STRIVE
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Management Options for the Collection, Treatment and Disposal of Sludge Derived from Domestic Wastewater Treatment Systems

STRIVE

Environmental Protection Agency Programme

2007-2013

SSTI Strategy for Science, Technology and Innovation

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

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- Office of Environmental Assessment
- Office of Communications and Corporate Services

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EPA STRIVE Programme 2007-2013

Management Options for the Collection, Treatment and Disposal of Sludge Derived from Domestic Wastewater Treatment Systems

(2012-W-DS-9)

STRIVE Report

Prepared for the Environmental Protection Agency

by

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DISCLAIMER

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Table of Contents

Executive Summary

There are an estimated 497,000 domestic wastewater treatment systems (DWWTS) in Ireland. DWWTS which are not properly maintained and operated may pose a risk to human health and impact negatively on the environment. The periodic removal of sludge from a DWWTS is necessary, to ensure adequate treatment of the wastewater and the reduction of their impact on the environment.

The adoption of new regulations relating to DWWTS maintenance and de-sludging (S.I. 220/2012 and S.I. 223/2012) will result in large annual volumes of sludge being evacuated, the majority of which will be transported to existing wastewater treatment plants (WWTPs) for screening, blending, dewatering treatment and reuse or disposal.

Assuming the reuse of untreated sludge on individual farms, in accordance with current legislation, the total annual volume of sludge to be evacuated from DWWTS nationwide is estimated in Section 3 of the report at 473,381 m^3, at a de-sludging frequency of three years and based on an average DWWTS tank volume of 3.5m^3. The current spare available capacity of existing sludge reception facilities to receive DWWTS sludge is approximately 234,676m^3, indicating a volume deficit for receipt of 238,705m^3 i.e. 50% of evacuated DWWTS sludge generated annually.

Analysis of existing wastewater infrastructural capacity and operational practices indicates that the current lack of sludge screening facilities at WWTPs commonly results in the discharge of sludge tankers to the inlet of wastewater treatment process, resulting in the shock loading of the WWTP, disruption of the biological process, higher energy costs and a reduction in the quality of final effluent discharged to receiving waters.

A GIS analysis of the spatial distribution of DWWTS vis-à-vis existing sludge reception facilities with spare capacity in Section 4 indicates that:

a) 85% of all DWWTS nationwide are >25 km away from existing sludge reception facilities with spare capacity.
b) 23% of all DWWTS nationwide are located > 80 km from existing sludge reception facilities with spare capacity.

The Scottish Water utility company currently operates a good environmental practice model using mobile dewatering trucks to de-sludge DWWTS. It is envisaged that such a model may extend the sustainable transport distance up to 80 km - this distance will of course be dictated by the market. Nonetheless, based on the GIS analysis and best practice in Scotland, consequently de-sludging DWWTS by means of these mobile dewatering trucks on a scheduled rota system has the potential to reduce:

(i) the number of necessary wastewater treatment plant upgrades required, due to the larger sustainable transport distance, and
(ii) the maintenance cost of DWWTS de-sludging to the owner.

Existing wastewater treatment plant infrastructure in western and southern coastal regions of Ireland will require a large capital investment in order to adequately manage the anticipated sludge volumes associated with DWWTS regulations. In Section 4.5 of the report, a sensitivity analysis of the required capital works provision of sludge reception facilities vis-à-vis differing sustainable transport distances from DWWTS is presented.

In the event of the transport/discharge of DWWTS sludges to municipal plants, there will also be ongoing yearly operational costs to facilitate the transport, screening, blending, handling and treatment of untreated DWWTS sludge, and reuse or disposal of treated sludge. Therefore, in order to facilitate the provision of sustainable sludge collection, reception and transport, and in recognition of Ireland's status as an important food producer, it is recommended in Section 4.6 of the report that a single competent authority should be appointed to administer and implement sustainable management of DWWTS. It is also recommended that the competent authority should establish and maintain a database of registered DWWTS, which should include:

- the location of each DWWTS on a GIS
- the number of rooms/occupancy of the dwelling

- the calculated de-sludging frequency as determined by the regulatory authority (based on tank size and occupancy)
- the previous de-sludging record of each DWWTS, including details of licenced transport haulier and the destination for the evacuated sludge.

Water Service Authorities (WSA) and private sector companies, currently involved in municipal sludge treatment in Ireland, use five main methods of municipal sludge stabilisation/treatment; drying, mesophilic anaerobic digestion, thermophilic aerobic digestion, alkaline/lime stabilisation and composting, which are discussed in Section 5.1 of the report.

Although the current disposal route for almost all treated municipal sewage sludge is recycling to agricultural land, it is likely that Ireland's status as an agricultural food producer may result in ongoing curtailment of landspreading as a sustainable disposal route. In Sections 5.2 and 5.3 of the report, it is suggested that alternative recycling or disposal options, such as incineration, recycling to energy crops, pyrolysis and other feasible disposal routes for treated biosolids may need to be adopted on a significant scale, in order to deal with the volumes of municipal and the additional DWWTS sludge produced nationally.

Section 6 sets out the conclusions of the report, together with recommendations regarding the reception and management of DWWTS sludges generated annually consequent to regulation.

In addition to the main recommendations set out above, Section 6 further recommends that:

1. The current practice of discharging DWWTS sludges to the inlet works of a WWTP should be discontinued.
2. DWWTS sludge transported by suction tankers should only be discharged to plants which have screened sludge reception facilities and sufficient available handling capacity.
3. Alternative sludge recycling or disposal routes, such as incineration, recycling to energy crops, pyrolysis or the export of dried biosolids, will need to be adopted on a significant scale nationally, as spreading to land is becoming less of a disposal option.
4. Sewage sludge recycling to energy crops is unlikely to become a feasible sludge disposal route unless existing legislative restrictions are amended.
5. Scheduled de-sludging rotas would enable the use of alternative methods, such as dewatering trucks, permitting less extensive investment in sludge reception infrastructure.
6. In respect of DWWTS de-sludged using mobile dewatering trucks, it may be possible to introduce such sludges to the sludge handling/treatment process.
7. A cost-benefit analysis should be conducted to ascertain the optimum provision of sludge facilities nationwide, taking into account the options of upgrading existing WWTP infrastructure and the development of existing facilities operated by the private sector.
8. The recommended increase in sludge reception infrastructure and the handling /treatment/dewatering capacity at each of the recommended sites will be site-specific and will have to be determined by the competent regulatory authority.
9. A Quality Assurance System should be put in place for the treatment and disposal of sewage sludge, to guarantee that the required treatment process conditions to be achieved for the required bacterial die-off in treated sludge, as set out in Appendix 3 of the *"Codes of Good Practice for the use of Biosolids in Agriculture".* Such a system should promote/increase the use of this material as a fertiliser in agriculture and establish best practice in this regard.

It is clear from the foregoing that the regulation of DWWTS, and specifically the transport, treatment and reuse/disposal of DWWTS sludge in Ireland, will pose major challenges to the Water Service Authorities (WSA).

1. Introduction

1.1 Background

In Ireland, there are an estimated 497,000 domestic wastewater treatment systems (CSO, 2011) treating wastewater from houses that are not connected to a public sewer system.

Taking the view that Ireland had not correctly transposed into domestic legislation the provisions of the Directive on waste relating to the disposal of domestic wastewaters in the countryside through septic tanks and other individual wastewater treatment systems, the Commission brought proceedings before the Court for failure to fulfil obligations in 2008. By judgement of 29 October 2009, the Court found that Ireland had failed to fulfil its obligations.

As it was not satisfied with the measures adopted by Ireland to comply with that judgement, the Commission brought a further action for failure to fulfil obligations before the Court, in which it proposed that Ireland be ordered to pay a lump sum and daily fines. In its judgement, the Court found that Ireland has not yet adopted in full the measures necessary for the implementation of the 2009 judgement, so that it was necessary to impose upon it the payment of a penalty payment. In particular, the Court pointed out that the *Water Services (Amendment) Act, 2012* requires implementation, not all of which has yet been adopted and that the national inspection plan for individual wastewater treatment systems had still to be developed. It also stated that a definitive deadline for the registration of these systems has not been set.

However, taking account of the efforts made by Ireland to comply with that judgement, and the fact that its ability to pay has been diminished as a result of the economic crisis, the Court imposed on Ireland a penalty payment of €12,000 for each day of delay in adopting measures necessary to comply with the 2009 judgement, from the date on which judgement is delivered in the present case to the date of full compliance with the 2009 judgement.

In May 2013, the case was closed, by which time Ireland had paid €2,648,000 in fines.

To provide for the regulation of domestic wastewater treatment systems (DWWTS), the Government introduced the Water Services (Amendment) Act, 2012.

While DWWTS have the potential to impact on ground and surface waters due to their location in vulnerable areas, the risk of impact to ground and surface waters is dependent on the level of treatment that the DWWTS and its associated percolation area provides.

DWWTS effluent contains high levels of nitrogen and phosphorus. Nitrogen and phosphorus are essential for plant growth, therefore leading to eutrophication and algae blooms when present in water courses. Phosphorus is generally the limiting nutrient for eutrophication in freshwater ecosystems, while nitrogen is the limiting nutrient in the marine environment. Enhanced algae growth results in hypoxia in water bodies, leading to deterioration in water quality and the death of other organisms and fish. DWWTS effluent also contains microbial pathogens, such as bacteria, viruses, fungi, yeast and protozoa, which can be harmful to human health.

Therefore, DWWTS which are not properly maintained pose a risk to human health and have the potential to put the environment at risk through the escape of inadequately treated effluent to ground and surface waters. The periodic removal of sludge from a DWWTS is necessary to ensure adequate treatment and to maintain the liquid/settled sludge interface below the outlet level of discharge to percolation areas.

In accordance with Statutory Instrument S.I. 223/2012, a DWWTS must be evacuated at intervals according to the tank capacity, the number of persons resident in the premises, or as recommended by the manufacturer. The implementation of the regulations will potentially result in substantially greater annual volumes of sewage sludge being transported, stored, treated and dewatered, when compared to current uncontrolled de-sludging and disposal practices. The existing EPA Code of Good Practice relating to the use of sewage sludge in agriculture, recommends that such sludge should be subjected to one of a range of treatment processes prior to landspreading, whereby pathogen die-off is achieved as a result of temperature elevation, pH elevation, or both.

In Ireland, current annual municipal sewage sludge accounts for approximately only 5% of the total organic material landspread annually. The vast majority of material, generated nationally, originates from agricultural sources and is landspread untreated onto agricultural land without achievement of pathogen or bacterial die-off (Fehily Timoney Report, 1994). With the ambitious stocking rate targets for farm animals inherent in 'Harvest 2020', it is likely that the cumulative sewage sludge from municipal and DWWTS sources will continue to account for a small percentage of the total organic material generated annually into the future.

1.2 Report Scope

The aim of this report is to provide an overview of existing legislation relating to DWWTS maintenance, as a precursor to determining volumes arising from the periodic de-sludging of DWWTS, and informing best practice regarding the collection, transport, treatment and re-use/disposal of the additional predicted DWWTS sludge volumes associated with the implementation of the new DWWTS regulations.

The report assimilates information, obtained during the study from correspondence with the 34 Water Service Authorities (WSA), designed to ascertain the status of existing and planned sludge infrastructure at municipal wastewater treatment plants (WWTPs) within their function areas as Water Service Authority (WSA) under the *Water Services Act, 2007*. The study sought to establish the extent to which planned sludge infrastructure had been provided in the intervening years since adoption of Sludge Management Plans and determine the capability or otherwise of existing wastewater treatment infrastructure to cater for the anticipated additional sludge volumes under the new DWWTS regulations.

The objectives of the study were to assess the following:

- Future management options relating to the collection, treatment and disposal of sludges derived from DWWTS in Ireland.
- The locations of existing WWTPs with screened sludge facilities, suitable for the import of DWWTS sludge.
- The spare capacity of the aforementioned existing sludge reception facilities to receive and blend DWWTS sludge with waste-activated sludge generated at the municipal WWTP facilities.
- The locations of and available spare capacity of WWTPs with dewatering facilities.
- The sludge treatment methods currently employed by the Water Service Authorities (WSA) and/or by private sector sludge handlers, contracted by these WSA.
- The current recycling or disposal routes for treated sewage sludge, i.e. biosolids.
- The extent and spatial distribution of infrastructural deficits with regard to sludge reception, blending, treatment and disposal.
- The potential for the establishment of alternative biosolids disposal routes which offer an alternative to recycling to agricultural land.

The report evaluates the extent of deficits in existing WWTP sludge infrastructure and current regulation, which need to be addressed in order to provide:

- feasible transport methods and reception facilities, which allow for the spatial distribution for sewage sludge, originating from the recurring necessary de-sludging of DWWTS nationwide;
- sustainable long-term recycling/disposal routes for dewatered sewage sludge cake, or treated/dried biosolids, which takes account of the residual fertiliser value of 'treated' biosolids vis-à-vis the emerging reluctance of agricultural food producers to accept treated sewage sludge on land, as determined by quality assurance schemes associated with grain, dairy and beef production.

2. Legislation Review

2.1 Domestic Wastewater Treatment System Legislation

The *Water Services (Amendment) Act, 2012 (No. 2 of 2012)* legislates for:

- the registration of domestic wastewater treatment systems (DWWTS),
- the inspection of domestic wastewater treatment systems, and
- the remediation of those that pose a risk to human health or to the environment.

The *Water Services (Amendment) Act, 2012 (No. 2 of 2012)* also required that the EPA develop a National Inspection Plan having regard to risks to human health, water, air, soil, odours and risks to the countryside or areas of special interest.

The *Water Services Acts, 2007* and the *2012 Domestic Wastewater Treatment (Registration) Regulations, 2012 (S.I. 220/2012)* required the registration of domestic wastewater treatment systems (DWWTS) by 1st February 2013.

In accordance with S.I. 223/2012, the onus is on the DWWTS owner to ensure that:

- The DWWTS is operated and maintained in such a way that no domestic wastewater or effluent escapes from the system other than from the designed discharge point.
- Roof water or surface run-off is not permitted to enter the domestic wastewater treatment system.
- All parts and components are fit for purpose and kept in good order so that the DWWTS does not pose a risk to human health or the environment.

The Regulations also deal with the frequency of de-sludging:

- a DWWTS must be de-sludged at intervals according to the tank capacity, and
- the number of persons resident in the premises connected to it, or
- as recommended by the manufacturer.

The current *EPA Code of Practice: Wastewater Treatment Systems for Single Houses (PE<10)* states that a DWWTS should be de-sludged every 12 months (EPA, 2010).

