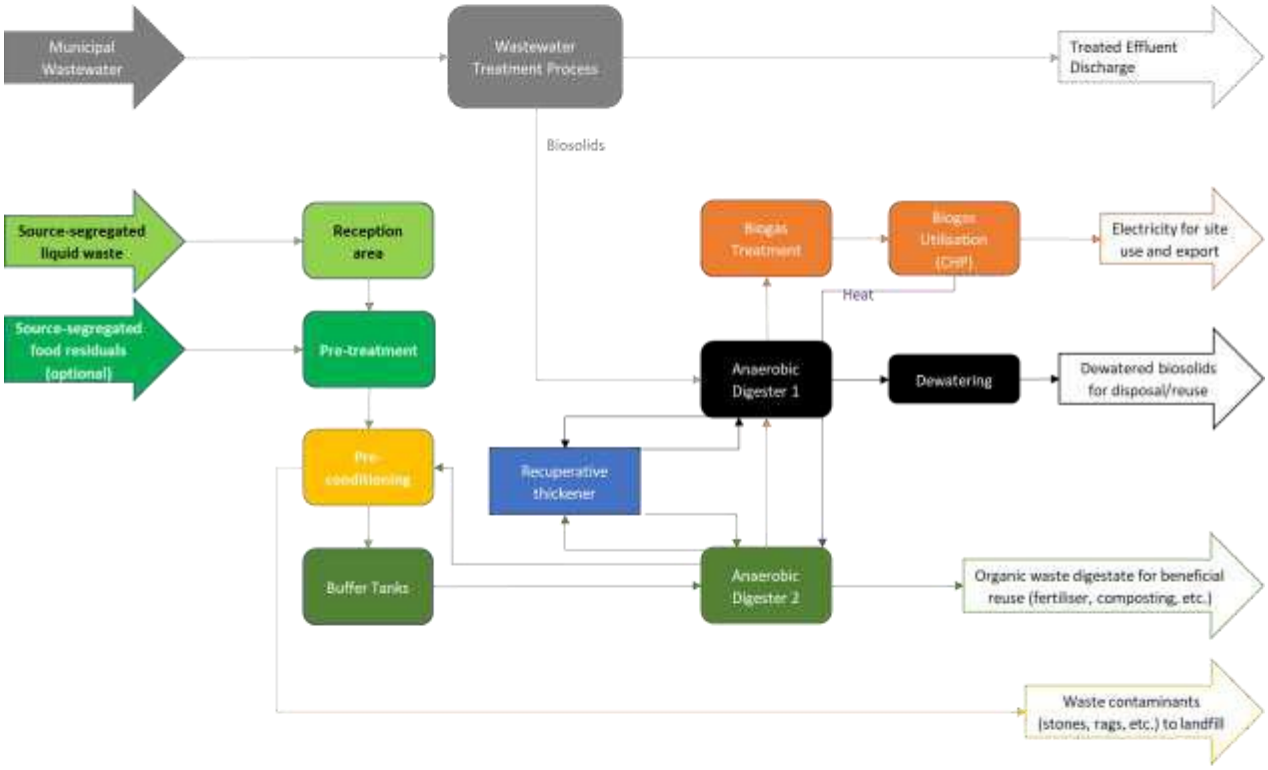


Figure 23: Pathways for processing organic matter for application to land

The WWTP biosolids are received from the existing WWTP infrastructure (primary sedimentation tank with sludge thickening). The source segregated liquid organic waste is received in a liquid waste reception in a series of steps, consisting of grit-removal and contacting. The source segregated solid food residuals are received in a dedicated food waste reception building, macerated, pre-conditioned and contacted with food waste digestate.

The anaerobic digesters (2 x) operate in parallel mode, at mesophilic temperature (37°C) and with Hydraulic Residence Times (HRT) of 12-15 days. Digester 1 operates typically in mono-digestion mode with pre-thickened primary sludge and without solid organic waste addition.

Digester 2 operates always in co-digestion mode with highly variable daily loads of rich liquid organic waste (high FOG, high BOD) and variable daily loads of solid food residuals. In rare occasions where the liquid industrial food waste and/or grease trap waste exceed the digester 2 treatment capacity, the surplus liquid waste can be added to digester 1 instead of digester 2.

The recuperative thickener (RT) facility is typically dedicated to digester 2 when all liquid organic waste is added to the food waste digester train (digester 2). The typical RT operation mode for digester 2 is to thicken digester contents to 3-3.5 % TS (typical upper solids capacity cap of municipal sludge digesters) with daily RT operation times of up to 20 hours/day. Solids residence times (SRTs) in the order of 30-40 days are expected.

When the upper solids capacity cap in digester 2 is reached, the RT facility can be disconnected from digester 2 and the digester operated for several weeks without use of the recuperative thickener. Typically, the digester then continues to operate stably and gradually reduces its solids content back from 3-3.5 % TS to 2-2.5 % TS (lower solids capacity bottom). This mode is called a “sea-saw RT operation”.

During the solids weaning phase of digester 2, the RT-facility is connected to digester 1. Typical digester 1 RT operation mode is to thicken the Digester 1 contents up to 2-2.5 % TS (typical operation range of municipal sludge digesters with co-digestion) with daily RT operation times of up to 20 hours/day. When 2-2.5 % TS is reached in digester 1 or digester 2 reaches 2-2.5 % TS (whichever comes first), the RT facility will be disconnected from digester 1, flushed with site process water (thickener and pipework), the flushwater returned to Digester 1 and Digester 1 then operated for several weeks without recuperative thickener. The RT function can be then transferred to Digester 2 or remain idle.

The thickener is the main potential source of cross contamination between digester 1 and 2. It is absolutely critical to follow correct rinsing protocol and prudent testing protocol to prevent cross contamination.

The digestion process has no process stage that is dedicated to an effective pathogen destruction (pasteurisation). Integration of such a step into the WWTP would be cost prohibitive due to the CAPEX, integration costs into the site heat loop with “pasteurisation priority”, high annual heat demand from the high annual digestate volumes (15,000 tpa) and the limited spare heating capacity in the WWTP site heat loop.

Biogas from both digesters is combined and once conditioned, i.e. de-humidified and de-sulphurised, used in a Combined Heat and Power (CHP) unit to generate power and heat for digester heating. Electricity is used for on-site use and distribution to the grid. When the genset fuel demand exceeds the biogas supply, the waste and biosolids digestion biogas is blended with some natural gas.

Table 31: Anaerobic Co-Digestion facility design capacity (combined trains)

Parameter	Unit	Value
Waste capacity (combined)	t/year	75,000
Digester volume	m^3	2 x 1,350
Heat production (combined)	MW_{th}	approx. 1
Electricity production (combined)	MW_{el}	0.7
Digestate production (Digester 2)	t/year	Up to 15,000
Nitrogen load in digestate (Digester 2)	t/year	Up to 35-63
Phosphorus load in digestate (Digester 2)	t/year	Up to 3 - 22
Potassium load in digestate (Digester 2)	t/year	Up to 20-80

1.1.3 Digestate Validation and Utilisation

The facility is designed, validated and operated in compliance with the Bioenergy Association (BANZ) Technical Guide 8: The Production and Use of Digestate as Fertiliser. The management adopted a robust Quality Management System, governing the areas of feedstock quality control, process management based on HACCP (Hazard Analysis and Critical Control Point) Plan and product (digestate) management and control.

Neither of the digestion process trains have a pasteurisation step or on-site digestate storage, a pre-requisite of compliance with the Biofertiliser certification quality protocol (to be developed).

Despite the lack of pasteurisation, the quality of the digestate produced at the facility from the food waste digestion train (Digester 2) meets the qualitative criteria specified in the Technical Guide 8, incl. physical contaminant and residual biogas production. It also meets the A1 class quality requirements specified in the 2017 DRAFT Water NZ Guidelines for Beneficial Use of Organic material[6].

