SEPTIC TANK FAILURE IN NZ: HOW SERIOUS IS THE PROBLEM?

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ABSTRACT

This paper summarises a review carried out for the Ministry for the Environment on the current understanding of the incidence of on-site wastewater treatment system 'failures' in New Zealand, and the public health risks and environmental effects of such failures. While acknowledging the shortcomings in the available information, the following key conclusions were drawn:

1. There are in the order of 250 communities across the country with significant numbers of failing on-site wastewater treatment systems, mainly septic tank systems, comprising a total of about 42,000 houses.

2. Some of these failures would not be remedied by improved maintenance, since some failures are due to the siting of septic tanks in inappropriate locations (e.g. areas with high groundwater table).

3. Many failing systems will be affecting the localised area around the septic tanks, and nearby stormwater drains, presenting significant public health risks.

4. More than 100 streams and more than 100 coastal sites are potentially affected by failing septic tanks. The number of potentially affected lakes and rivers is much smaller.

5. The number of groundwater systems that are potentially affected remains largely unknown. Effects on groundwater are likely to be considerably under-reported. However, relatively few municipal groundwater drinking water supplies are at risk from septic tanks.

KEYWORDS

Septic tank failure; water pollution; public health risk

1 INTRODUCTION

The Ministry for the Environment (MfE) is proposing a new National Environmental Standard (NES) for the inspection and maintenance of on-site wastewater treatment systems. As part of the development of this standard, MfE commissioned Covec Ltd to carry out a cost-benefit analysis for the NES. To support the cost-benefit analysis, Environmental Management Services Ltd reviewed the current understanding of the performance of on-site wastewater treatment systems in New Zealand, including the incidence of system 'failures', and the public health risks and environmental effects of such failures.

On-site wastewater treatment systems are defined here as systems that treat domestic wastewater (sewage) on the site that the wastewater originates from. The vast majority of these systems in New Zealand are septic tank systems, so this paper focuses on septic tank failures. The paper also focuses on septic tanks for dwellings in rural communities. It does not address isolated rural dwellings, small rural schools, marae, rural community halls, small accommodation facilities, or small rural businesses.

More detail on the study that this paper reports on can be found in the author's report 'Incidence And Effects Of On-Site Wastewater Treatment System Failures In New Zealand', available free from MfE's website www.mfe.govt.nz.

2 BACKGROUND

2.1 HOW DO SEPTIC TANKS FAIL?

In general, 'failure' is defined here as when inadequately treated wastewater enters groundwater or surface water, or rises to the ground surface. This can occur in a number of ways:

- The septic tank can leak directly into the ground
- The septic tanks has been connected, either intentionally or by accident, to stormwater pipes or open stormwater drains
- The pipes in the disposal field have become blocked, causing wastewater to discharge in a concentrated manner into the ground
- The disposal field soil is not pervious enough, causing wastewater to rise to the ground surface (or sometimes discharge directly into groundwater through large cracks in the soil)
- The disposal field soil is too pervious (e.g., coarse sands or gravels), allowing the wastewater to enter groundwater without adequate treatment in the unsaturated soil (removal of contaminants such as pathogens is much more effective in unsaturated than saturated soils).
- The disposal field is too close to the groundwater table (i.e. high groundwater situations), allowing the wastewater to enter groundwater without adequate treatment.

2.2 WHAT EFFECTS OF FAILURES CAN OCCUR?

While domestic wastewater has a number of characteristics that can cause adverse effects on people and the environment, the main contaminants of concern are pathogens (disease-causing organisms) and nutrients. The effects of septic tank failures can include:

- Disease in people (usually young children) having direct contact with wastewater lying on the ground surface.
- Disease in people caused by drinking contaminated water (usually from shallow groundwater bores located near septic tank disposal fields).
- Methemoglobinemia ('blue baby syndrome') caused by elevated nitrate concentrations in groundwater used for drinking water.
- Disease in people (most often young children) from contact recreation (swimming and paddling) in contaminated stormwater drains, streams, lakes, estuaries and beaches.
- Disease in people caused by eating contaminated shellfish, either from private or commercial shellfish gathering. Shellfish tend to concentrate the pathogens that occur in the water, making their consumption a higher risk than contact with the water itself.
- Economic effects caused by having to close shellfish farms (even if no disease is actually caused).
- Nuisance weed growth and/or algal blooms caused by elevated nutrient levels. This can have secondary effects on people and aquatic animals from algal toxin reactions.