2.2 DWWTS De-sludging, Sludge Collection and Transport

In accordance with S.I. No 223 of 2012:

- De-sludging is to be carried out by an authorised waste collection contractor - an individual, partnership or company who has a waste collection permit.
- Under the *Waste Management (Collection Permit) Regulations* (S.I. 820/2007 as amended by S.I. 87/2008), those intending to carry out waste collection activities must have a waste collection permit. The waste collection permit register is held by the National Waste Collection Permit Office (NWCPO) who can be contacted by telephone at 057 9357428 or the waste collection permit register can be accessed via www.nwcpo.ie/search
- The DWWTS contents have to be reused or disposed of in accordance with relevant national legislation – see Sections 2.3 and 2.4. Note in particular the duty of care provisions under waste legislation and regulations for use in agriculture.
- The DWWTS owner must obtain evidence of disposal from the authorised waste collector and retain a receipt of de-sludging for five years. It is envisaged that a record of DWWTS evacuation will also be maintained by a competent regulatory authority.

2.3 Sludge Reuse or Disposal Legislation

The reuse or disposal of sewage sludge, if not carried out appropriately, can have a negative effect on food safety, animal health and the environment, and must comply with particular requirements. Depending on how the sludge is treated, the reuse/disposal of the material may be regarded as a product or a waste and, consequently, may have to be dealt with differently in accordance with legislation.

2.3.1 Duty of care under waste legislation

Under Section 32 of the *Waste Management Act, 1996* a waste holder (defined as "the waste producer or the person in possession of the waste" - the "waste producer" is "anyone whose activities produce waste…") has a duty of care in relation to waste - note a waste within the W*aste Management Act, 1996* is "any substance or object which the holder discards or is required to discard" and the waste holder cannot:

- cause or facilitate the abandonment, dumping or unauthorised management or treatment of waste, or
- hold, transport, reuse or dispose of waste, or treat waste, in a manner that causes or is likely to cause environmental pollution.

It is the responsibility of the original waste producer or other waste holder to carry out the treatment of waste himself or herself, or have the treatment managed correctly - by "an appropriate person" - an authorised waste collector. A waste collector may bring the material to a waste reuse or disposal facility. Waste disposal and reuse activities in Ireland are required to hold an authorisation in accordance with the *Waste Management Act, 1996*. A four-tier system of authorisation has been established for the regulation of such activities at a facility. A waste reuse or disposal activity at a facility is either:

- an exempted activity (no authorisation required),
- an activity requiring a Waste (or IPPC) licence,
- an activity requiring a Waste Facility Permit, or
- an activity requiring a Waste Certificate of Registration/Registration Certificate.

Depending on the authorisation required, these activities are controlled either by the Environmental Protection Agency (EPA) or by Water Service Authorities (WSA) within their functional areas. Either the WSA or EPA can advise in this regard.

If the material is being transferred to a sewage sludge facility for disposal, the *Waste Management (Registration of Sewage Sludge Facility) Regulations, 2010,* S.I. No 32/2010 apply. These Regulations provide for the registration and regulation of sewage sludge facilities in order to meet the requirements of the Waste Framework Directive. Facilities already regulated under other environmental legislation, such as licenced facilities under the Waste Management Acts, are excluded.

2.3.2 Use of sewage sludge in agriculture

In accordance with S.I. 223/2012, the owner of a DWWTS may carry out de-sludging of that system and use its contents in agriculture, subject to adherence with all relevant national legislative requirements or directions pertaining at the time and in particular with the provisions of :

- The *Waste Management (Use of Sewage Sludge in Agriculture) Regulations, 1998* (S.I. 148/1998),
- The *Waste Management (Use of Sewage Sludge in Agriculture) (Amendment) Regulations, 2001* (S.I. 267/2001), and
- The *European Communities (Good Agricultural Practice for Protection of Waters) Regulations, 2010* (S.I. No 610 of 2010).

DWWTS sludge is not treated sludge and therefore cannot be used in agriculture, unless it can be previously injected or otherwise worked into the land, with the one exception of spreading on grasslands which will not be grazed on for at least the following six months. The following are, thus, the requirements:

In accordance with S.I. 148/1998 and S.I. 267/2001:

- Only treated sludge may be applied to land (treated sludge means where it has undergone biological, chemical or heat treatment, etc., so as to significantly reduce its fermentability and the health hazards resulting from its use).
- If used in agriculture, untreated sludge must be injected or worked into the soil.

A person using sludge in agriculture must ensure that it is not used except in accordance with a Nutrient Management Plan.

- The Nutrient Management Plan must be submitted to the Water Service Authority (WSA) for approval prior to any landspreading taking place and must also comply with the European Communities (Good Agricultural Practice for Protection of Waters) Regulations, 2010 (S.I. No 610 of 2010).
- Land application of sludge as a fertiliser is dependent on the nitrogen (N) and phosphorus (P) quantities in the sludge. N and P limitations are specified in S.I. 610/2010.
- Soil and sludge analysis must be carried out in accordance with S.I. 148/1998 as amended.
- S.I. No 267/2001 indicates that sewage sludge applied to agricultural land must be based on the quantity of heavy metals in the sludge. Table 2.1 indicates the amounts of specified heavy metals to be observed.
- However, high heavy metal concentrations are typically not associated with DWWTS.

Table 2.1 Limit values of heavy metal concentrations in soil and heavy metal concentrations in sludge for use in agriculture based on a 10 year average.

	Limit Value (as per S.I. 148 of 1998)	(as per S.I. 267/2001)
Heavy Metal	**Maximum values for concentration of heavy metals in soil (mg/kg DM)**	**Heavy metals which may be added annually based on a 10 year average (kg/ha/year)**
Cadmium		0.05
Copper	50	7.50
Nickel	30	3.00
Lead	50	4.00
Zinc	150	7.50
Mercury	1	0.10
Chromium	Not specified	3.50

2.4 Sludge Disposal Legislation Concerning Food Crops

In accordance with S.I. 148/1998 and S.I. 267/2001, untreated sludge cannot be used or supplied for use on land on which fruit or vegetable crops are growing. Untreated sludge cannot be applied to land, intended for the cultivation of fruit or vegetable crops to be eaten raw which are in direct contact with soil, for a period of ten months prior to and during harvesting. Treated sludge cannot be used or supplied for use in grassland or forage crops where the grassland is to be grazed or the forage crops to be harvested within three weeks of such use.

In 2008, the Food Safety Authority of Ireland (FSAI) called for tighter controls on the use of municipal sludge on land used for food production. The FSAI indicates the requirement for source control and monitoring of municipal and industrial sludge and the management of sludge treatment to ensure that chemical or microbial contaminants are consistently minimised. Due to the concern of the introduction of pathogens and chemical contaminants to the food chain, the Food and Feed industry will not accept grain from land which has been treated with municipal or industrial sludge (Irish Grain Assurance Scheme (IGAS) 2012).

2.5 EU Member States - Standards on Sludge Used in Agriculture

There are a number of EU Directives which relate to the recovery, reuse and disposal of sewage sludge, and its effect on the environment. Directive 91/271/EEC provides for the treatment of urban wastewaters. Article 14 of the Directive encourages the use of sewage sludge, where appropriate, stating **"***Sludge arising from wastewater treatment shall be re-used whenever appropriate. Disposal routes shall minimise the adverse effects on the environment*".

Recycling of sewage sludge to farmlands and land restoration/reclamation has become the main disposal route followed by incineration, while disposal to landfills has significantly decreased.

Disposal of sewage sludge to landfill is dealt with in the EU Directive 1999/31/EEC, which has impacted on the amount of sludge going to landfill due to strict standards relating to landfill of biodegradable municipal waste. The Directive set out targets to reduce the amount of sludge that can to go landfill by 65% by 2016.

The use of sewage sludge in agriculture is governed by the EU Directive 86/278/EEC. National regulations in some member states require higher standards than those set out in the Directive 86/278/EEC. In general, the heavy metal concentration limits in national legislation of most EU Member States are more stringent than those specified in the Directive. While Denmark, Finland, Slovenia, Sweden and the Netherlands have adopted more stringent national requirements when compared to those in Directive 86/278/EEC, a number of other EU Member States, including Ireland, have similar national requirements to those specified in the EU Directive.

An estimated 40% of sewage sludge produced in EU countries is spread on agricultural land (EC 2008). In five of the EU States (Ireland, Denmark, France, Spain and the UK), greater than 50% of the sewage sludge produced is used in agriculture. In four EU Member States, less than 5% of the sewage sludge production is used in agriculture. In Belgium (Brussels and Flanders) and Romania the use of sewage sludge in agriculture is essentially prohibited due to stringent limits on heavy metal concentrations in sewage sludge (EC 2008). The use of sewage sludge in agriculture has been banned in Switzerland. Regulations in Denmark, Finland, France, Italy, Luxembourg and Poland include limit values on pathogens, particularly Salmonella, in sewage sludge (Inglezakis et al. 2011).

Austria, Belgium, Czech Republic, Denmark, France, Germany and Sweden limit synthetic organic contaminants (e.g. AOX, DEHP, PAH, PCB) (EC 2002, Inglezakis et al. 2011).

The UK and Sweden signed voluntary agreements on the use of sludge in agriculture. These voluntary agreements are more severe than the national regulations in terms of allowable limit values and treatment required.

In the UK, the "Safe Sludge Matrix" imposed a ban on the use of untreated sludge on agricultural land used to grow food crops on the 31st of December 1999 and on land used to grow non-food crops from the 31st of December 2005 onwards.

3. Domestic Wastewater Treatment Systems - Sludge Volume and Spatial Distribution

3.1 Background

There are an estimated 497,000 domestic wastewater treatment systems (DWWTS) in Ireland (CSO, 2011), the vast majority of which are located in rural areas. DWWTS are used to treat effluent from households that are not connected to a public sewerage system.

Conventional DWWTS construction consists of a septic tank and a percolation area. The septic tank itself typically removes 50-70% of the suspended solids, 25-50% of the Biological Oxygen Demand (BOD) and facilitates the partial digestion of the organic matter retained in the tank which occurs under anaerobic conditions. The partially clarified effluent is discharged to the percolation area.

The majority of the effluent treatment occurs in the percolation area through biological process and infiltration into the biomat and subsoil layers. In more recent times, secondary on-site treatment systems have also been employed in Ireland, which provide on-site treatment of the effluent discharged from the septic tank.

As a septic tank fills with sludge, the retention time is shortened. This renders the settling process less effective and allows the escape of solids into the percolation area when the sludge liquid interface reaches the level of the outlet.

An accumulation of sludge in the percolation area leads to clogging of the soil infiltration system and premature failure of the DWWTS. Therefore, the periodic removal of the sludge from the septic tank is essential in maintaining effective performance of the treatment system.

3.2 DWWTS Sludge Evacuation

In accordance with the *Water Services Acts, 2007* and the 2012 (Domestic Wastewater Treatment Systems) (S.I. 223/2012), all DWWTS must be periodically evacuated. The frequency of evacuation depends on a number of factors:

- The capacity of the septic tank, and
- The number of persons living in the dwelling, or
- The recommendations of the tank manufacturer.

Table 3.1 indicates the estimated sludge evacuation frequency based on the tank size and number of persons living in the household. On average, a septic tank should typically be evacuated every 1.5 - 5 years. The current frequency of DWWTS evacuation and the associated volumes of DWWTS sludge to be transported to WWTPs in Ireland are very low.

Periodic de-sludging, as provided for in S.I. 223/2013, will result in an increase in sludge volumes by orders of magnitude to be transported, stored, dewatered, treated and reused/disposed of their own land, subject to compliance with all national legislation (S.I. 223/2012).

Table 3.1 Estimated septic tank de-sludging frequency (years). Adapted from Jarrett (2004).

Tank Size	De-sludging Frequency – Number of Persons						
	1	**2**	**3**	**4**	**5**	**6**	**7**
3 m^3	9.6	4.5	2.8	2.0	1.4	1.1	0.8
3.5 m^3	11.3	5.4	3.3	2.4	1.8	1.4	1.1
4 m^3	13.0	6.2	3.9	2.8	2.1	1.6	1.3

Under current legislation, farmers are permitted to evacuate their DWWTS and reuse its contents on their own land, provided it is not used for agricultural purposes for six months after application.

Three methods of DWWTS evacuation are available and currently employed in Ireland:

- Evacuation by suction tanker operated by a licenced contractor.
- Evacuation using a mobile dewatering truck operated by a licenced contractor.
- Evacuation of own DWWTS located on farm land by a farmer.

Evacuation of a DWWTS using a suction tanker usually involves the removal of the entire contents of the tank, consisting of the settled sludge layer and the supernatant liquid separated from the settled sewage. This mixing of DWWTS contents typically results in the dilution of the settled sludge to concentrations between 1-2% dry solids, which can also contain extraneous materials and solid detritus which may be in the DWWTS or which may have been discharged thereto.

The DWWTS contents are then landspread by farmers on their own lands or transported by a licenced haulier to sludge reception facilities for screening, blending, dewatering and treatment.

Due to the dilute condition of this evacuated sludge from DWWTS and the insufficient availability of screened sludge reception facilities nationwide (as discussed later in Chapter 4), the practice of discharging such sludge through the screened inlet of wastewater treatment plants into the liquid wastewater stream is widespread practice at present.

Using a suction tanker, the transport of 3-4m^3 of dilute sludge evacuated from a DWWTS is considered economically unsustainable, due to the cumulative wastewater treatment plant (WWTP) gate reception charges and the transport cost per DWWTS, especially when this transport distance is greater than 25 km (i.e. approximately one- hour journey for a suction tanker).

Following the pumped evacuation of the DWWTS contents, a mobile dewatering unit (Figure 3.1) conditions the sludge, prior to the dewatering of the DWWTS contents, leading to a reduction of sludge volume to be transported off-site by up to 70%. The dewatering process is aided by the addition of polyelectrolyte which acts as a coagulant. The dewatered sludge typically contains 6-8% dry solids. The separated supernatant liquid following dewatering is returned to the DWWTS, which facilitates reseeding of the system.

Figure 3.1 Mobile dewatering truck.

The dewatered primary sludge may be treated directly by means of a treatment process, such as composting, or delivered to a municipal wastewater treatment plant with sludge reception facilities, where it can be screened and blended with waste activated sludge from the plant before subsequent dewatering and treatment.

It is envisaged that the use of mobile dewatering trucks could extend the sustainable transport distance for the dewatered sludges up to a maximum of 80 km. The use of a mobile dewatering unit to evacuate and dewater the sludge from DWWTS prior to its transport to reception facilities, offers a more sustainable alternative to the use of suction tankers. These dewatering trucks are fully sealable following the de-sludging process and are capable of transporting the evacuated sludge from 15-20 such DWWTS during a single transport run, thereby facilitating a more economical transport cost per DWWTS and lower consequent charges to the DWWTS owner.