The facility has three (3) main options to use for validation of their digestate:

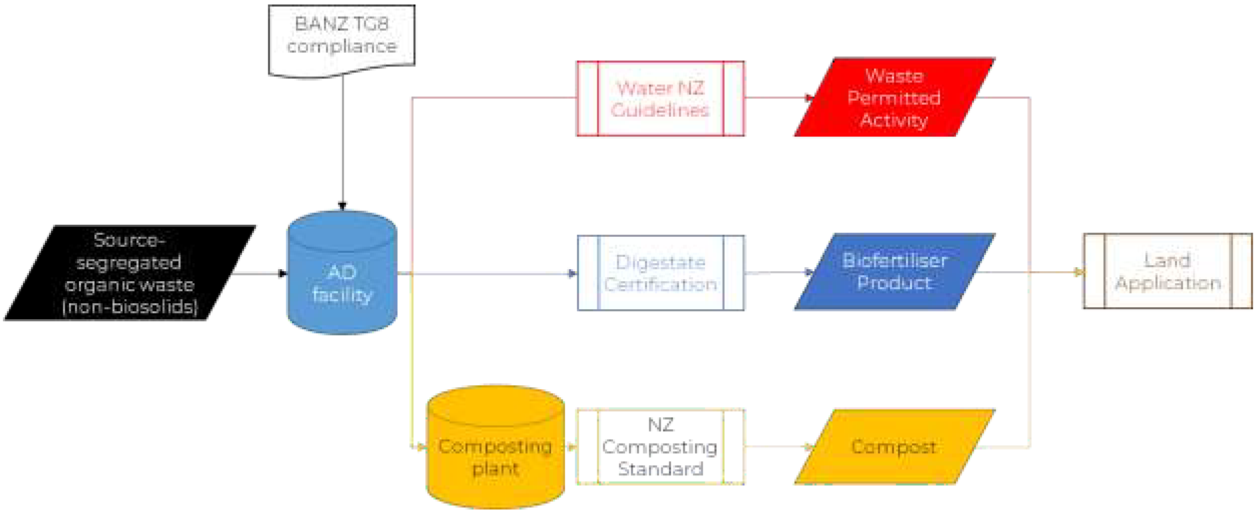


Figure 24: Pathways for evaluation of organic matter for land application

1.2 SOLUTION

1.2.1 Biosolids Digestion Training (Digester 1):

The digestate produced in Digester 1 originates from biosolids. The use and quality requirements are therefore governed by Water NZ Guidelines for Beneficial Use of Organic Materials on Productive Land. Technical Guide 8 specifically excludes this feedstock from its scope.

The biosolids digestion train digestate leaves the facility as a waste product and as such its use is subject to changes in legislation governing waste management.

1.2.2 Organic Waste Digestion Training (Digester 2)

The facility management carried out a cost-benefit and risk analysis of the three options available for the digestate from Digester 2 when operated in a food waste mono-digestion mode with liquid organic FOG, dairy and solid food residuals. The analysis methodology was identical to the options analysis in case 1 of this series of case studies:

Table 32: Options for processing organic matter for application to land

Option	Benefits	Risks/Drawbacks
1 – waste	Low cost – permit required (subject to local regional authority)	Subject to change in legislation
		Relies on long-term contracts
		Extensive product testing required
2 – biofertiliser	Highest value product	Cost of certification
	Recognition in agriculture, horticulture	Rigorous Input/Feedstock quality control required
	Customer/User's confidence in safe and of consistent quality	High emphasis on Quality Assurance
3 – compost	Low set-up cost	Relies on long term availability of composting plant
		Generates lower value product

1.2.3 Option 1 – Waste

Under this option, the facility is expected to comply with Technical Guide 8 and meet requirements of the DRAFT Water NZ Guidelines for Beneficial Use of Organic Products on Land (2017)[7]. The owner of the facility needs to seek confirmation from the local Regional Authority that application of the produced digestate is considered a Permitted Activity and does not require any further permits despite the lack of pasteurisation process.

The DRAFT Water NZ Guidelines (2017) require that the operators establish a rigorous product quality testing programme to demonstrate ongoing compliance with the quality criteria specified in the Guidelines.

The digestate leaves the facility as a waste product and as such its use is subject to changed legislation governing waste management. It carries low credibility despite its high nutrient content. Due to the perceived low added value of the product, the producer is recommended to seek long- term supply contracts with local farmers based on the NPK nutrient content to reduce the risk associated with product sale.

This option has a low set-up cost, yet the cost of frequent product compliance testing is high. The producer is unlikely to receive any revenue from the supply of digestate. In fact, in more AD- saturated markets, producers are required to pay farmers for the offtake of the digestate (up to $10/tonne)[39]. For the purpose of this case study, it is assumed that the offtake of digestate is cost-neutral.

1.2.4 Option 2 – Biofertiliser

Certified Biofertiliser signifies that the digestate was produced using an effective quality management system. This provides an assurance that the materials have a consistent quality and are safe and reliable to use, which increases the size of the market and reduces the risks associated with the offtake of digestate from the facility.

[39] http://www.organics-recycling.org.uk/uploads/category1060/Financial_impact_assessment_for_anaerobic_digestate.pdf

Under the certification scheme, the Biofertiliser is recognised by local authorities and potential users for its nutrient value. The monetary value of the digestate depends upon what mineral fertiliser pricing benchmark is adopted. Digestate typically replaces a broad based NPK fertiliser containing all three of the primary macronutrients: Nitrogen (N), Phosphorus (P) and Potassium (K).

Based on its current market prices of mineral fertiliser, the equivalent price for digestate is $10-$20 NZD/tonne. This price factors in the increased cost of transport and spreading compared to mineral fertilisers. A conservative price of $5/tonne is assumed for the purpose of this case study to reflect the low maturity of the current digestate market.

The higher perceived commercial value of a BANZ TG8 complying Biofertiliser product, in comparison to digestate use as waste or compost feedstock, is dependent on tested bacteriological qualities and the absence of metal contamination.

Bacteriological quality

A major problem with the food waste train (**Digester 2**) digestate compliance with the biofertiliser status is the inherent uncertainty of the bacteriological quality of the digestate. The food waste digestion process train **has no digestate pasteurisation step and no on site digestate storage**, a requirement of the TG8 and the future Biofertiliser certification quality protocol (TBD). The CAPEX required for installation of a pasteurisation step was assessed as unfeasible for the facility.

The Digester 2 train does not receive any faecal matter derived feedstocks and specifically excludes the use of sewage and manure derived materials and is based entirely on digestion of source segregated food industry feedstocks. Therefore, human and animal disease causing enteric bacteria, enteric viruses and prions are practically fully excluded by the feedstock types acceptance screen at the facility and are thus excluded from the digestate unless accidentally introduced by contamination at source.

Literature suggests that the beneficial pathogen-reducing effect of pasteurisation can be reproduced in digesters which are efficiently mixed and contacted[40&41]. In this case study 4, significant CAPEX resources have been invested for efficient mixing and prior to a digester upgrade for food waste digestion.

It is therefore possible that the digestate from Digester 2 train will comply with the bacteriological and pathogen content criteria despite the absence of the pasteurisation step.

Heavy metal content

Table 33 presents the expected metal content ranges in feedstocks as perceived by the New Zealand Waste Management Institute (WasteMINZ), Water NZ and NZ Crown Research Institutes[40]. It is clear from Table 33 that concerning Copper (Cu) and Zinc (ZN) contamination can also be expected in certain

[40] Prescribed tests for digestate bacteriological quality using indicator organisms such as E. coli or FCB (faecal coliform bacteria) to control faecal matter contamination risks of the digestate could thus produce commercially harmful false positive results because the tests are not for specific pathogen types related to the feedstock source. TG8 and PAS110 err thus on the side of caution in their bacteriological quality testing of digestate.

[41] WasteMINZ 2013. The Beneficial Use of Organic Wastes in New Zealand, 24th October 2013

vegetable derived food stuffs in New Zealand conditions and can be extreme in chicken and pig manure and mushroom compost.

Therefore, depending on the make-up of the feedstock treated in the Digester 2 train, the digestate may comply with the heavy metal quality criteria specified in the TG8 for compliance with the future Biofertiliser certification status. This can be confirmed by consistent and regular testing of the feedstock and the produced digestate and/or selective treatment of low risk feedstocks.

Table 33: Metal contents in selected composting feedstock materials in New Zealand

Product	As	Cd	Cr	Cu	Ni	Pb	Zn
Greenwaste & foodwaste	14	1.1	30	56	37	100	280
Chicken manure	26	0.06	23	43	6	6	295
Pig manure	1	0.06	2	49	2	2	580
Horse manure	3	0.02	6	13	3	8	87
Sheep pellets	3	0.10	9	22	4	17	140
Mushroom compost	36	0.08	8	94	6	10	270
Biosolids Guidelines (max)	**20**	**1.0**	**150**	**60**	**60**	**250**	**300**

Despite the potential to comply with the qualitative criteria of the Biofertiliser certification protocol (TBD), the lack of a pasteurisation step in the processing train prohibits the facility and consequently the digestate product from receiving the status of a Biofertiliser under the current framework.