The risk of people contracting diseases from micro-organisms (pathogens) in septic tank discharges is referred to in this report as 'public health risks'. The public risks of methemoglobinemia from drinking water are considered to be substantially less than those from pathogens in drinking water.

2.3 INFORMATION SOURCES FOR THIS STUDY

This paper is based on a desk-top review of existing information on the incidence of septic tank failures, and consequent effects on the receiving environment. A number of information sources were drawn on:

- The Water and Sanitary Services Assessments (WASSA) that were carried out in the mid 2000s by all territorial local authorities as required under the Local Government Amendment Act.
- Published scientific papers.
- Published reports from the 'grey' literature, i.e. not published in scientific journals. Most of these reports have been commissioned by regional councils or territorial local authorities.
- Miscellaneous unpublished documents (e.g. council letters and memos that have been sourced from council staff).

2.4 LIMITATIONS OF THE STUDY

In an ideal situation, to assess the risks of septic tank failures on a national scale one would need to determine how many septic tanks there are in New Zealand, how many of these are 'failing' or underperforming, and what the public health risks and environmental effects of each of these failures are (or at least, the effects of failures of 'clusters' of septic tanks). In reality there is a paucity of knowledge of all of these matters. Furthermore, it was beyond the scope of the study to review all the existing information on septic tanks in New Zealand. Therefore the assessments and conclusions contained in this paper must be viewed in the light of the limitations of the available information.

3 INCIDENCE AND LOCATIONS OF FAILING SYSTEMS

3.1 METHOD

It was found that the best source of information on the incidence and location of failing systems was the WASSA. Therefore the WASSA of 60 of the 74 TLAs in New Zealand were reviewed in considerable detail (a further 8 could not be obtained from the respective local authorities, and another 6 were ignored because these TLAs had no communities serviced by septic tank systems). The following information was collated and analysed:

- Location of communities where significant levels of failures are known, highly likely or suspected
- Number of houses and/or population in each community (where available)

For each of the communities identified with failing systems, the author then used topographic maps to identify the type of adjacent water body that was most likely to be potentially affected, grouped as follows[1]:

- 'Groundwater'
- 'Stream'
- 'River'
- 'Lake'
- 'Estuary'
- 'Sheltered marine' (sheltered from high energy water movement, e.g. harbours)
- 'Open coast' (generally high energy marine environment).

It is noted that all the affected communities have or are likely to have localised effects from failing septic tanks, including effects on nearby stormwater drains (except perhaps for those with very free draining soils).

3.2 NUMBER OF COMMUNITIES WITH PROBLEMS WITH SEPTIC TANKS

A total of 227 communities were identified as having problems with their septic tanks from the WASSA that were obtained. Of these, slightly over half (126) were identified as known or highly likely to be at risk of failure, with the remainder identified as suspected to be at risk.

This data does not include at-risk communities in the 8 TLAs for which WASSAs were not obtained. If it is assumed that the average number of communities with failing septic tanks in these 8 TLAs is the same the 60 communities that were reviewed, this would result in a total of about 250 communities across the whole country.

3.3 TOTAL NUMBER OF HOUSES/POPULATION IN AT-RISK COMMUNITIES

Unfortunately, data on the populations and numbers of houses was only available for 73 of the 227 identified at-risk communities. The populations in these 73 communities ranged from 30 to about 1,500, while the

[1] This grouping system was based on a system developed by Paul Barter in Barter & Robertson (2002), Chapter 6: 'Risk analysis: Characterising the Receiving Environment', contained in: 'New Zealand Municipal Wastewater Monitoring Guidelines'. (Download available free from MfE's website).

numbers of houses ranged from 17 to about 500. The total number of houses in the 73 communities was estimated as about 12,200 (where populations rather than numbers of houses were identified in the WASSA, the numbers of houses were estimated by assuming 2.7 residents per house). This implies an average of about 170 houses in each of the 73 communities.