However, the use of such mobile dewatering units is likely to only be commercially viable when operated on a scheduled rota system for DWWTS evacuation. It may not be possible to use mobile dewatering units in all areas due to the size and rigid structure of the unit. In such cases where accessibility is an issue, a tractor and suction tanker may be required in some situations for DWWTS evacuation.

3.3 DWWTS Sludge Composition

DWWTS sludge contains significant quantities of organic matter and nutrients; predominantly nitrogen, phosphorus and potassium without the presence of heavy metals sometimes associated with industrial wastewaters. These nutrients are beneficial to plant growth and indicate the value of treated DWWTS as a fertiliser. DWWTS sludge also contains pathogens such as bacteria, viruses, fungi, yeast and protozoa which can be harmful to human health and whose number are greatly reduced following treatment.

The dry solids content of evacuated sludge is dependent on the method of evacuation and the solids/supernatant interface in the tank, which in turn is a function of the de-sludging frequency, temperature and house occupancy.

3.4 DWWTS Sludge Volumes

In 2011, the average house occupancy ratio nationwide in Ireland was 2.8 (CSO, 2011). Based on Table 3.1 and a DWWTS size ranging from 3-4 m^3 in size, an average de-sludging frequency ranging from four to three years respectively is suggested, based on full occupancy of a house. In the case of holiday homes, a large number of which are located on the western seaboard, the de-sludging frequency would be determined by a regulatory authority based on information available regarding average yearly occupancy. Following discussion at steering meetings on the project, it was agreed that a de-sludging frequency of three years would be assumed as part of this study for the purpose of sludge volume estimation.

Based on the complete evacuation of contents of the average 3.5 m^3 septic tank, using suction tankers, the total annual volume of sludge to be evacuated from DWWTS is estimated at 580,161 m^3 @ 1-2% dry solids. Assuming that the reuse of untreated sludge from farmhouses to land will continue in the majority of farms as part of the new regulated DWWTS maintenance regime (S.I. 223/2012), the estimated annual sludge volume from DWWTS to be transported off-site to sludge reception facilities is 473,381 m^3 @ 1-2% dry solids.

When mobile dewatering trucks are employed to evacuate DWWTS sludges (excluding farmhouses), the expected dry solids concentration of sludge, retained in the truck, is estimated at 6-8%, corresponding to a greatly reduced yearly volume of 124,320 m^3.

Sludge holding tanks and, where provided, sludge reception facilities at WWTPs are located in the sludge process stream, following the municipal wastewater treatment process.

In general, such sludge reception facilities comprise:

- A dedicated area for the reception of sludge and the facility for trucks to enter and exit.
- Screens to remove any large debris from the primary sludge.
- A sludge blending tank or picket fence thickener (PFT) in which the screened DWWTS sludge is blended with the waste-activated sludge from the municipal wastewater treatment process before proceeding to thickening, dewatering, treatment and subsequent recycling to land or disposal.

A study was carried out to investigate the existing annual spare capacity to receive and blend DWWTS sludge at WWTPs in Ireland. The study indicated an annual spare capacity of 234,676 m^3.

This represents a volume deficit of 238,705 m^3 @ 1-2% dry solids (i.e. 50% of total generated annually).

Figure 3.2 depicts the predicted annual sludge volumes pertaining to the evacuation of DWWTS and the current national spare capacity to receive DWWTS sludge, based on the location of all DWWTS mapped on a GIS.

A large infrastructural deficit exists with regard to the available spare capacity at sludge reception facilities, particularly in the west and south coastal areas (shaded blue in Figure 3.2), where the concentration of DWWTS and consequent additional sludge volumes are greatest.

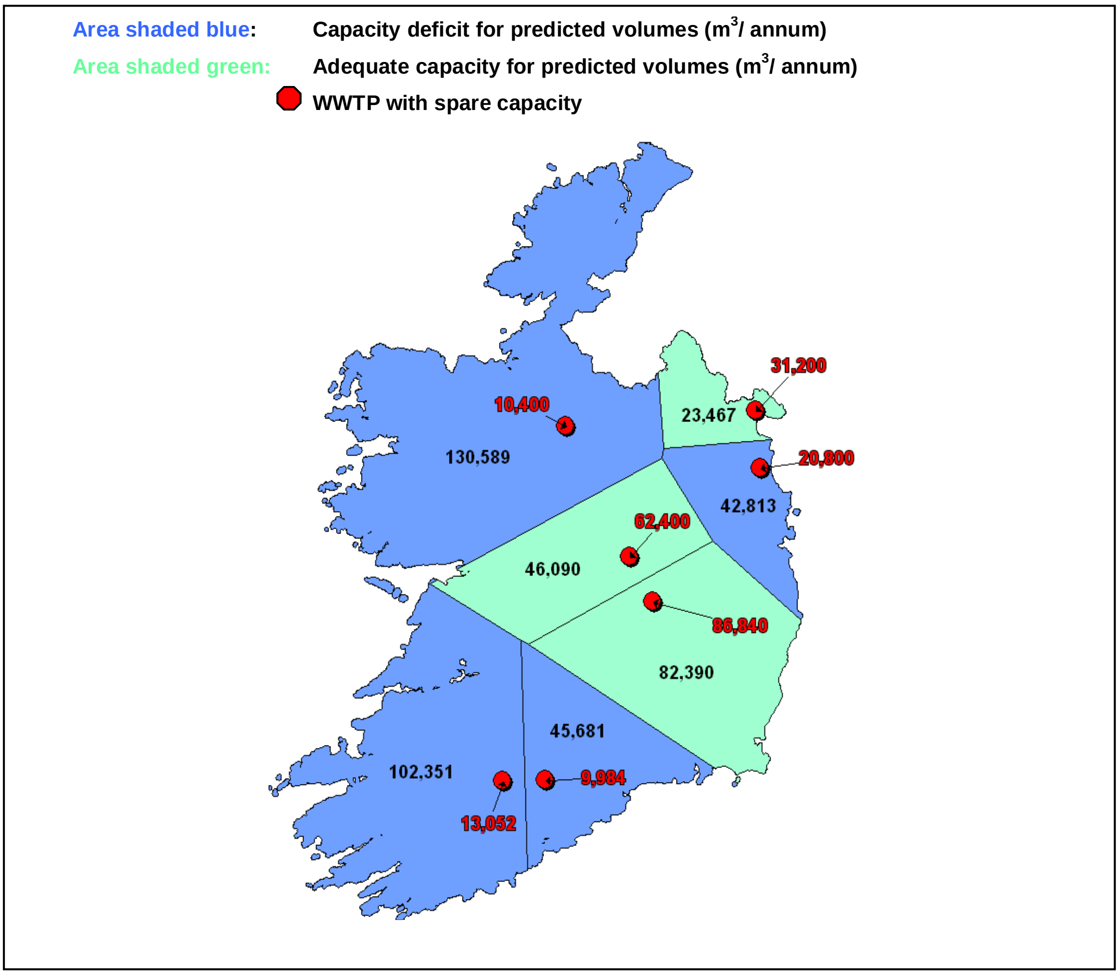

Figure 3.2 Estimated annual sludge volumes pertaining to DWWTS evacuation (Black) and the current spare capacity to receive and blend DWWTS sludge at seven WWTPs (Red).

4. Review of Planned and Existing Sludge Infrastructure

4.1 Sludge Management Plans

In 1997, the Department of the Environment, Community and Local Government (DECLG) introduced policy for each WSA to produce individual or combined Sludge Management Plans concerning the management of wastewater sludge within each region. Based on Article 14 of the Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment, in the intervening years, each local authority in Ireland formulated and adopted its own unique Sludge Management Plan. The proposed management of municipal wastewater treatment plant sludge is based on a "hub-centre and satellite" system for the transport and treatment of sludge. This system proposed that sludge from outlying WWTPs be transported to the nearest nominated satellite centre for blending and dewatering. It was proposed that the dewatered sludge from these satellite centres should be then directed to the nearest hub-centre (centralised treatment centre) for treatment and reuse/disposal.

Figure 4.1 indicates the locations of the sludge hub-centres and satellites as proposed in the Sludge Management Plans. A number of satellite and hub-centre scenarios were identified in several Sludge Management Plans. In total, the Sludge Management Plans proposed for the provision of up to:

- 200 dewatering facilities
- 113 satellite centres containing sludge reception facilities for the import of sludge
- 60 sludge hub-centres for the treatment of sludge prior to disposal or reuse.

In general, the provision of sludge processing infrastructure has not happened to the extent planned.

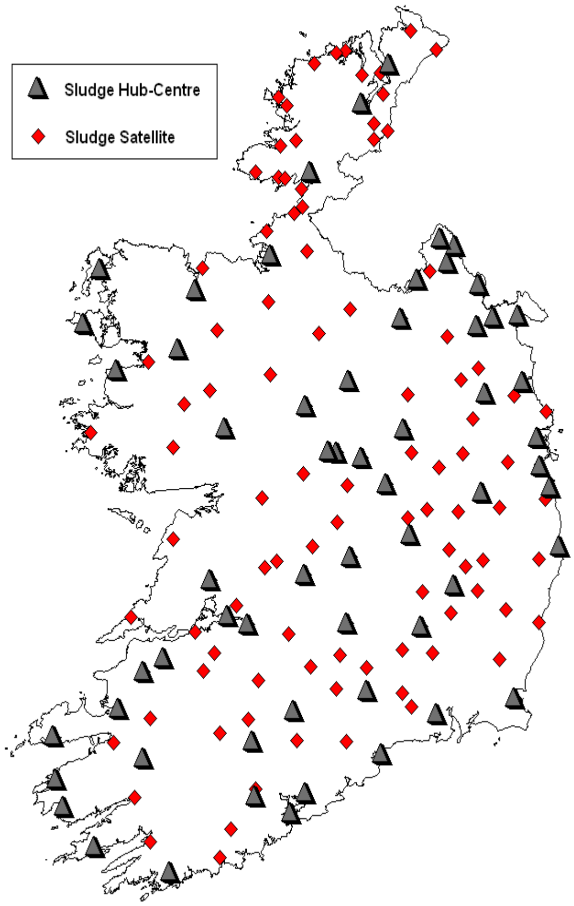

Figure 4.1 Proposed locations of sludge satellites and hub-centres as proposed in current Sludge Management Plans nationwide.

4.2 Existing Wastewater Treatment Plant Infrastructure

As part of this project, a study was undertaken to establish the status of existing wastewater treatment infrastructure based on interaction with existing WSA and the completion of a questionnaire, which was formulated as part of the project and circulated to each of the 34 WSAs.

The objective of the study was to assess the following information on existing sludge infrastructural capacity and location:

- The locations of existing wastewater treatment plants with screened sludge facilities including reception plant and blending/thickening tanks, suitable for the import of DWWTS sludge.
- The spare capacity of the aforementioned existing sludge reception facilities to receive and blend DWWTS sludge with waste-activated sludge generated at the facility.
- The locations of wastewater treatment plants with dewatering facilities and the current profile of such plant usage as a means of assessing possible available spare capacity.
- The sludge treatment methods currently employed by the WSAs and/or by private sector sludge handlers, contracted by these WSA, together with the geographical locations of both these municipal and privately-owned sludge treatment facilities.
- The current destinations for treated biosolids recycling or sludge disposal employed by, or on behalf of, WSA.

The results of the study indicate that there are:

- 28 existing wastewater treatment plants with screened sludge reception and blending facilities for accepting DWWTS sludge
- Seven wastewater treatment plants with spare blending and storage capacity for the acceptance of DWWTS
- 180 wastewater treatment plants with dewatering facilities (belt press or centrifuge)
- 17 sludge hub-centres.

The data relating to sludge reception facilities gleaned from the study was graphically represented on a GIS basis and is set out in Figure 4.2.

The study also indicated that:

- A number of private sector companies were involved in the transport, treatment and recycling/disposal of WWTP sludge primarily using biosolids treated using lime stabilisation treatment methods.
- The use of a number of existing municipal sludge digestion treatment plants at hub-centres had been discontinued due to the high operational costs compared to other treatment and reuse/disposal alternatives. The sludge generated at these plants was transported by a private sludge handler and treated off-site at their facility using an alternative technology prior to recycling to land.

4.2.1 Sludge reception facilities

In Ireland, the practice of importing DWWTS sludge through the inlet works of a wastewater treatment plant, upstream of the biological treatment process, is widespread. This is due to the lack of screened sludge reception and blending facilities at the majority of wastewater treatment plants. The low dry solids content of DWWTS sludge and supernatant liquid evacuated by means of suction plant also forces many wastewater treatment plant operators to import the contents through the inlet works.

The introduction of unscreened DWWTS sludge to a WWTP can give rise to numerous operational problems at the plant, such as blocking of and damage to pumps. Therefore, in WWTPs where screened sludge reception facilities are not present, the only recourse open to a plant operator is to introduce the unscreened sludge at the inlet works of the plant where screens are present.

This practice of importing primary DWWTS sludge upstream of the biological treatment process is neither economical nor sustainable for the following reasons and can lead to deterioration in quality of the treated effluent discharged to receiving waters.

1) Importing dilute mixed DWWTS sludge upstream of the treatment process uses up available spare biological capacity at the plant.
2) Depending on the loading and designed capacity of a municipal wastewater treatment plant, importing DWWTS sludge through the inlet works can result in shock loading of the plant. This leads to an imbalance in the food to microorganism ratio (F/M ratio) and the mixed liquor suspended solids (MLSS) necessary to ensure the settleability of the mixed liquor in the settlement stage of such activated sludge treatment processes.
3) Importing DWWTS sludge through the inlet works results in a large increase in energy requirements due to additional oxygen requirements in the aeration stage of the treatment process.

If the current practice of importing sludge through screens at the plants inlet works continues, it is likely that the possibility of shock loading at the biological stage of WWTPs will result due to the increased annual DWWTS sludge volumes, where accepted, at the inlet of wastewater treatment plant processes.

Of the 1,079 agglomerations in Ireland, only 28 have screened sludge reception facilities, as shown in Figure 4.2. Only seven of these wastewater treatment plants, denoted in red on Figure 4.2, have available spare capacity to receive, blend and store sludge originating from DWWTS, as discussed in Section 3.4.

Figure 4.2 indicates that the majority of the sludge reception facilities are located in the east and south of the country, distant from rural areas where the volume of sludge from DWWTS is greatest (Figure 3.1).