The facility may attempt to gain the Biofertiliser status in the future by demonstrating the safety and complaint quality of the Digester 2 digestate via a long-term testing campaign. This is subject to acceptance by the Biofertiliser certification body.

The production of digestate within the wastewater treatment plant makes digestate marketing as biofertiliser impractical due to the product perception as having association with human waste processing, and due to issues related to site security and access, public health and safety.

In order to minimise the risk of cross-contamination with the biosolids-derived product, many comparable installations would physically separate the Digester 2-dedicated pasteurisation step (if included in the future), reception buffer tank and digestate offtake to outside of the WWTP boundary.

1.2.5 Option 3 – Compost

Under this option, the digestion facility is expected to comply with Technical Guide 8. The digestate quality and testing will be subject to the requirements of the receiving Composting facility.

The supply cost of digestate to the Composting facility is likely to be negotiated individually but may be as high as $50-$100/tonne based on current commercial rates. This is due to the relatively high operating cost of composting facilities and low value of compost as a marketable product.

The highest risk of this solution lies in the reliance on a long-term offtake contract with the receiving composting facility.

For the purpose of this case study, it is assumed that a favourable rate of $5/tonne can be negotiated with the composting facility and the product quality monitoring cost will be similar or lower than those required in the other two options.

The commercial model analysed for this case study 4 assumes that the food waste digestion train (Digester 2) digestate status as Biofertiliser was not attainable due to the lack of a pasteurisation step.

1.2.6 Commercial model

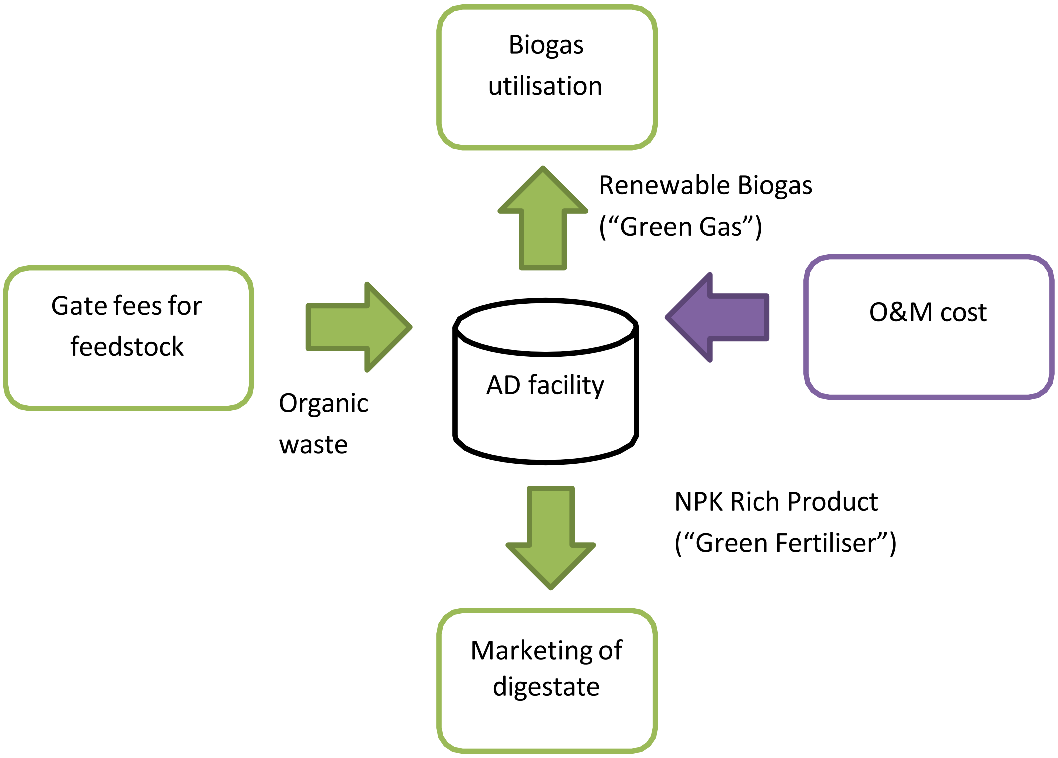


Figure 25: Typical business model for a commercial Anaerobic Digester facility

A typical business model for a commercial AD facility treating source segregated organic waste draws on revenue from gate fees (collected from feedstock suppliers or as avoided disposal cost), revenue from biogas utilisation (in form of heat, energy, CO2), and the sale of biofertiliser.

A multiyear performance analysis of this plant[42] when operated with liquid organic trade waste has shown that the added liquid trade waste with high FOG content had a neutral effect on the dry matter amount of biosolids digestate solids when compared with the digester plant operation without addition of trade waste due to the synergistic effect of co-digestion.

[42] JH Thiele et al (2016). Improved Trade Waste Co-digestion. Water e-journal Vol 1 No 3. On-line journal of the Australian Water Association. ISSN 2206-1991

As detailed above, it is likely that the sale of biofertiliser into the open market in this organic waste co-digestion business model with separate digestion trains cannot be realised with significant revenue due to lack of a product pasteurisation step at the WWTP.

Digestate marketing into the open market as “controlled liquid waste” at “zero” digestate purchase cost to the buyer is likely (similar to liquid manure) because the heavy metal content of the digestate is low and the expected bacteriological quality is high and could be proven in separate resource consent applications as permitted activity for food crops, pasture and greens (golf course etc.) maintenance.

Construction of a new greenfields AD facility typically involves a large capital investment, which presents a substantial risk to the project developer/owner. For example, for the situation described in case study 1, the construction costs of $30 million are estimated (EcoGas Press release, 2019). Therefore, the contractual commitments for waste supply, biogas and Biofertiliser sales would need to be long-term (> 10 years) to justify the investment.

In case of the construction costs of added infrastructure for case study 3, the construction costs were less than 1/10th of the case study 1 construction costs and a simple payback of less than 4 years was calculated[14]. In the case study 3, the waste supply contract with one supplier (dairy company) was sufficient and gate fees of the co-digestion facility during a 5-year period could be kept below 50 % of corresponding landfill gate fees (Refer to Case Study 3 for more details).

In case of the construction costs of added infrastructure for case study 4, the construction costs were 1/10th of the case study 1 construction costs. However higher OPEX (staffing for solid food waste reception and facility) would give a simple payback of about 11 years at a gate fee of 30 $/t for the liquid food waste (table 3).

With two main liquid waste suppliers (dairy company, waste hauler for grease trap waste) gate fees at the co-digestion facility during a 10-year period could potentially be kept below 50 % of corresponding landfill gate fees.

The (feedstock/biogas/biofertiliser) customers’ key risks during this period is whether the negotiated price becomes expensive compared to future alternative options for waste disposal, fertiliser and energy supply.

Table 34: Anaerobic Digestion facility (2 parallel trains) – expected business performance

	Construction costs (incl. waste reception)	Operating cost	Revenue from liquid organic waste gate fees	Revenue from biogas sales as genset fuel	Simple Payback Period
Gate fee: 30 $/m^3	$ 3 million	$ 0.26 million/ annum	$ 0.38 million/ annum	$ 0.17 million/ annum	< 11 year
Gate fee: 50 $/m^3	$ 3 million	$ 0.26 million/ annum	$ 0.63 million/ annum	$ 0.17 million/ annum	< 6 year

Electricity: 0.15 $/kwh. **Polymer:** 10 $/kg and 6 kg polymer/t DS.
Value of biogas: 0.025 $/kwhbiogas. **Trade waste processing capacity:** 13,000 wet t/annum

It should be acknowledged that policy decisions introducing a cost of carbon to reduce emissions (from waste disposal, industrial heat and fertiliser usage) suggests that the cost of traditional alternative organic waste disposal options (landfilling/ composting) will likely increase in real terms over time.