A crude estimate of the total numbers of houses in the about 250 at-risk communities was made by linearly extrapolating the average numbers of houses in the 73 communities discussed above. This results in an estimate of a total of about 42,000 houses. It is noted that this estimate could have a margin of error of +/- 20%.

It should also be noted that the above analysis does not take into account failing septic tanks in isolated rural dwellings, which is quite widespread in some areas (e.g. Taieri Plains and Southland Plains).

3.4 AREAS MOST AT-RISK

There are a number of factors that increase the risk of septic tank failure, including:

- Poorly drained soils
- High groundwater table
- Small lot size
- Poor maintenance
- Overloading during summer due to visitor influx

These factors appear to have lead to a relatively small number of TLAs being disproportionately represented with high numbers of at risk communities, as follows (listed from north to south, not in order of priority):

- Far North District Council
- Rodney District Council
- Auckland City (Waiheke Island)
- Thames Coromandel District Council
- Marlborough District Council

Other TLAs that also have a relatively high incidence of known or suspected problems include Whangarei District Council, Western Bay of Plenty District Council, Gisborne District Council, Manawatu District Council, Selwyn District Council, Christchurch City Council (Marshlands), and Dunedin City Council. It should however be noted that some TLAs may have under-reported septic tank problems; in particular, those TLAs with potential septic tank risks to groundwater.

3.5 RECEIVING WATERS POTENTIALLY AFFECTED

The assessed numbers of receiving waters that could potentially be affected by failing septic tanks are listed in Table 1. It is noted that this is an estimate of water bodies that could potentially be affected. Other factors, discussed below, limit the sensitivity of some of these water bodies to contaminant inputs.

The figures in Table 1 need to be regarded with some caution, and should be considered very approximate estimates only. If anything, they are likely to underestimate the number of water bodies potentially affected, due to under-reporting by local authorities. This is particularly true for effects on groundwater, as discussed in the following section.

Table 1: Estimate of approximate number of receiving waters potentially affected by failing septic tanks, based on WASSA surveys

Localised area around septic tanks, & nearby stormwater drains	Multiple sites at 200-250 communities
Groundwater sites	c. 10*
Streams	100-120
Rivers	10-20
Lakes	c. 10
Estuaries	10-20
Sheltered marine	40-60
Open coastal	30-50

* this is considered to be well under-estimated – refer to comments in text below

4 EFFECTS OF FAILING SYSTEMS

The effects of failing septic tanks systems were assessed by reviewing a range of studies reported in New Zealand's grey literature[2]. The studies show that highly variable effects of septic tanks on receiving waters have been observed. Confounding factors that make the assessment of effects difficult include differentiating human sources from other sources, including water fowl, rural runoff, and domestic and feral animals. Results are also influenced by seasonal and weather-related variability. Nevertheless, it is possible to make some general conclusions on the basis of the studies reviewed, as follows.

Public health effects (microbiological and nitrate contamination):

1. Although no formal studies of **localised** effects from septic tanks (i.e. within the property on which the septic tank is located) were obtained, there is considerable anecdotal evidence from the WASSA and interviews with local authority staff that localised public health risks can be significant in areas with poorly drained soils, high water tables, and with septic tanks that are poorly operated and/or maintained. Given that such contamination can result in untreated or inadequately treated sewage pooling on the ground surface, there is a serious risk of illness for the inhabitants of the dwelling, especially young children.