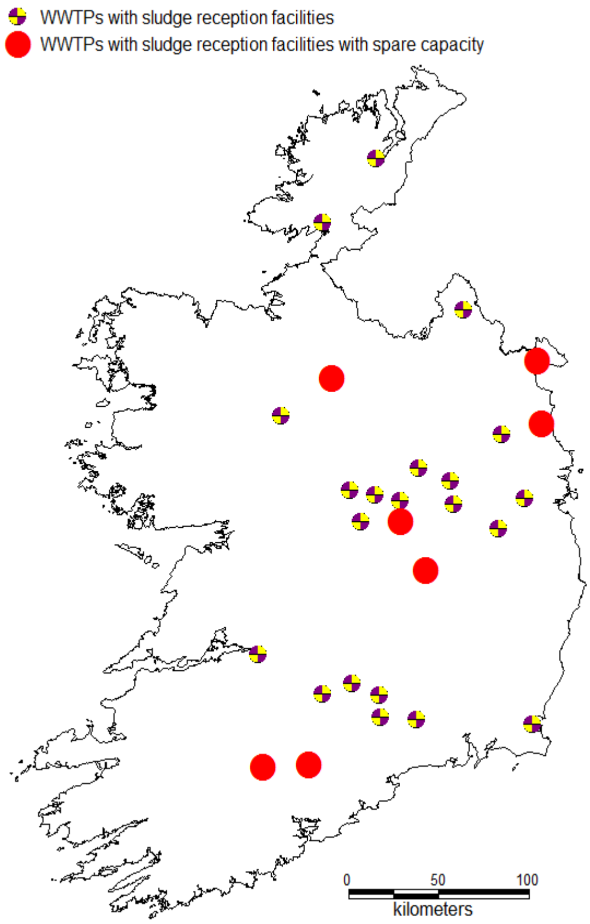

Figure 4.2 Locations of 28 WWTPs with sludge reception facilities, only seven of which have available spare capacity.

4.3 Sustainable Transport Distance using Suction Tanker for DWWTS De-sludging

4.3.1 Distance to sludge reception facilities with spare capacity

The spatial distribution of DWWTS in Ireland vis-à-vis sludge reception facilities with spare capacity is illustrated in Figure 4.3, which contains 18,488 points, each corresponding to the centroid of the CSO "Small Areas" and containing data obtained from Small Area Population Statistics (SAPS) (CSO, 2011). Therefore, each point contains the number of DWWTS in each small area as specified in the SAPS from CSO, 2011. On average, each point corresponds to approximately 27 DWWTS. (Min: 0 Max: 366).

Analysis of the dataset indicates that 85% of DWWTS nationwide are greater than 25 km away from the seven existing sludge reception facilities with spare capacity. Table 4.1 sets out the number of DWWTS inside the sustainable transport distance (25 km) for sludge tanker evacuation (approximately one-hour journey) and the number of such DWWTS requiring various transport distances in excess of this 25 km distance.

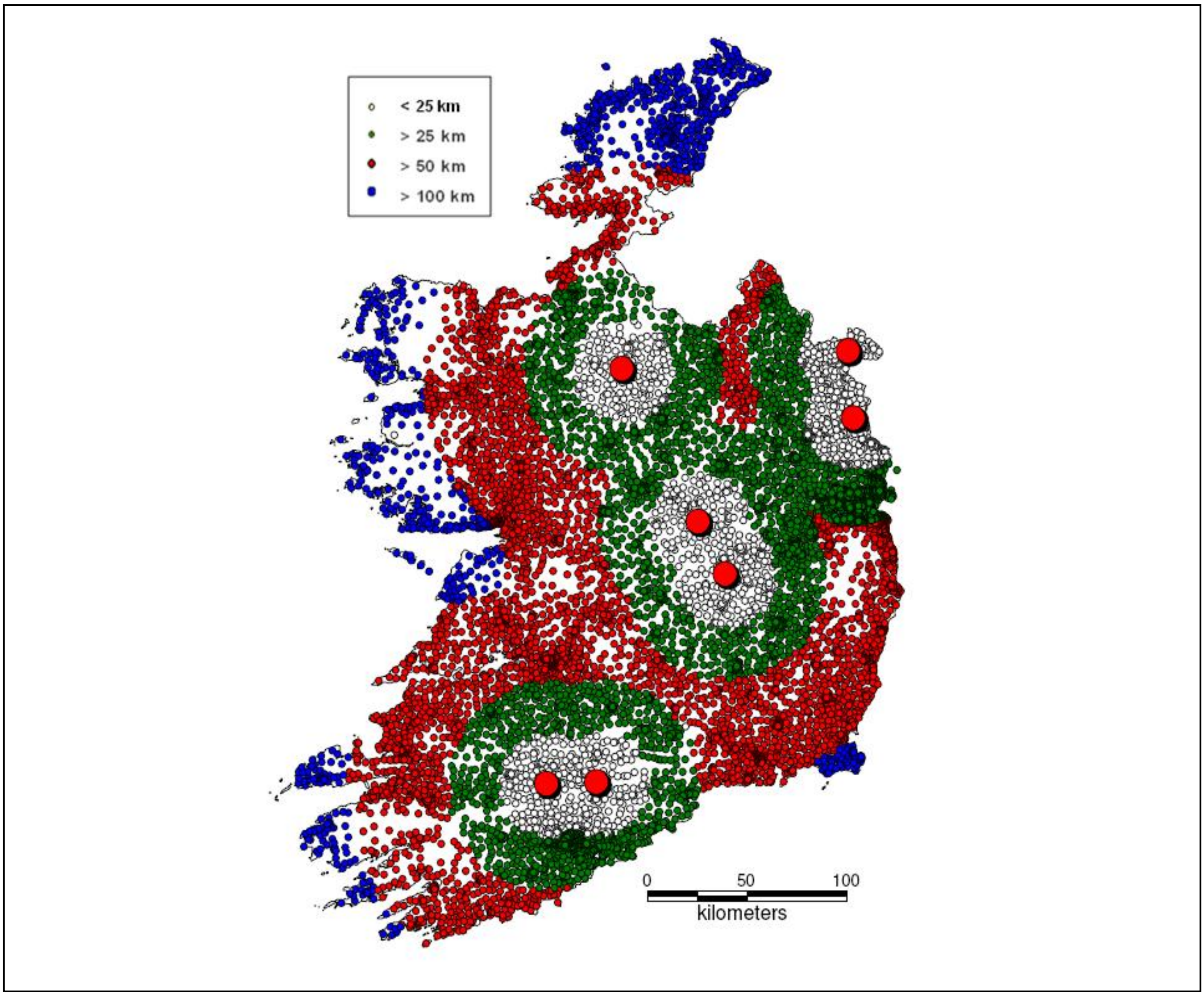

Figure 4.3 Thematic map indicating the distance from DWWTS to the seven existing sludge reception facilities with available spare capacity.

Table 4.1 DWWTS with associated transport distances to existing sludge reception facilities.

Distance to Reception Facilities	Number of DWWTS
< 25 km	76,577
25 - 50 km	165,130
50 - 100 km	208,518
> 100 km	47,056

As the situation currently stands, only 76,577 (15%) DWWTS are located within a sustainable transport distance of sludge reception facilities which currently has capacity to accept DWWTS sludge. 51% of all DWWTS nationwide are located over 50 km from available reception facilities, while 9% are located greater than 100 km from sludge reception facilities with spare capacity.

Therefore, with 85% of all DWWTS in Ireland situated outside of a sustainable distance from reception facilities with spare capacity, it is clear that large infrastructural deficits exist with regard to the spatial distribution of existing infrastructure to accept the DWWTS sludge volumes associated with the new proposed DWWTS maintenance regulations.

4.3.2 Distance to sludge reception facilities assuming enhanced capacity at 21 WWTPs

Figure 4.4 indicates the distance from DWWTS to wastewater treatment plants with sludge reception facilities, subsequent to the implementation of a future decision to increase the capacity at 21 of these municipal WWTPs. Following the provision of reception facilities at these WWTPs, 47% of DWWTS would be within 25 km of sludge reception facilities (Table 4.2). A large infrastructural deficit remains; 261,434 DWWTS located greater than 25 km from sludge reception facilities.

Table 4.2 DWWTS and associated distances from sludge reception facilities with enhanced capacity at 21 WWTPs.

Distance to Reception Facilities	Number of DWWTS
< 25 km	235,847
25 - 50 km	172,124
50 - 100 km	80,905
> 100 km	8,405

89,310 (18%) DWWTS are located a distance greater than 50 km from sludge reception facilities. These DWWTS are predominantly located in the west and south coastal areas (Mayo, Galway, Clare, Kerry and West Cork), as illustrated in Figure 4.4.

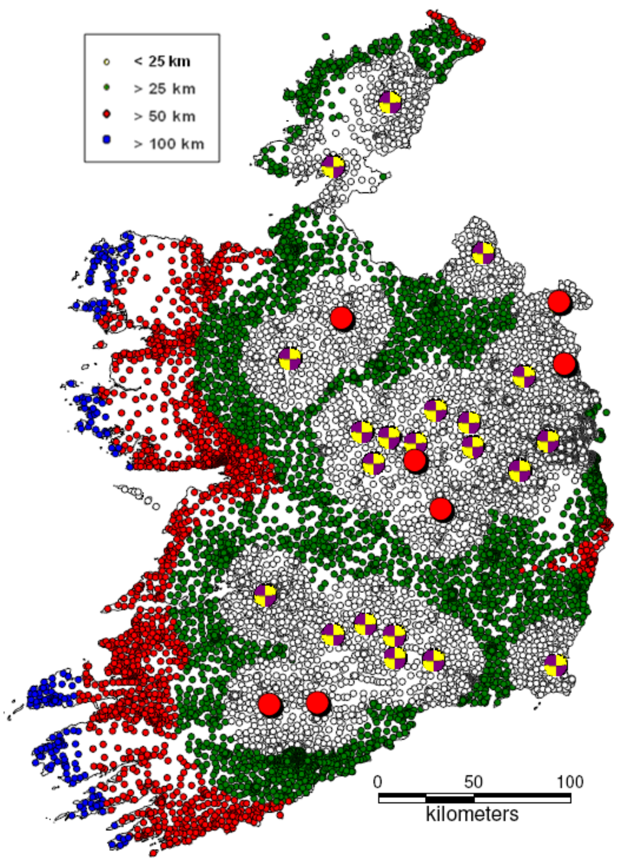

Figure 4.4 Thematic map indicating the distance from DWWTS to sludge reception facilities assuming enhanced handling/treatment capacity at 21 WWTPs.

4.4 Sustainable Transport Distance using Mobile Dewatering Equipment

4.4.1 Existing best practice models for DWWTS sludge collection

A sustainable model for DWWTS de-sludging will be based on the necessary regular de-sludging of DWWTS and the disposal of such evacuated sludges in a suitable reception facility, where infrastructural facilities are capable of receiving, handling and treating resultant sludges prior to their safe disposal/recycling. Commercially available dewatering trucks are capable of dewatering up to 15-20 DWWTS based on the achievement of 6-8% dry solids in the truck.

A good environmental practice model for DWWTS sludge collection is currently operated by the Scottish Water utility, using mobile dewatering trucks, and is designed to provide an efficient and cost effective service to persons not served by sewage collection systems. This service model is based on three types of collection scenarios namely:

a) A **Scheduled Service** based on a signed contract with the house owner to provide a regular de-sludging service at an agreed frequency (£164 per service de-sludging)

b) An **Unscheduled Service** completed within five days when requested by the house owner (£238.30 per service de-sludging)

c) An **Urgent Response Service** completed within two days when requested by the house owner (£342.90 per service de-sludging or the actual cost, if more)

prior to the transport of dewatered sludges to infrastructural facilities run by or paid for by Scottish Water.

An efficient business model for such a collection service would dictate that optimal collection would involve a 'milk run' type service within a defined area each day with minimal distance between successive de-sludgings task and a nominal final transport distance to feasible reception facilities.

It is suggested that following the scheduled collection of multiple DWWTS, an 80 km or one-hour journey for the dewatering truck following a day's work may be the maximum feasible transport distance to facilitate an efficient business model.

4.4.2 Distance to sludge reception facilities with spare capacity

If the sustainable sludge transport distance for de-sludged DWWTS by the use of mobile dewatering units is taken as 80 km (i.e. approximately one-hour journey for dewatering truck), 112,816 DWWTS (23%) are located greater than 80 km from existing sludge reception facilities with spare capacity.

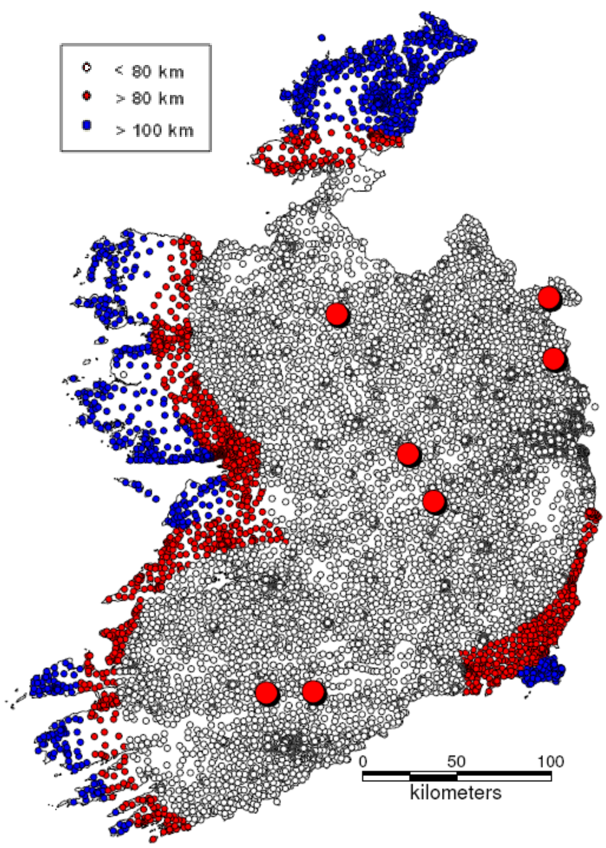

Figure 4.5 Thematic map indicating the distance from DWWTS (mobile dewatered) to existing sludge reception facilities with spare capacity.

Consideration of Figure 4.5 shows that the majority of the remaining DWWTS over 80 km from sludge reception facilities would be situated in Donegal, Mayo, Galway and Kerry.

4.4.3 Distance to sludge reception facilities with enhanced capacity at 21 WWTPs

Assuming the blending, thickening and dewatering capacity to receive sludge is increased at the 21 existing WWTPs with reception facilities, only 21,704 (i.e. 4%) of all DWWTS, situated predominantly in the west of counties Mayo, Galway and Kerry, would be located greater than 80 km from reception facilities (see Figure 4.6).