1.3 Conclusion

This case study explains the options for application of the proposed validation framework for the use of digestate from anaerobic digestion facilities on municipal wastewater treatment plants with separate digestion trains for organic waste and biosolids. Key conclusions include:

- Separate digestion of liquid and solid organic waste at a wastewater treatment plant does not produce digestate of the required quality to achieve certification as a Biofertiliser due to the lack of pasteurisation step.
- Achieving the required certification would require process modification to achieve standards for pathogens adding business risk (through additional investment costs) particularly given the uncertainty associated with the sale of biofertiliser
- The benefits of organic waste digestion on municipal WWTP however include:
    - minimising capital costs and integrating the organic waste digestion into operating premises,
    - increased energy production at wastewater treatment plans offsetting energy costs and providing carbon mitigation,
    - collecting gate fees for the treatment of the imported organic waste

The solution described in the case study 4 is very attractive from the perspective of the society, rate payers, decision makers and planners for the following reasons:

- An affordable transition to circular economy principles in organic waste management.
- Savings in the order of $ 0.5 – 1 billion in CAPEX costs that would be needed for an equivalent 20-30 large, dedicated food and organic waste digestion plants for the NZ organic waste industry[43].

[43] J H Thiele (2007). National Putrescible Waste Biofuel Potential Assessment. 44 pages. Report for SCION and Foundation for Research, Science & Technology, EnergyScape Project

- A significant landfill gas emission reduction and biofuel production from diversion of landfilled suitable industrial organic waste[44] into wastewater treatment plant-based co- digestion of organic waste (separate digester train model)[17].

In comparison to Case study 3, this proposed scenario offers the following considerations:

- When the biosolids processing is separated from the organic waste processing (this case study 4), the financial risks are increased due to the increased CAPEX costs compared to a liquid organic waste co-digestion only process (case study 3).
- When the biosolids processing is separated from the organic waste processing (this case study 4), "operation scale factored" financial risks are similar or slightly reduced compared to a dedicated greenfield facility for organic food waste digestion at a much larger scale (case study 1), despite a potential additional revenue that may be generated from biofertilizer sale in the large scale facility.
- The main reason for a somewhat lower financial risk for organic waste digestion at WWTP sites with smaller scale via retrofit of existing works are twofold; the lower overall organic waste digestion CAPEX for the added minor works that are required and the lower exposure to fluctuations in gate fees and waste supply contracts due to alternative disposal options.
- However, higher digestate re-use risks exist in terms of marketing, value add or even disposal in the municipal WWTP integrated organic waste processing case analysed here when compared to the dedicated greenfield facility for organic food waste digestion at a much larger scale (see case study 1).
- It needs to be clearly stated that one may expect resistance from the municipal WWTP owners and the operating staff against a case study 4 of organic waste digestion integration into municipal WWTP operations due to the following factors:
    1. The biogas production increase in case study 4 is only marginally higher than case study 3.
    2. Handling of solid food waste is more complicated than the handling of easily pumpable liquids.
    3. The risks to the operation of the balance of the treatment plant are higher due to the additional waste material, odour emission risks, vector attraction in reception areas, and higher N and P nutrient amounts in the digestate if disposal through the plant is required in case of emergencies.
    4. Higher vehicle traffic and site security risks.
    5. The trend of automation and staff rationalisation in the municipal WWTP industry makes it counterintuitive to add more process complexity and staff responsibility without significant financial incentives and rewards.

[44] JH Thiele (2017). The potential of further biogas plant in New Zealand. Proceedings of the BANZ workshop: Processing Food and Municipal Waste to Energy, Hamilton 19 September 2017

Appendix F – HACCP TEMPLATE & EXAMPLES

Template HACCP Plan

Introduction

This Hazard Analysis and Critical Control Point (HACCP) assessment has been conducted as part of the Digestate Biofertiliser Quality Criteria application by [Company name] for the receipt and use of [types of waste accepted] to produce certified biofertiliser from anaerobic digestion.

The steps followed were:

- Analyse potential microbial hazards and releases
- Identify the points where these hazards may occur during processing operations
- Decide which points are critical to ensure microbial and environmental safety
- Identify, propose and implement effective controls and monitoring procedures at identified critical points

The Company

[Insert a short summary of the company and the AD activities carried out on site]

The Stages of HACCP

Terms of Reference

The assessment was carried out to identify potential hazards associated with the [site name] biogas facility, with respect to the environmental release of pathogens associated with [waste types accepted e.g. source segregated food waste].

HACCP Team

The HACCP team consists of [insert names and job titles].

Anaerobic Digestion Facility Description and Intended Use

The [site name] is designed to produce a nutrient rich biofertiliser from waste derived from [insert number] sources:
[insert names of waste types accepted].

Process flow diagram
The process flow drawing [insert HACCP diagram reference], is used for this HACCP analysis. For the purposes of the HACCP analysis the following process stages were identified:

[Insert list of site process stages below]

Site Name:			**HACCP Assessment**
Rev No:		Issue Date:	
Revision Date:			
Author:		Approved By:	

Example:

1) *Source segregated food waste intake*
2) *Source segregated food waste processing*
3) *Mixed waste stream pasteurisation*
4) *Post AD contaminant treatment*
5) *Egress of untreated wastes*
6) *Post AD digestate*

Hazards and control measures

The safety hazards considered were microbiological release from the AD facility and microbial cross contamination from untreated food waste areas to treated food waste areas within the AD facility.

Table 1 below shows the potential hazards identified for each of the process areas defined in Section 0 and the control measures necessary or in place to minimise or eliminate the potential hazard.

Physical contamination of Digestate product beyond limits is also included.

Table 1: Potential hazards identified for [insert site name]

[Insert Table 1]

Example Table 1:

Process	***Hazard***	***Control Measure***
Food waste in, arrival on site	*Receipt of waste categories contrary to Digestate criteria*	*Check that Waste is covered by Digestate criteria – supply agreement and waste delivery note*
Food waste in, arrival on site	*Aerosol/odour Release*	*All waste to be delivered in either sealed vessels or covered vehicles.*
Food waste in arrival on site	*Spillage*	*No opening or unloading of vehicles unless in waste receiving and pre-processing area.*
Food waste in - arrival on site	*Vehicle collisions*	*Controlled traffic flows.*
Food waste in – delivery to food waste receiving tank	*Aerosol/odour Release*	*Receiving and pre-processing area under negative atmospheric pressure. Double door entry system in place. Inner door covering reception pit only opened if outer door closed, a vehicle is present for unloading and aerosol/odour control unit (biofilter) is in operation.*
Food waste in – delivery to food waste receiving tank	*Spillage*	*Below ground level reception pit designed to minimise spillage. Unloading point of delivery vehicle will 'overhang' waste receiving vessel.*

Food waste in – delivery vehicle exits from receiving and pre-processing area	*Contamination of exterior of delivery vehicle with food waste*	*Unloading point is directly into food waste reception pit which is designed to minimise spillage and contamination Pressure wash system available to wash delivery vehicle. Any minor spillages washed away and vehicle washed prior to leaving facility Washings directed to food waste reception pit.*
Food waste in – delivery vehicle exits from receiving and pre-processing area	*Aerosol/odour release*	*Vehicle cover(s) and/or liquid waste vessels seals to be in place before exit from receiving and pre-processing hall. Double door entry system in place. Outer door only opened if inner door closed, a vehicle is present for exit and aerosol/odour control unit is in operation.*
Food waste in – food waste receiving vessel	*Overfilling from food waste delivery*	*Operator to ensure sufficient space in reception pit for load being delivered. Capacity of reception pit is such that more than one day anticipated waste can be accommodated.*
Liquid waste in – extended storage vessel	*Overfilling from liquid delivery*	*Operator to ensure sufficient space in extended storage vessel.*
Food waste in – food waste receiving vessel	*Overfilling from dairy waste delivery*	*Operator to ensure sufficient space in extended storage vessel.*
Food waste in – transfer of food waste from receiving vessel to contaminant removal system	*Aerosol/odour release*	*Receiving and pre-processing area under negative pressure with respect to atmospheric pressure. Double door entry system in place. Outer door to be closed and aerosol/odour control unit in operation during waste transfer.*
Food waste in – transfer of food waste from receiving vessel to contaminant removal system	*Spillage*	*Transfer grab crane manually operated. Contaminant removal system receiving hopper overhangs waste receipt vessel. Spillages washed back into food waste receiving vessel*
Primary Processing – contaminant removal	*Aerosol/odour release*	*Receiving and pre-processing area under negative pressure with respect to atmospheric pressure. Double door entry system in place. Outer door to be closed and aerosol/odour control unit in operation during waste transfer.*
Primary Processing – contaminant removal	*Spillage*	*Spillages washed back into food waste receiving vessel.*
Primary Processing – Squeeze pressing	*Aerosol/odour release*	*Receiving and pre-processing area under negative pressure with respect to atmospheric pressure. Double door entry system in place. Outer door to be closed and aerosol/odour control unit in operation during processing.*
Primary Processing – Squeeze pressing	*Spillage*	*Spillages washed back into food waste receiving vessel*
Primary Processing – Squeeze pressing	*Squeeze pressing - size control*	*Squeeze press is set to produce material of 12 mm Ø or less. Squeeze screen is checked following manufacturer's procedure. Daily visual checks of feedstock post-bio-squeeze ensures 12mm requirement is maintained.*
Primary Processing – Squeeze pressing	*Squeeze press screen failure*	*Any failure of the bio squeeze stops the entire processing system. Bio squeeze performance is monitored by an electrical power overload sensor and pressure monitor of the primary piston rams powering the squeeze process.*