2. There are few investigations into **groundwater** contamination, apart from some research-orientated studies carried out by ESR. The paucity of studies may be due to the lack of obvious problems with septic tanks in areas with very free draining soils. However, it appears that the risks to unconfined aquifers in gravels and coarse sands can be significant, with viruses being able to survive for long periods of time and travel considerable distances (hundreds of metres) before being inactivated.

[2] Details on these studies can be found in the author's report 'Incidence And Effects Of On-Site Wastewater Treatment System Failures In New Zealand', available free from MfE's website www.mfe.govt.nz

Furthermore, nitrate concentrations can be significantly elevated from clusters of septic tanks discharging into groundwater.

3. Many **stormwater** drains and small **streams** (including small freshwater lagoons near beaches) show signs of microbial contamination that is highly likely attributable to nearby septic tanks.

4. Few studies have been carried out on the effects on larger streams and **rivers**. However, these water bodies usually provide a high degree of dilution for septic tank discharges, and if microbiological pollution is significant in these larger watercourses, it is more likely due to rural runoff from the wider catchment than septic tanks.

5. Studies of septic tanks near to **lakes** show that effects are generally limited to shallow groundwater downslope of the septic tanks and near-shore surface waters near drain outlets. Effects on the main body of the lake are usually negligible because of dilution, unless the water body is small (e.g. an enclosed bay) and the contribution of contaminants from septic tanks is high in comparison to other sources such as farm runoff.

6. There are relatively few investigations available on septic tanks effects on **estuaries**. However there appears to be a significant incidence of bacterial contamination where there is a high density of septic tanks near to the estuary and tidal flushing is limited. Risks are probably greater in terms of consuming shellfish from these areas compared to contact recreation.

7. Bathing beach water quality monitoring shows that **open coast beaches** are, in general, less susceptible to significant microbiological contamination, due largely to the high dilution of the contaminants. However, the public health risk at beaches can not be completely dismissed, even if water quality monitoring shows compliance with contact recreation guidelines. This is because some pathogens can cause illness in very low concentrations (e.g. human adenoviruses).

Nutrient enrichment effects (environmental effects):

Very few studies have identified significant environmental effects on receiving waters due to nutrient inputs from septic tanks. Nutrient inputs are generally not in high enough concentrations in comparison to other catchment sources to influence nuisance plant growths. Effects will generally be limited to enclosed, sensitive water bodies with a high input of nutrients from septic tanks in comparison to nutrient inputs from other sources.

5 RISKS TO RECEIVING ENVIRONMENTS

As discussed above, the effects from nutrients from septic tanks on receiving waters are relatively low compared with public health risks, so the remainder of this paper focuses on public health risks. The public health risk posed to the different receiving environments from inadequately treated septic tank discharges is influenced by a number of factors, the main ones being:

- The degree of **dilution** of contaminants likely to occur in the receiving environment (for example, there will obviously be a much greater degree of dilution in a river than in a small stream).
- The frequency of human **contact** with the particular receiving environment

These factors are analysed for each receiving environment in Tables 2 and 3 below.

Table 2: Degree of dilution available in potentially affected receiving environments

Receiving environment	**Degree of dilution**	**Comments**
Localised effects	Very low	Very little if any dilution.
Groundwater	Low to moderate	Dilution dependent on lateral groundwater flow rates and rainfall recharge. Typically relatively low in comparison to other receiving waters, especially during prolonged dry periods.
Stormwater drains	Low to moderate	Little dilution during dry periods. However some septic tank discharges to stormwater drains occur only during rainfall, when greater dilution is available.
Streams (including freshwater lagoons)	Low to moderate	Dilution dependent on stream flow. Could be relatively low in small streams during dry periods.
Rivers	High	
Lakes	Moderate to high	Usually a reasonably degree of dilution unless there are a large number of septic tanks discharging into an enclosed bay.
Estuaries	Moderate to high	Usually considerable dilution due to tidal flushing.
Sheltered marine waters	Moderate	Reasonable dilution due to tidal flushing.
Open coastal waters	High	Usually a high degree of dilution due to high energy environment (waves and currents).