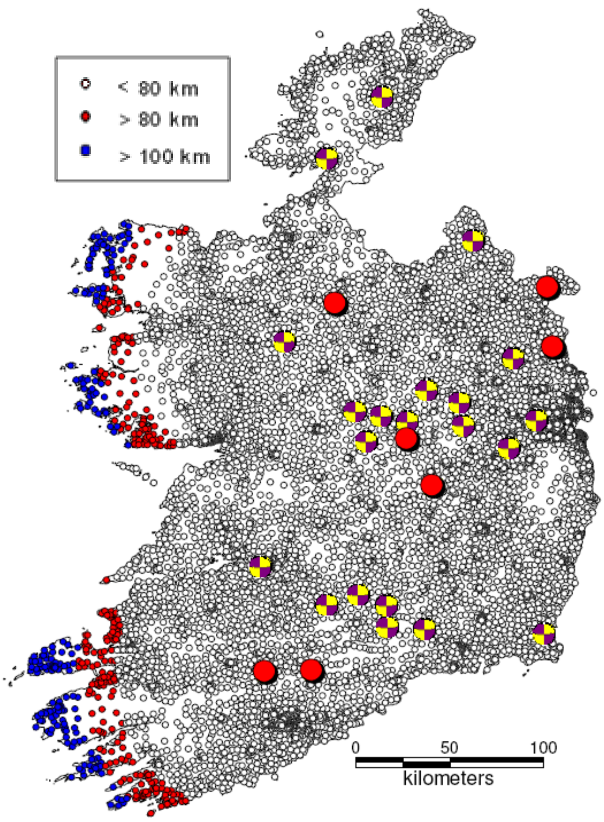

Figure 4.6 Thematic map indicating the distance from DWWTS to sludge reception facilities assuming enhanced capacity at 21 WWTPs.

4.5 Upgrade of Sludge Facilities to Meet DWWTS Sludge Requirements

In order to assess the options to overcome the scale and spatial distribution of the infrastructural deficits, with regard to the sludge acceptance capacity and transport distance to sludge reception facilities discussed in Sections 3.4, 4.3 and 4.4, a number of scenarios are examined:

1. The do-nothing scenario involving the continued use of suction tankers based on a sustainable transport distance of 25 km.
2. A sensitivity analysis of scheduled evacuation of DWWTS using mobile dewatering trucks with a range of suggested sustainable transport distances of up to 80 km.

In the Irish context, the above sensitivity analysis seeks to determine the optimal balance between the likely capital works provision to address the infrastructural deficit in sludge reception/treatment facilities and the different collected sludge transport distances up to 80 km.

4.5.1 Continued use of suction tankers

Assuming this do-nothing scenario, the following infrastructural provision would be required:

a) 21 WWTPs, which currently have sludge reception facilities, would require an increase in capacity of the Picket Fence Thickener (PFT) or construction of a sludge blending tank.
b) 13 WWTPs require the addition of screened sludge reception and blending facilities.

These 13 WWTPs are situated in close proximity to the concentration of DWWTS which currently are located greater than 25 km from existing reception facilities and were chosen based on the status of existing sludge handling facilities and the relative merits of known siting constraints. Figure 4.7 shows suggested locations for the 13 sludge plant upgrades at WWTPs required to manage the predicted additional DWWTS sludge volumes in a sustainable manner.

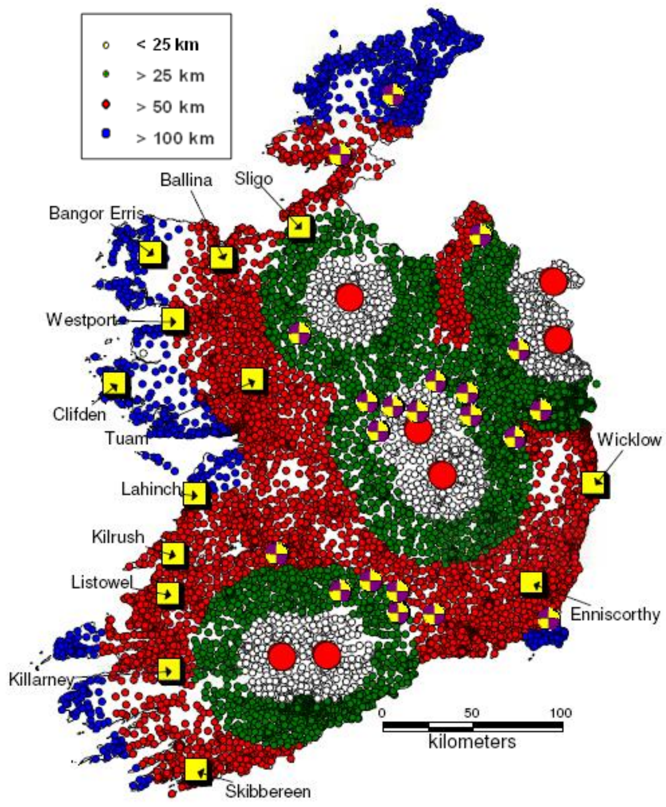

Figure 4.7 Suggested sludge plant upgrades, assuming a sustainable sludge transport distance of 25 km.

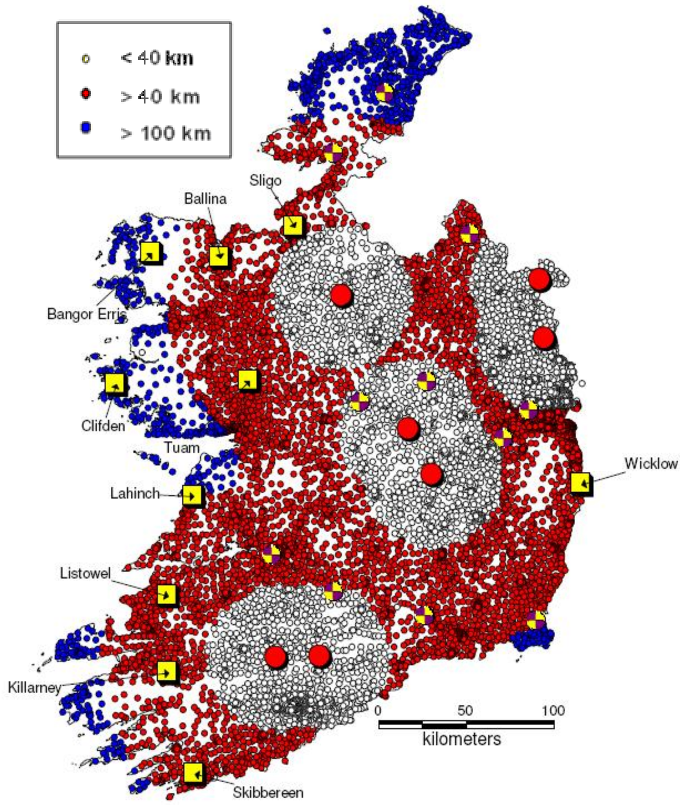

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Figure 4.8 Suggested locations of WWTP upgrades, assuming a sustainable sludge transport distance of 40 km

4.5.2 Evacuation using mobile dewatering trucks (40 km transport distance)

Assuming the scheduled use of mobile dewatering trucks to de-sludge DWWTS and a transport distance of 40 km, the following sludge infrastructural provision would be required:

a) 11 WWTPs, which currently have sludge reception facilities, require an increase in capacity of the PFT or sludge blending tank.

b) 10 WWTPs located in Mayo, Galway and Kerry and Wicklow require the addition of screened sludge reception and blending facilities.

Figure 4.8 indicates the suggested locations of capacity and plant upgrades required to manage predicted sludge volumes.

4.5.3 Evacuation using mobile dewatering trucks (60 km transport distance)

Assuming a transport distance of 60 km, the following sludge infrastructural provision would be required in order to meet predicted sludge requirements:

a) Six WWTPs, which currently have sludge reception facilities, require an increase in capacity of the PFT or sludge blending tank.

b) Seven WWTPs require the addition of screened sludge reception and blending facilities.

Suggested locations of plant and capacity upgrades are shown in Figure 4.9.

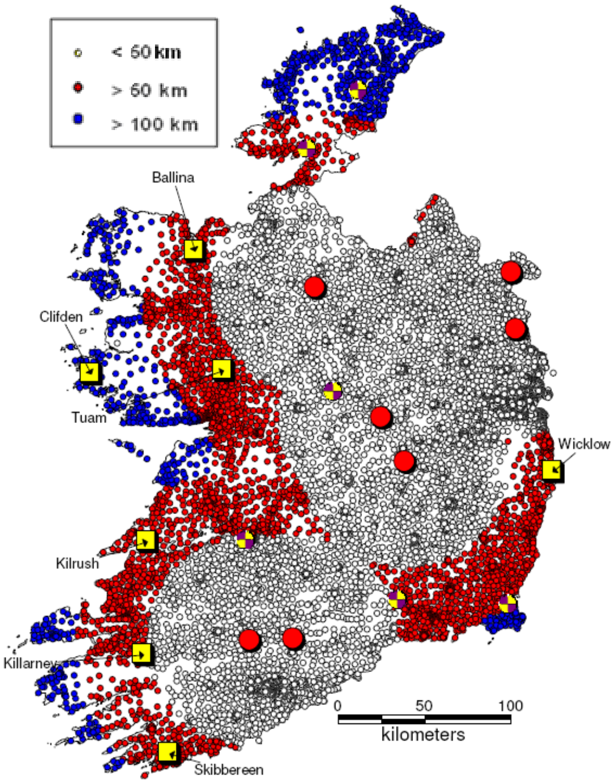

Figure 4.9 Suggested locations of WWTP upgrades, assuming a sustainable sludge transport distance of 60 km.

4.5.4 *Evacuation using mobile dewatering trucks (80 km transport distance)*

Assuming a sustainable transport distance of 80 km by mobile dewatering trucks to de-sludge DWWTS, the following reduced sludge infrastructural provision would be required:

a) Three WWTPs, which currently have sludge reception facilities, require an increase in capacity of the PFT or sludge blending tank. An increase in capacity may also be required at the seven WWTPs which currently have spare capacity in order to cater for predicted DWWTS sludge volumes.

b) Three WWTPs, located in Mayo, Galway and Kerry, require the addition of screened sludge reception and blending facilities.

Figure 4.10 indicates the suggested locations of capacity and plant upgrades required to receive, blend and dewater predicted DWWTS sludge volumes.

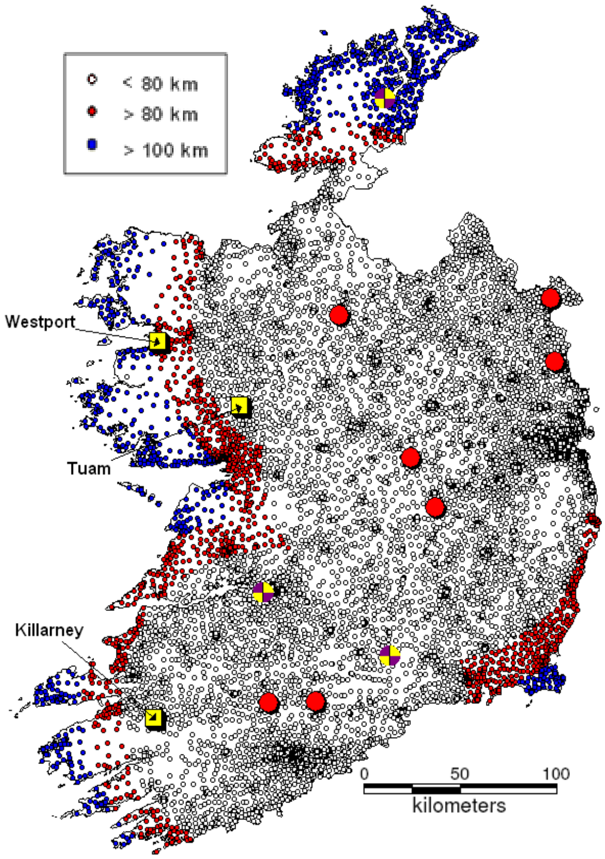

Figure 4.10 Suggested locations of WWTP upgrades, assuming a sustainable sludge transport distance of 80 km.

Evacuation of DWWTS by means of mobile dewatering trucks on a scheduled rota system has the potential to reduce the number of necessary wastewater treatment plant upgrades required, due to the larger sustainable transport distance.

4.6 Future Management Options

In order to facilitate the provision of sustainable sludge collection, reception and transport, and in recognition of Ireland's status as an important food producer, it is essential that a single competent authority should be appointed to administer and implement sustainable management of DWWTS.

The suggested function of the proposed competent body should include the maintenance of a database of registered DWWTS, which should include the location of each DWWTS on a GIS basis, the number of rooms/occupancy of each dwelling, the calculated de-sludging frequency as determined by the regulatory authority (based on tank size and occupancy), and the previous maintenance record of each DWWTS.

The DWWTS maintenance record should include details of previous tank de-sludging by a licenced transport haulier and the destination for the evacuated sludge. The regulated scheduling of DWWTS de-sludging, driven by compliance with regulation, may facilitate the development of a market for sludge transport/reception by private operators as an alternative to the current reception of dilute evacuated DWWTS sludges at municipal WWTPs.

If municipal plants are the only feasible option for the reception and treatment of this sludge, the de-sludging of DWWTS in Ireland will pose major challenges to existing Water Service Authorities (WSA) in the short-term, and to the emerging new water utility, Irish Water, in the future.

Existing wastewater treatment plant infrastructure is not capable of receiving or managing the volume or spatial distribution of DWWTS sludge that will be generated following the implementation of DWWTS legislation.

Following receipt of such imported sludges, the Water Services Authority (WSA) will be responsible for disposal/reuse of such sludges and for the planning and procurement of new sludge handling infrastructure to increase the available capacity to receive and manage these expected additional annual DWWTS sludge volumes. In addition to these necessary capital expenditure (CAPEX) costs and yearly operational expenditure (OPEX) costs, it will be necessary to resource and fund the additional costs associated with the reception, screening, blending, thickening, dewatering, treatment and disposal/recycling of DWWTS sludge. Charging for DWWTS sludge acceptance will be essential for the Water Service Authority/Authorities (WSA) to cover CAPEX and OPEX, using the polluter pays principle.

If other sludge disposal options, not involving recycling of treated sludges (discussed in the following Chapter 5), become the dominant disposal route, the treatment element of sludge handling will not be required. If a sustainable collection and transport model can be developed around scheduled DWWTS de-sludging (using dewatering trucks), the transport of collected sludges directly to facilities, necessary to prepare sludges for these alternative disposal routes, may be feasible.