Primary Processing – suspension storage	*Aerosol/odour release*	*Receiving and pre-processing area under negative pressure with respect to atmospheric pressure. Tanks vented to main waste receiving tank. Double door entry system in place*
Primary Processing – suspension storage	*Spillage*	*Storage tank has high level warning system. Switches off liquid/dairy waste flow and audible alarm. Spillages washed back into food waste receiving vessel*
Primary Processing – liquid waste input	*Microbial inputs from liquid wastes*	*Liquid wastes/slurries will be pasteurised prior to entry into the digestion vessels.*
Primary Processing – dairy waste input	*Microbial inputs from dairy waste*	*Dairy waste will be pasteurised prior to entry into the digestion vessels.*
Pasteurisation	*Insufficient temperature obtained*	*Process is under a supervisory control and data acquisition (SCADA) system. Heat exchanger and transfer loop temperature control parameter is set at 74 °C. Material cannot leave transfer loop to pasteurisation vessels unless it is at or above 74 °C. Digester vessel pasteurisation tank has additional isolated heated water supply to keep contents at 72 °C. Heat exchanger, transfer loop and pasteurisation tank have multiple temperature measurement points. Temperature measuring devices will be checked for accuracy annually by outside testing body and monitored daily by plant operator.*
Pasteurisation	*Insufficient residence time*	*If a temperature of 72 °C is not maintained for at least 61 minutes then the mixed waste slurry is transferred back to the food pit.*
Pasteurisation	*Pasteurisation tank valve failure*	*Pasteurised mixed waste is passed back to the food pit. Double valve system prevent passage to digester vessel.*
Pasteurisation	*Pasteurisation tank level meter failure*	*Mixed waste is passed back to the extended storage vessel via an overflow pipe. Gas balance pipe connected to extended storage tank to prevent feedback of unpasteurised material.*
Pasteurisation	*Waste release during cleaning and or maintenance*	*Treated food waste side of system shut down and enclosed before maintenance of heat exchanger and transfer lines. Mixed waste slurry in heat exchanger collected into rigid, cage protected, sealable vessels, with drip catchers installed below and returned to extended storage vessel.*
Post Digestion - contaminant treatment	*Contamination of treated food waste screw press*	*The screw press is located on top of digester 2 outside of the waste reception and primary processing facility. Digestate from the screw press will be transferred directly to the digestate storage tank with no re-entry into the waste reception and primary processing facility. Solid waste is transferred by chute to the autoclave located in the waste reception and primary processing facility. A non-return flap in the chute and the negative air pressure in the waste reception and primary processing facility will prevent air contact between the two areas.*

Post Digestion - contaminant treatment	*Microbial export*	*Separated contaminants undergo squeezing and cleaning to remove microbial threat before exit from facility for recycling. Liquid and organic fraction from squeeze press returned to suspension storage vessel and checked with a sieve*
Egress of waste	*Microbial export*	*All primary processing equipment (reception vessel, grab hoist, feeding belt, contaminant separator, bio squeeze and transfer vessel) internally and externally cleaned in situ at end of working day. The extended storage vessel will be cleaned when empty. The untreated food waste areas of the AD facility will undergo a 'deep' clean on a weekly basis*
Vehicular egress of waste to 'clean' areas	*Microbial export*	*No vehicles will travel between the waste reception and post digestion areas. Catering waste deliveries are subject to wheel wash upon exit. Animal by-product deliveries are subject to a full wash and disinfect.*
Foot-borne egress of waste	*Microbial export*	*Barrier system in place between untreated food waste areas and treated food waste areas requiring change of footwear and outer clothing when crossing. Foot wash disinfectant trays in place. In addition, all equipment in the waste reception area is for use only in that area.*
Egress of waste - pests	*Microbial export*	*Pests and vermin, including insects, will be controlled by a recognised suitably qualified contractor. Air intakes to the facility have insect screens and louvres to minimise access when not in use.*
Biofilter	*Microbial export*	*Biofilter media has an expected lifetime of 4 years and will be changed on regular basis. Daily checks will include human olfactory tests. Odour testing to check on effectiveness. Regular water dampening of media to maintain biological community health.*
Post AD digestate	*Microbial contamination*	*Samples of digestate will be submitted monthly for E. coli at an approved laboratory. Samples of digestate will be taken, during storage, for microbial testing, Salmonella sp, at an approved laboratory. In addition, digestate will be tested to the Biofertiliser Quality Criteria standard for other potentially toxic and physical contaminants.* *The Standard Operating Procedure (SOP) for a pathogen failure is available in Appendix 1.*
Post AD digestate	*Contamination of Biofertiliser Product*	*All digestate removed from digester tanks goes through via the contaminant removal system ('skimming' system). The 2mm screen on the separator ensures nothing larger than 2mm can enter the digestate storage tank for testing.*
Digestate retention	*Post Pasteurisation*	*Digesters will hold pasteurised material for a minimum of 70 days, this is calculated using the volume of the digester and the daily feed rate.*

Identification of the Control points and Critical Control Points

A control point (CP) or critical control point (CCP) is defined as a point, step or procedure where control can be applied and a hazard can be prevented, eliminated or reduced to an acceptable level and where no subsequent part of the process will deal satisfactorily with it.

[Insert list of site control points and critical control points for the potential hazards identified in Table 1].

Example: The following control points and critical control points were identified from the potential hazards shown in Table 1.

1) *Acceptance of waste categories contrary to Resource consent and/or Digestate Biofertiliser Quality Criteria*
2) *Aerosol and/or odour release during the entire AD process*
3) *Microbial egress from the AD facility following spillage of either unpasteurised food waste or unpasteurised mixed waste*
4) *Squeezed material is of a diameter greater than 12 mm*
5) *Insufficient temperature obtained and/or residence time achieved during pasteurisation*
6) *Release of mixed waste material during the pasteurisation process*
7) *Release of mixed waste material during maintenance of pasteurisation equipment*
8) *Contamination of digestate by untreated food waste material*
9) *Contamination of Biofertiliser product by physical contaminants*

Table 2 on the following pages provide detailed summaries of these for the site including the process steps, hazards, control measures, CCP Number, CP Number, target levels and tolerance, monitoring procedures, corrective actions, records and responsible persons. Table 3 on the following pages provides details of the hazards and control points associated with the site's waste transfer station.

Monitoring procedures

Details of the agreed monitoring control procedures at each CP and CCP are contained in the relevant [insert company's relevant SOP/ monitoring system details e.g. SOP and SCADA system]. [Insert details of the system's warning system when a control parameter falls outside specified range].

Corrective actions

Any system failure identified by [insert company's monitoring system] or visual inspections by the plant operator(s) must be rectified before the AD plant can continue to operate. All system failures are to be logged and monitored for recurring failures.

Records and documents

[Insert site name] maintains a [insert details of Quality Management System (QMS), including operating procedures, monitoring and continual improvement].

Example:

The site maintains a Quality Management System (QMS) based on the principles of ISO 9001:2008 and includes detailed standard operating procedures for each aspect of the AD process, strategies for preventative and corrective actions, the monitoring of the effectiveness of these actions and the continual improvement of the operation of both the AD facility and the QMS. The HACCP analysis will form part of the QMS and will be subject to continual review by the plant management and operations team. Reviews and internal audits are carried out on an annual basis with procedures in place to amend the HACCP Plan as and when any process changes require.