Table 3: Frequency of human 'contact/exposure' to receiving environment, assuming that environment is affected by septic tanks (seasonal - assume summer conditions as worst case scenario)

Receiving environment	**Frequency of contact/ exposure**	**Comments**
Localised effects	High	People may be walking through the affected area on a daily basis. High probability of contact, especially for small children e.g. toddlers.
Groundwater	Very high if groundwater being used for domestic supply; otherwise low	If groundwater used as drinking water supply, risk of exposure is very high.
Stormwater drains	Low to high	Depends on the nature of the drains. Can be high risk of contact where stormwater is flowing through high recreation areas such as across beaches, especially for children. Note that risk of ingestion of contaminated water by children is higher than for adults.
Streams (including freshwater lagoons)	Low to moderate	Depends on the location and 'attractiveness' of the stream. Can be attractive play areas for children.
Rivers	Low to moderate	Generally low, except at popular swimming holes.
Lakes	Moderate to high	High risk of contact, depending on public access and weather conditions.
Estuaries	Moderate to high	Moderately high risk of contact; very high risk if in shellfish gathering area.
Sheltered marine waters	Moderate to high	High risk of contact, depending on public access and weather conditions.
Open coastal waters	Moderate to high	High risk of contact, depending on public access and weather conditions.

Taking into account the analysis in Tables 2 and 3 and the number of the water bodies that are potentially affected by septic tanks, the overall public health risk to receiving environments from septic tanks in the national context is ranked as follows (greatest risk to lowest):

1. Localised effects and stormwater drains (including drains that flow onto beaches)
2. Small streams (including freshwater lagoons at beaches)
3. Groundwater (this assumes that there are now very few shallow groundwater drinking water supplies located near to septic tank disposal fields, which is considered a reasonable assumption based on the information in the WASSA surveys)
4. Sheltered marine waters and estuaries
5. Lakes
6. Rivers and open coastal waters (noting that high risks exist for stormwater drains and small streams discharging across beaches)

6 CONCLUSIONS

1. There are in the order of 250 communities across the country with significant numbers of failing septic tanks. These communities comprise a total of around 42,000 houses (this estimate must be regarded as very approximate, and it is noted that not all of these houses will have failing systems). This estimate does not include isolated rural dwellings.

2. Some of these failures would not be remedied by improved maintenance, since some failures are due to the siting of septic tanks in inappropriate locations (e.g. areas with high groundwater table).

3. Many failing systems will be affecting the localised area around the septic tanks (i.e. within a few metres of the septic tanks), and nearby stormwater drains.

4. It is estimated that more than 100 streams and more than 100 coastal sites (comprising estuaries, sheltered marine waters, and open coast beaches) are potentially affected by failing septic tanks. Again, these must be regarded as very approximate estimates. The number of lakes and rivers that are potentially affected is much smaller.

5. The number of groundwater systems that are potentially affected remains largely unknown. It is considered that effects on groundwater have been considerably under-reported, largely because problems are not immediately evident to residents or TLA staff, whereas research has shown that unconfined aquifers are vulnerable to septic tank discharges. However, it appears that relatively few domestic water supplies are at risk from septic tanks, since most domestic wells that were historically at risk have now been replaced with reticulated council water supplies.

6. It is considered that the risks to the environment from nutrient discharges from septic tanks are small in comparison to the potential public health risks. This is largely because the nutrient inputs to water bodies from septic tanks are usually small in comparison to inputs from other catchment sources.

7. When the amount of dilution and the likelihood of public contact/exposure is taken into account, the relative public health risks of failing septic tanks in terms of the different receiving environments in the national context can be ranked as follows (from highest risk to lowest risk):

    (i) Localised effects and nearby stormwater drains (including drains that flow onto beaches)
    (ii) Small streams (including freshwater lagoons at beaches)
    (iii) Groundwater
    (iv) Sheltered marine waters and estuaries
    (v) Lakes
    (vi) Rivers and Open coastal waters (noting that high risks exist for stormwater drains and small streams discharging across beaches)

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