5. Sludge Treatment, Recycling and Disposal Routes

5.1 Sludge Treatment

Sewage sludge accounts for approximately 5% of total organic sludge produced in Europe (EC, 2008). The "*Code of Good Practice for the Use of Biosolids in Agriculture*" published by DECLG in 1996 states that *"Untreated wastewater sludge should not be landspread or injected into soil"* and sets out process criteria to ensure adequate treatment of sewage sludge. Treatment of municipal sludge eliminates or substantially reduces pathogens in the sludge. Municipal sludge which has been treated to an approved standard is referred to as biosolids. By comparison, the remaining 95% of total sludge originates from agricultural sources and is spread untreated on agricultural land.

In Ireland, the percentage of sludge recycled to agriculture decreased from 70% in 2007 to 62% in 2009 [EC, 2008]. Other treatments such as composting and land remediation accounted for 38% of the sludge disposal in 2009, an increase of 13% from that of 2007. A significant reduction was noted in sludge going to landfill; decreasing from 17% in 2005 to 0.1% in 2009 [EC, 2008].

Five main methods of municipal sludge stabilisation/treatment are currently carried out in Ireland:

- Mesophilic anaerobic digestion
- Thermophilic aerobic digestion
- Drying
- Alkaline/lime stabilisation
- Composting.

5.1.1 Anaerobic and aerobic digestion

Anaerobic digestion of municipal sludge is a multistage bacterial process carried out in the absence of free oxygen which reduces the organic content and the number of pathogens in the sludge and generates biogas containing methane, carbon dioxide and other trace gases.

The methane produced can be utilised as an energy source. Anaerobic digestion reduces the volume of the total sludge mass, therefore reducing costs associated with transport, recycling or disposal of the digestate. Mesophilic anaerobic digestion (MAD) is digestion of sludge at a temperature of 35˚C ± 3˚C for a retention time of at least 12 days, or digestion at a temperature of 25˚C ± 3˚C for a retention time of at least 20 days, in order to ensure stabilisation of the sludge. A pasteurisation phase must also be achieved in which sludge is retained at a temperature of ≥ 70˚C for one hour or ≥ 55˚C for two hours.

Aerobic digestion is the breakdown of organic matter in the presence of free oxygen. Thermophilic aerobic digestion is digestion of sludge over a period of seven days. A temperature of ≥ 55˚C must be maintained for at least four hours. Thermophilic aerobic digestion (TAD) is carried out at a temperature of 50-55˚C and has an average retention time of 48-72 hours. The temperature must be greater than 70˚C for at least one hour followed by a temperature of ≥ 55˚C for at least two hours, or ≥ 50˚C for at least four hours to ensure adequate pathogen reduction.

There are currently nine MAD plants and one TAD plant in Ireland, which were constructed for the treatment of municipal sewage sludge. High capital and operational costs are associated with digestion of sludge, as well as lengthy retention times. Consequent to correspondence with the 34 Water Service Authorities (WSA) by means of a questionnaire, it is evident that in many cases Water Service Authorities (WSA) have ceased the operation of these digestion processes in favour of treatment options, such as alkaline stabilisation, due to the lower cost currently associated with the stabilisation process.

5.1.2 Alkaline stabilisation

Alkaline stabilisation is the addition of $Ca(OH)_2$ (lime) to dewatered municipal sludge in order to raise the pH and temperature, which inactivates pathogens. In accordance with the "*Code of Good Practice for the Use of Biosolids in Agriculture*", the quantity of lime added must increase the pH to >12 and the temperature to 70˚C for 30 minutes, or to increase the pH above 12 for 72 hours and maintain a temperature of ≥ 52˚C for 12 hours or greater. The high temperature and pH inhibits biological action, therefore inactivating pathogens in the treated biosolid product. Other alkaline material, such as cement kiln dust, can be added to stabilise municipal sludge. However, lime is the material commonly used in Ireland for municipal sludge stabilisation.

Capital costs associated with the alkaline stabilisation process are generally low, however, alkaline stabilisation results in an increase in sludge volume, giving rise to additional costs associated with transport and recycling of the lime stabilised sludge cake to land.

Lime stabilisation plants are currently operated by Water Service Authorities (WSA) as well as by a number of private sector companies in Ireland. In many cases Water Service Authorities (WSA), when employing private operators to collect and treat municipal sludges, are opting for lime stabilisation over other treatment processes due to the lower gate fees currently associated with the process.

5.1.3 Composting

The composting process involves biological degradation and stabilisation of organic compounds under thermophilic conditions, which produces a stable end product which can be beneficially recycled to land as a soil conditioner. Compost improves the structure, workability and aeration of the soil.

The two main composting methods are windrow composting or, alternatively, static pile or in-vessel composting. Windrow composting involves retaining the material at 55˚C for at least 15 days. A temperature of ≥ 55˚C must be maintained over five turnings of the material.

Static pile composting requires a temperature of ≥ 55˚C to be maintained for at least three days.

Successful composting is dependent on a number of factors;

- Moisture content; 50-60%
- Carbon-nitrogen ratio; 25-35
- Bulking agents; added,
- pH; optimum pH of 6.5-7.2.

The addition of cellulose material is used to increase C:N ratio but also adds cost to the process.

A number of private sector companies are currently involved in composting of municipal sludge in Ireland, but the relatively lower current cost of lime stabilisation seems to be limiting the potential for further expansion of non-organic compost of dewatered sewage sludges.

5.1.4 Drying

Drying of municipal sludge produces an expensive but stable 'treated' end product, due to the pathogen die-off achieved at high temperatures during the drying process. Drying produces a Class A biosolid which can be beneficially recycled to land as a fertiliser. The treatment process significantly reduces the volume of biosolids to be recycled to land. Numerous different methods have been shown to be successful.

The drying treatment process can be categorised under two headings; direct drying and indirect drying.

a) Direct drying

Hot air comes into contact with the wet sludge particles. The hot air increases the temperature of the sludge resulting in the evaporation of water to produce a dried end product that contains ≤10% of the initial moisture content.

b) Indirect drying

The sludge is dried through conduction of heat through a heat transfer surface. The wet sludge comes in contact with the heated surface, which induces an increase in temperature of the sludge, resulting in the evaporation of water. Non-thermal drying methods have also been shown be successful, such as high pressure homogenisation.

The most common drying process employed in Ireland is thermal drying. There are currently 13 thermal dryers treating municipal sludge in Ireland. Thermal drying is energy intensive and high operational and maintenance costs are associated with the treatment process.

5.2 Sludge Recycling and Disposal Routes

Article 14 of the Urban Wastewater Treatment Directive (91/271/EEC) states that; *"sludge arising from wastewater treatment shall be re-used whenever appropriate. Disposal routes shall minimise the adverse effects on the environment".* The Directive also states that the authorities should ensure that the disposal of sludge from urban wastewater treatment plants (UWWTP) "*is subject to general rules or registration or authorisation*".

In the vast majority of cases, the ultimate disposal route for biosolids in Ireland is recycling to agricultural land. However, as there are increasing pressures on the availability of land banks for landspreading of biosolids, an examination of all alternative recycling and disposal routes is warranted.

5.2.1 Sludge recycling to agriculture

The primary method of biosolids recycling in Ireland is via landspreading on agricultural land. Treated biosolids are a rich source of nutrients which promote plant growth, thereby providing a low-cost alternative to conventional fertilisers. The organic matter present in the treated biosolids acts as a soil conditioner, which improves the quality of the soil properties. When treated in accordance with the "*Codes of Good Practice for the Use of Biosolids in Agriculture"* and recycled in accordance with a Nutrient Management Plan, the recycling of biosolids to agricultural land is a beneficial pathway for re-use, in accordance with the Article 14 of the *Urban Wastewater Treatment Directive* (91/271/EEC).

However, Ireland's status as an agricultural food producer and the increasing importance of quality assurance schemes, such as the Beef Assurance Scheme and the Irish Grain Assurance Scheme, are putting increasing pressures on the availability of land for the recycling of biosolids (or untreated sludge), both from municipal wastewater treatment plants and domestic wastewater treatment systems.

This trend is driven by a perception issue by the food production sector with the use of treated biosolids. This issue may be due in part to the lack of confidence that best practice guidelines for sludge treatment are being followed, which in turn is due to a lack of regulatory enforcement relating to the quality of biosolids end product being landspread. If the perception issue remains unchanged, it is apparent that alternative recycling or disposal options will need to be adopted on a significant scale, in order to deal with the volumes of sludge produced nationally, and additional yearly volumes which will result from a regulated system for DWWTS requiring scheduled de-sludging.

5.2.2 Sludge recycling to energy crops

Energy crops are high-yield, low-maintenance crops which are specifically cultivated in order to use their biomass as a source of energy for heat and electricity production. In Ireland, a number of Bioenergy Schemes, co-funded by the EU under the Rural Development Programme, were launched by the Department of Agriculture, Marine and Natural Resources to build on the progress made during the earlier pilot phase in 2007.

Under these Schemes, farmers were eligible to receive a grant up to a maximum of €1,300 per hectare to cover 50% of establishment costs of the energy crop plantation. However, to date, there are approximately 1,500 acres of willow *(salix alba)* plantation, with only 2,500 hectares committed to miscanthus *(miscanthus giganteus)* production.

In recent years, willow has become the favoured energy crop in Ireland due the following:

- The high biomass yield
- The value of the end product in wood chip production
- The high chloride content of miscanthus forms clinker in boilers which can result in damage and problems in boilers burning miscanthus.

Willow plantations (known as short rotation coppice (SRC)) have higher nutrient requirements and require three times more water uptake than miscanthus, therefore indicating the suitability of SRC for bioremediation. The application of sewage sludge or biosolids to short rotation coppice (SRC) offers an alternative sustainable sludge recycling route, while also providing low cost fertiliser to facilitate biomass production.

Numerous studies indicate that, when managed correctly, willow plantations successfully take up nutrients with no liquid discharge following sludge recycling to land.

However, current regulatory procedures, relating to the use of land for energy crop production, serves as a disincentive to the development of this recycling route for sewage sludge. Energy crops are not included in the current definition of agriculture in the *Waste Management (Use of Sewage Sludge in Agriculture) Regulations,* 1998 (S.I. 148/1998), as these regulations were published before the more recent growth of interest in energy crop production. Consequent to these regulations, a Waste Facility Permit is required for the recycling of sewage sludge to energy crops. The present status of the regulations is counterintuitive, favouring the recycling of sewage sludge to food and animal feed crops, while restricting the recycling of sewage sludge to non-food crops such as willow. Energy crops are included in the definition of agriculture in a number of European documents, such as Ireland's National Nitrates Action Programme S.I. No. 378 of 2006 *European Communities (Good Agricultural Practice for Protection of Waters) Regulations, 2006*. The recognition of energy crop production as agriculture in *the Waste Management (Use of Sewage Sludge in Agriculture) Regulations* would greatly rationalise and simplify the procedures around the recycling of sewage sludge to energy crops. The energy crop recycling route is likely to only cater for a small percentage of future municipal and DWWTS sludge volumes, unless the barriers to using this route are removed by inclusion of energy crops in the definition of agriculture contained in the *Waste Management (Use of Sewage Sludge in Agriculture)* Regulations.

5.2.3 Incineration

Sludge incineration is a combustion reaction in which dewatered sludge or biosolids are burned in a combustion chamber in the presence of excess oxygen to form carbon dioxide, water and ash. Heat generated can be removed and used for process heat or to generate electricity.

Three primary methods of sludge incineration are employed in Europe:

a) Mono-incineration is incineration of the sludge alone.
b) Incineration of sludge along with other wastes.
c) Co-incineration is incineration in which sludge is used as fuel in waste to energy facilities or following drying as fuel for material production, for example, in the cement industry or coal-fired power stations.

Incineration of domestic waste and sewage sludge results in the production of flue gas, ash, wastewater and energy.

Ireland's first municipal waste to energy incinerator at Duleek, County Meath is fully operational since 2011, with the capacity to accept up to 200,000 tonnes of waste and produce 15 mW of electricity into the national grid.

Challenges associated with incineration are the cleaning of flue gas emissions, and the disposal of fly ash.

5.2.4 Landfill

Landfilling is broken into two categories, mono-deposits and mixed-deposits, relating to landfilling of sludge alone or sludge mixed with municipal wastes, respectively.

It is not a sustainable disposal route for sludge disposal. Disadvantages associated with landfilling are emissions to the air through the release of greenhouse gases, such as methane and carbon dioxide, as well as releasing pollutants to soil and water courses, such as heavy metals and synthetic organic compounds.

The EU Landfill Directive 1999/31/EEC has impacted the volume of sludge going to landfill, due to strict standards contained therein relating to landfill of biodegradable municipal waste. The Directive set out targets to reduce the amount of biodegradable municipal waste that can go to landfill by 65% below 1995 levels by 2016. Consequently, the quantity of sludge going to landfill in Ireland has decreased significantly since the introduction of the 1999 EU Landfill Directive (1999/31/EEC). Therefore, as disposal to landfill is being phased out, this disposal route for municipal and/or DWWTS sludge is not a sustainable option for the future.

5.2.5 Land reclamation

Recycling of sewage sludge to land restores derelict land, promotes the growth of vegetation and stabilises soil to prevent soil erosion. Sewage sludge contains organic matter and nutrients, which encourage vegetation growth and therefore creates a growing medium for vegetation when mixed with material that lacks nutrients.

Site suitability and risk assessments must be carried out prior to land reclamation to assess elements, such as the risk to ground and surface water, the existing soil, and any public nuisance risks such as odour. Land reclamation enables beneficial non-food crops such as SRC to be planted (Section 5.2.2). As land area suitable for land reclamation and SRC is limited, it is likely that this recycling route to reclaim would only offer a solution for a small percentage of the municipal and DWWTS sludge produced nationally.

5.2.6 Pyrolysis and gasification

Other technologies such as pyrolysis and gasification are also used to a limited degree in Europe.

a) Pyrolysis is the decomposition of organic matter in biosolids to form gas, bio-oil and char. The decomposition occurs under conditions of high pressure and temperature. Pyrolysis occurs at lower temperatures than incineration or gasification.

b) Gasification induces a chemical reaction between the carbon in the volatile organic fraction of the biosolids with air, oxygen, carbon dioxide, steam or a mixture of the aforementioned gases. The reaction occurs at a temperature of 260-760˚C. Heat and synthetic gas (syngas) are formed following gasification. The reaction occurs under limited oxygen conditions, i.e. there is just enough oxygen to generate heat to drive the chemical reaction.

Pyrolysis and gasification of sewage sludge are not currently used on a large scale in Ireland; therefore significant infrastructure would need to be put in place to deal with the volume of sludge produced nationally.

5.2.7 Other alternative recycling/disposal routes

Dried sludge may be palletised, leading to ease of handling and lower transportation costs. Other possible alternative disposal routes for dried or composted sludge are as follows:

- The use of new innovative processes for conversion of sewage sludges to diesel fuel.
- The use of dried product as furnace fuel (i.e. cement factory) or fuel for power stations in Ireland or abroad.
- The development of a market for beneficial reuse of dried sludge outside of the European Union in areas where organic fertiliser is not available in significant amounts.