Three separate recording systems are used, a facility daily inspection log, an AD facility process log and an AD facility preventative maintenance and corrective action log. The facility has achieved ISO 45001:2018, 19/02/2021.

Table 2: Summary of identified critical control points and monitoring, corrective and reporting actions for

[insert site name]

[Insert Table 2]

Example: Table 2

Process Step	*Hazard*	*Control Measure*	*CCP No*	*CP No*	*Target Levels & Tolerance*	*Monitoring Procedure*	*Corrective Actions*	*Records*	*Person Responsible*
Food waste in, arrival on site	*Receipt of waste categories contrary to Resource Consent and/or Digestate Biofertiliser Quality Criteria*	*Check that Waste type number on waste delivery note is covered by site's resource consent and Digestate Biofertiliser Quality Criteria*		*1*	*No non-permitted waste allowed on site.*	*Delivery vehicle driver to be given a permission to unload document by weighbridge operator. Plant operator supervising unloading procedure must receive the permission to unload document before vehicle is allowed to unload. A visual inspection, to check that the waste is as described on the transfer note, will also be undertaken as the waste is unloaded.*	*Stop all primary processing and remove non-permitted waste from site to appropriate disposal facility.*	*Permission to unload document and source segregated food waste receipt logged. Information added to rejected loads record.*	*Plant Operator*

Process Step	Hazard	Control Measure	CCP No	CP No	Target Levels & Tolerance	Monitoring Procedure	Corrective Actions	Records	Person Responsible
Aerosol and/or odour release during waste disposal within transfer station.	Microbial, odour and environmental contamination	Transfer station under negative air pressure moving airflow through biofiltration system via fans		2	No aerosol and/odour release from the AD facility.	Extraction to Biofilter logged. Biofilter aerated and dampened regularly as per weekly check sheets. Daily odour monitoring takes place on site as per weekly check sheets	Stop all delivery to transfer station if biofiltration system is not running. Retain negative pressure prior to any reopening of doors	Primary processing check list. Daily inspection log.	Plant operator
Aerosol and/or odour release during the entire AD process.	Microbial, odour and environmental contamination	AD facility under negative air pressure by biofiltration system and air supply for the CHP unit. Double doors system during waste deliveries.		3	No aerosol and/odour release from the AD facility.	Extraction to Biofilter logged. Biofilter aerated and dampened regularly as per weekly check sheets. Daily odour monitoring takes place on site as per weekly check sheets.	Stop all primary processing if biofiltration system is not running. Retain negative pressure prior to any reopening of doors	Primary processing check list. Daily inspection log	Plant operator
Waste receipt and primary processing	Cross contamination between untreated and treated waste areas.	Waste spillages cleansed immediately. Delivery vehicles washed down. Barrier system in place.		4	No microbial environmental contamination or cross contamination between untreated and treated waste areas.	All spillages and cleaning procedures employed to be recorded for future improvement.	Minimise potential for spillages.	AD plant process log	Plant operator

Process Step	Hazard	Control Measure	CCP No	CP No	Target Levels & Tolerance	Monitoring Procedure	Corrective Actions	Records	Person Responsible
Primary Processing	Squeezed material is of a diameter greater than 12 mm.	The screen of the bio squeeze is set to produce material of 12 mm Ø or less.	1		No squeezed material of diameter >12mm to enter pasteurisers and AD vessels.	Visual checks of bio squeeze machinery. 12 mm threshold checked according to manufacturer's	Stop all primary processing until bio squeeze fault is corrected.	Daily inspection log	Plant maintenance engineer
Pasteurisation	Insufficient temperature obtained and/or residence time achieved during pasteurisation.	Pasteurisation process is under control by a SCADA system.	2		No unpasteurised material entering digestion vessels.	SCADA system continually monitors temperature of the pasteurisation loop and vessels. Material cannot leave loop unless at a minimum temperature of 74 °C.	Stop feed to pasteurisation loop if set temperature parameters have not been reached. Investigate and fix cause of low temperatu	SCADA system data storage and printed copies for AD plant process log. Data transferred to site diary	Plant operator and plant maintenance engineer
Pasteurisation	Release of mixed waste material during pasteurisation process.	Valve or level meter failure causes waste to be sent to storage vessel. Return pipe systems	3		No microbial export or cross contamination.	SCADA system constantly monitors moisture sensors in pasteurisation vessel return and overflow	Stop feed to pasteurisation loop if moisture alarms sounded. Investigate and fix cause of	SCADA system data storage and printed copies for AD plant process log. Data	Plant operator
Pasteurisation	Release of mixed waste material during maintenance of pasteurisation equipment.	Treated system shut down before maintenance of pasteurisation system. Waste collected into sealable vessels.	4		No release of mixed waste material during maintenance of pasteurisation equipment.	Visual inspection of affected areas during maintenance. Ongoing supervision of operation.	Correct fault and carry out appropriate remedial action. Clean away any spillages and 'deep' clean	Plant Maintenance log	Plant maintenance engineer

Process Step	*Hazard*	*Control Measure*	*CCP No*	*CPNo*	*Target Levels & Tolerance*	*Monitoring Procedure*	*Corrective Actions*	*Records*	*Person Responsible*
Digestion	*FeCl2 additive for digestion tanks for chemical desulphurisation*	*Desulphurisation chemical added to digestions tanks through mechanical pumps, operated via the SCADA*		*4*	*0.4L per tonne of dry matter feedstock, (currently 20% dry matter)*	*Feedstock regularly checked through analysis for dry matter. Daily feed rate checked – additive will be*	*Amend additive rate depending on feedstock and dry matter within the digesters*	*Daily inspection log*	*Plant Manager*
Post digestion physical contaminant	*Contamination of Biofertiliser products with physical contaminants from within the digester, beyond the limits specified in Digestate Biofertiliser Quality Criteria.*	*All digestate removed from digesters via contaminants removal separator and screen. No alternative route possible for digestate to enter the Biofertiliser product storage*	*5*		*Parameters as set in Digestate Biofertiliser Quality Criteria for stones, Physical contaminants and sharps. Lowest sizing 2mm for physical contaminants and limit.*	*Correct operation and screen holes sizing visual check carried out as part of weekly maintenance routine.*	*Stop further transfer to Biofertiliser product tank. Fix screen or issues contributing to bypass. Take representative sample from Biofertilise*	*Daily inspection log*	*Plant operator and plant maintenance engineer*

APPENDIX G – INCIDENT MANAGEMENT PLAN EXAMPLE

[INSERT SITE NAME] **INCIDENT RESPONSE PLAN**	
Company Name	[Insert company name]
Company Address	[Insert company address]
Site Address	[Insert site address]
Site Grid Reference/NZTM	[Insert site grid reference]
Site Activities	[Insert summary of site activities]
Number of Staff	[Insert summary of number of staff based at the site and roles they fulfil]
Surrounding Area	[Insert the type of land use surrounding the site]
Plan Date	[Insert date plan effective from]
Version Number	[Insert version number]
Plan Author	[Insert name of plan author]
Plan Authorised By	[Insert name of individual who authorises the plan]
Review Date	[Insert date for plan to be reviewed]
Date of Next Exercise	[Insert date for next exercise to test this plan]
Objective of Plan	To compile all information needed on site to manage an incident and minimise the impact upon the environment
External Plan Consultees	[Insert details of any external parties who were consulted in the creation of this plan]
Distribution List	[Insert details of who this plan is held by eg main office, regulator, emergency services etc]

EXTERNAL CONTACTS		
Contact	**Office Hours**	**Out of Hours**
Emergency Services (Fire/ Police/ Ambulance)		
Local Police		
Local Hospital		
Regional Council		
District Council		
Gas Company		
Electricity Company		
Specialist Spill Clean Up Contractor		
INTERNAL CONTACTS		
Names and Position of Staff trained to activate and coordinate Plan		
Company CEO		
Site Manager		
Health, Safety & Environment Manager		
Operations Manager		
Energy Generation Manager		
Site Contractors		

Site Overview:

[Insert a summary of the activities that take place at the site]

WASTE INVENTORY					
Trade Name/ Substance	Solid/liquid/ gas/powder	UN Number	Max Stored on Site	Location Marked on Site Plan	Type of Containment
[Insert details of the wastes found on site, quantity stored and location, example shown below]					
Wastewater	*Liquid*	*N/A*	*2941m3*	*Balance Tank*	*Tank*
Sludge	*Liquid*	*N/A*	*3067m3*	*2 X Thickened Sludge Storage Tanks*	*Tanks*
Sludge	*Liquid*	*N/A*	*2320m3*	*2 X Post Screening Sludge Tanks*	*Tanks*
Sludge	*Liquid*	*N/A*	*1626m3*	*2 X Post Digestion Sludge Tanks*	*Tanks*
Sludge	*Liquid*	*N/A*	*10,019m3*	*4 X Digesters*	*Tanks*

CHEMICAL PRODUCT INVENTORY (See relevant COSHH sheets)					
Trade Name/ Substance	Solid/liquid/ gas/powder	UN Number	Max Stored on Site	Location Marked on Site Plan	Type of Containment
[Insert details of the chemicals held on site, example shown below]					
Diesel Oil	*Liquid*	*1202*	*52m3 in tanks and <5m3 in containers*	*Next to GBT building; two tanks next to workshop and attached storage hut; next to the inlet; between NTF 3 and 4.*	*Tanks and containers*
Polymer	*Liquid and powder*	*N/A*	*20m3 as liquid and storage of up to 10 X 1m3/750kg bags*	*Inside dryer building.*	*Powder inside bags, liquid in tanks*

Anti-scale	*Liquid*	*N/A*	*2m3*	*Inside dryer building.*	*IBC*
Anti-foam	*Liquid*	*N/A*	*5m3*	*Inside GBT building; inside dryer building.*	*IBC*
Sodium Hydroxide	*Liquid*	*1823*	*44m3*	*Near the inlet; next to Weatherlees cake reception*	*Tanks*
Ferric Sulphate	*Liquid*	*1760*	*37m3*	*Near the inlet*	*Tank*
Sodium Hypochlorite	*Liquid*	*1791*	*35m3*	*Next to Weatherlees cake reception*	*Tank*
Calcium hydroxide/ liquid lime	*Liquid*	*N/A*	*28m3*	*Next to gas bag*	*Tank*

POLLUTION PREVENTION EQUIPMENT INVENTORY (ON AND OFF-SITE RESOURCES)			
Type	Location	Qty	Staff Contact
[Insert details of site's pollution prevention equipment, example shown below]			
Spill Kits	*Next to liquid lime tank*	*1*	*AN Other xxx xxx xxxx*
	Inside MCC next to Cake Reception	*1*	*AN Other xxx xxx xxxx*
	Next to ferric sulphate tank	*1*	*AN Other xxx xxx xxxx*
Fire Extinguishers	*Inside dryer building*	*6*	*AN Other xxx xxx xxxx*
	Inside Cake Reception building	*1*	*AN Other xxx xxx xxxx*
	Inside office building	*7*	*AN Other xxx xxx xxxx*
	Inside workshop	*10*	*AN Other xxx xxx xxxx*
	Inside GBT building	*3*	*AN Other xxx xxx xxxx*
	Inside recirculation building	*3*	*AN Other xxx xxx xxxx*

SUPPORTING EMERGENCY PROCEDURES	
When this Plan should be Activated	[Insert the procedure name/number that covers this situation]
When to contact Emergency Services	[Insert the procedure name/number that covers this situation]
When to contact Utility Companies	[Insert the procedure name/number that covers this situation]
When to Contact Local Authority	[Insert the procedure name/number that covers this situation]
Staff Evacuation Procedure	[Insert the procedure name/number that covers this situation]
Special methods for dealing with Substances that pose a particular environmental risk	[Insert the procedure name/number that covers this situation]
Fire Fighting Strategy	[Insert the procedure name/number that covers this situation]
Use of Spill Kits and other pollution control equipment	[Insert the procedure name/number that covers this situation]
Procedure for recovering spilled product and legal disposal of waste	[Insert the procedure name/number that covers this situation]
Handling Media enquiries	[Insert the procedure name/number that covers this situation]

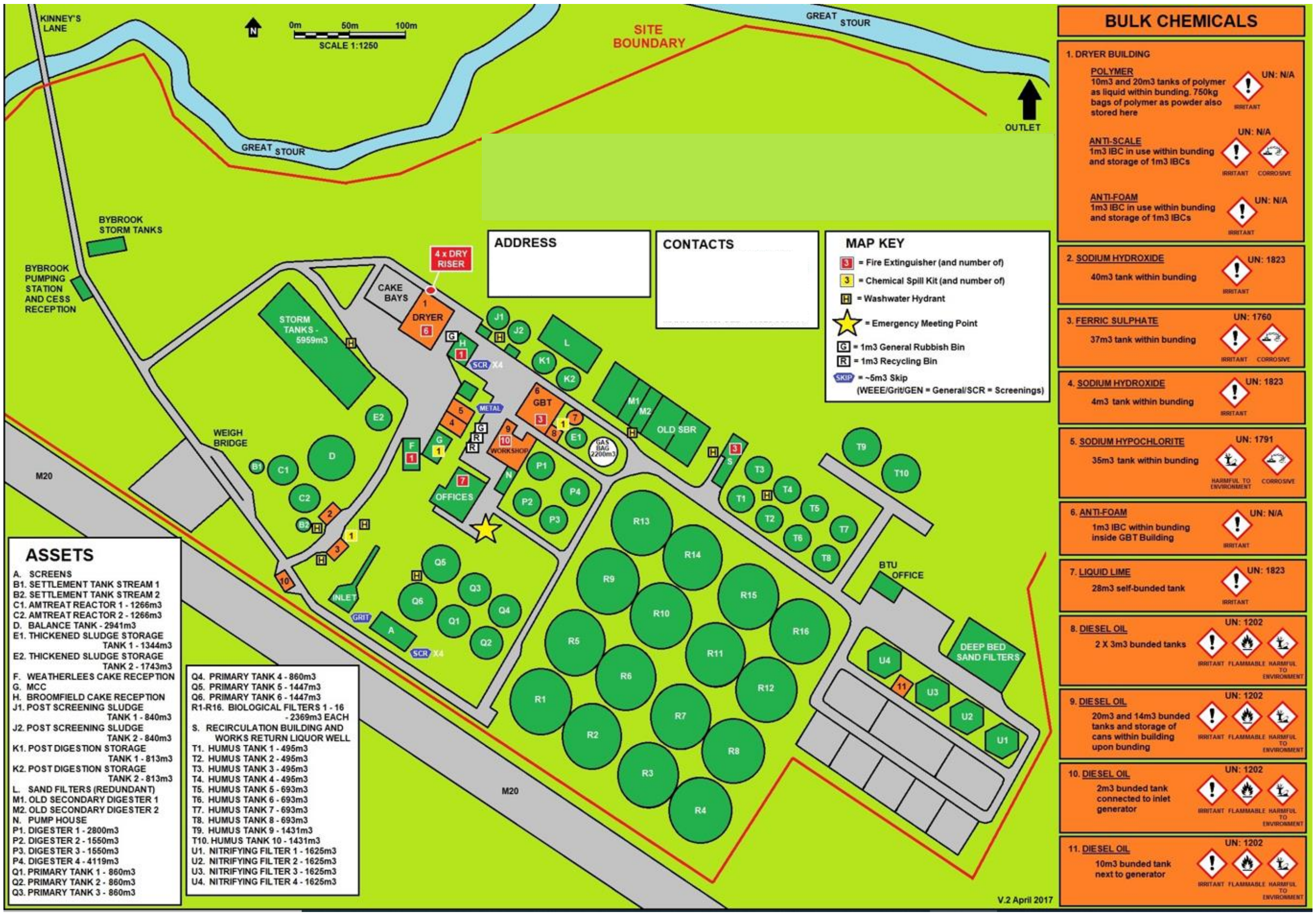
Incident Procedures:

The procedures listed below should be followed in the event of an incident, upon discovery of an Incident the Site Manager shall call [insert details of who site manager should contact within your organisation who will manage the incident] to report the incident and for them to determine the required level of response and classify and manage the incident according to [insert company procedure name/number for overall management of incidents]**.** Site specific plans should be coordinated using [insert Site IMP Map name, example Site IMP map shown below this table] and the equipment listed in this plan and any further information obtained from site or personnel.