5.3 Feasible future disposal routes for DWWTS sludges

It is evident that a number of the more expensive alternative recycling or disposal options outlined above will need to be adopted in order to meet the national requirements for the recycling or disposal of sewage sludge emanating from municipal plants and DWWTS. The need to adopt and/or develop some of these alternative technologies will be particularly urgent if the current practice of recycling treated municipal biosolids to agricultural land and landspreading untreated DWWTS sludge to a farmer’s own land continues to decline, in order to comply with producer and consumer quality assurance schemes.

The spread out spatial distribution of DWWTS in Ireland means that the majority of these DWWTS are located distant from existing sludge reception, handling, dewatering and treatment facilities. The development of a sustainable transport model for scheduled DWWTS de-sludging, as part of a regulated licenced system, is likely to dictate that a large percentage of primary DWWTS sludge evacuated nationwide will end up mixed with municipal sludge in existing and augmented sludge reception, handling and dewatering infrastructure.

As an alternative, the adoption of mobile dewatering truck collection of DWWTS sludge (as discussed in Chapter 4), by increasing the sustainable transport distance, may open the possibility of private industry receiving DWWTS solids directly and developing a market for other disposal routes for dried or treated biosolids or for untreated sludge cake. However, the sewage sludge treatment disposal market is likely to be determined by the cost model driving the treatment/recycling /disposal of the larger volume of mixed municipal and DWWTS sewage sludge.

Consultation with the various private industry stakeholders undertaken during this project established the need to regulate the quality of 'treated' biosolids produced and landspread, in accordance with the existing "*Code of Good Practice for use of Biosolids in Agriculture – Guide to Farmers*" published by DECLG in 1996.

The development of such regulation/mandatory standards may help to address the perception issues emerging with regard to the discontinuation of sewage sludge use on lands used for food production. Regulating the quality of the treated biosolids product and assuring the achievement of the required pathogen die-off, as set out in the above Code of Good Practice, may help to establish the low risk of human pathogen transfer from properly treated biosolids into the food chain and facilitate Ireland's retention of a sustainable recycling route for a low-cost treated fertiliser to land, based on a Nutrient Management Plan, thereby obviating the need to import more expensive chemical fertilisers.

6. Conclusions and Recommendations

6.1 Conclusions

In Ireland, there are an estimated 497,000 domestic wastewater treatment systems (CSO, 2011) treating wastewater from houses that are not connected to a public sewer.

The Government introduced the *Water Services (Amendment) Act, 2012* to provide for the regulation of DWWTS. Based on a review of current legislation relating to DWWTS, the estimation of likely sludge volumes pertaining to the periodic evacuation of DWWTS, the spatial distribution of such volumes, the status of existing infrastructure to receive, blend and treat DWWTS sludge, and an analysis of sludge treatment and reuse or disposal options, the following conclusions can be made:

1. *The Water Services (Amendment) Act, 2012* (No. 2 of 2012) legislates for the registration of DWWTS, the inspection of DWWTS and the remediation of those that pose a risk to human health or to the environment.

2. In accordance with the requirements of Statutory Instrument S.I. 223/2012, a DWWTS must be evacuated at intervals according to the tank capacity and the number of persons resident in the premises connected to it or as recommended by the manufacturer. Based on these criteria, the average de-sludging frequency for DWWTS will vary from 1.5-5 years. The adoption of such de-sludging frequencies based on DWWTS type and household occupancy rate will result in substantially increased annual volumes of sludge to be transported, stored, treated and reused/disposed of, when compared to current uncontrolled de-sludging practices.

3. The average domestic house occupancy ratio in Ireland is 2.8. For the purpose of estimating the total annual volume of sludge to be evacuated from DWWTS, a de-sludging frequency of three years is assumed.

4. The quantification of untreated primary sludge from DWWTS in Chapter 3 indicates that the total annual volume of sludge to be evacuated nationwide from all DWWTS at the aforementioned de-sludging frequency is estimated at 580,161 m^3, based on the complete evacuation of the tank contents and an average volume of 3.5 m^3 for historically-sized septic tanks in Ireland. It is estimated that the expected dry solids contents of such suction evacuated sludge could vary between 1% and 2% depending on the level of solids/supernatant interface in the tank, which in turn would be a function of de-sludging frequency and house occupancy.

5. The *"Code of Practice for use of Biosolids in Agriculture – Guide to Farmers",* published by DECLG in 1996, states that "*Untreated wastewater sludge should not be landspread or injected into soil".* However, under current legislation (S.I. 223/2012) farmers are permitted to evacuate their DWWTS and use its contents on their own land, provided it is not grazed for six months after application (S.I. 223/2012). Assuming that the reuse of untreated sludges from farmhouses will occur in the majority of farms as part of the new DWWTS registration system, the estimated annual sludge volume from DWWTS to be transported off-site to sludge reception facilities is estimated to reduce to 473,381 m^3 at 1-2% dry solids.

6. The current and poor practice of importing DWWTS sludge to a wastewater treatment plant via the inlet works upstream of the biological treatment process is widespread due to:
   - the lack of screened sludge reception facilities in the majority of Irish wastewater treatment plants
   - the low dry solids contents of the combined sludge and liquid supernatant contents of septic tanks evacuated using only suction plant.

   This practice of discharging primary DWWTS sludge upstream of the biological treatment process of a WWTP, rather than blending them with waste-activated sludge post biological treatment, is neither economical nor sustainable in that it takes up available spare biological capacity at the plant and can lead to deterioration in the quality of the treated effluent discharged to receiving waters. Depending on the current loading of municipal plants vis-à-vis their designed capacity, the current practice of importing DWWTS sludge through the inlet works can result in the shock loading of the WWTP, leading to an imbalance in the mixed liquor suspended solids (MLSS) and the food to microorganism ratio (F/M ratio) necessary to ensure optimum treatment efficiencies and the settleability of the mixed liquor in the settlement stage of such activated sludge treatment processes. It is likely that this possibility of shock loading at the biological stage of WWTPs will increase, consequent to the increased annual volumes of DWWTS sludge likely to be accepted following the implementation of a regulated DWWTS licencing system.

7. Results from a review of the current Sludge Management Plans (SMP) adopted by each Local Authority within the last 10-12 years indicates proposals for the provision of dewatering facilities at 200 wastewater treatment plants, up to 113 sludge satellite centres throughout the country containing imported sludge reception facilities and 60 sludge hub-centres for the treatment of sludge prior to disposal. Analysis of the existing infrastructure in Chapter 4 indicates that, in the majority of cases, the Sludge Management Plan recommendations have not been carried out. Investment in the provision of the necessary additional infrastructure has not been realised at the majority of designated WWTPs, since the adoption of these SMPs. The plants where infrastructural investment has been realised since the mid 2000s, based on these SMPs, are located in the east and south of the country, distant from the more rural areas where the concentration of DWWTS is greater.

8. A study was undertaken to establish the status of existing wastewater treatment infrastructure in Chapter 4, based on the completion of a questionnaire and interaction with existing water service authorities. This study indicated that there are:
   - 28 wastewater treatment plants with screened sludge reception facilities
   - seven wastewater treatment plants with spare blending and storage capacity for the acceptance of DWWTS sludge
   - 180 wastewater treatment plants with dewatering facilities
   - 17 sludge hub-centres.

9. The use of mobile dewatering trucks to effect DWWTS evacuation and transport to sludge reception facilities may offer a more sustainable alternative to the use of suction tanks. This dewatering truck method of DWWTS evacuation can facilitate the following:
   - The at-source screening of the evacuated DWWTS contents and the application of polyelectrolytes as an organic coagulant, leading to a reduction in the amount of sludge to be transported by up to 70% and the achievement of dry solids contents of approximately 6-8%. The estimated annual sludge volume to be transported to sludge

reception or treatment facilities by mobile dewatering trucks is 124,320 m^3.

- A decrease in sludge volumes and a corresponding increase in the solids contents of sludge to be accepted at municipal WWTPs or other privately-owned treatment facilities.
- The biological reseeding of the DWWTS by returning the separated supernatant liquor to the DWWTS.

The dewatered primary sludge may then be treated directly by a sludge treatment process, such as composting, or transported to a municipal WWTP for blending with waste-activated sludge, prior to thickening, subsequent treatment using either existing municipal treatment infrastructure or privately-owned treatment and dewatering. However, the use of such mobile dewatering equipment is likely to only be commercially viable when carried out based on a planned rota system for DWWTS evacuation using a so-called ”milk run” system.

10. The analysis of GIS plotted WWTP infrastructure vis-à-vis DWWTS locations in Chapter 4 indicates that there is a large deficit in existing infrastructure with regard to sludge reception, screening and blending facilities. The information gleaned from the above interaction with local authorities indicates that twenty-eight wastewater treatment plants have screened sludge reception and blending facilities. Of these twenty-eight, only seven wastewater treatment plants are stated as having available spare capacity to accept sludge originating from DWWTS. The current spare available capacity of these existing seven sludge reception facilities to receive DWWTS sludges is approximately 234,676 m^3, indicating a volume deficit for receipt of 238,705 m^3 of evacuated sludge at 1-2% dry solids (i.e. 50% of total generated nationally).

11. The spatial distribution of DWWTS vis-à-vis existing sludge reception facilities with spare capacity is examined in Chapter 4. The analysis indicated that 85% of DWWTS nationwide are greater than 25 km away from a wastewater treatment plant with available sludge reception and blending capacity. 9% of all DWWTS are located over 100 km from one of these facilities. The transport of DWWTS sludge using suction tankers for greater than 25 km is considered unsustainable. It is envisaged that the use of dewatering trucks to effect screening, thickening and volume reduction of evacuated DWWTS sludge would extend the sustainable transport distance to sludge reception facilities, whether in public or private ownership, to 80 km.

12. Assuming that the decision is made to increase the capacity to accept DWWTS sludge at the remaining 21 WWTPs which currently have sludge reception facilities, only 47% of DWWTS will be located less than 25 km from the nearest sludge reception facilities. A large infrastructural deficit will still remain, with 261,434 (53%) DWWTS at a distance greater than 25 km from screened sludge reception facilities. The majority of these are located in the west and south coastal areas (Mayo, Galway, Clare, Kerry, West Cork) (Chapter 4, Figure 4.4). If the sustainable transport distance is increased to 80 km, 112,816 (23%) DWWTS are located greater than 80 km from WWTPS, which currently have sludge reception facilities and spare capacity to accept DWWTS sludge. If the capacity to accept DWWTS sludge at the remaining 21 plants, which currently have sludge reception facilities, is increased, 21,704 (4%) DWWTS are located greater than 80 km from sludge reception facilities.

13. The process conditions to be achieved by the following five main sludge treatments, used in Ireland, are set out and discussed in Chapter 5:
    - Mesophilic Anaerobic Digestion
    - Thermophilic Aerobic Digestion
    - Lime Stabilisation
    - Composting
    - Thermal Drying.

The cost of achieving the process temperatures (and pH in the case of lime stabilisation), as recommended by the *"Code of Practice for use of Biosolids in Agriculture"*, depends very much on the moisture content of the sludge to be treated, thereby making the blending and thickening of DWWTS sludge a necessary prerequisite to treatment and the associated required pathogen die-off prior to reuse.

14. Currently, Water Service Authorities (WSA) operate 17 sludge hub-centres for the treatment of sewage sludge, using primarily lime stabilisation, mesophilic aerobic digestion and, in one case, thermophilic aerobic digestion.

15. The private sector is also involved in septic tank evacuation, the transport of sewage sludge to and from municipal WWTPs, and the treatment of both organic food/dairy sludge and non-organic municipal sewage sludge, using a variety of different technologies such as lime stabilisation, composting and thermal drying

16. An examination of treatment and disposal options for sewage sludge is carried out in Chapter 5. The current disposal route for almost all treated (and also untreated) municipal sewage sludge, following treatment by both the Water Service Authorities (WSA) and the private sector, is landspreading or use as a soil conditioner. However, Ireland's status as an agricultural food producer and the increasing importance of quality assurance schemes, promoted for beef and grain production in Ireland, is likely to reduce the on-going acceptability of using the landspreading disposal route for treated sewage sludge, including DWWTS sludges.

17. Due to the aforementioned increasing pressures on the availability of landbanks for the recycling of biosolids, it is evident that a number of the alternative recycling or disposal options, outlined in Chapter 5, will need to be adopted in order to meet the national requirements for the recycling or disposal of DWWTS sludge. Disposal to landfill will not be an option for the future, due to the requirements of the Landfill Directive, 1999/31/EEC. Dried sludge can be used as furnace fuel in cement factories or as fuel for power stations. Sludge incineration, pyrolysis or gasification disposal routes require significant infrastructure to be put in place to deal with the volume of sludge produced nationally. Recycling routes such as land remediation and short rotation coppice are likely to only cater for a small volume of the sludge produced nationally due to limited suitable land area. Alternative disposal routes, such as the conversion of dried sludge to diesel fuel or the export and reuse of dried sludge, in areas outside of the EU where organic fertiliser is not available in any significant amount may warrant consideration. The recycling route to energy crops is not well developed in Ireland. The application of sewage sludge to energy crops, such as willow, offers an environmentally beneficial alternative disposal route to spreading on agricultural land. Legal anomalies and procedural constraints associated with applications to develop such plantations act as a disincentive. Energy crops are not included in the current definition of agriculture in *Waste Management (Use of Sewage Sludge in Agriculture) Regulations, 1998* (S.I. 148/1998). Consequent to these regulations, a Waste Facility Permit is required for the recycling of sewage sludge to energy crops. This serves as a disincentive to the development of this recycling route for sewage sludge.

It is clear from the foregoing that the regulation of DWWTS in Ireland will pose major challenges to Water Service Authorities (WSA). Subsequent to new legislation enacted in 2013, Irish Water will be designated the title of Water Service Authority (WSA) for the country (as defined in the Water Services Act, 2007). While the existing water service authorities (i.e. local authorities) have been charged with the inspection of existing DWWTS in the interim, the new Water Service Authority (Irish Water) will be, from January 2014, the owners of the municipal infrastructural assets to be used for the reception and treatment of sludge and will be responsible for the following:

- The planning and procurement of the new sludge acceptance infrastructure and the augmentation of existing sludge handling and treatment capacity to deal with the expected additional yearly volumes of DWWTS sludge accepted from householders not connected to public sewers.
- The capital works to replace the spare available infrastructural capacity taken up by the additional yearly volume of DWWTS sludge.
- The yearly OPEX costs associated with the screening, thickening, treatment, dewatering and disposal of the additional DWWTS sludge.
- The maintenance of sludge register with respect to the disposal routes for treated sewage sludge.