Incident	Hazard	Objective	Initial Incident Response Plan	Southern Water Procedure to be Followed
[Insert details of site's incident management procedures, example shown below]				
Spill transferring wastes *E.g. failure of tanker coupling during sludge discharge*	*Spill of waste onto unmade ground or surface water*	*Stop spillage as soon as possible, contain spillage and clean up accordingly*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 480*
Spill transferring chemicals *E.g. Diesel spillage during*	*Spill of chemicals onto unmade ground or surface water*	*Stop spillage as soon as possible, contain spillage and clean up*	*Individual discovering incident to contact Site Manager*	*FEC 322* *EMS 382* *COSHH REGISTER*

generator diesel tank refilling		*accordingly*	*immediately and relevant implement procedures*	
Overfilling vessels *E.g. Pumps blocked, causing tank to overfill*	*Spill of waste or chemicals onto unmade ground or surface water*	*Stop spillage as soon as possible, contain spillage and clean up accordingly*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *FEC 320* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480* *COSHH REGISTER*
Plant and equipment failures *E.g. pumps fail and processing of waste stops*	*Spill of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Stop spillage as soon as possible, contain spillage and clean up accordingly*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *FEC 320* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Containment failure *E.g. bund does not contain spillage*	*Spill of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Stop spillage as soon as possible, contain spillage and clean up accordingly*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Fires *E.g. Vehicle fire*	*Damage to assets and associated environmental impact*	*Contain fire and firewater and treat through wastewater process if possible*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Failure to contain firewater *E.g. fire occurs and fire water escapes*	*Spill of fire water into surface water or onto unmade ground*	*Contain firewater and treat through wastewater treatment process if possible*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Incorrect connection to drains and other systems *E.g. new construction work at site incorrectly connects drains*	*Release of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Identify misconnection and rectify fault to ensure drains go to foul sewer network*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*

to surface water system				
Incompatible substances coming into contact *E.g. two chemicals at the site come into contact and react*	*Release of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Stop reaction and treat waste or remove from site for treatment*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Unwanted/ runaway reactions *E.g. two chemicals at the site come into contact and react*	*Release of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Stop reaction and treat waste or remove from site for treatment*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Emission of effluent before composition checked *E.g. failure of turbidity monitor*	*Release of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Identify issue and resolve fault to ensure composition of effluent is checked before release*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Vandalism *E.g. Vandals steal electrical cabling controlling some of site*	*Release of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Identify issue and resolve fault to ensure composition of effluent is checked before release*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*FEC 307* *FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Flooding *E.g. River X bursts it banks*	*Release of waste or chemicals onto unmade ground or surface water or the atmosphere*	*Work with appropriate organisations to enable site to function when possible*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*CAT 303* *FEC 322* *EMS 360* *EMS 363 (oil)* *EMS 382* *EMS 480*
Gas Bag Failure *E.g. Gas Bag fails and biogas unable to be stored on site*	*Loss of biogas to the atmosphere*	*Divert biogas to Flare and repair Gas Bag as soon as possible*	*Individual discovering incident to contact Site Manager immediately and relevant implement procedures*	*EMP 201* *EMP 202* *FEC 301* *FEC 302* *EMS 260* *EMS 360*


KINNEY'S LANE
0m 50m 100m
SCALE 1:1250
GREAT STOUR
SITE BOUNDARY
OUTLET
BYBROOK STORM TANKS
BYBROOK PUMPING STATION AND CESS RECEPTION
4 x DRY RISER
CAKE BAYS
DRYER
STORM TANKS - 5959m3
GBT
WORKSHOP
OFFICES
GAS BAG 2200m3
OLD SBR
WEIGH BRIDGE
M20
INLET
GRIT
BTU OFFICE
DEEP BED SAND FILTERS
ADDRESS
CONTACTS
MAP KEY
= Fire Extinguisher (and number of)
= Chemical Spill Kit (and number of)
= Washwater Hydrant
= Emergency Meeting Point
= 1m3 General Rubbish Bin
= 1m3 Recycling Bin
= ~5m3 Skip
(WEEE/Grit/GEN = General/SCR = Screenings)
ASSETS
A. SCREENS
B1. SETTLEMENT TANK STREAM 1
B2. SETTLEMENT TANK STREAM 2
C1. AMTREAT REACTOR 1 - 1266m3
C2. AMTREAT REACTOR 2 - 1266m3
D. BALANCE TANK - 2941m3
E1. THICKENED SLUDGE STORAGE TANK 1 - 1344m3
E2. THICKENED SLUDGE STORAGE TANK 2 - 1743m3
F. WEATHERLEES CAKE RECEPTION
G. MCC
H. BROOMFIELD CAKE RECEPTION
J1. POST SCREENING SLUDGE TANK 1 - 840m3
J2. POST SCREENING SLUDGE TANK 2 - 840m3
K1. POST DIGESTION STORAGE TANK 1 - 813m3
K2. POST DIGESTION STORAGE TANK 2 - 813m3
L. SAND FILTERS (REDUNDANT)
M1. OLD SECONDARY DIGESTER 1
M2. OLD SECONDARY DIGESTER 2
N. PUMP HOUSE
P1. DIGESTER 1 - 2800m3
P2. DIGESTER 2 - 1550m3
P3. DIGESTER 3 - 1550m3
P4. DIGESTER 4 - 4119m3
Q1. PRIMARY TANK 1 - 860m3
Q2. PRIMARY TANK 2 - 860m3
Q3. PRIMARY TANK 3 - 860m3
Q4. PRIMARY TANK 4 - 860m3
Q5. PRIMARY TANK 5 - 1447m3
Q6. PRIMARY TANK 6 - 1447m3
R1-R16. BIOLOGICAL FILTERS 1 - 16 - 2369m3 EACH
S. RECIRCULATION BUILDING AND WORKS RETURN LIQUOR WELL
T1. HUMUS TANK 1 - 495m3
T2. HUMUS TANK 2 - 495m3
T3. HUMUS TANK 3 - 495m3
T4. HUMUS TANK 4 - 495m3
T5. HUMUS TANK 5 - 693m3
T6. HUMUS TANK 6 - 693m3
T7. HUMUS TANK 7 - 693m3
T8. HUMUS TANK 8 - 693m3
T9. HUMUS TANK 9 - 1431m3
T10. HUMUS TANK 10 - 1431m3
U1. NITRIFYING FILTER 1 - 1625m3
U2. NITRIFYING FILTER 2 - 1625m3
U3. NITRIFYING FILTER 3 - 1625m3
U4. NITRIFYING FILTER 4 - 1625m3
BULK CHEMICALS
1. DRYER BUILDING
POLYMER
10m3 and 20m3 tanks of polymer as liquid within bunding. 750kg bags of polymer as powder also stored here
UN: N/A
IRRITANT
ANTI-SCALE
1m3 IBC in use within bunding and storage of 1m3 IBCs
UN: N/A
IRRITANT CORROSIVE
ANTI-FOAM
1m3 IBC in use within bunding and storage of 1m3 IBCs
UN: N/A
IRRITANT
2. SODIUM HYDROXIDE
40m3 tank within bunding
UN: 1823
IRRITANT
3. FERRIC SULPHATE
37m3 tank within bunding
UN: 1760
IRRITANT CORROSIVE
4. SODIUM HYDROXIDE
4m3 tank within bunding
UN: 1823
IRRITANT
5. SODIUM HYPOCHLORITE
35m3 tank within bunding
UN: 1791
HARMFUL TO ENVIRONMENT CORROSIVE
6. ANTI-FOAM
1m3 IBC within bunding inside GBT Building
UN: N/A
IRRITANT
7. LIQUID LIME
28m3 self-bunded tank
UN: 1823
IRRITANT
8. DIESEL OIL
2 X 3m3 bunded tanks
UN: 1202
IRRITANT FLAMMABLE HARMFUL TO ENVIRONMENT
9. DIESEL OIL
20m3 and 14m3 bunded tanks and storage of cans within building upon bunding
UN: 1202
IRRITANT FLAMMABLE HARMFUL TO ENVIRONMENT
10. DIESEL OIL
2m3 bunded tank connected to inlet generator
UN: 1202
IRRITANT FLAMMABLE HARMFUL TO ENVIRONMENT
11. DIESEL OIL
10m3 bunded tank next to generator
UN: 1202
IRRITANT FLAMMABLE HARMFUL TO ENVIRONMENT
V.2 April 2017