The new Water Service Authority (WSA) and the local authorities working under Service Level Agreements will need the capability to generate an adequate income stream from the transport of DWWTS to municipal treatment installation, to fund the borrowings associated with the initial investment to provide a sustainable sludge acceptance model at municipal plants, the capital cost for planned replacement of existing sludge capacity used and the ongoing OPEX costs associated with treating and disposing of DWWTS sludge.

6.2 Recommendations

Based on the conclusions of this report, the following recommendations can be made:

1. The current practice of discharging evacuated DWWTS sludge to municipal collection systems or importing them through the inlet works of a WWTP should be discontinued to preserve the biological capacity of WWTPs, obviate the high cost associated with the aeration of these evacuated primary sludge, and prevent disruption to plant operation and quality of final effluent discharged to receiving waters from the shock loading that can ensue from uncontrolled deposition of such sludge volumes.
2. In order to protect plant and equipment in WWTPs, DWWTS sludge transported by suction tankers should only be discharged to plants which have screened sludge reception facilities and sufficient available handling capacity (thickening tanks and blending tanks) to deal with the likely yearly volume to be transported to each plant.
3. In respect of sludges evacuated and thickened using mobile dewatering trucks prior to transport to WWTPs, it may be possible to introduce such sludges to the sludge handling/treatment process of WWTP at a location downstream of sludge screening and thickening, due to the absence of detritus and the higher dry solids of the sludge.
4. In order to overcome the scale and spatial distribution of the infrastructural deficits with regard to the transport distance to sludge reception facilities, it is recommended that:
   a. For the existing ad hoc arrangement using suction tanks with a sustainable transport distance of 25 km (as per GIS analysis – may change in practice):
      - 21 wastewater treatment plants require an increase in capacity of the picket fence thickener (PFT) or the construction of a sludge blending tank.
      - 11 wastewater treatment plants require the addition of screened sludge reception and blending facilities. Tentative locations for these 11 wastewater treatment plants, as shown in Chapter 4, Figure 4.7, were chosen based on their location relative to the concentration of DWWTS (currently with long transport distances), the status of existing wastewater/sludge handling facilities and the relative merits of known siting constraints.
   b. For scheduled evacuation of DWWTS using a mobile dewatering tank with a sustainable transport distance of 80 km (as per GIS analysis – may change in practice):
      - 10 wastewater treatment plants, which currently have sludge reception facilities, will require an increase in capacity of the PFT or sludge blending tank.
      - Three additional wastewater treatment plants will require the addition of screened sludge reception and blending facilities, as shown in Chapter 4, Figure 4.8.
5. It is envisaged that evacuated sludge from the overwhelming majority of DWWTS that are not located on a farm will be delivered to existing WWTP sludge facilities. Existing facilities at these plants will require a capital investment by the Water Service Authority (WSA), who will also be required to bear ongoing yearly operational costs to facilitate the transport, screening, handling, treatment of untreated DWWTS sludge and reuse or disposal of treated sludge. While the Regulations implementing DWWTS registration require the

householder to retain a record of DWWTS maintenance and transport of sludge therefrom by a licenced haulier, it is recommended that the responsibility for planning the future repeated evacuation of these DWWTS should be designated to a competent regulatory authority.

6. The competent authority should establish and maintain a database of registered DWWTS, which should include the location of each DWWTS on a GIS basis, the number of rooms/occupancy of the dwelling, the calculated de-sludging frequency as determined by the regulatory authority (based on tank size and occupancy) and the previous de-sludging record of each DWWTS including details of licenced transport haulier and the destination for the evacuated sludge.

7. It is recommended that the optimal regulation and maintenance of DWWTS will be effected by their planned scheduled de-sludging. Such scheduled de-sludging rotas would enable the use of alternative methods such as dewatering trucks permitting less extensive investment in sludge reception infrastructure and longer transport distances by virtues of inherent screening and lower sludge volumes.

8. The recommended augmentation of reception infrastructure and the sludge handling/treatment/dewatering capacity at each of the above recommended sites, referred to in (4) above, will be site-specific and will have to be determined by the competent regulatory authority subsequent to:

   - A survey of existing sludge assets at each plant.
   - An analysis of the expected additional imported DWWTS sludge volume relative to the sludge volumes to be generated by existing and designed population equivalent discharging to the WWTP's collection system.
   - A cost-benefit analysis which would examine the relative benefits of scheduled de-sludging methodologies vis-à-vis the sustainability of ad-hoc de-sludging, with regard to cost of increased transport distances of pre-thickened sludge and the benefit of reducing the required number of reception sites and the capital investment in screening/thickening equipment at these sites.

9. The *"Code of Good Practice for the use of Biosolids in Agriculture"* state that "*untreated wastewater sludge should not be landspread or injected into soil*". However, legislation allows for this in practice. It is recommended that the existing "*Code of Good Practice for the use of Biosolids in Agriculture*" is implemented formally by legislation. Compliance with food Quality Assurance Schemes is likely to phase out the spreading of untreated DWWTS sludge on land by farmers.

10. Sewage sludge recycling to energy crops is unlikely to become a feasible sludge disposal route unless existing legislation is amended. As a result of onerous legislative requirements, it is recommended that the legislation should be amended to allow for sewage sludge to be used as fertiliser for energy crops. In any revision of the Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, it is recommended that when sewage sludge is used in agriculture, the outdated definition of agriculture in the Directive be superseded by one of the more recent definitions such as that contained within SI 378 of 2006, i.e. EC (Good Practice for protection of waters) which includes "the growing of crops (including forestry and horticultural crops)".

    The adoption of a definition of agriculture to include the growth of energy crops would reduce existing regulatory and procedural constraints which are currently an impediment in the development of

additional cultivations of willow plantations, which represent a sustainable method of treated sludge disposal/recycling.

11. Based on the conclusions of Chapter 5, it is also recommended that a quality assurance system be put in place for the treatment and disposal of sewage sludge. This system would ensure that all sewage sludge is handled in a traceable manner using standard procedures and guarantee that the required treatment process conditions to be achieved for the required bacterial die-off in treated sludge, as set out in Appendix 3 of the *“Codes of Good Practice for the use of Biosolids in Agriculture”*, are properly recorded by public and private operators operating sludge treatment facilities. Such a system would promote the fair development of competition between the various treatment technologies in the private sector.

12. It is recommended that the provision of governance arrangements for the collection, treatment and reuse/disposal of sludges evacuated from DWWTS will be necessary.

13. It is recommended that a cost-benefit analysis be conducted to ascertain the optimum arrangement of sludge facilities nationwide, taking into account the options of upgrading existing WWTP infrastructure and the development of facilities by the private sector.

7. References

75/442/EEC Council Directive 75/442/EEC of 15 July 1995 on waste

86/278/EEC Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture

91/271/EEC Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment

1999/31/EEC Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste

2000/60/EC Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

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S.I. 32/2010 Waste Management (Registration of Sewage Sludge Facility) Regulations, 2010

S.I. 148/1998 Waste Management (Use of Sewage Sludge in Agriculture) Regulations, 1998

S.I. 220/2012 Water Services Acts, 2007 and 2012 Domestic Wastewater Treatment (Registration) Regulations, 2012

S.I. 223/2012 Water Services Acts, 2007 and 2012 (Domestic Wastewater Treatment Systems) Regulations, 2012

S.I. 267/2001 Waste Management (Use of Sewage Sludge in Agriculture) (Amendment) Regulations, 2001

S.I. 378/2006 European Communities (Good Agricultural Practice for Protection of Waters) Regulations, 2006

S.I. 610/2010 European Communities (Good Agricultural Practice for Protection of Waters) Regulations, 2010

S.I. 820/2007 Waste Management (Collection Permit) Regulations, 2007

S.I. 87/2008 Waste Management (Collection Permit) (Amendment) Regulations, 2008

7.1 Glossary

BOD	Biological Oxygen Demand
CAPEX	Capital Expenditure
CCMA	County and City Managers' Association
CSO	Central Statistics Office
DECLG	Department of the Environment, Community and Local Government
DWWTS	Domestic Wastewater Treatment System
EPA	Environmental Protection Agency
EU	European Union
F/M Ratio	Food to Microorganism Ratio
FSAI	Food Safety Authority of Ireland
GIS	Geographic Information System
IGAS	Irish Grain Assurance Scheme
IPPC	Integrated Pollution Prevention Control
MAD	Mesophilic Anaerobic Digestion
MLSS	Mixed Liquor Suspended Solids
NWCPO	National Waste Collection Permit Office
OPEX	Operational Expenditure
PFT	Picket Fence Thickener
SAPS	Small Area Population Statistics
SLP	Sludge Management Plan
SRC	Short Rotation Coppice
TAD	Thermophilic Aerobic Digestion
UWWTP	Urban Wastewater Treatment Plant
WSA	Water Services Authority
WWTP	Wastewater Treatment Plant

An Ghníomhaireacht um Chaomhnú Comhshaoil

Is í an Gníomhaireacht um Chaomhnú Comhshaoil (EPA) comhlachta reachtúil a chosnaíonn an comhshaol do mhuintir na tíre go léir. Rialaímid agus déanaimid maoirsiú ar ghníomhaíochtaí a d'fhéadfadh truailliú a chruthú murach sin. Cinntímid go bhfuil eolas cruinn ann ar threochtaí comhshaoil ionas go nglactar aon chéim is gá. Is iad na príomh-nithe a bhfuilimid gníomhach leo ná comhshaol na hÉireann a chosaint agus cinntiú go bhfuil forbairt inbhuanaithe.

Is comhlacht poiblí neamhspleách í an Ghníomhaireacht um Chaomhnú Comhshaoil (EPA) a bunaíodh i mí Iúil 1993 faoin Acht fán nGníomhaireacht um Chaomhnú Comhshaoil 1992. Ó thaobh an Rialtais, is í an Roinn Comhshaoil, Pobal agus Rialtais Áitiúil.

ÁR bhFREAGRACHTAÍ

CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaol i mbaol:

- áiseanna dramhaíola (m.sh., líonadh talún, loisceoirí, stáisiúin aistrithe dramhaíola);
- gníomhaíochtaí tionsclaíocha ar scála mór (m.sh., déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta);
- diantalmhaíocht;
- úsáid faoi shrian agus scaoileadh smachtaithe Orgánach Géinathraithe (GMO);
- mór-áiseanna stórais peitreail;
- scardadh dramhuisce;
- dumpáil mara.

FEIDHMIÚ COMHSHAOIL NÁISIÚNTA

- Stiúradh os cionn 2,000 iniúchadh agus cigireacht de áiseanna a fuair ceadúnas ón nGníomhaireacht gach bliain
- Maoirsiú freagrachtaí cosanta comhshaoil údarás áitiúla thar sé earnáil - aer, fuaim, dramhaíl, dramhuisce agus caighdeán uisce
- Obair le húdaráis áitiúla agus leis na Gardaí chun stop a chur le gníomhaíocht mhídhleathach dramhaíola trí comhordú a dhéanamh ar líonra forfheidhmithe náisiúnta, díriú isteach ar chiontóirí, stiúradh fiosrúcháin agus maoirsiú leigheas na bhfadhbanna.
- An dlí a chur orthu siúd a bhriseann dlí comhshaoil agus a dhéanann dochar don chomhshaol mar thoradh ar a ngníomhaíochtaí.

MONATÓIREACHT, ANAILÍS AGUS TUAIRISCIÚ AR AN GCOMHSHAOL

- Monatóireacht ar chaighdeán aeir agus caighdeáin aibhneacha, locha, uiscí taoide agus uiscí talaimh; leibhéil agus sruth aibhneacha a thomhas.
- Tuairisciú neamhspleách chun cabhrú le rialtais náisiúnta agus áitiúla cinntí a dhéanamh.

RIALÚ ASTUITHE GÁIS CEAPTHA TEASA NA HÉIREANN

- Cainníochtú astuithe gáis ceaptha teasa na hÉireann i gcomhthéacs ár dtiomantas Kyoto.
- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

TAIGHDE AGUS FORBAIRT COMHSHAOIL

- Taighde ar shaincheisteanna comhshaoil a chomhordú (cosúil le caighdéan aeir agus uisce, athrú aeráide, bithéagsúlacht, teicneolaíochtaí comhshaoil).

MEASÚNÚ STRAITÉISEACH COMHSHAOIL

- Ag déanamh measúnú ar thionchar phleananna agus chláracha ar chomhshaol na hÉireann (cosúil le pleananna bainistíochta dramhaíola agus forbartha).

PLEANÁIL, OIDEACHAS AGUS TREOIR CHOMHSHAOIL

- Treoir a thabhairt don phobal agus do thionscal ar cheisteanna comhshaoil éagsúla (m.sh., iarratais ar cheadúnais, seachaint dramhaíola agus rialacháin chomhshaoil).
- Eolas níos fearr ar an gcomhshaol a scaipeadh (trí cláracha teilifíse comhshaoil agus pacáistí acmhainne do bhunscoileanna agus do mheánscoileanna).

BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Ghníomhaireacht i 1993 chun comhshaol na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaimseartha, ar a bhfuil Príomhstiúrthóir agus ceithre Stiúrthóir.

Tá obair na Gníomhaireachta ar siúl trí ceithre Oifig:

- An Oifig Aeráide, Ceadúnaithe agus Úsáide Acmhainní
- An Oifig um Fhorfheidhmiúchán Comhshaoil
- An Oifig um Measúnacht Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáide

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

Science, Technology, Research and Innovation for the Environment (STRIVE) 2007-2013

The Science, Technology, Research and Innovation for the Environment (STRIVE) programme covers the period 2007 to 2013.

The programme comprises three key measures: Sustainable Development, Cleaner Production and Environmental Technologies, and A Healthy Environment; together with two supporting measures: EPA Environmental Research Centre (ERC) and Capacity & Capability Building. The seven principal thematic areas for the programme are Climate Change; Waste, Resource Management and Chemicals; Water Quality and the Aquatic Environment; Air Quality, Atmospheric Deposition and Noise; Impacts on Biodiversity; Soils and Land-use; and Socio-economic Considerations. In addition, other emerging issues will be addressed as the need arises.

The funding for the programme (approximately €100 million) comes from the Environmental Research Sub-Programme of the National Development Plan (NDP), the Inter-Departmental Committee for the Strategy for Science, Technology and Innovation (IDC-SSTI); and EPA core funding and co-funding by economic sectors.

The EPA has a statutory role to co-ordinate environmental research in Ireland and is organising and administering the STRIVE programme on behalf of the Department of the Environment, Heritage and Local Government.

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An Ghníomhaireacht um Chaomhnú Comhshaoil

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SSTI Strategy for Science, Technology and Innovation

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government